14th Congress of the Polish Association of Thermology

and

Certifying course: "Practical application of thermography in medical diagnostics"

Zakopane, March 26 – 28, 2010

Scientific Programme

Saturday, 27th 2010

9:00-11:00 Session I
Chairmen: Prof. K. Ammer, Prof. J. Mercer

Vardasca R. (Portugal)	Barycentric warp model for hand thermal images standardisation.
Prof. Ammer K (Austria)	Cold challenge to provoke a vasospastic reaction in fingers determined by temperature measurements: A systematic review.
Vardasca T, Vardasca R (Portugal)	Hand cold stress test methods electronic evaluation and reporting.
Prof. Mercer J, de Weerd L. (Norway)	The use of infrared thermography in visualizing perfusion in the reverse sural artery (RSA) island flap preparation used in treating open of the lower extrimities.

11:30 – 13:15 Session II
Chairmen: Prof. A. Jung, Prof. E.F.J. Ring

Prof. Ring E.F.J. (United Kingdom)-	Revealing the Invisible.
Murawski P. Prof. Jung A., Dr med. Kalicki B., Dr med. Zuber J. (Poland)	Tele Med Net - medical platform for scientist and diagnostics, perspectives for thermography.

15:00- 16:00 Session III
Chairmen: Prof. B. Wiecek, Prof. A. Nica

Prof. Wiecek B., Wiecek M., Strakowski R., Owczarek G (Poland)	Application of thermography for searching people in hazard conditions.
Prof. Nica A., Mologhianu G., Murgu A. Ojoga F., Mitoiu B., Ivascu M. (Romania)	Clinical and and thermographic evaluation in the posttraumatic knee, . -
Dr Cholewka A., Prof Drzazga Z., Drop K Knefel G., Kawecki M., Nowak M. (Poland) -	Application of thermal diagnostics in hyperbaric oxygen therapy (HBO)

16:00-17:15 Training course
Chairmen: Prof. S. Klosowicz, Dr med. J. Zuber

Prof. Klosowicz S.(Poland) -	Some words about heat and temperature.
Presentation from the company VIGO	
Prof. Wiecek B. (Poland)	Comparison of cooled and uncooled cameras for biomedical applications

Abstracts

BARYCENTRIC WARP MODEL FOR HAND THERMAL IMAGES STANDARDISATION

Ricardo Vardasca

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Thermal images of hands provide clinical information. However due to the complex shape and different subject sizes. It is difficult to execute an accurate analysis. A standardisation method is needed to perform a comparison or an average of various images. The method used in this experiment is morphing triangulation, it consists of using an approximate geometrical shape similar to the capture mask, the shape is divided by anatomical regions of interest and those are triangulated based on the control points that define the model. The resultant image is generated by reverse correspondence of pixels that are obtained by equivalence based on barycentric coordinates. It will allow a scaling and alignment without scrambling the original data between different anatomical areas. This simple process of warping images is shown to meet the requirements presenting an accuracy of 98%. Standardising several hand images is possible using this technique along with extended statistical evaluation, discrimination and balancing of groups of images with minimal processing time.

COLD CHALLENGE TO PROVOKE A VASOSPASTIC REACTION IN FINGERS DETERMINED BY TEMPERATURE MEASUREMENTS: A SYSTEMATIC REVIEW

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Medical Imaging Research Group, Faculty of Advanced Technology, University of Glamorgan, Pontypridd, UK

BACKGROUND: Raynaud's Phenomenon is characterised by 3-phasic colour changes of fingers and/or toes caused by vasospam of the digital arteries due to low temperature and/or psychological stress. These colour changes may be accompanied by decreased skin temperature which can be identified by infrared thermal imaging.

OBJECTIVE: To identify procedures which address patient's preparation, temperature of the examination room, temperature and duration of the immersion bath, position of hands, time of follow-up after the cold challenge and method of evaluation

METHOD: A computer assisted literature search was performed for publications related to thermographic investigations of patients with suspected Raynaud's phenomenon in Embase, Medline, Google Scholar and the literature archive of the author.

RESULTS: Out of 170 hits in Google and 98 in Embase/ Medline, in total 50 articles and 6 reviews were included. The information on procedures performed was incomplete in the identified studies. There was a wide variation in water temperature of the immersion bath and also of duration of immersion. More than 20 different methods for evaluation of hand temperatures were reported

CONCLUSION: The description of the methodology must improve. A evidence based guideline for standard procedures of performing and evaluation of thermal images from patients with Raynaud's phenomenon is needed.

HANDS COLD STRESS TEST METHODS ELECTRONIC EVALUATION AND REPORTING"

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Cold Stress Test (CST) on hands has been used as a standard in thermography for assessing Raynaud's Phenomenon (RP) for years. This test has shown to be relevant for assessing specific vascular and neurological conditions when used in combination with other provocation tests. Different temperatures of water and recovering times have been used. Three methods to grade the test have been suggested; Ring suggested in 1980 the method of areas (Method 1), where the mean temperature of fingers excluding the thumb was subtracted to the mean temperature of the dorsal palm of the hand. The index values were calculated for the thermogram before the CST and from the final one (normally 10, 15 or 20 minutes depending on the recovery), for a final index both thermograms indexes were added for each hand, in case of an index value below -2.0ºC the hand was considered hipothermic.

Ammer recently suggested two methods based on thermal gradients/profiles, one using a thermal spot of at least 16 pixels on the middle of each finger (excluding thumb) distal phalanx and another spot of the same size on a proximal region of the respective metacarpal (Method 2) computing the mean temperatures of those spots, subtracting the finger spots from the metacarpals obtaining a index per finger. The other suggested method from the same author was to draw a line composed of 4 pixels from the middle of each finger (excluding thumb) distal phalanx to the proximal part of the correspondent metacarpal (Method 3) calculating the mean temperature of each part of the line, corresponding the distal part of the line to the finger and proximal to the metacarpal, once again to obtain the index per finger by subtraction.

Is objective of this experiment to compare the three methods of assessing CST of hands, to investigate the values of thermal symmetry on healthy volunteers on recovering of CST and provide a reporting solution of the obtained results.

The CST were performed according to the Glamorgan thermogram capture protocol using exposure of 1 minute to water at temperature of 20 ºC. 10 healthy volunteers were examined. Two types of CST were recorded, one combined with mechanical provocation before and another without previous provocation. A computational application using an anthropometric model of hands was developed allowing standardization of thermal images of hands based on anatomical landmarks and preserving its thermal values per hand area of interest (AIO). This tool also produces statistical values per hand AIO's. Another complementary tool was developed implementing the three methods of assessing CST generating each statistics per minute of recovery generating a full report in PDF and DICOM formats.

The method that provides better discrimination on identifying RP is the Method 2. All methods seem to be sensitive to false positive cases of RP. This information on a full report of the three methods might be relevant on future studies of upper extremities pathological states.

THE USE OF INFRARED THERMOGRAPHY IN VISUALIZING PERFUSION IN THE REVERSE SURAL ARTERY (RSA) ISLAND FLAP PREPARATION USED IN TREATING OPEN WOUNDS OF THE LOWER EXTREMITIES.

James B. Mercer[1,2] and Louis de Weerd[3]

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Soft tissue defects of the lower 1/3 tibia and dorsum of the foot present a challenging problem for plastic surgeons. The reverse sural artery (RSA) island flap has become the work horse for the closure of these defects. The flap is a so-called neurovascular flap, a flap that is based on the vascular network that accompanies a nerve. The RSA flap is harvested from the posterior side of the leg with its axis along the sural nerve and its basis approximately 5 cm above the lateral malleolus. This distally based flap receives its blood supply from a perforator that arises from the peroneal artery at the lateral distal third of the leg and that communicates with the vascular network accompanying the sural nerve. The direction of the blood flow in the flap is the reverse of normal. After transposition of the flap to the defect, the flap relies entirely for it blood supply on the perforator of the peroneal artery. However, after a 3 weeks period, vessels at the defect have made contact with the vessels in the flap. For cosmetic reasons it may be necessary to resect the skin bridge that connects the flap with the perforator This is only possible after vessels at the defect have grown into the flap and contribute to the flaps' blood supply. We demonstrate with a clinical case how infrared thermography can be used to visualize that such angiogenesis has happened and that the direction of the blood flow within the reverse sural artery flap become normalized again.

REVEALING THE INVISIBLE

EFJ Ring

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In recent years, medicine has benefited enormously from the emergence of a variety of imaging technologies. Almost every part of the electromagnetic spectrum has been used in a form of investigation. The earliest aid to medicine came from the microscope and the identification of bacteria, brought significant advances. The discovery of xrays and the emergence of radiological imaging as also made a major impact on modern medicine. Infrared radiation though identified in 1800 by Herschel, was not exploited properly until 1910, when Professor Robert Wood used an infrared film for infrared photography, which allowed some clarification of superficial blood vessels to be shown, using near infrared radiation. The advance in infrared thermal imaging came from the 1940's and subsequently wider use in the early 1960,s using electronic detectors brought passive non-contact imaging of surface temperature into many civil and medical applications.

However, infrared imaging was yet to find a new level of sensitivity and reliability that was accelerated by the advent of computing. As in many other medical imaging systems, the digital revolution has had a number of valuable attributes. One is in the use of false colour, because the human eye is limited in the number of grey shades that are naturally detected, but with false colours, even the limited 20 shades shown on the average radiology film can be increased to 200. Furthermore, it is possible to use software aids for reliable image capture, image analysis and the rapid storage and retrieval of images.

The way in which infrared thermal imaging was developed at Bath UK, for arthritis research, especially the objective measure of anti-inflammatory drugs are described. This led to a series of useful clinical trials throughout the 1970's to 1990's. These trials were based on the reduction of temperature over inflamed joints, or the assessment of changing response to thermal and mechanical stress tests, for evaluating efficacy of treatments in applied pharmacology.

The current issues around the mass screening for fever with thermal imaging are also of importance, and a clinical study of children in Warsaw has shown that standardized imaging of the face can be used, and in fact forms the basis of a new International Standard for detection for fever.

The imaging cameras have dramatically improved over the 50 years of development, and through the use of modern digital communication, it is hoped that the much needed database of normal reference thermograms for medical thermography can be achieved. This can be expected to improve education and international standardization for this technique that should increase its reliability and uptake across clinical medicine.

TELEMEDNET – MEDICAL PLATFORM FOR SCIENCE AND DIAGNOSTICS, PERSPECTIVES FOR A MEDICAL THERMOGRAPHY

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1ICT Department of Military Institute of Medicine'

2Pediatrics and Nephrology Clinic of Military Institute of Medicine

Over the past few years, the issue of medical research has expanded the number of new issues. Phenomena such as the need to optimize the treatment process, the search for new effective methods and the need for multi-analysis of large data sets meant that specialists on issues of construction of information systems and computer algorithms, and began to look for technology to support research in these areas. Due to the large and large-data sets made it necessary to use highly advanced software solutions that can effectively support scientific research in medicine and medical economics.

The "TeleMedNet" project will be implemented by a consortium consisting of two Polish medical entities: Military Institute of Medicine (Warsaw) and the Provincial Specialist Clinical Hospital (Wroclaw). Leader of the project is Military Medical Institute.

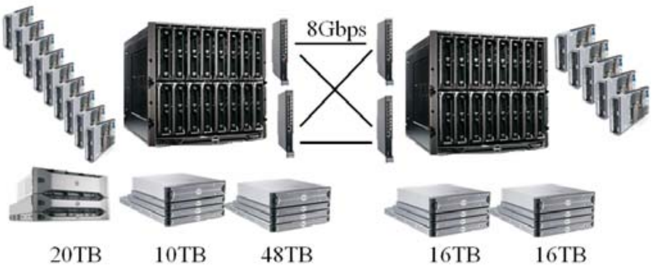
Activities conducted by the project team "TeleMedNet" aim to provide reliable infrastructure and the integration of the latest generation of computer systems. In this way, an integrated system to support action research workers and cutting-edge information and IT. Implementation of the project will conduct TeleMedNet modern scientific research in various areas of medicine based on verified clinical data. The project will produce an extensive infrastructure, which is made available to the medical scientific community to develop new lines of research in the future.

This will be achieved through:

- • The creation of infrastructure and applications to collect and store data.
- • Construction of a platform for sharing and analysis of collected data.
- Provide a safe and permanent access to infrastructure.
- Establish a database of medical costs of medical procedures.
- As a result of the project the medical scientific community will be given the resources of the safe processing and data sharing:

- Secure primary and backup localization
- Redundant, guaranteed 40(80) KVA power supply
- Redundant, synchronous internet connection (30Mbps expandable to 155Mbps)
- Full virtualization infrastructure (servers, storages, computer networks)
- Computer networks with 20 Gbps bandwidth at the backbone network
- Time server (time.wim.mil.pl)

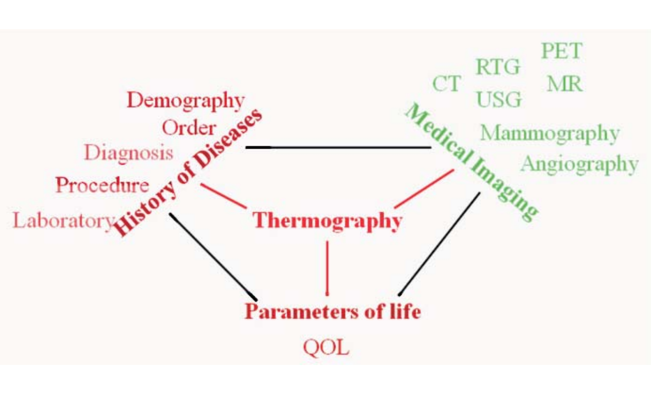
The infrastructure for collecting and processing data will be incorporated into primary and backup Data Center equipped with the infrastructure as shown.



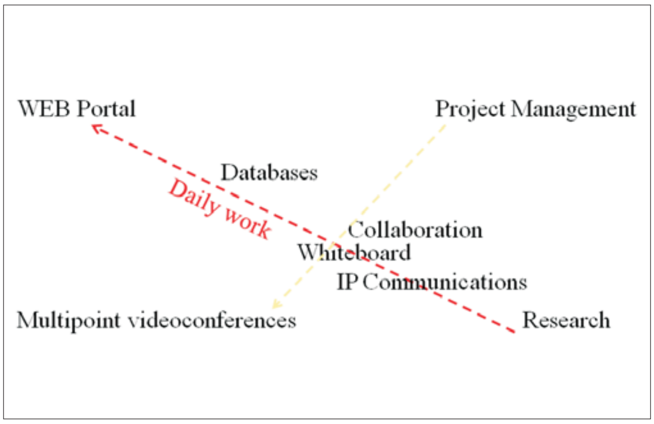
Critical elements of the data network will be connected to a fiber optic data computer network technology that uses a combination of Fiber Channel with 8Gbps bandwidth. Parallel computer network, where will be connected "customers' infrastructure, will be monitored on-line using professional equipment monitoring.

Part of the project is a development of systems for collecting medical data, including data necessary for a correct analysis of thermographic data.

The effect of system development will therefore rise to possibilities of multicriteria analysis of medical records including different types of data including medical images base on different sources.



The result of the project will also establish an infrastructure to a shared, simultaneous work of scientists and knowledge sharing. To this end, solutions are implemented to create the projects in terms of time, human resources and finance. These projects can be "discussed" with the use of many different communication techniques.



The proposed solution will also be used for routine medical research, discuss results and their presentation in the form of resources, knowledge bases and web portal http://telemednet.wim.mil.pl.

Project facts

„TeleMedNet – medical platform for science and diagnostics" POIG.02.03.00-00-042/09	
Beneficiary	Military Institute of Medicine, Warsaw Provincial Specialist Clinical Hospital, Wroclaw
The value of the project	5 828 695,24 €
Project period	2009 – 2012
Project Manager	Lt. Col. Piotr Murawski Msc Dsc e-mail: pmurawski@wim.mil.pl

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APPLICATION OF THERMOGRAPHY FOR SEARCHING PEOPLE IN HAZARD CONDITIONS

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In this work, we presented an algorithm and the software that allow searching people in complex, noisy and industrial environmental conditions. It can be applied in hazard situation, such as fire. The algorithm which is implemented operates in two steps. The first one is based on segmentation of thermal, monochromatic images using morphological methods and finding regional maxima that allows the image reconstruction. Then, images are binarised by thresholding and the next morphological operations are applied. This is done to separate regions glued by the small number of pixels and to recognize the vertical shape of an object. These images contain a lot of useless regions of interest, so it is necessary to select them conditionally. Regions having small areas and the long and narrow shape are eliminated. As a result, new rectangle regions of interest are created.

The next step is to calculate the parameters (image features) for regions of interest. We use I-order statistical and II-order based on concurrence-matrix parameters. In addition, we applied the wavelet transform and Run-Length matrix parameters. The last set of parameters based on temperature profile (distribution along the line) was also used. The following step of the algorithm is to select the features using Fisher coefficient which allows reducing them down to 6 the most discriminative ones. Such features are used for the classification performed by 3-layer artificial neural network. The second stage of the implemented algorithm is to connect areas having common pixels or which are located close to each other in vertical direction. Such regions are segmented once more in the way like in the first classification step. Next, the parameters are extracted and selected by Fisher coefficient and finally the people are found using the second artificial neural network. The example of working application is presented below. The software was implemented using MATLAB environment.

Figure 1.
A result of searching people, green boxes show the object correctly classified, red one – erroneous classification

CLINICAL AND THERMOGRAPHIC EVALUATION IN THE POST-TRAUMATIC KNEE

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BACKGROUND: The knee, as an intermediate joint in the kinematic chain of the lower limb, is very solicited from the mechanical, thermal and vascular point of view anatomic area. Either directly in athletes or indirectly the knee is exposed to micro and macrotrauma. Initially the knee is evaluated by the general practitioner or the orthopaedist, then by the rehabilitation specialist. The initial clinico-functional evaluation shows as a central factor the pain, then stiffness and instability, but does not measure dynamics in the vascular regenerative availability, as an essential factor in the knee rehabilitation.

AIM OF THE STUDY: The present study evaluates the dynamics of the periferial temperature, through thermal imaging and correlates it with the clinico-functional dynamics.

MATERIAL AND METHOD: We have studied a group of 25 patients with posttraumatic knee pathology: wrench, ligament rupture, meniscus fracture, tibial plateau fracture, and degenerative pathology. The patients followed a rehabilitation program, for 2 weeks, which included electrotherapy, thermotherapy, massage and kinetotherapy; they also have taken medical treatment.

The patients have been evaluated from clinical, symptomatic and functional point of view (pain, stiffness, muscular strength), radiologic (integrity of the bone structure), echografic (soft tissues integrity) and thermographic (availability of the periferic circulation).This parameters have been analyzed at the beginning and at the end of the rehabilitation program (after 2 weeks). Thermal imaging were taken on both anterior and posterior sides of the knee, according to the Glamorgan protocol-

RESULTS: The results obtained through thermographic measurements, have been correlated with the dynamics of functional evolution.

DISCUSSION: The purpose of the present study was to evaluate the dynamics of the peripheral temperature materialized through . Through biostatistic interpretation we appreciated the differences of temperature and thus we obtained an objective argument of the global clinical evolution.

APPLICATION OF THERMAL DIAGNOSTICS IN THE HYPERBARIC OXYGEN THERAPY (HBO)

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MATERIAL AND METHODS: The investigations were carried out at the Burn Treatment Center in Siemianowice Œl¹skie.

The total study population consisted of 19 patients (7 male and 12 female) age 51 ± 15. One session of hyperbaric oxygen therapy lasted 86 minutes. The pressure of air in the chamber was 2,5 ATA. The thermograms of chosen regions of interests (ROI) were performed before and immediately after HBO in the special room outside the chamber. Temperature in the chamber during therapy as well as in the measurement room was stabilized (22,5 ±1 C).

Prior to exposure to hyperbaric oxygen as well as prior to imaging, the wound was uncovered from bandages which were wrapped in a very loose manner and then left uncovered in order to reach thermal equilibrium of ulcer with the environment. Preparation of the limb was the same for all patients.

RESULTS AND DISCUSSION: HBO can reduce the swelling and increase the leak of fluid through the damaged blood vessels what helps the oxygen to get to the damaged tissue area and improves the wound healing. It also stimulate the activity of cells creating the fibres which are usually the basal of new healthy tissue. These reactions reveal in the changes of temperature and therefore can be evaluated by thermovision. It seems that the changes of ulcered skin thermal map may be connected with improvement of microcirculation and metabolism in chosen areas that suggest a beginning of the healing process.

The result of our studies show two types of skin thermal behaviour after hyperbaric oxygenation. For most of patients suffering from trophic ulceration of tibias the mean temperature of chosen ROI decreases after hyperbaric oxygenation similarly as for all healthy people. However, the opposite effect was also observed. There were patients for whom the increase of mean temperature was observed in the whole or only in the part of the disease area.

Moreover the statistical outlines performed for studied patients suffering from *trophic ulceration* showed the significant decrease (DT=2,0°C) of temperature for 60% of patients. On the other hand the increase of mean temperature (DT=0,5°C) was observed for 40% of patients.

It follows from our studies that after hyperbaric oxygen therapy the decrease of temperature was observed more often than the increase of temperature.

However it should be noted that the HBO effects are complicated what is reflected in different temperature changes. This problem requires a deeper medical analysis.

CONCLUSIONS The significant changes of skin temperature for patients suffering from *trophic ulceration* due to stay in hyperbaric chamber were observed. It seems that thermal imaging can be useful in monitoring HBO effects.

COMPARISON OF COOLED AND UNCOOLED CAMERAS FOR BIOMEDICAL APPLICATIONS

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In this paper the comparison between cooled and uncooled thermal imaging systems for biomedical applications is presented. This comparison mainly shows the difference in spectral characteristics of both solutions. The thermal uncooled microbolometer devices (Fig. 2), are only available in long wavelength spectral range. It is due to the lower detectivity. It is because low temperature object (about 300K) radiate much more of energy in the long-wavelength subband. On the other hand, the cooled cameras with much higher detectivity and sensitivity, have the very selective spectral characteristics (Fig. 1).

In cooled technology, the QWIP detectors easily allow to manufacture the multicolor devices (Fig.3). Unfortunately, QWIP has significantly lower detectivity in comparison to MCT detectors. Today the first multicolor structures using MCT are already available.

NETD is different for both technologies. Today for cooled 15mm pitch detector, it is possible to reach NETD<20mK, while 25 mm pitch microbolometer has NETD»40mK with the same optics. In addition, the time response, in the sense of integration and frame rate of the camera, is drastically worse for uncooled devices. The integration time for aSi 25mm pitch bolometr may not be lower than 10ms, while in cooled devices it can be scaled down to 50ms. It has significant impact of frame rate. The cooled systems are offered today with 20000frames/s frame rate, while the micromolomers cameras are only able to generate images at classical video speed, i.e. 25 images/s.

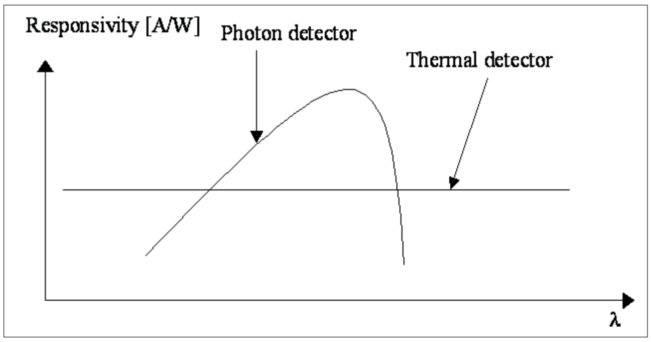

Fig. 1.
Spectral characteristics of cooled and uncooled IR detectors

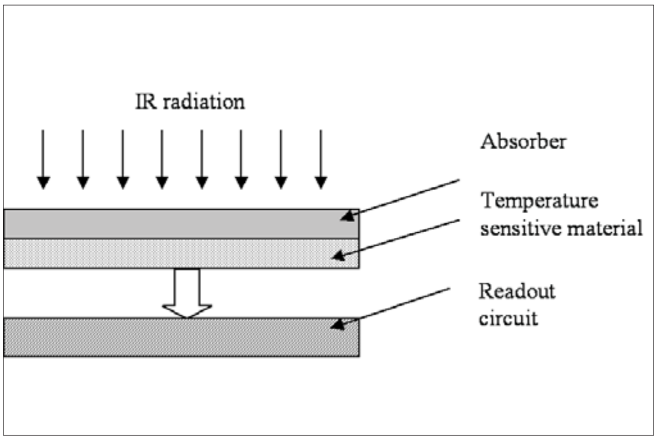

Fig. 2.
Cross-section of uncooled bolometer

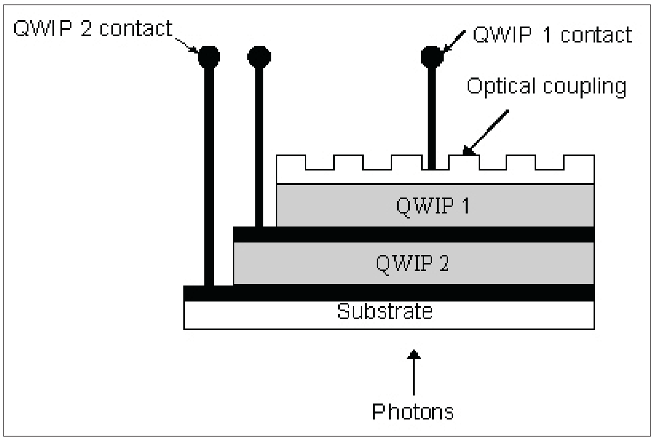

Fig. 3.
Cross-section 2-color QWIP detector