ISSN-1560-604X
Thermology international

Thermology International

Volume 26 (2016)
Number 1 (February)

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This journal is indexed in
EMBASE/Scopus

Published by the
European Association of Thermology

THERMOLOGY INTERNATIONAL

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Organ of the American Academy of Thermology
Organ of the Brazilian Society of Thermology
Organ of the European Association of Thermology
Organ of the Polish Society of Thermology
Organ of the UK Thermography Association (Thermology Group)

Contents (INHALTSVERZEICHNIS)

Review

Book/Publication Review

Meetings (VERANSTALTUNGEN)

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Editor in Chief:

Prof DDr. Kurt Ammer

European Association of Thermology (EAT)

Hernalser Hauptstr.204/14 A-1170 Wien, Österreich
Phone &:Fax (43 1) 480 54 23 :
email:KAmmer1950@aol.com

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Manuscripts should follow the recommendations of the International Committee of Medical Journal editors (ICMJE)[1] and for reporting health related studies the following standards are highly recommended:

CONSORT-(CONsolidated Standards Of Reporting Trials) for randomised controlled trials with parallel group design [2]

STROBE (STrengthening the Reporting of OBservational Studies in Epidemiology) for case control, cohort and crosssectional studies [3]

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) for systematic reviews and meta-analysis [4]

STARD (STAndards for Reporting of Diagnostic accuracy) for diagnostic tests [5]

CARE (Consensus-based Clinical CAse Reporting Guideline Development) for case or care reports [6]

SPIRIT (Standard Protocol Items: Recommendations for Interventional Trials) for study protocols [7]
SAMPL(Statistical Analysis and Methods in the Published Literature) for statistical reporting. [8]

In general, manuscripts hould be organized as follows: Introduction, methods, results, discussion, acknowledgements, references. A short abstract in English and, if possible, German (translation 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.

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 Dünndarmtransplantation. 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 the final versionas pdf-file.

The journal"Thermology international" is published four times/ year on the internet. Annual Subscription rate is 50.-, a single article costs 10.- € for 24 hours use..

The internet access to the journal is supplied free of charge to members of the European Association of Thermology.

References:

[1] International Committee of Medical Journal Editors. Uniform requirements for manuscripts submitted to biomedical journals. Medical Education 1999; 33; 066-078

[2] www.consort-statement.org

[3]www.strobe-statement.org

[4]www.prisma-statement.org

[5] ww.stard-statement.org

[6] www.care-statement.org

[7] www.spirit-statement.org

[8] www.equator-network.org/wp-content/uploads/2013/03/SAMPL-Guidelines-3-1

Uhlen Verlag Wien,
Ingeborg Machyl, Fachzeitschriftenverlag

Gusenleithnergasse 28a/1, A-1140 Wien
Thermology international
ISSN-1560-604X

Internet: http://www.uhlen.at/thermology-international

Thermography 2015 - a computer-assisted literature survey

Kurt Ammer

European Association of Thermology, Vienna, Austria
Medical Imaging Research Unit, Faculty of Applied Mathematics and Computing,University of South Wales, Treforest Campus, Pontypridd, UK

SUMMARY

The literature survey 2015 is based on 1046 papers found in W eb of Science (core collection) or the journals "Thermology international (TI), Vol.25" and "Pan American Journal of Medical Thermology (PAMJT),Vol.2" with the keywords "thermography" and "published in 2015". The papers were analysed with respect to the origin of authors, the language, and the journal and issue number of publication. The analysis was performed for the total sample of WoS papers and separately for the subgroup of WoS medicine & biology papers and all content from TI and PAJMT. Different to the surveys of previous years, more than half of papers originated from Europe and only 18 of all papers were not written in English. The majority of articles was dedicated to engineering and applied science. Applications in veterinary science, agriculture and various medical specialities was the object in approximately 400 papers. Only few papers reported results of clinical medical thermography in humans. The annual prevalence of publications on thermography is strongly dependent from the database used for the literature search

KEY WORDS: Thermography, literature search, applied science, engineering

THERMOGRAPHIE 2015 – EINE COMPUTER-GESTÜTZTE LITERATURSUCHE

Die Literatursuche für 2015 basiert auf 1046 Arbeiten, die unter den Schlüsselwörtern "Thermographie" und "2015 publiziert" in der Datenbank Web of Science (core collection, WoS) und im 25. Jahrgang der Zeitschrift "Thermology international" und im " Pan American Journal of Medical Thermology (PAMJT), 2.Jahrgang" gefunden wurden. Mehr als die Hälfte aller Autoren thermologischer Publikationen kamen aus Europa, und 98,4 Prozent aller Arbeiten wurden in Englisch publiziert. Die Mehrzahl der Artikel wurde zu Themen der angewandten Naturwissenschaft oder Technik publiziert. Anwendungen in der Veterinärmedizin, in Landwirtschaft und verschiedenen medizinischen Spezialgebieten war das Thema in ungefähr 400 Arbeiten. Nur wenige Publikation berichten thermographische Ergebnisse in der klinischen Humanmedizin. Die jährliche Häufigkeit von Publikationen über Thermographie ist eindeutig von der Datenbank abhängig, in der die Literatursuche durchgeführt wurde.

SCHLÜSSELWÖRTER: Thermographie, Literatursuche, angewandte Naturwissenschaft, Technik

Thermology international 2016, 26(1) 5-43

Introduction

This annual survey was first published in 1989, sponsored by the Austrian Society of Thermology and the Ludwig Boltzmann Research Unit for Physical Diagnostics. Until 1998, only "thermography" was considered as search term for this literature survey. In the following period that ended in November 2015, additional search terms such as "thermometry" "temperature measurement" 'skin temperature' and 'core temperature' have been used to widen the scope of this literature analysis. This year's survey returns the early literature searches which have been restricted to the search term "thermography.

Methods

In Thompson's database "Web of Science (Core Collection, WoS)" papers have been identified that showed the keyword "thermography" and have been published in 2015. This search yielded 898 hits. The filters "countries (=origin of author)", "language (of publication)", "research area", "WoS research field", "author" and "sources (journals or book)" were employed for further analysis. 206 papers were assigned to research areas related to medicine and biology (shown in table 1). Finally, all papers published in last year's volume of the journals "Thermology international (TI)" and "Pan American Journal of Medical Thermology (PAJMT)" were added to the database, resulting in a total of 1046 references.

All papers were allocated with respect to the subject of the publication using the list of research fields listed in table 1. The papers were analysed to show the origin of authors, the language, and the journal and issue number of publication. The analysis was performed for the total sample of WoS papers and separately for the subgroup of WoS medicine & biology papers and papers from TI and PAJMT. For further classification of the journals publishing the highest number of thermography papers in 2015, the Citation Report Database at Thompson Institute for Scientific Information (ISI) was searched to obtain their most recent Impact Factor.

Results

898 publications were obtained with the search profile. After adding 133 papers from Thermology international and 15 articles from the Pan American Journal of Medical

Table 1
Research areas related to medicine or biology

Web of Science research areas	records
Veterinary Sciences	28
Agriculture Dairy Animal Science	28
Radiology Nuclear Medicine Medical Imaging	25
Neurosciences Neurology	17
surgery	14
Plant Sciences	10
physiology	10
zoology	9
ophthalmology	9
psychology	8
life Sciences biomedicine other topics	8
Food Science Technology	7
Sport Sciences	7
medicine General internal	7
medicine Research Experimental	6
biochemistry molecular biology	6
biophysics	6
behavioural Sciences	6
medical informatics	5
dermatology	5
dentistry Oral surgery medicine	5
cardiovascular System cardiology	5
Rehabilitation	4
defaultpublic Environmental occupational health	4
orthopaedics	4
oncology	4
forestry	4
critical Care medicine	4
health Care Sciences Services	3
endocrinology metabolism	3
emergency medicine	3
cell biology	3
biotechnology applied microbiology	3
urology nephrology	2
reproductive biology	2
Integrative complementary medicine	2
rheumatology	1
psychology multidisciplinary	1
psychology developmental	1
pharmacology pharmacy	1
paediatrics	1
otorhinolaryngology	1
obstetrics gynaecology	1
infectious diseases	1
haematology	1
geriatrics gerontology	1
anaesthesiology	1
anatomy morphology	1

Thermology, this survey is based on a total of 1046 publications

Language of publication

There were only 18 papers that were not published in English, 9 in Portoguese (5 of those in the Pan American Journal of Medical Thermology), 4 in Spanish, 3 in German and 2 in Chinese.

Authors

In total, 3103 authors appeared in 1046 publications.Ricardo Vardasca, the recently appointed secretary of the EAT, was author or co-author of 17 papers. 2 of them are listed in WOS i.e. 1 journal article [1], 1 full text conference article [2]. All other appeared in the journal "Thermology international (1 meeting report [3], 13 extended conference abstracts [4-16] and 1 meeting abstracts [17]). Marcos Brioschi from Brazil appeared as first author in 3 journal articles [18-20] and in 3 extended conference abstracts [21-23]. He was co-author in 4 journal articles [24-27] and in 4 extended abstracts [14, 28-30].

The most frequently found author in WoS was Xavier Maldague, who is professor since 1998 at the Université Laval, in Québec City, Canada. His name appeared as co-author of 13 papers [31-43]. Next in rank with in 11 papers in total, was Vladimir Platonovich Vavilov from the Tomsk Polytechnic University in Russia, an expert in non-destructive testing. His name appeared as first author in 6 journal articles [44-49] and 1 full conference paper [50]. Vladimir Vavilov was co-author of 3 other journal articles [51-53] and another full length conference paper [54].

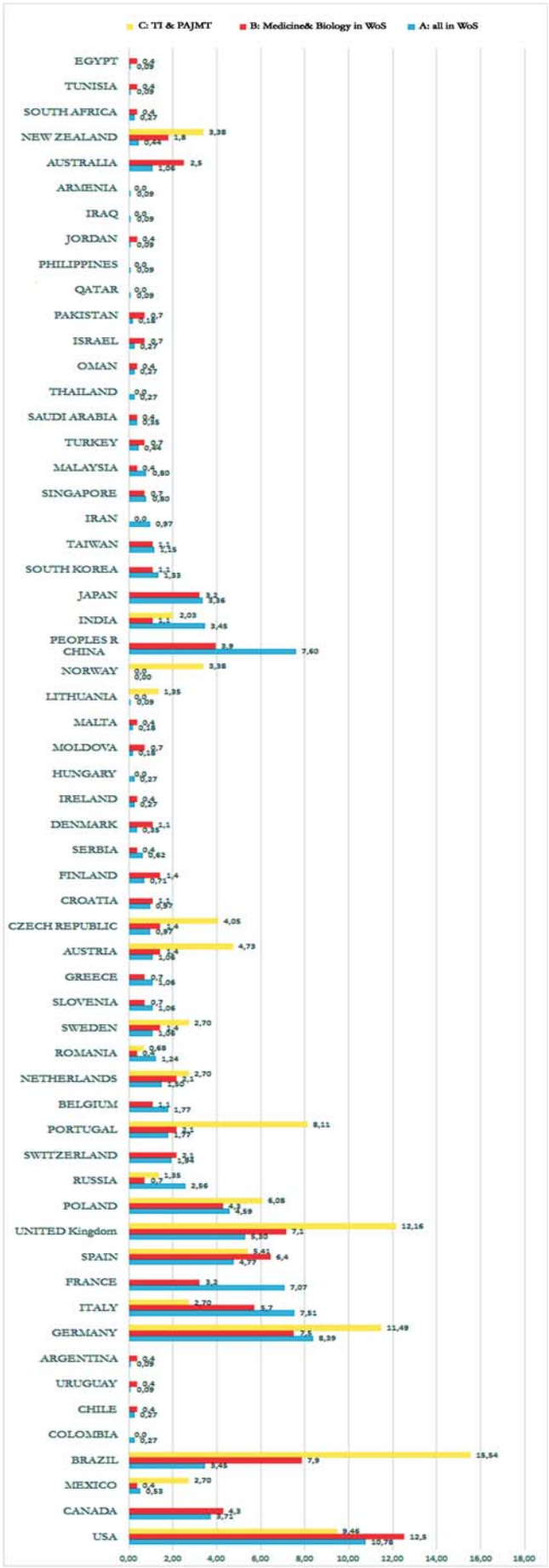
Figure 1 shows the nationality of authors and figure 2 their affiliation to continents. Affiliation to continents is presented for 3 groups of authors: A. all authors detected in WoS, B. all authors of papers related to medicine and biology C. all authors from Thermology international (TI] and Pan American Journal of Medical Thermology (PAJMT)

Thermography was performed in 59 countries. The percentage of papers varied between the 3 groups (Figure 2). In group A, 15% of papers originated from North America (predominately from USA). This percentage increased to 17.1% in group B and decreased to 12.2% for TI and PAJMT papers in group C. Slightly more variation was observed in papers from authors performing thermographic research in European countries: the percentage was 57.2 in group A, 53.9% in group B and 66.9 in group C. Large differences in percentage of papers were found for South America (group A: 4.2, group B: 8.9, group C: 15.5) and Asia (group A: 21.6, group B: 14.6, group C: 2.3).

Journals

In total, 457 journals and 24 proceeding books published thermography papers. 9 journals and 3 conference book series published 10 to 133 papers related to topic of this survey. First in rank was "Thermology international with 133 publications (3 editorials, 4 articles, 1 review, 92 extended

Figure 1
Countries, where thermography research was conducted



conference abstracts, 29 meeting abstracts, 4 notes) followed by "Proceedings of SPIE" with 69 papers and the journal "Infrared Physics & Technology" with 50 papers.

Table 2 lists the journal name, the number of papers of interest and their impact factor 2014. The impact factor for "Thermology international" was calculated in the way that Thermology international published between 2013 and 2014 in 8 issues in total 16 cite-able papers which received together 8 citations resulting in an impact factor of 8/16= 0.500. It is impossible to calculate an impact factor for conference proceedings or for the "Pan American Journal of Thermology". The latter started publication in 2014, and therefore does not have a citation history of two years prior to 2015.

A mean impact factor was separately calculated for journals that published thermographic papers in applied science, and in medicine and biology. The difference of impact was ~1.0 in favour of thermography in applied science.

Figure 2
Continents, where authors of thermography papers work

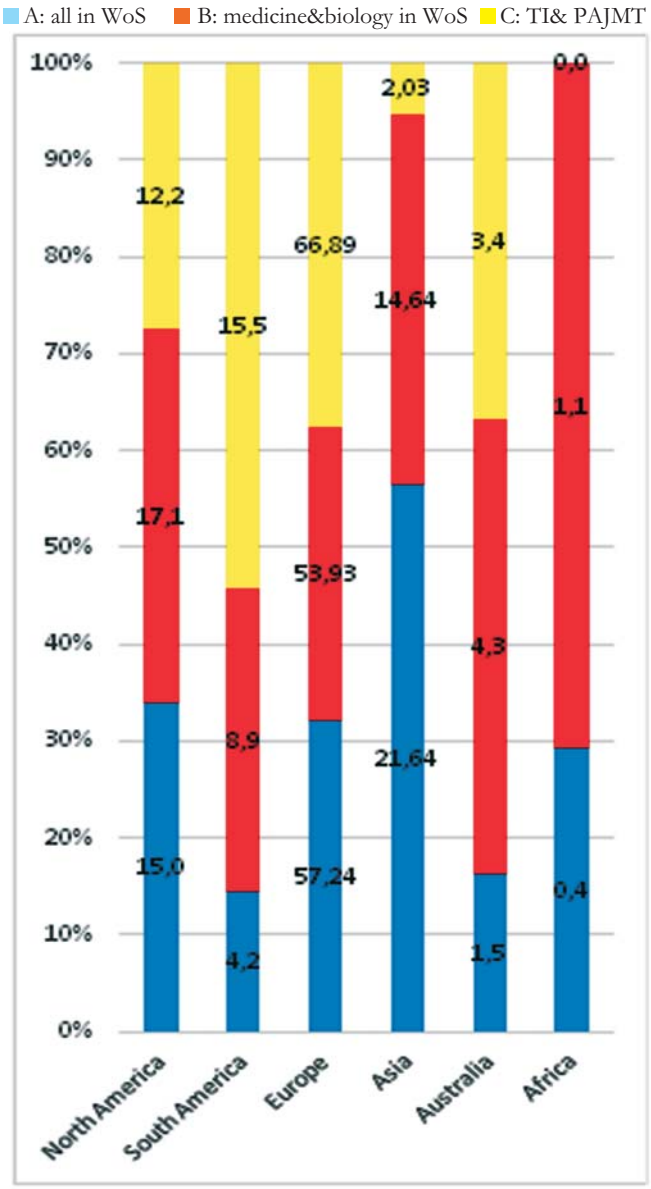


Table 2
Impact factors of journals that published high numbers of thermography papers

Source Titles That Published Thermography In Applied Science	records	Impact factor (IF) 2014
Proceedings of SPIE	69	n.a
Infrared Physics &Technology	50	1.550
Thermosense Thermal Infrared Applications XXXVII	29	n.a.
International Journal of Heat And Mass Transfer	18	2.383
Quantitative Infrared Thermography Journal	16	1.071
International Journal of Thermophysics	14	3.251
Experimental Mechanics	14	3.359
AIP Conference Proceedings	11	n.a.
Composite Structures	10	3.318
Applied Thermal Engineering	10	2.739
	Mean IF	2.517
Source Titles That Published Medical or Biological Thermography		
Thermology international	133	0.500 (IF 2015)
Pan American Journal of Medical Thermography	15	n.a.
Proceedings of SPIE	12	n.a.
Journal of Thermal Biology	6	1.505
12th International Conference On Quality Control By Artificial Vision	5	n.a.
Journal of Biomedical Optics	3	2.859
Journal of Medical Imaging and Health Informatics	3	0.214
Journal of Veterinary Behavior-Clinical Applications and Research	3	0.957
Physiology & Behavior	3	2.976
Veterinary Record	3	1.493
	Mean IF	1.501

IF = impact factor n.a. = not available

Type of publication

724 papers were classified as articles, and 40 as review. 135 full length conference papers, 92 extended conference abstracts and 40 meeting abstracts have been published. The remaining papers were classified as 11editorials and 4 notes.

Research Fields: Applied Science

The majority of papers retrieved in this year's search was dedicated to thermography in applied science. In table 3 research fields are ranked by the number of allocated papers. First rank was Engineering with 315 records, followed by Physics with 214 hits. The first field related to medicine or biology was veterinary science on rank 13.

Research Fields: Medicine or Biology

In WoS, 21 papers only were retrieved with the keyword "medicine" [2, 83, 205, 233,342, 382, 388, 439, 465, 483, 635, 692, 722,767, 777, 778, 803, 871, 877, 891, 905]. 7 papers had to be excluded because they did not report human thermography. 4 papers reported animal experiments [342, 692,722,777], one paper described the specifications and performance of an infrared imaging device [233] and another used a skin phantom for the evaluation of laser therapy [635]. A paper from Poland applied thermal imaging to distinguish between genuine and counterfeit drugs [905].

Interestingly, most of the papers labelled with medical specialities such as Ophthalmology, General Medicine, Surgery, Clinical Neurology and others as listed in table 1 were not retrieved by the search term "medicine". 10 of these papers had also to be excluded because they did not report medical investigations in humans [628, 718, 726, 800, 819, 898], studied tissue in vitro [66] or did not use thermography [768,781,903].

Thermal imaging in animals

Thermography was used in animal science for assessing health [199, 627, 709, 724], welfare [728,753] and response to various stress factors [642, 696,716, 727,730, 736, 752, 884] in various animal species such as dogs, cattle, birds, sheep, pigs and horses. Infrared imaging was also used for the evaluation of sheep bone regeneration in experimentally induced bone defects [717] and for the detection of breast tumours in dogs [722] and other animal experiments [342, 692,777].

Estimation of heat loss in air of an Antarctic marine mammal, the Weddell seal, was partly based on thermal images from free-ranging animals [820]. Heat transfer model estimates suggested that radiation contributed 56.6 ± 7.7 % of total heat loss. Convection and conduction accounted for the remaining 15.7 ± 12.3% and 27.7 ±9.3 %, respectively.

A study from Canada reported three categories of factors that affect the accuracy and repeatability of infrared based skin surface temperature measurements in cattle and emphasized the need to follow a standardised protocol for re-

Table 3
Research fields, where thermography was applied

RESEARCH FIELD	NUMBER	REFERENCES
Engineering	315	1,36, 38,40,48,50, 55-363,1005
Physics	214	4, 34,35,41,44,52, 364-504
Materials Science	207	32,33,45-47,49,51,506-611,759
Optics	144	37, 612-636
Instruments Instrumentation	115	637-646,921,922,960, 962,976,990,993,1000
Mechanics	87	647-654
Thermodynamics	80	655-671
Chemistry	47	672-681
Energy Fuels	43	682-690
Science Technology Other Topics	35	691-705
Veterinary Sciences	28	706-733,956-959,961,986-989,1015,1016
Agriculture	28	674,709,720,726,733,734-756
Computer Science	26	757-762, 929, 970, 971, 977-981
Construction Building Technology	26	763
Radiology Nuclear Medicine Medical Imaging	25	2,613,617,620,622,623,625-627,631,635,764-777,803,875,885, 984,1028,1033,1035-1038
Neurosciences Neurology	17	124,129,778-794,1002,1014,1016
Polymer Science	14	795,796
Surgery	14	628,779,781,786,787,790,797-804,983,1022
Nuclear Science Technology	13	805-810
Metallurgy Metallurgical Engineering	10	811-817
Physiology	10	82, 205,782,783,818-823,947-950,964,995,996,1004, 1006, 1007-1013, 1018
Plant Sciences	10	747, 824-833,920
Ophthalmology	9	834-842,994
Spectroscopy	9	843,844
Zoology	9	818,820,845-851
Remote Sensing	9	852-855
Automation Control Systems	9	856
Life Sciences Biomedicine Other Topics	8	857
Psychology	8	858-863,997,998
Sport Sciences	7	822, 864-872,1009-1013, 1025-1027, 1034
Food Science Technology	7	870
General Internal Medicine	7	871
Biophysics	6	872
Research Experimental Medicine	6	873-877,923,939
Other Medicine and Biology (details in table 1)	34	878-907,924-938, 940-946, 915-955,963, 965-969,972,973, 982, 985,991,992,999,1003,1017,1019,1020, 1021, 1023, 1024, 1029,1032,1039-1046
Meteorology & Atmospheric Sciences	6	908-910
Water resources	6	911,912
Environmental Sciences-Ecology	5	913
Geography	3	914
Geochemistry & Geophysics	1	915
Acoustics	4	916
Mathematics	6	917
Arts&Humanities	1	918
Non allocated papers to a field	6	3 ,919, 974,975,1030,1031,

cording and evaluation of thermograms strictly [749. A review on lameness detection in cattle addressed also the influence of environmental factors on temperature readings [637]. Neglect in control of these conditions, results in thermal images which cannot be interpreted.

Medical imaging

A review article on image-enhanced laparoscopy techniques for visualization of the extrahepatic bile ducts included infrared thermography as a promising method [803]. Authors from Russia hypothesized that the effect of remote ischemic preconditioning i. e. repeated episodes of brachial-cuff inflation/deflation can be predicted by temperature changes visible in thermal images simultaneously recorded from all extremities [875]. A review article on the use of infrared thermography for the assessment of myofascial trigger points included 4 papers only [885]. The authors concluded that there is no agreement in skin temperature distribution in the presence of trigger points.

Skin temperature measurement

The "Glossary of Terms for Thermal Physiology" defines "*Mean Skin Temperature" (T_{sk}):*
The sum of the products of the area of each regional surface element (A_i) and its mean temperature (T_i) divided by the total body (surface) area (A_b). $Tsk = S(A_i \cdot T_i)/A_b$ *[°C].*
Note: Mean skin temperature can be used as a physical variable in the calculation of heat balance or of heat content of the body. It is, however, not necessarily a good estimate of what might be sensed as a mean skin temperature according to the integrated neural input of the cutaneous thermoreceptors, because different surface regions may differ in their importance as thermosensor sites".

This temperature is almost always estimated and derived from skin temperatures recorded in different body areas, typically by contact thermometers. The International Organisation for standardisation published in 2004 the standard paper ISO9886: Ergonomics - evaluation of thermal strain by physiological measurements, in which the following formula for mean skin temperature is provided:

$$T_{sk} = (T_{neck}\,0.28) + (T_{scapula} \cdot 0.28) + (T_{hand} \cdot 0.16) + (T_{shin} \cdot 0.28).$$

Maniar et al. investigated by thermal imaging the homogeneity of temperature distribution in these four measurement sites given in the formula above [846]. They defined small rectangular areas of 30 by 30 pixels, and divided them into five subareas, each sized 15 by 15 pixels. Temperature differences between these subareas was calculated, but was minimal although statistical significant. Consequently, the largest potential error (mean±SD) in weighted mean skin temperature was 0.4 (±0.1) °C and the associated 95% limits of agreement for these differences was 0.2-0.5 °C. The authors considered the minimal differences in local and mean skin temperature to be physiologically not meaningful.

Marins et al recorded mean skin temperatures in 21 regions of interest from male and female members of the Brazilian Air Force at 7:00 AM and 7.00 PM [375]. Skin temperature increased in all measurement areas of all participants between the morning and the evening by approximately 1°C with the exception of hands where the temperature rose by 2 to 3°C. Hand temperature was higher in women than in men at both measurement points. In the morning, mean temperature of other anatomical regions than hands, was significantly lower in women. In the evening, only the thighs and lower legs showed significantly lower temperatures in women than in men.

A systematic review investigated the agreement of skin temperature measurements obtained by infrared and contact thermometers, and found poor agreement of both types of devices [83]. A study, conducted in Spain, compared infrared thermography and thermal contact sensors in measuring skin temperature during cycling. Fourteen cyclists performed in a moderate environment a 45-min cycling test at 50% of peak power output [465]. The correlation coefficient was high of the two methods of temperature measurement when obtained before cycling ($r = 0.92$), but decreased slightly, immediately after the cycling ($r = 0.82$) and significantly after the cooling-down phase ($r = 0.59$).

The distribution of facial skin temperature was reported in a sample of 25 healthy subjects at rest and in various conditions such as chewing nuts, drinking water or inhalation [459]. Authors from Poland investigated in young adults of bother gender the distribution of skin temperature of trunk and upper and lower extremities in an anterior and a posterior view [388]. They found slight negative correlations between the percentage of total fat and the skin temperature in measurement areas on the trunk. A poster from Korea reported higher scrotal temperature in subjects being overweight or obese compared to men with normal weight or underweight [888].

Another paper reported skin temperature in athletes immediately after a training session of high intensity [865]. The objective of the study was to compare skin temperature after exercise that involve symmetrically both sides of the body such as two-oared rowing with a sport that requires asymmetric muscular activity such as in handball. After exercise, the decrease in skin temperature compared to baseline readings was in rowers almost identically on the left and right side of trunk, upper and lower extremities. In handball players, small but significant differences of approximately 0.4°C in skin temperature decrease were observed between right and left upper extremity.

A study from Brazil found a high correlation between thickness of the biceps brachii muscle and arm skin temperature after resistance training of arm flexors [822].

A review article that showed a high risk of bias, claimed that thermal infrared imaging proved to be a sensitive and reliable method for diagnosis, evaluation and monitoring of a number of knee conditions, including osteoarthritis, rheumatoid arthritis, ligaments and tendons problems [382]. Lasanen et al. studied suffering from patients with juvenile

idiopathic arthritis or autoimmune disease with arthritis such as systemic lupus erythematosus [205]. Results of thermal imaging were compared to clinical evaluations in knee and ankle. The temperatures were significantly higher in inflamed ankle joints, but not in inflamed knee joints.

Deep venous thrombosis

A study from China revived the thermographic diagnosis of deep venous thrombosis (DVT) [767]. The authors found a good agreement between the ultrasound Doppler based diagnosis and pathological findings in thermal images. Unfortunately, the rate of true negative findings was not reported, although a large sample of healthy controls without DVT has been investigated.

Endocrinology and Diabetic foot

A case report described a thermogram which raised the suspect of a diabetic foot [871]. Dutch authors developed an algorithm for automatic segmentation of feet in colour photos and their registration to thermal images [622]. Using this software, 35out of 37 diabetic foot ulcers were successfully detected. A case report discussed thermography as an alternative imaging modality in patients with thyroid hyper-function when radionuclide imaging is contra-indicated [788].

Safety of interventions

A study from Austria investigated the safety of laser acupuncture for infants by means of infrared images [891]. The mean temperature at the treated acupuncture point "Large Intestine 4" increased approximately by 2°C after 10min treatment. In one child, the temperature increased at the end of stimulation to 38.7°C, without any clinically visible changes on the skin surface.

Another study investigated with infrared thermography the magnitude of temperature change caused by two different surgical lasers during incision into glottis tissue [884]. Heat generation of vessel sealing devices during thyroidectomy was also monitored by thermal imaging [878]. The mean temperature in the field of coagulation varied between 78 and 82°C, the mean distance to the isotherm indicating 42°C was in the range between 9.6 and 10.6 mm.

There is increased interest to use thermal imaging to monitor cryotherapy [439]. A systematic review collected 19 articles, that reported infrared imaging bases skin temperature measurements after application of various forms of cryotherapy. None of the papers included reported temperature that might indicate possible freezing cold injuries.

Cold challenge

Vardasca et al could differentiate in a small sample of patients with Repetitive Strain Injury from healthy controls by finger temperature after they have undergone a mechanical provocation test followed by a cold challenge [2].

A study from Bath, England, compared in patients with primary or secondary Raynaud's phenomenon the findings of laser speckle contrast imaging with both infrared thermography and subjective assessment using the Raynaud Condition Score diary [823, 899]. There was good convergent validity of laser speckle contrast imaging with thermography and acceptable reproducibility of both modalities. Neither subjective nor objective assessments could differentiate between primary and secondary Raynaud´s phenomenon.

A group of authors from Slovenia, Austria and Sweden, reported rewarming rates of the finger and toe temperature after a severe cold stress test (immersion in 8°C water for 30 minutes) in alpinists with previous freezing cold injuries requiring digit amputations and matched non-injured alpinists [868]. There was no evidence of different skin rewarming rates between the injured and uninjured fingers or toes of elite alpinists.

Injury detection

3 papers reported the use of thermal imaging for either diagnosing or monitoring the healing process of bone fractures both in children and adults. A study from Spain found high diagnostic sensitivity and specificity of thermography for fractures confirmed by radiography [900]. A small pilot study, conducted in Croatia, recorded 4 times the temperature of both forearms after unilateral forearm fracture at weekly intervals, starting 7 days after injury [798]. The highest temperature difference between the fracture and the unaffected side was recorded 7 days after trauma, but decreased to normal values 2 weeks later. The same group investigated also the course of forearm temperature during healing of distal radius fractures in elderly adults [799]. They observed five weeks after fracture a mean temperature difference of 1.04 ± 0.53°C and 11 weeks after the injury the temperature difference was still 0.50 ± 0.30 °C. Another study from Spain studied patients attending an emergency department with thermal imaging [776]. The highest difference of mean temperature of corresponding anatomical regions was detected for bone fractures with T=0.9°C, followed by joint problems (T=0.7°C) and tendon and muscle affections (T=0.3°C).

Surgery

An animal experiment conducted in Romania, investigated the diagnostic power of infrared imaging(IRI) for the identification of perforator vessels in comparison to Colour Doppler Sonography (CDS) [770]. The authors reported a higher rate of false positive results of thermography affecting the positive predictive value (PPV) of the infrared based technique (PPV_{IRI} versus PPV_{CDS}: 81% versus 97%). However, all the dominant perforators were detected by both methods and confirmed by surgical exploration. As CDS mapping takes much longer time than thermal imaging, the authors recommend a combined method by identifying the dominant perforator by infrared imaging and confirm it with Colour Doppler Sonography.

Another novel use of infrared imaging in surgery is reported from Japan [896]. In an experiment in Lewis rats ex

vivo lung perfusion (EVLP) was assessed by infrared thermography. A thrombosis group and the control group (n = 6 in each group) was formed. All rats were heparinized and the lungs were flushed with 20 ml of Steen solution (i.e human serum albumin 70g/l). In the Thrombosis group, a 30-mg artificial thrombus was inserted into the left main pulmonary artery. All the lungs were perfused and ventilated using the EVLP system. Perfusion flow was increased every2 min up to 10 ml/min. The lungs were evaluated by collecting thermographical and physiological data during EVLP. The surface temperature of both lungs in the control group and the right lungs in the thrombosis group rose with increasing perfusion flow, whereas the surface temperature of the left lungs in the thrombosis group did not rise. As thermography could detect a mal-perfused region, thermographical evaluation may become a promising strategy to detect regional damage in donor lungs.

Breast

A number of papers was dedicated to segmentation, automatic detection and classification of regions of interest in breast thermograms [197, 241, 271, 419,436,475,621, 758, 761,872). Many of these papers do not differentiate between sensitivity as a measure of software performance and sensitivity of a diagnostic test in medicine. None of these studies used the developed software prospectively in sample of women with suspected breast disease, one study tested the software programme in 3 individual cases [419]. Another study compared the features of breast thermal images recorded in patients already been diagnose of breast cancer, with clinical, histopathological and immuno- histochemical findings [503]. The authors reported a relationship between immune-histochemical changes and skin temperature, but no influence of tumour size on temperature level was found.

Mammary glands during lactation were examined by infrared thermography and local tenderness in the four mammary quadrants was assessed with a pressure algometry [886]. The greater the degree of engorgement, the higher the temperature was observed, while flaccid mammary glands showed higher thresholds for pressure induced pain

A paper from Japan reported the results of influenza screening that used a system that combines microwave radar for measuring respiration rate, a light reflexion sensor for obtaining heart rate and infrared thermography for measuring facial temperature [902]. Pulse oximetry oxygen saturation (SpO_2) was measured as a reference. All data were processed by using a neural network and fuzzy clustering method. The system achieved a diagnostic sensitivity of 97.1% and a specificity of 81.3% in differentiation of influenza patients from healthy controls. Facial temperature was significantly different between healthy controls and influenza patients.

Dermatology

Japanese researchers reported that thermal images of the feet are of help in differentiation of tinea unguium-positive subjects from tinea unguium-negative patients in group of older adults with subungual hyperkeratosis [894]. The mean toe temperature in infected toe-nails (30.2 ± 2.6° C) was significantly lower than that in toes free of tinea unguium (32.8 ± 3.2 degrees. A cut-off temperature of 33.0° C, resulted in a sensitivity of 81.8% and specificity of 65.7%.

Analysis of infrared images with a novel software allowed automatic detection of the area of the tuberculine skin test [73]. Mean temperature of the tuberculin injection area was approximately by 1°C higher in positive cases than negative test results. The computer programme achieved a similar estimation of tuberculin reaction as the visual evaluation.

A study from Switzerland reported first results of lock-in thermography for detection of benign skin lesions [882]. The applied thermography system used a temperature-modulated airflow to periodically stimulate the skin surface. The infrared images recorded by a high sensitive camera have been demodulated according to the digital lock-in principle to compute a phase and amplitude image. Non processed thermal images were inferior in resolution to both, phase and amplitude images. Phase images were superior to amplitude images in visualisation of superficial ectasia or palm skin structure.

Discussion

Different to the literature surveys in previous years, the proportion of papers originating from European countries has increased by 20%. This was observed in papers reporting thermography in applied science, engineering and medicine or biology, but also when only medical and biological publication have been selected. The different proportion in origin of authors compared to previous annual literature surveys is probably caused by the database used for this year´s survey. The reason for selecting WoS was the fact, that all journals included have an impact factor, which is an established bibliometric measure that describes the visibility of publications in journals. It was repeatedly argued that thermography publications in journals with high impact factor can help to increase the reputation of infrared imaging. Journals, that published engineering or applied science thermography, had on average an higher impact factor than journals publishing papers in thermography in medicine or biology.

Health insurance companies and health authorities develop policy strategies related to thermography often on literature listed in WoS, although such a non-systematically performed literature search is bound to bias and suffer from being non comprehensive. This condition describes also the main limitation of the current review article.

Medicine and biology was the topic in 250 of 870 papers found in WoS, clearly indicating that applied science and engineering are the predominant fields of application for thermography. Adding publications from TI and PAJMT

increased the number of medicine & biology papers to a proportion of 40%. More papers reported thermography in animals than humans.

Much effort was made to develop software packages to automatically generate regions of interest and evaluation of these measurement areas. However, an agreed standard for evaluation of thermal imaging in medicine is not yet available. Normative temperature maps, that appeared recently, cannot be used as reference for assisted diagnose if they are not based on the same standard of body position, field of view and method of evaluation.

Another focus in image processing is image enhancing for better detection of heat emitting anatomical structures. This approach works well when applied to intra- or epicutaneous structures [73,882], but for tissue changes in deep layers such as tumours, the accuracy of this approach is not yet established. Most software for breast cancer detection was tested on historical samples of images and evaluation in prospective studies is still missing.

There is increasing interest in sports science to use thermal imaging for the evaluation of sports performance and injury detection. However, the interpretation of these findings is debatable as skin temperature is often understood as surrogate measure for perfusion. As blood volume is distributed to organs with respect to their functional needs, a competition between the organ function and skin blood flow may arise because the superficial vascular network in the skin functions as an important effector in thermo-regulation loop. Immediately after exercise, it might be not correct to conclude from skin temperature on muscle activity in the phase of reduced skin temperature when heat production by muscles has just terminated but dissipation of heat has not yet started. As heat travels mainly by convection, and not by conduction from deep tissue layers to the surface, the role of subcutaneous fat as an insulator can also be questioned. For establishing a relationship between muscle perfusion and skin temperature, blood flow in working muscles and overlying skin should be measured simultaneously with other techniques than thermography and these results must be compared with the changes of skin temperature. Without having such data available, promotion of infrared imaging as method for monitoring muscle function might harm the reputation of thermography, which is still suffering from non-fulfilled promises and expectations from the past.

In conclusion, this year´s literature survey shows that the annual prevalence of thermography papers is strongly dependent on the database used for the search. This statement applies to both, the number of publications and the field of application, where applied science and engineering are predominant. Software programmes for automatic evaluation of medical thermal images are seldom based on the results of prospective clinical studies. The potential of thermal imaging in the assessment of muscle function seems to be overestimated. Agreement on standard procedures for infrared imaging and its implementation in current praxis of medical thermography are strongly recommended.

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Address for correspondence

Prof Dr Kurt Ammer PhD

European Association of Thermology
Hernalser Haupstraße 209/14. 1170 Wien, Österreich

Email: Kammer1950@aol.com

Infrared Imaging

Review of the book "Infrared Imaging: A casebook in clinical medicine"
Edited by Francis Ring, Anna Jung and Janusz Zuber (IOP Publishing, Bristol, UK)

Kevin Howell

Institute of Immunity and Transplantation, Royal Free Hospital, London, UK ,
President, European Association of Thermology

It is pleasing to see this long-awaited follow up to the original "Casebook" (published in Poland twelve years ago) now available in print and as an e-book. As Kurt Ammer explains in the preface, things have moved on significantly over the last twelve years, with large improvements in infrared technology and our understanding of thermal physiology. This new book, richly illustrated throughout with colour thermograms, sets out to bring the reader up-to-date.

The text is presented in five sections: an opening technical discussion, followed by four sections covering the head and neck, trunk, upper extremities and lower extremities. This is a sensible approach which succeeds in splitting a large topic into manageable parts.

The technical section is particularly strong, with Francis Ring and Kurt Ammer discussing thermographic protocols and image analysis standards authoritatively. Chapter 5 is the standout contribution to the "Head and neck" section, describing the challenge of standards for fever screening using the inner canthus of the eye.

The section on the "upper extremities" covers Raynaud's phenomenon (in both its primary and secondary forms), peripheral nerve entrapments and hand-arm vibration syndrome in all the detail that one would expect, given the experience of the various contributing authors. There is little new here, but the material is an excellent primer for those unfamiliar with the field.

Compiling a coherent textbook from many contributing authors is a challenging task, and predictably there are a few imperfections in the new "Casebook". Surgical applications are under-represented, which is surprising given the revolution in low-cost and portable thermal imaging equipment which has been finding its way into operating theatres in recent years. Breast thermography is not discussed at all in the book. Although this is a controversial field, the topic sorely requires addressing with the same authority that the authors have applied to other areas. Complex regional pain syndrome is also addressed only very briefly, and with no mention of stress-testing to improve diagnostic reliability.

The quality of the thermal images presented is quite varied throughout the book. Whilst Kurt Ammer is absolutely correct to stress the importance of standardised imaging protocols and reproducible ROIs in the first section of the book, the editors have not always followed his advice in requiring this from other contributing authors. The book is also let down slightly by a small number of errors in figure captions (3.1, 3.2), incomplete captioning (15.3) and errors in tables (17.1). These only serve to confuse the reader, and should really have been trapped by the publisher at the proofing stage.

These small niggles apart, the Casebook is nonetheless one of the most comprehensive collections of clinical thermography cases ever published in one text, and would be a valuable addition to any thermographer's bookshelf.

So, all-in-all, does the Casebook succeed in bringing the reader up-to-date with modern clinical thermography? The answer has to be "yes, on some topics, but only partly overall." The fully authoritative casebook dedicated to our area of imaging science may be impossible to compile, but I look forward to the third version of the Casebook in a few years!

2016

Announcement and Call for Papers

2nd Seminar of Medical Infrared Thermography London

mIRtL

Friday, 29th April 2016, 10 am – 1 pm
Royal Free Hospital, London NW3 2QG

In association with **UCL**, the **European Association of Thermology** and the **Royal Free Hospital**

UCL

Royal Free London NHS
NHS Foundation Trust

The seminar is free to attend, but numbers are strictly limited. To reserve a delegate place or submit an abstract (maximum 100 words) contact the organiser Dr. Kevin Howell (Microvascular Diagnostics, Royal Free Hospital) at k.howell@ucl.ac.uk

PowerPoint presentations to be submitted via email by 22nd April. Please contact the organiser if you wish to bring your own media for presentation on the day.

For programme updates and further information:

Follow us on Twitter: **@MIRT_London**

Follow and like our Facebook page: **www.facebook.com/MIRTLondon**

8th April 2016
Technicians Member Certification Course
in Greenville, South Carolina.

9th April 2016
AAT Physicians Member Certification Course
in Greenville, South Carolina.

*Further information*http://aathermology.org/

17th–21th April 2016

Thermosense: Thermal Infrared Applications XXXVIII in Baltimore, Maryland, USA

Venue: Baltimore Convention Center

Thermosense is the oldest and largest international technical conference focused on scientific, industrial and general uses of infrared imaging, infrared temperature measurements, and image analysis. Its regular printed proceedings are found in most scientific and engineering libraries, providing an unequaled depth and breadth of technical information and reference data. Further information regarding Thermosense can be found at: www. thermosense.org .

Thermal/infrared related papers are solicited in the areas listed below, and are also welcome in other areas.

Aerospace Applications

Automotive Industry

Building Applications

Calibration

Detection Of Gas And Other Leaks

Environmental And Agricultural Monitoring

Fiber Optics For Infrared

- Detection of hazardous chemicals
- Remote sensing in high temperature
- and corrosive environments
- Medical applications.

Fire Analysis And Detection

Food Processing And Handling

Infrastructure

IR Image Fusion Applications

- biological and medical
- field security
- process monitoring
- hyperspectral
- structural analysis.

Manufacturing And Processing Industries

Materials Evaluation And ndt

Medical

- health screening and diagnostics
- veterinary applications.

NDT (Nondestructive Testing)

Power Generation And Distribution

Research And Development

REMOTE SENSING AND SECURITY

Further information at http://www.spie.org/Si110

3rd -4th July 2016
20th Meeting of the Polish Society of Medical Thermography Combined with The European Association of Thermology

At Gdansk University of Technology, Poland

All are warmly invited to a meeting at Gdansk University of Technology. This is a special pre QIRT conference meeting.

QIRT Conference begins 4th-8th July
(separate registration applies).

Welcome Sunday evening 3rd July

Scientific Sessions Monday 4th July

Accommodation (2 nights in Technical University residence) / meals registration.

EARLY RESERVATION FOR ACCOMMODATION ESSENTIAL

Inclusive rate 700 PLN by bank transfer in advance

Bank account details: BZ WBK S.A.
1 Oddzial w Gdansku ul. 3 Maja 3, 80-958 Gdansk
SWIFT: WBKPPLPP
IBAN PL 68 1090 1098 0000 0001 3200 0510

Abstract deadline for Polish/EAT meeting May 1st 2016

Send to prof. Anna Jung a.jung@spencer.com.pl

MEETING VENUE: Gdansk University of Technology, Narutowicza str.11/12, 80 -233 Gdansk Poland

SCIENTIFIC COMMITTEE:

Prof.Anna Jung MD, Ph.D (Poland)
Prof.Antoni Nowakowski Ph.D, Eng
Mariusz Kaczmarek Ph.D, Bsc
Zuber Janusz MD,Ph.D
Kevin Howell Ph.D (UK)
Prof. Kurt Ammer MD, Ph.D (AUT)
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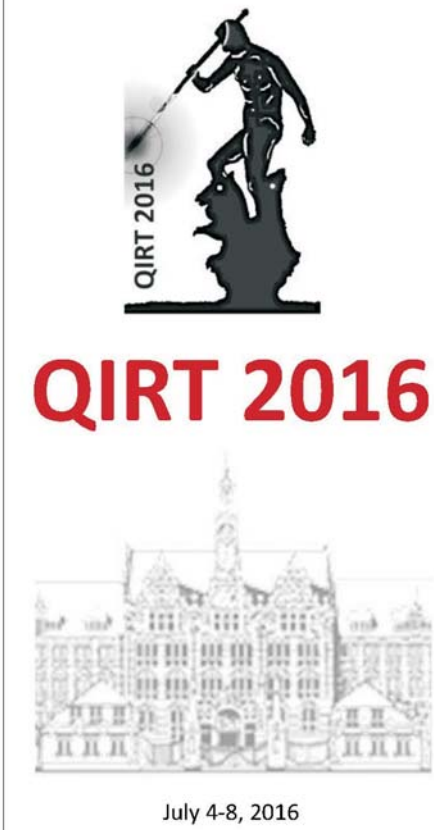

PROGRAMME AT A GLANCE.

3th JULY, SUNDAY

7 p.m. Welcome Dinner

4th JULY, MONDAY

9.00 - 11.00 Session I

11.00 - 11.20 Coffee break

11.20 -13.00 Session II

13.00 - 14.15 Lunch

14.30 - 16.00 Session III

16.00 - 16.15 Coffee break

16.15 - 17.30 EAT board meeting

18.00 - Get together and QIRT Welcome

11th - 13th July 20164th-8th July, 2016
QIRT Conference 2016

Gdansk University of Technology Gdansk – Poland

Scope of the Quantitative InfraRed Thermography Conference: State-of-the-art and evolution in the field of infrared scanners and imaging systems allowing quantitative measurements, and related data acquisition and storing systems.

Calibration and characterization of infrared cameras and related problems like certification, standardization, emissivity determination, absorption in media, spurious radiations, three dimensionality of observed objects.

Data reduction and image processing related to infrared thermography.

Application of infrared thermography to radiometry, thermometry, and physical parameters identification, in all fields: fluid mechanics, solid mechanics, structures and material sciences, non-destructive evaluations, electromagnetism, medicine and biomedical sciences, remote sensing, environment, industrial processes, etc.

• Conference Fees

Regular participants

- Early rate (deadline: May 20, 2016): **2600 PLN**
- Late rate (deadline: June 17, 2016): **3000 PLN**
- Very late registration before July 4: **3500 PLN**

Students

- Early rate (deadline: May 20, 2016): **1600 PLN**
- Late rate (deadline: June 17, 2016): **1800 PLN**
- Very late registration before July 4: **2000 PLN**

Accompanying persons

• Rate (deadline: June 27, 2016): **1000 PLN**

Further information:

Prof. Nowakowski antowak@biomed.eti.pg.gda.pl

Biomedical Engineering Dpt. Electronics, Informatics and Telecommunication Faculty Narutowicza Str. 11/12 80-233 Gdansk Poland

Website : www.qirt2016.gda.pl

11th - 13th July 2016
12th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics (HEFAT2016)

The conference is co-sponsored by the International Centre for Heat and Mass Transfer (ICHMT) and the American Society of Thermal and Fluids Engineers (ASTFE)

Venue:
Hotel Melia, Costa del Sol, Malaga, Spain

Purpose
The conference is broad in scope and provides a forum for specialists in heat transfer, fluid mechanics and thermo- dynamics from all corners of the globe to present the latest progress and developments in the field. The broad scope brings together a wide range of research areas from narrow fundamental work in nanofluids to import applications such as in the broad fields of energy, manufacturing, biomedical processes, production, education, instrumentation and control, and MEMS. This will not only allow the dissemination of the state of the art, but it will serve as a catalyst for discussions on future directions and priorities in these areas. The additional purpose of this conference is to initiate collaboration in research.

Further information:
Scholarly issues
(Only for abstracts, manuscripts and programme)
Prof Josua P Meyer
University of Pretoria. South Africa
E-mail: josua.meyer@up.ac.za

Administrative issues (Payment of registration fees, travel, accommodation, welcome, banquet, etc.)
The Inside Edge, Sheryl van den Bergh
E-mail: sherylvdb@ie.co.za

Conference website; http://edas.info/web/hefat2016/

10th- 11th September 2016

Annual Scientific Session of the American Academy of Thermology (AAT) in Greenville, South Carolina.

A Pre-Meeting Physicians Member Certification Course will occur on September 9th.

A Pre-Meeting Technicians Member Certification Course will occur on September 8th.

Further Information:

http://aathermology.org/