Crack Detection System

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Abstract:

This project aims at designing railway track crack detection using an Arduino and Raspberry Pi and Arduino as development boards, which is further connected with a sensor, either an Ultrasonic or IR sensor (in our project it is an ultrasonic sensor module *HC-SR04*). The purpose is that it detects the distance between objects by using the physical phenomenon of echo, high frequency sound waves are emitted from the sensor which on striking an object bounces back to the receiver in the sensor. In the case of IR sensors, an infra-red blaster is used to emit infrared waves which travel and strike the surface, bounce back to an infra-red sensor. The time taken for the ultrasonic wave or the infra-red wave is used to calculate the distance between the object's surface which gives us information about any abnormality on the surface of the object. Also, the GPS and the GSM service are used to send these location coordinates to the user's mobile, desktop, or web interface.

Lately, with the advancement of railways, the capability of the trains has been continuously increasing. Hence, an inspection of a rail track is a necessary task, which should be inspected periodically. Currently, the system that is being used is to track it by trained personnel, who walks along the track and search for defects. This certainly is a time taking process and hence, more time to fix the faults. So, to make it time-efficient, an automatic crack detection system is required.

Motivation:

There are many problems around us which we face in our daily life. We want to create a project that can help and benefit the people of our country, so we look into various public sector domains that are used widely that require some changes in the system. And one such domain that requires attention is transportation. Today, transportation is of utmost importance for its sustainability and safety due to its primary usage. There are many changes or updates that we can make in this sector for the betterment of our nation. Also, we learned quite a few things about IoT and how dynamic it is in the field of technology and its advancement. When we talk about transport, Railways occupies a leading position in India in reducing a fast-growing economy's growing needs, but there are still many problems which can be corrected to make this system more efficient. The main issue that is faced here is that there is no reliable and affordable equipment to diagnose train track issues and the lack of proper maintenance. The railway infrastructure dates back to the colonial history of India. These tracks were laid by the British back then for transporting goods from different parts of India. After the independence, this whole system that was once used to transport Indian goods to

the major ports for export were converted as a medium of transportation and in very few years became the most used mode of traveling as well as transportation. After these many years, a lot of things were upgraded but the system used for the maintenance of these decades-old tracks remains the same. With the increasing number of trains and usage of the railway system, the current methods of maintenance are not very productive and take a lot of time and labour.

Thereby, we thought of making this model that speaks of a proposed test train design for detecting obstacles and cracks in the tracks, similar to the line following the test train. This project will help improve the rail industry and many people will be benefited from this. It is the most economical and efficient solution provided to achieve good results of railways of our country to minimize the stats of accidents caused. Besides this, it also saves time and money when this project is applied in real life.

Related work:

According to our research-based study, we came across multiple research papers that discuss similar ideas. Most of the methods discussed in those research papers are about detecting a crack and sending an SMS to a particular mobile number. However, we believe that there are many other ways to use and deliver this data. In this paper, we have proposed some of these ideas with their benefits. We have also discussed some of the important aspects mentioned in most of these research papers, points to improve them, and a small demo project we built with the limited resources we had.

In **[1]** the authors propose a system where they use Raspberry Pi with a camera module on a mounted platform. The camera took images of the tracks and they used computer vision and image processing to detect cracks on the tracks.

The idea is quite fascinating and useful but many other ways are quite simple and less sophisticated than using computational intelligence and image processing. This requires a lot of extra resources and the maintenance of this system itself won't be very easy. As the parts used are comparatively expensive and repair is a bit difficult. This system could however be a real add-on as a surveillance module.

Another excellent application is seen in **[2]** where the authors discuss the use of neural networks for precise classification of cracks or damage and present an implication where a motorized cart is mounted with an Arduino board, IR sensors, and GPS/GSM modules which sends a notification into a mobile device when a crack is detected. This system is quite effective and less expensive to maintain.

With the technology stack discussed above, it's quite clear that almost all the solutions are collecting huge bundles of data that could be useful. We can use this data to train more and more classification models to make detections more precise.

Methodology:

The components being used:

-Ultrasonic sensor: This is an electronic sensor that measures the distance of objects by emitting ultrasonic high-frequency sound waves and converting the reflected sound waves into electrical signals. These waves travel faster than the speed of audible sound (i.e. the sound that humans can hear).

-GPS

The Global Positioning System is used to receive the position data of an individual or vehicle and display it on a digital map. It will also have an interface to the communication link.

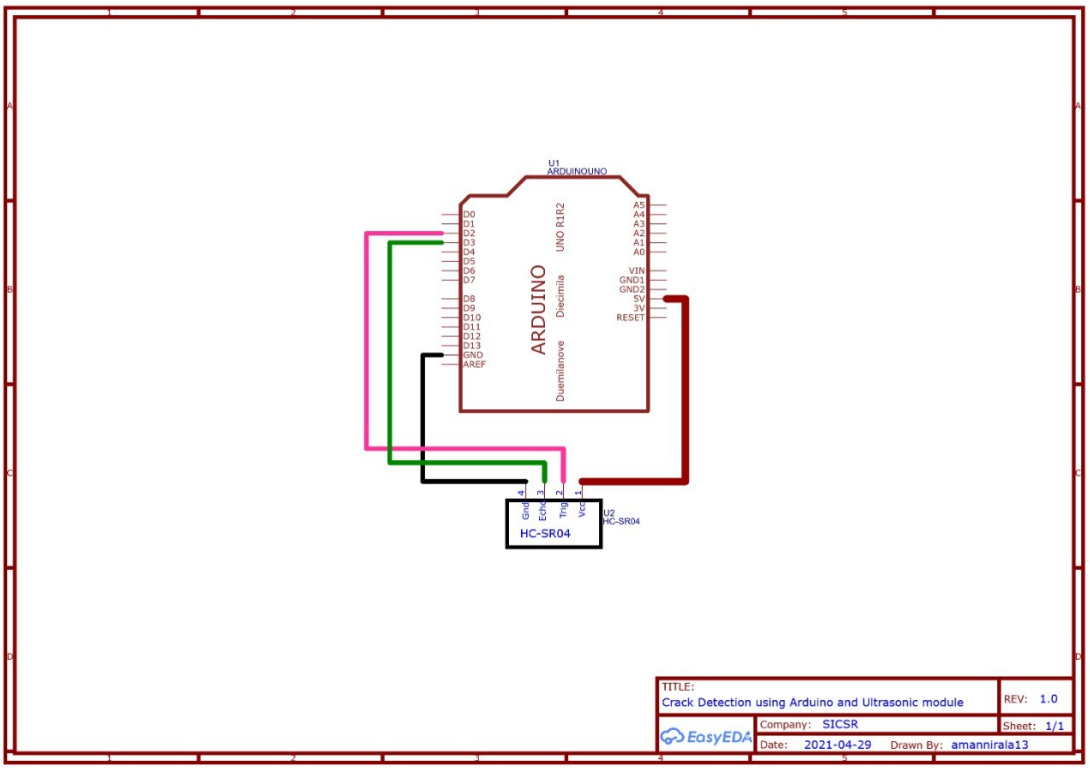
-GSM module (not included in the demo)

The GSM net used by cell phones provides a low-cost, long-range, wireless communication channel for applications that need connectivity rather than high data rates. Its purpose is to send a text to the web portal. In the demo, we are using a remote SMS client because of its availability on multiple platforms, scalability, and unavailability of GSM module hardware.

- IR sensor

An infrared transmitter is one type of LED that emits infrared rays generally known as an IR Transmitter. On the other hand, IR Receiver is used to receive the infra-red rays transmitted by the IR transmitter. Instead of IR sensors, we will be using Ultrasonic sensors for the demo.

Circuit Diagram: (Fig 1)



The ultrasonic module HC-SR04 is a 4-pin system. One is VCC which is the 5V live pin connected to the 5V pin of Arduino. The ‘GND’ pin is the Ground pin connected to the Ground pin of the Arduino. The next is the Trig pin AKA ‘Trigger pin’ which is an output pin. It is connected to the digital I/O pin-number 2. It provides the pulse due to which the sensor module emits high-frequency sound waves of 40kHz. The last pin is the ‘Echo pin’ which acts as the input pin. It sends the signal back to Arduino w.r.t the time taken by the waves to reach back the sensor.

Mathematical relation:

Velocity of sound wave in air (v) = 343m/s.

$$v = \frac{S}{\Delta t}$$

Where **S = distance travelled by the wave** and Δt = **time taken**

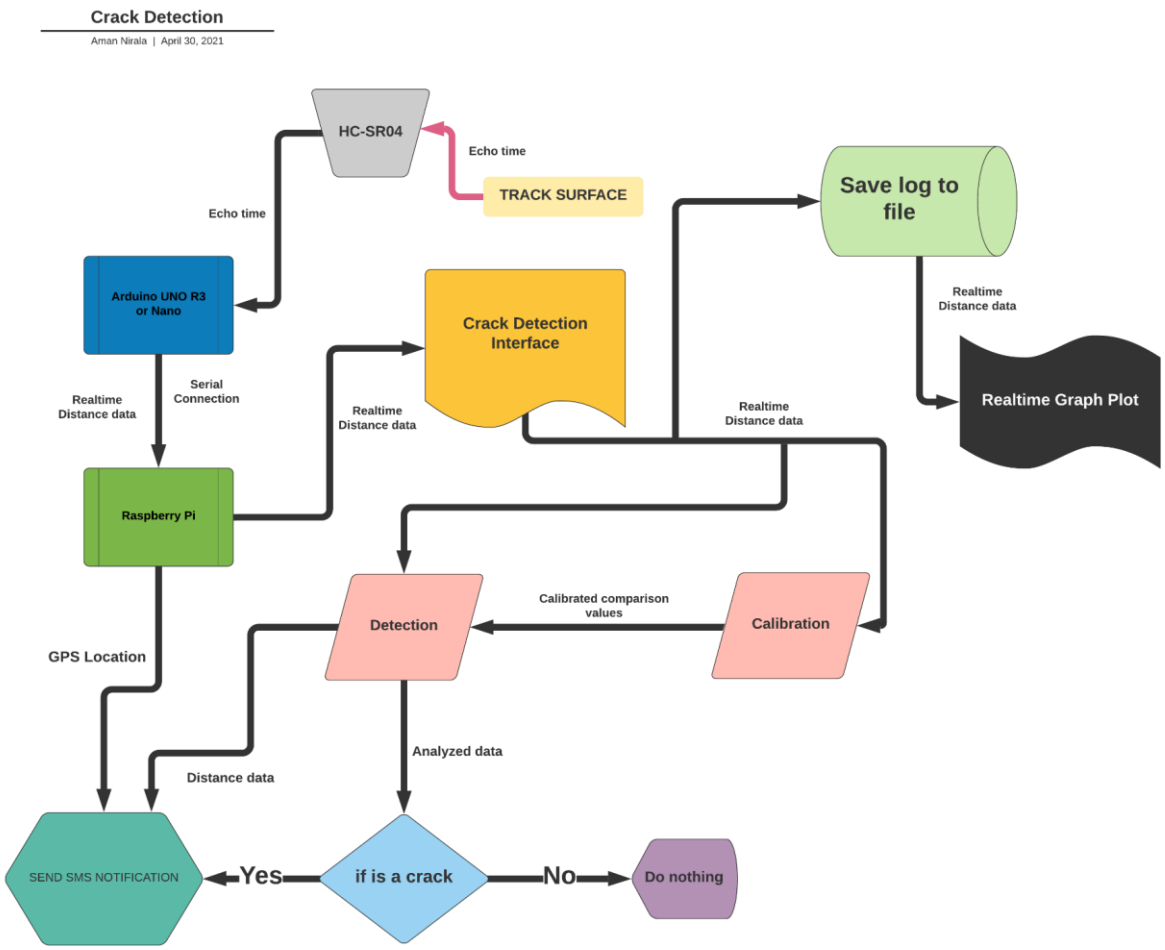
Since the wave does a round trip, the actual distance of the object from the source will be:

$$S_{actual} = \frac{S}{2}$$

Thus, distance of the object from the source of wave (**S**) is:

$$S_{actual} = \frac{\Delta t \times v}{2} \Rightarrow \frac{343\ (\Delta t)}{2} m \approx 170(\Delta t)\ m$$

Block Diagram (Fig: 2)



Arduino module

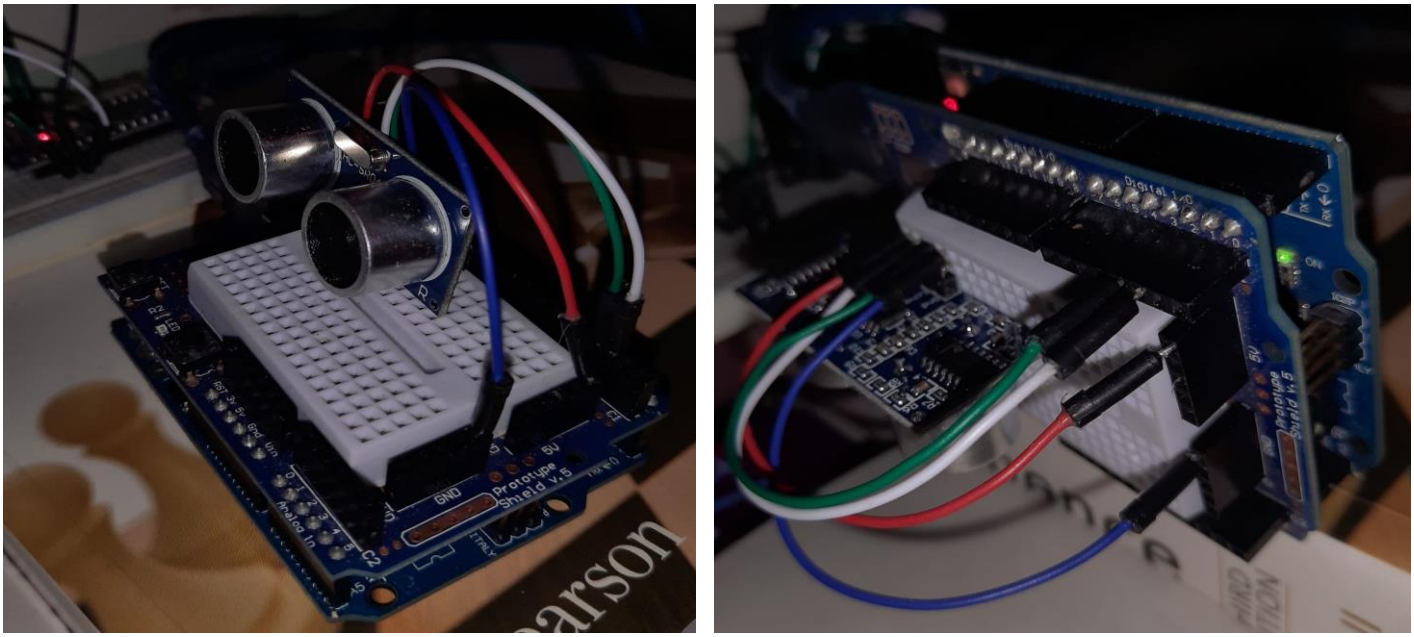


Fig 3: Arduino UNO with Prototyping shield and HC-SR04

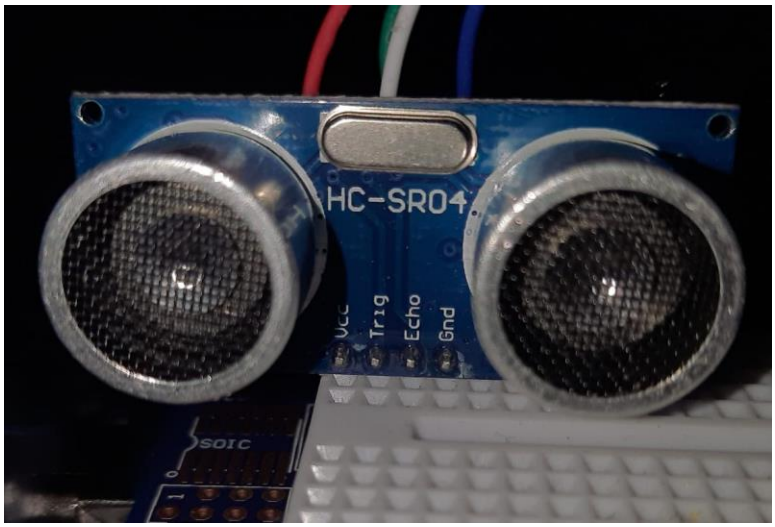


Fig 4: HC-SR04 sensor module

Result and Analysis:

-Result:

When the crack is detected on the track, an SMS is sent to the preferred number/portal by using a remote SMS client (will be using GSM modules in the future) and GPS service. The message contains a Google Maps link with the latitude and longitude of the place where the crack is detected.

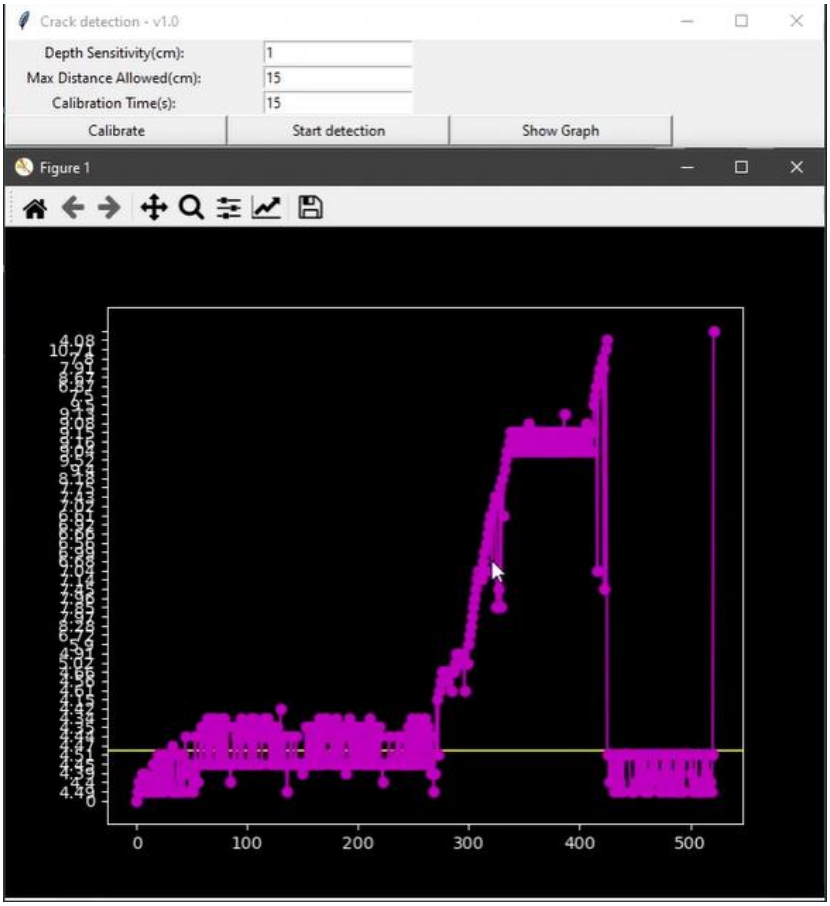


Fig 5: Live plot of reading from the sensor

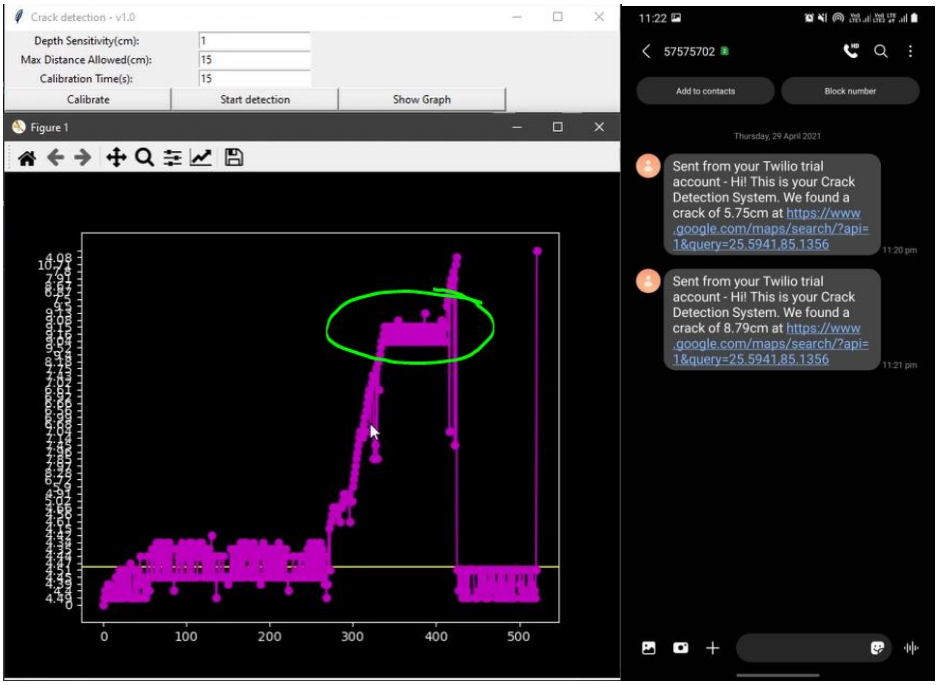


Fig 6, 7: Crack detected and an SMS is sent on our test number

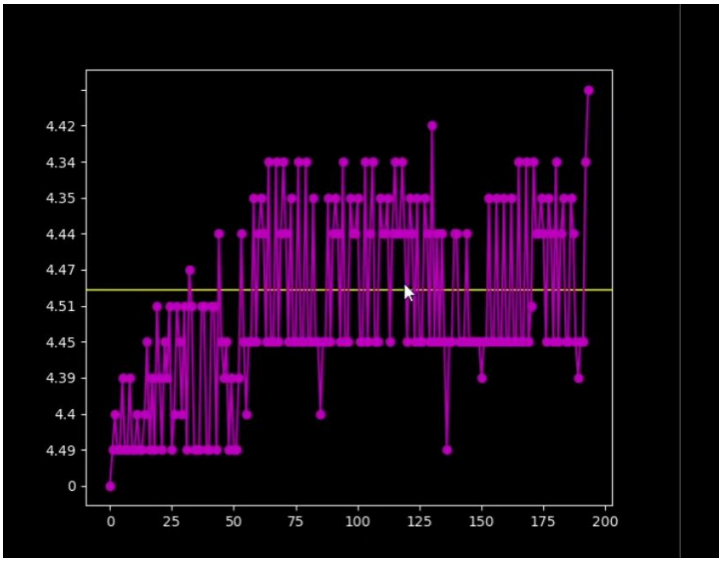


Fig 8: Few noisy readings which can be fixed by calibrating

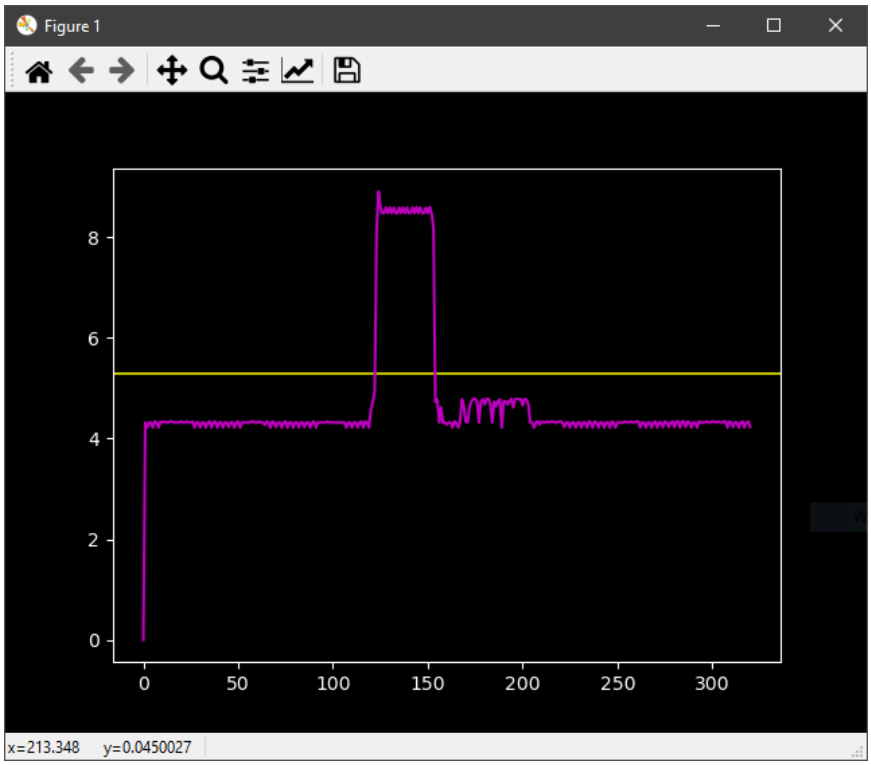


Fig 9: Output after error correction and calibration

-Analysis:

Advantages of Proposed System:

- Easy and automatic data collection that can be used for analysis and management.

- Enhancing the percentage of efficiency.

- Easy to maintain and low-cost hardware

- Less sophisticated mechanism

- Built on python which makes the client platform-independent and easy to maintain and develop further

- Versatile and easily scalable

- Ability to send alerts/warnings to particular train drivers.

Planned Work:

Currently, we are using the SMS-based system to deliver text messages regarding the cracks detected on the track. Moving further we will add a mobile device, web portal, and a cloud system to import the applied method and algorithm by shifting the workload from the edge to the cloud environment.

Conclusion:

In this paper, a method to distinguish cracks in rail route tracks has been introduced utilizing ultrasonic waves methods. The strategy replaces manual assessment of the track area, via programmed review. This will assist with cracks promptly and lessen the possibility of any mishappening. There will be less need for physical power, i.e., to manually detect every crack. Since the framework is automated and programmed, it will require less manual work and the utmost efficiency of the system can be ensured. This system can pinpoint the exact locations and send an immediate message in an economically accurate manner. In the following time, if applied at a larger scale, it will be time-saving and provide railways with a better safety system and effective testing infrastructure.

Source Code: https://github.com/amannirala13/Crack-Detection-System

References

[1] Karthick, N. (2017). Implementation of railway track crack detection and protection. *International Journal Of Engineering And Computer Science*. https://doi.org/10.18535/ijecs/v6i5.47

[2] Ghangale, A. M., Chakdhare, M. S., & Athawale, V. P. (2020). Crack Detection System for Railway Track Based Op-Amp with GSM Technique.