Facemask quality measurement using AMG8833 multiarray thermal sensor

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Abstract—Facemasks have become a necessary thing that people need to wear daily. Even though some people might already be vaccinated, there is still a chance that the Covid-19 virus could still infect them. Hence, this paper presents a device developed to help determine the quality of face masks crucial in preventing the spread of the virus. These devices can calculate the temperature outside the face mask at a maximum distance of three meters. The way this device works is by measuring the temperature released out of the face mask. Here, the developments of the device with the ability to help determine the quality of face masks are explained and discussed. In the end, the device is perfectly functioning and definitely would assist in verifying the quality of the face masks being worn by someone. Two types of faces are used as test materials: the KN95 type face mask and the 3ply facemask used in Malaysia. Each facemask collected data from 30 minutes to 300 minutes for ten subjects over ten days. Studies that have been conducted show that the thermal value of the KN95 facemask increased to 30.27°C after 5 hours of use. At the same time, the 3ply type facemask offers a thermal value of up to 34.58°C after 5 hours of use. This shows a thermal value difference of up to 4.31°C for both facemasks after 5 hours of use.

1. Introduction

There are many Covid-19 cases in Malaysia. Even though we beat it once back in 2020, the number of Covid-19 cases increased after a few months. As such, the government had taken many steps to reduce the number of Covid-19 cases in Malaysia. NGOs in Malaysia had also played their role to help reduce the number of Covid-19 instances until now. The type of people who are concluded in the affected group are usually those who lose their job during the pandemic, lose the ability to continue their business, etc. The list of those affected continues to grow rapidly and exponentially following the lockdown period that the government has decided as a countermeasure for the rising number of cases. The number of patients still has not died down even after the government has taken various steps [1][2].

The government applied a Standard Operation Procedure (SOP) for the whole nation. The SOP when entering a shop/premises was to wear a mask, check the body temperature, and scan the “MySejahtera” app [3]. This method is straightforward, but it proves its effectiveness by achieving 0 cases in 2020. But now, in 2021, even though we use the same manner, the numbers have still not subsided. What is wrong? What causes this to happen? And many more questions popped up in the minds of many. After many clusters were discovered, the answers to these questions have been found by the authorities. The problem was that people always wear the same mask for a span time of more than three days when visiting stores or stalls. This is one of the main reasons why the number of Covid-19 cases is still high [4].

This paper presents a development of a device capable of determining the safety and quality of a face mask, which is the primary defense we have to fight against the Covid-19 virus while being outside our houses. Hence, it may reduce the case of people infected with the Covid-19 virus to a greater extent.
There are two objectives to develop this device, i) to develop a device to detect the level of quality of a face mask worn by a user and ii) to develop a device that helps to decide whether users are allowed to enter a premise or not.

As stated, the device carries a novelty; as said, the first Malaysian made a mask quality detector for detecting the quality of face masks.

The developed device provides more confidence to the community and government, and thus it helps decrease the rate of infection against the Covid-19 virus. This paper is organized as follows. Section II presents the development of the device to help determine the quality of face masks. Lastly, Section III is a conclusion.

2. Development of the Device to Determine the Quality Of Face Masks

Generally, the development of the device has a few steps, which are included, which are face masks data collection and face mask classification in figure.1 shows the device of mask quality detector.

![Figure 1. The Mask Quality Detector](image)

Visual displays showing the quantity of infrared radiation emitted, transmitted, and reflected by an object are also known as thermal imaging. It's difficult to acquire an exact temperature of an item using this approach since there are numerous sources of infrared radiation. Rather than measuring the actual temperature, the camera uses several sources of data depending on the areas surrounding the item to estimate that number. The AMG IR-8833 Thermal camera was utilized in this investigation to detect the role condition. The AMG IR-8833 is an infrared-based camera with an array of 8x8 grid segments (matrix) or a perimeter of around 64 points.

The AMG8833 thermal imaging sensor array reports an accuracy of ± 2.5°C in the range of 0 – 80°C. It can detect a temperature from a distance of up to 7 meters. Its maximum frame rate is 10Hz to create a mini thermal camera with ten frames per second. The sensor, available on a breakout board via Adafruit, was used. Breakout boards are available through various manufacturers to facilitate the adoption of multiple sensors and components for quick and cost-effective prototyping. Long-term solutions may require customized Printed Circuit Board Assemblies to allow for optimal component footprint and performance.
Figure 2. Circuit Connection

The list price of the breakout board at Rm197.00 renders it usable in a solution where cost optimization is a key goal. In addition, the reported accuracy of the sensor breakout board compares to the ±2.34°C mean difference between noncontact infrared temperature measurement and tympanic temperature reported in a clinical study [5].

Adafruit AMG8833 IR Thermal Camera Breakout is an 8x8 array of thermal sensors that is the best choice for this project. It can be integrated with Arduino Mega 2560 and display (Figure 2 shows circuit connection). The AMG8833 passively measures heat radiation from an infrared-emitting grey body. The temperature is calculated by employing the Stefan-Boltzmann law:

\[ \Pi = \varepsilon A \sigma T^4 \]  

Where \( \varepsilon \) is called the emissivity (between 0 and 1), \( A \) is the surface area, \( \sigma \) is the Stefan-Boltzmann constant, \( T \) is the body's temperature, and \( \Pi \) is the radiative power. Typical infrared thermometers (thermocouples) measure radiative power, so a conversion is needed to approximate temperature. A simple equation for approximating the temperature of a grey body is as follows:

\[ V \approx k \left( \frac{T_{obj}}{4} - T_s^4 \right) \]  

Where the \( V \) above represents the voltage measured by the raw sensor, the variable \( k \) is an empirical constant that absorbs the \( A, \varepsilon, \sigma, \) and electronic noise that may exist. The \( T_s \) is the sensor's temperature itself, and the remaining \( T_{obj} \) is the object's temperature being measured. The sensor temperature is being subtracted to ensure that the sensor's temperature is not biasing the object temperature measurement. To get an accurate temperature, these sensors are often calibrated using the target material at different temperatures to ensure the value of \( k \) is accurate. Moreover, once this is done, an empirical equation for object temperature can be implemented:

\[ T_{obj} \approx \left( \frac{V}{k} + T_s^4 \right)^{1/4} \]  

Furthermore, this equation is the ‘final’ approximation for determining the temperature of a grey body using an infrared detector [6]. Thermal Camera Sensor Contactless temperature measurement enables the surface temperature to be identified without physical contact between the measurement object and the temperature sensor. It is based on the optical analysis of the infrared radiation emitted by the measurement object. This radiation is focused through a lens onto a detector which translates it into an electrical signal. This can then be converted to an output size proportional to the object temperature utilizing signal processing. Figure 3 shows the measurement process of the sensor.
3. The Subjects
In this study, ten male subjects age 20 to 25 years old took part, and they are named S1, S2, and S3 till S10 are prepared with the high-quality face mask. The subjects are requested to keep using the same facemask inside the college and during the study at faculty. Most of the subjects were students from the Diploma Mechatronics Engineering, Faculty of Electrical Engineering Technology University Malaysia Perlis. This study shows the quality of the face mask based on thermal and the maximum hours of using it before it would be risky to use anymore because it will cease to provide the necessary protection against the virus. Figure 4 – Figure 6 shows the level of risk depending on the quality of the face mask.

4. The Tasks
For the task, all subjects were asked to blow with an average force through the face mask they were wearing on the same day; the amount of heat dissipated from the face masks was measured by the sensor and displayed on the TFT LCD in real-time. The average reading of the excellent quality face mask temperature is then recorded. After that, the subject was requested to repeat the same task with different moments from one another. Some will only have about five days until they are needed to perform the task again; some are required to use the face mask until a solid 10-day period before being required to complete the task again. The subjects are free to do their daily routine as usual and considering that they are from the same school their routine will only differ on weekends. We can neglect this because of the movement order that the government has in place that has restricted the subjects to go outside the campus area.

5. Results
This test measures the filtration efficiency of face masks based on temperature towards a constant airflow rate. A total of 10 subjects were involved and produced 100 sampling data (taken for 5 hours at 30-minute intervals) for ten days. This data was taken to obtain the amount of thermally generated during the study period. Once the data is taken, it can be seen that the KN95 type facemask is better than the 3ply. Thermal changes at 30 minutes to 300 minutes; KN95 = 1.4°C while 3ply = 3.58°C. The temperature at the 30th minute for KN95 is only 28.87°C while 3ply 31°C, which is 2.13°C is the difference.
This study shows that the use of 3ply is not suitable for more than 180 minutes because the resulting thermal rate is higher after this period (Table 2).

| Time (m) | KN95  | 3ply  | Difference |
|----------|-------|-------|------------|
| 30       | 28.87 | 31    | 2.13       |
| 60       | 28.87 | 31.61 | 2.74       |
| 90       | 29.37 | 32.07 | 2.7        |
| 120      | 29.57 | 32.42 | 2.85       |
| 150      | 29.59 | 32.4  | 2.81       |
| 180      | 29.78 | 32.86 | 3.08       |
| 210      | 29.98 | 33.53 | 3.55       |
| 240      | 30.11 | 34.09 | 3.98       |
| 270      | 30.17 | 34.51 | 4.34       |
| 300      | 30.27 | 34.58 | 4.31       |

Table 2 shows the thermal changes at 30 min, 150 min, and 300 min for the 3ply type facemask. A total of 64 data points were taken on this type of facemask—the temperature change at each end of the 3ply facemask every time he takes it.
Table 2. 64-point Measurement Thermal Value at Facemask based on time

| Time | Temperature Value (°C) | Temperature Average (°C) |
|------|------------------------|--------------------------|
| 31.25 | 31.5 | 31.25 | 31.25 | 31.5 | 31.5 | 31.5 | 31.25 |
| 30.75 | 31.25 | 31.25 | 31.5 | 31.5 | 31.25 | 31.75 | 31.5 |
| 31 | 31 | 30.75 | 31.25 | 31 | 30.75 | 31.5 | 31.75 |
| 31.25 | 31 | 31.25 | 31 | 30.5 | 31 | 31.25 | 31.25 |
| 31.25 | 31 | 31.25 | 31 | 31 | 31.5 | 31.25 | 31.25 |
| 31.5 | 31.25 | 30.5 | 30.5 | 31 | 30.75 | 30.5 | 31 |
| 30.25 | 30.75 | 30.5 | 30.75 | 30 | 30.25 | 30.25 | 30.75 |
| 30.75 | 30.25 | 31.25 | 30.5 | 30.5 | 30.25 | 30.5 | 30.75 |
| 150 | 32.5 | 33 | 32.25 | 33 | 33 | 33 | 32.5 |
| 32.75 | 32.75 | 32.75 | 32.75 | 32.75 | 32.75 | 32.75 | 32.75 |
| 32.25 | 32.25 | 32.5 | 32.75 | 32.25 | 32.5 | 32.5 | 32.75 |
| 32.75 | 32.5 | 32 | 31.75 | 32.25 | 32.5 | 32 | 32.75 |
| 32.25 | 32.25 | 31.75 | 32 | 32.25 | 32 | 32.75 | 32.75 |
| 31.75 | 32 | 31.75 | 32.5 | 31.75 | 32.5 | 31.25 | 31.75 |
| 32 | 31.75 | 32.75 | 31.75 | 32 | 31 | 31.5 | 31.75 |
| 35 | 35 | 35.5 | 35.25 | 35 | 35.25 | 34.5 |
| 35 | 34.5 | 34.5 | 35 | 35 | 34.5 | 34.5 | 35 |
| 35 | 34.5 | 34.75 | 34.25 | 34.25 | 34.5 | 34.5 | 34.25 |
| 35.25 | 34.25 | 34.25 | 34.25 | 34.25 | 34.5 | 34.5 | 34.25 |
| 35.25 | 35 | 34.5 | 34.5 | 34 | 34.25 | 34.5 | 34.75 |
| 35 | 34.75 | 34 | 34 | 34 | 34.5 | 34.75 | 34.5 |
| 34 | 34.25 | 34.25 | 34.25 | 34.5 | 34.75 | 34.5 | 34.5 |
| 34 | 34.75 | 34.5 | 34.75 | 34.75 | 34.25 | 34.25 | 34.25 |

6. Conclusion

Realizing the problems encountered, we have used this "Mask Quality Detector" in the study campus to detect the face masks worn by the students before entering the laboratory and lecture hall. The positive impact can be seen with the "Mask Quality Detector" that we created; it has managed to detect some students who still use their face masks with insufficient quality. It is hoped that this invention can help reduce the spread of respiratory diseases that are spread through this virus and protect healthy people from being infected or prevent infected people from infecting others. This device can also determine whether the user is allowed to enter a premise or not. It was next, being able to curb the rate of Covid-19 outbreak transmission. Finally, this device can also raise public awareness of the importance of maintaining personal safety from the plague. The use of face masks is not only to enter a premise. Hence, the objectives of this study are entirely achieved.
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References

[1] Shah, A. U. M., Safri, S. N. A., Thevadas, R., Noordin, N. K., Abd Rahman, A., Sekawi, Z, & Sultan, M. T. H. 2020 COVID-19 outbreak in Malaysia: Actions taken by the Malaysian government. International Journal of Infectious Diseases, 97, 108-116.

[2] Yau, E. K. B., Ping, N. P. T., Shoesmith, W. D., James, S., Hadi, N. M. N., & Loo, J. L. 2020 The behaviour changes in response to COVID-19 pandemic within Malaysia. The Malaysian journal of medical sciences: MJMS, 27(2), 45.

[3] Hasan, S. S. C., Mohamed, D., & Yusoff, Y. 2020 Mysejahtera app and the Privacy Rights in Times of Covid 19: the Legal and Syariah Perspectives. INSLA E-Proceedings, 3(1).

[4] Tang, K. H. D. 2020 Movement control as an effective measure against Covid-19 spread in Malaysia: an overview. Journal of Public Health, 1-4.

[5] Nasir, M. 2020 Monitoring Of Body Temperature Non Contact Using AMG8833 Thermal Camera And Face Detection. In Prosiding Seminar Nasional Terapan Riset Inovatif (SENTRINOV) (Vol. 6, No. 1, pp. 396-403).

[6] Valiente Jr, L., Garcia, R., Catapang, J. L., Manalili, E. A., & Salapantan, A. 2019 Swine grunt analysis through intensity and frequency isolation with thermography using Adafruit AMG8833 IR thermal camera breakout for swine stress detection and reduction. In Fourth International Workshop on Pattern Recognition (Vol. 11198, p. 111980K). International Society for Optics and Photonics.