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The error rate of human body temperature measurement using a thermal imaging camera in the conditions of the Slovak Republic

Chybovosť merania ľudskej teploty pomocou termovíznej kamery v podmienkach Slovenskej republiky

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Abstract:

The coronavirus, COVID-19, has affected people's lives almost all over the world. Its occurrence has caused a slowdown in the economies of such developed countries as Germany. The Slovak Republic has been struggling with its effects since about March 2020, when the first cases of the disease began to appear and the everyday life of Slovaks began to be affected. The Government of the Slovak Republic has taken several specific measures to prevent the loss of human life of citizens. One of the measures was the measurement of the human temperature of citizens entering selected types of buildings to prevent the possible spread of a pandemic.

The article aims to point out the possibilities of measuring human temperature to identify a potential disseminator of COVID-19. The article compares several options to point out the shortcomings of each option. The primary interest is directed to the shortcomings of measuring human temperature using a camera system.

Keywords: *coronavirus, temperature staining, human body temperature, thermal imaging camera, software.*

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Abstrakt:

Koronavírus, COVID-19, nárazovo ovplyvnil život ľudí takmer na celom svete. Jeho výskyt spôsobil spomalenie ekonomík aj takých rozvinutých krajín ako je napríklad Nemecko. Slovenská republika bojuje s jeho dopadmi približne od marca 2020 kedy sa začali objavovať prvé prípady nákazy a bežný život Slovákov začal byť ovplyvňovaný. Vláda Slovenskej republiky prijala viacero špecifických opatrení v snahe predísť stratám na ľudských životoch občanov. Jedným z opatrení bolo aj meranie ľudskej teploty občanov vstupujúcich do vybraných typov objektov v snahe predísť prípadnému rozširovaniu pandémie.

Článok je zameraný na poukázanie možností merania ľudskej teploty s cieľom identifikovať potenciálneho šíriteľa COVID-19. V článku je vykonaná komparácia viacerých možností s cieľom poukázať na nedostatky jednotlivých možností. Primárny záujem je smerovaný na nedostatky merania ľudskej teploty pomocou kamerového systému.

Kľúčové slová: *koronavírus, meranie teploty, ľudská teplota, termovízna kamera, softvér.*

Introduction

COVID-19 is an infectious disease caused by a coronavirus infection called SARS-CoV-2, which was first identified in a patient in the Chinese city of Wuhan in December 2019. The main symptoms of the disease on COVID-19 include fever above 38 ° C, cough, difficulty breathing, muscle or head pain, loss of smell, and taste [1].

Since then, it has gradually spread worldwide, and by May 2020, there have been almost 6.3 million cases registered worldwide, of which approximately 380,000 have resulted in the death of the infected person. From these numbers, it is clear how fast COVID-19 had and still has. If we wanted to average the above-mentioned values, we would find that there are approximately 1.05 million infected patients per month in COVID-19. We could see a positive in the number of deaths, the value of which is of course high, but in comparison with the number of identified patients, it is negligible. From the above, we can deduce a larger number of cured, or those who overcame the COVID-19 infection [1-2].

So far, at the end of May 2020, approximately 1,500 cases of infection have been identified in Slovakia, and in only 28 cases has the disease ended in the death of the infected person. Undoubtedly, however, the early and reaction of the government of the Slovak Republic, which has been repeatedly described by the world media as exemplary. In the Slovak Republic, a large number of preventive measures have been introduced to combat the pandemic caused by the coronavirus. Gradually, operations were closed, people moved to the home office or stayed at home due to an obstacle in the profession, meeting, gathering more people was avoided, and mandatory wearing of drapes or other upper respiratory protection was introduced. The Slovaks became accustomed to the measures, and thanks to their conscientious adherence, the government gradually began to relax them after almost two months. Despite the favourable development, Slovaks will have to come to terms with certain restrictive conditions at least in the foreseeable future. According to the regulation of the Public Health Office of the Slovak Republic, these conditions include the measurement of human temperature as one of the basic indicators of potential spreaders of coronavirus. Measurement of human temperature should be performed at each entrance to hospitals, production halls, important buildings such as schools, kindergartens, and the like [2-3].

Human temperature measurement for human testing to detect a potential COVID-19 diffuser can be performed using a certified handheld non-contact thermometer or a thermal imaging camera with specialized software. The choice of a suitable method of measuring human temperature is influenced by the type of object before entering the measurement. For example, a low-frequency entrance to the hospital can be provided by one staff certified by a non-contact thermometer. On the contrary, when exchanging work changes in the organization, it is certainly appropriate to use the possibility of mass measurement through a thermal imaging camera with specialized software. Since the value of body temperature, indicating the suspicion of a coronavirus spreader, is generally known, the software must operate with a minimum deviation, which places demanding demands on it. The aim is not to create unnecessary panic caused by additional examination or repeated measurements of human temperature [2-4].

According to the Public Health Office of the Slovak Republic, it should be implemented through the following principles [4]:

- measure human temperature with a certified non-contact medical thermometer,
- the person measuring the human body temperature must wear disposable gloves and a respirator, drape, shield or other adequate protection to cover the upper respiratory tract,
- the distance between two persons waiting to measure human temperature must be at least 2 meters,
- the thermometer must be pointed at the center of the forehead, a distance of 1-3 cm from the forehead skin is recommended, according to the thermometer manufacturer's instructions,
- perform regular decontamination of the thermometer, according to the manufacturer's recommendations.

According to the information of the office, it is also important to divide in which object the temperature was found. According to the recommendation of the Public Health Office, the buildings are divided into a workplace and a hospital. In the case of a workplace, we, therefore, mean all objects, buildings in which work is performed, but also production halls, plants, and the like. Therefore, if an elevated temperature is detected, up to 38 ° C, upon entering the workplace, the person should be sent home to the isolation, where he should regularly check his body temperature and, if further increased, contact his GP or line 112. In case of temperature above 38 ° C, after considering all other symptoms, the person is sent to home isolation and in case of any deterioration or appearance of any of the symptoms of COVID-19, he must contact his district doctor or line 112 immediately [4].

In the case of access to hospitals, there is a change in measures. If an elevated temperature of up to 38 ° C is measured at the person's entrance to the hospital, he or she is more likely to evaluate a questionnaire to assess the suspicion of infection. If the suspicion is confirmed, the collection of biological material will be ensured at the mobile collection point and if its current condition does not require hospitalization, the person will be sent to home isolation, where he is waiting for the test results. When measuring a temperature higher than 38 ° C, a questionnaire will also be taken to ensure that biological material is collected and, inter alia, the epidemiology department of the relevant regional authority will be notified of the identification of the person suspected of having COVID-19 [4].

From our point of view, the relevant concept of measuring human temperature can be applied to several companies, but not all. Such a procedure for measuring human temperature is relatively lengthy and requires a controlled procedure. In our opinion, it is unusable, especially when exchanging work changes in production plants, and it is more efficient to use measurements using a thermal imaging camera with specialized software for determining body temperature. It is for this reason that we have performed several tests aimed at defining the error rate of human temperature measurement using a thermal imaging camera.

Methodology

The experimental tests aimed to point out the need for the correct setting of the system parameters to avoid false, incorrect identification of the infected person. To measure human temperature, as well as to ensure space monitoring, it is necessary to test the system before it is put into operation.

Pilot, experimental tests had to be carried out to most accurately set the parameters of the system before it was used to monitor the temperature of students of the University of Zilina when moving out accommodation facilities. This eviction was ordered by the rector of the University of Zilina as a result of a pandemic caused by a coronavirus. We used the Micro-epsilon Tim 450 thermal imaging camera supplemented with TM Connect software to ensure control as well as experimental tests. The test kits we use are primarily used in industry to monitor critical processes such as microcontroller overheating or even metal and glass processing. The Micro-epsilon Tim 450 thermal imaging camera can measure temperatures in the range of -20 to 900 ° C and has a high sensitivity of 0.04 K.

Emissivity, one of the basic parameters in temperature measurement using thermal imaging cameras, could be defined as the average of the intensity of the radiated body to the intensity of the radiated body of a black body. According to the tables with recommended emissivity values, the value for measuring the temperature of the skin (human skin) is 0.98 [5].

The measurements took place in a closed room of the University Science Park of the University of Zilina. The image of the camera trying to determine the room temperature together with the TM Connect environment is shown in Figure 1.

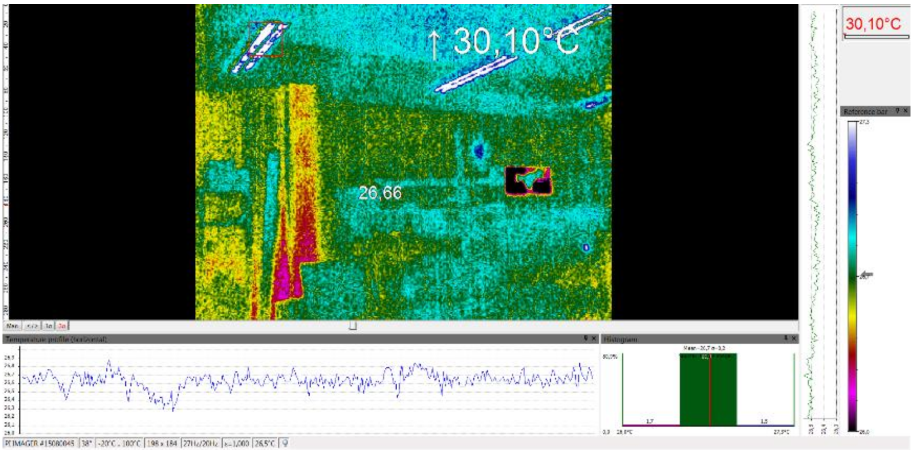

Fig. 1 Determination of the room temperature together with the program environment

As we can see in Figure 1, the program is set to find the warmest place within the scanned image, which it then marks with a red square. The measured value is then listed in the upper part of the program. Subsequently, it is possible to use the mouse cursor to determine the temperature at a specific point, which is shown in white. As we can see, it is quite difficult for the program to determine the room temperature as the camera is designed to measure the surface temperature of materials [6].

In the pilot experimental tests, we worked with setting the emissivity to 1 and 0,9. Before we started working with the camera and software, we measured our body temperature using a non-contact certified thermometer [7].

Results

Using an optional meter, a certified non-contact thermometer, we determined our body temperature before each measurement using the TM Connect software. We first tested a non-standard emissivity setting for human skin. We chose this option to be able to determine the deviation between the measured values. We proceeded from the assumption that in practice it may happen that the technician of the camera system incorrectly sets its value. Using a non-contact certified thermometer, we found that our body temperature before the experimental measurement was 37.3 ° C. we set the emissivity value to 1 and 0.9. Measurements with set emissivity 1 are shown in Figure 2.

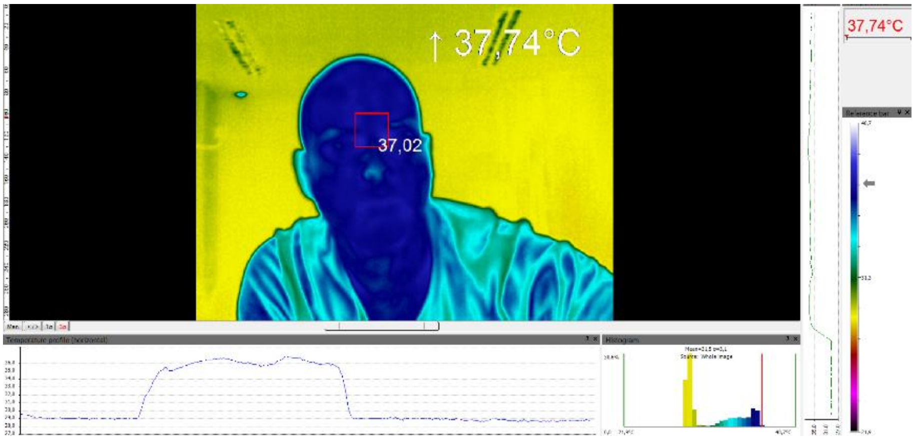

Fig. 2 Measurement of human temperature with set emissivity 1

As we can see in Figure 2, a body temperature of 37.74 ° C was measured using a thermal imaging camera, which represents a difference of 0.44 ° C. Interesting is the value written in white, which tells us about the temperature at one point obtained using the mouse cursor, which we pointed to the center of the red square. In this case, the difference is 0.28 ° C. Subsequently, we set the emissivity value to 0.9, which is only 0.1 less. This value is for paper or sand materials. Temperature measurement with an emissivity of 0.9 is shown in Figure 3 [8].

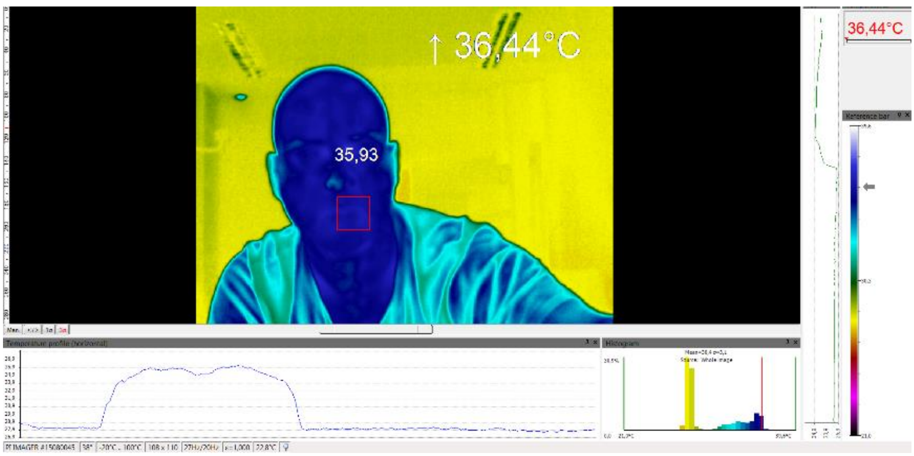

Fig. 3 Measurement of human temperature with set emissivity 0.9

As we can see in Figure 3, with a non-standard setting of the emissivity value, we measured a temperature of 36.44 ° C, although the system evaluated that the warmest place, in this case, is around the mouth. If we take these results into account, the difference between the real and measured temperature would be 0.86 ° C. However, as in the previous experiment, we placed the mouse cursor in the middle of the forehead, where we measured the temperature at 35.93 ° C. If we start from this value, the temperature difference would be 1.37 ° C.

In the case of comparing both measured values, i.e. at emissivity 1 and 0.9, we achieved a difference of 1.3 ° C at a change of 0.1. Such values were also confirmed in other measurements, which we carried out within the scientific research activities of the department.

Discussion

The aim of the pilot tests was, in addition to setting the correct functionality of the thermal imaging camera for the needs of measuring human temperature, also to point out the need for the correct value of emissivity. We approached this as the first step in long-term testing of the reliability of human temperature measurement using thermal imaging cameras [9].

In addition to emissivity, there are several influencing factors that we encountered during experimental testing. Among these factors, we can include, for example, the distance of the scanned object, human, from the thermal imaging camera. As the distance increases, the measurement error rate increases in direct proportion, or the deviation of the measurement reliability increases. We performed our measurements at a standard education of approximately 1 meter, at which we achieved the most accurate values. Another limiting condition that we encountered is a comprehensive setup of the system in terms of its activity. In our case, we had defined that the system would look for the places with the highest temperature and mark them with a red square, as we assumed that it would be the upper part of the person's head. However, in several tests, also in Figure 3, we encountered the fact that the warmest place was marked the lower part of the head, or the background, which was not related to the temperature of the person. Therefore, we would recommend more efficient settings and measurements, for example using a predefined square in the image or using the mouse cursor. Both options are adjustable in the software we test as well as in other commercial or professional systems [10].

Conclusion

The paper aimed to point out a pilot experimental testing of human temperature, pointing out the need for the correct setting of the measuring system. In our pilot tests, we focused on the non-standard setting of emissivity as one of the main factors in the use of thermal imaging cameras. During several measurements, we concluded that there is a different parameter of 1.3 ° C to 0.1 emissivity value in the case of the human body. This value came out as an average of more than 50 repetitions and therefore we presented a sample measurement in the article, with just such a difference. In the future, we would like to follow up on the obtained results and verify the difference parameter with another thermal imaging camera with software.

Another factor that directly affects the quality of human temperature measurement is the distance of the scanned object to the thermal imaging camera. A distance of approximately 1 m proved to be effective in which the system reached almost identical values as in the case of the previous inspection performed by a non-contact certified thermometer. At higher distances, we achieved a significantly higher value of measurement error. In the future, we would like to build on the results obtained and use experimental tests to achieve a recalculation of the error rate for distance, ie to create a kind of head map. The map created and defined in this way would provide us with information about the expected error rate of the system, which would allow us to directly influence the measurement result.

At present, the initial phase is completed and we continue with the second phase in which we focus on creating a system with controlled input due to acclimatization to ambient temperature. We approached the given plan because there are cases of infected persons on COVID-19, whose temperature was not measured correctly due to the air conditioning in the vehicle. Creating an acclimatization space would eliminate the likelihood of such cases. Part of the acclimatization space would then be to define the length of stay in it, about the age of the person.

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