Screening Fever, A New Approach

António Cardoso

CATIM - centro de apoio tecnológico à indústria metalomecânica
Rua dos Plátanos 197, 4100-414 Porto

SUMMARY

The use of the inner canthus in Humans as a reference for core temperature can be compromised by a number of factors that can lead to faulty measurement.
Despite at inner canthus the ophthalmic artery flow beneath, cerebrovascular disease at internal carotid artery will diminish flow at downstream arteries, and consequently, the amount of heat dissipated at inner canthus and the temperature at surface, drops. Accumulation of mucus discharge at inner canthus will enhance the dropping. Thermographically speaking, the area has an emissivity very well determined, 98 %, which implies, besides this accuracy, the determination of reflected apparent temperature.
On the other hand, external auditory meatus are wave-guides and need to be kept at constant temperature; otherwise the velocity of sound propagation will vary along its length, creating echoes inside of themselves. In this way, external auditory meatus are isothermal cavities and due to its geometrical configuration, an illusion of black body is always present at the interface with the exterior. Unlike the tympanic thermometers which are affected by crooked meatus or wax, because they have to "see" the eardrum, thermographic cameras do not have the accuracy compromised, provided that, the problem is not visible from the outside. In all other situations, the external auditory meatus, when observed from the outside, always have an emissivity of 100 %, relieving the measurement from determination of the reflected apparent temperature.
With this technic, screening fever can be done on people walking in line, without being at a controlled environment and with all sources of error removed.

1. INTRODUCTION

We don't measure temperature with thermographic cameras, we calculate temperature. Thermographic cameras are imagers, each pixel represents an amount of energy sent towards the camera from a surface
This energy has two components, an emitted one and reflected one. Usually, most of surfaces belong to opaque objects; the transmitted component is usual consider, or is, 0. In the application described below the transmissivity is 0
In these cases the equation:

$$W = \sigma(\varepsilon T_{surface}^{4} + (1-\varepsilon) T_{reflected}^{4}) \quad (1) \qquad (1)$$

is used for express the relations between relevant physical quantities.

In each case we have W = the magnitude of Pointing vector towards the camera, σ = Stefan-Boltzmann constant ε = emissivity, $T_{reflected}$ = reflected apparent temperature has to be determined.

2. INNER CANTHUS

In infected patients, during the epidemic of SARS, a huge increase of temperature on eyes zone had been found. This fact in combination with morphology of the ophthalmic artery leads to considerer the inner canthus a possible spot to estimate core temperature in Human Beings.
Ophthalmic artery is fed by internal carotid artery and split itself beneath inner canthus in nasal artery and frontal artery.
Despite these characteristics, inner canthus has a series of snags that compromise, thermographically speaking, the accuracy of the calculations for core temperature.
Human skin is believed to have an emissivity of 98 %, regardless color skin. This, impose an estimation of reflected apparent temperature.
Not doing this, a reference source with a very well knew emissivity and with a very well defined

temperature has to be put in the field of vision to allow the computing of reflected apparent temperature. Placement of source has to be on the same plane of the inner canthus. Otherwise reflected apparent temperature "seen" by the inner canthus and reference source will be different.
Filling 75 % of the camera field of vision with the face of the patient to ensure MFOV smaller the inner canthus size, compromise in several ways the estimation of reflected apparent temperature. First, the rule mentioned before cannot be kept. Second, the narcissism effect of the camera, and possible the operator, over the scene from the camera is huge.
Since the outer layer of the skin has no irrigation, heat flow can only be achieved in a passive way, thermal conduction. This layer will act as low-pass filter and the temperature calculated will be always below or above core temperature, depending if room temperature is below or above core temperature. Mucus discharge at inner canthus also increases this effect.
Cerebrovascular disease also compromise the calculation by promoting false negatives, this syndrome diminish the flow capacity of the internal carotid artery, and consequently the blood flow at ophthalmic artery and heat flow at inner canthus.
Doing efforts before remote fever screening is also strongly not recommend because produce false positives. To allow more blood flow, and help dissipate the heat excess, capillary vessel section increase. This increases facial temperature.

3. EXTERNAL AUDITORY MEATUS

External auditory meatus are wave guide and need to be isothermal cavities to achieve its function. The skin inside and the ear drum have to be at same temperature or variations of sound speed will be present along the meatus, producing echoes and other problems related to poor propagation of the sound waves. Besides thus, when a cavity has a shape that doesn't allows seeing inside, this means the presence of an illusion of a black body.
Equation (1) changes to

$$W = \sigma T_{surface}^{4} \quad (2)$$

Equal as any isothermal cavity, the meatus is completely surround by a volume, the head, with a ratio of 3.5 between length and diameter (1 *cm* × 3.5 *cm*). Has a conical shape with the top cutted (ear drum).

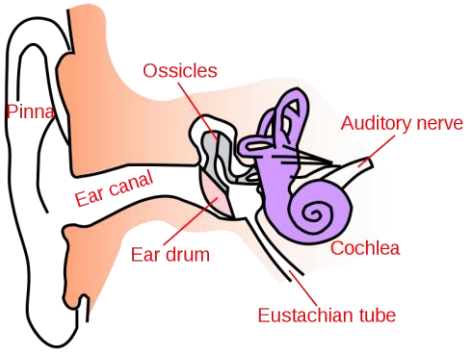

Fig. 1 - External auditory meatus, Gray's subject #229 1036

Like a black-body of room temperature all radiation entering the meatus is trapped inside. The radiation exiting is radiated inside. The meatus when observed from the outside with a thermographic camera appear as an isothermal surface. No details can be seen inside. Only a flat surface at the same temperature can be observed, an "optical" illusion.
This virtual surface, by definition, has an emissivity of 1. No calculus or estimation of reflected apparent temperature and emissivity are need.
Twisted meatus or wax accumulation are no longer a problem, if are not seen from the outside MFOV is the major concern on this kind of calculation. Cameras need to have a MFOV smaller than the diameter of the meatus. Besides this, cameras need to have emissivity selectable to 1 and preferable a box tool with the reading of the maximum.

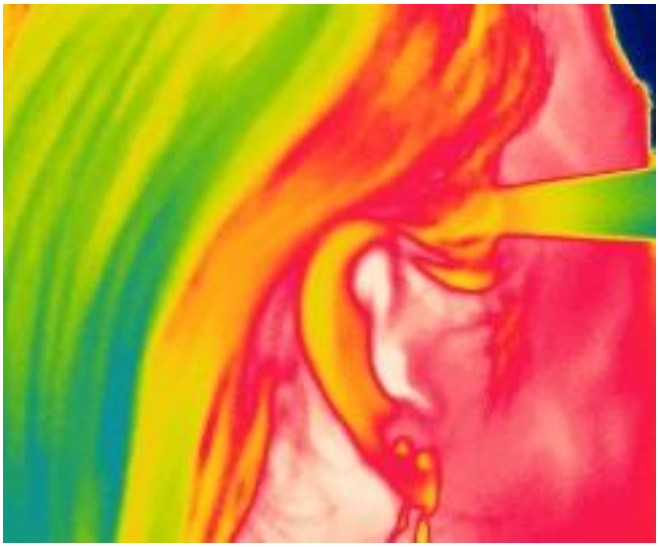

Fig. 2 - Thermogram of the ear.

With adult patients, the cameras available in market have the MFOV smaller enough to allow an accurate reading in the limit. However, at paediatric practice, a camera with a detector of 320 × 240 pixels could be necessary. Cameras with detectors of 120 × 120 pixels, 25 ° FOV and 12 *cm* of minimal

focus distance, regarding the MFOV (2.31 *mm*), are examples of ideal cameras for all practices.

Fig. 3 - Child being monitoring during sleep.

4. RESULTS

Auburn University studies resulted in revision of the Horse Protection Act in 1983. This revision was also followed by implementation of new guidelines imposed by the USDA-APHIS. Along with physical examination and evaluation of horses for show purposes, thermography was also used by USDA-APHIS services as a diagnostic aid for detecting cutaneous inflammatory reaction to the horse's' limbs. Over time, use of thermography was discontinued and horse inspection for horse shows was again done by physical examination that also included digital palpation.
Since the 1970's to the present day, prosecution of owners and trainers accused of soring horses has been attempted. APHIS had taken a position in the early 1990's that palpation by itself is sufficiently reliable to accurately determine whether a horse has been sored or not. In some cases, horses that were banned from showing were a cause of litigation in federal courts. Recent rulings by Federal Law Judge Peter M. Davenport questioned whether palpation alone was sufficient "scientific" means to allow expressing an expert opinion. He cited a Supreme Court case which set forth four factors to determine that reliability. He used thermography references of published papers in veterinary medicine. Because of his recent ruling, APHIS lost the court case. USDA-APHIS now wishes to reinstitute the use of thermography as an additional means to document if the horse was sored or not.

5. DISCUSSION

The efficacy of non-contact, electronic infrared thermography has been demonstrated in numerous clinical settings and research studies as a diagnostic tool for veterinary medicine. Sometimes it is very difficult to use radiology, ultrasonography, or magnetic resonance imaging for large animals like horses and cattle (bulls). These procedures require direct contact with the animal, and in some cases the animal must be under general anesthesia to perform these tests. Thermography which can be performed in an unsedated animal has been very helpful as a preliminary diagnostic tool in many clinical cases. Painful conditions associated with peripheral neurovascular and neuromuscular injuries can be easily diagnosed by thermography.

6. CONCLUSION

In modern days', flights are a major concern because of their role in disease transmission. Nowadays, the longest flight is less than 24 hours long and this is the time needed for a H5N1, or other virus, to travel across the world.
The current method at airports implies at least the removal of glass to observe the temperature in the inner canthus. Since a 98 % emissivity should be expected, errors are to be consider. False positives are annoying for those spotted, but the major concern is with false negatives. In airports where the access from the plane to the terminal is done exposed to the elements under frosty weather, the face of patient can chill and the alarm at the thermography camera doesn't goes on and the detection is faulty.
Thermography cameras with detectors of 640 by 480, or greater, strategically placed in the access to and from the terminal could provide detection from a safe distance. Persons only have to be asked to remove the hair from the front of the ear canal and in the camera a box with the size of the detector and alarm has to be set.

REFERENCES:
(None Provided)

For Correspondence:
António Cardoso
CATIM - centro de apoio tecnológico à indústria metalomecânica
Rua dos Plátanos 197, 4100-414 Porto
antonio.cardoso@catim.pt