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Railroad Track Maintenance Device

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Abstract – *Railway track inspection systems play a crucial role in maintaining railway networks safe and to avoid dangerous accidents. In developing countries like India and Africa, most of these inspections are carried out manually. This is done by trained railway employees walking along the track with the equipment in search of defects. Its status is then written down in a report. This operation structure is not viable because of the amount of time required, its accuracy and absence of objectives. Enhancements for the current manual inspection process are possible by using advanced sensors and embedded systems. The implemented system is designed to automatically inspect the tilt angle, the space between the tracks and the distance covered during the inspection. The system captures data from the sensors which are placed on the axle of the rail inspection car. The data readings are processed through a microcontroller and are recorded in metric units. The system simultaneously displays data on an LCD panel in real time.*

***Keywords**: Track Maintenance, Digital Inspection*

Nomenclature

LCD	Liquid Crystal Display
I/O	Input/output
PWM	Pulse Width Modulation
UART	Universal Asynchronous Receiver/Transmitter
ICSP	In-Circuit Serial Programming
IDE	Integrated Development Environment
PSD	Position Sensitive Detector
IRED	Infrared Emitting Diode
IoT	Internet of Things

I. Introduction

India has a 67,312 km long railway track route running across the country. In Future, 25000 km long new tracks are supposed to be laid down by 2020. The Indian Railway plays the role of catalyst of the Socio-Economic development for the country [1]-[2]. Railways need to manage frequent inspections of their tracks to sustain safe and efficient transport operations. The process of rail track inspection requires enormous monetary funds, human resources and engrossed track capacity. However, maintenance works on tracks are almost always conducted without interrupting the usual transit of trains [1]-[19]. Workers on maintenance sites are therefore exposed to the danger of injury or crash in case of undetected train transit [3].

Fig. 1 shows the current mechanism used in developing countries like India to check the tilt angle of the tracks. This system uses principles of a spirit level. It plays a significant role in railways to avoid the derailment of the train because it is the primary task of inspection and provides the angle of banking of the track.

This system is implemented in most developing countries of the world. The manual [4] oriented inspection of tracks is much familiar and it is implemented in most railroad authorities. In India, the process of checking the angle of banking and distance in railway tracks are still carried out manually.

Fig. 1. The conventional measurement system of tracks

This manual process has the following disadvantages.

The railway administration trains its employees on how to use the detection equipments, but sometimes an employee is not able to detect errors because of the carelessness, and this gives rise to the case of human error. In India, 87% rail accidents occur due to human error, 51% out of which occur due to the failure of railway staff [5].

An innovative approach based on image analysis and processing to reconstruct the whole track profile is presented in [6]. At prototype level, it has been showed the possibility of real-time functioning with good accuracy, using algorithmic pre-processing and neural processing. It is presented a methodology to optimize the processing system regarding the tradeoff between accuracy and computational complexity. The presented methodology was general and not only related to the described application, enlightening how a strong modular analysis at system level is effective in maintaining a complex overall system behavior with simple functionality in the modules.

Alippi, et al. [7] presented an innovative approach to track profile measurement. A real-time image processing- based technique was adopted to reconstruct and measure the profile by analyzing a laser-scanned CCD-camera image. An accuracy of the same magnitude of the track roughness was achieved with a still monitoring system. However, the results for the system on board of a moving rail carriage were not obtained and it was focused only on one characteristics of the rail track.

Using the conventional methods for maintenance of rail tracks is not feasible in this generation.

This type of monitoring system is unsatisfactory because it is slow and lacks of accuracy. This slows the process of locating faults. Heavy traffic demands a periodic inspection and more stringent maintenance requirements but railroad employees have less time to accomplish them [8].

To avoid these types of incidents, an automatic railway track maintenance system is needed [9]. The objective of this paper is to check the workability of using sensors technology to make track inspection more efficient and effective. Hence, to reduce delay, the system deals with the automatic detection of the banking angle, the space between the tracks and the area covered during the inspection. The device will present data on an LCD in real time and will also store data simultaneously.

In this way, the system increases inspection efficiency, reduces the time required and gives more accurate and frequent information of the railway track.

That increases the accuracy and efficiency of maintenance, makes it more reliable and data is digitally stored thus avoiding human error.

Lamedica, et al. [10] illustrated a methodology for the prediction of the service quality of a high-speed railway system as a function of reliability and maintainability of the subsystems forming a transit system, failure recovery policy of failed subsystems and degraded conditions of traffic management, quantifying the delay trip acceptable by passengers.

The training technology might seem to be advancing at a slower pace as a suburban train service paving its way from one station to another, but with the emerging of new technologies in the field of electronics (mainly in embedded systems), it is getting easier for the locomotive industry to use these technologies at their best not only to automate the processes but also to ease the process of error detection, hence reducing human efforts [11].

II. Proposed Work

Fig. 2 shows the block diagram of the implemented digital track maintenance system. The descriptions of the sensors being used for the system are shown as in the following subsections.

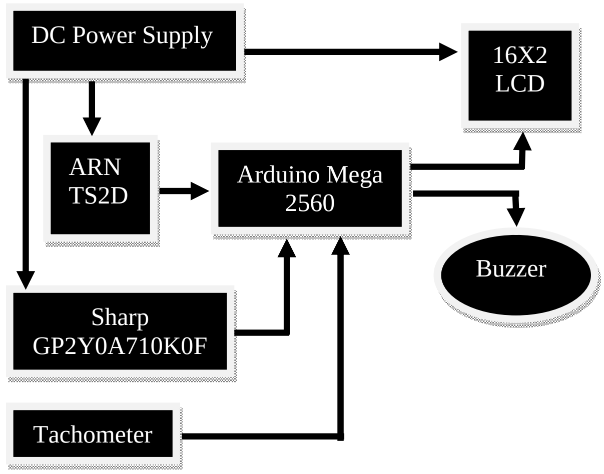

Fig. 2. Block Diagram of Track Maintenance Device

II.1. Arduino Mega 2560

The *Arduino Mega 2560* [12] is a microcontroller motherboard which supports the integration of different sensors. It is based on ATmega2560. It has 54 digital I/O pins, 16 analog inputs, 4 UARTs, a 16 MHz crystal oscillator, an ICSP header and a USB connection. The main purpose of using the Arduino Mega 2560 board is its easy interfacing with different sensors and the integrated development environment (IDE) software that is being provided with the board to program the different sensors and board. The Arduino Mega 2560 serves as a great development platform for 8-bit microcontroller projects. What is great about the Mega and the Arduino family as a whole is the ability to transport the code from one hardware solution to another and even to customize PCBs.

II.2. Aeron Sensor

Fig. 3 shows the tilt sensor used in this project, the *Aeron TS2D Digital Tilt Sensor* [13], which has an accuracy of 0.1-degree and also provides dual-axis stability over time and temperature. Moreover, it is a concise cost-effective tilt sensor, which gives accurate tilt information about the roll axis. It provides output (digital formats - RS232, RS485 MODBUS RTU) in the static or non-accelerated environment. Initially, solar tracking devices used optical encoders that made them monotonous to set the correct angle and also caused a lot of wear and tear of the mechanical devices. It is a solid-state device which can be easily deployed without making any mechanical modification. The device is also free from maintenance. The purpose of selecting the

Aeron digital tilt sensor is its high accuracy. With such high accuracy, it becomes easy to detect the misalignment between the tracks, which can cause the locomotive to derail. Moreover, minute errors are calculated in degrees, so that they can be quickly fixed and save a lot of human efforts to detect the errors and fix them.

Fig. 3. ARN TS2D Sensor

II.3. Distance Sensor

One of the most important phenomena in track inspection is to maintain the distance between two wheels. In India, the distance between the two wheels of any locomotive must be maintained at 1,676 mm. Thus, in order to maintain this distance and reduce errors, the *SHARP GP2Y0A710K0F* [14] sensor shown in Fig. 4 is used. This sensor measures the distance between the two tracks when the inspection van is running and reads the distance between the two wheels. The range is between 100 and 550 cm. It is an integrated sensor consisting of a PSD, IRED and signal processing circuit. The important factor of this sensor is that the diversity in the reflectivity of the object, the environmental temperature and the operating duration do not affect distance detection due to the adoption of the triangulation method. It can also be deployed as a proximity sensor.

Fig. 4. SHARP GP2Y0A710K0F

II.4. Tachometer

As the locomotive moves ahead detecting errors at different angles and levels, the other important phenomenon that needs to be tracked and stored is the distance traveled by the vehicle. The reason behind it is the further development and enhancement of railroads.

The use of railways for transportation and commutation is rapidly increasing. It is needed that the rail network adequately copes with the ever-increasing public demand. A distance sensor is used for tracking the distance traveled by the vehicle.

II.5. Display

In order to track and measure errors, a display 16×4 Standard Hitachi HD44780 has been used, having a compatible interface and easy connection. The LCD will display data in real time so that the operator can carry out the operations if the track has defects.

III. Implementation

The whole purpose of designing this device is to make the process of error detection in track maintenance easy and to get results in digital form [15]-[16]. Fig. 5 shows the proposed system.

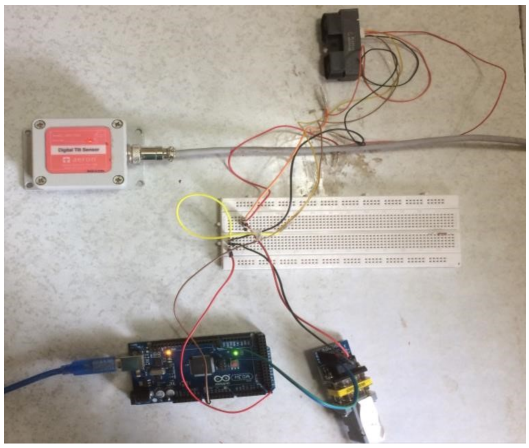

Fig. 5. Testing of implemented system

With the integration of all sensors on the microcontroller motherboard, as described above, these results can be achieved. In the current system, the operator has to drive the rail inspection device to remote places where new tracks have been laid and check the banking angle and the distance between the two tracks.

Thus, in order to reduce this human effort and get more accurate results, this device comes into picture.

The device is powered by an industrial power supply of 12 volts, 9 volts and 5 volts which will power the digital tilt sensor, the microcontroller motherboard and the LCD display (see Fig. 2). The industrial power supply was specifically designed to power all these devices keeping in mind the power needed for the working of all these devices. Once the power is supplied to the microcontroller, the latter is automatically set ON and similarly are the powered sensors. The preloaded program in the microcontroller is set on a loop, hence it can immediately show the output as it is turned on. The sensors are set into motion and they start sensing the alignment of tracks, the distance between the wheels and also start measuring the distance traveled by the device.

The operator has to move the device at a constant speed (walking pace) and keep an eye on the display to note the fluctuations while moving forward.

Fig. 6 shows the flowchart of proposed digital track maintenance system. The sensors start sensing and send raw data back to the microcontroller. The microcontroller reads this raw data from sensors and processes it within the microcontroller with the code that has been set into it.

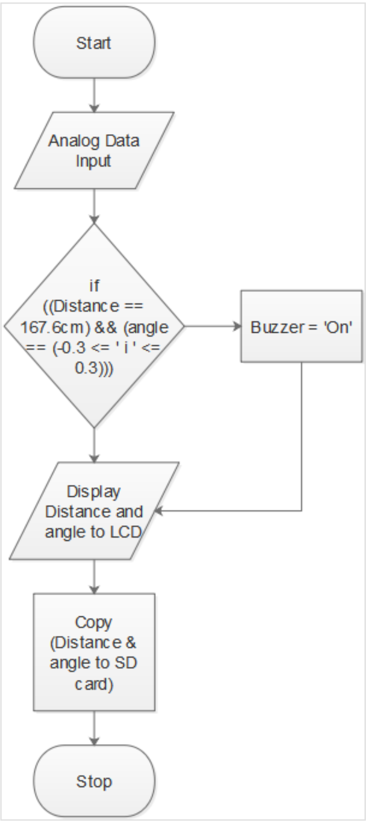

Fig. 6. Flowchart of proposed digital track maintenance system

If the readings are out of the default range, then a buzzer will be turned on. The LCD will display the data readings all the way during maintenance. This helps the operator in immediately fixing the defects and in increasing the efficiency and accuracy of the work performed.

IV. Results

The Aeron digital tilt sensor and Sharp distance sensor were tested at multiple locations on the track to check their accuracy. Table I reports the comparison between the digital method and the conventional method of banking angle testing. The conventional readings are taken from the spirit level measuring technique and the digital readings are taken from the Aeron TS2D sensor.

The sensor was used for measuring the difference on the x-axis only i.e. the roll axis. The readings were taken during the system testing, each at a distance of 100 m.

Table I shows that the proposed method with the digital tilt sensor gives an accuracy of 0.1 degrees and the conventional method accuracy was 1 degree for the banking angle.

The digital method provided highly accurate results and also recorded data automatically, making the inspection faster and easier.

Table II shows the track distance measurement comparison between the proposed and the conventional method. The proposed method resolution is 1 cm while the conventional method gives resolution of 2 cm.

TABLE I
BANKING ANGLE COMPARISON

Sr. No.	Digital Method	Conventional Method
1.	-0.3	0.0
2.	-0.3	0.0
3.	0.2	0.0
4.	0.4	0.0
5.	0.5	0.0
6.	0.7	0.0
7.	0.9	1.0
8.	0.4	0.0

TABLE II
DISTANCE BETWEEN TRACKS COMPARISON

Sr. No.	Digital Method	Conventional Method
1.	1676	1676
2.	1676	1676
3.	1675	1676
4.	1675	1676
5.	1676	1676
6.	1675	1676
7.	1676	1676
8.	1674	1674.5

The distance sensor by Sharp has an accuracy of 1 cm and it was tested at a standard distance of 1676 mm, which is the standard broad gauge track size in Central Railway, India. The system was also checked at night time and it showed no change in the accuracy of the results. This made the system feasible to be used at any time.

V. Conclusion

The recent advances in railroad infrastructure and their implications on track maintenance and stability has been studied. The proposed digital track maintenance system will give a 0.9 degrees of accuracy in banking angle measurement and 1 cm accuracy in track distance measurement than the conventional method.

In order to improve the safety, accuracy and speed of railway track maintenance work, a comparative study about accidents on track maintenance has been carried out and recognized that many accidents occurred due to human errors. The use of the proposed device can reduce the labor requirement, in order to avoid human error in Indian Central railway system. It also digitalizes data, making it accurate and hassle-free.

The proposed system is installed on an IoT supported inspection van with an inbuilt motor to drive autonomously and remotely provide data to the officer in charge of taking immediate action.

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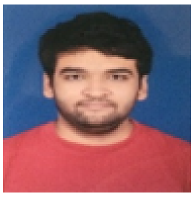

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