

## A Reference for Human Eye Surface Temperature Measurements in Diagnostic Process of Ophthalmologic Diseases

<sup>1</sup>M. Tkáčová, <sup>2</sup>J. Živčák, <sup>2</sup>P. Foffová

<sup>1</sup>CEIT-KE, Košice, Slovakia,

<sup>2</sup>Technical University of Košice, Faculty of Mechanical Engineering, Košice, Slovakia  
Email: maja.tkacova@gmail.com

**Abstract.** *The study is focused on the area using infrared diagnostics for ophthalmic applications, with the aim to obtain the physiological surface temperatures database of healthy eyes. The contactless, noninvasive and painlessness infrared thermography (IRT) was used (Thermocamera Fluke Ti 55/20, Fluke, USA and the software SmartView 2.1, Fluke, USA) to create a database of 28 thermograms of healthy human eyes. As an identification markers - a circular polygon and three points T1, T2 and T3 on the linear horizontal axis of the eye were assessed. The results show that the overall average temperature of the cornea of the eye is  $34,5 \pm 0,8$  °C.*

*Keywords: Thermography, Ophthalmology, Temperature*

### 1. Introduction

For many years temperature is the first measurement of a physical property for determination of diagnosis in the medicine. From electromagnetic theory it is a form of infrared energy being emitted from the first molecular surface of a body (skin). Infrared imaging is the detection and conversion of energy from a section of the infrared spectrum, into the visible spectrum. Surface energy levels are affected by the environment, operational conditions, heat transfer processes of a human body and the surface characteristics.

Thermography is a non-invasive, contactless temperature measurement technique used to produce a colored visualization of thermal energy emitted by the measured surface. Each pixel in the image depicts the radiance falling on the focal plane array/ microbolometer– type detector used in an IR camera.

Current applications infrared thermography in ophthalmology include:

- diagnosis of glaucoma, an eye disorder in which the optic nerve suffers damage, permanently impacting vision in the affected eye(s) and progressing to complete blindness if untreated. It is often, but not always, associated with increased pressure of the fluid in the eye;
- monitoring surface temperature of a healthy eye;
- thermographic monitoring of tear ocular film;
- thermography and comparison of normal, ischemic and hyperaemic eye;
- the impact of contact lenses for the eye surface temperature and other

Our study is based on monitoring the temperature of the healthy eye to get the reference database for diagnostic process support of ophthalmologic diseases.

### 2. Subject and Methods

Skin temperature on human eyes from our database (n= 28) were measured with an infrared camera (ThermaCam Fluke Ti55/20, Fluke, USA) with 10,5 mm lens (10,5 mm F/0,8; 8-14 μm). The thermal sensitivity of the camera is 0.05°C at 30°C of a blackbody. Camera works in the spectral range from 8 to 14 μm (human body infrared radiation is highest in the spectral

range around 9,66  $\mu\text{m}$ ) and the calibrated temperature range from -20 to 100  $^{\circ}\text{C}$ . Camera resolution is 320 $\times$ 240 pixels (total 76.800 pixels). Data were obtained through a high-speed (60Hz) analysis.

Emissivity of the skin was set in the camera software to 0,98, the ambient temperature was measured by handheld thermometer (Testo 810). Before each recording the camera was calibrated using the system's internal calibration process. All thermograms (n=28) were processed by SmartView 2.1 software.

Object of our measurements were volunteers, their average age was 24 years.

### Methodology of Measurement

Our measurements were carried out under the same conditions, same room (air-conditioned) ambient temperature 20  $^{\circ}\text{C}$  ( $\pm 1^{\circ}\text{C}$ ). Each eye was scanned separately. The 10.5 mm lens was used and constant distance between camera lens and the human eye was maintained ( $d = 5$  cm) as it is shown in Fig. 1.

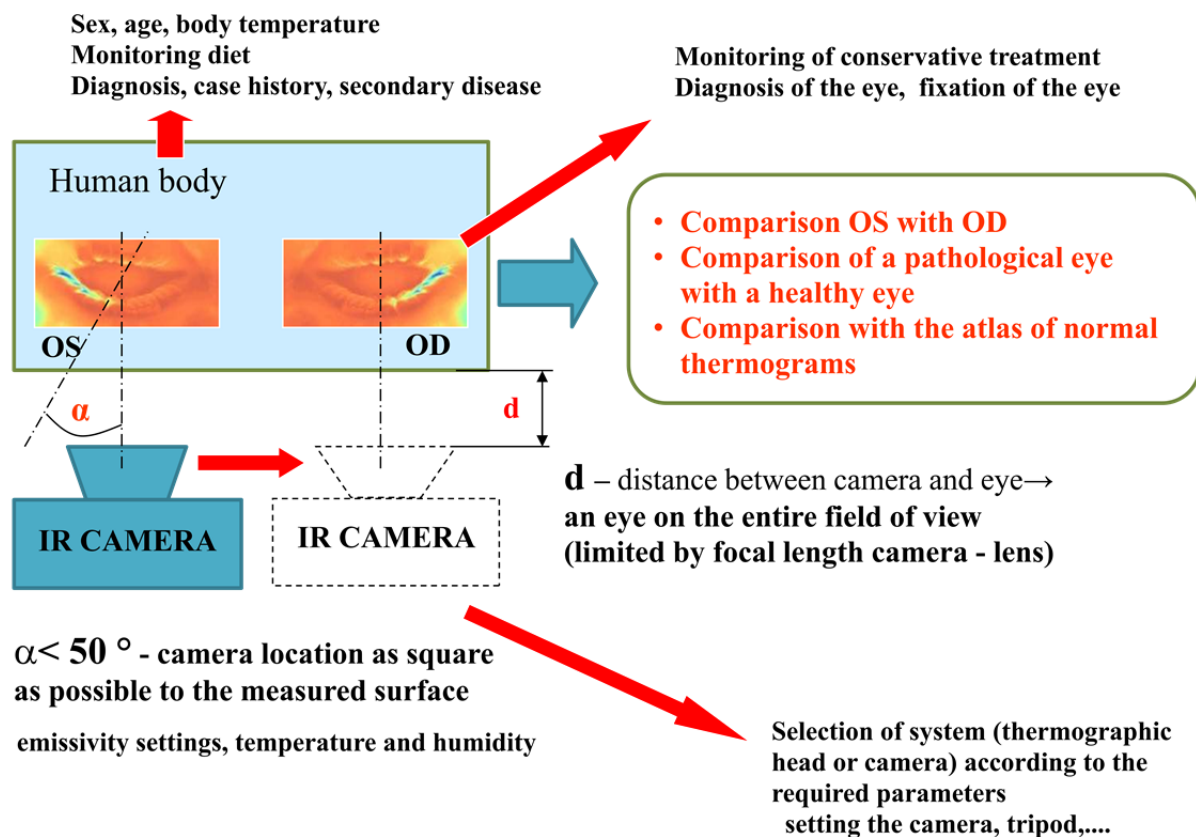


Fig. 1. Methodology of measurement

For identification of the area of interest, a circular polygon and three points T1, T2 and T3, which on linear horizontal axis on the eye were defined, see Fig. 2.

### 3. Results

The following average temperatures in T1, T2, T3 markers were obtained:  $\bar{x}_{CT1} = 34,70^{\circ}\text{C}$ ,  $\bar{x}_{CT2} = 34,17^{\circ}\text{C}$ ,  $\bar{x}_{CT3} = 34,74^{\circ}\text{C}$ , where  $\bar{x}_{CT1}$  is average temperatures in T1,  $\bar{x}_{CT2}$  is average temperatures in T2 and  $\bar{x}_{CT3}$  is average temperatures in T3. The total average temperature in all markers where calculated  $\bar{x}_{CT1,T2,T3} = 34,54^{\circ}\text{C}$  with the standard deviation of  $\pm 0,81^{\circ}\text{C}$ .

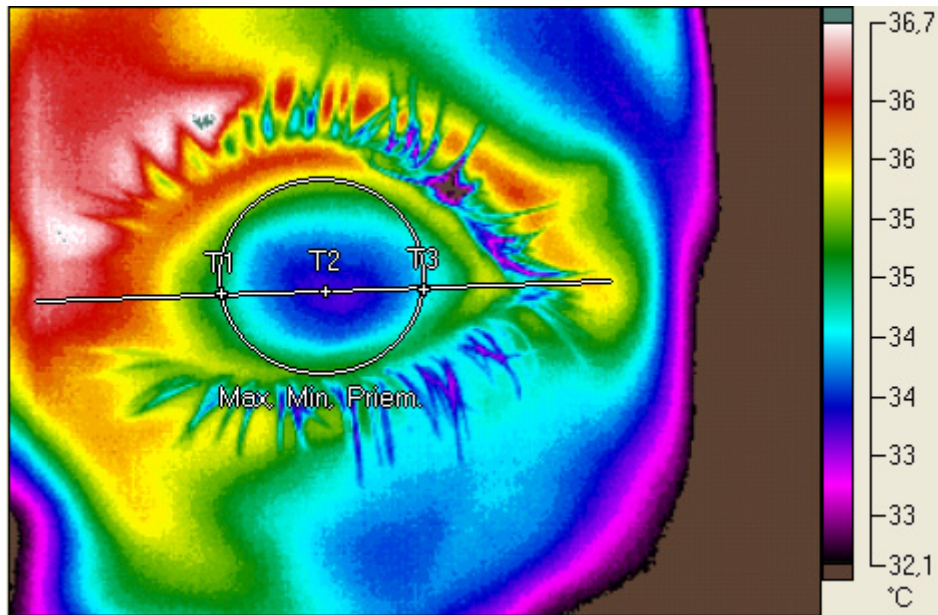


Fig. 2. Thermogram of the left eye with defined points of measurement.

Maximum, average and minimum temperature were obtained from defined points (T1, T2, T3), like in Fig. 3.

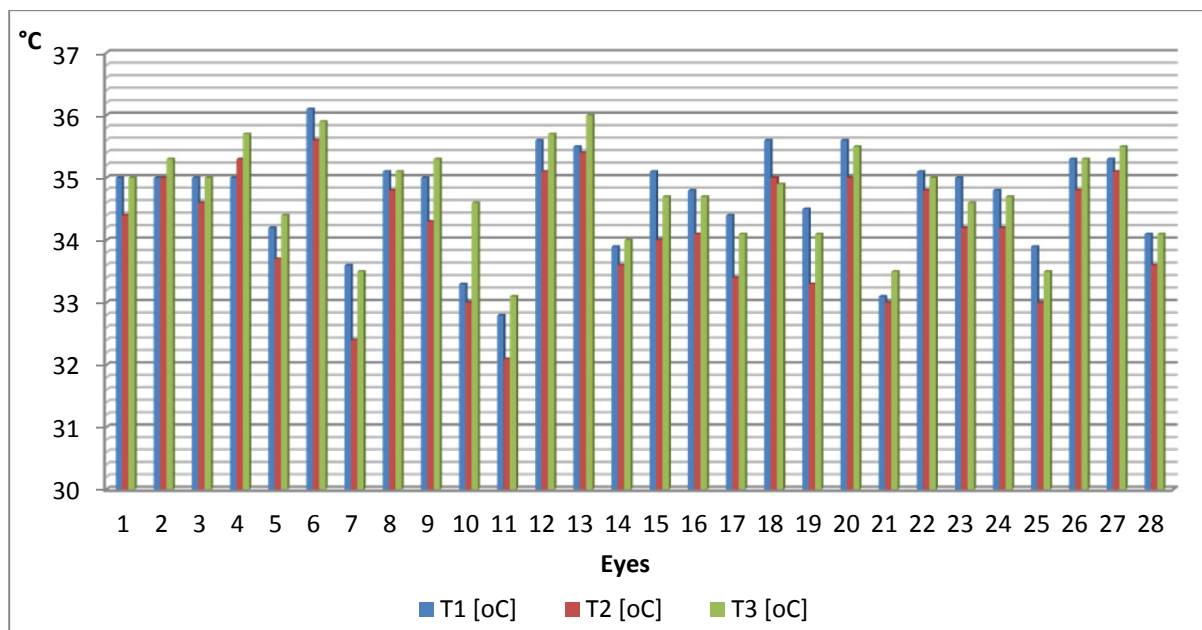


Fig. 3. Graph of temperature value from defined points of measurement

#### 4. Discussion

Studies published worldwide indicate that thermography is a valuable diagnostic method in ophthalmology, in order to objective detection of some ophthalmologic diseases and conditions (monitoring of tear ocular film, ischemic and hyperaemic eye, diagnosis of glaucoma, etc.). The database of healthy eye surfaces temperature is important to differentiate the healthy eye and pathological condition of the eye in specific ophthalmologic diseases.

## 5. Conclusions

In the study a methodology of thermographic measurements was assessed. After the processing of the thermograms, the average temperatures of the cornea in all measured subjects were calculated. Results show, that a total average temperature in the cornea of the eye in markers T1, T2 a T3 is  $34,51 \pm 0,82$  °C. The minimum temperature of the cornea eye was  $33,82 \pm 1,10$  °C and maximum temperature  $35,41 \pm 0,73$  °C. The results show that the overall average temperature of the eye surface is  $34,51 \pm 0,82$  °C. The bigger statistically significant group is planned to get the significant reference values.

## Acknowledgements

This contribution is the result of the project implementation: Center for research of control of technical, environmental and human risks for permanent development of production and products in mechanical engineering (ITMS:26220 120060) supported by the Research & Development Operational Programme funded by the ERDF.

## References

- [1] Gordon, M; Thurdals, M: Repolarization Changes Displayed in Surface ECG Maps. A Simulation Study. *International Journal of Bioelectromagnetism*, 4 (5): 92-104, 2002.
- [2] Nowakowski, A.; Kaczmarek M., Ruminski J.; Hryciuk M.; Renkielska A.; Grudzinski J.; Siebert J.; Jagielak D.; Rogowski J.; Roszak K.; Stojek W.: Medical applications of model based dynamic thermography, Proc. SPIE, v. 4360, 2001, 492 – 503.
- [3] Murawski, P.; Jung A.; \_uber J., Kalicki B., The project of an open and extendable database for thermal images archiving, IFMBE Proc. 2-nd European Medical and Biological Engineering Conf., Vienna, 2002, 1618 – 1619.
- [4] Jones, B.; Plassman, P.: Computational approaches to image processing for improved interpretation and analysis, IEEE Eng. in Medicine and Biology, v. 21, 6, 2002, 41 - 48.
- [5] Ring, E.; Ammer, K.: The technique of infrared imaging in medicine. *Thermology International* 2000;10:7-14.
- [6] Jones, C.; Ring, E.; Plassmann, P.; Ammer, K.; Wiecek, B.: Standardisation of infrared imaging: a reference atlas for clinical thermography—initial results. *Thermology International* 2005; 15:157-8.
- [7] Morgan, P.; Tullo, A.; Efron, N.: Infrared thermography of the tear film in dry eye. Manchester, 1995. s. 615-618.
- [8] Betney, S.; Morgan, P.; Doyle, S.; Efron, N.: Corneal temperature changes during photorefractive keratectomy. Philadelphia, 1997. s. 158-161.
- [9] Morgan, PB, Soh MP, Efron N, Tullos AB. Potential applications of ocular thermography. *Optom Vis Sci* 1993;70:568–76.
- [10] Tan, Jen-Hong; Ng, E.Y.K.; Rajendra Acharya, U.; Chee, C.: Study of normal ocular thermogram using textural parameters; *Infrared Physics & Technology*; Volume 53, Issue 2, March 2010, Pages 120-126.