Convolutional Neural Network Implementation in Detection of Approach Lights Lighting Condition

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Abstract. Approach Light is an aircraft visual landing aid in a certain form of lighting to assist pilots when landing an aircraft in the dark or bad weather (below average visibility) in order to land safely. With the important role of the Approach Light in the aircraft landing process, the ON and OFF lighting condition of the Approach Light is necessary to be monitored. The design of this research uses artificial intelligence technology that can determine whether the lights on the Approach Light are in ON or OFF condition using camera's image capture. To find out whether the lights are on or not, Convolutional Neural Network is implemented in this monitoring technique to process image classification oh the lights. It can also send evidence in the form of captured images classified on the website as evidence of monitoring results that can be confirmed by technicians if any inappropriate classification results occurred. The results showed that the classification results for each brightness step obtained average values of 95% in accuracy, 90% in prediction precision, and 98% in prediction sensitivity. According to this good result of values, it is expected to give positive contribution for the technicians so that flight operations disruption can be minimized.

Keywords: Approach Lights · Image Processing · Convolutional Neural Network · Artificial Intelligence · Monitoring

1 Introduction

Approach Light is one of the visual aircraft landing aids in the form of lighting or commonly called AFL (Airfield Lighting) which serves to assist pilots when landing (landing) when it gets dark or when the weather is bad (visibility is below average) so that can land safely. It consists of several bars and each one of its bars consists of several lamps arranged in parallel according to the specified configuration. Information and visual cues in Approach Light are applied by adjusting the configuration, color, and light intensity of the lights on the Approach Light (Fig. 1).

Pilots not only see the instruments in the cockpit of the aircraft when landing, but also see the terrain conditions outside the aircraft with the help of visual lighting from the AFL, one of which is the Approach Light to help pilots see the approach path to the runway in visibility. Low in order to synchronize between the instrument and visuals.

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Fig. 1. Approach Light in one bar

Therefore, it is necessary to keep the lights on or not on the Approach Light to maintain visibility and configuration at night or in bad weather in accordance with established regulations.

It is important to know whether this light is on or not because it can affect the pilot's vision and the smooth running of the flight. Factors that affect the approach light not turning on include the absence of power from the CCR (Constant Current Regulator), broken primary or secondary cables or open circuits, damaged series transformers, damaged lamps due to short circuits, and ages of lamp is too old.

The Approach Light is far from the technician's place on standby, namely at MPH (Main Power House). The technician must wait for a complaint or report from the pilot to find out the condition of the Approach Light whether there are lights that are off or a collapsed support pole that can affect the pilot's visibility when landing. A temporary solution that can be done by technicians is to carry out periodic checks or patrol the field to determine the condition of the Approach Light whether there are obstacles or not, and also to minimize complaints from pilots regarding AFL facilities to ATC.

To support the operational reliability of the Approach Light, it is necessary to do active facility preparation, namely by checking whether the lights on the Approach Light are on or not. With the problems faced by technicians, the authors are compelled to try to solve the problem with alternative methods or other options in monitoring the condition of the Approach Light lamp from far away. Therefore the author will make an **Implementation of Convolutional Neural Network on Light Condition Detection of Approach Lights**.

2 Research Methods

Based on the block diagram above, it can be explained that the camera will capture images of the lighting conditions on the Approach Light. In this study, the test was carried out on a mockup approach light. The approach light mockup that will be made by the author consists of several components, namely the Tj-399 Lamp as an Approach Light, Selector Switch as a switch to select the desired brightness level, Resistor to determine the resistance value used to produce a certain brightness level, buck converter to limit the voltage that enters the lamp and the ON/OFF switch to determine the condition of the lamp as a simulation of the Approach Light. The results of the images captured

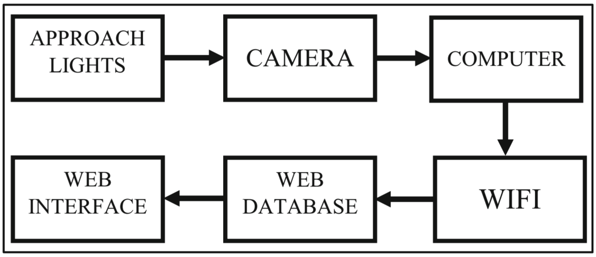

Fig. 2. Block Diagram of System Works

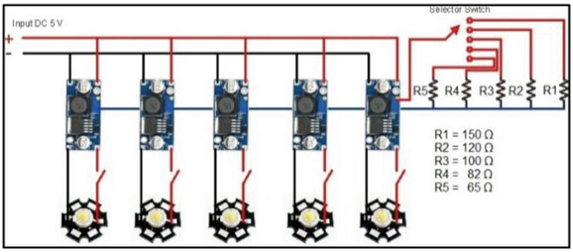

Fig. 3. Mockup Approach Light Wiring Diagram

by the camera will be processed and classified by the program on the computer. The classification results will be sent and displayed on a website page using a wifi network. On the website page, there is a notification of the condition of the light on the Approach Light and also a history in the form of a database to store data from the classification results obtained previously (Figs. 2 and 3).

The picture above is a wiring diagram of an Approach Light mockup. In the wiring diagram, it is explained that the input voltage of 5 VDC will supply the lights by passing through the buck converter, switch, and selector switch. In this mockup, the author uses a selector switch with 1 input and 5 outputs in order to resemble the CCR (constant current regulator) function which can adjust the brightness level (brightness step) on the Approach Light (Fig. 4).

The way this system works is to use the camera as a medium for capturing objects and the Approach Light condition as the object captured by the camera. Catching Approach Light conditions in real time or directly. The image captured by the Approach Light condition is used as input and then the image results are processed to be classified.

The processed image is then segmented in color by changing the original color of the image to grayscale or black and white. Then from the black-and-white image, the light from the lamp can be determined by the edge or the outermost side of the light emitted by the lamp using the thresholding function. After the edge of the light is determined, the image is filtered or filtered using the gaussian blur function and the carry edge detector to refine the image to make the classification process even easier. After the image is filtered, the program will look for the contours of the light in the image using the find contours function. When the contour of the light in the image has been found, the program will analyze the condition of the Approach Light in the image, whether it is on or not (Fig. 5).

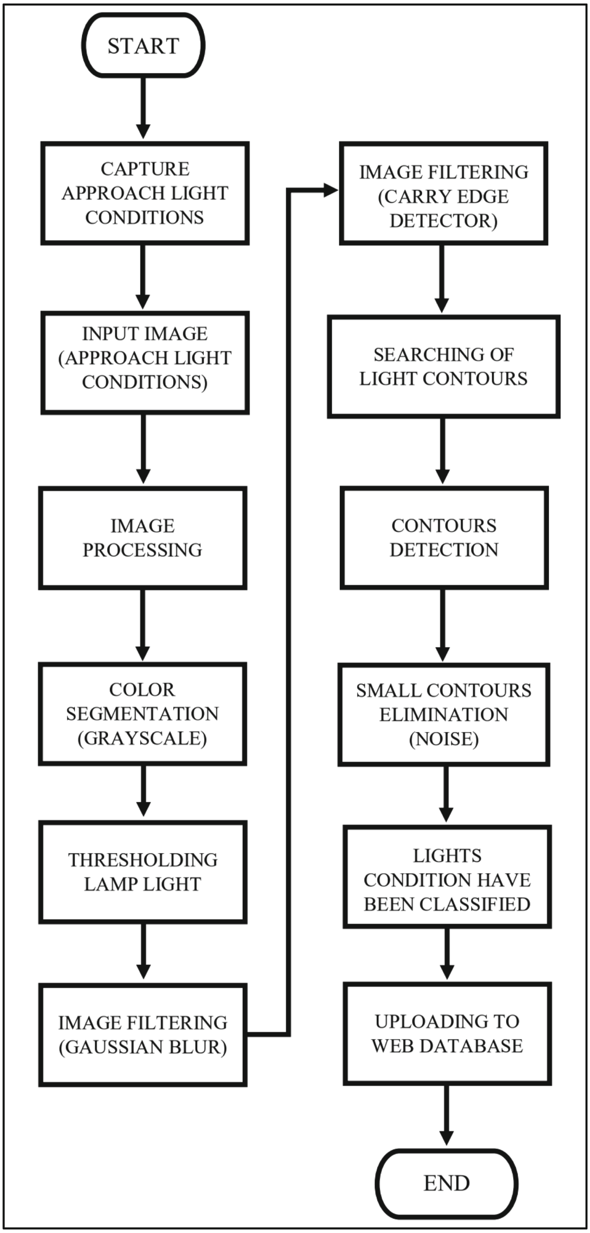

Fig. 4. Flowchart of Classification System Works

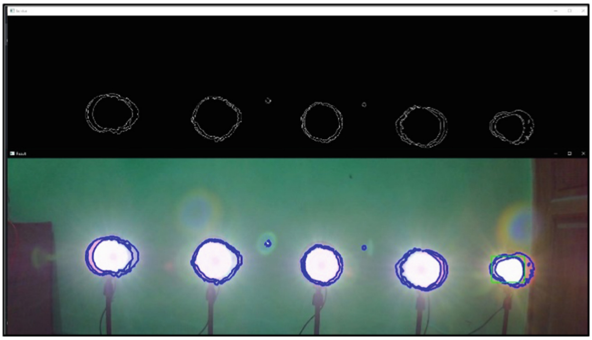

Fig. 5. Thresholding and Filtering Lights Condition

In order to improve accuracy in classifying the approaching light condition, the authors add a function to eliminate small contours that are considered as light reflections or noise that can interfere with the program during classification. If the image has been classified, the classification results will be sent to the website database to be monitored or monitored by technicians.

3 Testing Technique

3.1 Classification Program Test

The classification program of lights condition that the author made here is useful for giving orders starting from the camera that will take every condition of the light on the Approach Light, processing and classifying the results of the image, to sending the classification results to the website. The purpose of this test is to make sure the program code in the python language that the author wrote can run properly according to his task. The author's classification program is made to classify the captured images from the camera and divide them into two classes or two conditions, namely the condition of the lights on the Approach Light on and off.

The first classification program test procedure is to open the pycharm application, then run the classification program code. Make sure the camera is pointing at the five Approach Lights. Simulate a blackout on the Approach Light by turning off one of the lights. Then compare the results of the classification program with the actual reality.

3.2 Classification Result Display Test

The website that the author created here is useful for displaying the results of the classification of the condition of the Approach Light lamp, both on and off conditions. The purpose of this test is to ensure that the python program and the website program can be synchronized properly and as expected.

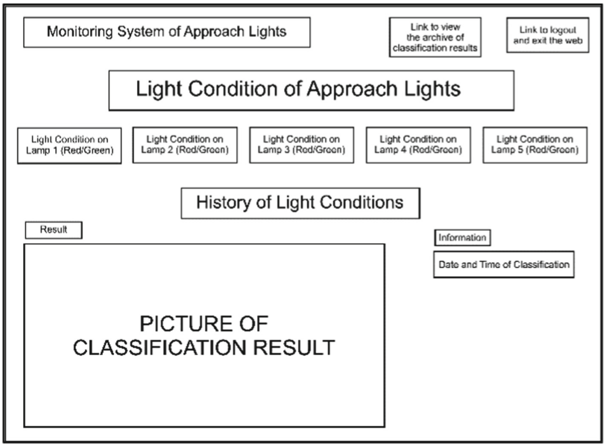

Fig. 6. Website Interface Layout

The display of the classification results is made for monitoring the condition of the Approach Light lamp from a distance just by looking at the website. This test is done by comparing the pages displayed on the website with the classification results obtained from the python program. The following is an image of the layout of the website page display according to the script code that has been designed. If the light is on, information on the approaching light condition will be conveyed as green, otherwise if the light is off or off it will be presented as red (Fig. 6).

The first procedure for testing the display of classification results is to run the localhost program on the laragon application. Open a browser and enter the localhost address, then login with the appropriate username and password. Then simulate the lights on on the Approach light by turning on all lights, turning off all lights, and turning lights off and on with variations.

4 Data Analysis Technique

Data analysis techniques is to analyze whether or not the performance of a classification model in this study can be seen from the performance measurement parameters, namely the level of accuracy, precision, and sensitivity. To calculate these factors, a matrix is needed, namely the confusion matrix. The confusion matrix can be seen in the Table 1.

Table 1. Confusion Matrix Table

		Predicted Values	
		Positive	Negative
Actual Values	Positive	True Positive	False Positive
	Negative	False Negative	True Negative

From the confusion matrix table above, there are 2 variables when predicting events, namely positive and negative. The positive prediction in this study is when one of the Approach Light lights turns off (OFF). While the negative prediction here is when one of the Approach Light lights is on (ON).

There are outputs for each variable in actual conditions or actual events after classification, namely True Positive (TP), False Positive (FP), False Negative (FN), and True Negative (TN). All possible true events are Positive (P) and all possible true events are also Negative (N). This value can be used to measure the level of accuracy using the following equation:

$$Accuration = \frac{TP + TN}{P + N} \tag{1}$$

Accuracy is used as a measure of the accuracy of a model in doing classification. Meanwhile, to calculate the precision level of event prediction, the following equation can be used:

$$Prediction\,precision = \frac{TP}{TP + FP} \tag{2}$$

Precision describes how precise a model is when predicting positive events in a series of predictive activities. In addition to precision and accuracy, to be able to see more deeply the performance of a system, it can also be seen the sensitivity of the system (recall) to a class. Predictive sensitivity (recall) can be calculated using the following equation:

$$Prediction\,Sensitivity = \frac{TP}{TP + FN} \tag{3}$$

5 Research Result

This section discusses the results of testing and discussion of the system planning that has been made. The tests carried out here are testing the results of the classification program. This test is carried out to test the program on this monitoring system can classify the flame correctly or not. This test is carried out with the camera distance from the appropriate Approach Light lamp (all lights on the approach light are visible in the camera frame) which is 250 cm (Figs. 7 and 8).

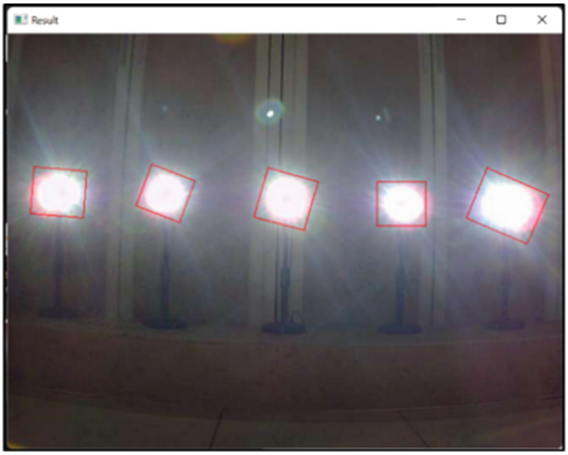

Fig. 7. Classification Result of 5 Lights ON Condition

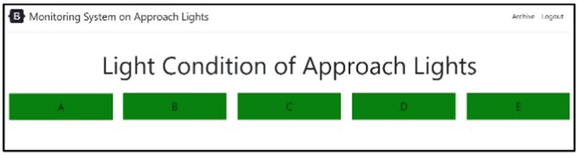

Fig. 8. Website Interface of 5 Lights ON Condition

The first test of the classification program of light conditions is testing of the condition of the Approach Light with all lights on. In the classification results, the lights are detected according to the same results as actually, namely all lights are on and none is off, meaning that the Approach Light is in normal condition. The classification results and the display displayed on the web page are the same. The five lights are displayed on the website page with the same results as the classification program, namely all lights are on (Fig. 9 and 10).

The next test of the classification program of lights conditions is testing the condition of the Approach Light with all lights off. In the classification results, the detected lights correspond to the same results as the fact that no lights are on or all lights are off. The classification results and the display displayed on the web page are the same. The five lights are displayed on the website page with the same results as the classification program, namely all lights are off (Fig. 11 and 12).

The next test of the classification program of light conditions is testing the condition of the Approach Light with three lights off. In the classification results, the detected lights correspond to the same results as in reality, namely two lights are on and three lights are off. The classification results and the display displayed on the web page are the same. The five lights are displayed on the website page with the same results as the classification program, namely 3 lights are off and 2 lights are on.

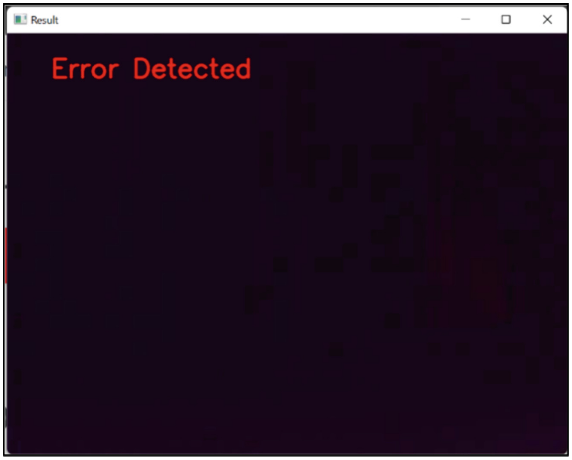

Fig. 9. Classification Result of 5 Lights OFF Condition

Fig. 10. Website Interface of 5 Lights OFF Condition

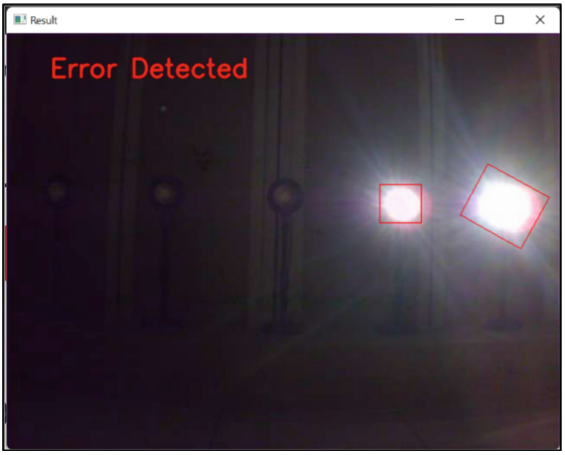

Fig. 11. Classification Result of 2 Lights ON and 3 Lights OFF Condition

Fig. 12. Website Interface of 2 Lights ON and 3 Lights OFF Condition

Table 2. Confusion Matrix of Classification Result

BRIGHTNESS STEP	ACTUAL		PREDICTION RESULT	
			ON	OFF
1	ON	30	26	4
	OFF	30	0	30
2	ON	30	26	4
	OFF	30	0	30
3	ON	30	27	3
	OFF	30	0	30
4	ON	30	29	1
	OFF	30	1	29
5	ON	30	28	2
	OFF	30	1	29

Based on the test results above, it can be concluded that the classification program works well because it can classify the on condition of the Approach Light lamp according to the existing reality, namely classifying the condition of the light on as light on and off condition as light off.

6 Accuracy Level Test

To measure the level of accuracy of a classification system, it is necessary to do calculations according to the equation formula. There are five levels of lamp brightness (brightness steps) that will be tested starting from the lowest brightness step (step 1) to the highest (step 5). Testing the level of accuracy using the confusion matrix is carried out at brightness steps 1 to 5 and the data results are obtained as shown in the Table 2.

From the test data obtained, the next step is to calculate the accuracy, prediction precision, and prediction sensitivity using Eqs. (1), (2), and (3). Accuracy calculation data on brightness steps 1 to 5 get different results at each step. From this test the authors get the results of the data collected in the Table 3 (Fig. 13).

Table 3. Accuracy Level of Classification Result

Brightness Step	Accuration	Prediction Precision	Prediction Sensitivity
1	93%	86%	100%
2	93%	86%	100%
3	95%	90%	100%
4	96%	96%	96%
5	95%	93%	96%

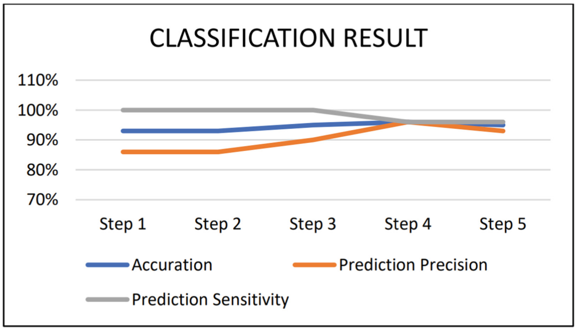

Fig. 13. Graph of Accuracy Level Result

From these data, the highest percentage of accuracy and precision prediction obtained when the program classifies Approach Light lamps is at brightness step 4, which is 96%. While the percentage of the highest level of predictive sensitivity is at brightness steps 1, 2, and 3, which is 100%.

In brightness steps 1 and 2, the percentage level of prediction precision is below 90%, which is 86%. This is because the light is dim which causes the camera to get less light from the lamp so that there are some tests in which the lights are actually on but are classified as lights off. At brightness steps 4 and 5 the predicted sensitivity level is 96%, this is because the light is too bright which causes the camera to receive light reflecting from one lamp to another so that there is an in-depth test that the lights are actually off but classified as lights on.

7 Conclusion

From the whole test of the author's research, the following conclusions can be drawn:

1. This system can determine whether the lights on the Approach Light are on or not using image capture by a classified camera and the results can be viewed remotely via website.
2. This system can assist technicians in checking the light condition of the Approach Light without having to go to the field directly and the technician also does not need to change the existing installation of the Approach Light because in the monitoring process it does not use sensors and only uses classified camera catches.

8 Discussion

The system performance is influenced by specification of the hardware and the program itself. Therefore, some consideration of higher specification in hardware and software is suggested to improve it, such as for the camera specification in order to capture images with better results to increase accuracy when classifying, the program itself to speed up the classification process, the feature added to be able to choose the Approach Light configuration to be monitored so there is no need to change the program again, and the combination of the monitoring system with a current sensor so that the information is more accurate. The expectation of better system performance will give better operation system in the airport operational condition and situation.

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