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Untuk melaksanakan kegiatan Publikasi pada *International Symposium on Physics and Applications (ISPA), Journal of Physics: Conference Series* dengan judul:

"Development of Low-Cost Thermal Camera for Examine Human Body Temperature"

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1st International Symposium on Physics and Applications

Darminto, Yuwana, L., and Sungkono

Department of Physics, Institut Teknologi Sepuluh Nopember

E-mail: sungkono@physics.its.ac.id (mailto:sungkono@physics.its.ac.id), ispa@its.ac.id (mailto:ispa@its.ac.id)

The 1st international Symposium on Physics and Applications, 1st ISPA or ISPA 2020, was held from December 17 to 18, 2020 on Department of Physics, Institut Teknologi Sepuluh Nopember (ITS). The event was organized by the Department of Physics, Faculty of Sciences and Data Analytics, ITS. Considering the covid-19 pandemic and the travel restriction, ISPA 2020 was conducted via Zoom Meeting. In addition, the symposium is supported by Airlangga University, State University of Surabaya, and National University of Singapore. This Proceedings issue compiles oral presentations that were submitted by the authors after rigorously reviewed by a special committee designated by the Journal of Physics Conference Series (JPCS) editor for ISPA.

Hopefully, we can develop research collaboration for supporting and increasing the quality of research in the physical sciences and its applications. We are grateful to the organizing and editorial committee that have actively contributed to accomplish a well-balanced scientific program. We also thank to graduate students lively participated, the keynote and invited speakers and also the participants who are going to be the presenter in ISPA 2020. The organizing and editorial committee, keynote and invited speakers are listed below.

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Bekti Ponco Saputro (Institut Teknologi Sepuluh Nopember)

Keynote Speakers

No	Name	University/Institute/Organization
1	Bobby Eka Gunara	Institut Teknologi Bandung, Indonesia
2	Shammim Ahsan	Khulna University, Bangladesh
3	Hidetaka Arimura	Kyushu University, Japan
4	Kuo-Fong Ma	National Central University, Taiwan

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5	Tosawat Seetawan	Sakon Nakhon Rajabhat University, Thailand
6	Muhammad Mahyiddin Ramli	Universiti Malaysia Perlis, Malaysia

Invited Speakers

No	Name	University/Institute/Organization
1	Hiroaki Yamanaka	Tokyo Institute of Technology, Japan
2	Suryani Dyah Astuti	Airlangga University, Indonesia
3	Hery Suyanto	Udayana University, Indonesia
4	Kuwat Triyana	Gajahmada University, Indonesia
5	Suasmoro	Institut Teknologi Sepuluh Nopember, Indonesia
6	Agus Purwanto	Institut Teknologi Sepuluh Nopember, Indonesia

In the symposium, we invited 6 keynote speakers and 6 invited speakers from Thailand, Malaysia, Taiwan, Japan, Bangladesh, and Indonesia. The symposium has successfully obtained positive responses from researchers by collecting significant and qualified 72 papers for oral presentations that have selected from 98 abstracts received. The presenters and participants are shown in **Figure 1**. The all papers are included addressing the research topics of the conference including theoretical physics, laser and optoelectronics, instrumentation and acoustics, earth sciences (geophysics), bio and medical physics, and material physics.

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Preface

To cite this article: 2021 *J. Phys.: Conf. Ser.* **1951** 011001

Preface

The first edition of international symposium on physics and applications, 1st ISPA, was held from December 17 to 18, 2020 on Department of Physics, Institut Teknologi Sepuluh Nopember (ITS). The event was organized by Department of Physics, Faculty of Sciences and data analytic, ITS. The symposium is supported by Airlangga University, State University of Surabaya and National University of Singapore. However, due to the COVID-19 pandemic, The 1st ISPA 2020 was conducted virtually on December 17 to 18, 2020 in Surabaya, Indonesia through the Zoom Meeting platform.

In the symposium, we invite 6 keynote speakers and 6 invited speakers from Thailand, Malaysia, Taiwan, Japan, Bangladesh and Indonesia. The symposium has received significant interest amongst the community with 72 papers for oral presentations that have selected from 98 applicants received. The All papers are included addressing the research topics of the conference including theoretical physics, laser and optoelectronics, instrumentation and acoustics, earth sciences (geophysics), bio and medical Physics, and physics of materials.

We are grateful to A. Rubiyanto, S. Pratapa, A. Rusydi, Madlazim, and M. Yasin, who served as members of the Advisory Committee and actively contributed to accomplish a well-balanced scientific program. To our great pleasure, also a considerable number of graduate students lively participated. The keynote and invited speakers and also the participants who going to be presented papers: Thank you once more!

We hope during the symposium that we can develop research collaboration for supporting and increasing the quality of research in the physical sciences, in Indonesia.

The Editors,

Prof. Darminto
Dr. Lila Yuwana
Dr. Sungkono

1st International Symposium on Physics and Applications

Darminto, Yuwana, L., and Sungkono
Department of Physics, Institut Teknologi Sepuluh Nopember
E-mail: sungkono@physics.its.ac.id, ispa@its.ac.id

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Hopefully, we can develop research collaboration for supporting and increasing the quality of research in the physical sciences and its applications. We are grateful to the organizing and editorial committee that have actively contributed to accomplish a well-balanced scientific program. We also thank to graduate students lively participated, the keynote and invited speakers and also the participants who are going to be the presenter in ISPA 2020. The organizing and editorial committee, keynote and invited speakers are listed below.

Organizing Committee
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4	Kuo-Fong Ma	National Central University, Taiwan
5	Tosawat Seetawan	Sakon Nakhon Rajabhat University, Thailand
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In the symposium, we invited 6 keynote speakers and 6 invited speakers from Thailand, Malaysia, Taiwan, Japan, Bangladesh, and Indonesia. The symposium has successfully obtained positive responses from researchers by collecting significant and qualified 72 papers for oral presentations that have selected from 98 abstracts received. The presenters and participants are shown in **Figure 1**. The all papers are included addressing the research topics of the conference including theoretical physics, laser and optoelectronics, instrumentation and acoustics, earth sciences (geophysics), bio and medical physics, and material physics.

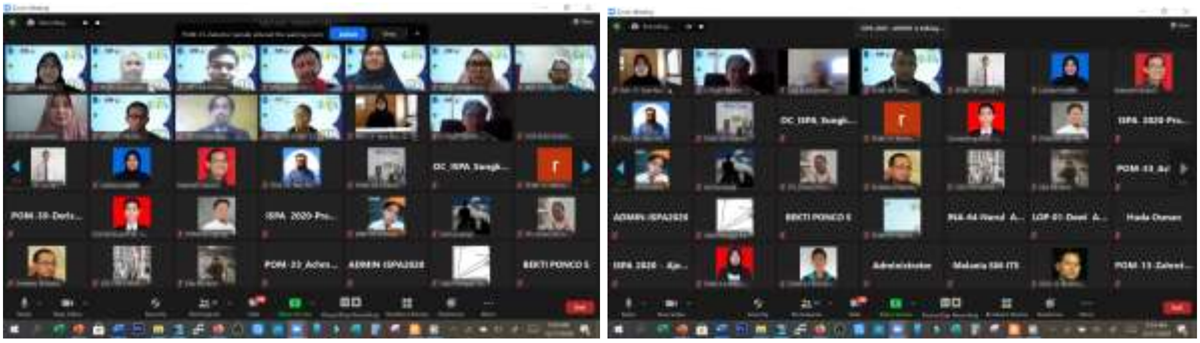

Figure 1. The participants of ISPA 2020.

The symposium is arranged for two days, the first day consisted of 3 keynote speakers, 3 invited speakers and 34 participants. As the first keynote speaker in plenary session, Dr. Muhammad M. Ramli from University Malaysia Perlis (UniMAP) - Malaysia, gave an excellent presentation on "Reduced-Graphene Oxide for Various Electronic Applications" (**Figure 2**). Keynote speakers present in plenary rooms (all participants the symposium) consecutively. Each keynote speaker will deliver their respective topic in the 30-40 minutes. Then the discussion (question and answer) between keynote speaker and audiences will be conducted in 10-20 minutes.

Figure 2. Keynote presentation from Dr. Muhammad M. Ramli

The second speech in plenary session was delivered by Prof. Kuo-Fong Ma from National Central University – Taiwan, with title of speech is "Earthquake: Knowns and Unknowns" (**Figure 3**).

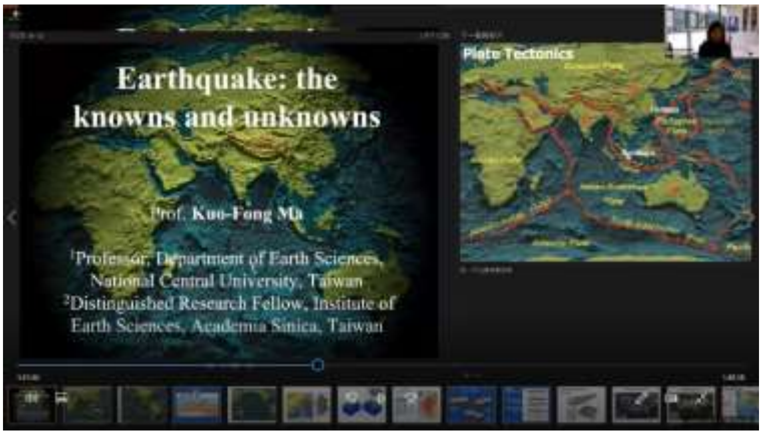

Figure 3. Keynote presentation from Prof. Kuo-Fong Ma

The third speech in plenary session was delivered by Prof. Shamim Ahsan from Khulna University – Bangladesh, with the title of speech is "Prospects of CO_2 Laser Polishing Technique" (**Figure 4**).

Figure 4. Keynote presentation from Prof. Shamim Ahsan

After the keynote speaker session, 3 invited speaker and 34 oral presentations were divided into 3 rooms based on work topics. Furthermore, invited speakers present their topic after plenary seasons in 25-30 minutes and discuss with participant in 10-15 minutes. Invited speaker rooms are parallel. In the parallel rooms, participants present their papers after invited speaker in 10-15 minutes and following discussions with others in 5 minutes. Following is the list of invited speakers:

1. Prof. Kuwat Triyana from Gajah Mada University - Indonesia with the title of speech is "Functionalized Quartz Crystal Microbalance with Polyvinyl Acetate/Citric Acid Nanofiber for Detecting Trimethyl Amine".
2. Prof. Hiroaki Yamanaka from Tokyo Institute of Technology - Japan with the title of speech is "Exploration Geophysics for Earthquake Disaster Mitigation"
3. Prof. Suasmoro from Institut Teknologi Sepuluh Nopember - Indonesia with the title of speech is "Iron and Copper based BO6 octahedron of perovskite: Structure, Oxidation state, Electronic and Magnetic properties"

On the second day, this conference consisted of 3 keynote speakers, 3 invited speakers and 38 participants. The first speech in plenary session on second day was delivered by Prof. Hidetaka Arimura from Kyushu University - Japan, with the title of speech is "What is the medical physics from academic point of view?" (**Figure 5**).

Figure 5. Keynote presentation from Prof. Hidetaka Arimura

The second speech in plenary session on second day was delivered by Prof. Bobby Eka Gunara from Institut Teknologi Bandung – Indonesia, with title of speech is "Higher Dimensional Static Black Holes" (**Figure 6**).

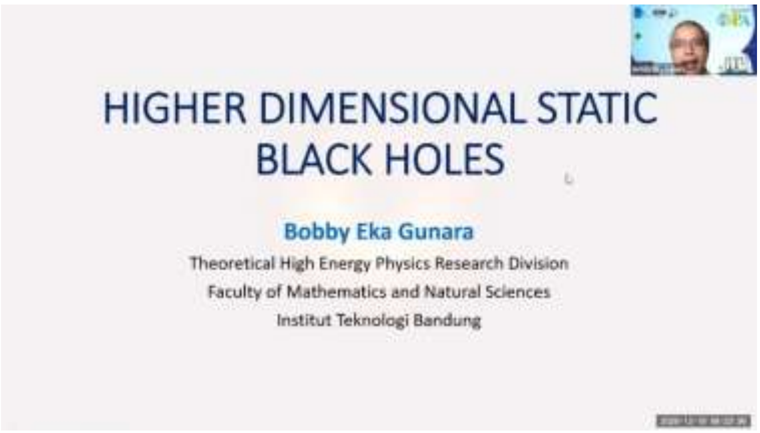

Figure 6. Keynote presentation from Prof. Bobby Eka Gunara

As the last keynote speaker in plenary session on second day, Prof. T Seetawan from Sakon Nakhon Rajabaht University – Thailand, gave a presentation on "Advantage of Flexible Thermoelectric Module for Small Generator."

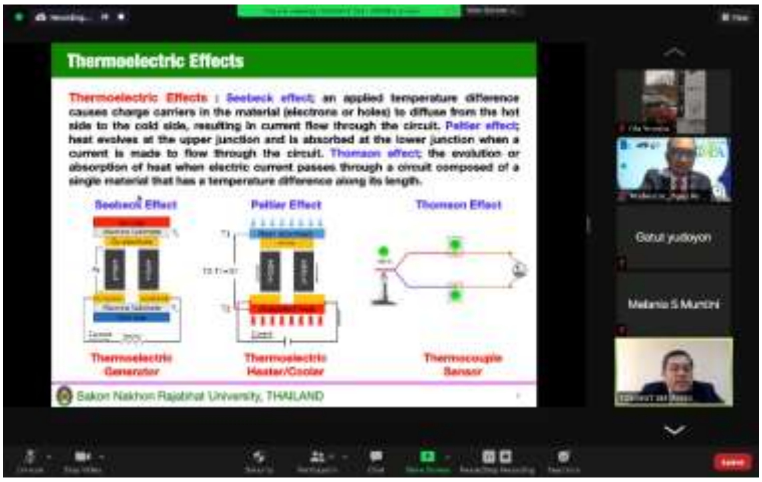

Figure 7. Keynote presentation from Prof. T Seetawan

After the keynote speaker session, 3 invited speaker and 38 oral presentations were divided into 3 rooms based on work topics. This is the list of invited speakers:

1. Prof. Suryani Dyah Astuti from Universitas Airlangga - Indonesia with the title of speech is “The Role of Organic Photosensitizer in Antimicrobial Photodynamic Inactivation (PDI)”.
2. Prof. Hery Suyanto from Udayana University - Indonesia with the title of speech is “Organic Materials Utilization for Biomarker and Forensic Needs by Using Laser-Induced Breakdown Spectroscopy (LIBS) Method”
3. Prof. Agus Purwanto from Institut Teknologi Sepuluh Nopember - Indonesia with the title of speech is “Relation between Channel and Measurement Matrices for Successful Quantum Teleportation.”

Here are several photos of oral presentation activities of the participants.

Figure 8. Several oral presentation activities

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Development of Low-Cost Thermal Camera for Examine Human Body Temperature

S I Purnama, I Hikmah and M A Afandi

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Thermogun is non-contact thermometer to examine people whom body temperature above 37°C that is used to screening human body temperature while entering public areas such as schools, offices, and supermarkets. Thermo gun is widely used yet not effective because it measuring single point around body or face which cannot represent whole body. Thus, the development of thermal camera is important. This research focusing on development of low-cost and low-resolution thermal camera to replace thermo gun. Thermal camera measure 36°C, 37°C, 38°C object temperature and gives accuracy respectively 99.38%, 99.39% 99.41%. Therma camera not only give high accuracy but also high precision. The precision for same temperature respectively 35.01 ± 0.63 when measure 36°C object temperature, 36.55 ± 0.26 when measure 37°C object temperature, and 37.27 ± 0.49 when measure 38°C object temperature. This result is satisfied and good enough to examine human body temperature.

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Development of Low-Cost Thermal Camera for Examine Human Body Temperature

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Development of Low-Cost Thermal Camera for Examine Human Body Temperature

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Abstract. Thermogun is non-contact thermometer to examine people whom body temperature above 37°C that is used to screening human body temperature while entering public areas such as schools, offices, and supermarkets. Thermo gun is widely used yet not effective because it measuring single point around body or face which cannot represent whole body. Thus, the development of thermal camera is important. This research focusing on development of low-cost and low-resolution thermal camera to replace thermo gun. Thermal camera measure 36°C, 37°C, 38°C object temperature and gives accuracy respectively 99.38%, 99.39% 99.41%. Therma camera not only give high accuracy but also high precision. The precision for same temperature respectively 35.01 ± 0.63 when measure 36°C object temperature, 36.55 ± 0.26 when measure 37°C object temperature, and 37.27 ± 0.49 when measure 38°C object temperature. This result is satisfied and good enough to examine human body temperature.

1. Introduction

Body temperature is one of significant parameter to determine whether somebody has Covid-19 [1]. Worldwide has been agree for mass screening to restrict people with high grade fever entering specific areas during high infectious periods [2]. The instrument widely approved for non contact human body temperature measurement during the COVID-19 pandemic is thermometer gun [3]. Thermometer gun obtained data by sending screening area with infrared signal and read the temperature emitted. However, the temperature data acquired from one point of detection is giving one more questions, wether it represent the temperature of the entire human body. In order to increasing the accuracy of non contact human body temperature measurement, we propose a low cost thermal camera to widen measuring area to increase the precision of human body temperature data.

Thermal cameras are passive sensors that capture the infrared radiation emitted by all objects [4]. It is able to capture 10 μm infrared signals emitted by human body [5]. The advantages thermal cameras over opticals were when the ambient light intensity is low, thermal cameras still detecting the presence of objects than optical cameras because the heat radiation from the object to be detected [6].

The amount of sensors used in thermal cameras affect the image resolution [7]. Measurement range of AMG8833 thermal camera between 0°C to 80°C with ± 2.5°C accuracy. It is able to detect objects up to a distance of 7m. This camera has an image resolution of 8x8 or 64 pixels and working with maximum frame rate of 10Hz or 10 frames per second. The angle of view of the sensor is 60° [8]. Thermal camera can visualize the heat that is spread in the object [9]. With the help of programming, we can imitate the heat data of an object in the form of an image or quantitative image in the form of a color bar. Between low temperature objects and high temperature objects, the color in the image that is formed will be different [10]. Increased precision can be obtained by averaging the temperature data from all detection points [11]. An infrared thermal camera takes a temperature map of human body and measure it with the exact localization of specific areas from 2-dimensions thermal map is difficult [12]. We improve this precision with the neighbor pixels aproach. The development of system using thermal camera AMG8533 as a temperature sensor and Arduino Uno as microcontroller. The data obtained will be proceed by matlab programming to obtain image output result. The distance between the object and the camera affect temperature reading resulting in possibilities different measurement. aWe vary objects with different temperatures to obtain an image display of the temperature then analyze the resulting image. The analizing process starting from the point with the highest temperature to the points in the surrounding area to obtain the accuracy and precision of the obtained temperature data.

2. Method

This study uses AMG 8833 low-resolution thermal camera, microcontroller AT Mega 328, and LCD. Input of the device is thermal camera AMG 8833, microcontroller as a process device, and LCD is an output device.

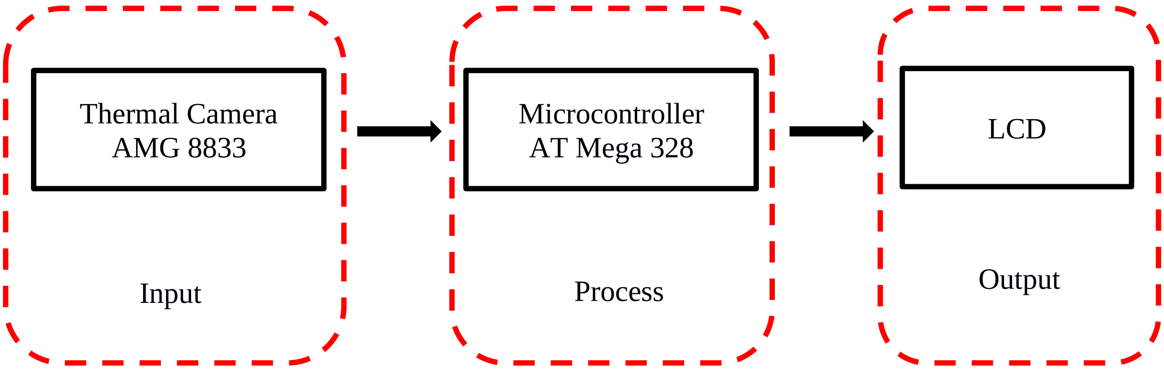

Figure 1. General System

Figure 1 shows the general system for this study. AMG 8833 is a low-resolution thermal camera. This camera gives 8x8 pixels of temperature reading. Each pixel contains of temperature information at one point. Therefore, temperature information that can be read using this thermal camera is 64 point. AMG 8833 more cheap than other thermal camera because of the resolution. As an input, AMG 8833 send the data to the microcontroller. Data send trough I2C communication using SDA and SCL wire to the microcontroller.

Table 1. Pin Configuration of AMG 8833 and Microcontroller

AMG 8833 Pin	Microcontroller Pin
VCC	3.3V
GND	GND
SDA	PC4
SCL	PC5

Table 1 shows the configuration of AMG 8833 pin and microcontroller pin. Since AMG 8833 use I2C communication, all 64-temperature data will be sent to the microcontroller through SDA and SCL wire. Microcontroller will read the data and search the hottest temperature throughout 64 pixels. After finding the hottest temperature, the microcontroller will continue to find its position trough the x and y cartesian axes of the hottest pixel. Lastly, the microcontroller will calculate the data then send it to LCD. The calculation is shown in (1).

$$acc = 100 - \left(\left|\frac{(AV - TV)}{AV}\right| x\ 100\%\right) \quad (1)$$

Formula 1 is used to calculate the accuracy of AMG 8833 temperature reading AMG 8833. AV stands for actual value. Actual value is a value of object temperature measured by thermometer digital. TV stands for test value. Test value is a value of temperature that AMG 8833 gives when read the object with specific actual value.

$$Precision = \frac{\sum_{x=1}^{5} P_x}{5} \pm \frac{\sum_{y=1}^{5}(P_y - AP)}{5} \quad (2)$$

Formula 2 used to calculate precision of temperature reading using AMG 8833. P_x and P_y stands for 4 pixels around the hottest pixel and the hottest pixel data temperature. AP stands for average pixel from hottest pixel and 4 pixels around the hottest pixel. The number 5 stands for hottest pixel and its neighbour. When the hottest pixel position in cartesian X is 5 and Y is 7, the 4 pixels position is X = 4 and Y = 7, X = 5 and Y = 6, X = 6 and Y = 7, X = 5 and Y = 8. Thus, P_1 is temperature information for hottest pixel X = 5 and Y = 7, P_2 is temperature information for X = 4 and Y = 7, P_3 is temperature information for X = 5 and Y = 6, P_4 is temperature information for X = 6 and Y = 7, and P_5 is temperature information for X = 5 and Y = 8. This position $P_2 - P_5$ can be changed depending on the position of the hottest pixel.

3. Results and Discussion

Based on the test result, thermal camera gives high accuracy and precision to measure object temperature. As human body mostly consists of water, we use water as an object that represents human body temperature due to difficulty to adjust human body temperature into varied temperature. It has an affinity to represent the human body and easiness to adjust the temperature. This test uses 3 varied temperatures to measure that is 36°C, 37°C, and 38°C. This varied temperature is representing the threshold of normal person and fever person. Normal human body temperature ranges between 36 – 37 and fever person ranges between 37 – 38. The experiment of each temperature repeated 3 times.

Table 2. Mapping Temperature for 36°C

Pixel Y \ Pixel X	1	2	3	4	5	6	7	8
1	28.00	28.00	29.67	30.00	29.33	29.33	29.00	28.33
2	28.00	28.00	29.00	31.67	31.67	29.67	29.00	29.00
3	28.33	30.00	34.33	35.33	35.00	35.00	29.67	29.00
4	28.33	33.00	35.33	35.33	35.67	35.67	33.00	29.00
5	28.67	34.67	35.33	35.33	35.67	35.33	34.33	29.33
6	29.33	33.33	35.33	35.67	35.33	36.00	33.33	29.00
7	29.00	31.00	34.33	35.67	34.67	32.00	29.33	28.33
8	28.00	28.67	30.67	32.33	30.67	29.00	28.33	28.00

Table 2 represents thermal camera output. Pixel X and pixel Y are the position of the IR array and the value on the table is the temperature. This research focuses on 8 x 8 low resolution camera. The total array pixel is 64 pixel and all pixel have temperature information. According Table 1 hottest temperature is 36.00°C at X = 6 and Y = 6. The coldest temperature is 28.00°C at many pixels in the Table 1 such as X = 1 and Y = 1. The position of cold pixel mostly on the edge. That means cold pixel is not an object but something that is outside of the object. Thus, the measurement of the object doesn't need to measure the edge. The measurement is focusing on the hottest pixel and examining the edge of the hottest pixel to validate the temperature.

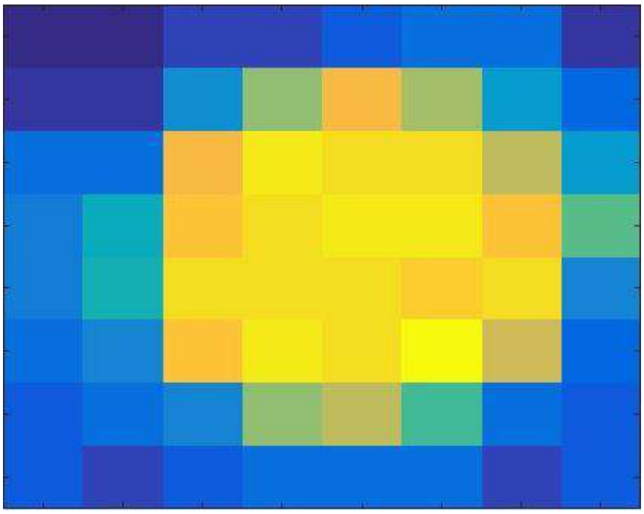

Figure 2. Thermal Camera Image

Figure 2. is the output of thermal camera in image form. Figure 2. Shows that the most luminous colour at pixel X = 6 and Y = 6. That means the hottest pixel is the most luminous colour of the thermal camera image. The value of edge hottest pixel can be below or same as the hottest pixel. This information can be used as the research data to examine performance of thermal camera. The hottest pixel is not at the middle of the object but the edge of object. Measuring just 1 position for human body temperature measurement will lead to error measurement.

The accuracy of thermal camera obtained from comparing hottest pixel and object temperature. The precision obtained from average of edge hottest pixel and comparing object temperature with many tests. This study uses 3 varied object temperature and 3 tests. Thus, data is 3 data tests for 36°C, 3 data tests for 37°C, and 3 data tests for 38°C. Parameter that want to get is accuracy, precision, minimum temperature pixel value from the edge of hottest pixel, hottest pixel, and range. From Table 1 the hottest pixel at X = 6 and Y = 6. Thus, the edge of hottest pixel position is X = 5 and Y = 6, X = 6 and Y = 5, X = 7 and Y = 6, X = 6 and Y = 7. The temperature value for that position is 35.33°C, 35.33°C, 33.33°C, and 32.00°C. Now the temperature data frame is 36.00°C, 35.33°C, 35.33°C, 33.33°C, and 32.00°C. Accuracy for the data is 100% because the hottest pixel is the same with object temperature, precision is 33.99 ± 1.55, the coldest temperature is 32.00°C, the hottest pixel is 36.00°C, and the range is 4. With the same experimental steps, we get 3 data for 36.00°C object temperature.

Table 3. Data Analysis for 36°C Object Temperature

Number of Testing	Min Temperature	Hottest pixel	Range	Accuracy	Precision
1	32.00	36.00	4.00	100.00%	33.99 ± 1.55
2	35.33	35.67	0.33	99.07%	35.60 ± 0.10
3	35.00	35.67	0.67	99.07%	35.46 ± 0.24

Table 2 informs that thermal camera gives high accuracy to measure 36°C Object Temperature. Average of the accuracy is 99.38%. The most accurate measurement is the testing one gives 100%

accuracy and the lowest accuracy is 99.07% from testing 2 and 3. Measuring the precision parameter of the thermal camera gives a good result. Average of this parameter is 35.01 ± 0.63 with the average range is 1.6. Thermal camera gives good result for measuring object temperature in a temperature 36°C.

Table 4. Data Analysis for 37°C Object Temperature

Number of Testing	Min Temperature	Hottest pixel	Range	Accuracy	Precision
1	36.33	36.66	0.33	99.08%	36.46 ± 0.15
2	36.33	37.33	1.00	99.10%	36.53 ± 0.37
3	36.33	37.00	0.67	100.00%	36.66 ± 0.26

Table 4 informs that thermal camera gives high accuracy to measure 37°C Object Temperature. Average of the accuracy is 99.39%. The most accurate measurement is testing 3 gives 100% accuracy and the lowest accuracy is 99.08% from testing 1. Measuring the precision parameter of the thermal camera gives good results too. Average of this parameter is 36.55 ± 0.26 with the average range is 0.6. According to data analysis from Table 2 and Table 3, thermal camera gets good result to measure normal people. For the 36 – 37°C measurement test gives high accuracy. Thermal camera gives good result for measuring object temperature that has a temperature of 36°C.

Table 5. Data Analysis for 38°C Object Temperature

Number of Testing	Min Temperature	Hottest pixel	Range	Accuracy	Precision
1	37.00	37.66	0.66	99.10%	37.29 ± 0.21
2	35.33	38.00	2.67	100.00%	37.19 ± 0.74
3	36.00	38.33	2.33	99.13%	37.33 ± 0.53

Table 5 informs that thermal camera gives high accuracy to measure 38°C Object Temperature. Average of the accuracy is 99.41%. The most accurate measurement is testing 2 which gives 100.00% accuracy and the lowest accuracy is 99.10% from testing 1. Measuring the precision parameter of the thermal camera gives a good result too as the previous testing. Average of this parameter is 37.27 ± 0.49 with the average range is 1.88. According to data analysis from Table 3 and Table 4, thermal camera gets good result to measure fever person. For the 37 – 38°C measurement test gives high accuracy. According to the whole test, thermal camera gets the advantage comparing with thermo gun. Thermal camera can more representing human body temperature because of the measurement is not based on one position that thermo gun is just one region. Thermal camera can pick the hottest pixel from 64 data and thermo gun just 1 data. Thermal camera gives high accuracy and precision even though low resolution.

4. Conclusion

This study can conclude that screening body temperature using thermo gun can be replace using low resolution and low-cost thermal camera. This research prove that thermal camera has high accuracy and precision. Thermal cam gives 99.38% for the accuracy and the precision is 35.01 ± 0.63 for 36°C object temperature, 99.39% for accuracy and 36.55 ± 0.26 for precision when measure 37°C object temperature. Lastly, thermal camera gives accuracy 99.41% and precision 37.27 ± 0.49 when measure 38°C object temperature. This result is satisfied for examine human body temperature. The advantage of thermal camera compared to thermo gun is the hottest pixel detection. Thermal camera can examine which pixel get the hottest temperature when thermo gun just detect the temperature from small of region. Screening body temperature using thermal camera is more suitable rather than thermo gun.

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