ISSN-1560-604X
Thermology international

Thermology international

Volume 10 (2000)
Number 1 (January)

formerly European Journal of Thermology

Published by the

Ludwig Boltzmann Research Institute
for Physical Diagnostics
Austrian Society of Thermology

THERMOLOGY INTERNATIONAL
(formerly EUROPEAN JOURNAL OF THERMOLOGY)

Volume 10 (2000) **Number 1 (January)**

Published by the
Ludwig Boltzmann Research Institute for Physical Diagnostics and the Austrian Society of Thermology

Organ of the American Academy of Thermology

Organ of the European Association of Thermology

Organ der Deutschen Gesellschaft für Thermologie

Organ der Österreichischen Gesellschaft für Thermologie

Organ of the UK Thermography Association (Thermology Group)

Instruktionen für Autoren

Manuskripte müssen dem Schriftleiter zugesandt werden und dürfen noch nicht veröffentlicht sein.

Die Manuskripte von Übersichts- und Originalarbeiten werden 2 unabhängigen Begutachtern vorgelegt, die über Annahme oder Annahme nach Änderung des Manuskriptes entscheiden.

Mit der Annahme der Arbeit gehen alle Rechte an den Herausgeber über.

Verantwortlicher Schriftleiter:

Dr. Kurt Ammer

Ludwig Boltzmann Forschungsstelle
für Physikalische Diagnostik,
Hanuschkrankenhaus, Heinrich Collinstraße30
A-1140 Wien, Österreich,
Tel: (43 1) 914-97-01 Fax: (43 1) 914-92-64
e-mail: KAmmer1950@aol.com

Publiziert werden:

Editorials
Übersichten
Originalien
Berichte über interessante Publikationen aus dem Gebiet Thermologie
Mitteilungen der Amerikanischen Akademie für Thermologie; der Britischen Assoziation ür Thermographie (Thermologie Gruppe); der Deutschen Gesellschaft für Thermologie; der Europäischen Assoziation für Thermologie und Mitteilungen der Österreichischen Gesellschaft für Thermologie
Veranstaltungshinweise

Manuskripte sollen mit den Empfehlungen des Internationalen Komittees der Herausgeber von Medizinischen Zeitschriften (ICMJE) (1,2) im Einklang stehen.Es ist auf eine klare Gliederung der Beiträge vorzugsweise in der Form:Einleitung, Methode, Ergebnisse,Diskussion, Danksagung, Literatur, zu achten. Jeder Arbeit ist eine Kurzfassung in Deutsch und Englisch voranzustellen. Bis zu 5 Schlüsselwörter sollen den Inhalt der Arbeit zusätzlich charakterisieren.

Tabellen und Abbildungen sollen gesondert dem Manuskript beigelegt werden. Legenden werden auf einem Extrablatt beigegeben.

Die Einreichung der Arbeit auf Diskette unter Angabe des verwendeten Systems ist möglich und erwünscht. Ein Ausdruck des Textes ist der Diskette beizulegen.

Literaturangaben sind auf einem gesonderten Blatt erbeten und sind in der Reihenfolge aufzulisten, in der sie im Text genannt werden..Die Literaturzitate werden durchnumeriert; im Text werden nur die entsprechenden Nummern angegeben. Die nachstehende Beispiele basieren auf dem Format der Amerikanischen Nationalbibliothek für Medizin im Index Medicus. (Eine komplette Liste von Beispielen bei 1).

a.) Zeitschriftenzitate

Namen der Verfasser, Vorname(n) (abgekürzt)(die ersten 6 Autoren müssen angeführt werden, mehr als 6 Autoren werden mit “et al” angegeben), vollständiger Titel der Arbeit, abgekürzter Titel der Zeitschrift, Jahr, Band, Seitenzahlen.

Luther B, Kreyer I, Dobi I. Die Anus-praeter-Thermographie als Methode zur Früherkennung vaskulärer Komplikationen nach Dünndarmtransplantation. ThermoMed 1990: 6: 115-17.

b.) Buchzitate

Name der Verfasser, Vorname(n) (abgekürzt), vollständiger Titel der Arbeit, Herausgeber, Titel des Buches, Ort,Verlag, Jahr, Seitenzahlen.

Gautherie M, Haehnel P, Walter JM, KeithL. Long-Term assessment of Breast Cancer Risk by Liquid Crystal Thermal Imaging. In: Gautherie M, Albert E; editors. Biomedical Thermology. New York: Alan R.Liss Publ;1982. 279-301.

Von Text und Abbildungen werden den Autoren Andrucke zur Korrektur zugesandt. Jeder Autor erhält 20 Sonderdrucke seiner Arbeit kostenlos.

“Thermology international” erscheint 4 mal jährlich. Ein Jahresabonnement kostet ATS 460,- ein Einzelheft ATS 140- .plus Porto (ATS 60.-pro Heft außerhalb Österreichs).

Für Mitglieder der Österreichischen Gesellschaft für Thermologie, der Deutschen Gesellschaft für Thermologie und der Amerikanischen Akademie für Thermologie ist die Zeitschrift im Mitgliedsbeitrag inkludiert.

Literatur

(1)International Committeof Medical Journal Editors. Uniform requirements for manuscripts submitted to biomedical journals. Can. Med Assoc J 1997;156;270-7.

(2) International Committeof Medical Journal Editors. Additional statements from the International Committeof Medical Journal Editors. Can. Med Assoc J 1997;156; 571-4.

Uhlen-Verlag,
Moßbacherg.29,A-1 140 Wien
Thermology international
ISSN-1056-604X

Inhaltsverzeichnis (CONTENTS)

Übersicht (REVIEW)

Originalien (ORIGINAL ARTICLES)

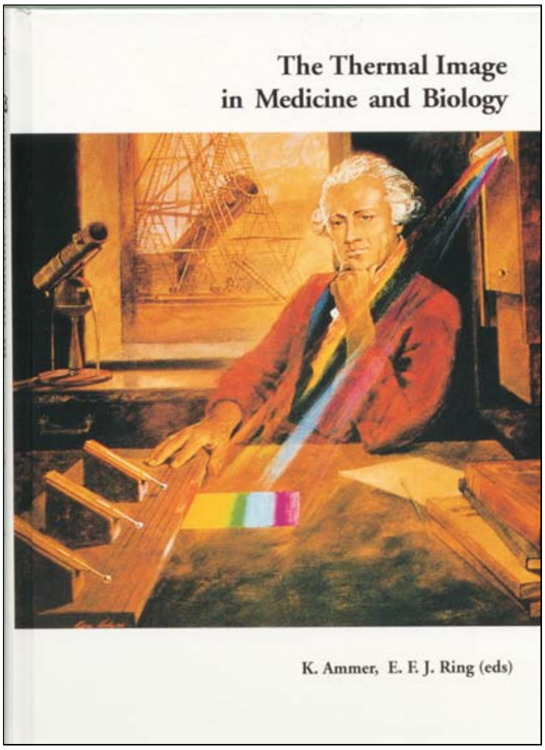
Berichte (REPORTS)

News in Thermology (THERMOLOGISCHE NACHRICHTEN)

Mitteilungen der Deutschen Gesellschaft für Thermologie
(INFORMATION FROM THE GERMAN SOCIETY OF THERMOLOGY)

Mitteilungen der Österreichischen Gesellschaft für Thermologie
(INFORMATION FROM THE AUSTRIAN SOCIETY OF THERMOLOGY)

Veranstaltungen (MEETINGS)



The Thermal Image In Medicine & Biology

1995, ISBN 3 900466 57 2
240 pp. plus XVI colour plates

ed. K.Ammer, EFJ.Ring

Thermal Imaging, Microwave Detection

Image Processing, Thermal Image Applications

Recent advances in medical thermography

Thermal physiology and the skin

Veterinary thermography

Medical applications of thermal imaging

Vascular applications.

This book, based on the proceedings of an international conference, provides the most up to date review of the current state of the art in thermal imaging. The clinical applicatons include vascular skin reactions, varicosed veins, deep vein thrombosis and Raynaud's Phenomenon. Lumbar disc herniation, post surgical evaluation of the knee and the hand (carpal tunnel syndrome), tennis elbow and thoracic outlet syndrome are also described.
The methodology itself and comparative studies with other techniques such as ultrasound, CT and MRI make this a practical manual for the physician or technologist employing these investigations.

Only available from The European Association of Thermology, order below at the direct sale price of $50 U.S. or 500.- Austrian Schillings to the following account 965 023 054 at Bank Austria, No 20151 in Vienna, Austria. Price includes mail in Europe, all other destinations add $10 or 120.-Austrian Schillings.

ORDER

The Thermal Image In Medicine & Biology .....copy/ies

Name.. fax no.................................

Address...

....country..code/ZIP............................

amount due..........................

I wish to subcribe to **Thermology international**

(1 yr subscription 700.- Austrian Schilling or US $ 70.- including mail costs)

1 yr subscription............................

TOTAL PAYMENT TO THE EUROPEAN ASSOCIATION OF THERMOLOGY................................

send with payment (international order or proof of bank transfer) to

Dr.Kurt Ammer, European Association of Thermology
Hernalser Hauptstr. 209/14, A-1170 Wien, Österreich
Bank Austria, Vienna, Austria, bank number: 20151,
account :European Association of Thermology, account number: 965 023 054

Instructions for authors

Manuscripts should be mailed to the editor and should not be submitted elsewhere. All manuscripts (i.e. reviews and original articles) will be read by two independent reviewers. With the acceptance of the paper all copyrights are transfered to the publisher.

Editor in Chief

Dr. Kurt Ammer

Ludwig Boltzmann Forschungsstelle für Physikalische Diagnostik, Hanuschkrankenhaus Heinrich Collinstraße 30 A-1140 Wien, Österreich, Phone: (43 1) 914-97-01 Fax:(43 1) 914-92-64 Personal e-mail:KAmmer1950@aol.com

We publish

Editorials

Reviews

Original articles

Reports on thermological publications of interest

Announcements from

The American Academy of Thermology,
The Austrian Society of Thermology
The German Society of Thermology
The Thermology Society of Great Britain
The European Association of Thermology

Information and abstracts
from conferences and symposia

Manuscripts should follow the recommendations of the International Committe of Medical Journal editors (ICMJE) (1) and should be organized as follows: Introduction, methods, results, discussion, acknowledgements, references. A short abstract in English and, if possible, German (trans- lation will be offered) should head the manuscript. Following the abstract, up to 5 key-words should characterize the paper.

Tables, Figures and Legends for illustrations should appear each on an extra sheet of paper.

Submission on computer discs with name of the used system is encouraged. A print of the disc content should be enclosed.

References should be numbered consecutively in the order in which they are first mentioned in the text. Identify references in text, tables, and legends by Arabic numerals in parentheses. Use the style of the examples below which are based on the formats used by the US National Library of Medicine in Index Medicus (complete list of examples on (1)).

Standard journal article (List the first six authors followed by "et al" if the number exceeds 6).

Luther B, Kreyer I, Dobi I. Die Anus-praeter-Thermographie als Methode zur Früherkennung vaskulärer Komplikationen nach Dünndarm-transplantation. ThermoMed 1990; 6: 115-7.

Chapter in a book

Gautherie M, HaehnelP, Walter JM, Keith L. Long-Term assessment of Breast Cancer Risk by Liquid Crystal Thermal Imaging. In: Gautherie M, Albert E, editors. Biomedical Thermology. New York Alan R.Liss Publ; 1982. p. 279-301.

Before publication proof prints will be mailed to the main author for corrections. Each author will receive 20 free copies of the reprint.

The journal"Thermology international" (formerly "European Journal of Thermology") is published four times/year. Annual Subscription rate is ATS 460.-, a single copy costs ATS 140.- plus mailing costs (ATS 60/copy; outside Austria).

The journal is supplied free of charge to members of the American Academy of Thermology, the Austrian Society of Thermology and also to members of the German Society of Thermology.

References:

(1)International Committeof Medical Journal Editors. Uniform requirements for manuscripts submitted to biomedical journals. Can. Med Assoc J 1997;156;270-7.

(2) International Committeof Medical Journal Editors. Additional statements from the International Committeof Medical Journal Editors. Can. Med Assoc J 1997;156; 571-4.

Uhlen-Verlag,
Moßbacherg.29, A-1140 Wien
Thermology international
ISSN-1560-604X

The Technique of Infra red Imaging in Medicine

[1] **EFJ Ring,** [2] **K Ammer**

1 Royal National Hospital for Rheumatic Diseases, Bath BA1 1RL UK

2 Ludwig Boltzmann Institute for Physical Diagnostics, Vienna Austria

Summary

Infra red imaging can only produce reliable and valid results if the technique follows established standards. In medical applications these standards are based on the physics of heat radiation and the physiology of thermoregulation of the human body. This paper describes the requirements for the location, setting up the equipment and the preparation of the human subject to be investigated. A list of references is given to support each part of the recommended procedure. Despite the fact that thermal imaging has been available for many years, there are still some applications of this technique which require more research.

Key words: Infra red imaging, standards, thermoregulation, heat radiation

Die Methode der Infrarot-Thermographie in der Medizin

Mit der Infrarot-Thermographie kann man nur dann zuverlässige und valide Ergebnisse erhalten, wenn man diese Technik in standardisierter Weise einsetzt. Für den medizinschen Gebrauch basieren diese auf der Physik der Wärmestrahlung und der Physiologie der Infrarot-Thermographie des menschlichen Körpers. Diese Arbeit beschreibt die Anforderungen an den Untersuchungsraum, an die Ausrüstung und für die Vorbereitung der zu untersuchenden Person. Eine Literaturliste sichert jeden Teil dieses empfohlenen Vorgehens ab. Trotzdem besteht für manche Anwendungen noch immer Forschungsbedarf.

Schlüsselwörter: Infrarot-Thermographie, Standards, Thermoregulation, Wärmestrahlung,

Introduction

Infra red thermal imaging has been used in medicine since the early 1960's. Early imaging systems were large with very limited facilities for display and temperature measurement, In the 1970's computer image processing of thermograms became available, with increased possibilities for quantitation and archiving of images (1). This resulted in an increased awareness for the need for standardisation of technique. Two publications were initiated by working groups within the European Thermographic Association (now European Association of Thermology) to address this question. The first, Standardisation of Thermography In Locomotor Diseases - recommended procedure (2) set out the basic requirements for technique agreed by a European panel of rheumatologists and radiologists. This paper which was published in 1978, contained many elements of standardisation which applied to other clinical applications of thermography. The second, Skin Temperature Measurement in Drug Trials was presented by a group of authors who described the essential techniques for the use of thermography in clinical drug trials (3). The proceedings of a special conference on breast diseases published in 1983 included a chapter on Standardisation of Thermal Imaging: Physical and environmental influences (4). A further statement from the European Association of Thermology was published in 1988 on the subject of Raynaud's Phenomenon: Assessment by Thermography. More recently an overview of recommendations gathered from The American Academy of Thermology, The Japanese Society of Biomedical Thermology and the European Association of Thermology was collated and published by Clark et al. in 1997 (6). This paper is based on the practical implications of the foregoing papers taken from the perspective of the modern thermal imaging systems available to medicine.

1. Location for thermal imaging

1a Investigation room

The room used for thermal imaging must meet certain basic requirements. These are- adequate size for working - where up to 2 meters may be needed between the patient and the subject and adequate space to locate the image processing equipment and space for one or more patient cubicles. A rough indicator for the least distance in one direction can be derived from the optical features of the lens i. e. the distance between the camera and the patient to take an image of the upper or lower part of the human body or of an object of 1,2 m height. This means that a minimum size of 2x3 meters is required, but that a larger room , 3x4 meters or more will be preferable.

1b Ambient temperature control.

This is a primary requirement for most clinical applications of thermal imaging. A range of temperatures from 18°C to 25°C should be attainable and held for at least one hour to better than 1^0C. At lower temperatures, the subject is likely to shiver, and over 25°C room temperature will cause sweating, at least in most European countries. Variations may be expected in colder or warmer climates, in the latter case, room temperatures may need to be $1\text{-}2^0$C higher (7).

The type of examination used will determine the ideal ambient temperature. Many clinical examinations are performed with partial disrobing of the patient. When larger areas of the body are unclothed and exposed to the air for longer periods, the lower ambient temperatures will cause discomfort (8, 9) and may result in reflex vasoconstriction. Inflammatory lesions are more clearly visualised in a cool environment, typically 20°C. Examination of the extremities, where the sympathetic nervous system influences the result, a warmer ambient of 22-24°C is generally recommended.

Additonal techniques for cooling particular regions of the body have been developed (10,11) (e.,g.water immersion of the hands in a stress test).

1c Room Temperature Indication

Indication of the air temperature is important, a large digital display which is visible anywhere in the room should be used. Air temperature is affected not only by heat generated by electronic equipment, but also by the human body. For this reason the air-conditioning unit should be capable of compensating for the maximum number of patients and staff likely to be in the room at any one time. These effects will be greater in a small room of 2x3 meters or less. Air conditioning equipment should be located so that direct draughts are not directed at the patient, and that overall air speed is kept as low as possible. A suspended perforated ceiling with ducts diffusing the air distribution evenly over the room is ideal (12), although more expensive to construct, than the simple wall mounted systems.

1d Computer Equipment

Image processing equipment needs space located away from the patient area, to avoid heat disturbance. A sink with water supply is often required for water stress tests. Furniture may also include a multi-position chair with attached leg rests, and a bowl or table on castors at a suitable height for a sitting patient.

1e Patient Cubicle

Finally a cubicle or cubicles within the temperature controlled area is essential. These should provide privacy for disrobing and a suitable area for resting through the acclimatisation period.

2. The Imaging System

2a. A new generation of infra red cameras have become available for medical imaging. The older systems normally single element detectors using an optical mechanical scanning process, were mostly cooled by the addition of liquid nitrogen (13,14, 15). This had the effect of limiting the angle at which the camera could be used which restricted operation.Electronic cooling systems were then introduced, which overcomes this problem. The latest generation of focal plane array cameras can be used without cooling, providing almost maintenance free technology (16).

Almost all systems now use image processing techniques and provide basic quantitation of the image (17,18, 19). In some cases this may be operated from a chip within the camera, of may be carried out through an on-line or off-line computer. For older equipment like the AGA 680 series several hardware adaptations have been reported to achieve quantitation of the thermograms (20,21,22).

2b Temperature Reference

Earlier reports stipulate the requirement for a separate thermal reference source for calibration checks on the camera (23). Many systems now include an internal reference temperature, with manufacturers claiming that external checks are not required. Unless frequent servicing is obtained, it is still advisable to use an external source, if only to check for drift in the temperature sensitivity of the camera. An external reference, which may be purchased or constructed, can be switched on with the equipment, and left running throughout the day. This allows the operator to make checks on the camera, and in particular provides a check on the hardware and software employed for processing. These constant temperature source checks may be the only satisfactory way of proving the reliability of temperature measurements made from the thermogram(24).

2c Mounting the Imager

A camera stand which provides vertical height adjustment is very important for medical thermography. Photographic tripod stands are inconvenient for frequent adjustment and often result in tilting the camera at an undefined angle to the patient. This is difficult to reproduce, and unless the patient is positioned so that the surface scanned is aligned at 90^0 to the camera lens, distortion of the image is unavoidable. Studio camera stands are ideal, they provide vertical height adjustment with counterbalance weight compensation. They are stable with a weighted base on wheels which enables the operator to rapidly set up the camera in any reproducible position. Most stands can hold the camera to within 10cms from the floor (the patient can also stand on a low stool to avoid parallax even in a standing position). Maximum height required will depend on the use of a low couch, or whether all positioning is achieved with the patient standing or sitting in a chair. A pillar height of 2 meters or 2.5 meters can be used. It should be noted that the type of lens used on the camera will affect the working distance and the field of view, a wide angle lens reduces distance between the camera and the subject in many cases, but may also increase peripheral distortion of the image. Ceiling mounted stands used in radiology and nuclear medicine can also be used, but are likely to require positioning motors if the camera is beyond the operators reach.

2d Camera Initialisation

Start up time with modern cameras are claimed to be very short, minutes or seconds. However, the speed with which the image becomes visible is not an indication of image stability. Checks on calibration will usually show that a much longer period from 10 minutes to several hours with an uncooled system are needed to achieve optimum conditions for quantitative imaging (4,25).

2e Image Processing

Software packages for thermal imaging are provided by some manufacturers, few of which are specifically designed for medical applications (17,18). One specialised software system designed for medical use meets international standards when used according to recommended techniques (26). Archiving of both images and relevant clinical data is an important requirement for medical thermography.

3. The Patient

3a Patient Information

Human skin temperature is the product of heat dissipated from the vessels and organs within the body, and the effect of the environmental factors on heat loss or gain. There are a number of further influences which are controllable, such as cosmetics (27), alcohol intake (28) and smoking (29,30,31). These should form part of the request made to the patient when calling him or her for examination. In general terms the patient attending for examination should be advised to avoid all topical applications such as ointments (32,33) and cosmetics on the day of examination to all the relevant areas of the body. Large meals and above average intake of tea or coffee should also be excluded, although studies supporting this recommendation are hard to find and the results are not conclusive

(34,35,36). Patients should be asked to avoid tight fitting clothing, and to keep physical exertion to a minimum. This particularly applies to methods of physiotherapy such as electrotherapy (37,38,39), ultrasound (40), heat treatment (41,42,43), cryotherapy (43,44,45,46), massage (47,48,49) and hydrotherapy (50,51,52) because thermal effects from such treatment can last for 4-6 hours under certain conditions . Heat production by muscular exercise is a well documented phenomenon (53,54, 55,56,57).

Drug treatment can also affect the skin temperature. This phenomenon was used to evaluate the therapeutic effects of medicaments (3). Drugs affecting the cardiovascular system (58,59, 60, 61) must be reported to the thermographer, in order that the correct interpretation of thermal images will be given.

3b Pre-Imaging Equilibration

On arrival at the department, the patient should be informed of the examination procedure, instructed to remove appropriate clothing and jewellery, and asked to sit or rest in the preparation cubicle for a fixed time. The time required to achieve adequate stability in blood pressure and skin temperature is generally considered to be 15 minutes, with 10 minutes as a minimum (62,63,64). After 30 minutes cooling, oszillations of the skin temperature can be detected, in different regions of the body with different amplitudes resulting in a temperature asymmetry between left and right sides (63). Some evidence has been found for a circadian rhytm of both core and skin temperatures (20, 34,65,66). During this preparation time the patient must avoid folding or crossing arms and legs, or placing bare feet on a cold surface. If the lower extremities are to be examined, a stool or leg rest should be provided to avoid direct contact with the floor (67). During the examination paper or linen towels may be required to avoid overcooling of the feet.

3c Positions for Imaging

As in radiology, it is preferable to standardise on a series of standard views for each body region. The EAT Locomotor Diseases Group recommendations include a triangular marker system to indicate anterior, posterior, lateral and angled views (2, 68). Modern image processing software provide comment boxes which can be used to encode the angle of view which will be stored with the image(26). It should be noted that the position of the patient for scanning and in preparation must be constant. Standing, sitting or lying down affect the surface area of the body exposed to the ambient, therefore an image recorded with the patient in a sitting position may not be comparable with one recorded on a separate occasion in a standing position.

3d Field of View

Image size is dependant on the distance between the camera and the patient and the focal length of the infrared camera lens. The lens is generally fixed on most medical systems, so it is good practice to maintain a constant distance from the patient for each view, in order to acquire a reproducible field of view for the image. For example a single hand may be recorded in a 20x20cm field of view, while a picture of both lower limbs from knees to ankles may require a 50x50cm field. If deviations in camera angle from the normal position on the stand are required, these should be recorded for future use. If different thermograms different field of of the same subject are compared, the variable resolution can lead to false temperature readings (69). Most hospitals now use a standard format for patient identification and demographic detail. As much detail as possible should be recorded with the thermogram to avoid misidentity. The time and date of examination should also be recorded, which most computer software will provide as standard (70).

4. Report Generation

4a Colour and Temperature Scale

Individual software programmes now largely dictate the layout for a clinical report. This will normally consist of the images, the demographic data and any measurements made from image processing. Every image or block of images must carry the indication of temperature range, with colour code/temperature scale. The colour scale itself should be standardised. Industrial software frequently provides a greyscale picture and one or more colour scales. The default colour scale is often to show white as hot, then yellow, and then red, following the hot metal scale. The so-called rainbow or spectral order of colours is more widely recognised, especially by colleagues who are not used to the other colour scales used by engineers. A false colour finely graded scale is also possible, this can be ranged from dark blue at the cold end through green to red, and will convey a similar degree of image contrast to a monochrome black and white picture.

4b Processing the Reported Image

Background temperatures which can obscure the clinical image, should be avoided, and cleaning the image by processing e.g. squeezing the temperature range or overwriting the lower temperatures with a background of white, grey or black will improve the visual presentation. Care taken when the pictures are recorded will minimise these problems. The use of hardboard or cold towels arranged just prior to image recording will often improve the image clarity. Regions of interest, spot measurements sites etc. Should be indicated, and if these mask the clinical picture, a separate image without these processing indicators should be provided. It is important to note that while a high number of colour shades can be displayed on a computer monitor screen, most printers to date are less able to reproduce all the fine detail. Settings for the image on the screen should be tested on the printer to ensure that subtle differences in the image which are important are not lost in a lower contrast printed image.

4c Archiving Images and Data

Computer file archives are now commonplace and are a valuable reference for repeated investigations on the same patient. A multiple window facility in the software will allow the operator to recall a series of earlier pictures for comparison, and to ensure that the same positions and temperature settings have been used. A matrix of 4x4 images is adequate with possibilities to zoom on any combination of frames for the report (24). The numerical data relating to each image must be clearly identified with the original image to which it relates.

If a standardised challenge test such as a cold stress test for Raynaud's phenomenon has been used, the relevant images should be printed, preferably to show the pre and post stress thermograms together with the temperature data extracted from them. Where normal values for indices (71,72,73) or temperature values (74, 75) are known, these should be included in the report.

Conclusion

Good technique is essential with infra-red imaging, which is a physiological procedure. Attention to details as described will improve physicians ability to use the technique as a diagnostic aid and for monitoring change from treatment or from the natural course of the disease. Good documentation, and self explanatory reports will improve the clinical acceptability of the technique. Such requirements are expected from any imaging procedure used as medico-legal evidence. The same standard should apply to routine clinical investigations with thermal imaging. Poor image reproduction and incomplete reporting will serve to deter clinical use. Few non-invasive imaging techniques are easily quantified as is the case with infra red imaging. The modern equipment available since 1999 is of superior quality and reliability than any previously used in medicine.

References

1.) Ring EFJ Thermography and Rheumatic Diseases. Thermography, Bibl. Radiol. 6. 97-106 Karger, Basel 1975.

2.) Engel JM, Cosh JA, Ring EFJ, Page Thomas DP, Van Waes P, Shoenfeld D. Thermography in Locomotor Diseases - Recommended Procedure. Eur. J Rheum. Inflamm 1979; 2: 299-306.

3.) Ring EFJ, Engel JM, Page -Thomas DP Thermologic methods in Clinical Pharmacology - Skin Temperature Measurement in Drug Trials, Int. J Clinical Pharmacol Therapy & Toxicology 1984; 22: 20-24.

4.) Ring EFJ Standardisation of Thermal Imaging in Medicine: Physical and Environmental factors in Thermal Assessment of Breast Health. Ed Gautherie M, Albert E, Keith L, 29-36. MTP Press Ltd. (Lancaster/Boston/The Hague) 1983.

5.) European Association of Thermology, Aarts N, Black CM, Bosiger P et.al. Raynaud's Phenomenon: assessment by Thermography Thermology 1988;3: 69-73

6.) Clark RP, de Calcina-Goff M. Guidelines for Standardisation in Medical Thermography Draft International Standard Proposals.Thermologie Österreich 1997; 7:2 47-58.

7.) Ishigaki T, Ikeda M, Asai H, , Sakuma S.Forehead-Back Thermal Ratio for the Interpretation of Infrared Imaging of Spinal Cord Lesions and Other Neurological Disorders. Thermology 1989, 3: 101-7

8.) Issing K, Hensel H: Temperaturempfindung und thermischer Komfort bei satischen Temperaturreizen. Z Phys Med Baln Med Klim 1982, 11: 354-365

9.) Mabuchi K, Kanbara O, Genno H, Chinzei T, Haeno S, Kunimoto M: Automatic control of optimum ambient thermal conditions using feedback of skin temperature.Biomedical Thermology 1997, 16: 6-13

10.) Schuber TR, d. Haute JV., Hassenburger J, Beller FK. Directed dynamic cooling;a methodic contribution in telethermography. Acta thermographica 1977, 2:94-99

11.) Di Carlo A. Thermography in patients with systemic sclerosis. Thermol Österr 1994, 4/1: 18-24

12.) Love T.J. Heat Transfer Considerations in the Designof a Thermology Clinic. Thermology 1985, 1: 88-91

13.) Dibley DAG. Opto-Mechanical Systems for Thermal Imaging. In: Ammer K, Ring EFJ. Editors, The Thermal Image in Medicine & Biology. Vienna, Uhlen-Verlag, 1995, p.33-39

14.) Friedrich KH. Assessment criteria for infrared thermography systems. Acta thermographica 1980, 5: 68-76

15.) Alderson JKA., Ring EFJ: 'Sprite' High Resolution Thermal Imaging System. Thermology 1985; 1: 110-14

16.) Kutas M. Staring Focal Plane Array for Medical Thermal Imaging. In: Ring EFJ Phillips B, editors, Recent Advances In Medical Thermology. New York.; Plenum Press,. 1984. p.185-194

17.) Engel JM: Thermotom- ein Softwarepaket für die thermographische Bildanalyse in der Rheumatologie. In: Engel J-M, Flesch U, Stüttgen F. Hrg, notamed, Baden –Baden, 1983,. pp.110-117

18.) Bösiger P, F.Scaroni: Mikroprozessor- unterstütztes Thermographie-System zur quantitativewn on-line Analyse von statischen und dynamischen Thermogrammen. . In: Engel J-M, Flesch U, Stüttgen F. Hrg, notamed, Baden –Baden, 1983,. p.125- 130

19.) Brandes P: PIC-Win-Iris Bildverarbeitungs-software. Thermologie Österreich 1994, 4: 33-35

20.) Ring EFJ: Quantitative thermography in arthritis using the AGA integrator. Acta thermographica 1977, 2: 172-176

21.) Parr G, Prees M, Salisbury R; Page Thomas P, Hazleman BR: Microcomputer Standardization of the AGA 680 M System. In: Ring EFJ Phillips B, editors, Recent Advances In Medical Thermology. New York.; Plenum Press,. 1984. p.211-214

22.) Van Hamme, H., De Geest G.,. Cornelis J: . An Acquisition and Scan Conversion Unit for the AGA THV680 Medical Infrared Camera. Thermology 1990, 3: 205-8

23.) Committee on Quality Control and Qualifications of the American Academy of Thermology: Technical Guidelines , Edition 2, Thermology 1986, 2: 108-112

24.) Ring EFJ. Quality Control in Infrared Thermography. In: Ring EFJ Phillips B, editors, Recent Advances In Medical Thermology. New York.; Plenum Press,. 1984. p.185-194

25.) Ring EFJ, Minchinton M, Elvins DM. A Focal Plane Array System for Clinical Infrared Imaging. IEEE/EMBS Proceedings, Atlanta 1999. Paper 11.6.3 .p.1120

26.) Plassmann P, Ring EFJ, An Open System for the Acquisition and Evaluation of Medical Thermological Images. Eur. J Thermology 1997; 7/4: 216 - 220.

27.) Engel J-M. Physical and Physiological Influence of Medical Ointments of Infrared thermography. In: Ring EFJ Phillips B, editors, Recent Advances In Medical Thermology. New York.; Plenum Press,. 1984. p.177-184

28.) Mannara G; Salvatori GC; Pizzuti GP. Ethyl alcohol induced skin temperature changes evaluated by thermography. Preliminary results. Boll Soc Ital Biol Sper 1993 69/10:587-94

29.) Usuki K; Kanekura T; Aradono K; Kanzaki T Effects of nicotine on peripheral cutaneous blood flow and skin temperature. J Dermatol Sci 1998; 16/3:173-81

30.) Gershon-Cohen J, Haberman J: Thermography of smoking, Arch Environ 1968, 16:637-641.

31.) Gershon-Cohen J, Borden AG, Hermel MB. Thermography of extremities after smoking. Br J Radiol 1969, 42: 189-191.

32.) Hejazi S, M.Anbar. Effects of topical skin treatment and of ambient light in infrared thermal images. Biomedical Thermology 1993, 12: 300-305

33.) Ammer K. The Influence of Antirheumatic Creams and Ointments on the Infrared Emission of the Skin. In: Benkö I., Balogh A., Kovacsics I Lovak. I; editors, Abstracts of the 10th International Conference on Thermogrammetry and Thermal Engineering in Budapest 18-20, June 1997, Budapest, MATE, 1997p.177-181.

34.) Reinberg A. Circadian changes in the temperature of human beings. Bibl Radiol 1975/6:128-39

35.) Federspil G; La Grassa E; Giordano F; Macor C; Presacco D; Di Maggio C Study of diet-induced thermogenesis using telethermography in normal and obese subjects. Recenti Prog Med 1989 80/9: 455-9

36.) Shlygin GK; Lindenbraten LD; Gapparov MM; Vasilevskaia LS; Ginzburg LI; Sokolov AI: Radiothermometric research of tissues during the initial reflex period of the specific dynamic action of food. Med Radiol (Mosk) 1991;36/5:10-2

37.) Danz J, Callies:R.Infrarothermometrie bei differenzierten Methoden der Niederfrequenztherapie. Z:Physiother 1979, 31: 35-39

38.) Rusch F, Neeck, G.;.Schmidt K.L:Über die Hemmung von Erythemen durch Capsaicin. 3.Objektivierung des Capsaicin-Erythems mittels statischer und dynamischer Thermographie.Z.Phys Med Baln.med.Klim.1988, 17: 18-24

39.) Mayr H, Thür H., Ammer K. Electrical Stimulation of the Stellate Ganglia. In: Ammer K., Ring EFJ, editors, : The Thermal Image in Medicine and Biology, Wien Uhlen, Verlag, 1995, p.206-209.

40.) Danz J, R.Callies:Thermometrische Untersuchungen bei unterschiedlichen Ultraschallintensitäten. Z:Physiother 1978, 30: 235-340

41.) Rathkolb O, Ammer K. Skin Temperature of the Fingers after Different Methods of Heating using a Wax Bath. Thermol Österr 1996, 6: 125-129

42.) Ammer K, Schartelmüller T: Hauttemperatur nach der Anwendung von Wärmepackungen und nach Infrarot-A-Bestrahlung. Thermol Österr 1993; 3/2: 51-57

43.) Goodman PH, Foote JE, Smith RP: Detection of Intentionally Produced Thermal Artifacts by Repeated Thermographic Imaging. Thermology 1991, 3: 253-260

44.) Dachs E, Schartelmüller T, Ammer K: Temperatur zur Kryotherapie und Veränderungen der Hauttemperatur am Kniegelenk nach Kaltluftbehandlung. Thermol Österr 1991; 1: 9-14

45.) Rathkolb O; Schartelmüller T, Hein L, Ammer K: Hauttemperatur der Lendenregion nach Anwendung von Kältepackungen unterschiedlicher Größe und Applöikationsdauer: Thermol Österr 1991, 1; 15-24

46.) Ammer K. Occurence of hyperthermia after Ice Massage. Thermol Österr 1996, 6: 17-20

47.) Danz J, Callies R; Hrdina A: Einfluß einer abgestuften Vakuumsaugmassage auf die Hauttemperatur. Z.Physiother 1981; 33:85-92

48.) Eisenschenk A, Stoboy H: Thermographische Kontrolle physikalisch-therapeutischer Methoden. Krankengymnastik 1985; 37: 294

49.) Kainz A: quantitative Überprüfung der Massgewirkung mit Hilfe der IR-Thermographie. Thermol Österr 1993; 3/2: 79-83

50.) Rusch D, Kisselbach G: Comparative Thermographic assessment of Lower Leg Baths in Medicinal Mineral Waters (Nauheim Springs). In: Ring EFJ Phillips B, editors, Recent Advances In Medical Thermology. New York.; Plenum Press,. 1984. p.535-540

51.) Ring EFJ, Barker JR, Harrison RA Thermal Effects of Pool Therapy on the Lower Limbs. Thermology. 1989;3:127-131

52.) Ammer K: Einfluß von Badezusätzen auf die Wärmeabstrahlung der Haut. ThermoMed 1994; 10:71-79

53.) Konermann H, Koob E.Infrarotthermographische Kontrolle der Effektivität krankengymnastischer Behandlungsmaßnahmen Krankengymnastik 1975, 27; 397-400

54.) Smith BL, Bandler MK, Goodman PH: Dominant Forearm Hyperthermia: A Study of Fifteen Athletes. Thermology 1986, 2:25-28

55.) Melnizky P, Ammer K. Schartelmüller T. Thermographische Überprüfung der Heilgymnastik bei Patienten mit Peroneusparese. Thermol Österr 1995; 5: 97-102

56.) Ammer K. Low muscular acitivity of the lower leg in patients with a painful ankle
Thermol Österr 1995, 5: 103-107

57.) Mabuchi K, Chinzei T. Ikeda M, Saiti I ,. Fujimasa I: Development of a data processing system for a high-speed thermographic camera and its use in analyses of dynamic thermal phenomena of the living body. In: Ammer K., Ring EFJ, editors, : The Thermal Image in Medicine and Biology, Wien Uhlen, Verlag, 1995, p.56-63

58.) Ring EF; Porto LO; Bacon PA. Quantitative thermal imaging to assess inositol nicotinate treatment for Raynaud's syndrome. J Int Med Res 1981; 9/6:393-400

59.) Lecerof H; Bornmyr S; Lilja B; De Pedis G; Hulthen UL. Acute effects of doxazosin and atenolol on smoking-induced peripheral vasoconstriction in hypertensive habitual smokers. J Hypertens Suppl 1990;8/:S29-33

60.) Tham TC; Silke B; Taylor SH Comparison of central and peripheral haemodynamic effects of dilevalol and atenolol in essential hypertension. J Hum Hypertens 1990;4 Suppl 2:77-83

61.) Natsuda H; Shibui Y; Yuhara T; Akama T; Suzuki H, Yamane K; Kashiwagi H. Nitroglycerin tape for Raynaud's phenomenon of rheumatic dis -ease patients—an evaluation of skin temperature by thermography. Ryumachi 1994;34(5):849-53

62.) Ring EFJ. Computerized thermography for osteo-articular diseases. Acta thermographica 1976, 1:166-173

63.) Roberts DL., Goodman PH: . Dynamic Thermoregulation of Back and Upper Extremity by Computer-Aided Infrared Imaging.Thermology. 1987; 2:573-577

64.) Mabuchi K, Genno H, Matsumoto K, Chinzei T,. Fujimasa I: Autonomic thermoregulation and skin temperature: the role of deep body temperature in the determination of skin temperature. In: Ammer K., Ring EFJ, editors, : The Thermal Image in Medicine and Biology, Wien Uhlen, Verlag, 1995, p.121-129.

65.) Damm F, Döring G, Hildebrandt G. Untersuchungen über den Tagesgang von Hautdurchblutung und Haut-Temperatur unter besonderer Berücksichtigung der physikalischen Temperaturregulation. Z Physik Med Rehabil 1974, 15: 1-5

66.) Heller M, P.Engel: Die Wirkung lokaler Wärmeanwendungen (Fango-Paraffin-Packungen) auf Kreislauf und Thermoregulation bei Applikation zu verschiedenen Tageszeiten. Z Phys Med Baln Med Klim 1982; 11: 383-390

67.) Cena K: Environmental Heat Loss. In: Ring EFJ Phillips B, editors, Recent Advances In Medical Thermology. New York.; Plenum Press,. 1984. p.81-93

68.) Engel JM: Kennzeichnung von Thermogrammen. In: Engel J-M, Flesch U, Stüttgen F. Hrg, notamed, Baden –Baden, 1983,. pp.176- 81

69.) Schartelmüller T,.Ammer K. Räumliche Auflösung von Infrarotkameras. Thermol Österr 1995, 5: 28-31

70.) Ring EFJ, Dicks JM Spatial resolution of New Thermal Imaging Systems, Thermology International 1999; 9/1: 7-14

71.) Ring EFJ. A thermographic index for the assessment of ischemia. Acta thermographica 1980, 5: 35-38

72.) Ring EFJ. Objective measurement of arthritis by thermography. Acta thermographica 1980,; 5: 14-18

73.) Engel J.-M., Saier U. Thermographische Standarduntersuchungen in der Rheumatologie und Richtlinien zu deren Befundung. Luitpold, München, 1984

74.) Schartelmüller T; Ammer K. Infrared Thermography for the Diagnosis of Thoracic Outlet Syndrome: Thermol Österr 6: 130-134, 1996

75.) Goodman PH, Murphy MG, Siltanen GL, Kelley MP, Rucker L Normal Temperature Asymmetry of the Back and Extremities by Computer- Assisted Infrared Imaging: Thermology. 1986; 1: 195-202

Address of the author

Prof.Francis Ring

Department of Clinical Measurement
Royal National Hospital of Rheumatic Diseases

Upper Borough Walls, Bath BA1 1RL, UK

(Manuscript received on 10.12.1999, accepted on 3.1.2000)

Citations

Please cite this paper as

Ring EFJ, Ammer K The technique of infra red imaging in medicine Thermology international 2000; 10/1: 7-14..

This paper was cited by

1. Acharya UR, Ng EYK, Tan J-H, Sree SV. Thermography Based Breast Cancer DetectionUsing Texture Features and Support Vector Machine. J Med Syst, accepted 7.10.2010

2. Akimov EB,. Andreev RS,. Arkov VV, Kirdin AA, Saryanc VV,. Sonkin VD, Tonevitsky AG. Thermal “Portrait” of Sportsmen With Different Aerobic Capacity. Acta Kinesiologiae Universitatis Tartuensis. 2009, 14: 7-16

3. Ammer K Ring F. Standard Procedures for Infrared Imaging in Medicine. In: Diakides NA, Bronzino JB (ed) Medical Infrared Imaging 2008,CRC Press, 22.1-122.14

4. Ammer K Need for Standardisation of Measurements in Thermal Imaging In: Wiecek B (ed) Thermography and Lasers in Medicine. Akademickie Centrum Graficzno-Marketigowe Lodart S.A, Lodz, 2003, p. 13-18, ISBN 83-890003-82-1

5. Ammer K, Ring EF. Thermographie bei Erkrankungen des Bewegungsapparates. ÖZPMR: Österr Z Phys Med Rehabil 2010, 20(1) 7-24

6. Ammer K, Ring EFJ, Plassmann P, Jones BF. Rationale for standardised capture and analysis of infrared thermal images. In.Hutten H, Krösel P, eds. Proceedings Part II, EMBEC´02 2.European Medical & Biological Engineering Conference. IFMBE, Graz, 2002, pp.1608-1609

7. Ammer K. The Glamorgan Protocol for recording and evaluation of thermal images of the human body. Thermology international 2008, 18: 125-144

8. Bajwa, UI; Vardasca, R; Ring F; Plassmann P. Comparison of boundary detection techniques to improve image analysis in medical thermography. Imaging Science Journal 2010, 58(1)12-19

9. Bezerra LA, Oliveira MM, Rolim TL, Conci A, Santos FGS, Lyra PRM,. Lima Estimation of breast tumor thermal properties using infrared images. Signal Processing, In Press, Corrected Proof, Available online 12 June 2012

10. Bharara M, Cobb JE, Claremont DJ Thermography and Thermometry in the Assessment of Diabetic Neuropathic Foot: A Case for Furthering the role of thermal techniques. The International Journal of Lower Extremity Wounds, 2006, 5(4):250-60.

11. Bonnett P, Hare DB, Jones CD, Ring EF, Hare CJ. Some Preliminary Observations of the Effects of Sports Massage on Heat Distribution of Lower Limb Muscles During a Graded Exercise Test. Thermol int 2006, 16(4): 143-149

12. Cherkas LF, Howell K, Carter L, Black CM, MacGregor AJ. The use of portable radiometry to assess Raynaud's phenomenon: a practical alternative to thermal imaging- Rheumatology, 2001; 40(12):1384-7

13. Cholewka A • Knefel G, •Stanek A, Kawecki M, Nowak M, •Sieron A, Drzazga Z. Thermal imaging and TC oximetry measurements of hyperbaric oxygen therapy (HBO) effects on trophic ulceration of the crura. J Therm Anal Calorim 2012; 108 (1) 25-31

14. Cholewka A, Drzazga Z, Sieron A, Stanek A, Knefel G, Kawecki M, Nowak M. Some Applications of Thermal Imaging in Medicine. In Drzazga Z; Slosarek K. eds, Some Aspects Of Medical Physics - In Vivo And In Vitro Studies (Monographs of Polish Journal of Environmental Studies) 1: 51-58, 2010

15.Cholewka A, Drzazga Z, Sieron A, Stanek A. Thermovision diagnostics in chosen spine diseases treated by whole body cryotherapy. J Therm Anal Calorim, 2010; 102 (1)113-119

16. Cholewka A, Drzazga Z, Knefel G, Kawecki M, Nowak M. Obrazowanie termograficznew tlenoterapii hiperbarycznej (HBO)Thermal imaging in hyperbaric oxygen therapy (HBO). Acta Bio-Optica et Informatica Medica 2010, 16 /2) 120-122

17. Cholewka A, Drzazga Z, Michnik A, Sieroń A, Wisniowska B. Temperature Effekts of Whole Body Cryotherapy Determined By Thermography. Thermol int. 2004, 14(2) 57-63

18. Cholewka A, Drzazga Z, Sieroń A Monitoring of whole body cryotherapy effects by thermal imaging: preliminary report. Physica Medica, 2006, 22; 57-62

19. Cholewka A, Stanek A, Sieron A Drzazga Z. Thermography study of skin response due to whole-body cryotherapy. Skin Research and Technology 2012; 18(2) 180-187

20. Costello JT, McInerney CD, Bleakley CM, Selfe J, DonnellyAE. The use of Thermal imaging in assessing skin temperature following cryotherapy; A review. Journal of Thermal Biology, 2012; 37(2) 103-1108

21.Costello JT, Culligan K, Selfe J, Donnelly AE. Muscle, Skin and Core Temperature after 2110uC Cold Air and 8uC Water Treatment. PLoS ONE 2012; 7(11):e48190.

22.Damijan Z, Uhrynski A. The Influence of Driver's Working Environment on Thermical Changes of Their Organism, Acta Physica Polonica A 2010, 118 (1) 35-40

23. Dawson TL. Beyond the visible: ultraviolet and infrared radiation. Rev Progress Color 2005, 35(1) 31-41

24. Dębiec-Bąk A, Anna Skrzek A, Podbielska H. Application of thermovision for estimation of the optimal and safe parameters of the whole body cryotherapy. J Therm Anal Calorim 2012 (Accepted: 28 September 2012)

25. Dekhtyar YP, Nichiporuk VI, MironenkoCA Kovalchuk IS Wenger EF, Dunaevskij VI, , Kotovsky VY. Platz und Rolle der Infrarot-Thermographie unter den modernen diagnostische Methoden Elektronik und Kommunikation 2010, 192-196

26. Dudić S,Ignjatović I,Šešlija D, Blagojević V, Stojiljković M, Leakage quantification of compressed air using ultrasound and infrared thermography, Measurement 2012, 45: 1689–1694

27. Ferreira JJ, Mendonça LC, Nunes LA, Andrade Filho AC, Rebelatto JR, Salvini TF. Exercise-associated thermographic changes in young and elderly subjects. Ann Biomed Eng. 2008;36(8):14-20

28. Ferreira JJ. Efeitos dos exercicios de aquecimento e alongamento na flexibilidade de sujeitos idosos. Thesis Unversidade Dederal de Sao Carlos, 2008

29. Fikackova H, Ekberg E-C Can infrared thermography be a diagnostic tool for arthralgia of the temporomandibular joint?Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology, 200, 98(6): 643-650

30. Giloh M, Shinder D. Yahav S, Skin surface temperature of broiler chickens is correlated to body core temperature and is indicative of their thermoregulatory status. Poult. Sci. 2012, . 91(1) 175-188

31. Gomez Carmona PM. Influencia De La Información Termográfica Infrarroja En El Protocolo De Prevención De Lesiones De Un Equipo De Fútbol Profesional Español (Influence Of Infrared Thermographic Information In The Injury Prevention Protocol Of A Professional Spanish Football Team) Thesis, Madrid 2012. Universidad Politécnica De Madrid Facultad De Ciencias De La Actividad Física Y Del Deporte - INEF

32. Hildebrandt C, Raschner C. An Intra-Examiner Reliability Study of Knee Temperature Patterns With Medical Infrared Thermal Imaging. Thermology international 2009, 19(3):73-76

33. Hildebrandt C, Zeilberger K,Ring EFJ, Raschner C. The Application of Medical Infrared Thermography in Sports Medicine. In: Zaslav KR, ed, International Perspective on Topics in Sports Medicine and Sports Injury, InTech, February 2012, p,257-274, ISBN 978-953-51-0005-8

34.Hildebrandt C., Raschner C, Ammer K. Recent Application of Medical Infrared Thermography in Sports Medicine in Austria. *Sensors* **2010**, *10*, 4700-4715

35. Himashree G, Dass D, Singh S, Lama H, Chauhan SKS, Bhaumik G, Banerjee PK Thermographic Evaluation of Experimentally Induced Superficial and Deep Frostbite in Rats. Thermology international 2007, 17(2): 51-58

36. Jenkins S, Brown R, Rutterford N. Comparing Thermographic, EEG, and Subjective Measures of Affective Experience During Simulated Product Interactions. Int J Design 2009, 3(2) 564

37. Jenkins SD, Brown RDH, Donne KE. Infrared thermography in design research. In Schwäbisch Gmünd. Cumulus Working Papers. Publication Series G, University of Art and Design Helsinki, 18/07, 2007, 41-47

38. Kapoor P, Prasad SVAV. Image processing for early diagnosis of breast cancer using infrared images. The 2nd International Conference on Computer and Automation Engineering (ICCAE), 2010, Singapore, 26-28 Feb. 2010, pp.664-566

39. Kerr, J. Review of the effectiveness of infrared thermal imaging (thermography) for population screening and diagnostic testing of breast cancer. NZHTA Tech Brief Series 2004; 3(3)

40. Kocić M, Lazović M, Dimitrijević I, Mančić D, Stanković A. Procena terapijskog efekta lasera male snage i interferentnih struja kod bolesnika sa kompleksnim regionalnim bolnim sindromom primenom infracrvene termovizijske kamere**.** Evaluation of low level laser and interferential current in the therapy of complex regional pain syndrome by infrared thermographic camera. Vojnosanitetski Pregled 2010, 76; 755-760

41. Kononova S.A.,. Markelova N.G,. Urakov A.L, Shkljaeva S.E. About Possibility of Application Infra-Red Thermometry In Medicolegal Researches of Bruises of A Skin. Medical Examination problems. SCIENTIFIC-PRACTICAL EDITION № 2-3 [34-35] VOL. 8 april- september 2009, 14-17

42. Korukçu M.Ö, Kilic M., The usage of IR thermography for the temperature measurements inside an automobile abin, Int Commun Heat Mass Transf (2009) 36:872-877,

43. Lahiri BB,. Bagavathiappan S,. Jayakumar T, Philip J Medical applications of infrared thermography: A review. Infrared Physics & Technology 2012; 55: 221–235.

44. Lampe R., Kawelke S., Mitternacht J., Gradinger R. Thermographie: Temperaturregulation bei Patienten mit infantiler Zerebralparese. J Neurol Neurochir Psychiatr 2010; 11 (Pre-Publishing Online).

45. Lamprecht I ; Maierhofer C ; Rollig M A thermographic promenade through the Berlin Botanic Garden. Thermochimica Acta, 2006; 446(1-2) 4-10

46. Lamprecht I ; Maierhofer C ; Rollig M**.** Infrared thermography and thermometry of phototropic plants. Journal of Thermal Analysis and Calorimetry 2007, 87 (1): 49-54

47. Li W, Wu X, Zhang Y, Yu M. Wavelet-Based Far Infrared Medical Image Compression with Histogram Shifting . The 1st International Conference on Bioinformatics and Biomedical Engineering, 2007. ICBBE 2007.Publication Date: 6-8 July 2007

48. Martini G, Murray KJ, Howell KJ, Harper J, Atherton D, Woo P, Zulian F, Black CM. Juvenile-onset localized scleroderma activity detection by infrared thermography. Rheumatology, 2002, 41(10):1178-82.

49. Melnizky P, Ammer K Einfluss von Alkohol und Rauchen auf die Hauttemperatur des Gesichts, der Hände und der Kniegelenke Thermology international 2000, 10(4)191-195

50. Mikulska D, Maleszka R, Parafiniuk M. Próba Zastosowania Termografii Jako Metody Diagnostycznejw Dermatologii Na Podstawie Badań Prowadzonych W Latach 2001–2005 (The Useful Ness Of Thermography As A Diagnostic Method In Dermatology On The Basis Of Clinical Trials In 2001–2005**)** Annals of the Pomeranian Medical University 2006, 52, 3, 91–97

51. Mikulska D, Maleszka R, Kacalak-Rzepka A. Zastosowanie termografi i wizyjnej w diagnostyce zespołu Melkerssona-Rosenthala (Application of thermal imaging in Melkersson-Rosenthal syndrome diagnostic) Dermatologia Kliniczna 2008, 10 (3): 149-151

52. Mikulska D, Zaluga E, Maleszka R, Ratajczak-Stefanska V, Parafinuk M. Application of thermal imaging for the evaluation of the patch test. Thermol int 2005, 15(4): 134-139

53. Mikulska D. Dermatoscopy and thermal imaging: a comparative investigation of melanocytic nevi of the skin. Thermol int 2008, 18(3): 101-106

54. Mikulska D. Próba Zastosowania Termografii W Diagnostyce Znamion Melanocytowych Skóry (Thermographic Examination of Cutaneous Melanocytic Nevi) Annales Academiae Medicae Stetinensis 2009, 55, 1, 31–38

55. Mikulska D. Współczesne Możliwości Zastosowaniatermografii Wizyjnej W Diagnostyce Medycznej (Contemporary Applications Of Infrared Imaging In Medical Diagnostics) Annals of the Pomeranian Medical University 2006, 52, 1, 35–40

56. Moreira, Danilo Gomes. Termografia corporal em repouso de homens e mulheres.(Infrared body at rest of men and women). Universidade Federal de Viçosa, June, 2011.

57. Muntinga E Detection Of Intraosseous Strainsin The Adult Tibial Bone With Thermography - A Pilot Study. Thesis Protocol Presented To The International Juryin Hertenstein, Switzerland, October 2011, Swiss International College of Osteopathy

58. Ng EYK A review of thermography as promising non-invasive detection modality for breast tumor, International Journal of Thermal Sciences (2008), 48(5) 849-859

59. Ng EYK. A Non-Contact Infrared Indoor Scanning of Mass Febrile Subjects In Controlling an Epidemic: A Review. In: Avian Influenza Research Progress. Von Ernesto P. Allegra, Nova Publishers, 2008. p.109-132.

60. Norheim AJ, Mercer J. Medisinsk termografi – alternativ diagnostikk? Tidsskr Nor Legeforen 2011; 131(18): 1758–9

61. Omabu Chisombili Patricia: Investigation Of Thermal Sensors For Trauma Localisation: MSc Thesis. in Computer And Network Engineering, Faculty of Arts,Computing, Engineering and Sciences at Sheffield Hallam University, 2009

62. Piñonosa, S., García, M.A., Sillero, M., Gómez, P.M., Fernández, I., Szendrei, B., Granja, Thermographic Profile For The Rehabilitation Of The Total ACL Rupture. , ECSS 2006, Abstract. 774

63. Plassmann P, Ring EFJ, Jones CD. Quality Assurance of Thermal Imaging Systems in Medicine. Thermol int 2006, 16(1) 10-15

64. Puzder A., Gworys K., Rechcińska-Roślak B., Gasztych J., Sopiński M., Jakubowska T., Markowska K., Oborzyński J., Pieszyński I., Gworys P., Kujawa J. Trial of Thermal Imaging In The Evaluation of Low Level Laser Therapy Effectiveness In Patients With Knee Joint Pain Syndrome Medicina Sportiva 2010; 14 (3): 114-120

65. Quek C, IrawanW, Ng EYK. A novel brain-inspired neural cognitive approach to SARS thermal image analysis. Expert Systems with Applications 37 (2010) 3040–3054

66. Ring E The historical development of thermometry and thermal imaging in medicine Journal of Medical Engineering & Technology, 2006 0(4):192-8

67. Ring EFJ, Jung A, Zuber J. Rutowski P, Kalicki B. Bajwa U. Detecting Fever in Polish Children by Infrared Thermography. In. QIRT 2008, proceedings of the 9th International Conference on Quantitative InfraRed Thermography July 2-5, 2008, Krakow-Poland, pp.125-128

68. Ring EFJ, . Hartmann J, Ammer K, Thomas R, . Land D, Hand JW. Infrared and Microwave Medical ThermometryExperimental Methods in the Physical Sciences, Volume 43, Chp , Elsevier, 2010

69. Ring EFJ, Ammer K The technique of infrared imaging in medicine In: Benkö I., A.Balogh, I.Kovacsics, I Lovak(eds): Abstracts of the 12th International Conference on Thermogrammetry and Thermal Engineering in Budapest 13-15, June 2001, MATE, Budapest, p.274, 2001

70. Ring EFJ, Thomas RA, Howell KJ. Sensors for Medical Thermography and Infrared Radiation Measurements. In. Jones DP, Biomedical Sensors, Momentum Press, New York, 2010, pp.417-442

71. Ring EFJ. Ammer K, Wiecek B; Plassmann P, Jones CD, Jung A. Murawski P. Quality assurance for thermal imaging systems in medicine. Thermol int 2007, 17(3): 103-106

72. Ring EFJ. Ammer K. Jung A. Murawski P. Wiecek B. Zuber J. Zwolenik S. Plassmann P. Jones C. Jones BF. Standardization of infrared imaging.Conference Proceedings. 26th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (IEEE Cat. No.04CH37558). IEEE. Part Vol.2, 2004, pp.1183-5 Vol.2. Piscataway, NJ, USA

73. Ring EFJ. The historical development of thermometry and thermal imaging in medicine. Thermol int. 2003, 13, 53-57

74. Ring EFJ. Thermal Imaging in Medico-Legal Claims (abstract). Thermol int 10(2) 97-98

75. Ring EFJ.The History of Quantitation in Thermal Imaging in Medicine. In Benkö I.Kovacsics I, Lovak I (eds): Abstracts of the 13th International Conference on Thermogrammetry and Thermal Engineering in Budapest 18-20, June 2003, MATE, Budapest, p.119-126, 2003

76. Ring F, Ammer K. Thermal Imaging in Diseases of the Skeletal and Neuromuscular Systems In: Diakides NA, Bronzino JB (ed) Medical Infrared Imaging 2008, 17.1-17.15

77. Ring F. Thermal Imaging Today and Its Relevance to Diabetes**.** J Diabetes Sci Technol. 2010; 4(4): 857–862

78. Ring FJ Standard protocols in Medical Thermography Image Capture Standardisation. In Wiecek B, ed. Proceedings of the IX Konferencja Krajowa TERMOGRAFIA I TERMOMETRIA W PODCZERWIENI TTP2011, pp.9-10

79. Ring FJ. Human Body Temperature. In: Wiecek B (ed) Thermography and Lasers in Medicine. Akademickie Centrum Graficzno-Marketigowe Lodart S.A, Lodz, 2003, p. 7-12, ISBN 83-890003-82-1

80. Rosenfeld L, Dekhtyarov Y, Mironenko S, Wenger E, Dunaevsky V, Kotovskyi V, Latenko E, Nazarchuk S, Soloviev E. Thermal diagnostics in assessing health status of young people aged 16 to 25 years. Electronics and Nanotechnology, April 12-14, 2011, Kyiv, Ukraine, *p. 131*

81. Rosenfeld LG, Samokhin AV, Venger EF, Loboda TV, Kolotilov NN, Kollyukh AG, . Dunayevsky VI**.** Remote Infra-Red Thermography As Modern Non-Invasive Method Of Diseases Diagnostics. Ukr Med Journal 6(68)-XI/XII (2008) 92-97

82. Sanchez Ionildo Jose. Superposition of thermography and magnetic resonance images: a new tridimesional medical imaging modality. 2009, Thesis (Doutorado em Engenharia Biomedica)- Programa de Pos-Graduacao em Engenharia Eletrica e Informatica Industrial. Universidade Tecnologica Federal do Parana, 2009

83. Schaefer G, Tait R, Howell K, Hopgood A, Woo P, Harper J. Automated Overlay of Infrared and Visual Medical Images. In: F. Dong. G. Ghinea and S.Y. Chen (eds.): User Centered Design for Medical Visualization, Medical Information Science Reference, 2008,Chapter VIII, pp. 174-183.

84. Simoes R, Vardasca R, Nogueira-Silva C. Thermal skin reference values in healthy late pregnancy. Silva Journal of Thermal Biology 2012, 37: 608–614

85. Siniewicz K, Wiecek B, Basczynski J, Zwolenik S Thermal Imaging Before and After Physical Exercises in Children with Orthostatic Disorders of the Cardiovascular System. Thermol int 2002, 12:148-155

86. Siniewicz K, Wiecek B, Basczynski J, Zwolenik S. Use of Thermal Imaging in Children with Orthostatic Cardiovascular Disorders: A New Method of Diagnosis. Thermol int 2001, 11(4): 168-175

87. Sivanandam S, Anburajan M, Venkatraman B, Menaka M, Sharath D. Medical thermography: a diagnostic approach for type 2 diabetes based on non-contact infrared thermal imaging. Endocrine 2012 , 42 (2) 343-351

88. Sree SV, Ng EYK, Acharya RU, Faust O. Breast imaging: A survey. World J Clin Oncol 2011 April 10; 2(4): 171-178

89. Stengg B, Prager Ch, Ammer K Komplexes regionales Schmerzsyndrom (CRPS 1 und 2) ÖZPMR; Österr Z Phys Med Rehabil 2003; 13(2):53-62

90. Surabhi Vijaykumar. Automatic features identification with Infrared Thermography in Fever Screening. Thesis, University of Ottawa, Canada, 2012

91. Szacsky Mihály.Triple theory., Szabad-Sajto Kulturalis es Ufjusagi Egesulet, 2009, Hungary

92. Szentkuti A, Skala Kavanagh H, Grazio S. Infrared thermography and image analysis forbiomedical use. Periodicum Biologorum 2011, 113(4) 385–392.

93. King PO,. Samohin A, Kashchenko O, Shinkarenko NV. The diagnostic role and comparison of radiosotopic bone scan and thermography in differential diagnosis in muskuloskletal system inflammatory processes.

94. Tkácová M, Hudák R, Živcák J. Infrared Diagnostics of the Human Hand. In: INES 2011 • 15th International Conference on Intelligent Engineering Systems • June 23–25, 2011, Poprad, Slovakia, 417-420

95. Tkacova M; Foffova P; Hudak R; Svehlik J; Zivcak J. Medical thermography application in neuro-vascular diseases diagnostics. IEEE 8th International Symposium on Applied Machine Intelligence and Informatics (SAMI), 2010, Herlany, 28-30 Jan. 2010, 293-296

96. Tkáčová M, Hudák R, Živčák J, Čekanová P, Medvecký S. Determination of Conditions and Positions for Obtaining Thermographic Atlas. In: Topics in Intelligent Engineering and Informatics, 1, Volume 2, Aspects of Computational Intelligence: Theory and Applications, Part 5, p. 375-391

97. Tkáčová M, Hudák R, Živčák J, Živčáková I. Infrared Thermography in the Evaluation of Carpal Tunnel Syndrome. In: Topics in Intelligent Engineering and Informatics, 1, Volume 2, Aspects of Computational Intelligence: Theory and Applications, Part 5, Pages 355-373

98. Vardasca R Template Based Alignment and Interpolation Methods Comparison of Region of Interest in Thermal Images. Proceedings of the 3rd Research Student Workshop, ed. P. Plassmann and P. Roach, pp. 21-24

99. Vardasca R, Bajwa U. Segmentation and Noise Removal on Thermographic Images of Hands. Thermol int. 2008, 18(3); 89-94

100. Vardasca R, Ring EFJ, Plassmann P, Joned CD. Thermal monitoring of hand stress during keyboard typing. In. Qirt 2008, proceedings of the 9th International Conference on Quantitative InfraRed Thermography July 2-5, 2008, Krakow-Pland, pp.169-174

101. Vardasca RAR. The Effect of Work Related Mechanical Stress on the Peripheral Temperature of the Hand. Thesis, July 2010, Medical Imaging Research Unit, Department of Computing and Mathematical Sciences, Faculty of Advanced Technology, University of Glamorgan, Wales, United Kingdom

102. Vardasca R, Ring F, Plassmann P, Jone**s C.** Thermal symmetry of the upper and lower extremities in healthy subjects. Thermology international 2012, 22: 53-60

103. Wiecek M, Strakowski R, Jakubowska T, Wiecek B. Zastosowanie tennowizji w badaniach przesiewowych na przykladzie zmian nowotworowych piersi (Application of thermovision in screening examinations on the example of breast carcinoma) Acta Bio-Optica et Informatica Medica 2010. 16(1) 49-54

104. Wright CI, Kroner CI, Draijer R. Non-invasive methods and stimuli for evaluating the skin's microcirculation Journal of Pharmacological and Toxicological Methods, 2006; 54(1) 1-25.

105. Yu WL, Zhen Wang, Lei Yin. The experiment study on infrared radiation spectrum of human body. In. IEEE-EMBS International Conference on Biomedical and Health Informatics (BHI), 2012, p. 752 - 754

106. Zalewska A, B. Wiecek. Dermatological applications of thermal imaging. Thermol int 2005; 15(2): 49-56

107. Zalewska A, Gralewicz G, Owczarek G, Wiecek B Thermography in psoriasis vulgaris evaluation Conf Proc IEEE Eng Med Biol Soc. 2005;1(1):627-630.

108. Zalewska A, Gralewicz G, Owczarek G, Wiecek B. Psoriatric lesion regression-thermographic evaluation. In. Qirt 2008, proceedings of the 9th International Conference on Quantitative InfraRed Thermography July 2-5, 2008, Krakow-Pland, pp.165-168

109. Zalewska A, Gralewicz G, Owczarek G, Wiecek Qualitative thermograhic analysis of psoriatic skin lesions - Proceedings of the 26th Annual International Conference of the IEEE EMBS San Francisco, CA, USA • September 1-5, 2004: 1192-1195

110. Zalewska A, Wiecek B, Zwolenik S, Lis M, Sysa-Jedrzejowska A.Evaluation of psoriasis vulgaris lesions based on thermography. Thermol int 2003, 13(4): 140-147

111. Zivcak J, Hudak R, Kneppo P. Application of infrared imaging in rehabilitation medicine in spinal cord injured individuals. INES '05. Proceedings. 2005 IEEE International Conference on Intelligent Engineering Systems, 2005. pp. 221- 224

112. Zivcak J, Hudak R, Tkáčová M**.** Švehlík J. A Role of Thermography in the Diagnostics of Carpal Tunnel Syndrom. Acta Mechanica Slovaca 2010; 14 (2): 26-33.

113. Zivcak J, Kneppo P, Hudak R Methodics of IR Imaging in SCI Individuals Rehabilitation Conf Proc IEEE Eng Med Biol Soc. 2005;7:6863-6

114. Zembol F. Analýza parametrů infračerveného zobrazení: bakalářská práce. Brno: Vysoké učení technické v Brně, Fakulta elektrotechniky a komunikačních technologií, 2011.

Emissivity – bottleneck and challenge for thermography

Boguslaw Wiecek[1], Anna Jung[2], Janusz Zuber[2]

[1]Technical University of £ódz, Institute of Electronics, Poland

[2]Central Clinical Hospital MMU, Warsaw, Poland

Summary

In this paper we present the importance and problem of emissivity evaluation for infrared thermography. We underline the importance of different definitions of emissivity, especially directional and spectral emissivity. The measured emissivities for semitransparent dielectric materials are presented, together with theoretical background to recalculate emissivity for thin and multilayer components.

Additionally, a multichannel system is presented, which reconstructs 3D scene. The system gives the ability to transform 2D-pictures acquired from two or more cameras into 3D-graphics to provide a 3D model of object's directional emissivity correction. This method requires at least two CCD cameras, being based on geometrical rules of stereoscopic sight.

Key words: Directional emissivity, thermal imaging, optical properties, photogrametric methods

Emissivität - Flaschenhals und Herausforderung für die Thermographie

Diese Arbeit beschreibt die Bedeutung und die Problematik der Emissivitäts-Bestimmung für die Infrarot-Thermographie. Wir betonen die Tatsache, dass unterschiedliche Definitionen von Emissivität bestehen und nennen die richtungs und die spektralabhängige Emissivität. Die Messergebnisse der Emissivität von semitransparenten dielektrischen Materialen werden vorgestellt, die auf Grund theoretischer Überlegungen eine Berechnung der Emissivität von dünnen und mehrfach geschichteten Komponenten gestatten.

Außerdem wird ein Mehrkanalsystem präsentiert, das die Rekonstruktion eines 3-dimensionalen Bildes erlaubt. Das System ermöglicht die Transformation 2-dimensionaler Bilder, die von 2 oder mehr Kameras gewonnen werden, in ein 3-dimensionales Modell, das die Korrektur der richtungsabhängigen Emissivität eines Objektes gestattet. Diese Technik, die auf den geometrischen Regeln des stereoskopischen sehens beruht, benötigt zumindest zwei CCD-Kameras.

Schlüsselwörter: richtungsabhängige Emissivität, Thermographie, optische Eigenschaften, photogrametrische Medthoden

Introduction

Emissivity is an expression used to characterise the optical properties of materials in sense of the amount of energy emitted in comparison with an ideal black body. Radiation of a black body is described by the emissive power $e_b(\lambda,\varphi,\theta)$ related to power emitted from a unit surface, into a unit elemental solid angle in $d\lambda$ spectral range. Unlike that for emission, radiation intensity $i_b(\lambda)$ is defined on the basis of projected area [1,2] and it *does* not depend on direction. (Figure 1). Total monochrome emission power passing hemisphere takes a form:

$$e_{b,\lambda} = i_b(\lambda)\int_0^{2\pi}\int_0^{\frac{\pi}{2}}\cos(\theta)\sin(\theta)\,d\theta\,d\varphi = \pi\, i_b(\lambda)$$

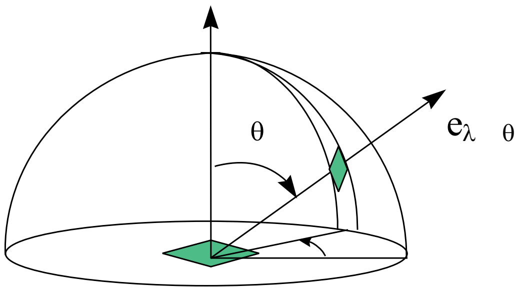


Figure 1.
Hemisphere for emissivity definition

Total radiation intensity can be evaluated using Planck law as:

$$I_b \quad {}_{0}\, i_b(\lambda)d\lambda \quad -T^4$$

while the total emission power:

$$E_b \qquad T^4$$

Based on total, monochrome and directional quantities representing the amount of energy emitted we can define at least a few emissivities.

Directional monochromatic emissivity

$$\varepsilon_{\lambda,\theta,} \quad \frac{e_{\lambda,\theta,}}{e_{b,\lambda,\theta,}} \quad \frac{e_{\lambda,\theta,}}{e_{b,\lambda,n}\cos\theta}$$

Monochromatic normal emissivity

$$\varepsilon_{\lambda,n} \quad \frac{e_{n,\lambda}}{e_{b,\lambda,n}}$$

Directional total emissivity

$$\varepsilon_{\theta} \quad \frac{E_{\theta,}}{E_{b,\theta,}} \quad \frac{{}_{0}\, e(\lambda,\theta,\ )d\lambda}{T^4\cos\theta}$$

Hemispherical total emissivity

$$\varepsilon \quad \frac{E}{E_b} \quad \frac{{}_{0}\, \varepsilon_{\lambda} e_{b,\lambda} d\lambda}{T^4}$$

where ε_λ is the hemispherical spectral emissivity defined as:

$$\varepsilon_{\lambda} \quad {}_{0}^{2} \quad {}_{0}^{\overline{2}} \varepsilon_{\lambda,\ ,\theta} \, d\theta d$$

Having so many different quantities defining emission properties of a real body would appear to complicate the practical determination of emissivity [1,2,4].

Thin and multilayer components

In various applications of thermography we deal with multilayer structures, where internal reflection takes place (Figure 2,3). This results in increased absorption, and results in higher emissivity. The same happens to thin layer coatings, especially if they are made from dielectrics.

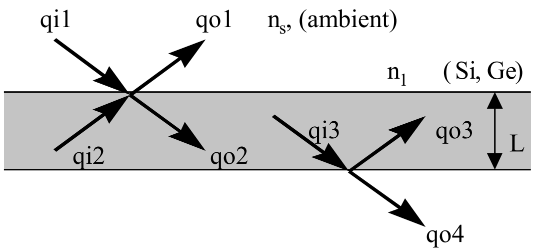


Figure 2.
Internal reflections in thin layer semiconductor component

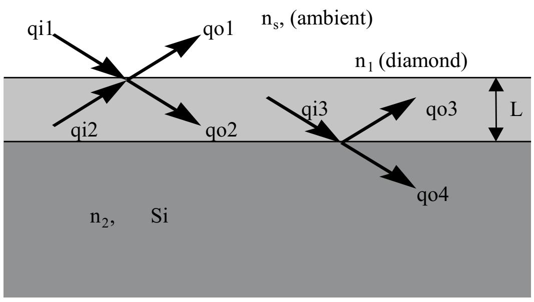


Figure 3.
Internal reflections in multlayer component with diamond coating

For the infinite dielectric using the electromagnetic theory of wave propagation one can derive the reflective coefficient in form of *Freshel's* equation as:

$$\rho(\theta) \quad \frac{1\sin^2(\theta \quad \chi)}{2\sin^2(\theta \quad \chi)} \quad 1 \quad \frac{\cos^2(\theta \quad \chi)}{\cos^2(\theta \quad \chi)}$$

where: θ, χ denote the incident and refraction angle, respectively.

Assuming the ambient has refractive index n_a=1, normal spectral emissivity can be easily evaluated from:

$$\varepsilon_{n\lambda} \quad 1 \quad \rho_{n\lambda} \quad \frac{4n}{(n \quad 1)^2}$$

where *n* is refractive index of the body.

For thin layer coatings the reflected (R), absorbed (A) and transmitted (T) energy are used to obtain the optical properties using of *Net- Radiation Method* [1].

$$R \quad \rho \frac{\rho \ \tau^2}{1 \quad \rho^2\tau^2}$$

$$A \quad \frac{(1 \quad \rho)(1 \quad \tau)}{1 \quad \rho\tau}$$

$$T \quad \frac{\tau(1 \quad \rho)^2}{1 \quad \rho^2\tau^2}$$

where: ρ and τ are reflectivity and transmissivity, respectively. The same can be calculated for two-layer structure, which results in more complex expressions:

$$R \quad \frac{\rho_1 \quad (1 \quad 2\rho_1)\rho_2\tau^2}{1 \quad \rho_1\rho_2\tau^2}$$

$$A \quad \frac{(1 \quad \rho_1)(1 \quad \rho_2\tau)(1 \quad \tau)}{1 \quad \rho_1\rho_2\tau^2}$$

$$T \quad \frac{(1 \quad \rho_1)(1 \quad \rho_2)\tau}{1 \quad \rho_1\rho_2\tau^2}$$

Using spectrophotometry equipment we measured the relative reflected and transmitted energy for semiconductors, and diamond coatings in spectral range 2÷14 mm. The results are shown in Figure 4. Using the expressions above, the optical parameters were obtained. They agreed with published values and measured by other methods, e.g. the refraction indexes are: n_{Ge}=3.99, n_{Si}=3.49 [5].

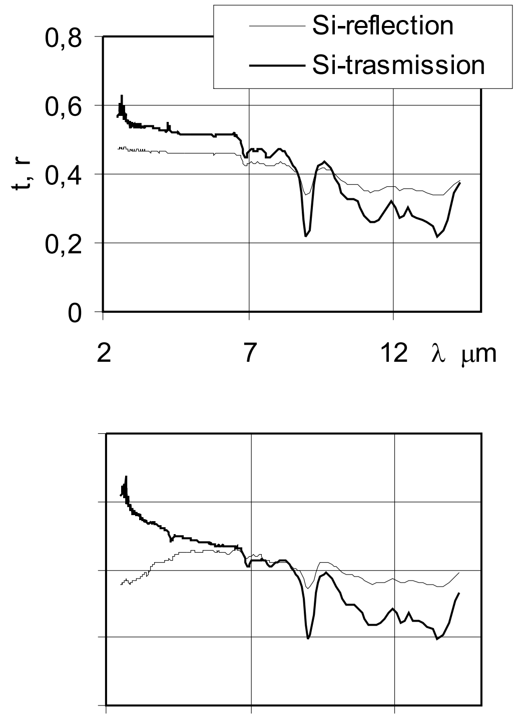


Figure 4
Spectral emissivity measurements for semiconductors

Table. Optical parameters for semiconductors

	R	A	T
Si, 2.5-5.5µm	0.46	0.01	0.53
Si, 8-12µm	0.38	0.26	0.36
Ge, 2.5-5.5µm	0.54	0.00	0.46
Ge, 8-12µm	0.54	0.01	0.45

	ρ	τ	ε	n
Si, 2.5-5.5µm	0.30	0.29	0.39	3.43
Si, 8-12µm	0.30	0.21	0.48	3.45
Ge, 2.5-5.5µm	0.37	0.37	0.26	4.10
Ge, 8-12µm	0.37	0.37	0.26	4.14

Emissivity versus temperature

Emissivity depends on temperature [1,3,4]. This phenomenon is clearly observed for metals, which are usually highly reflective materials. Such bodies are opaque, with a high attenuating factor. In theory, it means that the refractive index is a complex number, expressed as n= n'-ik'.

$$e_{n\lambda} \quad \frac{4n}{(n \quad 1)^2 \quad k^2}$$

Typically, for metals k'>n', and in such case the normal emissivity takes a form as above

[1,3]. Using Maxwell theory by describing the distribution of electrical and magnetic field for isotropic medium without the accumulation of static charge, for k'≈n' in the long wave spectrum (λ>5μm), the optical properties can be obtained as:

$$n_{\lambda} \quad k_{\lambda} \approx \sqrt{\frac{\lambda \mu_0 c_0}{4 \quad \rho}}$$

where: λ wave length, μ - magnetic permeability for vacuum, ρ - electrical resistively.

Finally, the emissivity coefficient takes a form of *Hagena-Rubensa* eqn.:

$$_{\lambda n} \approx \frac{2}{n} \quad 4\sqrt{\frac{\rho}{\lambda \mu_o c_o}}$$

Total emissivity can be obtained by integrating last eqn. over the entire spectral range. ,

$$_{n}(T) \approx 0.576\sqrt{\rho T}$$

where: ρ[Ωcm], T[K] [1,2,3].

More precise equations are below.

$$_{n}(T) \approx 0.576\sqrt{\rho T} \quad 0{,}177\rho T \quad 0{,}058\sqrt{(\rho T)^3} \ \ldots$$

$$_{n}(T) \approx 0.576\sqrt{\rho T} \quad 0{,}124\rho T$$

Electrical resistivity depends on temperature, and in consequence the temperature changes total emissivity. The simplified expression takes the form:

$$_{n}(T) \approx 0.0348\sqrt{\rho_{273K}}\,T$$

The last equation shows, that higher temperature causes the increase of normal emissivity. Unfortunately, for temperatures of the level of ambient the normal emissivity is still very low, e.g. for metals. In such cases the roughness of the surface of investigated body has the highest impact on the emissivity. [3].

Directional emissivity

In order to correct temperature according the directional emissivity one needs all information about 3D shape of observed objects, to take into account the angle subtended between an observer's vector and a normal to observed surface.

In general, the way to obtain the data from cameras is shown Figure 5.

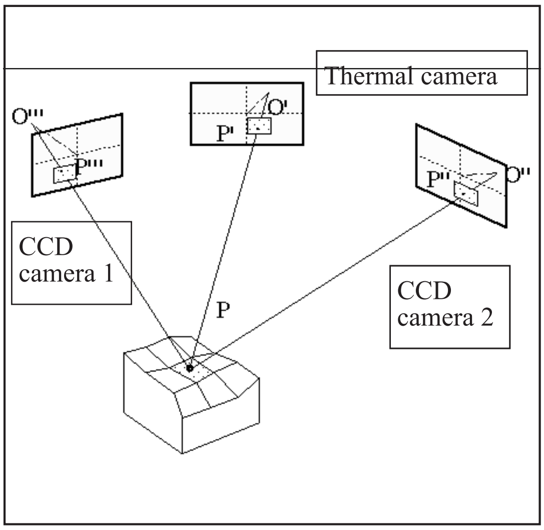


Figure 5
System setup for directional emissivity evaluation

We take co-ordinates of 6 points from each visual image. These six points on each video picture (called checkpoints) are used for video camera positioning, and are required for future co-ordinates to calculate ther unknown points. After positioning of video cameras, six extra points are marked on both the video and thermal images. These extra six points may be the same or different from the checkpoints used for video camera positioning. The software program automatically calculates co-ordinates of these extra points and computes the position of the thermal camera without any given co- ordinates of marked points appearing on the thermal image. This is very helpful because it is not easy to locate the six checkpoints on the thermal image. On the other hand, one can recognise the same points on each picture, including the thermal one. In the final stage of the algorithm, groups of three points mark the chosen planes, for which angle and distance are calculated, and these are used later for emissivity evaluation and temperature correction.

Typical thermal camera produces data corresponding to the radiation it has detected, not the computed temperature. Temperature is obtained from a calibration curve in the computer. For these experiment we used an INFRA- METRICS 760 thermal camera equipped with the digital acquisition system [3]. The correction of temperature for black body is the following:

$$T \quad \sqrt[4]{\frac{T_o^4 \quad T_a^4}{\cos}} \quad T_a^4$$

where: T_0, T_a are the temperature measured by the camera and ambient temperature, respectively.

Conclusion

This paper presents spectral and directional emissivity evaluation by theoretical consideration and measurements. A multichannel system implements photogrametric methods to reconstruct 3D scene, e.g.:*Direct Linear Trans- formation (DLT).* Our algorithm was prepared and implemented for thermography applications. *DLT* describes position of any 3D point on each picture. This method gives all necessary information about 3D position of the fixed point, including the distance between the camera and that point and the angle between normal to the surface and the axes of the camera. This allows a number of corrections to be made to thermal images, because the dependence between emissivity, the angle of inclination and distance are known. The calculated position of the fixed point is very accurate and precisely computed, so this algorithm is helpful in all high precision applications, specially if one uses system build of cameras positioned for this purposes. - The positioning of cameras is the most important part of a 3D extraction algorithm. The limitation of this algorithm in its usual form is the need of recognition of the position of chosen points on different images by the user and manually linking them to common surfaces.

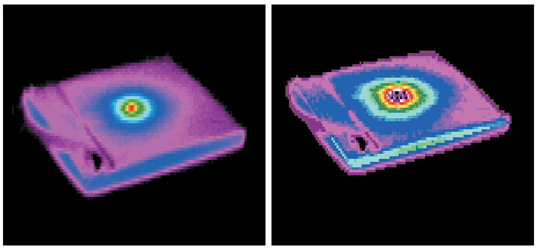


Figure 5
Thermal images before and after correction

Figure 7 Multichanel system for directional emissivity evaluation

References

(1.) R. Siegel, J. Howell: „Thermal radiation heat transfer". New York, Hemisphere Publishing Corp, 1989, ISBN 0-89116-506-1.

(2.) Wiêcek B., Zwolenik S: Advanced Multichannel Thermal and Visual System, III International Workshop on Advances in Signal Processing for Non Destructive Evaluation of Materials, August, 5-8, 1997, Quebec

(3.) Wiêcek B., Sawicki P., Stein, S: 3-D reconstruction for video and thermal images, 4th International Workshop Advanced Infrared Technology and Applications, Florence'97, Florence, Sept. 15-16, 1997

(4.) Z. Sitek, Fotogrametria ogólna i in¿ynieryjna. Przedsiêbiorstwo Wydawnictw Kartograficznych, Warszawa–Wroc³aw, 1991 (in Polish).

(5.) P. Sawicki, B.Wiêcek, CCD Multicameras interactive digital system for close range photogrammetric applications, International archives of Foto - grametry and remote sensing, Vienna, Austria, 1996.

(6.) T.B. Hobrought, A Future for Real-time Photogrammetry, Mensuration, Photogrametrie, Genie Journal 9/85 p.312-315.

Korrespondenzadresse des Autors
Dr.B.Wiecek
Technical University of £ódz,
Institute of Electronics, Poland

(Manuscript received on 12.4.1999,
accepted in revised form on 12.10.1999)

Infra Red Thermography in Patients with Early Unilateral Parkinson's Disease

G. Dalla Volta°A.Pezzini+

°Unità Operativa di Neurologia. Istituto Clinico Città di Brescia. Brescia,. Italia

+ Clinica Neurologica .Ospedale Civile di Brescia. Brescia Iitalia

Summary:

Parkinson's disease patients may present a number of disordered thermoregulatory responses, including the impairment of heat dissipation and sweating, and severe hyperpyrexia after levodopa withdrawal. To test the pheripheral vasomotor tone in early unilateral parkinson's patients we carried out infra red thermographic evaluation to compare the affected to the normal side. The affected side was found to be hyperthermic compared to the non-affected side. No correlation was found between the thermal asymmetry and the severity of tremor, rigidity and sensory symptoms. We postulate that these results are the reflection of an imbalance in vasomotor tone related to the basic disease. The dopaminergic system may be involved in the central control of vasomotor tone.

Key words: thermography; Parkinson; central autonomic nervous system; vasomotor tone

Infrarotthermographie bei Patienten im Frühstadium einer halbseitigen Parkison-Erkrankung

Patienten mit Morbvus Parkinson können zahlreiche Störungen der Thermoregulation zeigen wie zum Beispiel Störungen der Wärmeabgabe und des Schwitzens sowie eine ausgeprägte Hyperpyrexie nach Absetzen einer Levadopa-Medikation. Um den peripheren Gefäßtonus im Frühstadium bei Patienten mit halbseitiger Parkinson-Erkrankung zu überprüfen, wurde die erkrankte Seite im Vergleich zur gesunden Seite infrarot-thermographisch untersucht. Die symptomatische Körperseite zeigte sich im Vergleich zur gesunden Gegenseite hypertherm. Weder die Intensität des Tremors, noch das Ausmaß der Rigidität oder der sensorischen Symptome zeigte Korrelationen mit der thermischen Asymmetrie. Wir postulieren, dass unsere Ergebnisse das durch die Grundkrankheit bedingte Ungleichgewicht des Gefäßtonus darstellen.Das dopaminerge Systeme könnte an der zentralen Kontrolle des Gefäßtonus mit beteiligt sein.

Schlüsselwörter: Thermographie; Parkinson; zentrales autonomes Nervensystem; Gefäßtonus

Introduction

A growing weight of laboratory evidence has implicated the role of the central dopaminergic systems in physiologic thermoregulation. This is effected through the control of pathways that mediate peripheral vasomotor tone, in addiction to the known adrenergic, cholinergic and serotoninergic neurotransmitter systems (1).

Long before the appearance of motor disorders, Parkinson's disease (PD) patients may exhibit a number of ill-defined autonomic complaints, such as subjective heat or cold sensations. These early symptoms are often unilateral, antedate the motor impairment and correspond to the side where the motor impairment will develop. Later in the course of the disease, disordered thermoregulatory responses may become clinically significant (2,3).

Since infra red thermography is a reliable instrument for the evaluation of cutaneous heat dissipation, we employed this technique to study the vasomotor tone in unilaterally affected PD patients. In normal subjects without vascular, joint or nerve root disease, heat dissipation, reflecting the vasomotor tone, is strictly symmetrical between the two sides of the body . (4,5)

On the assumption that vasomotor impairment may occur unilaterally in early PD we expected to find an imbalance in heat dissipation between the two sides in those patients in whom motor disorders are still unilateral or predominate on one side.

Material and Methods

We studied 28 patients, selected from the outpatients records of the Clinica Neurologica of the University of Brescia who fulfilled the following inclusion criteria:

clinical and neuroradiological diagnosis of idiopathic Parkinson´s disease

- strictly or predominantly unilateral motor involvement
- absence of peripheral artery or venous disease
- absence of active inflammatory joint disease
- absence of peripheral trunk or nerve root disease

The general characteristics of the population we studied are shown in Table 1.

Motor symptoms were clinically confined to one side of the body in 24 patients, while in the remaining 4 patients they were bilateral but asymmetrical, predominating on one side. The severity of tremor, akinesia and rigidity, was evenly distributed across the patients. The overall degree of functional impairment was mild, with a mean Hoen and Yahr score of 1.2.

We performed infra red thermographic (IRT) examination of upper and lower limbs in all patients included in the study. None of the patients was on therapy at the time of the first full examination.

A subsequent thermographic examination was performed after a two months course of therapy with L-Dopa.

The conditions under which the examination was performed were constant for all patients, according to the Guidelines of the Academy of Neuro-Muscular Thermography (6).

In each patient the cutaneous thermal dissipation was evaluated by comparing the affected to the normal side in both the upper and the lower limbs. In the 4 patients with bilateral motor signs the "affected side" was considered to be the one with more severe impairment.

The results of the examination were deemed positive if a thermal difference of more 0.5°C between right and left side of the body was detectable.

Results

Cutaneous temperature distribution at first ex -amination was found to be asymmetrical in all patients, displaying a relative hyperthermia on the affected side with respect to the contalateral [figure 1 ,2 and 3]

In the four patients with bilateral motor involvement a hyperthermic pattern was found on the side with the most relevant motor impairment.

L-Dopa therapy, on the other hand, had an effect on the IRT examination, since only 5 patients showed an asymmetric thermographic pattern after a 2 months course of treatment. [Tab 2].

Table 1
General characteristics of PD patients

Number of patients	28
Male /female	16 / 12
Age	57 (51-64)
Time since onset (years)	3.5 (2-6)

Table 2
Distribution of patients according to the results of IRT before and after therapy

	First thermographic examination, t_0	Second thermogaphic examination (after 2 months of L-Dopa therapy, t_1)
Number of patients	28	28
Number of patients with an asymmetric thermographic pattern	28	5
Number of patients with normal thermographic pattern	0	23

Discussion

The specific result of this investigation is the detection of asymmetry in cutaneous temperature distribution in PD patients with predomi-

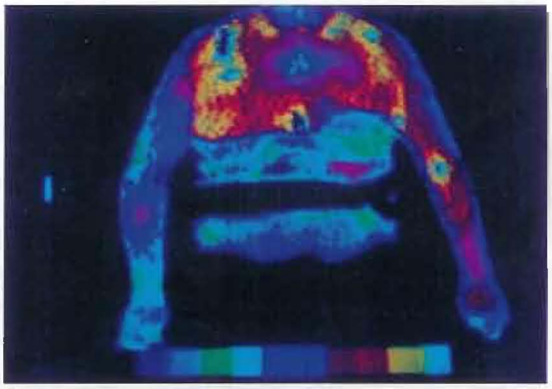


Figure 1
Severe hyperthermic pattern of the upper left limb,without a dermatome distribution.

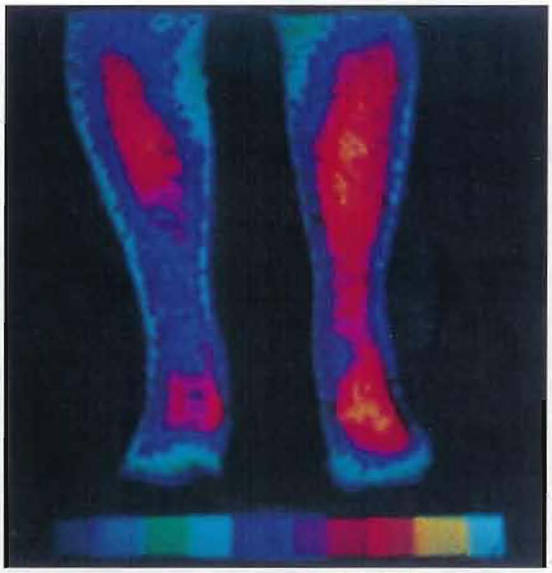


Figure 2
Hyperthermic pattern of the lower left limb in the same patient.

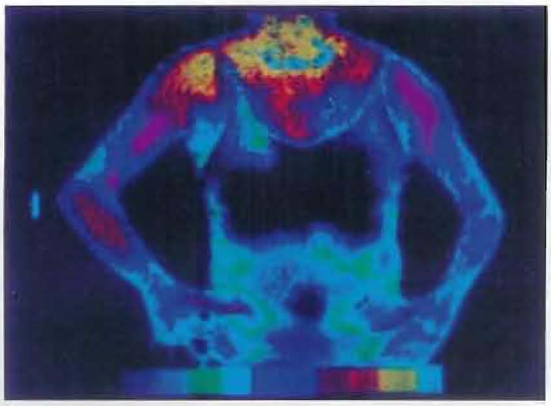


Figure 3
Moderate hyperthermic pattern of the right arm.

nantly or exclusively unilateral motor impairment: there was a relative increase of cutaneous temperature in the affected compared to the non affected side.

We postulate that these results reflect an imbalance in vasomotor tone related to the basic disease.

The general picture tends to favour a hypothermic role for dopamine, through the control of both vasomotor tone and sweating. Our data indicate that the peripheral vasomotor tone may be unilaterally affected in early PD. We suggest that defective central dopaminergic transmission may play a crucial role for the observed asymmetry. The finding that, after a 2 months course of L-Dopa treatment, thermal asymmetry was less pronounced or absent, is in agreement with this concept

These data support the hypothesis that basal ganglia may be involved in the central regulation of autonomic functions.(7)

References

1.) Spalding JMK, Nelson E. The autonomic nervous system. In Baker AB, Baker LH (Eds) Clinical Neurology. Harper & Row, Philadelphia, 1985

2.) Koike Y, Takahashi A. Autonomic dysfunction in Parkinson's disease. Eur neurol 1997; 38 Suppl 2:8-12

3.)Goetz CG, Lutge W, Tanner CM. Autonomic dysfunction in Parkinson's disease. Neurology 1986; 36:73-75

4. Uematsu S. Cerebral cortex in the control of skin temperature in man. Thermology 1990, 3: 199-204.

5.) Abernathie M. Thermography: a window on the sympathetic nervous system. Editorial . Thermology 1988;3-1:5-6

6.) Ring EFJ. Standardization of thermal imaging in medicine: physical and environmental factors. In: Thermal Assessment of Breast Health, ed.Gautherie M, Albert E, Keith L.. MTP Press Ltd. Lancaster/ Boston/ The Hague; 1983: 29-36

7.)Turgut M. et al. Asymmetry of sympathetic activity in a rat model of Parkinson's disease induced by 6-idroxydopamine : haemodinamic , electrocardiographic and biochemical changes. Res Exp Med (Berl) 1998; 197(5): 281-92.

Address of the Author
Giorgio Dalla Volta; MD

Unità Operativa di Neurologia
Istituto Clinico Città di Brescia.

Brescia; Italy

(Manuscript received 06.11.1999, accepted on 12.12.1999)

Kenneth Lloyd Williams MD FRCS

Francis Ring

Royal National Hospital for Rheumatic Diseases, Bath, BA1 1RL, UK

One of the pioneers from the early days of medical thermology died in November 1999.

'Ken' Lloyd Williams was a British surgeon who developed the technique of thermography for many years in cancer research. I first met him at The Middlesex Hospital in London in 1960 where he and his wife Frances were making serial measurements of breast temperatures with a Schwartz thermopile. A science journal called Discovery featured an article by Max Cade from an aircraft engineering firm (Smith's Instruments) called 'seeing in the dark'. This described an old prototype infra red scanner built in 1942. Ken contacted the author and borrowed the machine called the Pyroscan for use on his patients. A year later the scanner came to Bath and was used to study heat from inflammatory arthritis. In 1964 Ken Lloyd Williams moved to Bath as a consultant surgeon. He quickly established a laboratory (Department of Measurement and Clinical Research) equipped with a new version of the pyroscan. His work in this area continued for some twenty years.

His first papers were published in 1960 (1,2). In 1963 He won a WHO travelling fellowship and visited Dr Ray Lawson in Canada. Lawson had also made many temperature measurements with a bolometer on his cancer patients (3). Both surgeons sharing a research interest, they remained in contact for many years. Many grants for research were won by Ken, and a continuos flow of conferences and publications followed. His main findings were summarised in the statement " The hotter the tumour, the worse the prognosis." This was demonstrated in his paper given at the Boerhaave Conference on Medical Thermography in Leiden The Netherlands in 1968.

The results his work at that time showed that of 75 patients followed for 5 years all patients with a rise in temperature over the primary tumour of < 1^0C had an 80% survival. 38 patients had a tumour rise of 1-2^0C, and 63% survived, in 23 cases with 2-3°C tumour rise 48% survived, and in 9 cases over 3°C, non had survived the 5 years (4).

In 1982 when the European Association of Thermology Congress was held in Bath, Ken Lloyd Williams spoke on "A Thermographic Prognostic Index (5). There he reported on work in collaboration with Bowling Barnes, Gershon Cohen and Joanne Haberman in the USA, their cumulative findings had been published at a special meeting of the New York Academy of Sciences in 1964. The collective conclusions were:

- 1. Not all cancers are hot
- 2. There is a spectrum of rise in temperature from zero to 7°C
- 3. Some of the very hot cancers are hotter than core temperature
- 4. The hotter the cancer the worse the prognosis
- 5. The hotter the tumour the worse the pathological staging
- 6. The hotter the tumour the worse the pathological grading

He drew attention to the findings of Gautherie, Stark and Amalric who separately showed that in follow up of so-called false positive thermograms, between 25% and 40% of the patients in these studies went on to develop cancer in 5 years. A typical remark appears in the 1982 proceedings in which he states:

“*It is 20 years since the first crude thermogram came on the scene. Since then the machinery has improved to a state where it will do all we ask of it.*

Perhaps we are not asking the right questions.

Perhaps we are too interested in pictures and not enough in changing state in relation to time, to thermal stress or drugs.”

The last paper to be published by his group on the subject of breast screening for breast Cancer appeared in 1990. In this paper the results of 10,229 women with clinical and thermographic examination yielded a sensitivity of 61% and specificity of 74%. However, using the criteria of temperature difference of 1.5°0C in this large study, the authors found that 71% of the women who developed cancer in the 5 year follow up had had a normal thermogram, leaving 29% with an abnormal thermogram in the preclinical category. They concluded that thermography was not sufficiently sensitive to be used as a screening test for breast cancer (6).

The most outstanding thing about Ken Lloyd Williams to his many friends and colleagues was his unflagging vision for the future. Shortly after moving to Bath he persuaded the authorities to set up one of the first intensive care department in the UK. In 1967 he pioneered a project relating to anaesthetics, so that equipment designed by a Bath colleague was brought to manufacture. This was the beginning of The Bath Institute of Medical Engineering which he formed and chaired for many years. This Institute continues to grow and successfuly incorporates science and engineering at Bath University with medical research in Bath.

When Bath University opened first in 1968, Mr Lloyd Williams was involved in many planning discussions in order to forge links with the medical activities and research in Bath. He later was involved in the inauguration of the Wolfenson Medical Research Centre at the main Hospital, which later became Bath University School of Postgraduate Medicine.

The well appointed Bath Postgraduate Medical Centre used for local medical meetings was also Ken’s inspiration. This led him to start a medical Illustration and clinical photography

Figure
Left to right Dr George Kersley Rheumatologist, Mr Nils Bjork AGA Sweden, Francis Ring, & Ken Lloyd Williams watching a demonstration of the first AGA IR scanner with an oscilloscope display in Bath 1964.

department to raise the standard of presentations at the centre. When confronted by severe space restrictions, he found a means for his colleagues and himself to set up private practice in Bath by purchasing a large house near the Hospital. Today this has been replaced by a larger private Hospital on the edge of the city of Bath, yet another result of pioneering work of Ken Lloyd Williams in the city of Bath.

He was popular with colleagues and especially helpful to junior doctors ready to patiently explain any detail. Although retired from surgery more than ten years ago, he was often present at clinical and science meetings at Bath University and Bath Clinical Society. He was highly regarded in the community for his skill as a surgeon, and will be missed by his colleagues for his expertise, personality and great vision.

References

1. Lloyd Williams K, Lloyd Williams F, Handley RS Infra red radiation thermometry in clinical practice. Lancet 2:958-959 1960

2. Lloyd Williams K, Lloyd Williams F, Handley RS Infra-red radiation thermometry in the diagnosis of breast disease. Lancet 2:1378-1381 1960

3. Lawson RN. Implications of surface temperatures in the diagnosis of breast cancer. Canadian Medical Association Journal 75: 309 1956

4. Lloyd Williams K. Thermography in the prognosis of breast cancer. Medical Thermography Leiden Postgraduate Course, Bibliotheca Radiologica 5, ed.Herma Von Voss, & Thomas, Karger Basel 1969

5. Lloyd Williams K. A thermographic prognostic index in Recent Advances in Medical Thermology ed. Ring EFJ Phillips B, 551-557 Plenum Press, New York 1984

6. Lloyd Williams K, Phillips BH, Jones PA, Beaman S, Fleming PJ. Thermography in screening for breast cancer. J. Epidemiology & Community Health 44:112-113 1990.

Address of the author:

Prof.Francis Ring

Clinical Measurements

Royal National Hospital for Rheumatic Diseases, Upper Borough Walls, Bath BA1 1RL, U.K

A World of Thermography
William Herschel Infrared Bicentenary Conference
Held at Guildhall, Bath, England; March 9-11, 2000

Thursday 9th March

10:30	Coffee	
11:00- 12:00	Registration	
12:30	Lunch	
13:30	Opening	Dave Dibley
14:00	William Herschel and the Development of Infrared Imaging	Francis Ring
14:30	An Electronic Archive of Thermal Imaging Papers	Bryan Jones
15:00	Tea	
15:30	Thermomechanical Properties Calibration for Construction Industry Cementitious Material Using Infrared Camera and Conventional Methods	R Delpak
16:00	Application of Thermography for Determination of Thermal Properties Using Inverse Heat Conduction Formulation	Rita Hu Ching Wen
16:30	Thermographic Survey and Pressure Testing of Building Envelopes	Steven Dudek
17:00	New Developments in Building Inspection	Boguslaw Wiecek
17:30	Thermographic Surveys of Buildings: Which is Best Internal or External Surveys?	Steven Dudek
18:30	Exhibition closes, Herschel House Museum open late	
19:30	Reception with the Mayor of Bath, The Roman Baths	

Friday 10th March

09:00	Latest Developments in Portable Imaging Systems	Dave Furley
09:30	High Quality Blackbody Sources for Infra-Red Thermometry and Thermography Between -40°C and 1000°C	Graham Machin
10:00	Developments in Fixed, Industrial Imaging Installations	John Dixon
10:30	Coffee	
11:00	Developments in Focal Plane Arrays for Thermal Imaging	Tim White
11:30	Corrosion Detection With Infrared Imaging	Andrej Nowicki
12:00	NDT Damage Detection Using Thermography for Metallic and Cementitious Materials Used in Construction Industry	A. Wawrzynek

12:30	Lunch	
13:30	Application of Lock-in Theremography To Measurement of Stress and Determination of Damage in Materials	Pierre Potet
14:00	A New Flaw Inspection Method Based on Lock-in Temperature Measurement Under Thermal Wave Stimulation	Takahide Sakagami
14:30	Development of Standards for Thermographic NDT	Hermann Heinrich
15:00	Tea	
15:30	Mathematical Filtering of IR Images for Integrated Circuit Techniques	Imre Benkö
16:00	Thermography Setting Boundary Conditions for Computational Fluid Dynamics	R Preston
16:30	The Use of Infrared Imaging in Astronomy	Mark Brake
17:00	Thermal Imaging In Virtual Reality - A Look Into The Future	Colin Pearson
17:30	Standardisation of infrared thermography for estimation of moisture contents in porous materials	Nicolas P Avdelidis
18:30	Exhibition closes, Herschel House Museum open late	
19:30	Conference Dinner, talk by Dr Alan Chapman, Oxford University The Herschel family, The Pump Room	

Saturday 11th March

09:00	Mechanical Stress Induced Changes Detected With Thermal Imaging	Kurt Ammer
09:30	Thermography in Rheumatology	Kevin Howell
10:00	Process Monitoring Through IR Images in The Medical Field	Imre Benkö
10:30	Coffee	
11:00	An Open System for Quantitative Analysis of Infrared Medical Images	Peter Plassman
11:30	Cutaneous Laser Surgery and Thermal Imaging	Roderick Thomas
12:00	Thermal Imaging in Cases of Peripheral Venous and Arterial Disease	Stig Pors Nielsen
12:30	Lunch	
13:30	Infrared Imaging in Diabetic Foot Ulceration	Richard Harding
14:00	Thermography of Horses Necks and Backs	C M Colles
14:30	Thermographic Evidence of the Effectiveness of Acupuncture in Equine Neuromuscular Disease	Dietrich G von Schweinitz
15:00	Tea	
15:30	Medical Thermal Imaging - a Vision Of The Future	Francis Ring
16:30	AGM of the ITA, all welcome, Exhibition open	
17:00	Exhibition closes	
19:30	The Annual Herschel lecture, Infrared Imaging in Space	Chairman Patrick Moore, Speaker Randii Wesson, NASA,

Thermomechanical Properties Calibration for Construction Industry Cementitious Material Using Infrared Camera and Conventional Methods

J.K.C. Shih*, A. Wawrzynek°, M. Kogut°,
R. Delpak+, C.W. Hu+, P. Plassmann+

* - Ming Hsin Institute of Technology, Taiwan,
°- The Silesian University of Technology, Poland,
+ - University of Glamorgan, UK

Advances in high technology activities are also reflected in construction of modern structures for use as residential, commercial and fabrication premises. Many materials are deployed for construction of these premises where each is used for a particular function. There is a clear need for determination of the respective mechanical properties to estimate the loaded deformation of such structures. In addition, calibration of the thermal properties helps to design buildings with environmental and energy considerations in mind. It is proposed here that the above thermal and thermo-mechanical properties are also used for integrity monitoring of such structures. The use of these parameters to detect structural faults, with view to repair and maintenance, is discussed elsewhere. The focus of this extended summary is to propose a slightly different application for thermal and themo-mechanical properties.

The standard laboratory tests to determine the relevant material parameters such as thermal conductivity k and specific heat coefficient Cp, are well established. There are many national and international procedures which have standardised the thermal properties evaluation processes. For many environmental and energy calculations related to building premises, these calibrated coefficients work remarkably accurately. However, if the coefficient determination is to be subsequently used for other unconventional purposes, there is little information to show that the standard laboratory methods determination fit for purpose.

Limited experience, relating to the present work, has indicated the unsuitability of standard laboratory procedures on a number of occasions. For example, the determination of k for concrete (and reinforced concrete) specimens, involves cutting a thin disc in order to establish the thermal gradient during a standard measurement process. This thin disc (with or without reinforcement) is clearly unrepresentative of a non-homogenous cementitious material such as concrete. To make the cylindrical or prismatic specimen "non-thin" involves unacceptable heat losses which renders the data at best misleading and at worst inaccurate.

The alternative is proposed to be the laboratory-based determination of thermal properties with realistically sized specimens, using thermography. There is envisaged to be only minimum amounts of insulation present at specific locations so that most of the specimen is exposed to the atmosphere which is controlled under standard environmental requirements. The thermographs, whether in steady state or transient condition, are compared with the predicted images from a suitable analytical model. Where there is agreement between the geometry and contours of isotherms, the assumed thermal and thermo-mechanical parameters are adopted as experimentally valid. Clearly for "n" unknown parameters to be determined, there is a requirement for "n" or more thermographs. The excess number of thermographs, over the minimum required number "n", can be used for statistical analysis in order to establish confidence levels related to the calculated parameters.

It is suggested that the properties calculated through back-analytical procedures, may constitute the most relevant parametric determinations yet, for use in predictive modelling. The main application is intended to be for in-situ damage detection and degradation evaluations.

The activities so far had involved determining the most suitable sizes for the concrete specimens and the most generic concrete mix so that it could be representative of the actual site conditions. The trials indicate that there is a great potential in using non-conventional thermal property determination methods for all construction materials whether cementitious or metallic.

Application of Thermography for Determination of Thermal Properties Using Inverse Heat Conduction Formulation

M. Kogut, A. Wawrzynek, R. Delpak, C.W. Hu

University of Glamorgan, Division of Built Environment, Mid Glamorgan, Treforest, CF37 1DL,

In this paper the thermal parameters using thermography for specimens made of cement mixes are determined. At the outset of analysis a series of laboratory controlled experiments have been carried out. Experimental results have been used as input data for inverse heat conduction (IHC) type of analysis. The solution is framed using the sensitivity coefficient method. The analysis has made adequate use of the finite element method from commercially available suite of programs. Additional software has been developed which acts as an interface between the analytical tool and a deterministic solution. The current analysis is formulated as a two-dimensional, steady state heat conduction problem. Unknown values of thermal properties influencing the heat flow phenomenon, such as thermal conductivity and film coefficient (heat transfer coefficient), in a conductive medium, have been obtained from solving the IHC problem. Numerical simulations of experiments show that for measurement noise levels of less than 5%, the obtained values of parameters do not differ from the exact values by more than 8%. This accuracy is satisfying from engineering viewpoint, since the useful application of thermographic measurements, as applied to the inverse problem formulation, has been established.

Thermographic Survey and Pressure Testing of Building Envelopes

Steven Dudek

Newcastle University, Department of Architecture
Newcastle upon Tyne, NE1 7RU

In the UK the increased levels of insulation incorporated within the building fabric has reduced energy consumption. As the energy loss due to conduction across the fabric decreases, the proportion of the total energy lost by infiltration increases. Now 50% of heat loss is via the fabric and the other 50% via ventilation and infiltration. Whilst the energy running costs of most businesses may be small in comparison to staff costs, a reduction in energy costs is seen as an area where savings can be made.

Recognising the importance of infiltration energy losses has resulted in an increase in the pressure testing of large commercial buildings. One large supermarket chain now insists on pressure testing their new superstores, expecting an air leakage rate of less than 5.0 m3/m2hr at 50 Pa. In the future this requirement is likely to reduce, as store owners seek to reduce costs whilst still maintaining customer service standards.

In terms of establishing the thermal integrity of the external envelop, a thermographic survey as a quality control process to check the quality of the installation of insulation in the external envelop of a building is a widely accepted and used. Pressure testing of buildings is only now becoming part of the quality control process to establish a buildings' air tightness. Combining the two processes is a rare event.

When combining the two test procedures, extra information is obtained. The principal air leakage sites can be identified and their ranking in terms of air leakage can be determined.

This paper explains how these techniques are combined and demonstrates their effectiveness on both non-domestic and domestic buildings. The results are supported by previous laboratory work which established the air leakage rate of a junction and its associated thermographic image for a range of temperature and pressure conditions.

Thermographic Survey's of Buildings: Which is Best Internal or External Survey's ?

Steven Dudek

Newcastle University, Department of Architecture
Newcastle upon Tyne, NE1 7RU

Thermographic survey to detect thermal insulation anomalies is used as a quality control procedure, which will lead to a reduction in the energy consumption of a building. When conducting the survey the contractor has two choices, either internally or externally survey the building. Each approach has its advantages and disadvantages.

External survey's are relatively easy to undertaken and cause little or no disturbance to the building occupants. Surveying domestic building on all facades can be restricted, as assess to gardens surrounding the property can de difficult especially when surveying early in morning or late at night when darkness impairs vision. Because the external facade is viewed the surveyor has no knowledge about conditions on the other side of the facade, and this can lead to misinterpretation of the thermogram. Finally the temperature differences between the insulated and uninsulated parts viewed externally can be small.

Internal survey's are intrusive to the building and cause disturbance to the buildings occupants, however by entering the building the conditions with in the building can easily be established. In some instances the external walls can be obscured by large items of furniture. Air leakage sites into the building can easily be located. And for a given thermal anomaly the temperature differences seen by the infrared camera will be twice that seen externally.

The paper presents the results of both internal and external thermographic survey's of insulated buildings. The paper discuss the advantages and disadvantages of the two approaches and demonstrates that whilst internal survey's are more difficult and expensive to undertake they yield more reliable, understandable results. Both domestic and nondomestic are considered.

Mathemathical Filtering Of IR-Images For Integrated Circuit Techniques

Imre Benkö,

Technical University of Budapest Faculty of Mechanical Engineering, Department of Energy, Budapest, Hungary

Computer processing of the IR-images speeds up considerably the evaluation of the measurement results. Processing of digitalised IR-images may be carried out by a variety of approaches and methods. On the whole, it may be said that it is expedient to suit the strategy and the method of evaluation to the phenomenon under scrutiny. This, in some cases, calls both for heat engineering experience and technical intuition. Image filtering is a special, not commonly used method of infra-red image analysis. We have no information about the publications of mathematical filtering of IR-images. My first one was published in that topic in 1997. [3). The mathematical IR-image filtering in general is suitable for detecting some thermal faults which are difficult to percept otherwise. Image filtering is based on the adequate transformation of the temperature field, i.e. the modification of the temperature values in the pixels of the image [1).

Introduction

This paper only covers the data obtained through the computer processing of IR-thermograms which had to be evaluated because of the IR-images gained from various measurements and the nature of the objectives [2, 3).

The methods of filtering can be grouped as follows: smoothing filters, sharpening filters, band filters, gradient filters. It is important to emphasise that after the filters are applied, the colours and temperatures indicated in the resultant image have no relation to the actual temperatures but to the physical essence of filtering method selected. The illustrations for the infra-red image analysis are taken from the electronics industry (see Figs. 1.a. and 1.b. in [4)).

Generalities

The principal objective of image enhancement techniques is to process an image so that the result should be more suitable for a specific application than the original image. In the IR-thermogrammetry the goal of the image processing is to obtain a new IR-image showing some thermal faults or singularities in the temperature field. It is to be noted that the image enhancement techniques are very much problem-oriented.

Generally, image enhancement methods are based on either spatial or frequency domain techniques. The spatial domain refers to the image plane itself, and approaches in this category are based on direct manipulation of pixels in an image. Frequency domain processing techniques are based on modifying the Fourier transform of an image. In this paper we use the spatial domain methods only.

Analysis of thermal singularities of an IC

In this section we present several techniques for the enhancement and evaluation of IR-images. The illustrations are taken from the field of IC-techniques. We have used the following titles of figures for presenting the advantages of filtering. Examples for the filtering of component side are in the 1st type figures. (Sobel) and applied Roberts gradient to the same ones we get the thermal singularities. So the recommendable process of mathematical filtering applying to the original IR-images, in similar technical cases is the following. The first step: the sobel filter is a sharpening one equalizing the smaller temperature differences so the contours of the high temperature-field can be achieved.

The second step is a subsequent filtering of the 1st type figures by Roberts gradient (RG). RG-filtering keeps all of the pixels having a gradient value bigger than a threshold and the other one get a background level value. Generally the 2nd type figure has a threshold: 80 and a background: 15 value and shows the "hot-field" of the IC-component side.

Some common evaluation for analysis of chip side are also presented. For comparison of "classical" and filtering evaluation of IR-images, we present some possibilities for IC-chip side.

3rd type of figures shows an examination of the temperature distribution along lines created horizontally and vertically and a histographic processed result, representing the more significant characteristics of the histogram in the specified area: e.g. the highest (*max*: 65,4ºC), the lowest (*min:* 28,6ºC) and the middle (*avg*: 37,7ºC) temperature, etc. there is a three-dimension relief display, too.

References

[1)Gonzales R.G., Woods R.E., Digital image processing, Addisson-Wesley, Wokingham, UK., 1977

[2)Benko I., Applications of infrared thermogrammetry in thermal engineering. Quantitative Infrared Thermography (QIRT 92), Eurotherm Séries No.27., Editions Européennes Thermique et Industrie, Paris, 1992, pp. 343..349.

[3)Benko I., Infra-red picture analysis in thermal engineering, Proceedings of 10th Int. Conf. on Thermal Engineering and Thermogrammetry, edited by I. Benko, MATE TE & TGM, Budapest, 1997, pp. 46..52

[4)Benko I., Applications of infrared filtering in electronic technology, Book of Abstracts of QIRT'98, edited by B. Wiecek, PKOptoSEP, Lodz, 1998, pp. 86..87

An archive of early thermal imaging for medicine papers.

B F Jones, E F J Ring

School of Computing, University of Glamorgan,
Pontypridd, CF37 1DL

Infrared thermal imaging has been applied to medical research since 1960 in several research centres in Europe, the USA and Japan. Its great attraction is that the process is non-invasive since it captures an image of the natural black-body radiation from the patient. Considerable work was undertaken into the study of a number of diseases such as rheumatoid arthritis where joints may be inflamed and peripheral vascular disease where an increased density of blood vessels may cause hot spots on the skin surface.

During this period, several important basic principles of thermal imaging were established, such as the thermal symmetry inherent in a healthy subject. The volume and quality of this work was such that two peer reviewed Journals were established. The European Association of Thermology was formed in 1972, and the first Journal dedicated to the subject, ACTA THERMOGRAPHICA, was published in Italy by an Editorial Board chaired by Prof. Pistolesi. Some years later, the Journal was discontinued and the American Academy of Thermology published a larger format and glossy Journal of Thermology together with the International Bibliography of Thermology. Both were dedicated to human body temperature and thermal imaging. This Journal was also discontinued some years later.

Neither Journal is readily available in libraries, and the wealth of reference material is in danger of being lost. The US National Technology Transfer Center and the BMDO agreed to fund the production of a CD ROM to disseminate this material to researchers in medical thermal imaging. The information is also available via the World Wide Web pages at Glamorgan (URL) though the speed of access is slow. It is important to avoid 're-inventing the wheel' during the resurgence of interest in thermal imaging prompted by the availability of the advanced infrared cameras that have been developed by the US military over the last twenty years. The improvements in technology have been dramatic and with the ending of the cold war, one of the peace dividends has been an enthusiasm to transfer that technology to medical applications, Substantial pro -gress has been made in increasing the speed and resolution of infrared cameras making them more reliable and easier to use in the hospital or clinic environment, Modern cameras may be cooled electrically making them much smaller and more versatile so that they maybe used during surgery.

Prof. G F Pistolesi of the Istituto di Radiologia. University Degli Studi di Verona, Italy, has given permission for the papers in "ACTA THERMOGRAPHICA" to be made available on CD ROM and we acknowledge their original source. Likewise, the President of the Academy, Sheng Tchou, MD, reported that the Executive Council of the American Academy of Thermology unanimously gave permission for the inclusion of papers horn the Journal of Thermology in the CD ROM. We give full credit of ownership to the Academy.

The papers on the CD ROM are held in portable document format (PDF) so that the papers can be searched for keywords; the appropriate Adobe Acrobat Reader software is included on the CD. The colour images are held in GIF format.

The Discovery of Infra Red Radiation

EFJ Ring

Royal National Hospital for Rheumatic Diseases;
Bath BA1 1RL UK

Sir William Herschel, musician and astronomer, is widely regarded as the person who first identified infra red radiation. In 1800 he presented his findings to The Royal Society, London that were published in March of that year in the Philosophical Transactions. Two centuries before Baptista Della Porto of Naples conducted experiments that showed that heat is reflected by a concave glass. In 1790, Provost in Geneva established his theory of exchanges in which he stated that all bodies radiate heat, the higher the temperature, the greater the radiation. This was to be the basis of Planck's law for radiation established in the early part of the 20th Century.

Herschel, a self taught astronomer had become salaried by King GeorgeIII to work as the King's Astronomer near Windsor Castle. He was concerned with both the science and art of telescope making as well as his regular astronomical observations. His astronomy papers in the Philosophical Transactions were prolific, and as a result he has been liberally quoted on a very wide range of astronomical subjects since the late 18th Century.

In researching the types of optical glass for telescope eyepieces, he set up an experiment to measure the heating effects of the colours of the prismatic spectrum. Using three thermometers borrowed from friends (which were not standardised in the way modern thermometers are today) he cast the rainbow spectrum on a table using a prism in a blackened window. Laboriously recording from all three instruments in as many separate colours as possible he found that the temperature recorded highest beyond the visible red end of the spectrum. He called this "Dark heat or Invisible Rays" for which we now use the term infra-red radiation. William Herschel carried out a number of related experiments, in which he demonstrated Della Porta's theory that heat can be manipulated as light. This he applied to tests of reflection and refraction using a candle flame and in one case a coal fire as the heat source. He also studied the phenomenon of absorption, and listed nine types of glass and their respective "stoppage of prismatic heat of the refrangibility of the Red Rays and the Invisible rays"

It is interesting that William's only son John, carried out further experiments in 1840 after his father's death. This was probably an attempt to justify some of the earlier experiments to his father's critics. This work led him to create the first image formed by solar heat in an evaporograph, where carbon particles from candle soot, were dispersed in suspension in alcohol according to the intensity of heat. He termed the result of this process a Thermogram, a term still in use today. Thus father and son, William and John Herschel were the pioneers of infra red thermography. It is also worthy of note that a close and lifelong friend of John Herschel was Charles Babbage, who is generally regarded as the pioneer of computing. His great invention of the Calculating Engine, and his descript ion of simple mathematical calculation programmes, predate modern software.

Today, infra red thermal imaging is commonly used with a computer, and many systems incorporate some digital image processing in their structure. William Herschel expressed his approval of his son's friend, and it is clear that all three met together from time to time while William was still alive. They could not have imagined that the collective research from each would provide the foundation for modern thermal imaging technology in the year 2000.

Latest advances in thermographic condition monitoring

David Furley

FLIR Systems Ltd, West Malling, Kent ME19 4A, U. K.

The use of thermography as an integrated part of a well organised condition monitoring programme is now widely recognised and standards for the practice documented in many companies.

The challenge now is to streamline the whole process to make the gathering of data simpler, less fatiguing and more reliable whilst also reducing the report generation task to the minimum PC keystrokes and retaining clear conclusions and recommendations.

The introduction of focal plane array (fpa) thermal imaging cameras that require no mechanical scanning enabled manufacturers to produce truly portable cameras similar to domestic camcorders. Apart from a dramtic improvement in resolution and image quality, the small size and reduced weight meant that the cameras could be used in confined locations and for longer periods of time without operator fatigue. Image storage on PCMCIA (flash) cards took away the need for video recorders and photographic devices to record data so that images along with all the related temperature information could be simply transferred to a PC for storage and analysis.

Size and weight were further reduced a couple of years ago with the arrival of the radiometric (temperature measuring) uncooled microbolometer detector which took away the last mechanical component, the stirling cooler. Now cameras were totally solid state with no mechanical component having a finite life. Start-up time was reduced to about 40 seconds compared to 6-8 minutes for a cooled device, power consumption was reduced and the battery could be integrated into the camera rather than worn on a belt.

These latest technology cameras were light, quiet, operable in one hand and offered huge image storage capacity of up to 1000 images on a PC card. They had dedicated PC software with an extensive choice of analysis functions and simple report generation.

In the quest for speed and accuracy however, this year has seen the introduction of a number of improvements to this concept.

A second generation of uncooled microbolometer has further enhanced both spatial and thermal resolution and a number of features have been added to assist the operator who is often using the camera for his full working day.

The ability to add a voice comment to a stored thermal image has been available for some time but to add this to a report meant transposing and retyping, always assuming you could make out the comment amidst the background noise of a steel works for example. Now with text annotation, a number of comments can be stored on pull down menus and stored with the image for automatic incorporation within a report.

A similar concept has been applied to the determination of emissivity with pull down menus with full descriptions of different surfaces. The operator then only has to select the material he is wanting to measure and determine whether it is polished or oxidised in the case of a metal and the correct emissivity factor is applied to the measurement.

With cameras capable of distinguishing 0.1 °C temperature difference, picking out a hotspot or area is not always easy. Isotherms (areas of similar temperature) have always assisted in highlighting problem areas but the concept has now been taken a stage further with a transparent isotherm that will not only highlight an area but also permit the operator to distinguish the hotspot within the isotherm area. By combining two of these colour isotherms on a black and white image two levels of alert condition are plainly visible to the operator.

Enhancements have also been made to the software that forms an integral part of the condition monitoring package, again with speed and simplicity in mind. To create a multi-page report using a standard template now only involves selecting the required images from the PC card and dragging and dropping them onto a desktop icon. As many parameters as required are included as well as any text annotation selected by the operator.

In conclusion, the practice of thermography is coming of age. Managers demand clear and accurate reports on which to base critical decisions and the quality and accuracy of the thermal image is all- important. As manufacturers e will continue to develop the entire concept, not just the product alone.

High quality blackbody sources for infra-red thermometry and thermography between -40°C and 1000 °C

Graham Machin, Brian Chu

CBTLM, NPL, Teddington, Middlesex, TW11 0LW, UK

NPL has designed and constructed four high quality infra-red (IR) blackbody sources to provide standards for the calibration of IR thermometers and thermal imaging systems. These are based around heat-pipe technology and are delineated by the working fluid of the cavity; ammonia (-40 °C to +50 °C), water (+50 °C to 275 °C), caesium (300 °C to 600 °C) and sodium (500 °C to 1000 °C). The emissivities of the cavities are in excess of 0.999 and the expanded radiance temperature uncertainties (U(k=2)) range from <0.1 °C at lower temperatures to about 0.2 °C at 1000 °C. The sources are used to provide traceability to ITS-90 via a calibration service, accredited by the United Kingdom Accreditation Service (UKAS; Calibration Laborato ry No. 0478).

This paper describes the general design of the NPL blackbody cavities and their capabilities. It then goes on to describe the use of the blackbody cavities for testing two different commercial thermal imagers. Imager 1 is based on scanning technology; imager 2 has a focal plane array detector package; both systems operate within the 3 to 5 micron wavelength band. Parameters tested are temperature accuracy, uniformity across the image plane and sensitivity to atmospheric carbon dioxide.

Thermal Imaging of Industrial Processes

John Dixon

Land Infrared, Dronfield, Sheffield, S18 6DJ; U.K.

The real cost of industrial thermal imaging systems has fallen considerably in recent years while the performance, reliability and functionality have increased. Improvements in "user-friendliness" and the ability to interface with other items of equipment have made the technology accessible to a wider range of organisations, especially those who do not have the resource to employ staff who are primarily experts in technology of thermal imaging. The resultant improvement in value for money and cost/benefit ratio has brought about an explosion in the range of industrial applications in which thermography is a viable technique.

Developments in infrared detection, optics, electronics, materials, manufacturing techniques and communication technology have each made a contribution to the advances in thermal imaging and the significance of the most important of these is discussed. As the diversity of the uses thermography increases, it has become necessary to tailor the design, not only of thermal imager but its peripheral equipment and the interfaces between them.

Examples of various applications from a diversity of industrial segments are used to illustrate the directions in which the technology has developed.

Thermography As A Maintenance Tool In Industry

A. N. Nowicki

IRIS,, Melton Mowbray, Leics. LE13 0AN; U.K.

Introduction of any new activity into industry usually has to be justified on a cost saving basis and thermography is no exception. Since the early seventies thermography began to be introduced into the industrial environment and is now an established inspection method which is highly recommended in all forms of preventive maintenance.

Because of the vastness of this subject it is difficult to cover all aspects of industrial applications in a single paper which has to be presented in a limited time. For this reason only three examples were selected in different spheres of activity to illustrate the potential of Thermography in the industrial environment:

1. Electrical application illustrating various types of problems that may be encountered in a High Voltage panel such as: defective switch connectors, overheating busbar joints or faulty cable connections.

2. Use of Thermography in 'Corrosion Under Insulation' detection in the Petrochemical Industry. External corrosion of carbon steel pipes and vessels presents a large problem in this industry and although there are a number of inspection techniques dealing with this subject, most are very slow and difficult to apply. Although Thermography will not detect all the corrosion problems that may be encountered, it is an extremely useful and cost effective tool in highlighting some of the more obvious defects.

3. 'Thermography in the Building Industry' is a subject well covered in numerous papers presented since the day the thermovision camera became small enough to be portable. Without spending too much tine on this subject, the enclosed example will illustrate how an immediate solution was found with the aid of thermography when presented with a heating problem in an office. During the winter staff in certain parts of the office were always complaining of being cold. Extensive visual inspection of the wall and windows in the 'cold zones' did not reveal anything abnormal, however, an internal scan of the walls with a thermovision camera in these areas immediately highlighted the cause of the problem.

Digital IR Imaging Capability with the Micro IR™ Uncooled Technology

T. White, A. Leary, K. Maschhoff

Sanders IR Imaging Systems, Lexington, MA 02421

IR Imaging has changed a great deal since it was last evaluated for medical applications. Systems are much more sensitive and much less expensive. Current uncooled imaging systems which sell for less than $20,000 in production are capable of NETD's of 0.05C and are as easy to use as a home video camera. The digital nature of today's imaging systems makes computer analysis and image archiving a straightforward data storage task. All of these advances have started a examination of microbolometer based uncooled sensors for IR imaging applications ranging from border surveillance to medical imaging and even space applications.

An initial installation of 150 MicroIR™ cameras has proven extremely effective on the US Mexico border.

Several informal tests have indicated promise for medical diagnostic purposes, and trauma applications are being investigated as well. Accelerated aging tests have demonstrated the feasibility of using MicroIR^{TM} sensors in earth-imaging satellite applications. This paper will present MicroIR^{TM} imager test results and tests to date as well as suggest some new areas for further work

NDT Damage Detection Using Thermography for Metallic and Cementitious Materials Used in Construction Industry

J.K.C. Shih*,.M. Kogut° , R. Delpak+, C.W. Hu+, P. Plassmann+, A. Wawrzynek°

* - Ming Hsin Institute of Technology, Taiwan,
° The Silesian University of Technology, Poland,
+ - University of Glamorgan, UK

Introduction

With the increasing need for quality assurance in construction industry, Infrared thermography is being developed for use as a monitoring tool. This is to indicate structural damage by studying the heat conduction properties in structures. This general technique has gained prominence in recent decades due to the applicability to other non-contact inspection activities. Thermography is hence capable of rapidly determining the location of abnormalities and anomalies with view to remediation and repair.

Application to Mechanical Damage Identification

Not all faults/imperfections cause severe harm to structures. It is therefore essential to identify the specified sizes of cracks, as a part of degradation evaluation activities. This could clearly lead to decision-making processes as related to preventative and pre-emptive strengthening and maintenance strategy.

Thermography as an Inspection Tool

Thermal imaging identifies the heat perturbations in a structural surface which may have been caused by a number of factors such as presence of delaminations or damage zones. The success in thermography monitoring is due to interference in the lines of heat flow through an originally perfect and isotropic/homogenous continuum. Ordinarily, the propagation of the heat flow is influenced by all geometrical anomalies or material discontinuities which is potentially capable of being detected by an IR camera of appropriate resolution. In this paper, the geometrical parameter, defining damage, is based on the induced change in the form of crack width which presents a resistance to heat flow.

The Present Objectives

The principle aim of the investigation here is to evaluate the surface temperature pattern captured by an IR camera in order to identify the position of the crack (and, other geometrical imperfections to a lesser extent) in cementitious and metallic materials. In this research, the temperature variation is sourced from a continuous and constant heat supply. Concrete specimens with specified geometrical discontinuities, to represent a crack, are cast with a specific mix design of 1(cement) : 2(sand) : 4(aggregate). This mix is intended to represent a generic industrial concrete as encountered in many construction sites.

Finite Element Analysis

A commercially available finite element (FE) software (ANSYS, Release 5.4,1997) is applied to (a) model the geometry of specimen, as well as, (b) to represent the temperature variation field due to a specified heat source. All current analytical models are based on two-dimensional heat flow formulation for the four widely materials used in construction, i.e. concrete, iron, aluminium and copper. The thermo-mechanical properties of concrete such as the conductivity k, specific heat Cp, heat transfer coefficient h, and density are accurately obtained in standard laboratory measurements. The thermal parameters of the above metals are taken from standard tables of material properties.

Results

The thermal field values for all materials of a given geometry, with various crack widths, have been predicated through FE modelling. From the numerical results, it is possible to estimate the crack width, based on the crack tip temperature differences. These results are unified through representation by a simple formula, to include variables such as crack width and temperature difference, etc, for all three metals. The data generated due to FE modelling was used to develop on empirical formula which matched closely the FE output data, where the comparative errors have been less than 1.6%.

The FE modelling was also applied to represent concrete specimens of identical geometry but with different crack widths. A separate empirical formula was also developed for concrete, to enable prediction of crack tip temperature differences. Comparison with measured values for selected data points has proved both accurate and encouraging with maximum errors between 1-2%

A New Flaw Inspection Method Based on Lock-in Temperature Measurement Under Thermal Wave Stimulation.

Takahide Sakagami, Shiro Kubo

Department of Mechanical Engineering and Systems,
Graduate School of Engineering, Osaka University, Japan

In this paper, the applicability of the newly developed two different lock-in thermographic NDT techniques is discussed. One of the proposed techniques is based on the lock-in measurement of the singular temperature field which appears near crack tips under the application of periodically modulated electric current. Experimental study is made on the resolution and the applicability in the detection of through-thickness and surface cracks embedded in steel and aluminum alloy plate samples. Modulated electric current is applied to the cracked sample by an induction coil. Temperature amplitude and phase delay thermal images synchronized to the reference current modulation signal are taken by the lock-in thermography. Significant temperature rise related to singular temperature field is observed at the crack tips in the lock-in thermal images. It is found that the cracks are sensitively detected by the lock-in thermography technique combined with near- tip singular temperature field measurement. The other technique is based on the lock-in measurement of the surface temperature under the application of periodical Xe light heating. Experimental study is made on the applicability in the detection of flat bottom hole defects. Xe light beam is periodically chopped by the electric shutter to stimulate thermal wave in the objected body. In-phase and out-of-phase temperature amplitude images are taken by the lock-in thermography, synchronized to the reference signal of the electric shutter operation. It is found that the location and size of the defects can be identified by the localized contrast change in the out-of-phase images. Further, the depths of the defects can be identified from the heat penetration depth which is changed by the frequency of thermal wave stimulation.

Training, Qualification and Certification of Thermographers and Development of Standards

Hermann Heinrich

University of Kaiserslautern, Germany

In the classic fields of Nondestructive Testing (NDT) it is well known and common that the personnel is trained, qualified and certified in a relativly uniform manner. In the past such a comprehensive practice was not known or usual for infrared thermography in Europe unlike the USA where for example ASNT was active.So far the training of thermographers based mainly on some kind of basic courses offered by the manufacturers of thermographic systems and especially on the activities as seminars and conferences of the German thermographers associations. On the other hand there exists in Europe the European Standard EN 473 “Qualification and certification of NDT personnel”. This standard which is valid for eighteen European countries includes explicit infrared thermography.

To improve the training situation, to harmonize the knowlegde of the thermographers and to introduce a quality measure for the customers of the thermographers in 1998 the German thermographers association and external experts began to develop a demanding and uniform educational program following the EN 473. The concept is based on a three-step course system corresponding to three different levels of knowledge and experience. Courses level I and level II in each case go on for five days and an additional day for the examination while the level III course is one day shorter.In the year 1998 a first level III course was carried out with the aim to get some certified experts as teaching staff to run in the following year 1999 the level II courses. These cour- ses were executed at the universities of Kaiserslautern and Rostock, Germany. After passing the examinations the first thermographers could be certified with a Europe-wide acknowledged certification. At the moment negotiations with other European countries take place with the aim to use the same system.The courses do not only include fundamentals of infrared thermography and instrumentation and of operating the system but also as a focal point the applications.

But the applications show a weak point. Until now there is a lack of practically usable and accepted standards. Germany introduced last year - due to European regulations - the European standard EN 13187 which is nothing else than ISO 6781. This ISO 6781 “Thermal performance of buildings” was submitted in 1982 (!) and is now totally out - of - date. For other applications of infrared thermography there does not exist up to now any national or European or international standard. Only in some countries, as in Germany or in UK there were published some kind of guidelines for example for electrical applications.

This situation demands an improvement. A first step was the ISO-conference in Vancouver, Canada, in 1999 where the ISO/TC 135 established SC 8 “Infrared thermography” with the aim to create international accepted standards.

Mechanical Stress Induced Changes Detected With Thermal Imaging

K.Ammer

Ludwig Boltzmann Research Institute for Physical Diagnostics; Vienna

The „fist manoever“ is part of the protocol for testing patients suffering from the mild form of thoracic outlet syndrome. During this test the arm is abducted in 90 degrees and the hand is pointing upwards. In this position the patient is opening and closing the fist thirty times. The temperature changes on the hands and forearm during this procedure are reported.in healthy subjects and patients suffering from mild thoracic outlet syndrome (TOS).

40 arms (21 with symptoms of TOS, 19 controls of 5 males and 15 females) were investigated. All subjects acclimatized for 10 minutes with bare arms to a room temperature of 24°C. Thermal images were taken of the forearm and hands before and after the fist manoever. Regions of interest were defined on the forearm between the elbow and the wrist and

over each single finger tip and metacarpophalangeal joint. A thermal gradient was calculated from the hand to the forearm (TGA). The temperature values were described statistically and values in both groups were analyzed by the non- parametric Mann-Whitney test.

The mean TGF (TGA) was pathological (smaller than -0,5 or-1.0 respectively) in 43 (55) fingers prior to the mechanical stress. After stress test 56 fingers presented with pathological findings of the TGF and 66 fingers with a pathological TGA. This increase of the temperature gradient was not caused by higher temperature readings over the forearm after the stress test (mean forearm temperature prior to the mechanical test. 33.2 ± 0.2 versus 33,0 after the stress test) but by a further decrease of the temperature of the finger tips after the mechanical stress. The temperature gradient and its change did not affect the difference of temperature between index and little finger, which is highly diagnostic for the mild form of TOS if less than –0.5.

A similar decrease of the temperature of finger tips was reported in patients suffering from repetitive strain injuries (RSI). Hazleman et al. found cold finger tips in every professional keyboard operator suffering from work induced pain, but only in some healty subjects similar,, but slighter changes. However, the mechanism causing this phenomenon might be different in keyboard typing and in subjects closing and opening the hand of the elevated arm.

Thermography in Rheumatology

Howell KJ, †Smith RE, Knight CJ, *Dziadzio M, Martini G, White AG, Black CM

Centre for Rheumatology, Royal Free and University College Medical School, Royal Free Campus, London S
†Department of Medical Physics, Royal Free Hampstead NHS Trust, London
*Istituto di Clinica Medica, Università di Ancona, Italy

Since its inception, medical thermography has played an important role in Rheumatology, since vascular manifestations are commonly seen in association with rheumatic disorders. Consequently blood flow may be modified, with a resultant change in skin surface temperature.

Raynaud's phenomenon (RP) is a disorder of the microvasculature characterised by intermittent ischaemia of the extremities on exposure to cold. The rewarming of digits after mild cold challenge of the hands or feet in water (15°C for one minute) is severely compromised and this can be readily confirmed with dynamic thermal imaging (1 frame per minute). Such measurements are employed in the study of pharmacological and other treatments used for RP, since they offer apparent objectivity in contrast to the subjective symptom diaries of patients.

Carpal tunnel syndrome, caused by median nerve compression, seems to be encountered with increased frequency in RP patients. Thermography can indicate such coexistence by revealing relative hyperthermia in the area of the hand innervated by the median nerve.

Reflex sympathetic dystrophy (RSD), often resulting from trauma-induced nerve injury, may also provoke vasomotor changes in patients leading to alteration of skin temperature. While the aetiology of RSD remains controversial, thermographic detection of abnormal vasomotor control complements other diagnostic imaging modalities and assists in early diagnosis and treatment.

Thermography also aids the assessment of the activity of inflammatory lesions in conditions such as *localised scleroderma.*

Dynamic and static thermal images will be presented to demonstrate the aforementioned applications.

Process Monitoring Through IR-Images in the Medical Field

I. Benkö[1], G.J. Köteles[2] and G. Németh[3]

1Technical University of Budapest, Department of Energy H-1521 Budapest, Hungary;

2"Frédéric Joliot-Curie" National Research Institute for Radiobiology and Radiohygiene, H-1775 Budapest, POB.101.,Hungary;

3"Haynal Imre" University of Health Sciences, Dept. of Radiotherapy, H-1389 Budapest, POB.112, Hungary.

Abstract

It is in fact a worldwide experience that many of the incidents and accidents involve only partial body irradiation and the extremities are the most frequently injured parts of the body. As it is still not general practice to use infra-red (IR) thermographic measurements for the more precise diagnosis of local injuries, the availability of these techniques are very rarely mentioned in the publications. In this paper we would like to call attention to what we had introduced more than a decade ago the use of IR-thermographic procedures in diagnosing local radiation injuries [6]. Further justification for introducing these techniques is that in the relevant cases the assessment of absorbed dose through the widely known biological indicators or biological dosimetry assays is hardly possible [5, 6).

Introduction

In determining temperature fields of various characteristics, one may choose between the following general methods, while their relative advantages and disadvantages must be decided in the light of the tests being done:

- the selection of the temperature interval to be tested and, within that, decision over the choice of the number and the widths of the isostrips;

- determining the temperature at specified points of the surface under test (e.g. the centre point of the hair cross);
- a comparison between temperature distributions along the horizontal and vertical lines;
- determining the temperature distribution and mean temperature in smaller specified areas of the surface tested;
- statistical methods for the description of temperature distribution (e.g. histographic processing, distribution curve of the histogram) and image filtering.

Method and examination

Histographic analysis is the usual mode of processing experimentally and otherwise obtained sets of data, but it may be considered as an efficient way for describing temperature fields, too. Thereby there is still little experience available for such applications and for the proper evaluation of all histogram characteristics [1,2,3,4).

The investigations on the beta-irradiated chest were performed by AGA THV 780 type infrared imaging equipment [6). The results of measurements were stored from the different investigations, during three weeks by an infrared video recording, which was evaluated by computerised technique.

The method of data analysis was elaborated and applied for the investigation of six patients. The irradiated areas as shown in [6) have absorbed 2.5 Gy at each session but from various energies. The radiation treatment was performed through consecutive weeks, 5 irradiation sessions per week applied daily, the beta-dose was 12 times 2.5 Gy. The treatments on weekend days were omitted. These post-operative irradiations always complete the complex therapy of breast cancer patients. The immediate effect could be seen already 20-30 minutes after irradiation.

References

[1)Benkö I. Quantitative analysis of medical infrared pictures. Thermologie,Österreich **2** Sonderheft, 1992, p.17.

[2)Benkö I., Köteles G.J. *Thermotechnical approaches to the investigation of local injuries caused by ionising radiation*. Periodica Polytechnica, Ser. Mech. Eng. 37. 1993, pp 197-213.

[3)Benkö I. *Histographical analysis of infrared images for medical diagnosis*. 8th Int. Conf. on Thermal Engineering and Thermogrammetry, Budapest, Hungary, 1993, pp. 307-308,

[4)Benkö I. *Possibilities of infrared imagery in the field of biology of ionising radiation.* Proceedings of the Workshop on Advanced Infrared Technology and Applications. Casa Malaparte - Capri (Italy), September 20-21, 1993. Fondazione "Giorgio Ronchi", Firenze, 1994, pp. 255-270.

[5)Benkö I., Köteles G.J.. - *Recent data concentring human reactions against ionizing radiation*. Proceedings of the "Recent Advances in Medical Thermology". Thermologie Österreich, 4, 1994, pp. 181-182.

[6)Benkö I., Köteles G.J., Németh G. - *Thermal imaging of the effects of beta-irradiation on human body surface.* Quantitative Infrared Thermography (QIRT '96, Stuttgart, Germany, September 2-5, 1996,. Eurotherm Series 50) p. 354-359. Edizioni ETS, Pisa, Italy.

[7)Benkö I., Köteles G.J., Németh G. - Use of thermogrammetry in diagnosis of local radiation injuries. Health Phys., 74, 1998, pp. 264-265.

An Open System for Quantitative Analysis of Infrared Medical Images

P. Plassmann1; E.F.J. Ring

1 University of Glamorgan, School of Computing, Pontypridd, Mid Glamorgan, CF37 1DL

2 Royal National Hospital for Rheumatic Diseases, Upper Borough Walls, Bath, BA1 1RL

Images in medical thermology are usually processed using propriety software designed by manufactures or distributors of image processing equipment. Naturally this has led to a large variety of image file formats, data exchange protocols, and image processing routines. The medical thermology community has now realised for some time the increasing need for standardisation and open systems in order to exploit the full potential of computer networks for communications and data exchange with colleagues. This has been aided by the increasing availability and capability of Internet and intranet systems where common standards or de-facto standards are defining the framework for communication and data interchange.

BTHERM, the Bath THERMal imaging system, addresses these issues. It is a comparatively low cost PC based computer system for the acquisition and analysis of images from a variety of IR cameras. Its core algorithms for image data acquisition, storage, manipulation, display and export to other systems are multi-purpose and can be used in virtually all domains of IR imaging°. Its functionality includes tools for statistical analysis, isotherm generation, noise reduction and colour scale manipulation which are common to most IR imaging applications.

The program concept is modular, allowing the addition (and removal) of dedicated modules for specialised disciplines such as medicine. This avoids the functionality overload found in many of today's software packages where the average user utilises only a fraction of the program's capabilities and is confused by the inevitable clutter generated by "functionitis" that leads to the need to click your way through a barrage of multi-layered sub- submenus before reaching the desired function. Stream lining functionality to the user's requirements also reduces the need for extensive training and reduces potential sources of error.

In the field of medical thermology BTHERM features a dedicated module for the “cold stress test” analysis which allows the straightforward observation of reactive hyperaemia and the diagnosis of Raynaud’s phenomenon. The process of analysis is event driven, i.e. the clinician is guided through the measurement process by the system. Help is available at staged levels ranging from elaborate explanations of the entire process including recommended ambient parameters, timing and procedures down to the point where help can be disabled altogether by the experienced user.

On the hardware side, connection to legacy AGEMA 780 series of infrared cameras is possible via a purpose-built frame grabber device. Using a PCI bus standard industrial frame grabber, the modular system can also accommodate all modern IR cameras which are capable of providing monochrome image output in standardised PAL or NTSC (Composite or S-video) formats. This advantage, however, comes at a price: although the images themselves are imported automatically, the specific IR camera settings such as temperature level (offset) and range have to be entered manually into the system. The same applies for the import of image files produced by other IR systems and also in the case of file export, which can be performed in a variety of standardised image formats such as JPG, BMP and GIF. Future work will address this issue and automated transfer of set-up data for the most popular cameras and IR packages may be incorporated into the system.

°The contributions by Delpak and Hu Ching Wen in this issue make reference to the use of BTHERM in the context of structural analysis and building surveying.

Thermal Imaging In Cases of Peripheral Venous and Arterial Disease

Stig Pors-Nielsen, Lars Thorbjørn Jensen

Department of Clinical Physiology, Hillerød Hospital, Denmark

Diagnosis and quantification of peripheral arterial and venous disease often require time consuming clinical measurements.Among the modialities used are: The strain gauge technique for peripheral blood pressure measurement in occlusive arterial disease and Raynaud’s disease; skin perfusion measurement with radioisotope technique at one or more sites for level of amputation; colour Doppler flow imaging with measurement of flow rates for diagnosis, localisation, and quantification of:

- a) postoperative obstruction and arterial-venous shunts of *in situ* by-pass grafts;
- b)thrombophlebitis, deep venous thrombosis, and
- c) incompetent communicating veins in patients with varices.

The aim of the present work, which is preliminary, was to examine whether thermal imaging could give supplementary information, decisive for treatment, and perhaps even replace classical clinical investigative procedures. We examined a total of 100 patients belonging to the groups described above, with a combination of thermal imaging and digital photography Equipment: Agema Thermovision® 570 IR camera and a Kodak digital science DC210 Zoom Camera. All patients were immediately before examined by one or more of the classical modalitics mentioned above.

The results of this preliminary study are as follows: Classical modalities can in some cases be replaced by thermography, e.g Raynaud’s disease can be diagnosed, quantified and excluded with thermography. Other cases benefit from thermography in the sense that the diseased site is rapidly identified for further but eventually more swift studies with classical techniques, e.g incompetent communicating veins can tentatively be identified by thermography for later rapid confirmation by flow Doppler investigation. Also, the ideal level of amputation is often very clearly delineated by thermography. Thermography is excellent for diagnosis and follow-up of thrombophlebitis.Further studies must show whether thermography can compete with strain gauge peripheral blood pressure measurement for quantification of arterial obstructive disease. It seems, though, that a normal thermography result can exclude any server degree of this condition.

Thermography is a potentially ideal tool for dynamic studies of peripheral venous and arterial disease (reactive hyperaemia in arterial obstruction, modified Trendelenburgh’s test for identification of the site of incompetent superficial-deep valves).

The use of Thermography in the diagnosis of back dysfunction in the horse.

C.M.Colles

Avonvale Veterinary Group; Banbury, OXON, OX15 6DT, U.K.

In 1995, Colles et all published a preliminary paper on the thermographic appearance of the horse’s back, and some changes observed in horses with back pain. Subsequently, we have used thermography to examine horses with non-specific loss of performance, (thought to be orthopaedic in origin), or gait abnormality (Pusey et all 1997). Thermography has also been used to monitor the response of horses to osteopathic treatment (Pusey et all 1995).

Subsequent to the paper in 1994, we have made thermograms of a number of horses that have satisfied the rider, a veterinary consultant in equine orthopaedics, and an osteopath that they are moving completely normally. Few horses fit into this category, but those that do have shown the normal heat patterns described by Colles et all 1994. We have carried out repeat thermographic examinations over several hours, and over a number of weeks to confirm that the findings are reproducible.

The main problems with reproducibility that are not seen in human patients, relate to the hirsute nature of the patients. A long period of time (up to two hours) is required for the patient to stabilise in a temperature controlled room, or the operator may adjust his findings to a different absolute temperature reading, diagnosing from the changes in pattern. Piebald horses (black and white) and Apolusa's present particular problems as the different colours of hair may be different density or length which in some cases causes reading artefacts. In the spring and autumn as the coats change, the different colours may moult at different times, again giving rise to artefacts (The winter coat is thicker and longer than the summer coat). The winter coat generally exhibits better insulation over the dorsal surface of the patient than the lateral surfaces, and so some allowance for temperature variation is required when interpreting the results. The presentation of patients covered in mud, or wet from rain or sweet is also a problem, but can be overcome with persistent client management.

In the last six years 2,500 horses with a history of abnormal gait, or failure to perform have been examined thermographically, and the riders' reports of symptoms related to the thermographic findings. Consistently these cases have shown that areas of reduced temperature represent muscle that is either showing greater muscle tone, or reduced ability to extend and contract, thought to represent sympathetic dystonia. Thus for example the rider's history complaining that the horse will not turn the neck to the right as readily as to the left, will be associated with a thermogram with reduced temperature on the left side of the neck. Reduced temperature in the gluteal muscles causes a shortening of the anterior phase of the hind limb stride, and reduced temperature in the semimembranosis muscles will be associated with failure to drive forwards, or to jump. Further abnormalities have been recognised and will be described in some detail at the congress "A world of thermography".

References

Colles C.M., Hola G., Pusey A.Thermal imaging as an aid to the diagnosis of back pain in the horse.In: Ammer K, Ring EFJ; editors, The Thermal Image in Medicine and Biology, Uhlen-Verlag, Vienna, 1995, p.164-167

Pusey A., Colles CM., Brooks J.Osteopathic treatment of horses - a retrospective study. British Osteopathic Journal. 1995; 16, 30-32

Pusey A., Holah G., Colles C M., Brooks J.,Detection of spinal dysfunction in horses using thermography.British Osteopathic Journal. 1997; 20, 27-28

The evaluation of venous system pathologies with thermal imaging

Anna Jung (3), B.Wiecek (4), J Zuber (1),
B Kalicki (1), S J Klosovicz (3),W.Perdzynski (2)

1. Paediatric and Nephrology Department of Central Hospital Clinic Military University School of Medicine, Warsaw, Poland
2. Paediatric Surgery Department of Central Hospital Clinic University School of Medicine, Warsaw, Poland
3. Crystal Physics and Technology Section of the Institute of Applied Physics MUT Warsaw, Poland.
4. Thermography Department, Institute of Electronics, Technical University of Lódz, Lódz, Poland

Pathology of the venous system poses a significant danger of thrombus formation and its complications. Statistics on this problem do not include children. However deep vein thrombosis is diagnosed in only 1/1000 of inhabitants of the CSA. Abnormalities of the venous system can occur in the early period of life. In addition to clinical identification there is a need for diagnostic imaging methods such as Doppler ultrasonography, since other methods of imaging venous-flow are invasive .

The advantage of thermography is that it is safe and non-invasive in contrast to venography, which introduces the greater risk for the patient. On the other hand, Doppler ultrasonography may not be useful in the search for changes in small vessels. Plethysmography used in those cases in disadvantaged by a high percentage of false positive results. Thermographic investigation is used in diagnosis e.g. thrombosis of veins), detecting the varicosed veins of the lower limbs, spermatic cord, and the diagnosis of arteriovenosus fistula patency. In diagnosing varicosed veins, a distinctive criterion is the temperature increase of at least 0.8°C in comparison to the symmetrical limb.

The authors illustrate with cases showing different types of venous pathologies in which thermographic investigation was used to ascertain the diagnosis, and, in the monitoring of the condition after hospital discharge. The studies were performed with the Inframetrics Thermal CAM SC1000 camera. The data were processed with the ThermoGRAM 95 Pro software of Inframetrics .

Infra-red Imaging in Diabetic Foot Ulcers

J.R.Harding*, D.F.Wertheim**, R.J.Williams**,
J.M.Melhuish***, D. Banerjee***,K.G.Harding***

*Department of Clinical Radiology, St Woolos Hospital, Glan Hafren NHS Trust, Newport, Gwent, NP9 4SZ (UK)
**School of Electronics, University of Glamorgan, Pontypridd, Mid Glamorgan, CF37 IDL (UK)
***Wound Healing Research Unit, University Department of Surgery, University of Wales College of Medicine, Heath Park, Cardiff, CF4 4X-N (UK)

Diabetic foot ulcers present a difficult problem in clinical management because of increased risk of soft-tissue infection in diabetes plus impaired local blood supply due to diabetic vascular disease. Infection of diabetic foot ulcers has particular risk of involvement of the adjacent bone resulting in the serious complication of osteomyelitis. This needs early aggressive antibiotic therapy to avoid even more serious secondary long-term complications, but unfortunately clinical diagnosis and radiological examination may be unhelpful in early osteomyelitis, when antibiotic therapy is most effective. Furthermore the large number of patients plus the chronic nature of diabetic foot ulceration precludes routine investigation for early osteomyelitis by X-ray or isotope bone scanning in every case, for logistic, radiation protection, and cost reasons. A previous preliminary study has shown significantly increased temperature on infrared imaging, not only around the ulcer, but in the entire foot in patients subsequently confirmed radiologically as having early osteomyelitis. This follow-up study has confirmed osteomyelitis, developing up to 2 months later, in some subjects with abnormal thermograms but normal radiographs on initial presentation, and has shown a return to a normal thermographic appearance in other patients in whom radiological examination has shown resolution of osteomyelitis following intensive antibiotic therapy.

Thermal Imaging - A Vision of the Future

EF Ring, P.Plassmann

School of Computing, University of Glamorgan, Pontypridd. CF 37 1DL. UK

Some sixty years have passed since the military experiments with infra red imaging were conducted during the 1940’s. Medical and industrial applications have been in use for forty years. The first detectors used were single element indium antimonide and cadmium mercury telluride, scanned by optical-mechanical systems. Displays have dramatically changed from the early electrosensitive paper printer (e.g.Mufax used for news telephony) to oscilloscope to separate cathode ray video monitors. Computerisation from the early 1970’s has further transformed the use of this technique. Improved colour enhanced displays, image processing and tools for quantitation have resulted from this major technological advance. Image files for archive, and comparison or subtraction of images is now possible. The methods of printing hardcopy continue to widen in choice and advance in quality and speed.

Today’s thermal imaging technology is fast, reliable and offers precise temperature measurement with relative ease. Focal plane array systems provide higher spatial resolution while the cameras themselves remain small and portable. Since the imaging speed is similar to visible light imaging (video), the opportunities for processing and image handling continue to develop.

What does the future hold for thermal imaging?

There is no doubt that the technological advances have served to make the technique more viable for industrial and civil applications. Military developments have shown the advantage of aerial thermography, which is now a regular part of environmental, agriculture and police surveys. Increased portability has greatly improved the use of this technique for industrial plant monitoring. In medicine, there are advantages in high speed and high resolution, but ease and reliability of operation has been the chief advantage. Computerised image handling, now more common in medical imaging, is compatible with other digital imaging techniques using the DICOM standard. Within the next ten years, we can expect hospitals and medical centres to change from film radiography to digital. Magnetic resonance imaging, ultrasound and computed tomography are already making use of digital processing and archives. Thermal Imaging can therefore be easily incorporated in the global image databases being prepared for hospitals in the near future.

Communication with the all digital imaging techniques between doctors hospitals and clinics is expected to increasingly become digital, replacing the inefficient handling of paper and films through manual transfer, post etc. from one centre to another. There are issues of confidentiality which affect industry and medicine. It is essential that data and images sent electronically are only readable by the intended recipient. Furthermore, the quality of the image, which usually requires compression for electronic transfer, must be recovered intact without loss of detail. These are the issues which form a crucial part of the development phase of digital imaging which are currently under investigation. A particular advantage of image transfer by electronic mail in medicine is the ability to refer a highly specialised image to an expert. It is also also possible to develop databases of normal and abnormal images for electronic comparison, which will have special value in training practitioners, or assisting those working alone in a remote location. A project to develop such a database for medical applications of thermal imaging is under discussion at the present time at The University of Glamorgan. Thermal Imaging in medicine has the advantage that a limited number of specialists are currently using the technique throughout the world, who would benefit from this kind of electronic link. A number of centres from almost every continent have expressed interest in this scheme. The problems which exist from the large number of medical centres using this approach for a common technology e.g. radiography are minimised with thermal imaging at the present time. Thermal Imaging may therefore prove to be a viable method for developing the early stages of electronic image communication in medicine.

Infrared Detection and Discoveries in Astronomy

Mark Brake & Martin Griffiths

University of Glamorgan Department of Astronomy,
Pontypridd, CF37 1DL,Wales

Infrared astronomy is a relatively recent field of development that has complemented both optical imaging and the advancement of post-war astronomical investigations in other regions of the electromagnetic spectrum such as radio, ultraviolet, X-ray and microwave. The development of infrared technology during the last war has led to spin-offs that have ultimately opened hitherto unknown regions of our universe and given remarkable insight into our models of stellar evolution.

Discovered by the famed astronomer William Herschel in 1800, the active application of infrared to astronomy has had to wait until the second half of the 20th century as techniques of rocketry and satellite detection came to fruition. During the 1970's and 1980's, both ground based infrared and satellite detection enabled astronomers to obtain their first glimpse of an invisible universe with remarkable properties. In this discourse we will concentrate on both a historical and scientific perspective, outlining the growth and application of infrared technology within the astronomical field, outlining what subsequent discoveries have indicated about the current state of our universal environment.

Standardisation of infrared thermography for estimation of moisture contents in porous materials

A. Moropoulou, N.P. Avdelidis, I. Tzevelekos

National Technical University of Athens, Department of Chemical Engineering, Section of Materials Science and Engineering, Athens, Greece.

Most damages in porous materials are a direct or indirect consequence of moisture concentration and transfer. In order to diagnose the actual damage, as well as the damage rate in building materials, is necessary to measure the moisture content in such materials. There have been several reports about moisture detection in porous media, using various direct techniques. In the present work, infrared thermography is used to measure the target emissivity and then evaluate the moisture content in reference specimens of porous materials in laboratory, in order to validate the examination of real scale material systems in situ. The achievement of reliable quantitative indirect estimation of moisture content by the use of the infrared thermography technique, is based upon a series of direct moisture measurements in stone specimens, investigated in parallel with the respective thermographs. Finally, a microstructural investigation of the stone specimens tested in the laboratory is taking place, using the mercury porosimetry technique, in order to interpret the moisture phenomena studied. The determination of these microstructural parameters indicates the microstructural requirements that porous materials have to fulfil, in order to infer longevity to the masonry structures.

Thermyal Imaging in Virtual Reality - a Vision of the Future

Colin Pearson

Building Services Research and Information Association,
Bracknell, Berkshire, RG12 7AH, UK

Virtual Reality (VR) presents images of an environment to a user in such a way as to convince the users senses that the environment is real. VR systems are increasingly used to show designers and operators environments that cannot be viewed because:

- the environment is not built
- is too hazardous
- is not accessible for some reason such as distance
- scale is wrong for humans
- visible spectrum is not appropriate for viewing it, or
- its fun!

Image processing capabilities of desktop computers are now approaching a level where they can be used for realistic real time image processing. This will lead to an explosion in imaging applications in the next ten years and infrared will play an important part.

VR systems usually rely on bulky, unwieldy devices for input and output, e.g. computer monitor spectacles and accelerometers suits. These often make it difficult for the operator to fully appreciate the environment. A system is being developed which uses a 3D imaging array to detect the body position and motion of the operator. The operator can then be 'reprocessed' in the computer and superimposed on the VR image. All the actions of the operator will be faithfully reproduced on the screen. A walking motion can be interpreted as walking through the virtual environment. This has immediate application in the architecture and construction industry where virtual walkthroughs are increasingly used for building visualisation before construction has started.

The projection of VR images need not be limited to a computer monitor. There are already VR centres that use back projection to produce large, and in some cases wide angle, images of the environment to give a more realistic experience. In such environments the 3D imaging array described above would not work because of interference from the background, but an infrared imaging system would pick up the operator and not the cool back- projection.

The applications of such systems reach far beyond architectural walkthroughs. Medical imaging now uses Computed Tomography, a form of VR, with imaging systems such as Magnetic Resonance Imaging. With these systems it is possible to conduct a virtual walkthrough of a patient's intestine or artery. Linking these systems to the proposed 3D operator imaging system could create a responsive VR tool that could also be adapted to the control of robots at any appropriate scale with IR cameras or other systems for vision.

VR is a powerful medium with a convergence between business applications and thrilling computer games. The use of VR for marketing and entertainment means that development is explosive and prices are plummeting. This should bring VR solutions in business, industry and medicine at a price we can all afford. Increased use of IR cameras in such systems will benefit every thermographer and IR manufacturers.

Developments in Building Inspection

Boguslaw Wiecek, Slawomir Zwolenik

Thermography Department, Institute of Electronics,
Technical University of Lódz, Lódz, Poland

Thermography is effectively used in evaluation of heat losses in buildings, and evaluation of quality of their isolation. These heat losses are typically characterised by the heat transfer coefficient - k defined as

$$k = \frac{Q}{\Delta T}$$

(1)

where: Q and ΔT denote heat flux and temperature difference between inner and outer side of the wall.

This approximation assumes a one dimensional heat conduction in the wall, what is more or less complied in practice. Because of difficulty of estimation of the hat flux crossed the wall, we assume the flux in the air equal with one in the wall. Obviously, the flux in the air depends on varying environmental parameters what make the whole measurement quite complex and difficult.

The main aim of this work is to evaluate both eat transfer coefficient - k and its dependence from the chosen environmental parameters. The outer temperature is measured by the thermographic camera, and compared with chosen contact temperature measurement for emissivity estimation. Heat losses in buildings are very sensitive to the environmental parameters, such as wind, sun illumination, ambient temperature, humidity, wall emissivity, etc. Some of this parameters was taken into account in this work.

Model of heat transfer across the wall

1-D model of heat transfer across the wall is presented in Fig. 1. The total heat transferred through is proportional to the differences between the temperature of the wall outside and inside of the building, as shows:

$$Q_T = k / T_{wi} - T_{wo}) \tag{2}$$

Where $k\left[W/m^2K\right]$ denotes heat transfer coefficient and $Q_T\left[W/m^2\right]$ is the heat flux through the surface.

The total heat transferred through the wall is divided into two parts - the radiation and convection fluxes:

$$Q_T = Q_r + Q_c \tag{3}$$

The radiation heat flux is indirectly measured by the thermal camera. It is balanced with the heat emitted to the environment and the heat absorbed by the wall:

$$Q_r = Q_{re} - Q_{ra} \tag{4}$$

where Q_{re} - the heat emitted to the environment, Q_{ra}- the heat absorbed. On the base of the Stefan- Boltzmann's law this equation may be rewrite as:

$$Q_r = Q_{re} - Q_{ra} = \varepsilon\sigma(T_{wo}^4 - T_a^4) \tag{5}$$

where σ - Stefan-Boltzmann's constant; ε - wall emissivity.

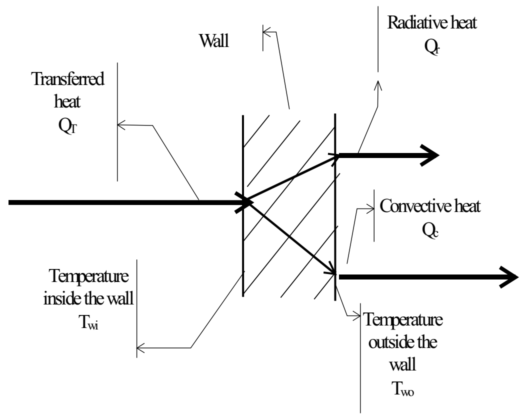


Fig .1. * 1D model of heat transfer across the wall

The convection heat flux is dependent on air movement along the building's walls. In most cases, when the building is higher than $l_{cr} \approx 0.6\,(T_{wo} - T_a)^{\frac{1}{3}}$, the movement is turbulent and, the convective heat losses equal to

$$Q_k = a(T_{wo} - T_a) \tag{6}$$

where a_C - convection heat transfer coefficient.

For turbulent movement *a* is described by equation:

$$a = b\,(T_{wo} - T_a)^{\frac{1}{3}} \tag{7}$$

The *b* coefficient, dependent on the temperature and many other parameters of the environment (e.g. humidity). For T_a » 0°C, one can take *b* » *1.72.*

The influence of wind during the measurements is important if its velocity is larger than $v_W{}^3 1$m/s. The wind makes the convection heat transfer much more effective. To take this fact under consideration, we refer to many articles in which there are many empirical equations.

For the air temperatures between -5°C to 5°C, the a coefficient may be calculated as:

$$a = 6.22 \frac{\nu^{0.8}}{l^{0.2}} \tag{8}$$

where v and l denote the speed of the wind and the length of the wall; respectively

For the wind speed less than 1 m/s the a coefficient should be calculated from equation (7). The emissivity may be taken from tables for proper type of cover of the building. To ensure the more precise calculus one may measure the outer wall temperature in chosen places either by the thermal camera and contact thermometer. The emissivity may be calculated (on the base of Stefan-Boltzmann law) as:

$$\varepsilon = \frac{Q_e}{\sigma T_{wo}^4} \tag{9}$$

where T_{wo} is the temperature measured with the thermometer, Q_e is the heat emitted by the wall by radiation, calculated as:

$$Q_e = Q_c - Q_r = \sigma T_c^4 - (1-\varepsilon)\sigma T_a^4 \tag{10}$$

where: Q_c is the heat measured by the camera, Q_r is the heat reflected by the wall.

Finally, the emissivity takes a form:

$$\varepsilon = \frac{\mathrm{T}_c^4 - \mathrm{T}_a^4}{\mathrm{T}_{wo}^4 - \mathrm{T}_a^4} \tag{11}$$

where T_c is the temperature given by the thermal camera.

In some types of the thermal cameras (e.g. INFRAMETRICS 760) this calculations are made internally in the camera and the data given by the camera are already corrected using the eq. (11).

The heat transfer coefficient k (for both strong wind and radiation) is expressed as:

$$k = \frac{\varepsilon\sigma(T_{wo}^4 - T_a^4) + a(T_{wo} - T_a)}{(T_{wi} - T_{wo})} \tag{12}$$

For turbulent convection with low wind speed k takes a form:

$$k = \frac{\varepsilon\sigma(T_{wo}^4 - T_a^4) + b(T_{wo} - T_a)^{\frac{4}{3}}}{(T_{wi} - T_{wo})} \tag{13}$$

Perspective distortion and geometrical correction

Some photogrammetry algorithms are implemen-ted by software to help image processing for buildings. A transformation of a surface in a central projection is one of the most useful. It allows collecting fragmented objects by taking into account the angle of viewing. Geometrically transformed images are easy to stick together and measure the real parameters of an object, e.g. an area, distance, etc.

Various software tools used well-known method for image gluing based on transformation, which uses the picture scaling, rotation and shifting - eq. (1). Such transform needs only 3 reference points defined on the plane.

$$\begin{bmatrix} X \\ Y \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \cdot \begin{bmatrix} x' \\ y' \end{bmatrix} + \begin{bmatrix} d_1 \\ d_2 \end{bmatrix} \tag{14}$$

where: a_{ij} - scaling and rotation coefficients, di - shifting coefficients, X,Y - co-ordinates after transformation, x', y' - co-ordinates of an original pixel.

This method is only valid if the original and transformed planes are in parallel, and therefore it uses only 3 reference points. The more useful method can transform the surfaces with different orientation in the 3D space as shown in Fig.2. This method needs 4 reference points, as it has 8 transform parameters as shown in eq. (15).

$$\begin{cases} X_i = \dfrac{u_1 \cdot x_i' + u_2 \cdot y_i' + u_3}{u_7 \cdot x_i' + u_8 \cdot y_i' + 1} \\ Y_i = \dfrac{u_4 \cdot x_i' + u_5 \cdot y_i' + u_6}{u_7 \cdot x_i' + u_8 \cdot y_i' + 1} \end{cases} \tag{15}$$

Where:
u_i – transform coefficients; X,Y – co-ordinates after transformation (real co-ordinates),
x', y' - co-ordinates of an original pixel.

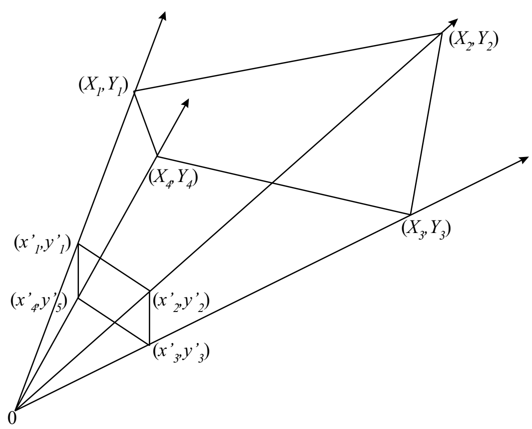


Fig.2. Plane-to-plane transform in central projection

Even better results can be obtained using more reference points and applying the least-square approximation method. The results of 4-point projection are presented in Fig.3. The original upper image is a projection of a front building side on the plane not perpendicular to the camera optical axis. The windows shown above are not of the rectangular shape. After transformation of the front building plane on the plane normal to the camera axis the windows become rectangular, and the entire scene keeps the real aspect ratio, significantly reducing the perspective distortions. After such correction it is quite easy to stick together a set of images and present the whole scene in the orthogonal projection.

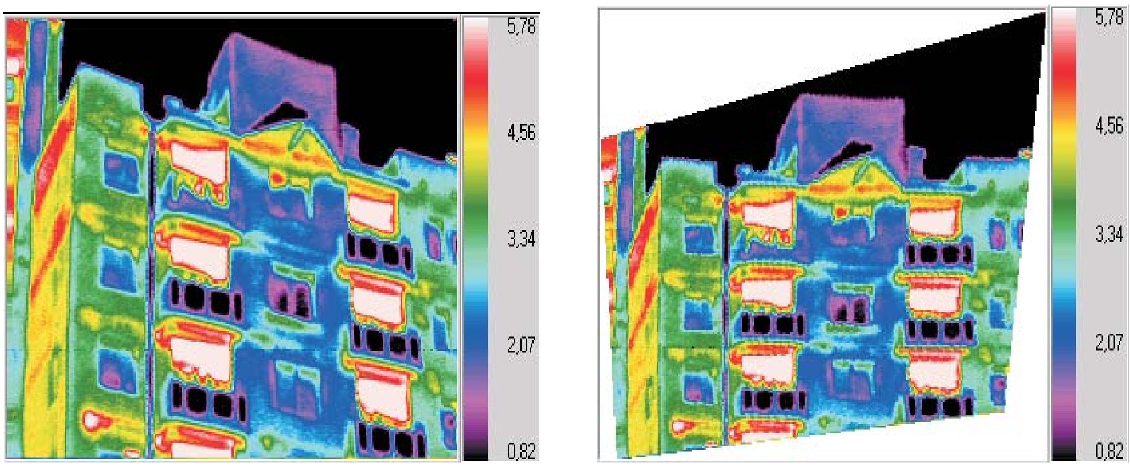


Fig. 3. Result of 2D plane-to-plane transformation

Application of Lock-in thermography to the measurement of stress and to the determination of damages in materials and structures

Pierre Bremond &Pierre Potet,

CEDIP Infrared Systems-France

This paper aims to illustrate the advantages of infrared thermography as a non-destructive, real time and non-contact technique. Due to the relation between temperature and mechanical behaviour, it is permitted to observe mechanical phenomena like:

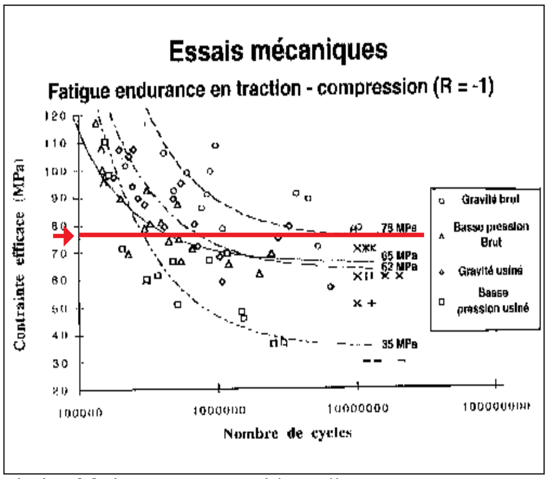
- Thermo-elastic effect to measure stresses;
- Process of damage and failure;
- Detection of intrinsic dissipation and evaluation of fatigue strength on sample.

In addition, thermography readily describes the stress or damage location and the evolution of structural failure. This paper emphases the use of **Lock -in thermography** to quantitatively evaluate the evolution of temperature generated by a specimen under fatigue test applied for a few minutes or less.

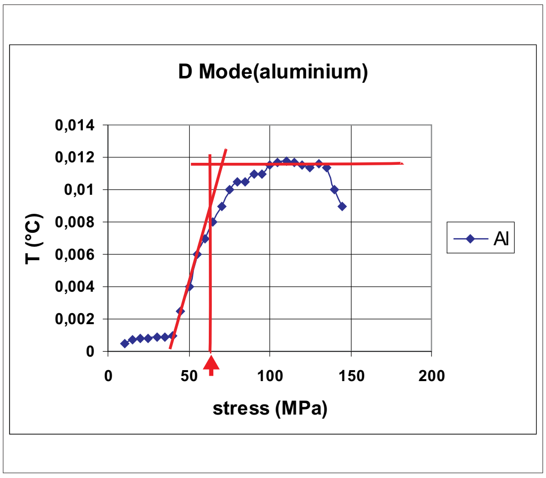
Experimental results by image

The Method to determine fatigue limit consists of detecting the emergence of intrinsic dissipation due to the thermo-mechanical coupling as specimen is excited by a dynamic load.

Comparison between lockin thermography and Wolher curve to evaluate of fatigue limit on aluminium specimen

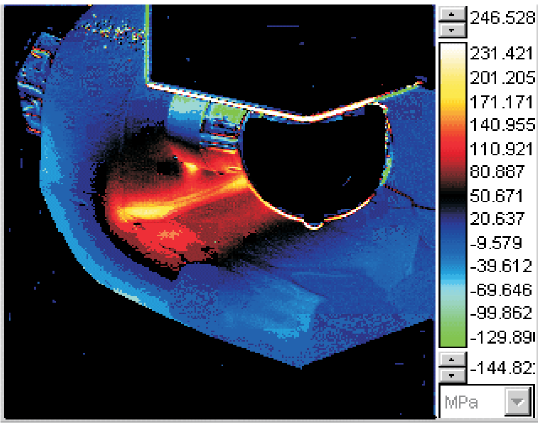


Limit of fatigue measure with Wolher curve

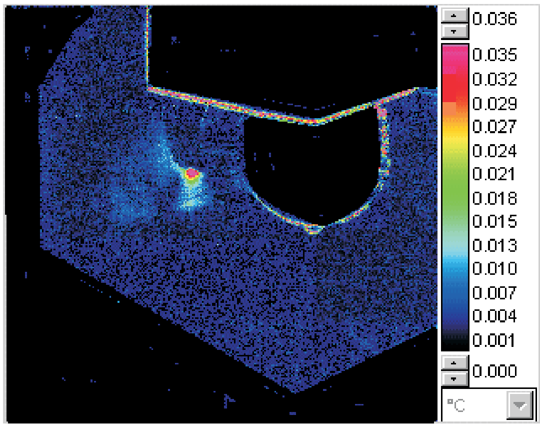


Measure of fatigue limit by Lockin thermography

Localisation of dissipated energy on automotive component



Stress map of automotive component during fatigue test



Map of dissipated energy during the same test

Conclusions

The energy dissipated by material under fatigue loading is a manifestation of damage. Due to ther-mo-mechanical coupling, infrared thermography provides a non-destructive, real time test with non-contact to observe the process of material degradation and to detect the occurrence of intrinsic dissipation.

The Lockin method is an industrial technique to detect the manifestation of physical process of fatigue and to evaluate rapidly, in few hours, the fatigue limit of automotive components.

The proposed technique has been applied successfully to aluminium specimen to determine the fatigue limit and on automotive component to locate the damaging zone.

Thermographic Evidence for the Effectiveness of Acupuncture in Equine Neuromuscular Disease

Dietrich G von Schweinitz

Equine Veterinary Clinic, Greyfriars Farm, Puttenham, Guildford, GU3 1AQ; U.K.

Thermographic scanning provides an objective method of detecting sympathetic-autonomic status of vasomotor tone in the horse by imaging thermal gradients. Through observing persistent abnormal sympathetic nervous tone causing hypothermic or hyperthermic regions the clinician is able to diagnose neuromuscular disease – a common but often unrecognised cause of chronic pain and performance problems in horses.

Thermography studies at the Equine Veterinary Clinic in Guildford demonstrate that acupuncture often corrects abnormal vasomotor tone within a half to three and a half hours of needling, usually resolving vasoconstriction affecting large thermatomes. Thermal imaging can provide objective, measurable evidence of the ability of acupuncture to restore normal homeostasis in the autonomic regulation of vasomotor tone and suggests that it may simultaneously relieve associated sensorimotor disease.

References

Acupuncture in Medicine, 1998, Vol. XVI/ 1:. 14-17.

Figure 1:
Thermograms of the dorsal spine showing caudal-thoracic heat- flare and hypothermia affecting the lumbar-sacral midline and especially the gluteals.

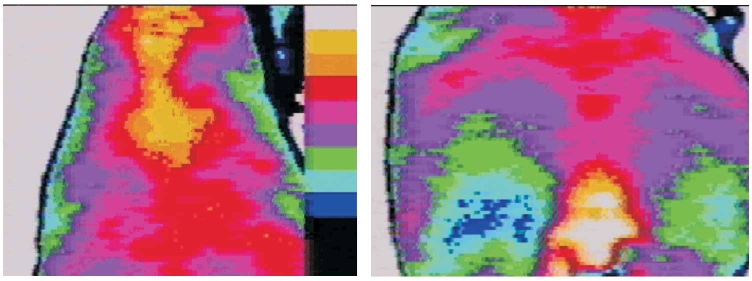


Figure 2.
Thermogram of the horse in Figure 1, one hour after acupuncture, showing marked correction of vasomotor tone .⇒

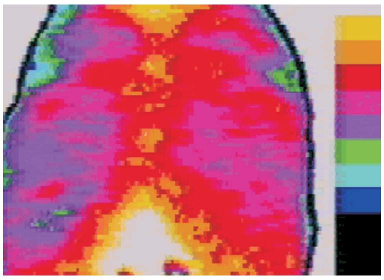


Figure3.
Horse with severe hypothermia from approximately T10 caudally: reflex sympathetic dystrophy ⇓.

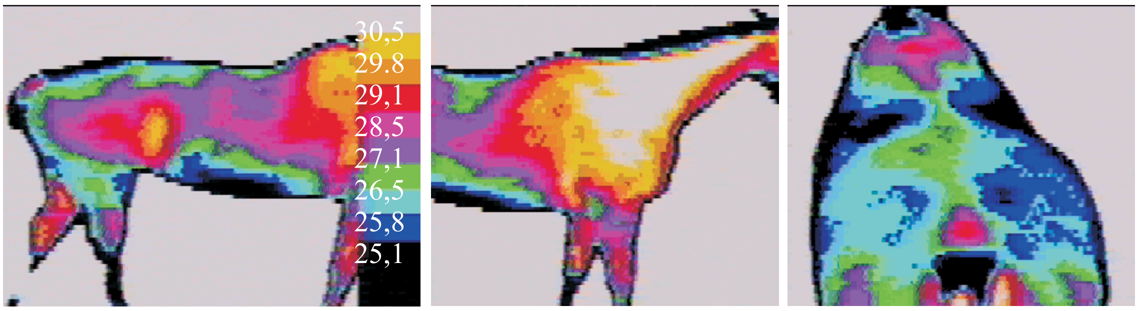
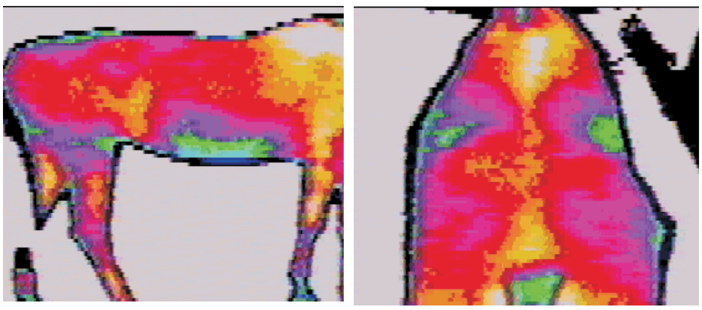


Figure 4.
Horse from Figure 3,three and a half hours after acupuncture. ⇒



Speakers

Ammer Kurt	Ludwig Boltzman Institute for Physical Diagnostics, Hanuschkrankenhaus, Heinrich Collinstr 30, A-1140, Vienna, Austria.; Phone: 0043 1 9149701; Fax: 0043 1 914 92 64; e-mail: KAmmer1950@aol.com
Avdelidis Nicolas P	National Technical University of Athens, Department of Chemical Engineering, Section of Materials Science and Engineering, 9, Iroon Polytechniou St., 15780 Zografou, Athens, Greece; Phone 01 7723276; Fax: 01 7723184; e-mail: avdel@central.ntua.gr
Benkö Imre	Technical University of Budapest, Department of Energy H-1521 Budapest, Muegyetem rkp. 7/D.208. Hungary, Phone: 00361-463-3273; Fax: 00:361-463-1110; e-mail: benko@eta.enrg.bme.hu
Brake Mark	University of Glamorgan Astronomy Field Leader; Pontypridd, CF37 1DL, c/o Martin Grifitths, 241 East Road, Tylorstown, Ferndale, Mid Glammorgan, CF43 3DA; Phone: 01443 482453; e-mail: mbrake@glam.ac.uk
Colles C M	Avonvale Veterinary Group;Ratley Lodge, Ratley, Banbury, OXON, OX15 6DT Phone: 01294 670501; Fax: 1294 670778; e-mail: Chris.Colles@btinternet.com
Delpak R	University of Glamorgan division of the built environment. Pontypridd, CF37 1DL. Phone: 01443 482730; e-mail: rdelpak@glam.ac.uk
Dixon John	Land Infrared; Dronfield, Sheffield, S18 6DJ; Phone: 01246 417 691; Fax: 01246 410 585; e-mail:John.Dixon@landinst.com
Dudek Steven	Newcastle University, Department of Architecture, Newcastle upon Tyne, NE1 7RU; Phone 0191 222 6004: Fax: 0191 222 6115; e-mail: S.J.M.Dudek@ncl.ac.uk
Furley Dave	Flir Systems International; 2 Kings Hill, West Malling, Kent ME19 4AQ Phone: 01732 221291; Fax: 01732 220014M e-mail: david.furley@flir.uk.com
Harding Richard	Department of Clinical Radiology, Royal Gwent Hospital; Glen Hafren NHS Trust, Newport, Gwent, NP9 4SZ Phone: 01633 238221; Fax: 01633 234324; e-mail: richard.harding@gwent.wales.nhs.uk
Heinrich Hermann	Bauphysik-Technische Gebaudeausrüstung-Baulicher Brandschutz Postfach 3049, D 67653 Kaiserslautern, GERMANY; Phone: 0049 631 205 3993;Fax. 0049 631 205 4131; e-mail: hheinrich@rhrk.uni-kl.de
Howell Kevin	Royal Free and University College Hospital, London, Royal Free Campus, Rowland Hill Street, London. NW3 2PF; Phone: 0171 794 0500 x: 4874; Fax.:0171 435 0143; e-mail: kjhowell@rfhsm.ac.uk, kevj@howell30.freeserve.co.uk
Jones Bryan	University of Glamorgan school of computing; Pontypridd, CF37 1DL. Phone:01444 482730; Fax:01443 482715; e-mail: bfjones@glam.ac.uk
Jung A	Crystals Physics and Technology Section of the Institute of Applied Physics MUT Warsaw, Poland
Machin Graham	National Physical Laboratory Centre for Basic Thermal and Length Metrology, Building 95, Queens Road, Teddington, Middlesex TW11 OLW ; Phone: 020 8943 6742; Fax: 020 8943 6755; e-mail:graham.machin@npl.co.uk
Nielsen Stig Pors	Department of Clinical Physiology, Hillrod Hospital, Helsevej2 DK3400 Hillerod Denmark; Phone: 0045 48 29 45 50; Fax: 0045 48 29 45 43; e-mail: spni@fa.dk
Nowicki Andrej	IRIS Infrared Inspection Services,95 Sandy Lane, Melton Mowbray, LEICS, LE13 OAN; Phone: 01664 563769; Fax: 01664 481568; e-mail: anowicki@iris-melton.freeserve.co.uk

Pearson Colin	UKTA; The Building Services Research and Information Association, Old Bracknell Lane West, Bracknell, Berkshire, RG12 7AH; Phone: +44 1344 426511; Fax:+44 1344 487575; e-mail: ukta@bsria.co.uk
Plassman Peter	University of Glamorgan school of computing;School of Computing, Pontypridd, Mid Glamorgan CF37 1DL Phone:01443 483486; Fax: 01443 / 482715; e-mail: pplassma@glam.ac.ukl
Potet Pierre	CEDIP; c/o Mr G Bailey, Reeds Cottage, Appleshore, Andover, HANTS, SP11 9AA; Phone:01264 772680; e-mail: cedip@wanadoo.fr
Ring Francis	Royal National Hospital for Rheumatic Diseases; Upper Borough Walls, Bath, BA1 1RL Phone: 01225 47 34 13; Fax: 01225 47 34 15; e-mail:francis.ring@cwcom.net
Sakagami Takahide	Department of Mechanical Engineering and Systems, Graduate School of Engineering, Osaka University, 2-1, Yamadaoka, Suita, Osaka 565-0871 Japan; Phone: 81-6-6879-7305; Fax: 81-6-6879-7305; e-mail: sakagami@mech.eng.osaka-u.ac.jp
Thomas Roderick	Swansea Institute, Faculty of Applied Design and Engineering; Mount Pleasant, Swansea, SA1 6ED Phone01792 481117; Fax: 01792 481158; e-mail: r.thomas@sihe.ac.uk /
von Schweinitz Dietrich G	Equine Veterinary Clinic, Greyfriars Farm, Puttenham, Guildford, GU3 1AQ Phone:01483-811006; Fax: 01483-811300; e-mail: dgvs@evc1.freeserve.co.uk
Wawrzynek A.	University of Glamorgan division of the built environment; Pontypridd, CF37 1DL; Phone: 01443 482730; e-mail: rdelpak@glam.ac.uk
Hu Rita Ching Wen	University of Glamorgan division of the built environment, Pontypridd, CF37 1DL. Phone: 01444 482730; email: cwhu@glam.ac.uk
White Tim	Sanders IR Imaging Systems,; 2 Forbes Rd, Lexington MA 02421; Phone:001 781 863-3119; Fax:001 781 863-3524; e-mail: tim.white@lmco.com
Wiecek Boguslaw	Institute of ElectronicsPolytechnic of Lodz18-22 Stefanowskiego str, 90-924 Lodz, POLAND; email:wiecek@ck-sg.p.lodz.p

8th European Congress of Thermology 3rd National Congress of the Italian Association of Thermology

Desenzano del Garda (Brescia, Italy) September 8-9, 2000, Palazzo del Turismo

President

Giorgio Dalla Volta (Brescia, Italy)

Scientfic Secretariat

Giorgio Dalla Vo1ta (Brescia, Italy)

Cesare Bonezzi (Pavia, Italy)

Organizing Secretariat

Essepi Studio

Via Costalunga 14, 25123 Brescia

Phone: (39)030382336 , Fax. (39)030382653

E-mail: essepist@tin.it

Web site: www.essepistudio.it

The AIT (Italian Association of Thermology) is honoured to promote the 8th European Congress and the 3rd Italian Congress that will be held in Desenzano, on the Garda Lake in September 2000, in the effort to harmoniously combine the scientific enrichment with the beauty of the Italian nature and culture.

This will be the best wav to step into the new millennium.

We have a strong, expectation to contribute to enabling the thermography users to take up the challenges of the future.

The congress wll continue the tradition -already established by the E.A.T - European Association of Thermology - and add new dimensions: as neurologists and neuroscientists we are part of an explosive growth of knowledge.

We have developed a new programme, including a “Teaching Course”, in order to allow new peoople to approach this interesting diagnostic method.

Desenzano welcomes you with peculiar charm of a traditional Italian village and with its very lively atmosphere.

Giorgio Dalla Volta, President of the Congress

SCIENTIFIC INFORMATION
Abstract submission

Abstracts related to the topics of the congress will be selected for oral or poster presentation.

Accepted abstracts will he published in the journal “Thermology International”, the official organ of the International Societv of Thermology.

Abstracts must be sent, together with the registration form and the payment of the registration fee, to the Organizing Secretariat Essepi Studio. If the abstract is not accepted and the author(s) do not participate in the congress, the registration fee will be refunded.

DEADLINE FOR THE
RECEIPT OF ABSTRACTS: **April 1, 2000**

The official letter of acceptance will be sent to the submitting authors by April 20, 2000.

Instructions for the preparation of abstracts

1) Abstracts with title, author(s), text must be printed within the frame of the abstract form (page 67) .

2) Underline the name of the presenting author. Type the title in capital letters.

3) Abstracts must be submitted also on a disk in PC format, the text typed with a common text programme (preferable MS Word)

GENERAL INFORMATION

How to reach the congress site

By aeroplane: the closest airports are Verona (km 50), Milano Linate (km 120), Milano Malpensa (km 190.)

By train: railwav line Milan-Venice (which includes also Verona).Choose the trains which stop in Desenzano,

By car: Motorway Milan-Venice (A4, wich includes also Verona and Bergamo.)Motorway exit: Desenzano.

Correspondence

All correspondence related to the congress should be sent to the Organizing Secretariat:

Essepi Studio

Via Costalunga, 14 - 25123 Brescia (Italy)

Phone: (39)030382336 - Fax: (39)030382653

E-mail: essepist@tin.it

Date and location

The congress will take place in Desenzano at the Palazzo del Turismo (Palace of Tourism), Porto Vecchio, Desenzano (Brescia), Italy, on September 3-9, 2000.

The Teaching Course will take place at the Congress Center of Thie West Garda Hotel, Via Prais,Padenghe (Brescia), Italy, on September 7, 2000.

Padenghe is located just outside Desenzano, at about 6 kms.

Registrations

For registration to the Congress and the Teaching Course send the enclosed registration form (page 65)duly filled in, accompanied by the payment of the registration fee, to the Organizing Secretariat Essepi Studio.

Forms sent without the payment of the fees will not be considered.

After the payment, Essepi Studio will send to the registered participants an invoice, that can be considered as a confirmation of the registration.

Fees

Teaching Course:
Itl. 700,000 + VAT 20% = Itl.. 840,000

This registration will include:
Admittance to the scientific sessions, certificate of attendance, congress folder, coffee breaks, lunches

Congress:
Before April 20, 2000
Itl. 550.000 + VAT 20$%= Itl. 660,000

After April 20, 2000
Itl. 700,000 + VAT 20% = Itl. 840,000

The registration will include:
Admittance to the scientific sessions, certificate of attendance, congress folder, a copy of "Thermology international"with the abstracts of the congress, coffee breaks, lunches, welcome cocktail on September 7, social dinner on September 8

Secretariat desk

The secretariat desk will operate in the congress area according to the following timetable:

Teaching Course Secretariat (at West Garda Hotel):Thursdav, September 7,h.9.00 - 18.00

Congress Secretariat (at Palazzo del Turismo):
Friday, September 8: h. 8.00 - 18.30
Saturday, September 9: h. 8.00 - 18.30

Working language

The working language of the congress and of the Teaching Course is English. No simultaneous translation will be provided.

Coffee breaks and lunches

Coffee breaks and lunches for the Congress and the Teaching Course will be served in the congress area and will be offered to all registered participants. Tickets will be included in the congress folder.

Social Program

Thursday, September 7;. 19.00
Welcome Cocktail at West Garda Hotel

Friday, September 8 , 20.30
Social dinner

Transfers

A bus transfer service will be organized from the hotels booked through the Organisation to the congress site and vice-versa during the congress.

Hotel accommodation

Participants who wish to reserve their hotel accommodation during the congress are kindly requested to send the attached hotel accommodaton form (page 66), duly filled in, to Essepi Studio.

The hoterl accommodation form must be accompanied by the payment of the hotel deposit,corresponding to the price of one overnight stay in the chosen hotel (see rates below), plus the reservation fee (It1. 30,000 per room).

The deposit must be net of all bank charges and will be deducted from the final bill by the hotel management.

Regular invoice of the complete payment will be issued bv the hotel management when che - cking out.

Essepi Studio will provide to send the invoice for the reservation fee

DEADLINE FOR HOTEL RESERVATION: June 1, 2000

Requests received after the deadline will be taken into consideration, but accommodation cannot be guaranteed.

No reservation requests will be accepted if not accompanied bv the deposit and the reservation fee.

Hotel Prices (B&B)

West Garda Hotel****

Single room	——
Double room	Itl. 250,000
Double room single use	Itl. 180,000

Hotel Residence Oliveto****

Single room	Itl. 150,000
Double room	Itl. 250,000
Double room single use	Itl. 180,000

Hotel confirmation

Essepi Studio will send a confirmation voucher onlv afterr receiving the payment of the hotel deposit and reservation fee.:The voucher will specify the name and the address of the hotel. lf no rooms are available in the chosen hotel, Essepi Studio will suggest other suitable accommodations When single rooms are no inore available, double rooms single use will be assigned.

Hotel cancellations

Cancellations of the hotel accommodation must be sent in writing to Essepi Studio. Cancellations received before June 15 will be entitled to a total refund (reservation fee excluded).No refund will be made for cancellations received after June 15. Refunds will be made after the congress.

Methods of payment

Pavments of the registration fees and of the hotel deposit must be net of all bank charges and can be bv:

- Bank chequee in favour of Essepi Studio srl. The cheque must be sent together with the registration./hotel accommodation forms.
- Bank to bank transfer in favour of Essepi Studio,) srl, acccount N. 8330 of Bank: Banco di Brescia, Agency 27, Via Ambaraga, Brescia (Italy) - ABI code .3500 - CAB code 11290

A copy of the transfer receipt must be sent together with the registration / hotel accommodation forms. The transfer receipt and registration form can be sent bv fax.

SCIENTIFIC PR0GRAMME

Thursday, September 7
West Garda Hotel (Padenghe, Brescia)

09.00- 18.00 Teaching Course

19.00 Welcome cocktail

Friday, September 8
Palazzo del Turismo (Desenzano, Brescia)

09.00-9.15 Opening of the congress
G. DALLA VOLTA (Brescia, Italy)

09.30-10.00 Main Lecture
Historical overview on thermography
E.F.J. RING (Bath, U.K.)

10.00-18.30 Scientific sessions

20.30 Social dinner

Saturday, September 9
Palazzo del Turismo (Desenzano, Brescia)

09.00-18.30 Scientific sessions and workshop on Headache and trigemino vascular system (Chairmen: G. DALLA VOLTA (Brescia, Italy); S.GOVINDAN (Pittsburgh, USA)

POSTER DISPLAY
September 8 – September 9

SCIENTIFIC SESSIONS

I. SESSION: Pain
Chairmen. EFJ. Ring (Bath, U.K.),
C. Bonezzi (Pavia, Italy),
Young-Soo Kim (Seoul, Korea)

II SESSION: Osteoarticular disorders
Chairman: K. Ammer (Vienna, Austria)

III. SESSION: Physiology of thermography: induced modification of microcirculation
Chairman: C. Bonezzi (Paviat, ltaly)

IV SESSION: ATM (joint syndrome)
Chairman: S. Ciatti (Prato, Italv)

V. SESSION: Thermographical detection of modification induced by pharmacological treatment
Chairmen:
G. Orlandini (Tortonia - Alessandria, Italy)

VI SESSION: Cortical mapping of the autonomic nervous system by thermography
*Chairman:*G. Dalla Volta (Brescia, Italy)

VII SESSION: Sleep and thermography
Chairman: S. Govindan (Pittsburgh, USA)

VIII SESSION: Forensic medicine
Chairmen: D. Camaioni (Rome, Italy),
G.Pari(Rimini. Italy)

IX SESSION: Vascular disorders
Chairman: A. Di Carlo (Rome, Italy)

X SESSION: Dermatology
Chairman: A. Di Carlo (Rome, Italy)

POSTERS

Poster display: September 8-9, 2000 - for all the duration of the congress

Poster discussion:
September 8, in the aftenoon

TEACHING COURSE

The Teaching Course will be held on September 17 a the Congress Center of the West Garda Hotel, Via Prais.,32 - 25080 Padenghe (Brescia), Italv about 6 kms from Desenzano).

Thee Course will deal with physiology of thermology, the central autonomic nervous svstem detection by thermography, neurological applicationi, the validity of thermography in the control of pain therapy, vascular application. peripheral neuropathy, ATM joint syndrome.

The course will be limited to a maximum number of 15 people.

News in Thermology

Announcement for the Guenter Bergmann Award 2000

The Guenter Bergmann Award is announced for the second time according to the conditions of the award.

The award-winner will be named during the Annual Conference of the German Society on August 5, 2000 in Celle, Germany.

Registration as an applicant must be completed - latest March 1st, 2000 via thermo2000@iname.com.

As every paper will be orally presented during the congress, abstracts must be submitted before March 1st. Every applicant for this award is required to send 3 copies of his scientific paper by March 31st, 2000 to:

The President of the German Society of Thermology

Dr Joachim-Michael Engel M.D.

marked PERSONAL

Rheumaklinik Bad Liebenwerda

Dresdener Straße 9

D-04924 Bad Liebenwerda. Germany

13th Thermological Symposium of the Austrian Society of Thermology

The date for 13th Thermological Symposium, organised by the Ludwig Boltzmann Research Institute for Physical Diagnostics and the Austrian Society of Thermology, will be 13h May 2000. The venue is traditionally the SAS Radison Hotel in Vienna. The main theme of this meeting is "New developments in thermo- logy " and contributions from the fields of medicine and biological engineering are anticipated. An overview of new equipment for the detection of infrared radiation will be given. Speakers from the organizing Boltzmann Institute will report the influence of typewriting on the finger temperature. A study of the effect of 2 cl whisky on the skin temperature of the face, the hands and the knees will be presented. However, other free papers outside of the main theme are welcomed.

Prof. Francis Ring from Bath will be the invited speaker of this meeting. He will lecture on "Thermal imaging as medico-legal evidence ".

For further information, please contact
Dr.Kurt Ammer,
Ludwig Boltzmann Research Institute for Physical Diagnostics, Heinrich Collinstr. 30, A-1140 Vienna, Austria,
Tel: +43 1 914 97 01 fax: +43 1 914 92 64
e-mail: KAmmer1950@aol.com.

Thermal imaging in Brazil

There is a growing interest in thermal imaging in Brazil. This was shown during the 2nd International Course on Pain and Thermo graphy, which was organized by Dr. A.Camargo in Sao Paolo as a satelite symposium of the Annual Brazilian Conference of Physical Medi- cine and Rehabilitation on October 9-11, 1999. This three day course was a mixture of theoretical lectures in the first two days and the demonstration of the the medical use of thermal imaging in the assessment of patients on the last day.

Prof.Francis Ring described the development of technology for temperature measurement, explained the standardisation of thermal imaging techniques and showed the relationship between skin temperature and blood flow, including cold stress testing. Quantitation of thermal images and quantitation methods, literature on thermal imaging and a report of international organisations & congresses was reported by Francis Ring. He presented also an overview on IR imaging and for diagnosis of inflammation and for treatment monitoring of inflammatory rheumatic disorders.

”Thermoregulation of the human body”, “diagnostic applications of the cold stress test to the hand”, “IR imaging and diagnosis of fibromyalgia”, “R.S.D. and thermography”, “repetitive strain injury” and”thermal images and investigation of lumbar spine problems” were the titles of Dr. Kurt Ammer´s lectures at this training course. D.Camargo gave a talk on pain and thermal imaging and a Brazilian physicist reported basic physics of heat radiation measurement and spoke about the development of a Brazilian prototype of an infrared imager.

At the opening day of the Brazilian Rehabilitation Congress a whole session, chaired by Dr.A.Camargo, was dedicated to thermal imaging. F.Ring was invited to a lecture on thermal imaging in rheumatology and K. Ammer presented an overview on the use of thermal imaging in rehabilitation medicine.

The physiatrist Dr.Camargo is actively promoting thermal imaging in Brazil and has raised a high level high interest in his collegues for this technique. If he continues to develop this successful work, a new Brazilian Society of Thermology may result.

Thermology Congress in Djerba

The Polish Society of Medical Thermology will organize their 3rd Congress combined with a Certification Course“Practical application of thermal imaging in medical diagnostics”in Djerba, Tunisia on September 21-28, 2000.

Congress fee: Before 15.03.2000-420 US$

Dro, 15.03 50 30.06.2000- 450 US$ due to the rise of charter flight prices

Congress fee includes

- The cost of the flight
  expected departure from Warsaw-Okecie airport on 21.09.2000, expected arrival to Warsaw-Okecie airport on 28.09.2000)
- The accomodation in the hotel nearby the sandy beach in double rooms with barhroom
- Buffet style breakfast and dinners
- The participation in sessions and congress proceedings
- Coffee breaks

An extension of the stay by one week is posible for the additional charge of 210 US$ (must be paid together with the basic fee)

The precise date of the departure (with a valid passport) will be announced in due course.

Payment should be done in Polish Zloty.

Scientific programme

Session 1 Thermal imaging in venous diagnosis

Session 2 Thermal imaging and other imaging methods in medicine

Session 3 Thermal imaging in recognition of diseases of the breathing system

Session 4 Application of thermal imaging in different braches of medicine

Session 5 Dynamic thermal imaging

Contributions should be sent to the Organizing Committee before 01.02.2000

Original papers will be published in the supplement of “Lekarz Wojskowy”(Military Physician) according to the current regulations. Papers should be sent in duplicate and on floppy disk before 14.04.2000. Authors are encouraged to send an additional abstract in English (in duplicate and on floppy disc) which will be published in “Thermology international”.

Certification Course
“Practical application of thermal imaging in medical diagnostics”

The first day 20.15 -21.30

The basics of thermophysiology - Assistant Professor J.Laszczynska

The basics of thermography in medical imaging- Assistant Professor S.Klosowicz

The second day 20.15-21.30

Processes of heat exchange in areas of the body with respect to thermographic examination-Assistant Professor J.Laszczynska

Theoretical basics of an application of theraml imaging in medical diagnostics. Image averaging-Assistant Professor B.Wiecek

The third day 20.15-21.30

Standardisation of thermographic measurements - MD J.Zuber

Thermographic workshops

The fourth day 20.15-21.30

Possibilities of the simultaneous application of thermography and video in medical imaging - MSc. S.Zwolenik

Thermographic workshops

The fifth day 20.15- 21.30

Archiving the results of the thermographic examination- MSc. S.Zwolenik

Thermographic workshops

A certificate from the Polish Society of Medical Thermology wil confirm the participation in this course.

For further information contact the organizing Committe at

Pediatric and Nephrology Clinic,
Central Clinical Hospital,
Military University, School of Medicine
Szaserow 128 str
00-909 Warsaw-60, PL

Tel/fax +48 22 6817236

Protokoll der Mitgliederversammlung der Deutschen Gesellschaft für Thermologie e.V. am 12.November 1999 im Hotel Sol Inn in Celle

D.Rusch, J.-M. Engel °

Kerckhoff Klinik Rheumatologie, Bad Nauheim

°Rheumaklinik Bad Liebenwerda,

Der Präsident eröffnet pünktlich um 19.00 Uhr die Versammlung. Er stellt fest, dass die Einladung zur Mitgliederversammlung ord nungsgemäß und fristgerecht versandt wurde.

Anwesend sind 5 stimmberechtigte Mitglieder der D.G.T. 3 Mitglieder haben sich entschuldigt. Daher schließt Dr. Engel die ordentliche Mitgliederversammlung wegen Beschlussunfähigkeit .

Um 19.15 Uhr eröffnet Dr. Engel die ebenfalls fristgerecht anberaumte, außerordentliche Mitgliederversammlung der D.G.T. mit gleicher Tagesordnung.

Bericht des Vorstands

Dr. Engel berichtet über die verschiedenen Aktivitäten des Vorstands und der Gesellschaft im vergangenen Jahr.

Internet-Seite der D. G. T

Die Internet Präsentation der D. G.T wurde realisiert - wie auf der letzten Mitgliederversammlung beschlossen. Allerdings wird das FORUM dieser Seite bislang nicht so gut be- sucht wie es gewünscht war. Es wird viel dafür getan, dass die Seite stets über die wichtigsten Suchmaschinen gefunden werden kann.

Thermology international

Dr. Engel dankt Dr. Ammer für die Herausgabe der Zeitschrift, in diesem Zusammenhang besonders für die in der jüngsten Ausgabe von Dr. Ammer verfasste weltweite Literatursammlung thermologischer Veröffentlichungen in wissenschaftlichen Zeitschriften.

Wissenschaftliche Präsentation der Thermologie

Dr. Engel und Dr. Frauenrath haben je ein Referat zu Anwendungen der Thermographie auf dem Schmerzkongress in Freiburg (Breisgau) im August 1999 gehalten. Sie hatten 7 bis 8 Teilnehmer von den etwa 300 Kongressisten. Dr. Engel bedauert, dass keine weiteren Anfragen nach thermologischen Methoden oder Kameras an ihn oder Herrn Dr.Kraus (Fa. Infratec) nach den Vorträgen und der Ausstellung von Gerät gefolgt sind.

Dr. Engel hat die ausführliche Behandlung des medizinischen Problems „Der diabetische Fuß“ in der Zeitschrift „Der Internist“ zum Anlass genommen, die Autoren der verschiedenen Fachbeiträge über die diagnostischen Möglichkeiten der Infrarot-Thermographie bei dieser schwerwiegenden diabetischen Komplikation zu informieren. Dazu hat er die Autoren angeschrieben und ihnen eine Kopie der Arbeit von Harding et al. geschickt, die mit dem Günter Bergmann Preis der D. G. T. im vergangenen Jahr ausgezeichnet worden ist. Bedauerlicherweise hat keiner der Autoren irgendeine Reaktion gezeigt.

Bericht des Sekretärs

Herr Dr. Rusch berichtet als Sekretär über den Mitgliederstand.

Die D.G.T. hat derzeit

65 ordentliche Mitglieder (davon 1 Firma)

2 Ehrenmitglieder

2 korrespondierende Mitglieder.

Dr. Rusch hat durch Postvermerk auf einem rückgesandten Brief vom Ableben des Kol- legen Flügge aus Hamburg erfahren und bittet die Versammelten, sich zum Gedenken zu erheben.

Bericht des Schatzmeisters

Als stellvertretender Schatzmeister berichtet Dr. Rusch außrdem über den Kassenstand und die Ein- und Ausgänge. Die größten Ausgaben sind die Zeitschrift und der Internetauftritt der D.G.T. Die Mitgliedsbeiträge der österreichischen Mitglieder nimmt Dr. Ammer entgegen und verrechnet diese mit den Beiträgen der D.G.T. für die Mitgliedschaft in der European Association of Thermology. Ein ähnlicher Weg für die Beiträge der Mitglieder in der Schweiz wird seit Jahren nicht mehr begangen. Dr. Rusch wird daher beauftragt, die dortigen Mitglieder anzuschreiben mit der Bitte um Überweisung der ausstehenden Mitgliedsbeiträge und um Erklärung über ihre weitere Mitgliedschaft oder Austritt aus der Gesellschaft.

Bericht der Kassenprüfer

Die Kasse wurde von Jost Bergmann und Dr. Hippchen geprüft und eine ordnungsgemäße Kassenführung ohne Beanstandungen bestä- tigt.

Auf Antrag von Dr. Kunz erteilt die Versammlung dem Vorstand Entlastung(einstimmig).

Neuwahl des Vorstands

Nach einstimmiger Wahl durch die anwesenden stimmberechtigten Mitglieder leitet das Ehrenmitglied Dr. Kunz die Neuwahl des Vorstands.

Für jede Position steht nur ein Kandidat zur Verfügung. In geheimer, schriftlicher Wahl werden folgende Herren gewählt:

Dr. Engel, Bad Liebenwerda, zum Präsidenten (einstimmig)

Dr. Ammer, Wien, zum Vizepräsidenten (einstimmig)

Dr. Frauenrath, Mönchengladbach, zum Vizepräsidenten (einstimmig)

Jost Bergmann, Celle, zum Sekretär (einstimmig)

Dr. Rusch, Bad Nauheim zum Schatzmeister (einstimmig).

Kongress THERMO 2000

Dr. Engel berichtet über die vielfältigen Aktivitäten zur Vorbereitung der nächsten Mitgliederversammlung und wissenschaftlichen Jahrestagung THERMO 2000 am 3.-5. August 2000 in der Kongress Union Celle. Bereits Anfang des Jahres wurden 3000 Kongress-Flyer gedruckt und verteilt. Im Internet wurde die Kongressankündigung eingestellt und in die Suchmaschinen und Kongresskalender gege- ben.

Während alle inhaltlichen Vorbereitungen zur THERMO 2000 zeitgerecht laufen und auch genügend Referenten und Akteure gewonnen werden konnten, haben sich bis 31.10.99 nur 3 Kongressteilnehmer vorangemeldet.

Die E.A.T. hat den Beschluss gefasst, Ihre 8. Jahrestagung in Italien abzuhalten.

Die Entscheidung der wissenschaftlichen Leitung der EXPO 2000 zur Aufnahme der THERMO 2000 in das EXPO-Programm steht noch aus.

Dr. Engel stellt daher den Antrag, bei unzureichender Deckung der voraussichtlichen Kongresskosten die THERMO 2000 rechtzeitig abzusagen und als Alternative am 5.8.2000 in der Galerie Bergmann in Celle die Mitgliederversammlung abzuhalten und die Preisverleihung des Bergmann-Preises 2000 vorzunehmen.

Die Mitgliederversammlung beschließt mit einer Enthaltung, der Vorstand möge das mit der Kongressorganisation beauftragte Messe- und Kongressbüro Lentzsch (Bad Homburg v.d.H.) bitten, bis zum Jahresende unter den Herstellern von Infrarot-Kamerasystemen Sponsoren zu gewinnen oder ausreichend Ausstellungsfläche zu verkaufen, um die Fix- kosten der THERM02000 zu finanzieren.

Gelingt das nicht, werden im Januar 2000 alle reservierten Optionen (Hotels, Kongress Union) und der Organisationsvertrag storniert und der Kongress abgesagt.

Statt dessen wird die alternative Lösung einer Mitgliederversammlung mit Preisverleihung am 5.8.2000 in der Galerie Bergmann gewählt. Dabei findet die Preisverleihung nur unter der

Voraussetzung statt, dass genügend formal und qualitativ den Ausschreibungsbedingungen genügende Arbeiten für den Günter Bergmann Preis 2000 eingereicht werden. Andernfalls wird eine neue Ausschreibung für das darauf folgende Jahr vorgenommen.

Verschiedenes

Besondere Anträge oder Anfragen liegen nicht vor.

Um 21.30 Uhr schließt der Präsident die Mitgliederversammlung 1999.

Nachtrag

In der Zwischenzeit musste die Thermo 2000 endgültig abgesagt werden. Anstelle wird am 5.August 2000 in Celle im Hotel Sol Inn die 20.Jahrestagung der Deutschen Gesellschaft für Thermologie veranstaltet und bei ausreichend vorliegenden Bewerbungen zum zweiten Mal der G.Bergmann Preis verliehen werden .

Für einen prächtigen Rahmen dieser Preisverleihung einschließlich heißer Jazzmusik (“Red Wings”) ist jedenfalls schon gesorgt.

Aktuelle Informationen können der Homepage der Deutschen Gesellschaft für Thermologie unter ”http://www.thermology.org” entnommen werden. Dort finden sich neben den Vereinsstatuten, den Statuten des G.Bergmann Preises, ein Diskussionsforum, Litera- tur, Veranstaltungshinweise und zahlreiche Links zu interessanten Internetseiten.

Generalversammlung der Österreichischen Gesellschaft für Thermologie am 20.10.1999

T.Schartelmüller

Sekretär der Österreichischen Gesellschaft für Thermologie

Die Eröffnung durch den Präsidenten erfolgt um 19:00 Uhr. Da die Zahl der anwesenden Mitglieder nicht zur Beschlussfähigkeit ausreicht, wird der Beginn auf 19:30 Uhr verschoben.

Bericht des Präsidenten

Die Österreichischen Gesellschaft für Thermologie hat derzeit 31 ordentliche, 1 Ehren- und 1 unterstützendes Mitglied.

Thermology international ist derzeit die einzige regelmäßig erscheinende Fachzeitschrift auf dem Gebiet der medizinischen Thermologie.

Bericht des Kassiers

Sowohl 1997 als auch 1998 konnten dank der Mitgliedsbeiträge, Spenden und Verkauf von Zeitschriften leichte Zuwächse des Vereinsvermögens erzielt werden.

Die Überprüfung der Buchhaltungsunterlagen ergab keine Unregelmäßigkeiten, daher konnte nach Antrag des Rechnungsprüfers der Kassier und somit auch der Vorstand entlastet werden.

Mitgliedsbeitrag 1999/ 2000

Der Antrag des Präsidenten auf Erhöhung des Mitgliedsbeitrages von ATS 400,- auf ATS 500,- jährlich wird einstimmig angenommen.

Neuwahl des Vorstandes

Präsident: Dr.Kurt Ammer

1.Vizepräsident: Prim.Dr.Otto Rathkolb

2.Vizepräsident: Dr.Josef Graber

Kassier: Prim.Dr.Johann Mayr

Sekretär: Dr.Thomas Schartelmüller

Rechnungsprüfer: Dr.Peter Melnizky, Prim.Dr.Günther Gàl

Die Wahl des neuen Vorstandes erfolgt ohne Gegenstimmen.

Allfälliges

Am 8.+9. September 2000 findet in Desenzano/ Italien der European Congress of medical Thermology statt, deadline für abstracts ist der 1. April 2000.

Im August 2000 Jahrestagung der Deutschen Gesellschaft für Thermologie in Celle/ D, Verleihung des G.Bergmann Preises.

Im Jahr 2001 wird der Weltkongress für Thermologie in Europa stattfinden, mit größter Wahrscheinlichkeit in Wien.

Schluss der Generalversammlung: 19:58 Uhr.

Veranstaltungen (MEETINGS)

22. February 2000

Infrared Thermograpy.
Modern developments

Venue: Fredriksberg Hospital, Kopenhagen, the Auditorium,

Date: 22.02.2000, 3.00 to 5.30, p.m

Programme:

Professor Francis Ring, Department of Clinical Measurement, Royal national Hospital for Rheumatic Diseases, Bath:
*IR thermography in medicin*e (40 min)

Lars T Jensen, B.Kristensen, S.Pors Nielsen, department of Clinical Physiology, Hillerød Hospital:
*IR imaging in arterial and venous diseas*e (20min)

*Refreshmen*t 15 min

Thomas Dresler, Præcisionsteknik A/S Copenhagen: *Modern IR cameras (20 min)*

P.E.Andersen, Forskningscenter Risø & Professor Peter Bjerring, University of Århus:
IR thermopgraphy in skin disease (20 min)

Panel discussion

Moderator: S.Pors Nielsen

9.-11.March 2000

A World of Thermography

International Thermography Association Conference in Association with the UK Thermography Association, at The Guildhall, Bath, England.

Information:
Colin Pearson, UKTA Secretary,
c/o The Building Services Research and Information Association,
Old Bracknell Lane West, Bracknell,
Berkshire, England RG12 7AH

tel +44 1344 42651 1, fax +44 1344 487575, e-mail ukta@bsria. co. uk or see the conference web page
ttp://members.tripod.com/ukta/Conf2000.htm

13.May 2000

13th Thermological Symposium of the Ludwig Boltzman Research Institute for Physical Diagnostics and the Austrian Society of Thermology

Theme: New developments in thermology

Venue: SAS Raddison Palais Hotel, Vienna

Information:
Dr.Kurt Ammer
Ludwig Boltzman Research Institute for Physical Diagnostics, Hanuschkrankenhaus,
Heinrich Collinstr.30;
A-1140 Vienna;Austria

Tel: +43 914 97 01 Fax:+43 919 92 64
Emal:KAmmer 1950@aol,com

26.-27.Mai 2000

Jahrestagung der Deutschen Gesellschaft für Thermologie in Bad Nauheim

Auskunft: Geschäftsstelle der Deutschen Gesellschaft für Thermologie
Rheinstr.5. D-76337 Waldbronn

Tel: +49 7243 66022 Fax:49 7243 6949

E-mail thermo@sauer.de

18-21. July 2000

QIRT 2000 (Eurotherm Seminar No64) in Reims, France

Deadlines:
January 15th, 2000
Deadline for abstracts

March 15th, 2000
Information about the acceptance of the paper final instructions for authors

April 15th, 2000
Mailing of final announcement, detailed programme and registration form

Information: QIRT 2000; Stephan Offermann

UTAP-LEO, Moulin de la Housse, B.P.1039
F-51686 Reims Cedex 2, France

Tel: +33 3 26913413 Fax: + 33 3 26913250

Email: http://www.univ-reims.fr/Qirt_2000

5.August, 2000

20th Annual Meeting of the German Society of Thermology in Celle
G.Bergmann Award for Thermology 2000

Venue: Sol In Hotel, Celle

Information:
Dr.J.-M.Engel
Chefarzt der Rheumaklinik Bad Liebenwerda, Dresdenerstr 9, 04924 Bad Liebenwerda

Tel:+49 35341901160 Fax: +49 35341 90 27 05
E-mail: rheumamike@iname.com

September 8-9, 2000

8th European Congress of Medical Thermology

VenueDesenzano, Brescia - Italy

Congress President
Dr. Giorgio Dalla Volta
Neurological Department
Istituto di Cura Città di Brescia
Via Gualla 15 – 25100 Brescia (Italy)
Phone: +39/03037101

Organizing Secretariat
Essepi Studio
Via Costalunga 14 – 25123 Brescia (Italy)
25123 Brescia (Italy)

Phone:+39/030382336- Fax:+39/030382653
E-mail: essepist@tin.it

September 21-28, 2000

3rd Congress of the Polish Society of Medical Thermology in Djerba, Tunisia plus

Certification Course
"Practical application of thermal imaging in medical diagnostics"

Information:

Prof.Dr.A.Jung

Pediatric and Nephrology Clinic,
Central Clinical Hospital, Military University, School of Medicine
Szaserow 128 str
00-909 Warsaw-60, PL

Tel/fax +48 22 6817236

Index, Volume 9, 1999
Thermology international

Papers

Autoren

8th EUROPEAN CONGRESS OF MEDICAL THERMOLOGY
3rd NATIONAL CONGRESS
OF THE ITALIAN ASSOCIATION OF THERMOLOGY

Desenzano del Garda, 8-9 September 2000

REGISTRATION FORM

Please type or write in block letters

First name ....

Family name ....

Fiscal address ....

Zip Code ....

Town ....

Country ....

Fiscal Code or VAT number ....
(for Italians and Europeans only)

Phone ....

Fax ....

E-Mail ....

Istitution/University/Hospital (complete address) ....

....

....

I send the following registration fee(s):

Teaching Course		Itl. ....
Congress: before April 20 ☐ after April 20 ☐		Itl. ....
	Total	Itl. ....

The payment in favour of Essepi Studio has been made by:

- Bank cheque in favour of Essepi Studio srl.

- Bank to bank transfer in favour of Essepi Studio srl, account N. 8330 of Bank: Banco di Brescia, Agency 27, Via Ambaraga, Brescia (Italy) - ABI code 3500 - CAB code 11290
I enclose copy of the transfer receipt.

Important Note: the payment of the registration fee made by companies or Institutions must be authorised by the companies/Institutions themselves. The authorisation must be sent in writing to Essepi Studio specifying the name, address and VAT Number (for Italian and European Companies) of the Company/Institution.

Signature .... Date ....

Return to:

Essepi Studio srl - Via Costalunga, 14 - 25123 **Brescia** (Italy)

8th EUROPEAN CONGRESS OF MEDICAL THERMOLOGY
3rd NATIONAL CONGRESS
OF THE ITALIAN ASSOCIATION OF THERMOLOGY

Desenzano del Garda, 8-9 September 2000

HOTEL ACCOMMODATION FORM

First name ....

Family name ....

Address ....

ZIP Code ....

Town ....

Country ....

Fiscal Code or VAT Number ....
(for Europeans and Italians only)

Phone ....

Fax .... E-mail ....

I would like to make the following reservation:

☐ West Garda Hotel ☐ Hotel Residence Oliveto

n. .... Single room(s) Itl. ....

n. .... Double room(s) single use Itl. ....

n. .... Double room(s) Itl. ....

Reservation fee Itl. 30,000 x n........room(s) Itl. ....

Total Itl. ....

Date of arrival .... date of departure .... no. .... of nights

The payment in favour of Essepi Studio has been made by:

- Bank cheque in favour of Essepi Studio srl

- Bank to bank transfer in favour of Essepi Studio srl, account N. 8330 of Bank: Banco di Brescia, Agency 27, Via Ambaraga, Brescia (Italy) - ABI code 3500 - CAB code 11290
Copy of the transfer must be sent together with the hotel accommodation form (form and receipt can be sent by fax)

Important Note: the payment of the hotel accommodation made by companies or Institutions must be authorised by the companies/Institutions themselves. The authorisation must be sent in writing to Essepi Studio specifying the name, address and VAT Number (for Italian and European Companies) of the Company/Institution.

Signature .... Date ....

Return to:
Essepi Studio srl - Via Costalunga, 14 - 25123 Brescia (Italy)

NAME AND ADDRESS OF THE PRESENTING AUTHOR

(type or write in block letters): ....

....

....

Phone .... Fax ....

TO BE SENT BY APRIL 1, 2000 TO:
ESSEPI STUDIO
Via Costalunga, 14 - 25123 Brescia (Italy)

ABSTRACT FORM

FIRST LINE OF THE TITLE

SECOND LINE OF THE TITLE

AUTHOR(S)' NAME(S)

ADDRESS

FIRST LINE OF THE TEXT

The European Association of Thermology

Associazione Italiana di Termologia

8th EUROPEAN CONGRESS OF MEDICAL THERMOLOGY

3rd NATIONAL CONGRESS OF THE ITALIAN ASSOCIATION OF THERMOLOGY

Desenzano del Garda (Brescia, Italy)

September 8-9, 2000

NOTE:

- Type the abstract with a laser printer or an electric typewriter.
- Type the title in capital letters.
- Underline the name of the author who will actually present the paper.
- Abstracts must be submitted also on a disk in MS DOS format, with the text typed in one of the most recent editions of Word.