Detection of Throat Disorders Based on Thermal Image Using Digital Image Processing Methods

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Abstract. Throat disorders are often considered trivial for some people, but if they are not treated immediately, they can result in more severe conditions and require a longer time to cure this disorder. Objective, safe and comfortable detection of throat disorders is important because throat disorders are an indication of inflammation which, if not treated immediately, can have negative consequences. This research aims to detect throat disorders based on thermal images using digital image processing methods. Image capture was carried out with the same color pallete range on the camera, namely 33°C-38°C. The image obtained is then cropped in the ROI, then the image is threshold with a gray degree of 190. Pixels that have a gray degree above 190 are converted to white, while those below the threshold are converted to black. Next, the percentage of each white and black area is calculated compared to the total ROI area. If the percentage of white area is greater than 38% compared to the area of the throat then it is identified as having a throat disorder, whereas if the percentage of white is less than 38% then it is identified as not having a throat disorder. The detection program created provides an accuracy of 87.5% on sample data of 8 test data.

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INTRODUCTION

Throat disorders are often considered trivial for some people, but if they are not treated immediately they can result in more severe conditions and require a longer time to cure this disorder. Objective, safe and comfortable detection of throat disorders is important because throat disorders are an indication of inflammation which, if not treated immediately, can have negative consequences. Inflammation of the throat can cause the temperature around the site of inflammation to become higher. One of the efforts made to detect body temperature non-invasively is using a thermo gun. However, thermo gun can only be used to measure body temperature in a relatively narrow area and need to be done at a very close distance, namely less than one centimeter. It is important to identify symptoms of the disorder as early as possible to prevent the condition from getting worse (Cristina, 2020). Thermal Camera is a tool to determine the temperature distribution of an object by using FPA (focal plane array) technology as a detector that will receive infrared signals. Thermal cameras are able to record objects in image form, so that all areas of the object that can be recorded by the camera can have their temperature measured at the same time, temperature variations emitted from the object are then converted into images that can be interpreted by experts. Thermal Cameras have been used for various purposes, including in medical diagnostics or clinical trials. The use of thermal cameras in the medical field includes detection breast cancer, determining wound status, and diagnosing deep vein thrombosis as well as diagnosing various other diseases (Seydi, 2017). In carrying out the correct interpretation of images, a quantitative approach is needed which can be obtained through digital image processing (Sumriddetchkajorn, 2016). The problem to be solved in this research is how to detect throat disorders safely and objectively and to find out the performance of methods for detecting throat disorders. The aim of this research is to detect throat disorders based on thermal images using digital image processing methods and to determine the performance of detecting throat disorders based on thermal images using digital image processing methods. This research is very important as an effort to detect throat disorders objectively, safely and comfortably.

RESEARCH METHODOLOGY

The throat anatomically consists of the pharynx and larynx, superiorly starting at the base of the skull and nasopharynx, extending to the esophageal inlet and most proximally to the trachea. Throat disorders can mean irritation, itching, burning, or pain in the throat area. Additionally, from the patient's perspective, throat may refer to the entire pharynx and larynx, the soft tissues of the neck, or one localized area. Throat disorders can be a presenting symptom of a variety of different diagnoses. Most throat disorders are caused by viruses (Anthony, 2004).

One of the characteristics of infrared is that it is invisible (Wrotniak, 2020). Like electromagnetic waves, infrared waves have reflection, absorption and transmission properties that depend on the material they are exposed to. Infrared waves can be easily absorbed by various materials (Jewett, 2004). The radiation emitted by an object at room temperature is mostly in the infrared region. This shows that objects will easily emit infrared radiation so that using infrared thermography techniques is easier (Adhi, 2013).

Infrared thermography is a non-invasive and non-ionizing imaging technique for recording body surface temperature (Kevin Howell, 2020). Temperature is an excellent indicator of health, because changes of just a few degrees in the skin can be used as an indicator of possible disease (Jones, 1998). Thermal cameras are passive sensors that capture infrared radiation emitted by all objects with temperatures above absolute zero and describe the emission of infrared radiation (Rikke, 2014). The fact that radiation is a function of an object's surface temperature allows cameras to calculate and display this temperature. However, radiation measured with a camera not only depends on the temperature of the object, but is also a function of emissivity. Radiation also comes from the environment and is reflected by objects.

Some parameters and factors that influence images recorded with modern infrared camera systems are object emissivity, camera distance to object, object size, relative humidity, environmental temperature, external optical transmission, temperature range (ΔT), temperature range + level, color palette, wavelength range of the camera, observation angle, temperature dependence of emissivity, optical properties of material between the object and camera, use of filters, thermal reflection, wind speed, solar load, shadow effect of nearby objects, humidity, and thermal properties of the object (Vollmer, 2010).

In practical measurements with an infrared camera, the object emits radiation towards the camera where the object is focused on the detector and measured quantitatively. Infrared radiation detectors usually only within a limited bandwidth of the infrared spectrum, i.e. they mostly perform measurements in the two main IR bands: MWIR and

LWIR. Systems that work in the NIR are tailored for specific applications only because the atmosphere tends to be opaque for that spectrum. The final result of the infrared system is a surface temperature map. Two-dimensional images are achieved by scanning mechanisms consisting of oscillating mirrors, or rotating refracting elements (such as prisms), which allow scanning of objects in both vertical and horizontal directions. Currently, new systems are based on staring focal plane array (FPA) technology. The overall performance of an IR imaging system is evaluated conventionally in terms of the useful and accurate information that can be obtained per unit of time, with several influencing parameters namely: thermal sensitivity or equivalent random noise level, frame rate or number of images per unit time, image resolution or the number of independent measurement data points on which the image is composed, the intensity resolution or the number of intensity levels that allow for small temperature differences. Thermal detectors convert the absorbed electromagnetic radiation into thermal energy which causes the temperature of the detector to rise. Then the electrical output of the thermal sensor is generated by a corresponding change in some physical property of the material (Meola, 2017).

This research was carried out based on systematic steps. At the data collection stage, the thermal sensor array image data is retrieved in digital form. Data collection was carried out at the Medical Instrumentation Laboratory, Department of Physics, Faculty of Science and Technology, Universitas Airlangga. The data collected is in the form of throat image data. The distance between the object and the camera is one meter then crop to get the region of interest only in the neck area. Data collection was carried out in the same room with the characteristics of a closed room, relatively close together so that the effects of shadows of nearby objects, thermal reflections, optical properties of the material between objects, and humidity had relatively the same values. The thermal camera used is a Caterpillar S60 thermal camera with White Hot mode, and the temperature range in the color palette is the same, namely 33°C to 38°C. In White Hot mode, objects that have a higher temperature are displayed in white and objects that have a lower temperature are displayed in black. This mode can also be used for detailed observations but keeps the display simple. The data obtained was divided into two groups, namely throat data that had no interference and throat data that contained interference.

The initial stage before image processing is determining good quality image data based on images captured by a thermal camera. Then, after sorting, the next stage is to group the data, namely images taken from people who have throat disorders (group A) and images taken from people who do not have throat disorders (group B). Next, the region of interest is selected so that an image is obtained only of the throat. Next, a threshold is carried out so that an image mapping is obtained that corresponds to the specified threshold value. then analyze and compare the suitability of the mapping results between throats that have disorders and those that do not have disorders based on the threshold values used. The results of mapping the throat that has problems are then used as a reference for analyzing test data.

The first stage in the software design scheme is data input from the thermal image. The next stage is cropping to obtain the Region of Interest (ROI) area. Next, the image in the throat area will be thresholded so that areas with gray levels above the threshold and those below the threshold are detected. Then the area that has a gray level above the threshold is compared with the total area of the ROI to determine whether there is a throat disorder.

RESULT AND DISCUSSION

This section contains several explanations regarding the detection of throat disorders from the results of thermal images of the neck using digital image processing. In this study, white hot mode was used because white hot mode is displayed in grey level form, where the gray level in the image is linear with temperature. When taking pictures, the minimum to maximum temperature range used on the camera is 33°C to 38°C. So by using greyscale equation we can find out the relationship between the degree of gray and the temperature to be sought.

$$greyscale = (T^{o}C - 30^{o}C)(255/10)$$

Throat image data was taken from 16 participants, namely 8 participants complained of experiencing problems with their throats, and 8 participants reported no problems at all with their throats. Data collection was carried out at the same distance, namely one meter, in the same place and at almost the same time. The Palatte color used has a temperature range from 33°C to 38°C, with a temperature of 33°C represented by black while a temperature of 38°C is represented by white, while temperatures between 33°C-38°C are represented by degrees of gray between 0-255. An example of a thermal image captured is shown in FIGURE 1.

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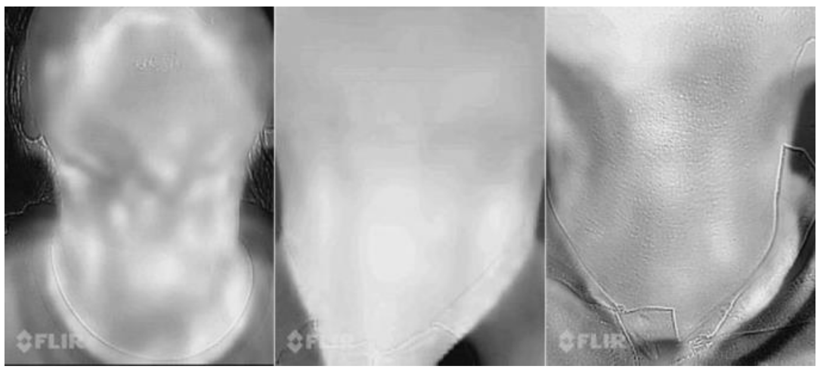
(a)



(b)

FIGURE 1. Thermal images of the throats of 3 participants who (a) reported no problems with their throats, (b) reported problems with their throats. .

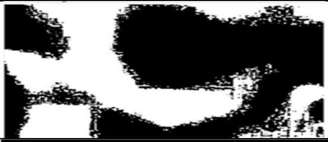
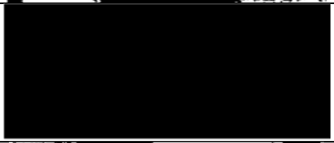
TABLE 1. Questionnaire about perceived symptoms

Object	Feeling itchy/uncomfortable in the area throat	Feeling pain in the throat area	Feeling pain/difficulty swallowing	Cough	Hoarseness	Burning feeling in the throat area
1	–	–	–	–	–	–
2	√	–	–	√		
3	–	–	–	–	–	–
4	–	–	–	–	–	–
5	√	√	√	√	√	–
6	√	√	–	–	–	–
7	–	–	–	–	–	–
8	–	√	√	√	√	–

In terms of medical diagnosis, a person is said to have a throat problem even if they only experience one of the symptoms as in TABLE 1. And what the test taker filled in on the questionnaire was in accordance with the results of the diagnosis using the software, except for the 6th person who was identified as having a throat problem according to the software. questionnaire did not experience throat problems. This difference in results could be caused by environmental influences.

The preprocessing window is used to rotate, crop and scale images. Rotation is carried out so that the position of the object in the image can be upright so that data processing can be more accurate. then carry out the crop process in the crop menu to get the region of interest (ROI), namely the neck area. The image cropping process functions to obtain accurate information from the image by reducing unwanted components. Meanwhile, scale is used to adjust the image so that it has the desired size.

TABLE 2. Conversion results from greyscale images to binary images

Object	Binary Image	Percentage of White Color	Percentage of Black Color	Results
1.		26 %	74 %	no throat problems
2.		44%	56%	suffer from throat problems
3.		16%	84%	no throat problems
4.		23 %	77%	no throat problems
5.		44%	56%	suffer from throat problems
6.		49 %	51 %	suffer from throat problems
7.		0%	100%	no throat problems
8.		81 %	19%	suffer from throat problems

Users can run this program by pressing the load image button, then the selected image will be displayed. If the image is still not upright, making it difficult for the cropping process later, then we can rotate it according to our needs by setting it in the rotate column. We can crop the left, right, top and bottom of the image using the crop column.

Users can adjust the part they want to cut so that they only get the neck. And if you want to make the image size uniform, you can use the scale column. The conversion results from greyscale images to binary images are shown in TABLE 2.

The Processing window is used to further manage the image after the preprocessing stage. In the processing window there is a threshold column, which functions to convert the greyscale image into a binary image. Each pixel will automatically be matched to the existing threshold limit. If a pixel has a degree of gray above the threshold limit, then the color of that pixel will be converted to white. Meanwhile, if in a pixel, the gray degree value is less than the entered threshold limit, then in that pixel the color will be converted to black. After that, enter the limit value in the parameter set column. The limit in this case shows the minimum percentage of the area that is white, meaning if the white area is larger than the limit, meaning the throat is experiencing problems. If the white area is less than the limit, then the throat is identified as having no problems. After creating the software, the next step is to determine the threshold and limits for data testing.

Threshold determination is carried out using a trial error system to find the difference in area between the throat which is disturbed and which is not disturbed. Threshold search is carried out using software. The results found quite a visible difference at the threshold value of 190 or the equivalent of a temperature of 36.7°C. By using 3 normal throat data, it was found that the percentage of throat area that had a temperature above the threshold was 29%, 19%, and 37 %. Meanwhile, in the image of the throat that is disturbed, the percentage of areas that have a temperature above the threshold is 42%, 61%, and 39%. So a limit can be set at 38%, which means that if after thresholding, the white throat image is less than 38%, then the throat is identified as having no problems. And if the area of the white throat is more than 38% then the throat is identified as having a problem.

CONCLUSION

Throat disorder detection based on thermal images has been carried out using digital image processing. Image capture was carried out with the same color range on the camera, namely 33°C-38°C. The image obtained is then cropped to match the expected Region Of Interest. Next, threshold is carried out on the grey scale image with a threshold value of 190. Pixels that have a gray degree above 190 are converted to white, while those below the threshold are converted to black. Next, the percentage of each white and black area is calculated compared to the total area of the Region of Interest. If the percentage of the white area is greater than 38% compared to the area of the throat then it is identified as having a throat disorder, whereas if the percentage of white is less than 38% then it is identified as not having a throat disorder. Based on the detection that has been carried out, an accuracy rate of 87.5% was obtained using 8 test data.

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