IMPLEMENTATION OF ANTI-COVID MEASURES IN UNIVERSITY EDUCATIONAL PROCESS TAKING ADVANTAGE OF THERMAL IMAGING APPROACH

Predrag Stolić[1], Zoran Stević[1,2], Zdravko Stanimirović[3], Ivanka Stanimirović[3]

[1]Technical Faculty in Bor, University in Belgrade
[2]School of Electrical Engineering in Belgrade, University in Belgrade
[3]Vinča Institute of Nuclear Sciences, University in Belgrade
Serbia, Bor
pstolic@tfbor.bg.ac.rs

By returning to the classical forms of teaching and attendance of classes in the faculty facilities, appropriate anti-covid measures have been introduced. One of those measures is the regular check of the students' temperature before accessing any form of teaching in the faculty classrooms. However, serious issues soon are manifested by measuring temperature with conventional non-contact thermometers. The paper shows how some of these issues and limitations can be overcome by using thermal imaging when controlling the temperature within anti-covid measures.

Keywords: COVID-19, primary screening, surface body temperature, thermal imaging, thermometers.

1. Introduction

To reduce the impact of the pandemic on public health and to adequately respond to the emergence of a new virus, many adequate measures have been taken, e.g. lockdowns, minimizing work processes, working from home, complete suspension of work in some institutions or restricting access to them. Education systems were no exception and also implemented those necessary measures in order to deal with the current pandemic crisis. At the beginning of the pandemic, the dominant measures were school closures and shifting to other learning possibilities using modern technologies, such as Internet, television and radio, aiming to provide continuous education even when the access to the education facilities was restricted. As a summer 2020 report from UNICEF [1] states, the described above scenario was used by more than 90% of the countries worldwide. Primary and secondary education mostly used all three mentioned technologies (Internet, TV, radio) to organize the learning process under COVID-19 restrictions, while higher education primarily used Internet, particularly specialized Learning Management Systems (LMS), because by that time higher education institutions had already developed online teaching processes as an alternative for regular teaching or as a solution for specialized online courses taught in normal circumstances.

However, it soon became clear that this teaching model is unsustainable, especially in higher education, due to the specifics of the teaching process itself. Theory can be successfully taught online, since the theoretical approach can be fully supported by the use of modern digital technologies. A more problematic endeavor is to move practical learning online. Practical classes can be shifted online only in part, not completely. For example, experiments conducted during classes in specialized chemical laboratories cannot be done online or at home.

They must be performed in specialized areas and under strictly controlled conditions, which means that the use of spaces within higher education institutions is necessary. Thus, since last year, most faculties have been using a hybrid teaching model. This means they still use online teaching in all cases where it is applicable, but also allow students into the facilities. When the regular teaching process is necessary, the students take their classes in appropriate classrooms or laboratories with appropriate anti-covid measures [2].

One of the dominant anti-covid measures is primary screening before any entry to the teaching facilities, and the key step in primary screening is to measure the body temperature of each student before allowing them entry (one of the symptoms in most COVID-19 cases is fever) [3]. This paper describes how students' body temperature is mostly controlled in higher education facilities, what issues are reported during measurements, and how to avoid some of them using thermal imaging instead of other measurement techniques.

2. Known issues with classical temperature measurement process

The standard procedure for measuring the temperature of students before letting them enter the classroom is to measure the current body temperature of each student individually with a non-contact thermometer. In such a case, the surface body temperature is taken on a specified available area of the body, usually on the forehead, at a distance from 1 to 3 cm [4]. If the temperature is lower than the predicted limit (various institutions set different limits — in most cases it is 37.0 or 37.5°C), the subject is allowed to enter the classroom or laboratory, otherwise the access is denied and the student must leave the building.

Despite the fact that this standard procedure is quite simple to implement, there have been noticed several dominant issues. The most obvious problem is false readings, which was particularly noticeable during the winter months, when students spend a lot of time indoors (do not go out during breaks and the like) and use only the so-called "enclosed spaces". When outside temperatures are low, all rooms inside the building are heated. Classrooms are arranged in such a way that some students get to sit very close to the heaters — in some cases the distance is only a few centimeters. And if we measure the temperature of a student between the classes and do not know that this student has just been exposed to the thermal radiation, we may get a false positive result, although in reality the student's temperature is normal. Sometimes, if the situation allows, the temperature is taken again after a while, and much more relevant values are obtained, but there also have been cases when false readings lead to an unnecessary panic and the student was forbidden to attend his class.

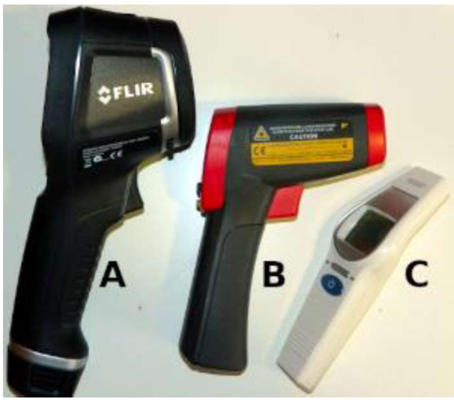

Fig. 1. Temperature measuring devices

Fig. 2. Ambient temperature monitoring set

To prove this observation, a small experiment was conducted. Testing subject was placed in a closed room without ventilation. Starting room temperature was 23.5°C and the surface body temperature (SBT) of the subject was 36.2°C. Then, the room was heated with a conventional heater and changes in the room temperature and the subject's temperature were recorded concurrently. SBT was measured using Alphamed UFR106 infrared forehead thermometer labeled with letter C in Fig. 1. This thermometer has a special body mode, which can measure SBT in the range from 32 to 43°C with an accuracy of ∓0.2°C within the measurement distance of 1—3 cm and operating environment between 10 and 40^{O}C. The room temperature was monitored with a set of devices shown in Fig. 2. The core component of this set was an SVT-01P/I probe for measuring temperature and humidity, which in our experiment was used only for temperature measuring. The said probe operates on 12—24 V DC and gives the output between 0 and 20 mA, which represents temperature values between 0 and 100°C. The probe was used instead of a commercial room thermometer to get more accurate readings. The obtained temperature values are shown in Fig. 3. The graph proves that a classic non-contact thermometer can give reading of body temperature that does not correspond to the real state of the observed subject. This situation can be mitigated by a series of repeated measurements, but in most cases, this is not possible due to the large number of measurements to be performed in a given situation on a large number of students.

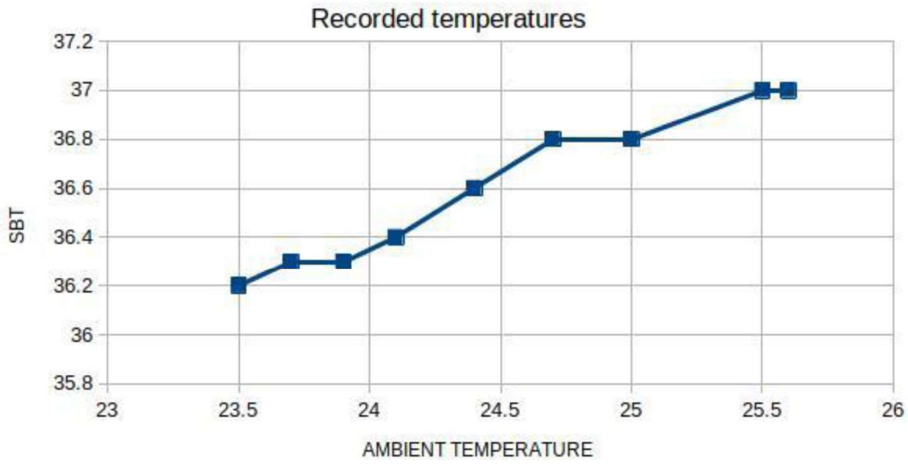

Fig. 3. Recorded surface body temperatures (SBT) of the subject for various room temperatures

Also, the use of classic non-contact thermometers manifests several other issues. The person performing the measurement must be very close to the subject, since the measurement is performed at a very short distance (1—3 cm). This puts the measurer at a certain risk because the required social distance of 1—2 m cannot be maintained. During the measurement, there may be an accidental change in the angle at which the measurement is performed, which can affect the result, since the point where the temperature is taken also changes. This can be avoided by using a non-contact laser-guided thermometer (labeled with letter B in Fig. 1), but due to certain risks created by the use of lasers, such devices are not recommended for SBT measuring.

3. Achieved improvements using thermal imaging process

In order to overcome the said limitations, the use of thermal imaging cameras as more reliable devices for temperature measurement in the situations described above should be considered. Thermal imaging as a proven technique is used in various different areas, and medical field is among them [5—7]. This, it can also be used for temperature measurement in primary screening. A typical thermal imaging camera is shown in Fig. 1 (labeled with letter A).

From the standpoint of usability of the obtained results, thermal imaging cameras have a hige advantage over the most commonly used devices for measuring SBT (different models of contactless thermometers). This advantage relies on the fact that thermal imaging cameras take into account two very important factors, i.e. the ambient temperature in which the measurement is performed and the emissivity of the object of measurement (or in this case the subject of measurement) [8].

Adjusting the temperature of the environment where thermal imaging is performed on the thermal imaging camera itself allows to compensate for the effects of the environment on the results of temperature measurements. This allows obtaining more reliable measurement results. Of course, some adequate external reading of ambient conditions must be provided, since there is no possibility of automatic recognition of environmental conditions on the camera itself. Also, different surfaces have different emissivity values (ε). Thermal imaging cameras are not typically intended for recording only human temperature characteristics, but they also have the capability of determining the emissivity parameter, which allows raising the level of measurement accuracy. The emissivity value for SBT measurement ranges from 0.95 to 0.98 depending on the human skin type, but in most cases, for the needs of SBT-related thermal imaging, the upper limit value is taken, $\varepsilon = 0.98$.

In this study, the FLIR E5 thermal imaging camera was used. This camera allows recording thermal imaging from a minimum distance of 0.5 m [9]. It is possible to set the distance from which thermal imaging is performed, which makes it possible to perform a quality thermal imaging from distances greater than 2 m. This allows maintaining social distance according to current COVID protocols and not putting the person performing thermal imaging at unnecessary risk. Another advantage of thermal imaging cameras is that they store thermograms in camera memory, and those can be used in case of a dispute, or can later be analyzed again for various purposes related to public health. Although it is not recommended, if the situation requires, one thermogram can include several observed subjects at the same time. This is possible because the camera allows increasing the recording distance without any significant decrease in the usability of the obtained results.

Any thermal imaging of SBT is a completely non-invasive method. It should be emphasized that in accordance with current ISO/IEC standards, thermal imaging allows measuring the region medially adjacent to the inner canthi as the most reliable measurement for SBT analysis, since this measurement site is considered to be the most stable [10]. By measuring other regions of the face, less realistic results can be obtained.

4. Conclusion

Thus, non-contact thermometers, which are the ones used in primary screening for covid-19 the most, show a number of serious issues. Thermal imaging cameras are much more expensive devices, but they successfully compensate for some flaws of other devices, while offering some new features that can be very important in real life use. Considering the current downward trend on prices for basic models, which are fully applicable in the cases of primary screening described above, thermal imaging devices should be seriously considered as preferable for controlling SBT in pandemic cases or similar situations.

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П. Столич, З. Стевич, З. Станимирович, И. Станимирович

Впровадження антиковідних заходів в навчальному процесі університету з використанням переваг тепловізійного підходу

Повернення до класичних форм навчання та відвідування занять на базі факультету викликало необхідність запровадження відповідних антиковидних заходів. Одним із таких заходів є регулярна перевірка температури студентів перед доступом до навчання в аудиторіях факультету. Однак при вимірюванні температури звичайними безконтактними термометрами виникають серйозні проблеми. В роботі показано, як деякі з цих проблем і обмежень можна подолати за допомогою тепловізійного зображення під час контролю температури в рамках заходів боротьби з COVID-19.

Ключові слова: COVID-19, первинний скрінінг, температура поверхні тіла, термографія, термометр.