18.Thermologisches Symposium der Österreichischen Gesellschaft für Thermologie und der Ludwig Boltzmann Forschungstelle für Physikalische Diagnostik

am 22. Oktober 2005 im Hanuschkrankenhaus,Wien

Programme

Chair: H.Mayr (Austria), Anna Jung (Poland)

9.15 RC Purohit , DD.Pascoe, JWaldsmith , TTurner , DHarper ,(USA)
Accepted and Non-Accepted Applications of Thermal Imaging in Veterinary Medicine

9.45 Discussion

9.50 Enhanced laser-tissue interaction using infrared thermography
RA. Thomas, K.Donne, M.Clement, G. Daniel (UK)

10.10 Discussion

10.15 Aspects of Standardisation in the Recording of Thermal Images – The Anglo-Polish Project..
EFJ Ring , P Plassmann, K Ammer, A Jung, J Zuber, B Wiecek (UK/Austria/Poland)

10.35 Discussion

10.40 K.Ammer (Austria)
Thermology International –the first 15.years

10.55 Discussion

11.00 Coffee Break

Chair: Ram Purohit (USA), F.Ring (UK)

11.30 R.Berz (Germany)
MammoVision

11.50 Discussion

11.55 J. Allen, G. Schaefer, CP. Oates, A. Chishti, I. Ahmed, D. Talbot, A. Murray (UK)
Automated infrared image processing for the assessment of arterio-venous fistula function in renal patients

12.15 Discussion

12.20 P. Murawski, Anna Jung, J. Zuber, B. Kalicki (Poland)
A polynomial series model of the facial thermogram for storage and presentation

12.40 Discussion

12.45 R Berz (Germany)
Pilot study on the heating effects at the human head due to mobile phones

13.00 Discussion

13.15 Close

Abstracts

ACCEPTED AND NON-ACCEPTED APPLICATIONS OF THERMAL IMAGING IN VETERINARY MEDICINE

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Infrared thermal imaging provides an accurate, quantifiable, non-contact, non-invasive measurement for mapping skin surface temperatures. Thermal imaging has been used since the late 1960's and early 1970's in veterinary medicine as a diagnostic tool for determination of various inflammatory and nerve and/or vascular cutaneous processes in many animal species. In recent years we have developed considerable listings of thermal imaging standards for equine practice and some other animal species. The indoor thermal imaging standards for environmental controls were established to obtain acceptable diagnostic thermograms, whereas outdoor thermal imaging lacks meaningful guidelines and inherent problems of not being able to control the environment, which may provide non-acceptable thermograms and lacks diagnostic values.

Internal and external factors also have a significant effect on skin surface temperature changes. Therefore, it is required to minimize these variables, which can have direct effects on skin blood flow changes. Some animals are not easy to handle and at times sedation or tranquilization is needed to control their behavior. As we know, tranquilizers and sedatives can and do alter thermal patterns and temperature gradients. A careful evaluation of uses and doses of sedation and tranquilization is thus needed.

Excessive hair covering in some animal species is not acceptable for diagnostic thermograms of the neurovascular system. On the other hand, some parts of the body such as scrotal and perineal areas lack hair covering and acceptable diagnostic thermograms can be obtained. In horses and some species with a very thin hair coat, diagnostic thermograms can be obtained without hair clippings, whereas in thicker or heavy coat species, clipping is required.

In conclusion, we know that exercise, heating, cooling, and the use of tranquilizers before and after thermal examination has also been efficacious for the diagnosis of neurovascular and inflammatory conditions in many animal species. As advanced portable equipment is now becoming available for use in veterinary medicine, we do need meaningful standards for the use of thermography in veterinary medicine.

ENHANCED LASER-TISSUE INTERACTION USING INFRARED THERMOGRAPHY

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The application of infrared thermographie methods in laser-tissue interaction continues to grow in signifieanee. The development of portable lasers has increased the application of laser therapy and in some cases the number of laser operators. The efficacy of manually operated lasers and treatment protocol is largely dependent on the skill of the operator including optimizing laser parameters. Therefore infrared thermography is able to enhance efficacy and reduce the incidence of unwanted side effects by:

. optimising laser parameters prior to therapy,

. monitor laser -tissue interaction during laser therapy and

. during computerised laser scanning of tissue.

Thermographic intervention will reduce the occurrence of excessive heating, missed treatment areas and reduce pain.

Alongside developments in laser technology is miniaturization and reliability of thermal detectors and improvements in display technology. It is envisaged that in the future smart laser devices will evolve with integrated thermographic capability. This paper begins this process by comparing thermographic results taken fom the skin surface during manual and computer laser scanning. These results are compared to a Monte Carlo model.

ASPECTS OF STANDARDISATION IN THE RECORDING OF THERMAL IMAGES – THE ANGLO-POLISH PROJECT.

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1 University of Glamorgan UK,.2 WIM, Warsaw,
3 Technical Univ. Lodz, Poland

An Anglo-Polish collaborative study was set up in 2001 between the medical imaging research group (U.Glamorgan, UK) and physicians and scientists in Lodz and Warsaw. The aim was to identify and resolve the sources of error and problems in medical thermal imaging. Standardisation of the patient preparation, imaging hardware, image capture and analysis has been studied and developed by the group. It is hoped that a network of specialist centres in Europe will work to establish the first digital reference atlas of quantifiable images of the normal healthy human body. From this database further processing techniques can then be used to classify abnormalities found in disease states. The collection of normal reference images is in progress. This paper specifies the areas found to be the source of unwanted variables, and the protocols to overcome them.

A multi-disciplinary team investigated each of the stages involved in performing a thermal imaging investigation on normal subjects. This team involved, physicians, clinical scientists and computer scientists from established centres of expertise in Poland and the UK. The aim is to investigate the total process of thermal imaging in a clinical environment, and to document all areas in which variables, which may affect the reliability of the process. This was completed at the end of 2003, and is described below. The ultimate aim, which is the second stage of the project, is to collect a statistical sample of normal men and women (and probably some children) for the reference atlas of the human body, based in the protocol which now has been presented at some international conferences on thermal imaging in medicine. Access to the atlas/database of normal subjects will become possible either by an on-line comparison with thermograms of diseased patients, or by an electronic or hardware publication.

THE STANDARD PROTOCOL

The main areas of a clinical thermal imaging procedure that need to be standardised are

1: preparation of the patient and the examination room environment

2 . standardisation of the thermal imaging system (including calibration)

3 image capture protocols

4 image analysis protocols

5 reporting, archi-ve and storage of images

6 education and training of clinical users of the technique.

STANDARDISATION OF THE THERMAL IMAGING SYSTEM

Several different thermal imagers are in medical use, with differing detectors, optical lenses, spatial resolution, and manufacturers calibration. It has been found that most camera systems, both with cooled and uncooled detectors require much longer to achieve radiometric stability than that given by the manufacturer.

This means that the common practice of setting up a camera just prior to use, is inadequate in most cases. Variation in the measurement from a black/grey body radiant source at a know temperature or temperatures must be established for each imaging system, and the minimum warm-up time put on record. In addition, most thermal imagers are calibrated by the manufacturer before delivery, and may not be checked again until a fault is detected. Furthermore, each manufacturer in each country may use a different reference system, resulting in a wide offset range in terms of absolute temperature. In order to correct for this, the project team are working with the National Physical Laboratory, UK in the development of a portable series of temperature standards which can be used to cross calibrate all imaging systems to be used in the multicentre image database collection. A large variable in camera position, caused by conventional photographic tripod use is simply overcome by the use of a large format camera studio stand, which allows vertical adjustment of the camera parallel to the ground.

IMAGE CAPTURE PROTOCOLS

This was considered to be a major source of variability, with varying camera angles and distances, making two or more images only partially comparable. A complete set of standard views was therefore devised, that require the camera to be mounted on a parallax free stand, ideally a heavy-duty studio pillar stand. The cameras can then be maintained at 90^0 to the target, and parallel to the ground. The investigator adjusts the distance between the subject (target) and camera to fit the thermogram of the area to be recorded as closely to a software mask outline. This brings the thermogram to approximately the same size for all normal adult subjects regardless of their body size. These masks cannot be used for children; special sets of these will be developed if a suitable set of younger thermograms can be added to the database. The chief outcome, however, has been the introduction of capture masks for each standard view of the human body. This is an electronic outline written in to the software, which automatically appears when each standard view is selected from the menu. The outline ensures that the target fills the frame as much as possible, and that the limits for each view are defined by anatomical description (i.e. visible topographic features).

The temperature range and level is not changed, although supplementary images can be added if essential to record the full dynamic range of the subject.

These standardised procedures allow the collective analysis of groups of subjects within specified age bands placed in decades of life.

IMAGE ANALYSIS

In addition to software masks to aid standard image capture, a set of regions of interest for temperature analysis have been drawn up for each standard view. These are accurately placed, again following anatomical definition, if the image has fitted well to the mask. Minor adjustments can be made if the fit is less good.

In order to create a mean normal image of each anatomical area, with defined standard deviations, a further process of morphing has been developed. In this way larger numbers of images for a selected age band, can be merged to derive a mean range of temperature and thermal patterns for each area of the body. Experiments have shown that even the same operator, poorly reproduces the usual practice of selecting rectangles or free drawing regions of interest. However, the policy of following described anatomical landmarks in drawing each region of interest results in very good reproducibility, whether made by the same operator or another. Such measures, which ensure that many of the subjective variables in analysis are removed or minimalized, are of critical importance in medicine

References

Ring et al. Technical challenges for the construction of a medical image database. SPIE Europe Int. Symposium. Jena, Optical systems design. Paper 5964-23. Proceedings

THERMOLOGY INTERNATIONAL- THE FIRST 15 YEARS

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The very first issue of a new journal „Thermologie Österreich" was published in May 1991,. At that time at least 3 journals dealing with the subject of medical thermology were available: Thermology, the journal of the American Academy of Thermology, Biomedical Thermology, published at that time papers in Japanese and ThermoMed, which was the publication organ of two German Thermology Societies. Acta thermographica, a journal from Italy published in English, has already ceased its publication in 1981. Although Acta Thermographica was a milestone for the distribution of thermological studies, the language standard of this journal induced ambiguity in many of natural English speakers. Therefore, one of the prime requirements for starting a new journal, was the commitment of a natural speaker to improve the English of manuscripts submitted by non natural speakers.

The journal was named "Thermology Österreich" from 1991 to Summer 1997, when it changed its name to "European Journal of Thermology, after the German Society has decided to use this renamed jouranal as official publication organ. However, in 1999 the journal was renamed again and became "Thermology international" that served also the American Academy of Thermology for publication.

The publication language was originally German, with an abstract in English and German. But very soon, full length articles appeared in English. The background material of an Instructional Course on Medical Thermography organized in Vienna in 1993 appeared bilingual in German and English, and a paper from Slovakia in the second issue of the 1993 volume was the first fully published in English with abstracts in English and German. In 1994, when 4 instead of 2 issue per year were published. 7 of 15 full papers and the regular Newsletter-Section appeared in English. In 2000 only 4 papers were published in German, and since 2001 everything is written in English.

From the very beginning, abstracts from meetings and conferences appeared in the journal. Until now the archives of the journal contain abstracts from 15 Symposia of the Austrian Society of Thermology, 3 International Conferences of Thermology (1992, 1998, 2001), 4 European Congresses of Thermology (1994, 1997, 2000, 2003), 9 Annual Meetings of the American Academy of Thermology (1994-1999, 2001,2002, 2004, 2005), 8 Annual Conferences of the Polish Society of Thermology (1998-2005) and 6 UKTA Meetings.Abstracts from the Annual Meeting of the Korean Academy of Thermology, the Annual Meeting of the German Society of Thermology .and the Industrial Austrian Society of Thermography appeared only once. The Medical Infrared Imaging Abstracts from IEEE-EMBS International Conferences between 1994 and 2002 have been reprinted.

Another regular feature of the journal, ist the annual review on papers dedicated to thermology. Originally this review collected publications on thermal imaging only, but included recently. other methods of temperature measurement and temperature related science in this literature search. This resulted in 2789 publications in the year 2004, and the total list of references from 1989 to 2004 shows 8133 titles. This list ia available from the website of the Medical Imaging Group of the University of Glamorgan at http://www.MedImaging.org. .

In 2000, a section on Technical/Industrial Thermology was established in order to widen the scope of the journal to fields outside of medicine and biology. In 2002, the medical database EMBASE agreed to include articles from Thermology international in this database, which is the second important data collection in the field of medicine. Until now, authors from 16 different countries have published 215 full length papers in Thermology international. Submissions from Poland, UK and Austria cover 69 percent of all publications. The most cited paper is by Ring& Ammer on The Technique of Infrared Imaging in Medicine, published in 2000.

MAMMOVISION

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MammoVision is a diagnostic system combining a seat with an adjustable stand for an infrared imager connected to a laptop with software designed for the analysis of female breast diseases. The camera stand permits optimal positioning for repeatable fields of view of individual breasts. For infrared imaging VarioScan High Resolution is used with a thermal resolution of 0.03 K.

The software provides data fields for biographical data of the patient and proposes a sequence of six body positions for imaging. Firstly, the left breast, then both breasts in the front view followed by the right breast are imaged, and after a period of cooling the same series of images is taken again. Software tools support the user in finfing the correct body position. In each image the mamilla is highlighted and the distance between mamilla and infrared camera is recorded. This data are used for repositioning when images need to be repeated.

The analysis software, named MammoVision Expert uses a grid for measurements. The grid devides the mamma in 4 quadrants and 3 circles. Each quadrant is than divided in two parts, resulting in 6 sectors per quadrant (figure 1)

In addition, the temperature of the mammila i.e.the inner circle and all other circles can be measured. In total 28 measured areas are defined for each breast. The following temperature statistics are available for each area: mean, minimum, maximum, standard deviation and range of temperature.

Combining the temperature readings from the breast prior and after cooling provides sufficient information for the differentiation of benign and malign changes of the female breast

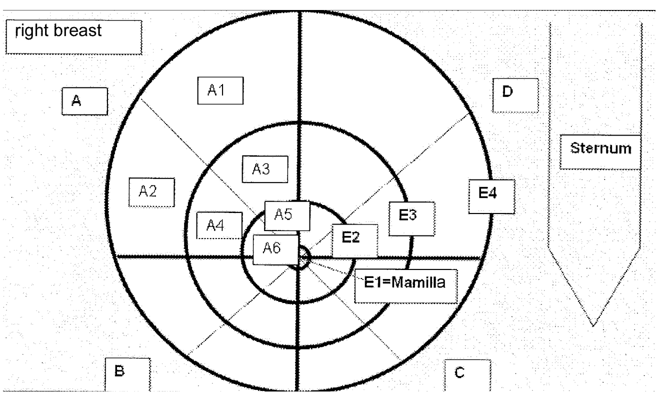

Figure 1
Measurment grid

AUTOMATED INFRARED IMAGE PROCESSING FOR THE ASSESSMENT OF ARTERIO-VENOUS FISTULA FUNCTION IN RENAL PATIENTS

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Vascular and clinical assessments of arterio-venous fistula function for patients undergoing renal dialysis can help identifying problems indicating fistula failure or excessive fistula flow which might result in vascular steal from the hand. Previous work has established a relationship between fistula region skin temperature (as measured using thermal imaging) and fistula blood flow (as estimated using colour duplex ultrasound at the brachial artery): fistula flows are significantly correlated with bilateral differences in maximum fistula region skin temperature. Whilst this result demonstrates the usefulness of thermal imaging in assessing fistula function it can require time consuming manual intervention in the form of interactively selecting the regions of interest in the infrared images. Furthermore, the analysis tends to be based on proprietary thermal imager system software which often provides only basic statistical information on the skin temperature distribution.

In this work we present a completely automated approach to renal fistula function assessment which removes this dependency and allows an instant analysis. Once the thermal image of the patient has been captured, image processing techniques are applied to automatically extract the regions of interest. The images are first thresholded (i.e. the intensities divided into ranges below and above an adaptively selected threshold) in order to remove the background, regions comprising the patient's arms are then segmented and labelled (i.e. left or right) whilst smaller segments (possibly comprising other body parts in the background or noisy patches) are discarded. Once the extent of the regions are established the bilateral temperature difference can be calculated and used for predicting fistula blood flow. Experimental results based on a study of 15 renal patients at the Freeman Hospital proved a high correlation between bilateral temperature difference and fistula flow ($R = +0.73$, $p < 0.01$) which were virtually identical to those obtained from the manual image extraction technique ($R = +0.71$, $p < 0.01$). This comparison with the "gold standard" based on manual region extraction clearly demonstrates the usefulness of the presented automated technique and its potential in practical clinical application.

A POLYNOMIAL SERIES MODEL OF THE FACE THERMOGRAM FOR STORAGE AND PRESENTATION

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OBJECTIVES: The aim of paper is a presentation of ta linear model of the face's thermogram for storage and reconstruction.

Typically, thermograms are saved as temperature area or a set of different coefficients which are useful for temperature calculation. This technique is easy and is used by many developsers of software for thermal imaging. This approach is acceptable as lang as only some images have to be archived.. However, when thousands of images must be stored , the size of the database increases dramatically.

The proposed model shows alternative technique for thermal image storage in a software for.automatic analysis of face's thermal image.

METHODS: The base for this method is an analysis of the temperature matrix as a result of the single man (face) observation. Any face thermogram can be represented by a sum of two areas: 1) face area, 2) background area. Interesting is that these areas can be recognized automatically. This feature is used to create a linear model of the thermal face representation. The shape of the human face can be defined as an elliptic area with some rotation. From mathematics point of view, an ellipse is a well defined object.

Accepting the shape of the face as an elipse, it becomese possible to define each point of the area as a function with two parameters: angle and distance from the small and long diameter intersection. Because the angle can change in range 0 to 360 degree, the shape of the face can be defined by a set of 360 functions. It is well known from mathematics that continuous function can be represented as a function series. Because each from 360 functions can be represented as a set of parameters then the total area can be represented and reconstructed by matrix of.360 x N numbers The value of "N" parameter is experimentally set to 10.

RESULTS: In a first study we tested the presented method in the 32 thermograms recorded from subjects with different age and gender. This preliminary study achieved good results.

In a second study we tested the presented method in 12 thermograms recorded from different subjects. 27 thermograms – 9 views from 3 distances (1, 2, 3m) were taken of each subject. The method worked correctly in most of the cases, but the best results were observed for thermograms which were in normal position (without vertical and horizontal rotation). This result has been expected. Problems have been observed when the distance was equal to 3m and also when the object (face of the subject) was rotated or the look of the imager was not perpendicular to the object.

CONCLUSIONS: The presented method can be useful for processing and storage of the face's thermal images. The biggest problem is that the typically used mathematical method for calculation of function coefficients is unstable. Therefore, we will investigate alternatively the LPC (Linear Predictive Coding) model for the thermal face representation in the future.

PILOT STUDY ON THE HEATING EFFECTS AT THE HUMAN HEAD DUE TO MOBILE PHONES

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Mobile telephones emit electromagnetic fields in the gigahertz range. The biological effect of high frequency fields is of thermal type, resulting in warming at a corresponding dose. However, additional warm parts are found at the mobile telephone caused by the batteries and display warmth.

This study investigated, whether differences can be found at the ear and in the periaurale region comparing a mobile telephone radiating actively and an inactive dummy. The result of this preliminary pilot study was that warming by the mobile telephone is higher than by the dummy at the outer ear; but in the periaurale region no difference in heating effect was detected. For the assessment of the skin effect and the the dermal absorption further and more extensive studies are required.