e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-11, Issue-3 (June 2021)
https://doi.org/10.31033/ijemr.11.3.5

Implementation of Implantation-Stagger Measuring Unit using Image Processing

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ABSTRACT

The electrical traction system of railways is a combination of physical upright structures and OCL(Overhead Contact Lines). The horizontal distance from the center of the track to the OHE mast called implantation, horizontal displacement of overhead contact wire with respect to the center of the railway track called stagger, and the perpendicular height of overhead contact wire from the ground are periodically checked by a lineman in order to ensure a safe distance from the railway track. In this paper, we have put forth an idea of building a distance measuring device to measure the implantation and stagger without touching the objects using Open CV on raspberry pi with a camera module which will be placed at the center of the track. The system will be having two features. To measure the distance of the nearest poles, the camera has to be placed facing the mast perpendicular to a circle of diameter appropriate which is placed on the pole for measurement purposes. And to measure the stagger, the camera has to be placed facing the overhead wire from the center of the track.

Keywords-- Electric Multiple Units, Implantation, Stagger, Mast, Overhead Contact Line(OCL), Overhead Equipment(OHE)

I. INTRODUCTION

Railway's electric traction system normally known as the OHE system is a combination of various hardware erected along the tract to facilitate the seamless traction power to the electric locos and Electric Multiple Units. The upright which holds the contact wire is known as masts placed beside tracks. The mast is erected on the foundation to hold the entire static and dynamic load of the OHE [1]. It is very important to maintain a proper predefined distance from the center of the track to the mast face, which is also a safety measure. This distance is also known as implantation to be recorded at specified intervals and maintain a record for monitoring. The distance of the mast from the center of the track should be regularly checked to have a safe distance from the railway track. This is generally done by a lineman who has to periodically measure and record the distance. Among the numerous components of high-speed electrical railways, overhead contact lines (OCLs) serve asone of the interfaces to constantly supply power to operating trains. However, due to the physical structure of OCL, the system is exposed to various mechanical and electrical effects[2].This wire layout will be in such a manner that is in a zigzag way to avoid damage or groove to pantograph (current collecting system of the locomotive) and damage thereafter. The stagger of the contact wire is the horizontal distance of the contact wire from the vertical plane through the center of the pantograph pan at the contact surface [3]. Therefore, the overhead wire gets displaced from the center, whose displacement has to be calculated, and get it fixed back. Normal practice is to measure these parameters manually using measuring tape and also in power blocks with pantograph of tower wagons. This project aimed to reduce manual work by automating this process of measurement. This is possible with the help of Computer Vision where the Raspberry Pi camera acts as the vision for the computer that captures the image, processes it, and gets the measuring work done with regards to Implantation and Stagger.

II. METHODOLOGY

2.1 System Architecture

An Application to determine the distance of the nearest poles from the track i.e.(Implantation) and the displacement of overhead wire with respect to the Centre of Track i.e.(Stagger) is built using Computer Vision. This serves the purpose of getting the measured distance from a frame that was initially captured through a Raspberry Picamera module.

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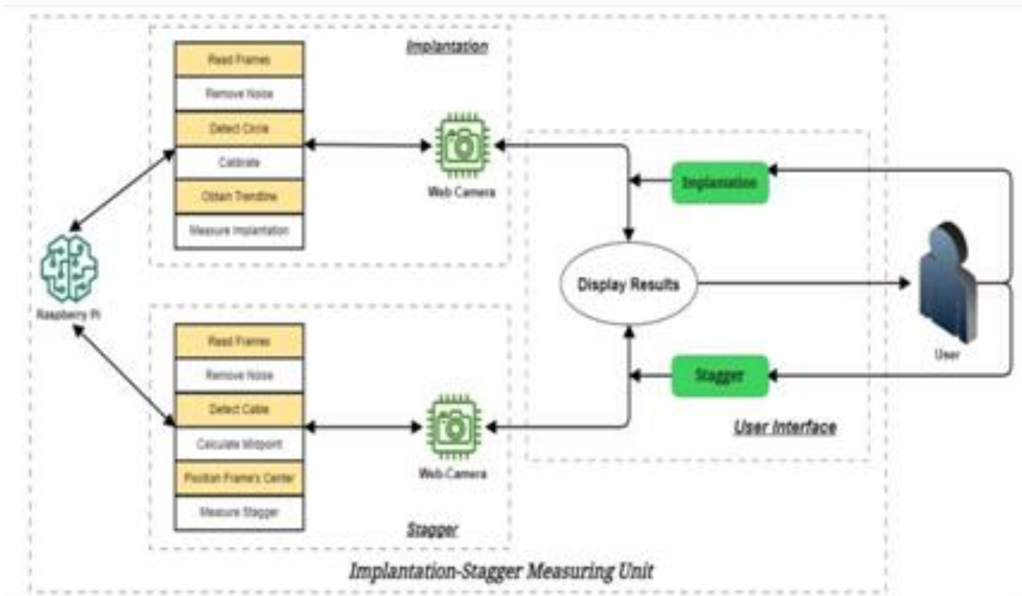

Figure 1: System Architecture

Initially, the User or the Line-Man has to choose one of the options displayed on the GUI interface. Say, he chose to measure Implantation, once he clicks the button, the Raspberry Pi camera module takes in a set of frames sends signals to the Raspberry Pi. Each frame is read, the noise is removed and the object detection takes place. Once the object is detected, the next sub-part will be the calibration of object distance with the contour area. Keeping the circle in front of the camera at some distance we note down the distance manually using a measuring tape and its corresponding contour area. Next, we move the object a little farther from the camera and repeat this process for several iterations at different distances. We next obtain a trend line with the help of the obtained data points with respect to the distance and the corresponding area. The equation that we get will be programmed thus facilitating the calculation of Implantation.' Similarly, when the user presses the Stagger button shown at the interface, it would again be the same process until removal of Noise and here, we detect the Overhead contact line.

2.2 Hardware

The Raspberry pi needs to be set up before using it. We have installed the latest Raspberry Pi OS for our Raspberry Pi. Then we installed the Python Library that we need for our program. After making the connection of the components to the Raspberry Pi. We use a wooden frame set up to place the Raspberry Pi camera. The height of the wooden frame is 1m and its place on the track in such a way that the shaft of the Wooden frame is at the center of the track.

Figure 2: Initial Set-up

2.2.1 Implantation

To get the implantation we are placing a Two-dimensional object say, a circle of on the mast from which we want to find the distance, we adjust the camera such that it faces the mast and we attach a laser pointer above the camera pointing towards the mast which will make sure that the camera and the object are at the same height so that the horizontal distance between them is parallel to the ground and not inclined at any angle. At the point at which the laser beam falls on the mast, we place our circle over there. After we power on the raspberry pi, the GUI interface is visible on the LCD, we click the Distance button to get the distance of the mast from the camera which is displayed on the GUI window itself.

2.2.2 Stagger

For the stagger, we place the camera at the center of the track in such a way that it faces the Overhead contact wire. Then we click the stagger button on the GUI interface to get the stagger of the Overhead wire which is visible on the frame. After calculating we may go back to the main GUI window by clicking on the Home button.

2.3 Software

An Application to determine the distance of the nearest poles(implantation) of the track and the displacement of overhead wire(Stagger) with respect to the Centre of Track was built using Computer Vision. This application serves the purpose of getting the measured distance for Implantation and Stagger from a frame that was initially captured through a Raspberry Picamera.

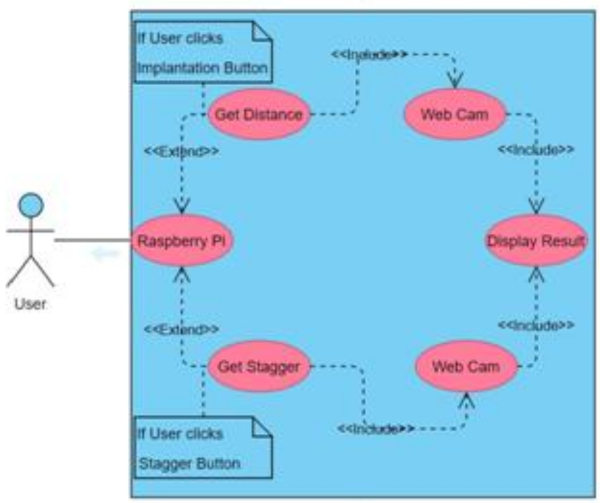

Figure 3: Use Case Diagram of Implantation-Stagger MU

2.3.1 Implantation

The Raspberry Pi camera continuously captures the set of frames which are individually processed by the program using the concepts of Image Processing in Python. The Implantation is measured using the concept of Object Distance calculation using Contour Area Method in Python- OpenCV. The principle using which we found the distance of the object from the camera is as: "Area enclosed by the contours of an object decreases as the object moves farther from the camera" [4]. This simply means that, if our object is near to the camera, the object will appear bigger. Thus, the pixel area occupied by the object will be more. As you move the object farther from the camera, the object size in the image will start to diminish. And hence the pixel area enclosed by the object will become smaller and smaller.

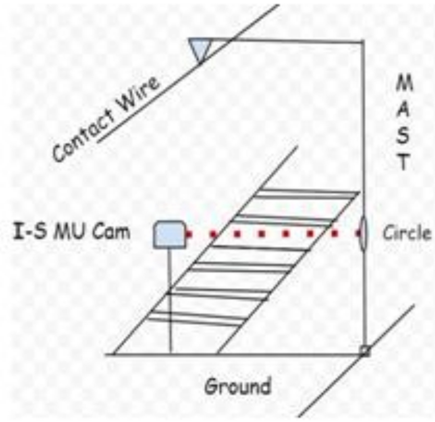

Figure 4: Implantation View

As shown in the Implantation View, instead of considering an entire mast as an object, we consider a specific portion of the mast. This is to ensure that there is a considerable difference in the area captured by the camera which is almost zero in the case of an entire mast because of its ever-increasing height which makes it difficult to calculate the mast's change in area with a change in the movement of the camera. Here, therefore, the object is a Two-dimensional Circle that is stuck at the mast which gives us a considerable difference in the area as the camera is moved to and from, along the line of action. Once the object is detected and the

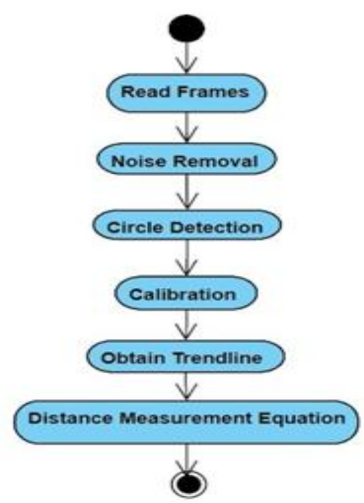

Figure 5: Activity Diagram for measuring Implantation

corresponding contour is drawn, the next part will be the calibration of object distance with the contour area. Keeping the circle in front of the camera at some distance we note down the distance manually using a measuring tape and its corresponding contour area. Next, we move the object a little farther from the camera and repeat the above process for several iterations at different distances. The

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next step is toplot this data on the x-y axis. The distance must be on the Y-axis. We find a trend line through these data points and find the equation of the trend line in excel. We can choose a linear, exponential, or polynomial trend line depending upon which fits best with the data. For us, the power equation worked best. The trend line which we got is shown below.

We enter this equation displayed on the graph in the code and finally display the distance of the object on the screen.

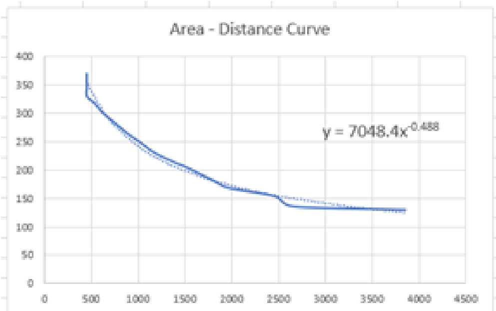

Figure 6: Area-Distance Curve

2.3.2 Stagger

For a stipulated maximum stagger, the length of the span is governed by curvature, blow-off of overhead equipment, the sway of the pantograph, and deflection of the mast under wind conditions [3]. This causes the displacement of the contact wire from the stipulated position which has to be fixed back. This Displacement is calculated with the help of Computer Vision where the endpoints of the contact wire are detected and a corresponding line is drawn indirectly indicating the detection of the wire.

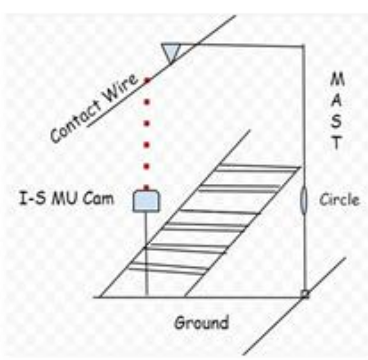

Figure 7: Stagger View

Once the wire is detected, as shown in the Stagger View, we then determine its midpoint and calculate the relative displacement of that midpoint from the center of the frame. The frame Resolution is mapped in such a way that the center of the railway track coincides with the center of the frame. This displacement in pixels is converted to centimeters considering the screen resolution and width of the sensor present in the Raspberry Pi camera. To avoid multiple wires from getting detected and thereby creating fluctuations in the result, we crop the image obtained by adding the crop-factor in the code in such a way that the contact wire is the focus of attention.

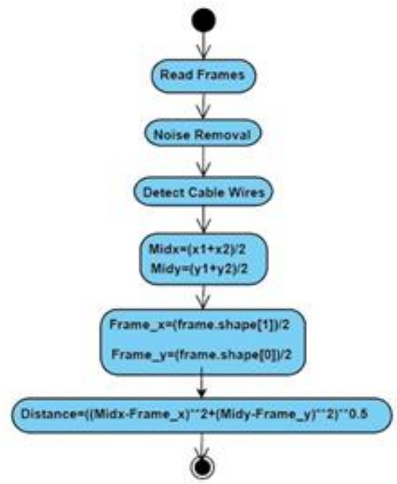

Figure 8: Activity Diagram for measuring Stagger

III. EXPECTED OUTCOME

The implantation usually measures between 2-4 m. The experiment after testing gave results with an error of 0.1 m as measured from the mast. The display of error suggests the accepted range in which the adjustment can be done according to the lineman's convenience. The Stagger usually measures between 7-20 cm. When tested Manually, it gave an actual measurement of 10.2cm, whereas our analysis gave an error of 0.04 cm as observed. The error range that is acceptable is 0.1cmas said by the Railway Officials.

Figure 9: Graphical User Interface - Home Window

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Figure 10: Graphical User Interface - Implantation Window

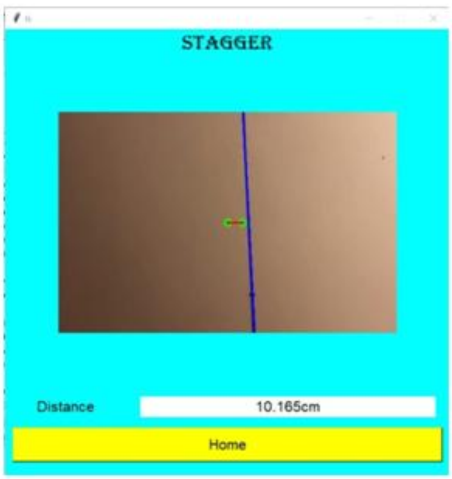

Figure 11: Graphical User Interface - Stagger Window

IV. CONCLUSION

This paper talks about an efficient way of measuring Implantation and Stagger with the help of Computer Vision, where the web camera acts as the vision for the computer which will then capture images, process them. The project if worked as per the problem statement would measure the appropriate distance for Implantation and Stagger as viewed by the required individuals according to the Image processed and the signals received by the Raspberry Pi and Camera module. Thus, the aim of this project was achieved which was to optimize the working and cut down the time-consuming activities, by developing a system that automates the measurement of Implantation and Stagger.

In future this project can be enhanced by adding a feature of measuring the perpendicular height of the railway overhead wire from ground which is also an important parameter that needs to be periodically checked by the lineman. An SMS Alert system can also be integrated, where the system will alert with a message with the status of the measured distance values. These messages can be sent to the group of railway officers concerned for the specific area. By utilizing various advances in technology, our aim is to complete these modules and present the system unit to railway officials concerned with this project.

ACKNOWLEDGEMENT

Success of a project like this involving high technical expertise, patience and massive support of guides, is possible when team members work together. We take this opportunity to express our gratitude to those who have been instrumental in the successful completion of this project. We would like to show our appreciation to our external guide Mr. Dheeraj Kallakuri for his constant guidance and our internal guide Ms. Rakhi Kalantri for providing us with regular inputs about documentation and project timeline. A big thanks to our HOD Dr. Lata Ragha for giving us an opportunity to be a part of this project.

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