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Image Analysis of PLC Diagnosis System

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ABSTRACT

In day to day life, the study on image analysis is increasing very rapidly. Especially, for traffic light image and for PLC diagnosis in dynamic and static environments. Therefore, researchers contribute more of their interest towards image analysis as well as PLC diagnostics system. Hence, this paper mainly focused on detecting LED and how it is useful in diagnosis of PLC. Many papers regarding LED detection system is proposed but mostly papers work on small scale like traffic signal light detection, whereas this system works on multiple panels containing many PLC to detect each LED present in multiple PLC. The main aim of our paper is to detect the LED and display the status of LED accurately in the user interface based on the logic of the machine equipment .Thus, we have proposed a system with a hybrid approach.

Key words : Image Detection, Image Processing, LED Detection, PLC Diagnosis, Hybrid approach.

1. INTRODUCTION

For the past twenty years, PLC diagnosis has become extremely difficult due to proprietary software provided only by the PLC manufacturer. In the event of failure of this software, it is extremely difficult to analyze the real-time changes occurring in the PLC system. One of the best possible solution is to diagnose these real–time dynamic changes by Image Analysis on IO cards of these PLC. It offers an added advantage because the system is electrically isolated thereby eliminating the risks of unwanted modifications in the existing system. However, PLC diagnosis has posed challenges especially in analyzing the image and computer vision. These researches involve knowledge from disciplines like Pattern recognition, image processing, computer vision and machine learning. The result of the PLC diagnosis system depends on the characteristics, region of interest, RGB - HSV color transformation, position, feature extraction. In this approach, LED detection for PLC diagnosis system is implemented which is to be implemented using image processing techniques.

1.1 PLC

Programmable logic controller is the heart of all the machines in the industry that control the manufacturing process.[7] The logic is stored in the PLC with the help of which business functionalities of the machine are carried out. As PLC is heart of all machines it should be highly reliable and with help of this approach the PLC will be continuously monitored to make it work efficiently. Thus, it provides an added layer of real-time monitoring of PLC IOs in the event of failure.

Generally, the PLC diagnosis system is designed and executed in seven steps:

1. Image Acquisition
2. Image Resizing
3. Converting to Gray-Scale Images
4. De – Blurring
5. Binarization
6. Thresholding
7. Slicing

Figure 1a: PLC

Fig 1a shows a sample PLC which was used for testing.

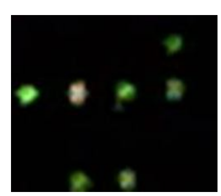


Figure 1b: Resized Image

Figure 1b shows a resized RGB color image of logic

$$h = \frac{d}{\sqrt{r^2+1}} \qquad (1)$$

Where h is the height of the resized image, d is the length of the image and r is the aspect ratio.

$$w = \frac{d}{\sqrt{\frac{1}{r}^2 + 1}} \quad (2)$$

Where w is the width of the resized image, d is the length of the image and r is the aspect ratio.

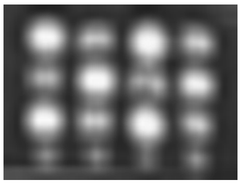


Figure 1c: Grayscale Image

Figure 1c shows a grayscale image of Figure 1a

$$\text{Grayscale image} = \frac{R+G+B}{3} \quad (3)$$

Where R is the Red pixel present in the image, G is the green pixel and B is the blue pixel.

Figure 1d: Binarized Image

Figure 1d shows the binarized image of Figure 1b after converting RGB image to grayscaled image and further binarising it by applying a threshold limit.

$$g(x,y) = \begin{cases} 1 & \text{if } f(x,y) \geq T \\ 0 & \text{otherwise} \end{cases} \quad (4)$$

Where T is the threshold limit

Figure 1e.: Sliced Image

Figure 1e shows a sliced part of a binarized image which is split into 16 equal parts.

In case of fault in any machine equipment will result in wrong LED status and such a fault should be notified as soon as possible so that it should not lead to any business loss. The purpose of this system is to detect LED status and produce the status in a user interface with less computational time and more accuracy. By less computational times denotes that it should display the LED in the user interface before the LED status gets refreshed in the PLC. A real time camera is used which continuously monitors the change n the PLC's and image processing techniques like image segmentation, slicing, thresholding, gray scaling, binarization, RGB-HSV color transformation and detecting region of interest has been used for the diagnosis of PLC. This system can detect images of multiple panels using a single camera and display the corresponding LED in the user interface accurately.

2. LITERATURE REVIEW

In this section, we describe certain research works implied by few researchers. [1] Michal Tarkowski, Przemyslaw Woznica and Lukasz Kulas proposed about an efficient algorithm for blinking LED detection dedicated to embedded systems equipped with high performance cameras. In this approach signal detection algorithm is used and the camera observes the scene in which the signal source can be present. Signal received by camera sensor's pixel is sampled with a frequency equal to camera FPS ratio. The camera image is stored in FIFO queue with length N. Further gray scaling and image enhancement techniques are applied. This approach proved to be efficient in reduction of computational time on changes occurring in the scene. [2] H. Chinthaka, N. Premachandra and Takaya Yamasato proposed about detection of LED traffic light by image processing for visible light communication system. In their approach they have used traffic light signal images. This signal will be processed using image processing using canny edge detection method to detect the outer pixels of the signal. Further Gaussian filter is used to smooth the image and the direction of each pixel is calculated using Sobel filter and non-maximum suppression. This approach is used to mainly detect traffic light by using circumscribing rectangles related to edge components of traffic light image and thus proved to be an efficient approach in detecting traffic light. [3] Yamini Gowardhan, Dr Ramchand Hablani proposed about detecting and analyzing traffic signs. Their process includes reading video, obtaining features by its color and shape. The images are stored in the database from which the features are extracted which is further used to calculate the Euclidian distance. The image having minimum distance is regarded as the best match and informed in the form of voice signal. [4] Ishan Kumar Shahu and Dr Ramchand Hablani proposed about detecting object in a video by calculating velocity of the object. In this process k-means algorithm has been used for object detection and noise removal mechanism has been used to detect false object. In this process less computational time is required as the velocity computation is used only for the detected object.[5] K Padmavathi and K Thangadurai proposed about plant leaves disease detection. Image Processing techniques like segmentation, preprocessing, clustering are used for detecting leaves diseases. In process of detecting infected leaves, color becomes an important aspect to know the intensity of disease. Median filtering method is used for image enhancement and segmentation for extraction for diseased portion is used mainly to classify infected leaves. As per their observation, RGB image has given better clarity and noise free image which was felt suitable for infected leaf detection than grayscale image. [6] Qingsong Zhu and Jiaming Mai proposed about a fast single haze removal using color attenuation prior technique. A linear model for modeling the scene depth of the hazy image has been created under this novel prior and by learning the parameters of the model with a supervised learning method with the help of which the depth information can be recovered. Using the hazy image they have estimated the transmission and have restored the scene radiation via atmospheric scattering model which helped them to remove the haze from the image. [7] Songxiao Cao and Xuanyin Wang in their paper researched about visual contour tracking based on inner-control model particle filter under noisy background. They have implemented inner-contour model to track contour object under normal background. Their main aim was to achieve robustness and effectiveness against complex background. Sobel edge detector has been used by them to detect edge information along normal line of contour. By sampling theinner part of normal line local color information to construct new normal line likelihood is obtained by them. The edge detection information, local color information and global color information were fused into new observation likelihood.

3. PROPOSED SYSTEM

The first step is capturing images of LED through a high resolution camera and store it in the localhost .This image will be enhanced by applying techniques like resizing, de-blurring, gray scaling, binarization. After image is enhanced splitting technique is used to split image into 16 or 32 parts depending upon LED panel and further the corresponding LED status will be stored in a JSON array which will be used to display the result in user interface.

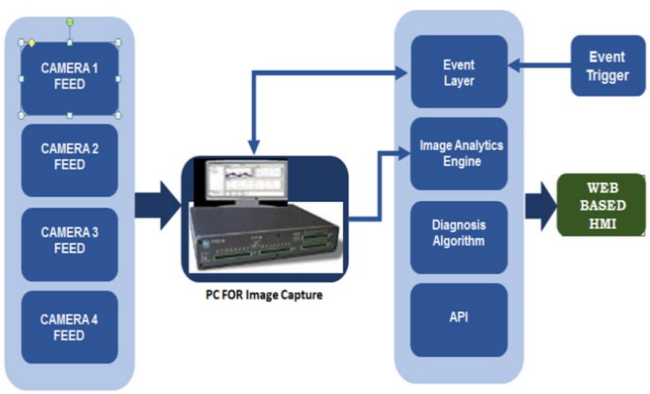


Figure 2: Proposed System

Figure 2 shows an architecture of the implementation

4. IMPLEMENTATION

The first step is to adjust the camera in such a way that it should not move or change its position. Now the camera should capture the images of PLC .We can adjust the camera in such a way that a master LED is considered as a reference point and numerical annotations in the PLC (Figure 1a) along with LED are clearly viewable. Once the image is captured, resizing (Figure 1b) of each grid should be done in such a way that grid covers whole 16 or 32 bit of LED.[10]Gray scaling (Figure 1c) is performed to convert colored RGB image to gray scaled image to get features of LED. After gray scaling is performed, an image that contains lot of noise and distortion is obtained. [9] De-blurring is used to remove the noise and distortion and it will bring clarity in the image.[11] Binarizing (Figure 1d) the gray scaled image will give us the white and black pixels in which the white pixels denote the presence of LED at that position. Now we will apply thresholding to image so that only pixel where concentration of LED is high will be displayed and the outer less concentrated part will be removed.[8]Once thresholding is applied now we will be having pixels as a dot which represents LED. Further we will slice the image (Figure 1e) into 16 parts as each part will contain the current LED status. The 16 LED statuses that are obtained currently will be stored in a separate JSON object. The JSON object notations are fetched and displayed according to the logic of the machine equipment through the user interface according to the respective numeric annotation which will define the healthiness of the PLC (Figure 5).If suppose the camera is not working or if the camera is shifted slightly by its current position or if any fault occurs in the system then there is a probability that wrong LED status will be displayed and logic will not work at that moment which will change the LED color from green to orange in the user interface denoting that system is not working appropriately (Figure 6) which denotes that PLC condition is unhealthy. At that moment the automatic running mode (Figure 3) in user interface will be switched to manual running mode and the operator has an option to manually feed the LED status in the screen and after submitting the button the LED statuses will be displayed in the user interface according to the appropriate logic of the equipment. The operator will try to resolve the problem occurred in the system. If he is unable to resolve the issue he will inform our organization and with the help of the present LED status and program code we will help them with the solution. If the fault is occurred in the camera position then the operator has an option to adjust the camera (Figure 4) using software that helps to adjust the cross reference to master LED and further the .manual mode will be switched to automatic mode (Figure 5) which will again result as healthy condition of PLC.

Figure 3: Manual Mode of Operation

Figure 3 shows the manual mode which will be used if the camera is not correctly positioned.

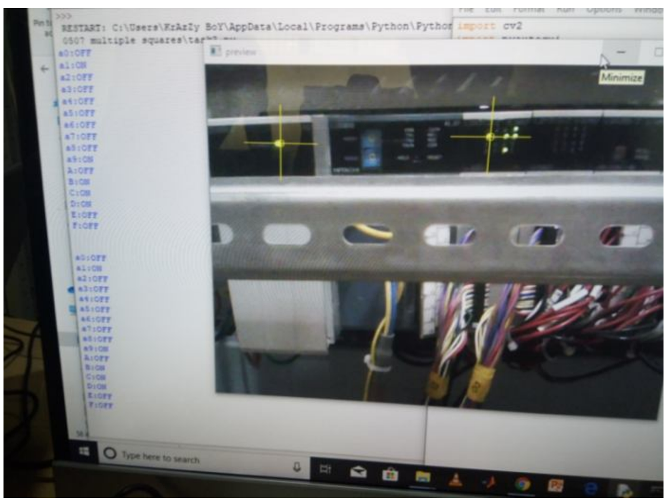


Figure 4: Camera Crosshair Adjustment Module

Figure 4 shows the script which will be used to reset the camera position .

5. RESULTS AND DISCUSSION

In this approach all the LED status was tested by giving several LED inputs and the outputs were shown appropriately in the user interface according to the machine logic, it was also tested in all lightning conditions thus giving an accuracy of 100% in each case. The problem mainly faced was due to camera positioning. Each time due to some disturbance the camera position gets changed. Hence a camera holder was built which is placed against the wall in such a place from where the LED can be clearly focused. Hence the camera position will not change unless some natural calamity occurs. Several tests were performed by changing the logic of PLC thus giving good results. The solutions for monitoring of PLC can be adapted regardless of different make of PLCs.

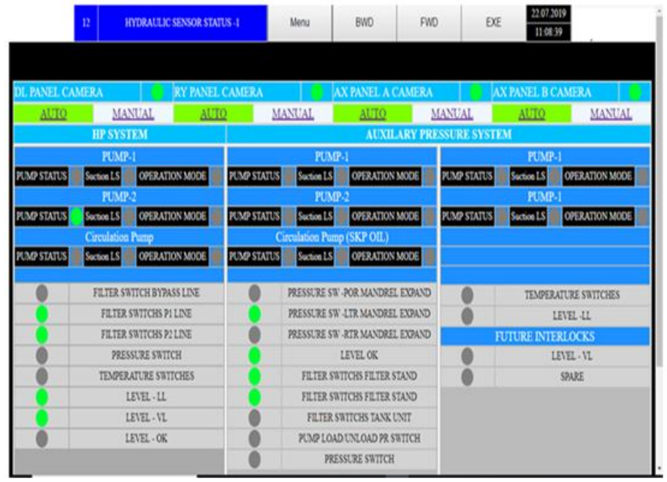


Figure 5: User Interface Showing Healthy Condition of PLC

Figure 5 shows the appropriate logic from the PLC displaying appropriately in user interface and hence all the top row lights are green in color.

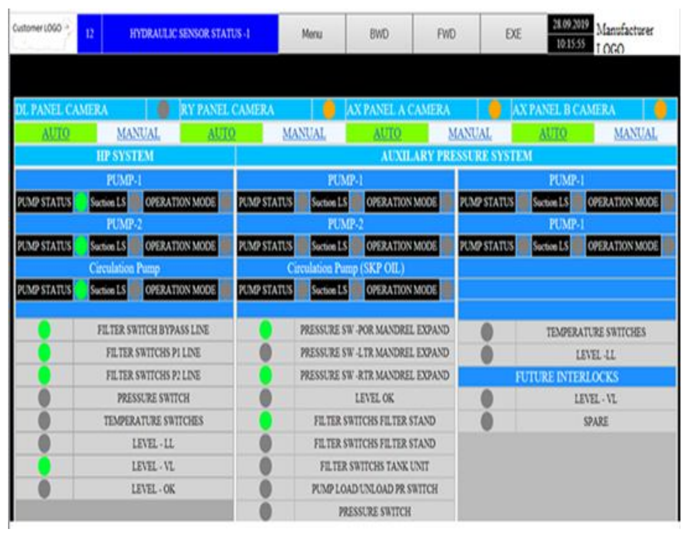
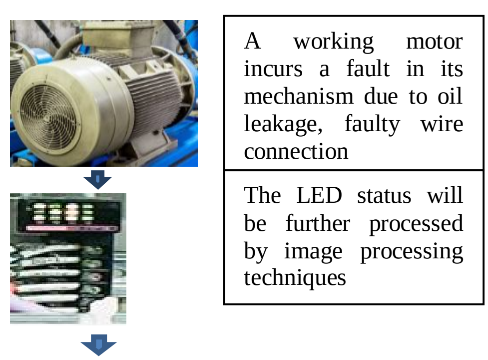
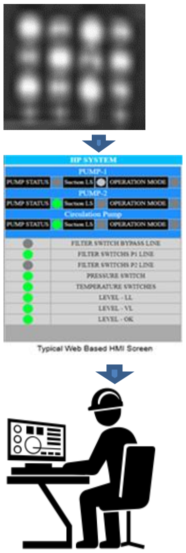


Figure 6: User Interface Showing Unhealthy Condition of PLC

Figure 6 shows the incorrect logic displaying in the user interface and hence the light in the top row in first column is black and rest are orange color.

5.1 Case Study





The faulty result will result in wrong display of LED in PLC

The logic given in the code will be displayed according to the result obtained from processed image

The operator who will continuously be monitoring the UI will be notified with the errors and alarms regularly incurred and further rectifications will be handled by him.

Figure 7: A Scenario

Figure 7 depicts a real-time scenario of how the system operates.

6. CONCLUSION

This approach describes about displaying LED status in the user interface and thus describes the condition of system. Image processing techniques were used to enhance the quality of image, with the help of which appropriate LED status is displayed in the user interface. This approach has the potential to produce good accuracy over multiple PLC simultaneously and it gives good results in any lightning conditions thus proving the system to be efficient and scalable. In future this system can be used for real time monitoring of traffic signals and also as human surveillance system.

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