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Aura detection using thermal camera with convolutional neural network method for mental health diagnosis

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ABSTRACT

Mental health is an important aspect in realizing overall health. For this reason, non-invasive medical equipment is needed for people with mental disorders. This study aimed to create a psychological health diagnostic tool by detecting auras using a thermal camera from facial objects. The contribution of this study is that the tool can detect the patient's aura without physical contact so that the patient is more comfortable and does not feel invaded. This research designed a system for detecting electromagnetic wave radiation energy emitted by the body using a thermal camera. Face detection in the input image was performed using a convolutional neural network (CNN) model single shot multibox detector (SSD), which is one of the CNN models that implements a bounding box to estimate the localization of detected objects. In this case, system testing was used to evaluate the performance of the CNN system algorithm for aura detection in terms of color (main color or average color). The results obtained were detectibility by 80%, selectivity by 88.88%, precision by 70%, sensitivity by 87.5%, and accuracy by 63.63%. The design of the aura detection system in this study will make it easier for psychiatrists and psychologists to help make a non-invasive diagnosis.

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1. INTRODUCTION

Mental health, in the forms of mental disorder, currently becomes a concern for the Indonesian government. According to the data issued by the ministry of health's basic health research (Riskesdas Kemenkes), 282,654 household members, or 0.67 percent of Indonesian people experienced mental disorders in 2018. Mental health is an important aspect of realizing overall health. In addition, it is also important to pay attention to physical health, fear of a disease such as a cough, migraine, fever, or bullying, that can also be one of the factors causing mental disorders [1]-[4]. About 450 million people are suffering from mental and behavioral disorders worldwide [5], [6]. According to WHO Asia Pacific Region (WHO SEARO), the highest number of depressive disorder cases is in India (56,675,969 cases or 4.5% of the total population), while the lowest cases is in Maldives (12,739 cases or 3.7% of the population). In order to provide mental health services, medical equipment that can diagnose people with mental disorders effectively and non-invasively is needed. In this case, diagnostic equipment for mental disorders is still relatively rare and very expensive, in addition to the periodic fees that must be paid for every purchase of software application extensions. Therefore, it is very important to provide diagnostic equipment software for mental disorders at a low price and more effective. Several previous articles have discussed aura detection based on biometric traits such as fingerprint, voice, speech, face, and retina [7]-[9].

In a previous study carried out by Fabijaeska and Sankowski [10], the aura removal algorithm method for aura phenomena was carried out for images at high temperatures. In the research, the specimen was heated to a high temperature until the light was emitted in the spectrum, causing the illumination of the photosensitive element of the charge coupled device (CCD) camera to saturate. Living organisms have a special field called the biofield that has a different structure in each layer of color, sound, shape, and structure called Aura [11]. Furthermore, Benke *et al.* [12] studied the characteristics of aura phenomena with 60 patients with heart disease and 40 patients with vasogespal syncope. The method used is a detailed anamnestic exploration. In addition, image processing has also been used by other previous researchers [13]-[15]. For example, Lee *et al.* [16] employed gas discharge visualization (GDV) for imaging techniques that are captured by biophotons and then emitted by the human body; this method is quite good for the quality of the reconstructed image [17]. Another research conducted by Poojay and Srinivas [18] reviewed various researchers about image analysis based on aura images. They stated that humans consist of many mysteries so that research on aura images can understand the individual's state of mind and health conditions. Furthermore, Rajesh *et al*. [19] through their study used aura images for medical diagnosis. In this case, experiments were carried out with 40 normal and abnormal subjects through a method where aura images were captured by mapping the energy of the five hand meridian points [20]. In addition, Rajesh [14] utilized the support vector machine (SVM) method to study patterns to recognize image textures based on the gray level aura matrix (GLAM). The success of this system resulted in an average value of 92%. However, this system is limited by distance, in which when the measurement distance is close, the texture will be more similar and vice versa.

Based on several studies on aura detection that have been described above, no one has ever used a thermal camera to capture aura images and display thermal images using the convolutional neural network-single shot multibox detector (CNN-SSD) method. Furthermore, through the combination of the concepts proposed by Stefan Bolzman and Plank, it is possible to analyze the field energy and the wavelength of the aura in the form of electromagnetic waves emitted from a person's body. Several researchers from various countries have developed image analysis based on image aura [21]-[24]. In this case, Poojay and Srinivas [18] has applied it using various patient objects. However, to the best of the author's knowledge, several authors have not investigated the aura image to detect mental disorders [18]. Therefore, the purpose of this study was to create a diagnostic tool for people with mental disorders by detecting auras using light spectrum analysis. The method used in this study was a camera to capture the object's posture and taps the aura object through the face. After that, the aura measurements were analyzed by light spectrum analysis. The output of the camera in the form of photos will open the interface which will then be displayed to the PC. This study can determine the presence of aura emitted from the human body, especially for those who experience mental health. The contributions of this research are:

- The tool can detect the patient's aura without physical contact so that the patient is more comfortable.
- The tool can provide comfort for patients because the examination was carried out in a non-invasive manner.
- The tool can help medical personnel to analyze mental disorders more easily using modern technology.

2. RESEARCH METHOD

2.1. Data processing

This research created a system that can detect electromagnetic wave radiation energy emitted by the body with a thermal camera. The initial stage was to detect facial temperature in humans. The input used by the system was in the form of a thermal image obtained from taking pictures using a thermal camera. Convolutional neural network is a method that belongs to the feed forward neural network class [25] which was inspired by the visual cortex of the brain and specifically for processing data that has a grid structure as described in Figure 1.

Face detection in the input image was performed using the CNN-SSD. In this case, SSD is one of the CNN models that implements bounding boxes to estimate the localization of detected objects. It has several advantages including speed and accuracy in recognizing objects compared to other models. Figure 1 shows that the face temperaturewas used as input, then the image preprocessing was carried out using a data set. Furthermore, the feature extraction process was carried out, continued by classification based on the CNN using the 2 convolution layer model to determine face detection, which can then be calculated radiation energy (Auras). CNN has several types of layers that were used. The convolution operation imposed on the function s(t) with weights (or often called kernels) w(t), $x*w$, is defined mathematically in (1).

$$s(t) = (x * w)\,(t) \tag{1}$$

The s(t) function gives a single output in the form of a feature map. The first argument is input which is x and the second argument is w as kernel or filter. If you see the input as a two-dimensional image, you can say t is a pixel and replace it with i and j. Therefore, the operation for convolution to inputs with more than one dimension can be written as (2).

$$S\,(i,j)\ =\ (K*I)\,(i,j)\ = \Sigma m\,\Sigma n\,(i+m,j+n)\ *K\,(m,n) \tag{2}$$

based on the (1) and (2) above, the basic calculation is in the convolution operation, where i and j are the pixel of the image. Meanwhile, m and n are the dimensions of a kernel. These calculations are cumulative and appear when K is the kernel, then I is the input. As an alternative, the convolution operation can be called a matrix multiplication between the input image and the kernel where the output was calculated by dot product. After the face was detected, the maximum facial temperature data would be extracted. After that, the system displayed the facial temperature that was successfully extracted. Then, by programming stefan boltman's concept/formula, the aura detection process was carried out. The workflow of the system can be seen in Figure 2. In this design, a thermal camera was utilized to see the energy wave radiation emitted by the body (aura), as supported by stefan boltman's concept, namely (3).

$$P = e\,\sigma A \tag{3}$$

P=the average radiant energy emitted; e=emissivity; σ=Stefan Boltman's constant=5.67 x 10^{-} (W/m^2K^4); A=the surface area of the object; T=the temperature of the object (^{0}C) and the max plank formula, namely (4).

$$E = 1{,}24.10 - 6/\lambda \tag{4}$$

E=radiant energy; λ=wave

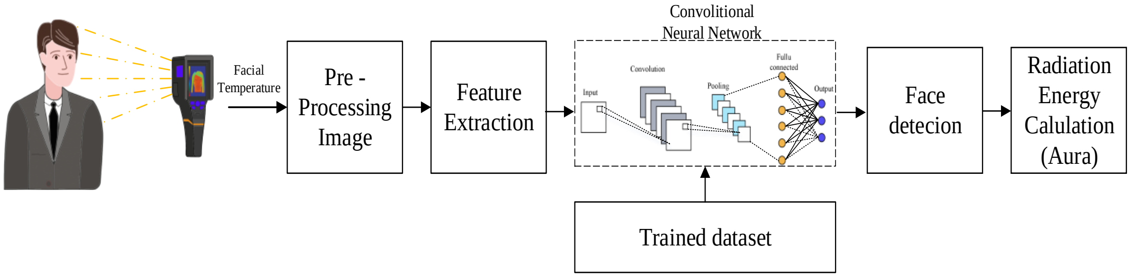

Figure 1. The design of aura detection based on the convolution neural network

2.2. Pre-processing data

The thermal image used had a resolution of 220×90 (10,800 pixels). The thermal image was taken using a UTi thermal camera circling the subject's face. Images provided by this data set have not been annotated. The dataset was further divided into training set and test set. The training set consisted of 400 images, while the test set consisted of 80 images. The illustration of preprocessing can be seen in Figure 2.

Based on the explanation on Figure 2, it is necessary to annotate or label the dataset before it was used as input, so that the machine can easily understand the pattern of the image. Furthermore, the training data augmentation is a deep learning process, which requires more data compared to the other types of machine learning. Through data augmentation, new data can be artificially created from the existing training data. Horizontal flip, image scaling, and image rotation were implemented in the training set. After the augmentation, the training set was 1,780 images, while the testing set was 108 images. In this case, tensor flow requires a label file to map each label used to an integer value. This map label was used in the model training and detection processes. Creation of tensorflow record files, the annotated image that has been created is converted to the tensorflow records (TFRecord) file format. TF record is a file format for storing data provided by tensorflow. Creation of region of interest (ROI) detection model was included in this study, where the detection was used on the face so that the temperature detection process could be carried out more quickly and easily without direct contact. The facial ROI detection model was created by training a pre-trained SSD-model. The model was retrained to be able to detect faces in thermal images using the tensorflow object detection API. Furthermore, the protobuf file was also used to configure the training and evaluation processes.

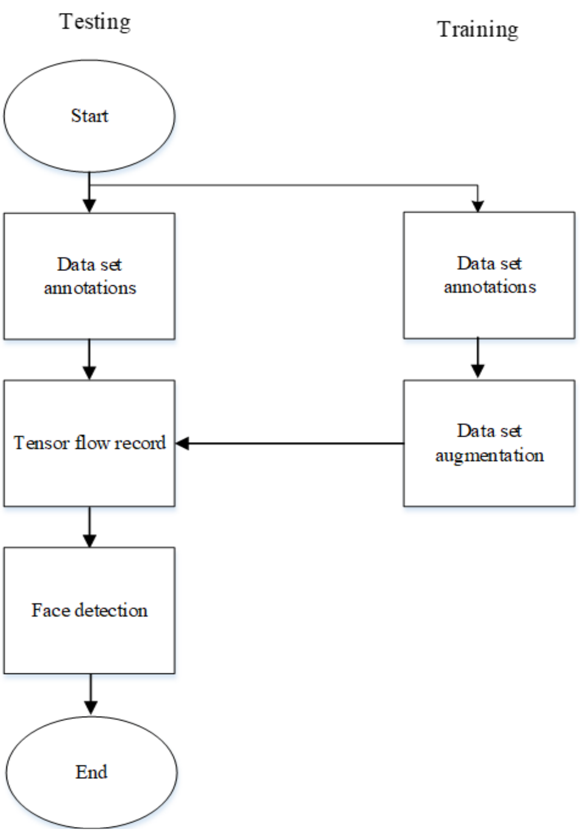

Figure 2. Preprocessing data of aura detection

3. RESULTS AND DISCUSSION

This study aimed to create a diagnostic tool for people with mental disorders by detecting auras using light spectrum analysis. The results of the research that have been achieved were the results of module design in the form of a human body aura tool module in the form of electromagnetic waves. Furthermore, the tool has been tried on during the data measurement to see the performance of the sensor used.

3.1. Acquisition of prepossessing data

The results of measuring the temperature of each person showed a different range. Therefore, the reference data that can be processed are also different from one data to another. Hence, before inputting the image data into data preprocessing, data obtained from a thermal camera image with a pixel size of 220×90 was first carried out. Furthermore, the contours/points of the image were determined to determine RGB so that temperatures can be obtained by determining the maximum and minimum temperatures. In this case, a certain temperature was obtained based on the contour we wanted. In collecting this data, the image contour was on the forehead/head contour. Figure 3 shows the process of taking image contours for preprocessing data. In Figure 4, image data collection on one of the respondents and the determination of the image contour point obtained RGB of 232,56,88 at a temperature of 34.45 ^{0}C with an average color of intense red. Furthermore, the same procedure can be done with the other images. In this research, contour data collection was carried out on 1 image for 11 respondents.

Figure 4 is an aura report from one of the respondents (RO1) taken from the aura camera as a gold standard. There is one main color or the average color of the aura, which is intense red. This color reflects the main characteristics of a person's personality or mental health. The images from aura camera were used as the gold standard for testing system performance.

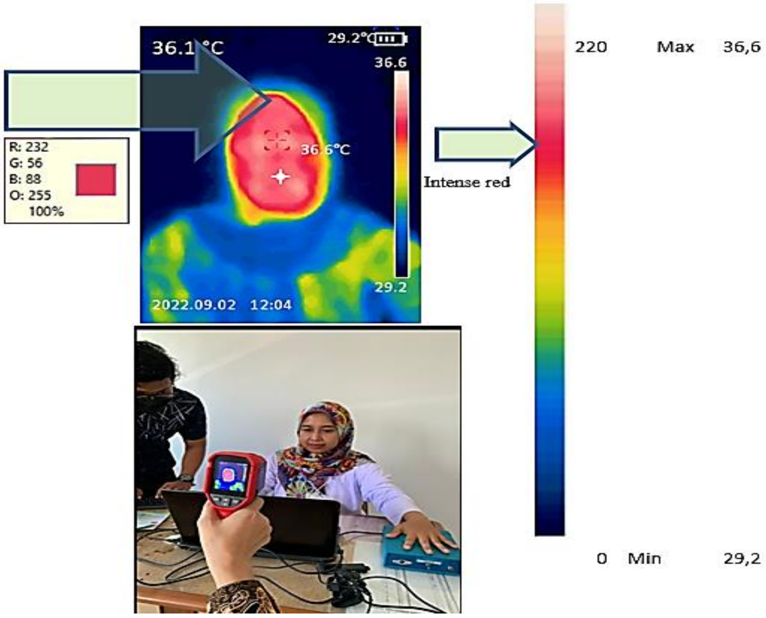

Figure 3. Taking the image of respondent RO1 from the thermal camera

Figure 4. Taking the image of respondent RO1 from aura camera-gold standard

3.2. Performance test of thermal camera

Retrieval of aura measurement data in the form of electromagnetic wave energy emitted from the human body, was carried out directly on 11 respondents to test the performance of electromagnetic wave sensors in detecting. The following is how to measure the energy field 6 times for each of 11 respondents aged between 30 and 70 years using the aura detection module that has been made described in Figure 3. To obtain the amount of energy emitted from the body (aura), data processing was carried out using the application of the concept of stefan boltman's law as in (1) above and plank's law as in (2). Based on the data processing, the following results were obtained. Table 1 shows the result of the measurement of electromagnetic waves energy emitted from the body (Aura) using the concept proposed by stefan boltman's law with temperature parameters using a thermal camera. In this case, through the combination of Plank's law concept, the wavelength can be determined.

Table 1. Measurement results of temperature, energy field and wavelength

No.	Respondent	Temp ^{0}C	Energy (eV)	Wavelength (λ)
1.	R01	34.75	4.73	2.62E-07
2.	R02	31.63	4.54	2.73E-07
3.	R03	32.73	4.61	2.69E-07
4.	R04	33.32	4.64	2.67E-07
5.	R05	32.82	4.61	2.69E-07
6.	R06	32.32	4.58	2.71E-07
7	R07	32.34	4.58	2.71E-07
8	R08	32.59	4.60	2.70E-07
9	R09	32.75	4.61	2.69E-07
10	R10	33.79	4.67	2.65E-07
11	R11	33.42	4.67	2.67E-07

In order to more clearly describe the relationship between temperature parameters and those emitted from the body, the following Figure 5 shows the graph of temperature and energy. Based on Figure 6, the energy emitted by the body is directly proportional to the temperature emitted by the body. body. The following is a graphical image of the wavelengths of the 11 respondents as described in Figure 5.

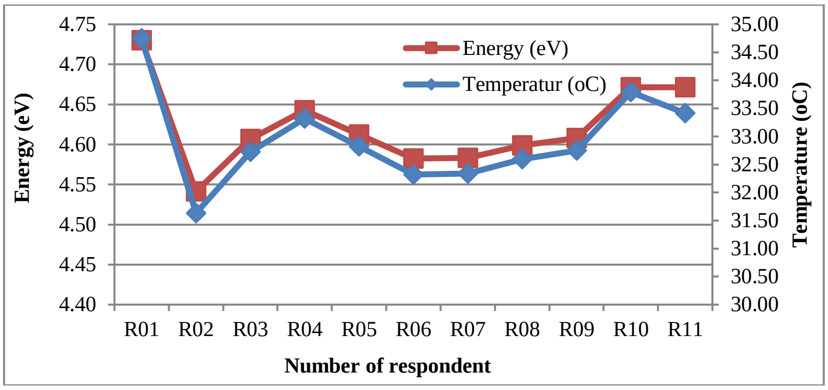

Figure 5. Graph of temperature and energy measurement

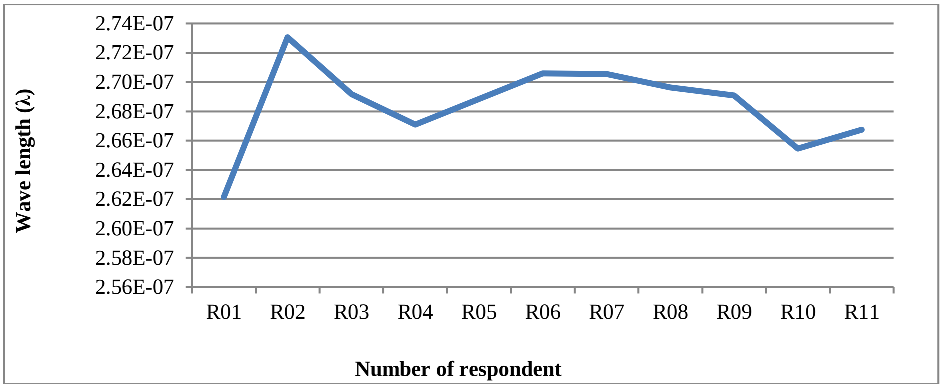

Figure 6. Graph of the wavelengths emitted from a body

3.3. Testing for performance system

System testing was carried out to evaluate the performance of CNN system algorithms for aura detection in terms of color (main color or average color). This was done by calculating the confusion matrix which can represent predictions and actual conditions from gold standard data. In measuring performance on the confusion matrix, there were several performance metrics that are commonly and frequently used, those are detectability, selectivity and accuracy, precision, as well as sensitivity. Furthermore, Table 2 presents the result of the confusion matrix to determine system performance in image processing from a thermal camera.

Table 2. Performance system in aura color detection from thermal camera images

No.	Respondent	Thermal camera	System	Result
1.	R01	Intense red	Intense red	TP
2.	R02	Orange	Green yellow	FN
3.	R03	Golden orange	Golden orange	TP
4.	R04	Orange	Orange	TP
5	R05	Golden	Golden	TP
6	R06	Yellow	Green	FP
7	R07	Red yellow	Green yellow	FP
8	R08	Green yellow	Green yellow	TP
9	R09	Pink	Pink	TP
10	R10	Golden orange	Golden orange	TP
11	R11	Intense red	Intense red	TP

On the matrices above, we obtained detectability=TP/(TP+FP)=8/(8+2)=0.80=80% and selectivity=TP/(TP+FN)=8/(8+1)=0.88=88.88%. Furthermore, the aura camera is the gold standard and was employed to see the performance of the testing system, as shown in Table 3.

Table 3. Aura color detection system performance with aura camera as gold standard

No.	Respondent	System	Gold standart	Result
1.	R01	Intense red	Intense red	TP
2.	R02	Green yellow	Blue	FP
3.	R03	Golden orange	Golden orange	TP
4.	R04	Orange	Red	FP
5.	R05	Golden	Golden	TP
6.	R06	Green	Aqua marine	FP
7	R07	Green yellow	Green yellow	TP
8	R08	Green yellow	Green yellow	TP
9	R09	Pink	Orange	FN
10	R10	Golgen orange	Golden orange	TP
11	R11	Intense red	Intense red	TP

Based on Table 3, we obtained precision=(TP)/(TP+FP)=(7)/(7+3)=0.70=70%; sensitivity=(TP)/TP+FN)=(7)/(7+1)=0.875=87.5%; and accuracy=(TP+TN)/(TP+FP+FN+TN)=(7+0)/(7+3+1+0)=0.636=63.63%. Furthermore, the testing system performance was determined by using the aura camera as the gold standard. According to the results obtained, it is considered the CNN-SSD method for aura detection with thermal camera images in this study needs to be improved because the resolution was not high enough. Aura detection using thermal aura has never been done by researchers before. The design of the aura detection system in this study will make it easier for psychiatrists and psychologists to help make a diagnosis.

4. CONCLUSION

The aim of this research is to create a mental/psychological health diagnosis tool by detecting auras using a thermal camera from facial objects. After completing the data preprocessing, training and system testing, it can be concluded that the CNN-SSD method can be implemented properly to detect auras in accordance with the purpose of this study, which is to design a system to detect aura emitted by the body through image analysis of thermal camera images. The results obtained from this study are that aura, which can be described as energy of light waves emitted from the body, can be detected with a thermal camera by analyzing the spectrum of light and temperature. The energy emitted by the body is directly proportional to the temperature emitted by the body. Furthermore, the results of the wavelength of light emitted by 11 respondents were 2.56.10-7 m-2.74.10-7 m. Based on the results of the wavelength range; the aura emitted by the body is an electromagnetic wave (infra red) that can be detected using thermal images. System testing is used to evaluate the performance of CNN system algorithms for aura detection in terms of color (main color or average color). This is done by calculating the confusion matrix which can represent predictions and actual conditions from gold standard data. The results obtained are detectability by 80%; selectivity by 88.88%; precision by 70%; sensitivity by 87.5%; and accuraracy by 63.63%. This system can be developed in further research by improving the accuracy. This can be done by increasing the resolution of the camera used and the number of input images and test data. Furthermore, in order to improve the design of this aura detection and perfect it into a diagnostic tool, it is necessary to combine electrophotonic sensors and cameras as well as a data base for psychological decisions.

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