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Preparation to Experimental Testing of the Potential from Using Facial Temperature Changes Registered with an Infrared Camera in Lie Detection

Подготовка до экспериментальных исследований возможности использования изменений температуры лица, записанных с помощью тепловизионной камеры для детекции лжи

Key words: infrared camera in lie-detection, thermovision in detection of deception

The numerous organic changes related to emotions include fluctuations in blood pressure that can be observed and registered in alterations of pulse rate and blood pressure, and also as changes of blood flow in the bare parts of the body (face, back

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of the neck) that are visible with the naked eye. As changes in blood supply resulting from emotions are also accompanied by changes in the chemical composition of blood that result from the activity of endocrine glands issuing hormones into the bloodstream, changes in blood supply are also accompanied by changes of face temperature. The body temperature in a healthy human ranges from 36°C to 37°C, and its natural fluctuations may lie in the range of around 0.6°C (Konturek 2014: 495). Lowering of the body temperature is accompanied by dilation of blood vessels, sweating, and slowing or stopping of thermogenic mechanisms. Increase of temperature, on the contrary, is accompanied by the narrowing of blood vessels and increased thermogenesis (Konturek 2014: 498). Psychological and psychophysiological literature has long listed changes of body temperature as an indicator of emotions (see e.g.: Ax 1953; Hilgard 1972). Measurement of the changing temperature of individual parts of the face with classical methods, i.e. with the use of contact thermometers, was very difficult technically and impractical to the highest degree, hence it has essentially not been applied in practice. Such a measurement could have become relatively easier if a method of imaging heat radiation issued by physical bodies, i.e. thermography (thermal vision), were resorted to. This method is generally applied in an various sciences and also for practical purposes. A device used for the observation and measurement of facial temperature changes in this method is an infrared (thermal vision) camera. It can be used to detect the temperature of an observed object and its changes.

It has long been postulated that an infrared camera could be used for observation and recording of temperature changes in the human face to detect emotions, and hence also for lie detection purposes. In Poland, such a generally formulated concept was announced as early as in 1979 by Hubert Kołecki (Kołecki 1979). The use of thermal vision for lie detection seems the more attractive as the method theoretically allows to perform such a detection without physical contact, and without attaching any sensors on the subject's body, and therefore, theoretically, also without his or her consent and even knowledge.

[This obviously gives rise to the development of new legal regulations, as all extant ones only refer to classical polygraph examinations, in which all the physiological correlates of emotions are observed with sensors installed on the body of the subject, and therefore require the subject's information and additionally consent. There is no room to discuss these questions here, as the presentation is limited to the discussion of the technical aspects of the exercise only.]

In the several recent years many experimental works aiming at obtaining this goal have been conducted, yet only a handful of general works on the subject have been published in Poland (Staszel, Wojtarowicz, Zając 2013). The first exercises conducted were not as much experimental research projects but simple demonstration of an infrared camera and the distribution of temperatures on the face obtained with it (Polakowski, Kastek, Pilski 2011). Available foreign literature is far richer and has recently received a broad discussion (Gołaszewski, Zając, Widack 2015). The results of experimental studies on the use of infrared camera for lie detection conducted so far seem fairly encouraging. It seems that changes of facial temperature could be at least another physiological correlate of emotions facilitating lie detection, besides such indicators as changes in the operation of the circulatory system, the breathing patterns, and the galvanic skin response (GSR). If facial temperature changes prove to be more diagnostic than the aforementioned physiological correlates of emotions registered by a classical polygraph, they could be considered an independent measure in lie detection or used in conjunction with other contactless (remote) methods (e.g. voice change analysis, eyeball tracking, etc.).

Yet the use of an infrared camera for continuous observation and registration of facial temperature changes in parallel with the application of a polygraph that would make it possible to compare the diagnostic values of facial temperature changes to the diagnostic value of a polygraph examination requires a parallel simultaneous registration of physiological variables with a polygraph and registration of facial temperature changes with an infrared camera. Running appropriate recordings simultaneously, however, encounters a number of difficulties of technical nature. The first is that the camera shows the image of the face, in which individual colours correspond to temperatures (see: **Fig. 1**). Temperature changes are displayed as shifting areas of colour. Therefore, the first technical problem is to select a number of points on the face, monitoring temperature changes in the selected points continuously, and representing temperature changes in time in the selected points in a graphic form. In other words, the first problem was the transformation of the changing image into a graphic form.

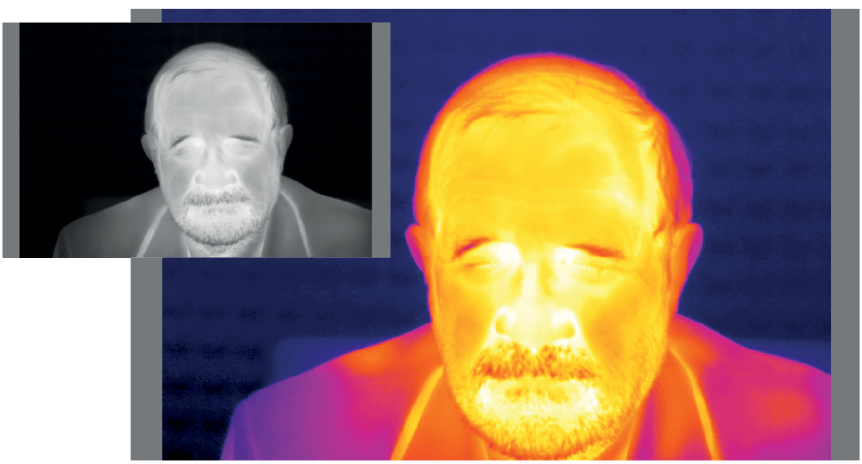

Fig. 1. Image of the face by infrared camera.

The following one, which needs a solution, is to have a fixed infrared camera continuously observe the same previously selected points on the face of the subject, especially as the subject may, often subconsciously, jerk the head when movements that result from answering the test questions occur. These cannot be eliminated, even if it were possible to stabilise the subject's head mechanically (e.g. with an orthopaedic device or some kind of brace), which in itself would be difficult, potentially hardly efficient, and furthermore highly impractical. The solution of the problem required writing a new piece of software that would make it possible to capture and record data from an infrared camera, and especially to present the temperature of the observed points in a graphic form along the time axis, simultaneously make it possible to denote on the graph the moment when the subject is exposed to a stimulus (test question). Moreover, the software must be constructed so as to allow continuous tracing of temperature changes in the previously selected points on the subject's face that are most diagnostic according to literature (see: Pollina *et al.* 2004; Pollina *et al.* 2006; Jain *et al.* 2012; Rajoub, Zwiggelaar 2014), and to do so, despite the movements of the subject's head and facial muscles. Application code was written in Matlab (2014 b) environment, which supports the FLIR (A655sc) infrared camera standard. Software development required also the use of Image Acquisition Toolbox support package. The data is transmitted from the camera to the computer over an Ethernet connection, the software grabs the "frames" (i.e. locations from which temperature measurement samples are taken) from both a digital and an infrared camera. The image from the digital camera is used for detection of the areas in which the infrared camera is to perform the measurements. Whenever an area has been correctly detected, the temperature is read from the corresponding "frame" of the infrared camera image. For temperature reading to be precise, the scanning area of the two cameras is shifted by the value that results from the physical distance between the two cameras mounted parallel to each other on a stand in an identical distance (120 cm) from the subject.

The processing capacity of the computer used (Dell xps 7021) proved a major limitation in the operation of the software. Initially, the number of acquisitions from the camera prohibited observation and calculation periods exceeding 15 seconds. This resulted from buffer overflow problems. To solve the problem, image transmission from the network camera to the laptop was limited to 9 kB MTU (maximum transmission unit). This provided a sufficient number of frames (12 frames per second, FPS) to conduct the necessary calculations, and extended the period of observation to 12 minutes, which is sufficient to run a polygraph test. After that time, the connection to the camera is refreshed, which clears the buffer. A following problem that called for solution was to devise an algorithm that could continuously trace selected points on the subject's face. The application makes use of Viola-Jones algorithm used for detection of objects on video streams. In this way, the data obtained is fed into a calculation sheet, which in turn generates a graph showing temperatures from the sampling points.

Fig. 2. Armchair, polygraph, cameras on stand, subject in the armchair.

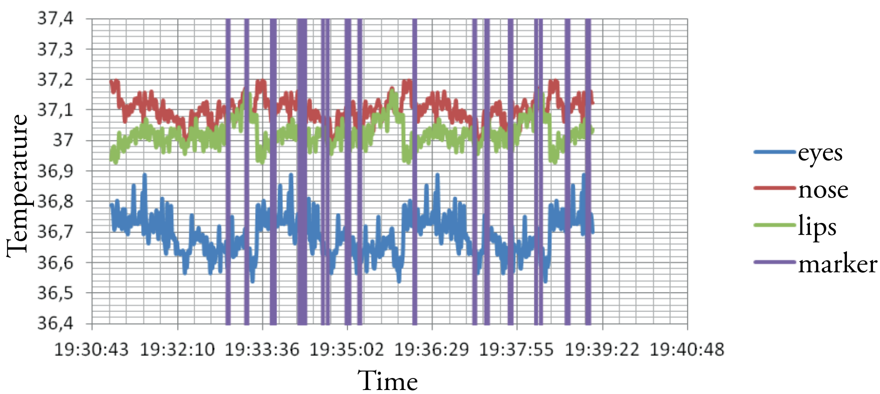

Fig. 3. A graph with the time and temperature axes with three temperature curves (eyes, nose, and lips).

In the study, we used Lafayette 4000 polygraph and a Flir Gige Vision A-600 camera. They were connected to a set composed of a Samsung R780 laptop, Dell Xps L702 X laptop, and a digital camera HIKVISION model DS.-2CD6026FHWD-A.

Fig. 4. Lafayette polygraph

Fig. 5. Infrared camera

Source: Images were taken from the websites of their respective manufacturers.

To allow parallel polygraph examination and tracing of facial temperature changes, an infrared camera was mounted on a stand, and focused on the face of the subject sitting in the polygraph examination room. The recording of the changes of temperature on the face was observed on a monitor by another expert in a separate room (i.e. not by the polygrapher performing the examination) and recorded. In this way, no people besides the subject and the polygrapher were present in the examination room during the polygraph examination, as required by good polygraph practice. The polygrapher and the expert observing facial temperature changes registered with an infrared camera can communicate throughout the experiment, using lan messenger 0.7 beta 4, which allows text messages exchanges between computers.

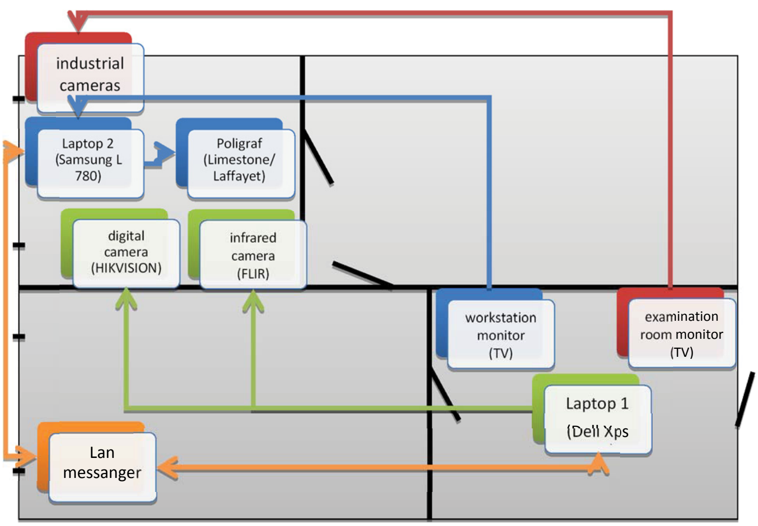

Fig. 6. Rooms where the experiment will be conducted plus listing of the basic equipment.
Source: The authors' own materials.

Only the overcoming of the aforementioned technical problems will make it possible to carry out the experiment aimed at comparing the diagnostic value of facial temperature changes with the diagnostic values of both complete polygraph examination and indications of its individual channels.

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