ISSN-1560-604X
Thermology international

Volume 21 (2011)
Number 2 (April)

Thermology International

Temperature of the face in children
Breast cancer screeing by thermography

Abstracts:
17th International Conference on Thermal Engineering
and Thermogrammetry, Budapest 2012

Published by the

European Association of Thermology
and the
Austrian Society of Thermology

This journal is indexed in
EMBASE/Excerpta Medica

THERMOLOGY INTERNATIONAL

Volume 21 (2011) **Number 3 (July)**

Published by the
Austrian Society of Thermology
and European Association of Thermology

Indexed in
Embase/Excerpta Medica

Organ of the American Academy of Thermology

Organ of the Brazilian Society of Thermology

Organ of the European Association of Thermology

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Screening for breast carcinoma:
What is the place of infrared thermal imaging ?

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Recently, some US providers of infrared diagnostic services received warning letters from the FDA due to the claim that infrared thermal imaging as ‘stand-alone’ procedure, is itself sufficient to diagnose breast cancer [1]. Phil Hoekstra, past president of the American Academy of Thermology expressed his consent with the FDA to regulate the activities of irresponsible users of infrared thermography [2].

However, another statement of Dr Hoekstra “a*ny objective review must conclude that Diagnostic Infrared Imaging as a screen for breast cancer is beyond any investigational level of development.*” may raise further discussion as infrared thermal imaging is not recommendend by any recent guideline for breast cancer screening . A review discussing supplemental screening method s for breast cancer, concluded “*because of the lack of any proven efficacy, thermography has no validated role in screening.*” [3]. Brodersen et al stated in a critical review on the benefits and harms of screening “*that no randomized trials have been conducted for screening for breast cancer with thermography, ultrasound or magnetic resonance imaging*” [4]. The also argue that “*observational studies are notoriously unreliable for estimating the benefits of cancer screening”.* A group of Australian authors could not find *“eligible papers for CT scanning, magnetic resonance spectroscopy (MRS), scintimammography, electrical impedance, infrared spectroscopy, light scanning, positron emission tomography, or thermography* “[5]. Lee et al. also mentioned that “*no large peer-reviewed studies support the routine use of other imaging techniques such as thermography, PET, transilumination, electrical impedance scanning or optical imaging for breast cancer screening* “[6]. None of these imaging modalities is endorsed by the American College of Radiology or the Society of Breast Imaging. [6](Table 1)

Table 1
Imaging modalities not recomendend for breast screening

	Brodersen et al 2010	Irwig et al, 2004	Lee et al 2010
ultrasound	X		
MRI	X		
thermography	X	X	X
CT scanning,		X	
magnetic resonance spectroscopy(MRS)		X	
scintimammography		X	
electrical impedance		X	X
infrared spectroscopy		X	
light scanning,		X	X
positron emission tomography,		X	X

For understanding the reasons, why thermography is not a recognised method for breast cancer screening, the terminology and methodology of medical screening is briefly reviewed.

What is screening ?

Nicholas J Wald gave the following definition in 1994: *“Screening is the systematic application of a test or enquiry to identify individuals at sufficient risk of a specific disorder to warrant further investigation or direct preventive action, amongst persons who have not sought medical attention on account of symptoms of that disorder.* “[7]. A similar definition ”*routine periodical investigation of large non symptomatic strata of the population*” was adapted by the German epidemiologist N.Becker (8) from Union Internationale Contre le Cancer (UICC). The screening procedure results in high probablity of having or not having the disease, and must be differentiated from early diagnosis of disease usually performed after positive screening or after an health check based on individual request. A positive screening result leads to diagnostic mammography eventually supplemented by ultrasound or magnetic resonance imaging. Finally, the diagnosis of cancer has to be confirmed by histology based on a biopsy from the suspected area of the breast.

The aim of screening for breast cancer is the reduction of mortality. This can be achieved by detection of the tumour in the preclinical, non symptomatic phase of the disease. Other outcomes such as survival time or distribution of tumour stage should not be used for the evaluation of an effective screening method. In addition, only prospective randomised studies which compare different screening tests, lead to unbiased results. Observational and retrospective studies do not allow to conclude on the effectiveness of a screening test.

Other important screening criteria are sensitivity, specificity and predictive value. While sensitivity is a measure how many investigated subjects have the suspected disease, specificity provides a figure of healthy subjects or respectively of subjects who do not carry a marker of the disease. Sensitivity and specificity are usually calculated from the distribution of true positive, true negative, false positive and false negative cases. Predictive values can be derived from true and false case, but they depend also on the prevalence of the disease in a given sample.

Table 2
Comparison of 2002 and 2009 USPSTF (=United States Preventive Services Task Force)breast cancer screening recommendations (modified from Hinz et al [12])

	2002 USPSTF guidelines	**2009 USPSTF guidelines**
Age to begin mammograms	40 years	50 years
Frequency of mammograms	Annually	Every 2 years
Age to end regular mammogram screening	No recommended age to stop screening	Insufficient evidence to assess benefits and harms of screening mammography in women aged ≥75 years
Clinical breast examination (CBE)	Insufficient evidence to recommend for or against routine CBE alone to screen for breast cancer	Insufficient evidence to assess additional benefits and harms of CBE beyond screening mammography in women aged ≥ 40 years
Self breast examination (SBE)	Insufficient evidence to suggest for or against either CBE or SBE	Recommends against SBE

Risks of screening

Gotzsche and coworkers described the benefits and risks of mammography screening for breast cancer, as follows [9]

- *If 2000 women are screened regularly for 10 years, one will benefit from the screening, as she will avoid dying from breast cancer*
- *At the same time, 10 healthy women will, as a consequence, become cancer patients and will be treated unnecessarily. These women will have either a part of their breast or the whole breast removed, and they will often receive radiotherapy and sometimes chemotherapy*
- *Furthermore, about 200 healthy women will experience a false alarm. The psychological strain until one knows whether it was cancer, and even afterwards, can be severe.*

A review from 2009 reported estimates of breast cancer mortality reduction in range between 24 and 48 % after correction for selection bias [10]. However, the observed reduction of mortality must not be explained as an effect of screening only, as adjuvant treatment contribute to mortality reduction in the same amount as the screening programme.

A recent analysis of the intention-to-treat results found an overall relative reduction in breast cancer mortality of 19% [11]. However, ther authors stated that benefits and harms, particularly over-diagnosis, need to be balanced as they differ by age-groups.

The guidelines of United States Preventive Services Task Force for breast cancer screeing, first published in 2002, have been revised in2009, when some important changes in recommendations have been made (table 2). A survey among gynecologic care providers.on their knowledge of and adherence to the revised cancer screening guidelines reported relatively low awareness of the revised guideline[12].

Screening with thermography

A health technology asssement report, published 2004 in New Zealand investigated two objectives: Firstly, what is the international evidence on the effectiveness, benefits, harms and costs of using infrared thermography as a screening tool for breast cancer and secondly, what is the international evidence on the effectiveness, benefits, harms and costs of using infrared thermography as an adjunctive diagnostic tool for breast cancer? [13].The report accepted only one study for the screening topic [14] and two others for the topic adjunctive diagnosis [15,16].

Although several authors reported large samples of patients investigated with infrared thermography for breast cancer, none of these studies was conducted in a systematic way and with a proper study design.

Gautherie & Gros reported the course of disease of 1,245 women with stage III thermograms at the initial examination. These cases were selected from approximately 58 000 women examined between 1965 and 1977. It is not described if the women were recruited through a systematic screening programme or were collected from individual requests for breast health checkings "*Of the 1,527 Th III patients, 784 (51%) had no abnormal physical, mammographic or echographic findings; 461 (30%) had conditions diagnosed as benign disease, mainly cystic mastopathy; and 282 (18%) had conditions promptly confirmed histologically as cancer From among the 784 apparently normal women, malignancy was detected in 177 within the first two years following initial examination, and an additional 121 cases were found during the following two years.*" [17] Unfortunately, details how the follow up was conducted, especially which finding resulted in a request for biopsy, are not provided. It remains unclear whether the mammography or the ultrasound image changed from normal to abnormal and how many of these suspicious findings have been confirmed by histology.

Agnes Stark and Stanley Way reported a large retrospective study in which 4621 women who deliberately asked for breast cancer screening were investigated by thermography and clinical breast examination[18]. Abnormal thermograms have been recorded in 628 women and these women were further investigated by mammography. Of these 628 mammograms 198 were considered negative, 326 abnormal but negative for malignancy, representing a false positive rate of 524/4621 = 11,3%. 42 mammograms were positive for malignancy and biopsy was performed resulting in 27 cases of cancer. 62 mammograms were considered suspicious of malignancy. During follow up.of the suspicious casese 9 other breast cancers have been detected. The true positive rate of thermography for histologically confirmed breast cancer was 36/4621 or 0.8%., the corrected false positive rate was 12.8%. 7 women without pathological findings in thermography and clinical examination developed breast cancer within 12 month after screening, therefore the false negative rate was equal to 0.015% and true negative rate was 86.1%.

An analysis of 16000 self-referred women found thermography less effective than mammography in the detection of small preclinical breast malignancies [19]. Biopsy was performed in 406 patients, 139 of them had histologically confirmed breast cancer. Although 17.9% (2864 patients) of all women had a positive thermogram, only 39% (54 cases) of all the proven cancer cases had a pathological thermogram. Mammography was positive in 91% of all detected malignancies.

Lloyd Williams conducted a study on breast screening com- paring thermography and clinical examination [14], Sus- picius cases have been referred to mammography . Patients were examined again after a period of 5 years, A positive thermogram was found in 2681 (26.2%) of 10229 women at their screening visit. For thermography true positive rate was 0.35 %, false positive rate was 26.0%, false negative rate0.25% and true negative rate was 74:0%.

None of these studies hat a randomised design, but all concluded that differentiation of breast diseases is not possible by thermography. Originaly included in all breast cancer screening programmes conducted in the seventies of the 20th century, infrared thermal imaging was abandoned due to its low diagnostic sensitivity {14].

No systematic screening with modern focal plane thermal imagers was performed yet [13]. However, a number of recent publication proposed infrared thermal imaging as appropriate technique for breast cancer screening, but in their arguments the authors confused screening with early diagnosis [20,21,22]

Adjunctive diagnosis by thermography

Keyserlingk et al reported a retrospective chart review selecting 100 women with either ductal carcinoma in situ (4 patients), invasive breast cancer stage 1 (42 patients) or stage 2 cancer (54 patients). All selected patients had received clinical breast examination, infrared thermography and mammography [15]. 61% of all patients had a suspicious palpable abnormality, 34% had an equivocal finding at palpation and only 5 women hand a non specific exam. Mammography was considered suspicious for cancer in 66%, while 19% were contributory but equivocal and 15% were considered nonspecific. Minor variations in infrared imaging were observed in 17% and 83% presented with 1 (34%, 2 (37%) or 3 (12%) thermal abnorrmalities. In addition, a sample of 100 women with benign histology were incompletely reported. Only 19 patients had normal findings in infrared thermography prior to biopsy. While only 30 % had preoperatively abnormal mammography, the indications for surgery in these 100 patients with benign breast disease remains unclear.

The frequently cited stud by Pariski used mammograms for the definition of regions of interest in infrared images [16]. The thermograms were evaluated by a software programme generating and index of suspicion of malignant disease. Information on the decision structure of the used algorithm is not provided. As 40% of recruited patients have been excluded from analysis, sensitivity of infrared imaging might have been overestimated. Details on mammography, clinical examination or ultrasound (in 45% of recruited patients) have not been provided.

Arora et al. applied infrared thermal imaging in a prospective clinical trial in 92 patients for whom a breast biopsy was recommended based on prior mammogram or ultrasound [23]. Based on thermal features, which are not described in the study, three scores were generated: an overall risk score ranging from 0 to 7 (screening mode) , a clinical score based on patient information, and a third assessment by artificial neural network. Sixty of 94 biopsies were malignant and 34 were benign. Thermography identified 58 of 60 malignancies with 90 to 97% sensitivity and 12 to 44% specificity depending on the mode used. The low specificity of thermal imaging is due to high numbers of false positive cases.

Wishart et al. reported also a study in which patients were investigated by thermal imaging prior to breast biopsy [24]. 100 women with a mean age of 57 (33 to 87) years had in total 106 biopsies, comprising 65 malignant and 41 benign findings. Analysis of the infrared scans was performed, blinded to biopsy results, in four different ways: screening report, artificial intelligence (neural network) expert manual review and a novel artificial intelligence programme. The screening report achieved a diagnostic sensitivity of 53% and specificity of 41 %. The neural network evaluation had with 48% a lower sensitivity than the screening programme but a much better specificity of 78%. Both the expert review and the modified artificial intelligence programme found a specificity of 48% and sensitivity of 78% and 79% respectively. Infrared imaging performed better in women younger than 50 years (21 patients) than in patients between 50 and 70 years (74 women)as in the latter group specificity was best in the modified artificial intelligence programme with 37%. However, due to the low number of younger patients the diagnostic power might be overestimated.

The most recent publication on the diagnostic value of thermal imaging for malignant biopsy findings was conducted in England [25]. Infrared thermograms were recorded prior to indicated breast biopsy, the thermograms were evaluated by an experienced physician and the results were compared with the histological findings. Thermography had 90 true-negative, 16 false-positive, 15 false-negative and 5 true-positive results. The sensitivity was 25%, specificity 85%, positive predictive value 24%, and negative predictive value 86%. The authors concluded that thermography "i*s not indicated for the primary evaluation of symptomatic patients nor should it be used on a routine basis as a screening test for breast cancer* ".

Conclusion

Despite numerous publications on breast thermography, the available evidence does not allow to recommend thermal imaging for neither screening nor adjunct diagnosis of early breast cancer.

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Temperature of the face in children and fever screening by thermography

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SUMMARY

Method. **Temperature of the inner canthus, forehead and nose was measured in 31 afebrile children (20 female, median age 9.1 years and 11 male, median age 9.0 years) using infrared thermography (using 7 x 7 pixel regions of interest).**

Results. **Median inner canthus temperature was 1.3°C warmer than the forehead, and 3.0°C warmer than the nose. The range of temperatures recorded across all subjects was 1.3°C at the inner canthus, 2.8°C at the forehead and 9.3°C at the nose. Similar results were obtained regardless of whether maximum or mean pixel values were considered from each region of interest. In 18 subjects who attended for thermography on multiple occasions, the intra-individual range of temperatures recorded in the median subject was 0.8°C at both the inner canthus and forehead, and 3.7°C at the nose.**

Conclusions. **Inner canthus temperature clusters tightly around the median value in afebrile children, is warmer than the forehead, and is recommended as the best site to estimate core temperature for fever screening purposes. Careful attention to imaging protocol and thermal camera calibration will be required to ensure screening accuracy.**

KEY WORDS: Fever Screening, Infrared Thermography, inner canthus, forehead, children

GESICHTSTEMPERATUR VON KINDERN UND FIEBERSUCHE MITTELS THERMOGRAPHIE

Methode: **Die Temperatur des inneren Augenwinkels, der Stirn und der Nase wurde bei 31 Fieber freien Kindern (20 weiblich mit einem medianen Alter von 9,1 Jahren, 11 männlich mit einem median en Alter von 9,0 Jahren) mittels Infrarot Thermographie unter Verwendung von Meßflächen in der Größe von 7 x 7 Pixel .**

Ergebnisse. **Die mediane Temperatur des innerern Augenwinkels war um 1,3°C höher als die Stirntemperatur und um 3,0°C höher als die Nasentemperatur. The range of temperatures recorded across all subjects was 1.3°C at the inner canthus, 2.8°C at the forehead and 9.3°C at the nose. Similar results were obtained regardless of whether maximum or mean pixel values were considered from each region of interest. In 18 subjects who attended for thermography on multiple occasions, the intra-individual range of temperatures recorded in the median subject was 0.8°C at both the inner canthus and forehead, and 3.7°C at the nose.**

Conclusions. **Inner canthus temperature clusters tightly around the median value in afebrile children, is warmer than the forehead, and is recommended as the best site to estimate core temperature for fever screening purposes. Careful attention to imaging protocol and thermal camera calibration will be required to ensure screening accuracy.**

SCHLÜSSELWÖRTER: Fiebersuche, Infrarot Thermographie, innerer Augenwinkel, Stirn, Kinder

Thermology international 2011, 21(3) 81-85

Background.

Acute respiratory infection poses a major risk to public health. Severe acute respiratory syndrome (SARS), first identified in China in November 2002, infected 8098 people in 26 countries in less than a year, and mortality amongst this group was almost 10% (1). The threat posed by influenza infection is also particularly important, but the severity of this threat varies widely according to the specific infection. In 1918-19, for example, a worldwide influenza pandemic is estimated to have killed between 40 and 50 million people (2). In contrast, the 2009 A/H1N1 pandemic killed less than 150 people in the UK up to November 2009 with a case fatality rate of less than 0.03% (3)

Pandemic refers to the worldwide transmission of an infectious disease between humans at a level greater than that which normally occurs. The pandemic phase of infectious disease preparedness is stage six on a six-point scale defined by the World Health Organisation (WHO) (4).

During periods of pandemic influenza infection, governments and public health organisations must implement plans for emergency preparedness in order to limit the effect of the disease on society and the economy (5). These plans are typically structured around three elements:

- limiting the spread of infection
- prompt and appropriate treatment for infected individuals
- resilience management of services affected by staff absence and logistics disruption

Most governments recognise that effective limitation of the spread of influenza can reduce the need to treat large numbers of patients and implement emergency plans: it is better to prevent the problem “at source” than deal with its ramifications later. In recent years, increasing globalisation and international travel have meant that the emphasis on limiting the spread of infection has become focused on national borders and ports of entry, particularly airports (6).

A key symptom of early influenza infection is a raised core body temperature i.e. fever, and fever screening at airports has been attempted during recent respiratory infection outbreaks (7). Infrared thermography shows promise for this purpose since the non-contact nature of the measurement has the potential to be both rapid and convenient, particularly if a facial site is recorded during transit through the airport. To date, however, thermography for fever screening has suffered from a lack of international standardisation and there is little data confirming the temperature of any candidate facial site in either a healthy or infected population. In order to help address this issue, the International Standards Organisation has drafted a standard outlining the recommended protocol for passenger screening (8). The inner canthus of the eye is preferred as the facial site most representative of core temperature and least influenced by environmental temperature. This is because the skin blood flow at the inner canthus arises from the internal carotid artery – a facial site supplied by deep rather than superficial arterial blood.

Ring et al. (9) and Pascoe and Fisher (10) have both studied the relationship between inner canthus temperature and other accepted measures of core temperature in groups of healthy children and young adults respectively. Their results appear to confirm the utility of the inner canthus as an estimate of core temperature, but more studies are required before thermography can be used with confidence as a fever screening tool. In particular there is a need for temperature data from children, who are likely to be the main carriers of infection during outbreaks of pandemic influenza (11).

In our retrospective study, we measured inner canthus temperature in 31 healthy (afebrile) children who attended the microvascular lab at the Royal Free Hospital for infrared thermography of the face as part of a research project into childhood morphoea (12). We also measured the temperature of the forehead and nose in each patient. We considered median skin temperature values in both boys and girls at first visit. In a smaller number of patients who attended for thermography on four or more occasions, we considered the intra-individual variability of facial temperature measurements. We compared our findings to other published measurements of facial temperature, and also considered the extent to which infrared imager performance might limit the utility of thermography for fever screening applications.

Method

We re-analysed the facial thermograms of 31 children with *en coup de sabre* morphoea who had attended the Royal Free Hospital as part of studies on morphoea co-ordinated by Great Ormond Street Hospital (12). Twenty of the patients were female (median age 9.1 years, range 17.3 years) and eleven were male (median age 9.0 years, range 10.4 years). All the patients and their parents/guardians gave informed consent for recording and analysis of a thermogram as part of the original study protocol (which was approved by the ethics committees of the Great Ormond Street and Royal Free hospitals). On the day of attendance all patients were fit and well, and presumed afebrile, although we recorded no other measurements of core body temperature.

Each 320 x 240 pixel thermogram was captured by a FLIR SC500 infrared imager (uncooled microbolometer, 7-14 μm) (FLIR Infrared Systems, West Malling, UK) which was factory-calibrated annually throughout the study period. Image analysis was performed using FLIR Thermacam Researcher software. All thermograms were anterior views of the face, recorded with the patient seated facing the imager, the imager adjusted to a height level with the face, and the face filling the entire field of view from the crown of the head to the chin. The thermogram temperature scale for presentation of all images was 30°C - 36°C (temperatures outside this display range were still included in analyses: camera range -40°C - 120°C at 14-bit resolution). All patients rested for 15 minutes at a room temperature of 23±1°C prior to thermography.

All the patients had a hemifacial distribution of en coup de sabre morphoea, a condition which can cause inflammation of the skin in a linear pattern affecting, *inter alia,* the eye, nose and forehead. Consequently, for the purpose of this study we chose thermographic regions of interest (ROIs) for temperature calculation from the side of the face contralateral to the morphoea lesions.

The three ROIs were:

- at the inner canthus of the eye
- at the forehead immediately superior to the apex of the eyebrow
- at the tip of the nose (no patient had a morphoea lesion at the midline of the face in this area)

An example thermogram showing the three ROIs is presented in fig. 1. All ROIs were squares of dimension 7 x 7 pixels, giving a measurement area across 49 pixels. We considered both the mean temperature value calculated from the 49 pixels, and also the maximum pixel value recorded within each ROI.

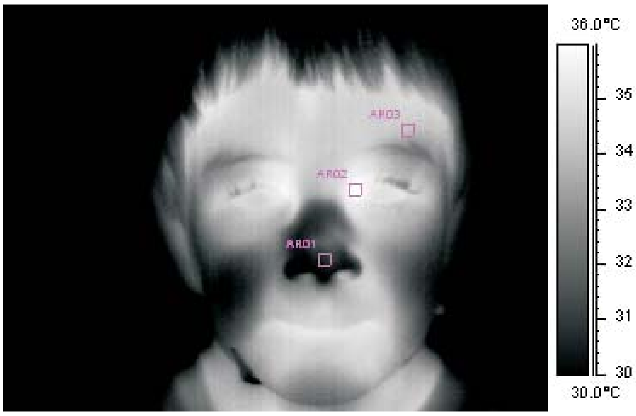

Fig.ure 1
Example facial thermogram with three ROIs.

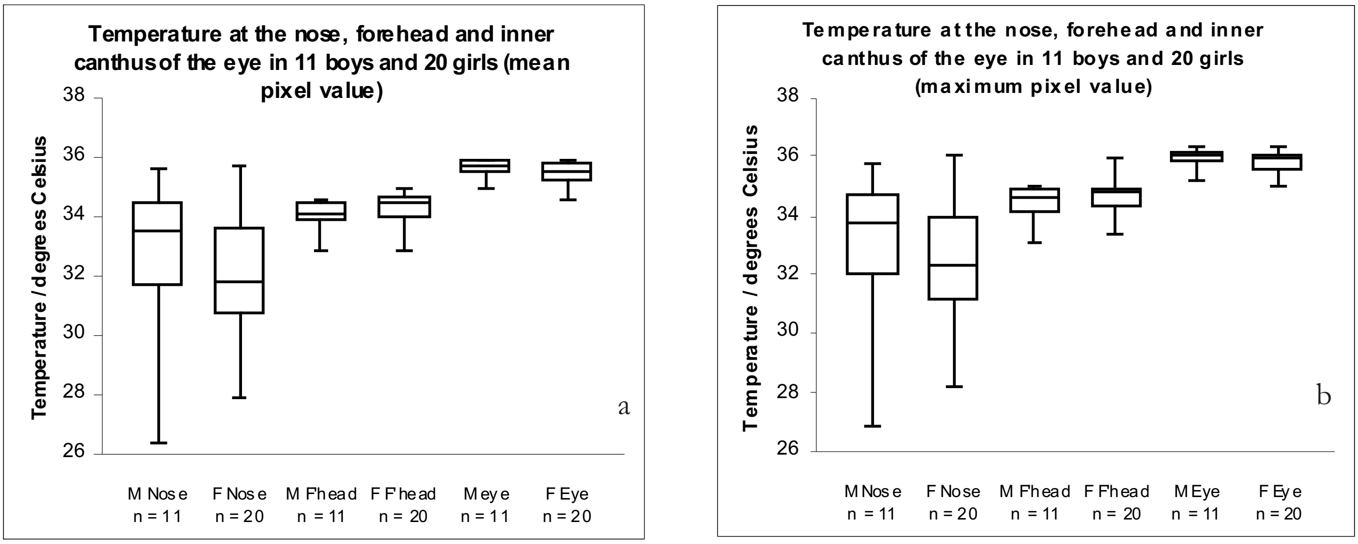

Figure. 2
: Temperature at the nose, forehead and inner canthus in 11 boys and 20 girls

Temperature data for all three ROIs was considered for all 31 patients at first visit. In addition, we looked at the intra-individual variability in facial temperature measurements in 18 of the patients who had attended for repeated thermography on between four and seven occasions over a period of up to 50 months.

Results

Temperature data recorded from the 11 males (M) and 20 females (F) at all three ROIs at first visit is plotted using the mean pixel values in fig. 2a. The same data is plotted in fig. 2b using the maximum pixel values detected within each ROI. In each boxplot the median value is represented by the bar, the box indicates the interquartile range, and the whiskers show the full range of the values.

We avoided detailed statistical analysis of such a small dataset; however trends from the data are clear from the box plots. Girls had a slightly lower median nose temperature than boys, but there were no evident differences between gender in the median values of temperature at the other two facial sites. Plotting the maximum pixel value elevated all median values by approximately 0.5°C in comparison to the plots using the mean pixel value from each ROI. The spread of the data about the median values was not changed by considering maximum pixel value instead of mean pixel value.

Using the maximum pixel values from fig. 2b, median inner canthus temperature was 35.9°C in girls and 36.1°C in boys (36.0°C across all subjects). The maximum inner canthus temperature recorded was 36.3°C. The inner canthus temperature ranged over 1.3°C across all subjects.

Median forehead temperature was lower than inner canthus temperature (by 1.3°C across all subjects) and the range of values across all subjects was 2.8°C. The lowest temperatures, along with the greatest range of values (9.3°C) were seen at the nose.

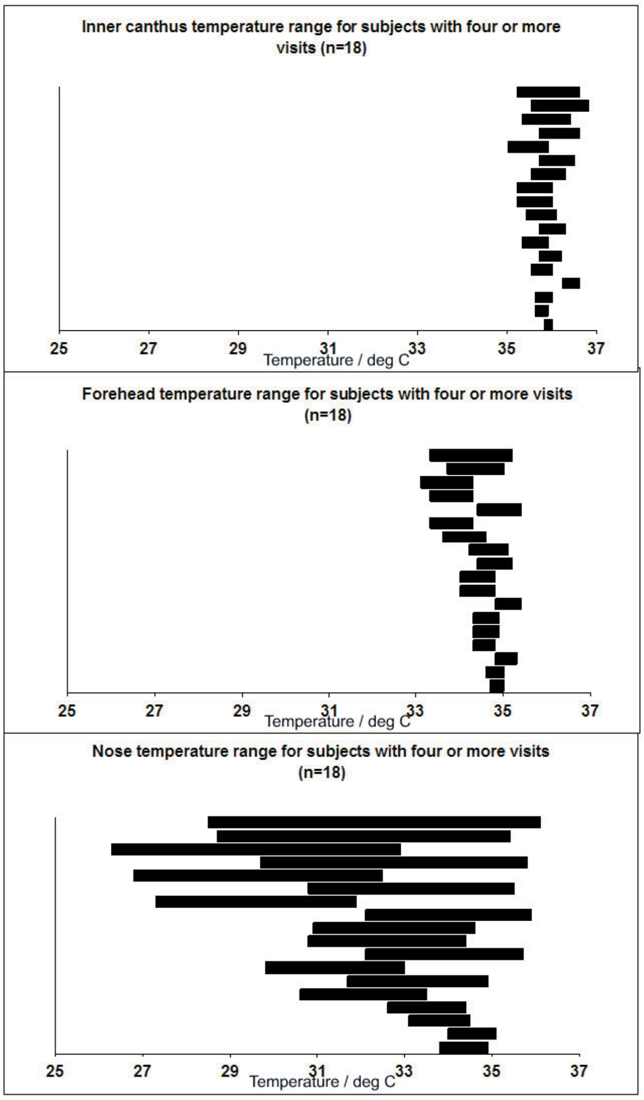

Figure. 3
Within-subject temperature range at the inner canthus, forehead and nose on repeated (four or more) visits (n=18)

Figure 3 describes the within-subject temperature ranges (using maximum pixel values) from the sub-group of 18 patients who attended for thermography on four or more occasions.

Subjects are plotted ascending the y-axis in order of increasing temperature range on repeated visits. At all three measurement sites, the maximum range of readings recorded on repeated visits was approximately twice the median value.

Discussion

The ideal fever detection protocol for screening large numbers of subjects in transit should have a low “false positive” rate (i.e. low type 1 error rate). This is essential in order that the flow of passengers is maintained and afebrile travellers are not inconvenienced needlessly by further checks. Equally, the protocol should exhibit a very low “false negative” rate (i.e. low type 2 error rate) if the spread of respiratory infection is to be avoided during periods of pandemic. In reality, screening test sensitivity and specificity must be carefully balanced to meet detection needs, and these are dependent on the cut-off point chosen to discriminate “normal” from “abnormal,” along with the distribution of the measurand in the healthy and disease groups, and also the uncertainty introduced by the limitations of the measurement instrument.

Our data for inner canthus temperature in afebrile children go some way to describing the temperature distribution across the healthy paediatric population. The 1.3°C range that we report suggests inner canthus temperature clusters quite tightly in afebrile children. This is one prerequisite for a screening test that may be able to differentiate the afebrile from the febrile. However our data do not address the distribution of inner canthus temperature in febrile children, and nor are we able to comment on whether there is substantial overlap between the temperatures that might be recorded in afebrile and febrile groups. Ring et al. (9) included a small group of febrile children in their study, and were able to show that inner canthus temperature in this group also clustered tightly, and showed minimal overlap with the temperatures recorded in an afebrile group. This augurs well for the utility of fever screening by thermography, but it may be necessary to characterise each pandemic respiratory infection on a case-by-case basis. Not all influenza-like illnesses may necessarily lead to high fever in the early stages of infection, and this would severely limit the utility of any fever-screening methodology (7).

The temperature data from the nose and forehead support the view that these sites are inappropriate for reliable estimation of core body temperature. Nose skin temperature is partly regulated by sympathetic factors, and therefore probably dependent on ambient temperature and emotional state. Harding et al. (13) have commented on the correlation between finger and nose temperature: our subjects with the coldest noses may simply be those with the strongest tendency to peripheral vasospasm on cold exposure.

The forehead is a more interesting site because many fever screening thermography protocols rely erroneously on this area to estimate the core temperature of the subject. Our data indicate that forehead temperature is 1.3°C cooler than the inner canthus of the eye: hence forehead temperature must be underestimating core temperature. Ring et al. (9) also reported the forehead to be 1.3°C cooler than the inner canthus. Our retrospective study lacked an independent control measure of core temperature (e.g. tympanic, axilla), so we are not able to comment on whether inner canthus temperature accurately estimates core temperature.

The range of forehead temperatures we report was 2.8°C: more than twice the range reported for the inner canthus. This is another factor limiting the suitability of the forehead as a fever screening site, and in conditions such as an airport (where environmental temperature varies more than in our thermography lab) we might expect the range of forehead temperatures recorded to be even wider.

Fig. 2 confirms that the same conclusions can be drawn from the temperature data regardless of whether maximum or mean pixel value is taken from each ROI. However there is an offset in the two types of reading of about 0.5°C, so the two analyses cannot be used interchangeably and it must be made clear which measurement protocol is being followed in all reporting. Maximum pixel value may be preferable due to ease of calculation in a rapid screening situation. Maximum pixel value analysis may be more susceptible to an instrument fault however: any individual pixel within the ROI that is not calibrated correctly could flag as an erroneous maximum value.

Instrument performance may indeed be the limiting factor in the utility of thermography for fever screening. Our maximum pixel value data indicate the median inner canthus temperature in afebrile children to be 36.0°C, and the median forehead temperature to be 34.7°C. Both of these values under-read the figures calculated by Ring et al. (9) by 0.6°C, although the standard deviation of the data is similar in both studies. This suggests an offset in the calibration of the thermal imaging devices used in the two studies. Whilst modern uncooled focal plane array imagers exhibit creditable stability of reading across repeated images, their absolute accuracy is typically quoted as ±2°C, which allows for a discrepancy of up to 4°C between any two factory-calibrated thermal imagers. Such uncertainty would be problematic when comparing fever data from two study sites, or indeed when applying a single recommended cut-off temperature for fever detection to multiple screening sites such as a national airport network.

Rigorous camera calibration in fever screening, as defined in the ISO guidelines (7), is therefore essential to the success of the technique. The calibration source should operate at temperatures relevant to face imaging (i.e. around 36°C) and should be available in-situ at every fever screening installation. Ideally it should be included in each face thermogram as a calibration control. Simpson et al. (14) have demonstrated a portable fixed-point validation system for medical thermography that reduces the uncertainty in thermography measurements to ±0.4ºC (k=2).

Conclusion

We have presented a small retrospective study which corroborates the important work of others in the validation of infrared thermography for pandemic fever detection. More work is required to validate thermographic fever screening performed to the ISO standard, and particularly to look at the performance of the technique in "real world" situations such as airports, across multiple centres, and with febrile subjects included.

Fever screening thermographs may also be of value in situations other than border control: they could be employed at any place where people gather and it might be desirable to restrict the transit of infected individuals e.g. in hospitals or schools.

Reliable fever detection by thermography is probably technically achievable, but it is only likely to be widely employed if the cost-benefit analysis is favourable. If the set-up and running costs of fever screening programmes outweigh the perceived socio-economic benefits of reduced infection rates then funding will not be forthcoming. In this context, the low-cost uncooled imagers now on the market in Europe at €3000 or less are worthy of further investigation. Image resolution is low (typically 200 x 200 pixels or less) and careful calibration will be particularly important, but nonetheless these devices might prove adequate for fever screening applications if employed to the ISO standard.

Thermography shows promise as a rapid fever detection technique, but only provided all components of the ISO standard are employed.

Acknowledgements

We thank Prof. P. Woo and Prof. J. Harper (Great Ormond Street Hospital, London, UK), Prof. C. Denton (Royal Free Hospital, London, UK) and Dr. L. Weibel (University Hospital of Zurich, Switzerland) for their contributions to the original study design and data collection.

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(Receiveid on 17.06.2011, accepted on 25.06.2011)

News in Thermology

Comment on FDA WarningLetters to thermographic equipment providers

Philip P. Hoekstra, III, PhD, DABT

Medicine as an industry and a practice is more heavily regulated by the various agencies of Government than the nuclear power industry. Diagnostic Infrared Imaging in all of its iterations and by what-ever name we wish to use (thermography, Digital Infrared Thermal Imaging, infrared mammography or thermology) has been a notable exception to this pattern of regulation. Doubtless this exception is due, at least in part, to the completely non-invasive and non-harmful nature of infrared imaging and the fact that it has not been incorporated into Radiology, as has every other diagnostic imaging procedure. Consider that X-ray mammography is the most regulated application in the entire heavily-regulated field of Medicine and the contrast becomes clear for Diagnostic Infrared Imaging as it is applied to the detection of breast cancer. Medical thermographs (the instruments) were actively applied in the diagnostic process for breast cancer, cerebral and peripheral vascular disease and peripheral neuropathies long before the US Food and Drug Administration received a Congressional mandate to regulate medical devices. Due to the high costs related to the FDA's formal approval process for Class I Devices, new generations of medical thermographs have been submitted to the FDA in order to be 'determined to be substantially equivalent' with the "Grandfathered" instruments as Class III devices through the 510(k) process.

Diagnostic Infrared Imaging has been known to and supported by various Federal regulatory agencies and institutes. In 1972, a letter from the Acting Commissioner of the US Health, Education and Welfare agency approved Diagnostic Infrared Imaging (thermography) as a diagnostic technique "beyond the experimental stage of development" for the detection of breast cancer, vascular disease and peripheral nerve disease as determined by an independent panel of experts as to be a Medicare benefit. In 1982, the FDA listed Diagnostic Infrared Imaging (thermography) as an adjunctive diagnostic screen for the detection of breast cancer. In 2005, the FDA reaffirmed Diagnostic Infrared Imaging for breast cancer screening. In 2002, the National Cancer Institute listed Diagnostic (Digital) Infrared Imaging as a means for the early detection of breast cancer and stated, "images of these temperature variations, which may be among the earliest signs of breast cancer". During the span of approximately forty years, Diagnostic Infrared Imaging, as an industry, has grown considerably in the aura of relative regulatory neglect but also without any effective standards for application or practices. While the growth of this industry has spired innovation and entrepreneurs, it has also attracted irresponsible claims for imaginary applications and pseudo- experts. While Medicine, as an institution, has either tried to ignore Diagnostic Infrared Imaging or exclude it as a medical practice, the growth of the industry has reached a scale that it is too widely recognized to ignore.

The FDA also has regulatory authority over the claims made by the manufactures and sellers of medical devices either from their literature or their websites. In the past few years, I have heard rumors of the FDA applying a new level of scrutiny to the Diagnostic Infrared Imaging industry while I have witnessed the promulgation of absurd claims for diagnostic application. Only recently has the rumored regulatory attention of the FDA been manifested in the form of Warning Letters that challenge the claims of some equipment sales companies. In their promotional material, these companies has misrepresented Diagnostic Infrared Imaging as a 'stand-alone' procedure, itself sufficient to diagnose breast cancer and made diagnostic claims for "Visceral Health", "Digestive Disorders: Irritable bowel syndrome, diverticulitis and Crohn's disease", "Immune Dysfunction", "Nutritional disease (alcoholism, diabetes)", "Fibromyalgia", "Chronic Fatigue" and "Gingivitis". The FDA contends these claims are "outside the 510(k) clearance of the device" and, then, the thermographic systems as "adulterated" and "misbranded". To the best of my knowledge and as a recognized expert in the field, I know of absolutely NO credible evidence for such novel applications for Diagnostic Infrared Imaging. These purported applications must be considered investigational at best and speculative by any objective standards. There is an implicit burden to substantiate the claims for applications of a medical device that has not been met (or, for that matter, even attempted) by these rogue companies. At least one company attempted to evade the regulatory scrutiny of their thermo- graphic system by rebranding it with an entirely novel classification as a "health indicator". I wish I knew what that meant.

There are more than one thousand articles in the peer-reviewed scientific and medical literature relevant to Diagnostic Infrared Imaging as applied as a screen for breast cancer and the experience of millions of world-wide case studies over more than fifty years. While not yet engrained into the mainstream of Medicine, any objective review must conclude that Diagnostic Infrared Imaging as a screen for breast cancer is beyond any investigational level of development. I urge that we should not abrogate our responsibility to our peers or our patients by representing Diagnostic Infrared Imaging as anything less than a legitimate diagnostic application for screening breast cancer in order to evade the scrutiny of the regulators.

I don't have any inside information relative to the scope or the scale of the FDA's recent regulatory actions for Diagnostic Infrared Imaging. While it is yet possible these actions could develop into a 'witch hunt'; thus far, the FDA's regulatory attention has been only been directed toward the most irresponsible claims of some of the rogue companies involved in Diagnostic Infrared Imaging, and I would contend that this bit of regulation is not misapplied.

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06 January 2011 FDA Warning Letter to Ms. Gaea Powell of Central Coast Thermograhpy in San Luis Obispo, CA.

22 March 2011 FDA Warning Letter to Dr. Joseph Mercola of Thermography Diagnostic Center in Hoffman Estates, IL.

04 April 2011 FDA Warning Letter to Dr. Peter Leando of Meditherm, Inc. in Parkland, FL.

The 11th Quantitative InfraRed Thermography Conference

hat will take place on June 11-14th, 2012 at University of Naples Federico II, Naples, Italy.

The Quantitative InfraRed Thermography (QIRT) conference is an international forum which brings together specialists from industry and academia, who share an active interest in the latest developments of science, experimental practices and instrumentation, related to infrared thermography.

The conference will include technical sessions with oral and poster presentations concurrent with an exhibit. You are invited to present your latest research, development or application at this meeting. The subject matter may cover any aspects of Quantitative Infrared Thermography.

The DEADLINE for submitting a 2-page abstract is DECEMBER 15, 2011.

Value Adding Factors

Abstract and Paper Submission handled electronically via the conference website

Papers will be published online in the QIRT Open Archives and can be found via Google Scholar. All accepted conference papers will be also distributed to conference participants in a USB flash drive. Selected papers will be published on QIRT Journal after review by experts.

High level Keynote lectures

Awards to the best three conference contributions from students

Extra Events: *QIRT Pre-Conference courses* (scheduled on Sunday, June 10), *Technical Visit to CIRA wind tunnels* (scheduled on Friday, June 15), *Symposium in honour of Prof. Giovanni M. Carlomagno* (scheduled on Monday morning, June 11).

The University of Naples Conference Centre, superbly located in Naples waterfront which is unique for its focus on creative, cultural, entertainment and leisure activity. Naples location offers also an ideal base for international visitors hoping to experience Campania's iconic attractions: Capri and Ischia islands, Herculaneum, Pompeii Positano, Sorrento, Ravello, all accessible within an hour.

The registration fee includes the USB flash drive proceedings as well as lunches, coffee breaks, the welcome reception and the social dinner. For regular participants only, fee includes also a subscription to the QIRT Journal for 2 years. A reduced student registration fee has been set in order to allow as many students as possible to attend this meeting.

An exhibition will take place during the workshop. Space is available for companies and institutions wishing to display their products and services and to develop new contacts and partnerships. Sponsorship opportunities are also available.

For further information and updates please visit:
www.qirt2012.unina.it or contact the organizing committee at qirt2012@unina.it

Please mark the above dates on your calendar and pass this information to colleagues who might be interested. Please feel free to contact me if you have questions or comments.

17th International Conference on Thermal Engineering and Thermogrammetry (THERMO)

SELECTED SHORT PAPERS and EXTENTED ABSTRACTS

Pixel-wise real-time advanced calibration method for thermal infrared cameras

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Introduction

Accurate radiometric calibration is a key feature of modern infrared cameras. Considering the newly available infrared focal plane arrays (FPA) exhibiting very high spatial resolution and faster readout speed, we developed a method to provide a dedicated radiometric calibration of every pixel. The novel approach is based on detected fluxes rather than detected counts as is customarily done. This approach features many advantages including the explicit management of the main parameter used to change the gain of the camera, namely the exposure time. The method not only handles the variation of detector spectral responsivity across the FPA pixels but also provides an efficient way to correct for the change of signal offset due to camera self-emission and detector dark current. The method is designed to require as few parameters as possible to enable a real-time implementation for megapixel-FPAs and for data throughputs larger than 100 Mpixels/s. Preliminary results with a high-speed 3 μm to 5 μm infrared camera demonstrate that the method is viable and yields small radiometric errors.

Radiometric Calibration

Infrared cameras have traditionally been calibrated using the detector raw output in units of counts. In this paper we present a new method that utilizes *count fluxes* instead of *counts*. This patent pending method allows to implicitly take into account the integration time and thus reduces the number of calibration data that need to be acquired and stored.

The new method proposed in this paper performs the radiometric calibration using count fluxes rather than counts.

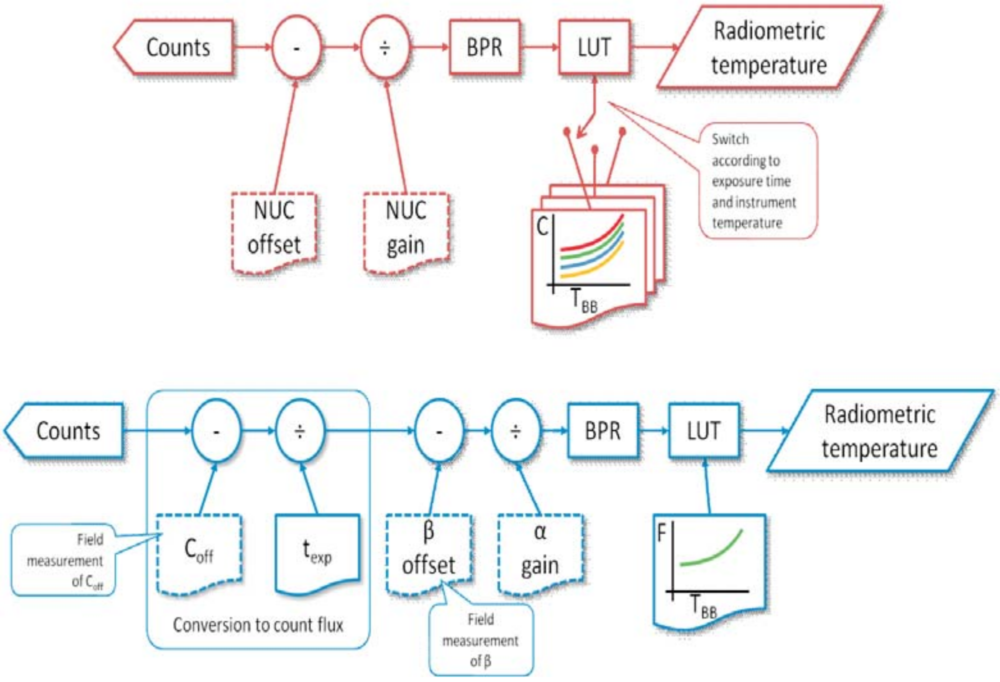

Figure 1
Application of the calibration coefficients with the traditional method (upper, red) and new method presented in this paper (lower, blue). Dashed boxes represent pixel-wise parameters. BPR stands for bad pixel replacement and LUT stands for look-up table.

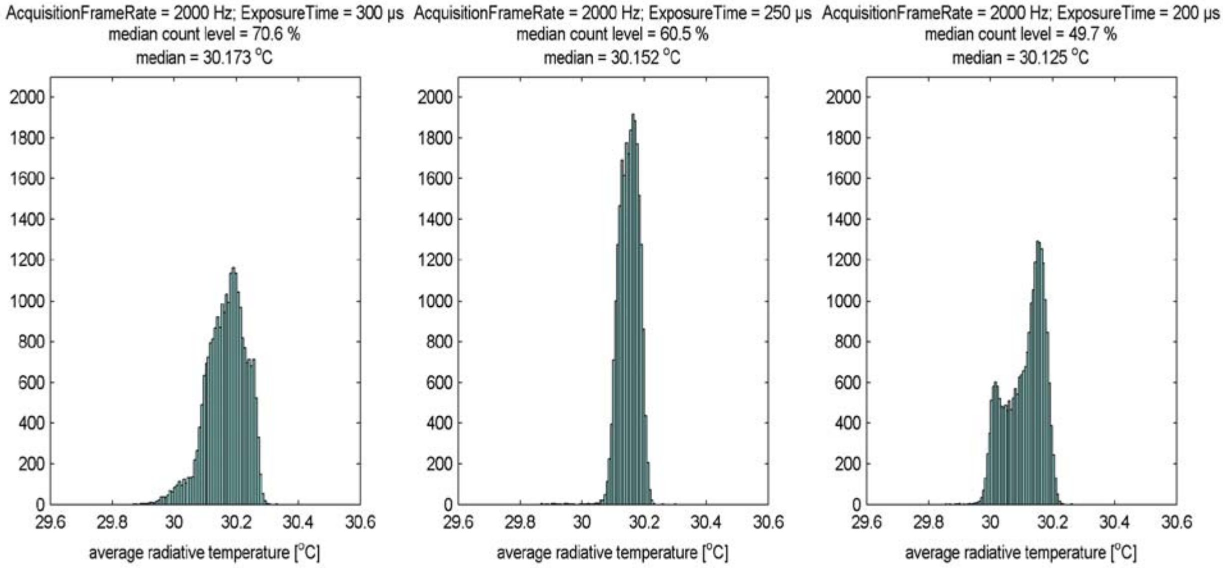

Figure 2
.Measured radiometric temperature of a blackbody set at 30 °C, using three different exposure times as indicated above each graph. The histograms show the results obtained by applying the method presented in this paper for all good pixels of the 3 μm -5 μm Telops FAST-IR infrared camera. Note that the average error is less than 0.2 °C, with the maximum error equal to 0.4 °C.

When applying this method, the first step consists in converting counts into fluxes by subtracting the C_{off} and dividing by the exposure time t_{exp} as shown in (lower). After conversion to fluxes, the pixel-wise offset and gain coefficients are applied in order to render all pixels equivalent, allowing a *single flux versus temperature relationship* to be applied to all pixels and for all integration times. This step removes the need to have several flux-to-temperature relationships as illustrated by the LUT relationships in .

Experimental Results

The proposed calibration method exposed in this paper has been validated using the FAST-IR MW, a high-speed MWIR camera manufactured by Telops. The camera is designed for high-speed operation (1000 full frames per second) and features the embedded electronics necessary to perform the radiometric calibration presented in this paper in real-time on the full data rate (> 100 000 000 pixels/s). Using the calibration coefficients and the method exposed in this paper, the measurements of the 30 °C blackbody for the six different exposure times were radiometrically corrected. The results are shown in , where histograms of the calibrated values for all the good pixels are shown. Note that the average error is less than 0.2 °C, with the maximum error 0.4 °C, further confirming the validity of the proposed method.

An example of data acquired with the Telops *FAST*-IR MW camera and calibrated with the new method is shown in . The image of a golf club just after hitting a golf ball is shown both for the raw uncalibrated image (left) and the radiometric temperature (right) obtained with our method. Note the ~5 °C temperature elevation at the location of the impact.

Conclusion

We have presented a new calibration process for thermal infrared focal plane array cameras. The method is designed to explicitly handle the integration time, to allow an easy correction of the instrument dark signal changes and to be implementable in the camera embedded electronics so it can perform calibration in real-time. Preliminary results with a 3 μm to 5 μm infrared camera show promising results.

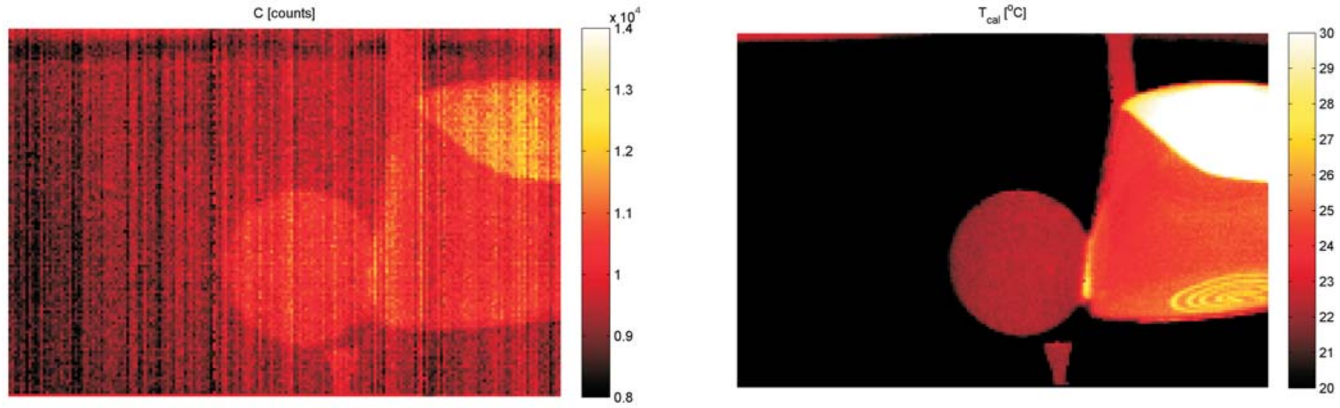

Figure 3
Uncalibrated image (left) of a golf club just after hitting a golf ball off a tee. Same image after applying the calibration process described in this paper (right), in units of radiometric temperature.

Infrared recognition in integrated-circuit techniques

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Introduction

Computer processing of the infrared (IR) images speeds up considerably the evolution of the measurements results. Processing of digitized 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 tailor the strategy and the method of evaluation to the phenomenon under scrutiny. This, in some cases, calls for both heat engineering experience and technical intuition. Image filtering is a special and not commonly used method of IR image analysis. The present author has no information about publications on the mathematical filtering of IR images.The first paper on that topic by the present author was published in 1997. The mathematical IR image filtering in general is suitable for detecting some thermal faults which are difficult to identify 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.

Analysis of thermal singularities of an integrated circuit

The applicability (advantages and limitation) of IR images and their scientific value are determined in the technical practice by the following main features:

(a) the type of the technical phenomenon investigated,

(b) considerati-on of rules of IR optics during the IR image taking and

(c)proper selecti-on of ambient parameters.

Under optimum conditions, the IR image will contain important information on the thermal character of the temperature field of the examined object or phenomenon. As a consequence, the evaluation of IR images, the thermal physical characteristics and the interpretation will contribute to the scientific value of IR images.

In the actual practice of IR image analysis the followin general methods may be chosen,while theire relative advantages and disadvantages must be decided in the light of the test being done. The first is the traditional phenomenological analysis, e.g.determination of the temperature at specified points of the (e.g. the centre point of the cross hairs) (see Fig. 3a), a comparison between temperature distribution along the horizontal, vertical or optional lines (see Fig.3a),and relief representation of the temperature field (see Fig.3c). Two new methods serve for mathematical evaluation of temperature fields:

(a) histographic analysis, i.e. the application of the distribution curve of temperature histogram for process monitoring (see Fig. 3b) [5] and

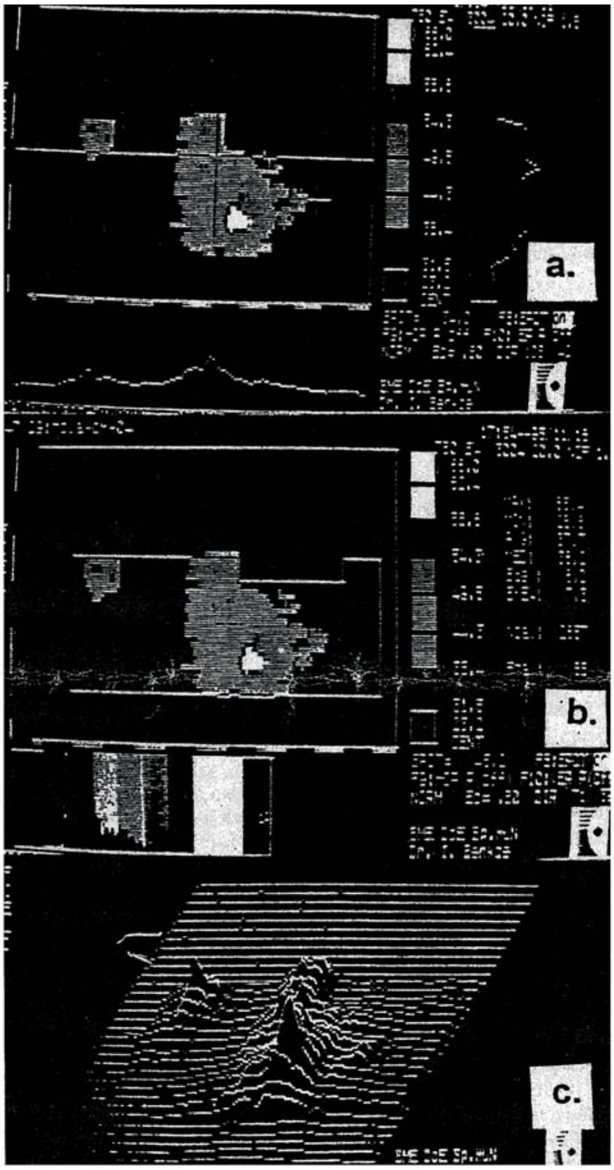

Fig. 3. *Common evaluation of IR images on the chip side; (a) line thermogram; (b) histogram; (c) relief*

(b)mathematical filtering of IR images to reveal the sites of highest temperature or of the largest temperature alteration.

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Analysis of infrared images through histographic method

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Introduction

Radiation therapy (radiotherapy) is a valuable technique used in medicine cancer treatment.

It is a fact 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

infrared (IR) thermographic imaging for the more precise diagnosis of local injuries, the availability

of these techniques is very rarely mentioned in the publications. In this paper attention is drawn to what was introduced more than a decade ago, namely the use of IR thermographic procedures in diagnosing local radiation injuries. Further justification for introducing these techniques is that, in the relevant cases, the assesment of absorbed radiation dose through the widely known biological indicators or biological dosimetry assays is not always possible.

Methode of examination

The investigations on the subjects treated with β irradiation to the chest were performed using AGA THV 780-type IR imaging equipment [5,6]. The images were stored from the different investigations, over 3 weeks by IR video recording, which was evaluated by computerized image analyses.

The method of data analysis was elaborated and applied for the investigation of six patients. The irradiated areas as shown in reference [5] (Fig.1) have absorbed 2.5 Gy at each session but from various energies. The radiation treatment was performed for consecutive weeks, five irradiation sessions per week applied daily; the β dose was 12 times 2.5 Gy. The treatment on weekend days were omitted. These post-operative irradiations always complete the complex therapy of breast cancer patients. The immediate effect could be seen within 20-30 min after irradiation.

Among essential values characteristic of the histograms, the following are selected: the highest (maximum), the lowest (minimum) and the average temperature in the defined area; the median, standard deviation and skewness; the number of pixels in the examined area and the maximum value on the ordinate of the histogram.

The distribution curve D of the histogram is the integral of the histogram (Fig.1) and the derivative dD/dt of the distribution curve gives the shape of the histogram (Fig.2). The series of distributions of histograms (Fig.3) is more visual

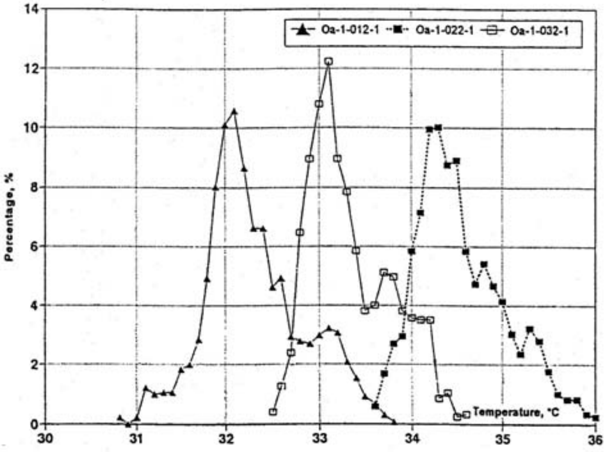

Fig. 1 *Series of histograms of the temperature values on the β-irradiated areas on the first (-▲-), second (-■-) and third (-□-) day during radiation treatment (first week)*

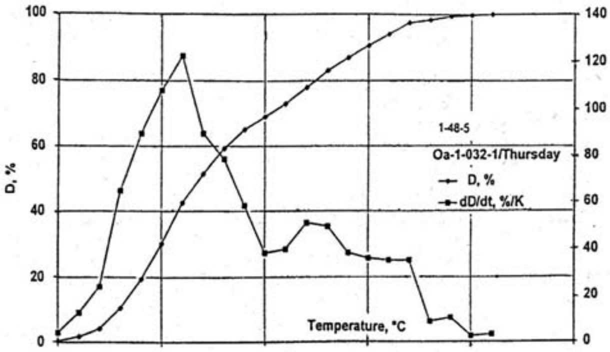

Fig. 2 *The distribution of a temperature histogram D and its derivative dD/dt, i.e. the shape of the histogram (after the second session)*

and efficient for comparisons than a series of histograms (Fig.1). For illustration, Figs 1 to 3 are taken from the effects of β irradiation.

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Infrared image analysis for biomedical use: a review of established and emerging applications in 2011

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Aim of the paper:

The review of infrared image capture and analysis methods in biomedical applications, that are already well-established or are under development, as of 2011.

The past few years have witnessed significant developments in far infrared image capture and analysis technologies and methods. Advanced uncooled infrared microbolometer sensors with 1.024x768 pixel resolution, active in the 8-14 µm spectral band, have become commercially available recently. These microbolometer sensors provide much improved signal to noise ratio and spatial resolution for the analysis of two-dimensional still infrared images, for traditional visual assessment or by image processing algorithms. The analysis of two-dimensional infrared images in the spatial domain is at present the most widespreadly used application of this technology, both in biomedical research and in everyday clinical practice. The different fields of use are briefly outlined hereunder.

Over the past three years infrared image processing capabilities have extended far beyond the assessment of images in the spatial domain. Analysis of consecutive infrared frames in real time in the time-frequency domain is one of the most exciting method under development for the investigation of a host of different biomedical phenomena, most prominently tissue arteriolar microcirculation. Proof of concept studies have shown that infrared imaging-derived temperature fluctuations (thermal oscillations) provide temperature profiles, that can be subjected to spectral (frequency) analysis. By applying fast Fourier transformation (FFT) on the thermal profiles over time, a power spectrum can be calculated. The calculated power spectral density (PSD) reveals the dominant frequency bands of temperature fluctuations and their corresponding spectral power magnitude.

Brief outline of reviewed biomedical application:

Analysis of two-dimensional infrared images by visual assessment is the traditional, and still most widespreadly applied way of utilizing infrared technology, both as a tool of clinical practice, as well as a biomedical research method. There are many recorded attempts of using infrared imaging in clinical practice, out of them several found their way into established medical practice. Hereunder is a by far not complete list of these application with a proven track record.

I. Clinical applications

Rheumatoid arthritis is characterized by recurring inflammatory processes of the joint, accompanied by hyperthermia of the skin surfaces covering the joints. Infrared thermography provides objective, quantifiable, reproducible measures of the intensity and extent of joint involvement. The therapeutic efficacy of different treatment options on reducing the intensity of inflammatory process can be objectively and quantitatively assessed and compared to each other by infrared imaging. This provides an alternative to the currently used semi-quantitative scoring schemes.

Raynaud disease is characterized by sudden, intermittent painful vasospasm of the digital arteries, provoked by cold or emotional stress. By infrared imaging the severeness of the disease can be quantified and consecutive attacks can be compared to each other. Due to the difference in the underlying disease processes, the primary and secondary forms of Raynaud syndrome can be differentiated by infrared imaging as well.

In **plastic and reconstructive surgery** infrared thermograpy is gaining acceptance in many ways. It is an excellent way to identify dominant perforator vessels before free flap surgery, that helps in preoperative planning. It is an outstanding method to monitor the perfusion of the free flap after anastomosing its vessels to the site of reconstruction, intraoperatively. In the postoperative period it is a sensitive, valuable method to assess the free flap in difficulty, and to decide whether the clinical symptoms are related to problems with flap perfusion or are due to other causes (infection, etc).

Solid organ transplantation is a treatment modality for the replacement of an organ that lost its capacity to comply with the organism's respective need. By far the largest group is kidney transplantation of all organ transplantations performed. The determination of donor organ viability is of paramount importance, that in a great part determines how the transplanted organ will function postoperatively. The assessment of the donor organ's function after transplantation is an equally critical step. The current assessment of organ ischemia is usually performed by observing and interpreting visual and tactile features of the transplanted organ, like color, mottling, and tissue turgor. Early, objective, intraoperative markers of clinically significant critical ischemia, leading to permanent organ damage are lacking. It is at the time of ischemic insult, that preemptive measures can be administered to prevent ischemia-reperfusion injury. Infrared imaging is an excellent tool for the assessment of donor organ's viability before its removal, and helps in deciding which organ should be considered for transplantation. After the transplantation is performed, infrared imaging provides clues on how the perfusion resumed in the recipient, and the orderly, controlled microcirculation of the transplanted organ is a predictor of its long term viability.

II. Infrared image analysis in the time-frequency domain to study thermal oscillations

- FFT analysis of infrared signals reveals the following frequency bands of blood flow oscillations in the normal human arteriolar microcirculation:
  cardiogenic: 0,6-2 Hz;
- respiratory: 0,145-0,59 Hz;
- myogenic (by vessel wall's smooth muscle cells' intrinsic activity): 0,052-0,144 Hz;
- sympathetic nervous system generated (neurogenic): 0,021-0,051 Hz;
- slow oscillations induced by nitric oxid from endothelial cells: 0,0095-0,020 Hz;
- very slow oscillations generated by the paracrine action of non-nitric oxid compounds, produced by endothelial cells: 0,005-0,0094 Hz.

The significance of the microcirculatory function, i.e. arteriolar (<300μm outer diameter) function in health and diseases is well appreciated. Regulation of the microcirculatory function is the fundamental adaptive mechanism, by which the perpetually changing diverse metabolic and thermoregulatory needs of the organs and tissues are simultaneously accommodated. The pulsatile, oscillatory function of the arteriolar system causes tiny rhythmic temperature fluctuations on the skin's or organ's surface, so micro-cir culatory function can be monitored as thermal oscillations over time. This makes infrared technology an ideal method of microcirculatory function testing. Impairment of the microcirculatory function in the skin is closely linked to, and is a good surrogate marker of tissue damage of the internal organs. Endothelial and sympathetic dysfunction, the major determinants of microcirculatory function impairment, are potentially modifiable factors in mass diseases like diabetes mellitus type 2, hypertension and meta-b olic syndrome. Infrared imaging is a promising candidate for the development of a clinically useful microcirculatory assessment device.

Summary of the results

Infrared imaging provides an excellent tool to track fundamental biological processes in health and diseases, because total heat output is strongly linked to the biochemical and biophysical processes of metabolism, and reflects cellular energy utilization. Infrared imaging is a valuable investigative method of the biomedical field. In the preclinical research setting, infrared imaging is a unique tool to provide real-time, unperturbed information on biological processes, due to its noncontact, noninvasive nature. In clinical medicine, in various medical subjects, it is used both in the diagnosis of diseases, as well as in the assessment of efficacy of different therapeutic interventions.

Conclusion

Infrared image capture and analysis is an outstanding technology, that allows the noncontact, noninvasive investigation of biological systems, both in preclinical research settings and in the clinical assessment of patients. The investigated object is not exposed to any harmful radiation or other interventions, and therefore infrared imaging can be considered as one of the few truly green imaging technology with great potential for widespread use on the biomedical field.

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How we should use thermography in breast disease treatment?

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S. Akamoto, M. Fujiwara, K. Kakinoki, T. Takama, M.Hagiike, K. Okano, Y.Suzuki

The Department of Gastroenterological Surgery, Kagawa University, Japan

Thermography is a functional examination method. It has many unique characteristics, which other morphological examination methods do not have. Thermographic researchers were interested in such characteristics. Then, many important facts were detected for thermological science. But, there might be a very interesting discovery for the researcher, which was useless in clinical medicine. A diagnostic result, which was recognized by thermography, might be detected more accurately by other examination methods. In this presentation I will enumerate the characteristics of breast thermography and discuss about which characteristics are important for the diagnosis and the treatment of breast diseases.

Thermography can detect non-palpable breast cancers. It can detect the breast carcinomas, which is not detectable by other morphological examination methods. It is able to forecast the carcinogenesis. Then, it may be useful for the mass screening of breast. The thermographic findings relate to the prognosis of breast cancer patients. They have close relationship with its progress stage. They are related to the proliferating ability of breast cancers. Then, it may be useful for foreseeing the prognosis of the patients. Thermal abnormality of tumor covering skin is related to the dilatation of the subcutaneous vessels. It seems to be influenced by the producing ability of chemical mediator in the tumors. The findings of nipple hyperthermia are also related to the distance from tumor to nipple. Then, it may be useful for determination of surgical method for each breast cancer patient.

However, the diagnostic accuracy of thermography can not surpass that of ultrasonography for breast diseases. There are many non-palpable breast cancers with micro-calcifications which were detected only by mammography. There are many reports "magnetic resonance imaging

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Application of infrared thermography for the assessment of burn wounds depth in children

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2) Medical University of Lodz, Lodz, Poland

SUMMARY

This paper presents the application of the infrared thermography for the assessment of burn wounds depth. The classification of burn wounds is done based on the analysis of infrared images combined with the ordinary images taken in the visible light. The assessment of the burn wound degree is crucial from the medical point of view, because it determines the proper treatment method. The classification results of the new method are compared with the traditional ones based on the results of the analysis of the biopsy material.

ANWENDUNG DER INFRAROT-THERMOGRAPHIE FÜR DIE BEURTEILUNG DER TIEFE VON VERBRENNUNGEN BEI KINDERN

Diese Arbeit beschreibt die Anwendung der Infrarot-Thermographie für die Beurteilung der Wundtiefe von Verbrennungen. Die Klassifikation der Verbrennungswunden erfolgt auf Basis der Analyse der Infrarotbilder in Kombination mit herkömmlichen Photographien. Die Beurteilung des Ausmaßes Brandwunde ist aus medizinischer Sicht von entscheidender Bedeutung, denn sie bestimmt die richtige Behandlungsmethode Die Ergebnisse der neuen werden mit der traditionellen Methode verglichen, deren Grundlage der Ergebnisse der Analyse von Biopsiematerial darstellt.

Introduction

The proper assessment of the burn wound depth is extremely important from the medical point of view. Namely, the burn wounds are treated differently, depending on their depth. The limit, according to the commonly used Jackson classification of burn wound, is set between the degrees IIa and IIb. The less serious wounds can heal themselves in the natural way, but the more severe have no chance of regeneration, because of the necrosis [1]-[2]. Therefore, the most im-

(MR)" are used for determination of the resecting line in breast preserving surgery. Then, the researchers should decide which way of thermographic usage could do what other examination methods could not do, and they should concentrate their effort to such study fields.

limits between the above-mentioned degrees. Obviously there exist diagnostic methods such as the clinical assessment by a physician or the evaluation of the biopsy material, but the first one is subject to human errors and the second one is invasive and painful for patients. The use of infrared thermography in medicine is not a new idea [3]-[4], but the recent advances in the infrared technology and image processing techniques allow significant advances in the diagnostics.

Infrared System

The infrared system was created based on the experiences gained during the work with the earlier system built in the 80s and using the Agema AGA 760 infrared camera [5]-[6]. The new system is based on the modern FLIR P660 camera with the built-in visible light camera allowing the automatic overlay of this image with the infrared one. The storage and the transmission of the images within the system complies with all the regulations concerning medical images, in particular the DICOM standards.

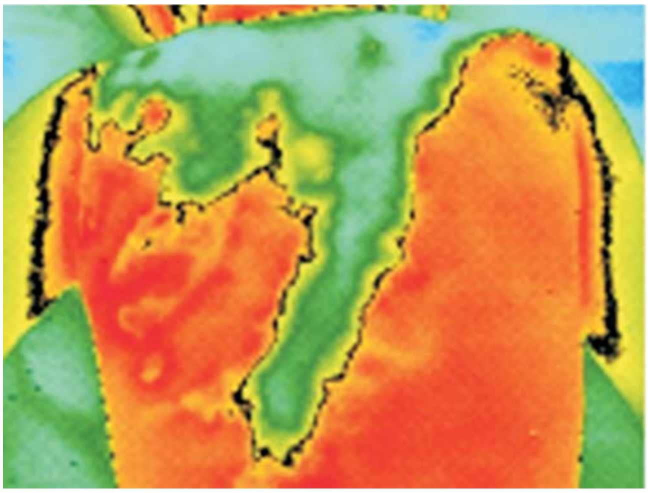

Figure. 1
Infrared image of a burn wound

Methodology

The microcirculation of blood in the burn wound tissues is changed which is reflected in the skin temperature, thus the infrared thermography seems to be a perfect choice for the assessment of burn wound depth. The analysis of temperature differences within the registered infrared images renders possible the classification of burn wound depth. Each image is segmented into individual areas having the same range of temperatures.

Results

The investigations carried out on a few tens of patients showed that the temperature of the skin within the burn wound is not uniform (see Fig. 1) and the differences can be as high as 3 K (see Fig. 2). Therefore, taking into account the capabilities of the modern infrared cameras, the proper classification of burn wounds is possible. The examinations demonstrated high correlation of the obtained results with histopathology assessment of the biopsy material and the clinical assessment. The final result of the image analysis is the map of necrosis within a wound. This map informs a surgeon in which areas tissue should be removed and which regions of the wound should be left intact.

Conclusions

The new method of the classification of the burn wound depth based on the analysis of infrared images is very promising. Compared to the traditional biopsy, it is contactless and non-invasive, hence it is much more tolerable for the patient and brings the same results from the diagnostics point of view. Additionally, the proposed method eliminates also 'the human factor' from the diagnostic process.

Acknowledgements

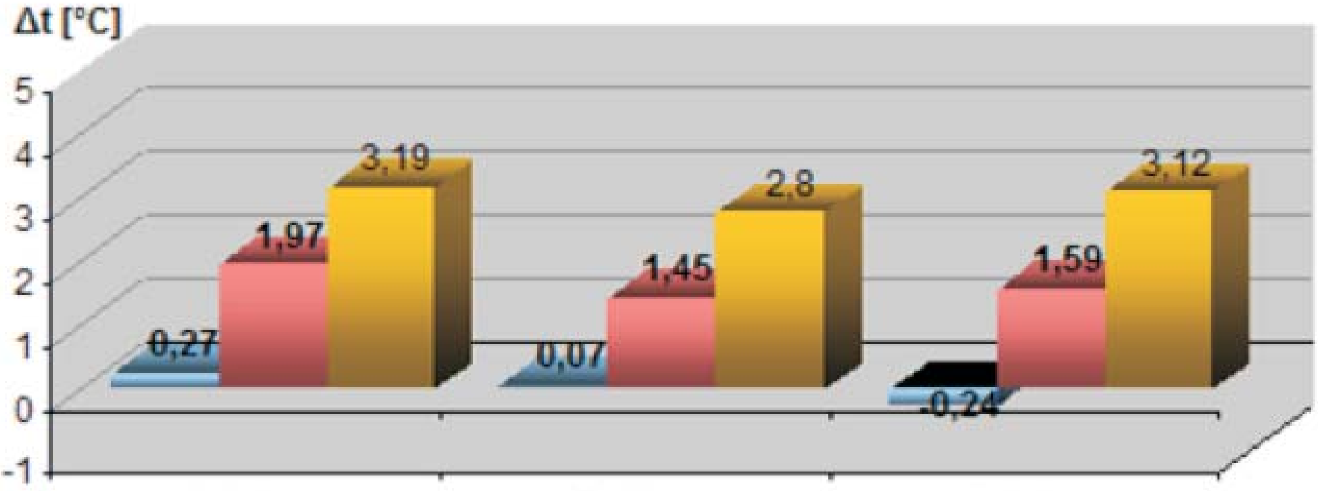

Fig.ure 2
Analysis of temperature within a wound.

The research presented in this paper was supported by the grant of the Polish Ministry of Scientific Research and Higher Education No. N515 2423 37.

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Correlation between autonomic nervous function and forehead/nasal temperatures in seniors during leg press

SUMMARY

We attempted to determine an index of the continual safety of seniors during exercise. Healthy male seniors aged more than 65 years (n = 11) participated in a leg press test. It was found that as the nasal temperature decreased during the test, the low frequency/high frequency (LF/HF) ratio also decreased. We suggest that the degree of decline of nasal temperature is an appropriate index indicating the participants’ relaxation status without touching their body.

KORRELATION ZWISCHEN DER FUNKTION DES AUTONOMEN NERVENSYSTEMS UND DEN TEMPERATUREN AN STIRN UND NASE BEI SENIOREN WÄHREND DER BEINPRESSE

Haben wir versucht, einen Index für die andauerende Sicherheit beim Training von Senioren zu bestimmen. Gesunden männlichen Senioren im Alter von mehr als 65 Jahren (n = 11) nahmen an einem Beinpresse-Test teil. Es wurde festgestellt, dass die Nasen-Temperatur während der Untersuchung abnahm, auch das Verhältnis von die nieder-f requenter zu hoch frequenter Herzvaribilität verringerte sich. Wir schlagen vor, den Grad der Abkühlung der Nase als geeigneten Index für die Entspannung des Patienten zu verwenden; zumal dieser Index ohne Körperkontakt bestimmt werden kann.

F. Takao. M. Bo’oka, Y.Okumoto, H.Nakamura, N. Shintani,Y.Nakamura

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Purpose

It is important for seniors to feel comfortable during regular exercise. We investigated the correlation between automatic nervous function and forehead/nasal temperatures. Heartbeat, brain electrical activity, and skin temperature were measured during leg press tests. We examined whether forehead and nasal temperatures could be used as an index of the safety and comfort of seniors during physical activities.

Methods

Healthy male seniors aged more than 65 years (n = 11) participated in a leg press test. The room temperature was set at 26°C. After a 20-min period of acclimatization, the participants performed leg press exercises with 40-kg loads for 5 min with their eyes closed.

The changes in thermographic images (detected using Infra-eye 1200A; Nihon Kohden), heartbeats, and brain electrical activity (detected using EEG-9100; Nihon Kohden) during the tests were recorded every minute.

The equipment for thermography was installed in front of the participant, as seen in the picture below, and the face temperature was measured every 30 s, starting from 5 min before the test until 5 min after the test. An electrode was glued to the head to measure brain electrical activity.

Changes in temperature were recorded every minute, and the increases and decreases in forehead and nasal temperatures were calculated every minute during the test.

We also calculated the low-frequency/high-frequency (LF/HF) ratio based on the frequency component of heart rate variability and the $\alpha/(\alpha + \beta)$% [the ratio of the content rates of the α and $(\alpha + \beta)$ waves] in O2-A2 of the right back of the head every minute during the test.

Results

1. The average nasal temperature decreased after leg press was started and increased after the end of the test. A small increase was noted in the average forehead temperature after the start of the test, and the temperature continued to increase even after the end of the test (figure 1).

2. Among the various parameters, including the LF/HF ratio, $\alpha/(\alpha + \beta)$, change in forehead temperature, and change in nasal temperature, determined at every minute during the leg press exercise, a significant correlation was noted only between the LF/HF ratio and change in nasal temperature ($p < 0.05$*; table 1). Further, the LF/HF ratio decreased with decrease in nasal temperature during the leg press. However, there was no correlation between the LF/HF ratio and change in forehead temperature. Thus, we infer that the degree of decline of the nasal temperature is an appropriate index to determine the activation of autonomic nerve function ($r = 0.317$; $p < 0.05$; figure2).

3. The activation of sympathetic nerves tended to be seen during leg press exercises performed with 40-kg loads. During the latter half of the test, the content rate of the á wave, á/(á + â), decreased with an increase in the LF/HF ratio ($r = -0.456$; $p < 0.05$; figure 3). This tendency was not noted during the first half of the test.

Conclusions

The LF/HF ratio has a significant counter-relation to $\alpha/(\alpha+\beta)$ during the second half of the leg press test. Moreover, as the degree of decline of the nasal temperature increased, the LF/HF ratio decreased. This suggests that the degree of decline of the nasal temperature shows how the parasympathetic nerve is activated. Therefore, the degree of decline of the nasal temperature would be an appropriate index indicating the participants' relaxation status without touching their body.

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Meetings

July 26th-27th, 2011

1st Practical course in medical infrared thermography in Portugal

Venue: Training Room 2, B Building, School of Technology and Management, Campus 2,
Polytechnic Institute of Leiria,
Leiria, PORTUGAL

Course Programme:

1st day – Tuesday, 26/07/2011

9h30-10h – Registration, Opening and Introduction (R. Vardasca)

10h-10h30 – History and developments on medical infrared thermography (F. Ring)

10h30-11h – Physical Principles of heat transfer (F. Ring)

11h-11h15 – Film: "Exposure to hot and cold"

11h15-11h30 – Coffee Break

11h30-12h30 – Thermal Physiology: “Understanding thermal distributions patterns of the skin surface” (J. Mercer)

12h30-14h – Lunch

14h-15h – Detector and camera systems (R. Thomas)

15h-16h – Causes for temperature changes in the human body (K. Ammer)

16h-16h20 – Coffee Break

16h20-16h35 – CTherm Introduction (P. Plassmann)

16h35-17h – Quality control and image processing (P. Plassmann)

17h-17h45 – Provocation Tests (K. Ammer)

17h45-18h30 – Standard Protocols (K. Ammer)

18h30-19h – Production of a medical thermographic report (K. Ammer)

19h – Closing of 1st day (R. Vardasca)

2nd day – Wednesday, 27/07/2011

9h30-10h – Introduction to the practical section (K. Ammer / R. Thomas)

10h-12h30 – Practical sessions

12h30-14h – Lunch

14h-14h30 – Evaluation of the practical sessions (K. Ammer / R. Thomas)

14h30-15h –Future developments for medical
l thermography (F. Ring)

15h-15h30 – Medical education, journals and conferences (K. Ammer)

15h30 - Closing (R. Vardasca)

Course Fee = 200.00€ (does not include lunch)

Accommodation is possible on request.

For registration or information, please contact:

Ricardo Vardasca, PhD

ricardo.vardasca@ipleiria.pt

Course Instructors:

Prof. Francis Ring, DSc – Head of Medical Imaging Research Unit, Faculty of Advanced Technology, University of Glamorgan (UK)

Prof. Kurt Ammer, MD, Ph.D – Institute for Physical Medicine & Rehabilitation, Hanusch Hospital, Viena (Austria) / Editor in chief of Thermology International/ General Secretary of the European Association of Thermology

Prof. James Mercer, Ph.D – Cardiovascular Research Group, Department of Medical Physiology, Institute of Health Sciences, Faculty of medicine, The University of Tromsø (Norway) / Department of Radiology, The University Hospital of Northern Norway, Tromsø (Norway) / President of the European Association of Thermology

Prof. Rod Thomas, Ph.D – Manager Thermography Division, TWI Cambridge / Faculty of Applied Design & Engineering, Swansea Metropolitan University (UK)

Dr. Peter Plassmann, Ph.D – Computing and Mathematical Sciences Department, Faculty of Advanced Technology, University of Glamorgan (UK)

Prof. Ricardo Vardasca, Ph.D – Computing Engineer Department, School of Technology and Management, Polytechnic Institute of Leiria (Portugal)

September 15th-17th, 2011

Thermografie- Forum-Eugendorf 2011
in Verbindung mit dem
Energie- u. Luftdichtheits-Symposium Eugendorf

2010 Tagungsort: Eugendorf /Salzburg Gastagwirt

Vorläufiges Programm

DDI Franz Mair- *Unabhängiges Kontrollsystem für Ausweise über die Gesamtenergieeffizienz*

DI Michael Pils - *Von der Bausünde zum Benutzerfehler - das Mysterium "Taupunkt"*

DI Nutz-Schaltenberg - *Richtiges Wohnen im Passivhaus- Auswirkungen des Nutzverhaltens auf Energiebilanz& Planungsdetails*

Architekt Prof. Dr.H.C.Leindecker- *LQG Datenbank - Ein Tool zur Qualitätssicherung und Optimierung von Gebäuden*

DI. Benjamin Zauner - *Luftdichtheit im Energieausweis*

Daniel Eisenmann- *Heizen mit Eis Solareis - die Zukunft des Heizens*

Dr. Renate Alijah - *Neues aus der Normung*

Ing. Gerhard Traxler- *Thermografische Auswertung in einer laserinduzierten Rissprüfung*

Ing Andreas Angerer - *Aufbau einer Photovoltaikanlager und Fehlersuche mittels Thermografie*

DI Günther Weinzierl- T*hermografie von Elektroanlagen- neue Wege der Qualitätssicherung am Beispiel der VDS-Zertifizierung*

Prof DI Dr Peter Zeller- *Solare Mobilität*

Weitere Redner:

Mathias Kupfer

Univ Prof Dr Mladen Andrassy

Dr. Christian Möller,

Dr. Beate Oswald- Tranta

Gerätepräsentationen

InfraTec (Ing.Andreas Angerer)

TROTEC (Georg Zischka)

Testo Messgeräte (DI(FH) Marcus Nemec)

Auskunft:
Prof. Ing. Fritz Mendel

Österreichische Gesellschaft für Thermografie
Danubiastrasse 12
A - 3400 Klosterneuburg

Tel. + Fax +43-2243-37744

Webpage: www.thermografie-forum-eugendorf.com

October 8th-9th, 2011

Use of Infrared Thermal Imaging in Veterinary Medicine in Epe, The Netherlands

Speakers. Dr. Ram C Purohit, DVM, PhD, DACT
Irma Wensink

Information: see page

Webpage: www.cursus-thermografie.eu

Email: praktijk@healthyhorse.nl

October 19th-21th, 2011

9th Conference on Thermography and Thermometry in der Praxis in Ustron - TTP 2011 (Krajowa Konferencja Termografia I Termometria W Podczerwieni)

Venue:Dom Wczasowy "Jawor" Sp. z o.o. w Ustroniu
ul. Wczasowa 51, 43-450 Ustroñ-Jaszowiec

Language: Polish, English

Information:
Sekretariat Konferencji TTP
Instytut Elektroniki
Politechnika Lódzka
ul. Wólczanska 211/215
90-924 Lódz

12thNovember 2011

24th Thermological Symposium of the Austrian Society of Thermology

Venue: Raddisson Blue Palais Hotel Vienna, Austria

Deadline for Abstracts: October 10th, 2011

Speakers:

Prof Francis Ring, UK

Prof James Mercer,Norway

Prof Boguslaw Wiecek, Poland

Prof Ricardo Vardasca, Portugal

Prof Kurt Ammer, Austria

Dr Jozef Gabrhel, Slovakia

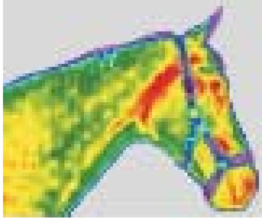
Dr Kevin Howell, UK

Information

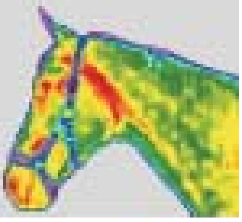
Prof K. Ammer, MD, PhD

Austrian Society of Thermology
Hernalser Hauptstr 209/14

Email: KAmmer 1950@aol.com



Praktijk Healthy Horse Thermografie



Use of Infrared Thermal Imaging in Veterinary Medicine.

October 8 and 9, 2011

At the Conference hotel Villa Heidebad in Epe, The Netherlands

These presentations are given by: **Dr. Ram C Purohit, DVM, PhD, DACT**

Professor Emeritus, Department of Clinical Sciences, College of Veterinary Medicine, Auburn University, USA

Saturday October 8th 2011

9:00AM – 9:15AM Registration (with coffee and tea)

9:15AM – 9:30AM Welcome

9:30AM – 10:15AM Introduction: A brief review of the historical development of Infrared Thermology.

10:15AM – 11:00AM Physiology of Thermal Imaging: Skin thermal properties, vascular blood flow and role of nervous system.

11:00AM – 11:30AM Coffee break

11:30AM – 12:10PM Thermography Standards in Veterinary Medicine.

12:10PM – 1:30PM Lunch

1:30PM – 3:00PM Dermatome patterns of Horses and Other Animal Species.

…Certain chronic and acute painful conditions associated with peripheral neurovascular and neuromuscular injuries are easy to confuse with spinal injuries associated with cervical, thoracic and lumbar-sacral areas. Similarly, inflammatory conditions such as osteoarthritis, tendonitis and other associated conditions may also be confused with other neurovascular conditions. Thus, it is important to map cutaneous patterns and differentiate the sensory sympathetic dermatome patterns of cervical, thoracic and lumbar-sacral regions in horses.

3:00PM – 3:30PM Break

3:30PM – 4:20PM Peripheral Neurovascular thermography.

…. Differential diagnosis of nerve vs. vascular injuries.

4:20PM – 4:45PM Signals of pain vs Thermography - Irma Wensink

4:45PM Adjourn

Sunday October 9th 2011

9:00AM – 9:15AM Welcome with coffee / tea

9:15AM – 10:30AM Use of thermography for clinical and subclinical cases of musculoskeletal injuries.

10:30AM – 10:45AM Break

10:45AM – 12:15PM Discussion of various clinical conditions which can be easily diagnosed by infrared thermal imaging.

12:15PM – 1:45PM Lunch

1:45PM Adjourn course program

(After completion of the entire course, you will receive a certificate of attendance.)

For more info, please visit www.cursus-thermografie.eu **Or mail to** praktijk@healthyhorse.nl

Www.healthyhorse.nl PRAKTIJK HEALTHY HORSE praktijk@healthyhorse.nl

26th-27thNovember, 2011

2nd International Consensus and Guidelines for Medical Thermography (2011 ICGMT)

2nd. International Working Group for Medical Thermography (IWGMT) Meeting

in Foz do Iguaçu Falls, Parana, Brazil .

Prof Francis Ring – 2011 IWGMT Honor President

Prof Manoel Jacobsen Teixeira – 2011 ICGMT Honor President

Prof Marcos Leal Brioschi – Congress President

Abstract acceptance: until 31th July, 2011

Information: www.termologia.org/icgmt

The Organising Committee has great pleasure to invite you to participate in the International Consensus Guidelines and Medical Thermography in 2011 (ICGMT 2011) taking place in Foz do Iguacu, Parana, on 24 and 25 November 2011. The main themes will be:

- ·PAIN CLINIC
- ·EXPERTISE MEDICAL & LEGAL MEDICINE
- ·ENDOTHELIAL DYSFUNCTION: CLINICAL CARDIAC & VASCULAR
- ·BREAST TUMOR

IWGMT - Be part of the International Group for the Development of Medical Thermography (IWGMT), a non-governmental, non-commercial, founded to spread the complementary diagnostic method for medical thermography, increase communication and collaboration among professionals involved in this area with those argue that health policies and provisioning of social funds. The IWGMT is a large global network, consisting of representatives from various countries and societies thermology doctor.

One goal of IWGMT is developing guidelines for improving the medical applications of thermography with more quality and more cost-effective health care based on ethical and scientific arguments and expert opinion.

The principles outlined in the Consensus will be implemented throughout the world. Will be adjusted according to the laws of each country, taking into account the socio- economic and health access.

The International Consensus is established by a group of experienced doctors in Brazil and abroad who collectively have worked for years with thermography and has published in this area by implementing protocols and information technology, increasing their scientific value, perfor- ming diagnostics, monitoring techniques and establishing predictions with success in the neuro-musculoskeletal, breast, vascular diseases, among others. The agreement will involve various medical specialties and subspecialties:

Pain Forensic Medicine Forensic & / Medical Examination Cardio logy Neurology Orthopaedics Rheumatology Rehabilitation Sports Medicine Oncology Endocrinology Dermatology Angiology Mastology Pediatrics Emergency Medicine Anesthesiology Neurosurgery General Surgery Vascular and Cardiac Surgery Plastic Surgery Thoracic Surgery Acupuncture

Based on the overwhelming success of in Fortaleza (Brazil), our meetings on the subject and the return of participants of medical societies in Brazil, the next symposium (ICGMT-2011) will be in Foz do Iguacu, Brazil in November 2011. It will be an event intended for scientific discussions by professors, lecturers and participants in a national and international forum for debate and finally the signing of a new record date for the official participants and members of IWGMT.

Do not miss this great opportunity!

Prof Dr Mark Leal Brioschi

Organizing Committee

2012

March 2012

16th National Congress of the Polish Association of Thermology in Zakopane

Abstract deadline: February 15th, 2012

*Deadline for hotel reservatio*n: March 1st, 2012

Registration fee: 200.-Euro

Local organizing committee

Prof. Anna Jung (Chair)

Dr Janusz Zuber (deputy Chair)

Dr Boleslaw Kalicki mgr ing. Piotr Murawski

Registration fee for non Polish participants will be paid in cash on arrival at the conference. Registration by e-mail is required before March 1st to ensure hotel reservation. After registration number is issued, delegates are committed to payment of the fee.
Registration includes welcome dinner Saturday, Lunch and accomodation.

Extra night + breakfast Monday + 50 .- Euro

Accompaning person – 150.- Euro

March in Zakopane is very attractive, being surrounded by the Tatra Mountains covered with snow. The International airport of Krakow, is a 2hr journey away. There is good connection from Krakow airport by railway to bus station in direct Zakopane

Further information

Prof Dr. Anna Jung
ajung@wim.mil.pl or a.jung@spencer.com

23 - 27 April 2012

SPIE Defense, Security + Sensing in Baltimore. Maryland, United States

Venue: Baltimore Convention Center

IR Sensors and Systems

Infrared Technology and Applications

Conference Chairs:
Bjørn F. Andresen, SCD Semiconductor Devices (Israel);
Gabor F. Fulop, Maxtech International, Inc.;
Paul R. Norton, U.S. Army Night Vision & Electronic Sensors Directorate

Thermosense: Thermal Infrared Applications

Conference Chairs:
Douglas Burleigh, La Jolla Cove Consulting;
Gregory R. Stockton, Stockton Infrared Thermographic Services, Inc.

Infrared Imaging Systems: Design, Analysis, Modeling, and Testing

Conference Chairs
Gerald C. Holst, JCD Publishing
Keith A. Krapels, U.S. Army Night Vision & Electronic Sensors Directorate

Important Dates

Abstract Due Date: 10 October 2011
Author Notification: 19 December 2011
Manuscript Due Date for On-Site Proceedings (Conference DS215 only): 13 February 2012
Manuscript Due Date for Post-Meeting Proceedings Volumes: 26 March 2012

Website: http.// spie.org/x6765.xml

June 11-14, 2012

11th Quantitative InfraRed Thermography Conference at University of Naples Federico II, Naples, Italy

Steering Committee
Chairman: D. Balageas, France
Vice-Chairman: X.Maldague, Canada

The DEADLINE for submitting a 2-page abstract is December 15, 2011

Further information
www.qirt2112.unina.it
or contact the organizing committee at qirt2012@unina.it

FIRST ANNOUNCEMENT

19th-21st July , 2012

11th European Congress of Thermology in Leiria combined with the 25th Thermological Symposium of the Austrian Society of Thermology

Applications in

Alternative Medicine
DermatologyDentistry
Fever Detection
Forensic Medicine
Physiotherapy
Rheumatology
Sports Medicine
Surgery
Thermal Physiology
Vascular medicine
Veterinary Medicine

Topics:

Camera technology
Image Processing
Standards
Static and Dynamic Thermography/Provocation tests

Key note lectures

History of infrared Thermography

Which Camera should I use ?

Infrared Imaging in Wildlife Animals

Infrared Imaging in Agriculture and Ecology

QIRT 2012
11-14 June Naples
The 11th International Conference on Quantitative InfraRed Thermography

Call for Papers

The Quantitative InfraRed Thermography (QIRT) conference is an international forum which brings together specialists from industry and academia, who share an active interest in the latest developments of science, experimental practices and instrumentation, related to infrared thermography.

Following conferences in Paris (1992), Sorrento (1994), Stuttgart (1996), Lodz (1998), Reims (2000), Dubrovnik (2002), Brussels (2004), Padova (2006), Krakow (2008) and Québec City (2010), the 11th Quantitative Infrared Thermography Conference, QIRT 2012, will take place on June 11-14th, 2012 at University of Naples Federico II, Naples Italy.

QIRT 2012 will cover, and it is not limited to, the following topics:

- State of the art and evolution in the field of infrared scanners and imaging systems, allowing quantitative measurements, and related data acquisition and processing.
- Integration of thermographic systems and multispectral analysis. Related problems like: calibration and characterization of infrared cameras; emissivity determination; absorption in media; spurious radiations, 3D measurements; certification and standardization.
- Thermal effects induced e.g. by electromagnetic fields, elastic waves or mechanical stresses.
- Application of infrared thermography to radiometry, thermometry and physical parameters identification in all fields such as (and not limited to): industrial processes; material sciences; termofluidynamics; structure and material non-destructive evaluations; cultural heritage; environment; fluid mechanics; medicine; biomedical science; food production.

Important Dates:

Abstract Submission Deadline:	**December 15, 2011**
Acceptance Notification:	**January 31, 2012**
Paper Submission Deadline:	**April 30, 2012**
Main Conference:	**June 11 – 14, 2012**

Abstract and Paper Submission

The participants are invited to submit to the QIRT 2012 Secretariat by December 15th, 2011 an extended abstract of 2 pages (letter size/A4 format), either for oral or poster presentation, including key figures and main results.

Following acceptance notification, camera ready,full paper of 6-10 pages including color figures should be submitted to the QIRT 2012 Secretariat by April 30th, 2012.

All submissions for oral or poster presentation will be handled electronically via the conference website www.qirt2012.unina.it.

Authors are requested to propose the thematic section in which the paper should be included.

Web-Based Proceedings

Papers will be published online in the QIRT Open Archives http://qirt.gel.ulaval.ca and can be found via Google Scholar. A USB flash drive with all conference papers will be also distributed to conference participants. Selected papers will be published in the QIRT Journal after a subsequent review by experts.

For further information and updates please visit: www.qirt2012.unina.it
or contact the organizing committee at qirt2012@unina.it

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Host organization

Dep. of Aerospace Engineering
University of Naples Federico II

QIRT 2012

Tutorials, Symposium and Technical Visit

In addition to the main technical program, the conference will include:

QIRT Short Courses

A - Basic Thermography, B - Application to Fluids, C - Application to Solids, D - Cultural Heritage and Buildings.

The Courses are scheduled on Sunday, June 10th, 2012. The tuition fee is 348 € (290 € + VAT 20%) for one or more courses. Course schedule: A in the in the morning B,C and D in parallel sessions in the afternoon.

Half Day Symposium in honour of Giovanni Maria Carlomagno

This symposium celebrates Carlomagno's long career as a scientist, featuring a small but very distinguished selection of friends who shared interest with Giovanni along his way. The half day symposium is scheduled in the morning of 11 June 2012.

Technical Visit to CIRA wind tunnels

On Friday June 15 is scheduled a technical tour of CIRA's SCIROCCO hypersonic plasma wind tunnel and Icing Wind Tunnel (IWT). SCIROCCO is one of the few facilities in the world able to perform thermo-structural testing on large-size or real-scale 1:1 models. The IWT is world’s largest and most advanced facility that allows performing both aerodynamic and ice-type testing.

Students Awards

The QIRT 2012 organizing committee strived to stimulate young researchers by awarding the best three conference contributions presented and authored only by students.

Conference Fees

Regular participants

- Early rate (deadline: April 30th 2012): (460 € + VAT 20%) 552 €
- Late rate (deadline: May 31th 2012): (540 € + VAT 20%) 648 €
- Desk registration rate: (615 € + VAT 20%) 738 €

Students

- Early rate (deadline: April 30th 2010): (290 € + VAT 20%) 348 €
- Late rate (deadline: May 31th 2010): (340 € + VAT 20%) 408 €

Fee covers: Conference USB Proceedings, Welcome reception, Conference dinner, 3 lunches and coffee breaks. Accommodation is not included. **For regular participants only, fee includes also a subscription to the QIRT Journal for 2 years** (Standard subscription rate 164€/year).

Accompanying persons

- Rate (deadline: May 31th 2012): (120 € + VAT 20%) 144 €

This amount includes the Welcome reception and Conference dinner.

Venue

QIRT 2012 will be held at the University of Naples Conference Centre which is superbly located in Naples waterfront, unique for its focus on creative, cultural, entertainment and leisure activities. Naples location offers an ideal base for international visitors hoping to experience Campania’s iconic attractions: Capri and Ischia islands, Herculaneum, Pompeii Positano, Sorrento, Ravello, all accessible within an hour.

For further information and updates please visit: www.qirt2012.unina.it
or contact the organizing committee at qirt2012@unina.it

return to TOC

Thermology international

Dr. Kurt Ammer
- Österreichische Gesellschaft für Thermologie
- Hernalser Hauptstr.209/14
- A-1170 Wien
- Österreich

- This journal is a combined publication of the Austrian Society of Thermology and the European Association of Thermology (EAT)
- It serves as the official publication organ of the the American Academy of Thermology, the Brazilian Society of Thermology tthe UK Thermography Association (Thermology Group) and the Austrian Society of Thermology.
- An advisory board is drawn from a panel of international experts in the field. The publications are peer-reviewed.

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- Österreich

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