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AN ADVANCED MODEL, FOR THE MONITORING ROBOT INTRANSFORMER STATION

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ABSTRACT

Nowadays, the automatic is intensively applied in power system, such as electronic meter, information systems. This has improved the transparency and accuracy in the electricity market. Therefore, the automatic in power system is encouraged to upgrade the next level, in which the automation in the trans- former station is put the high attention. Therefore, this paper presents an advanced model of a robot to monitor an automatic transformer station where there are no people in. Moreover, this model is used to build a real robot and confirm its robustness in the real transformer station in Hoi an, Danang city, Vietnam.

KEYWORDS: Image Recognition, Automatic Robot, Lab View, Transformer Station, Vietnam

INTRODUCTION

Currently, the Automatic Transformer Station (ATS) is the right solution for the power system because it is managed automatically. In the future, a series of automatic and remote control transformer stations will be put into operation. This is also an indispensable direction, towards the implementation of smart grid route.

In fact, the ATS is the optimal solution for the power system because it is managed and operated automatically. Besides, it is improving working productivity, minimizing employees, minimize cable investment, intermediate equipment, improve the reliability of the device's working precision, ensure continuous power supply, solve the problem of overload; minimizing operator malfunction, improving operator safety and meeting the requirements of the power market. Although the research to apply for quite a long time, the deployment of untranslatable ATS still many challenges.

Particularly, Vietnamese power system has intensively used the automatic in operation the system such as electronic bill, electricity bill payment via bank. It has reduced the cost of issuing traditional paper invoices, and has simplified the staff collect money. The technology has been applied, has brought many practical benefits, help the power companies to use human resources in a reasonable way. Electronic meters also contribute to the management of accurate metering and automation data, modernization of information systems serving customers, contributing to transparency in the business of electricity. Moreover, Vietnamese Power Company is investing, building many ATSs. By the end of 2014, the Tan Son Nhat 110 kV substation (directly under the Ho Chi Minh City High Voltage Grid Company, Ho Chi Minh City Electricity Corporation), will be officially put into operation, after the pilot period. After, successfully piloting Tan Son Nhat station, in 2015, there were five additional stations: Tang Nhon Phu Station, Saigon South 1, Phu My Hung A, Tan Quy (Cu Chi District) and Da Kao (District 1).

With the aim of reducing the number of passengers, improving operational efficiency in the 500kV, 220kV and 110kV Transmission Station, the Electricity of Vietnam has issued the document No. 4725 / EVN-KTSX (Nguyen Thai Hung 2016) dated November 11, 2015, for internal deployment. To organize the Remote Control Center (RCC) and the ATS without people directly with the orientation as follows:

- Apply automation solutions to reduce the number of operators at power plants and ATSs, improve working productivity and increase the reliability of power supply while ensuring safe grid operation;
- The target to reduce the number of people at 500kV, 220kV conventional transformer station by 2020, 110kV conventional transformer station is station without human operator.

Research and application of improved solutions for 110kV ATSs have been studied by some authors. However, the implementation has only been made for some 110kV ATSs that have computerized control systems and are independent of each province and have not been implemented, for all 110kV ATSs until 2020, in Vietnam.

Related Works

The robot carries infrared cameras, to monitor temperature at the "hot spots" in the station. A robot model with an infrared camera for temperature monitoring has been developed at the University of Sao Paulo, Brazil (J. K. C. Pinto et al., 2008). This is a robotic robot system, moving the robot in the air according to the orientation cable system. Robots and infrared cameras are remotely controlled via 2.45GHz wifi waves from the central control computer placed in the control room of the station. Thermal imaging images obtained from infrared cameras are transmitted wireless to the central computer for processing and it allows automatic detection of over temperature points in the station. Flying robots (C. Deng et al., 2008) are commonly used to monitor power transmission lines because of its wide operating range and flexibility. Robot flying camera can also collect images and send to the center. The self-propelled robot moves on the ground most suitable for automated research in substations because of its flexible operation. Robots are used to monitor equipment status in the station, device status and also used to monitor security. This robot model has been researched and developed in universities in China (R. Guo et al., 2010;S. Luet al., 2017, B. Wanget al., 2012;S. Lu et al. 2008). The robot carries a camera on the ground, automatically controlling it to various positions for image recognition and transfer to the central control computer. Self-powered robots are also studied in this project to increase the automation level of the robot.

Challenges and Contributions

From the discussions above, the main aim of this paper is to build a monitoring robot which can automatically operate in an ATS with some characteristics as follow:

- It is able to move wherever in the transmission station, thus reducing the number of required camera;
- The camera of the robot can turn to a large degree and the lend has a deep focus. It thus can see overall the transmission station;
- Using wireless technology to transfer data, thus it can move in any environment and avoid the disadvantage of the length of connection wire; Algorithm of recognizing image is developed in the Labview software.

However, to derive a complete robot which can automatically operate in an ATS, some challenges are detected and solved. This can be seen as the contributions of this paper as follow:

- Lack of the historical data which can be used to recognize the condition of the switch (open and close);
- The quality of image due to the reaction of brightness;
- The darkness can significantly affect the reliability of operation of the robot.

METHODOLOGY

The Model of the Monitoring Robot

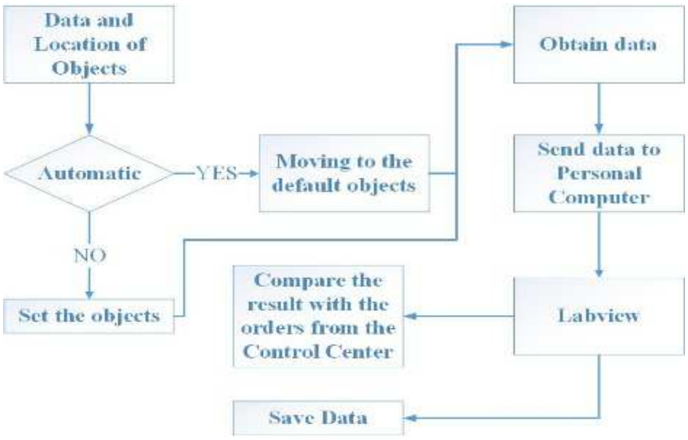

Figure 1: The Example of Three Points Method

The operation of the motoring robot is presented in Figure. 1 and the robot operates as follow

- The data and location of objects such as circuit breakers, switches and meters;
- The robot has two options: (i) automatic, and (ii) manual. In which, the manual option can select the objects to check, while the automatic option is not; The robot will collect the images and signal, then send them to the Personal Computer for the further investigations;
- The recognizing image process is made in the Labview software (Labview 2017);
- The final process is to compare the result with the orders made by the Control Center, to detect the fault.

Image Recognition

One of the most difficult works of this paper is the recognition of image in order to check the status of objects such as the meters to check the temperature of either high and low voltage core or oil of the transformer. Besides, the status of the switch is also a challenge since there is lack of the historical data. Thus, this paragraph explains the methodology to solve these issues.

These issues can be solved by some available functions in Labview (Labview 2017). About the meters in Fig. 2, three points method is applied, in which this function will recognize three points: $point_{start}$, $point_{end}$, and $point_{mid}$. From these three points, the function will compute the total degree Deg_{tot} of the range measurement and the degree of hour hand Deg_{hh}. Then, from the $point_{mid}$, the function will show, exactly the value of temperature.

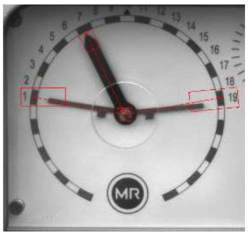

Figure 2: The Example of Three Points Method

The formula to compute the actual value of the example in Fig. 2:

$$\text{Result} = \frac{\text{Deg}_{\text{hh}}}{\text{Deg}_{\text{tot}}} * \text{point}_{\text{end}} + \text{point}_{\text{start}} \ (1)$$

Where Result is the actual value

Moreover, one of the most difficult issues is the status of the switch since the historical data is missing. In order to overcome this issue, the “match pattern” is used. Here, the minimum score presents the threshold; it means that if the percentage of duplication is below the threshold, the status of the switch is “open” and vice-versa.

TEST AND RESULT

Figure 3: The Monitoring Robot

The robustness and reliability of the robot in Fig. 3, it is tested in a real substation (110 kV Hoi An) in Fig 4. In this station, there are six points which need to measure and check as follow:

- The meter of transformer;
- The switches of phase A;
- The switches of phase C;
- The meter to measure the temperature of the high and low voltage;
- The meter of the status of the circuit breaker;
- The meter of pressure of oil in the transformer.

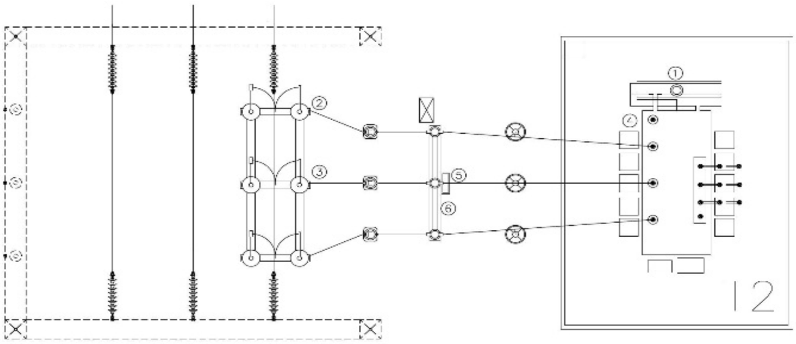

Figure 4: The Hoi an Transformer Substation

The robot is tested in two cases: (i) automatic, and (ii) manual setting. The result shows that the robot worked exactly in all cases such as the measure of temperature and status of switches. In the automatic mode, the robot goes from this point to another point as in Fig 5. It should be noted that these points are set as the default, in which R1, R2, R3, R4, R5, and R6 have represented the locations of objects in Fig. 4, respectively. One example is shown in Fig. 6.a for the meter of the transformer. Here, the robot detects exactly the actual temperature of objects such as the core of high and low voltage, and the oil of the transformer. Moreover, the status of the switch is also detected exactly with the threshold is 60 % as in Fig. 6.b Eventually, to overcome the darkness during the night, the led lights are installed on each subject to increase the brightness and saving energy.

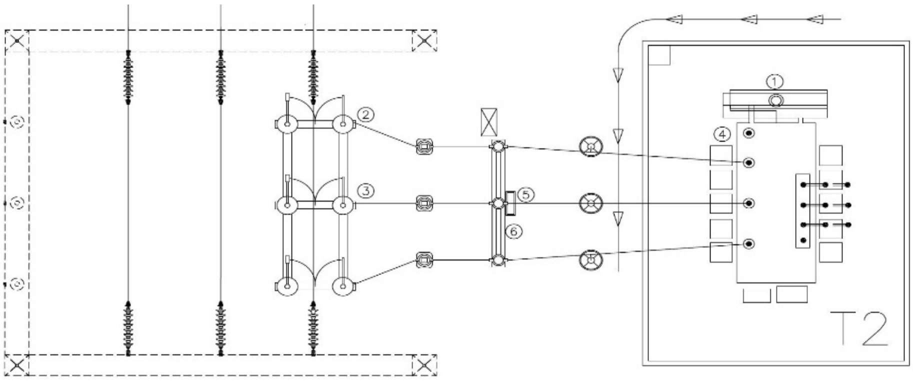

Figure 5: The Moving Direction of the Robot in the Substation in Hoi An

a) (b)

Figure 6: The Objects (a) The Meters of Transformer and (b) The Switch

In both cases, the robot works efficiently and correctly for both day and night, and in any case of weather in Vietnam.

CONCLUSIONS

This paper completely presents the model of a monitoring robot which can automatically operate in a transformer station. The challenges and solutions are also detected and presented in this paper. Finally, the monitoring robot is tested in a real transformers station; the result confirmed the robustness and reliability of the robot. Therefore, the application of this robot is promising in the real application.

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