PROJECT REPORT
on
Detection and Correction of potholes

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Figure 1: *

DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATION
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CERTIFICATE

The report is submitted in partial fulfillment of the degree course of Bachelor of Engineering in Information Technology, of University of Mumbai during the academic year 2019-2020.

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1 ACKNOWLEDGEMENT

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Project Team

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2 ABSTRACT

The system will count the number of potholes present on the roads where the system is installed and upload the data to the database in real time. This identification and counting will be done by using image processing techniques. After the data is uploaded on the database a bot will be deployed to the site where the pothole is identified, for the filling of the potholes. The pothole will be filled using thermosetting plastics for quick and efficient repairs. The idea is of filling the pot holes before they get any bigger than threshold size. Small potholes (12 inches diameter ,2 inches depth) can be easily fixed using the thermosetting plastic. The fixing of the pothole will be done by the automated bot and after the work is complete, the information will be updated in the system. For the bigger potholes already present, the image processing software will distinguish it from the smaller potholes to be fixed by the bot, and a message will be sent to the right authorities for the filling of the bigger potholes and once the fixing is completed the information will be uploaded in the database.

3 INTRODUCTION

Traffic congestion has been increasing world-wide as a result of increased motorization, urbanization, population growth and changes in population density. Congestion reduces utilization of the transportation, infrastructure and increases travel time, air pollution, fuel consumption and most significantly, traffic accidents .There is an exponential increase in the population of Mumbai. As people live in far places from their offices they believe in commuting through road transport or trains. This has led to faster corroding of the roads. These roads if left attended cause huge traffic snarls, delays and accidents which can cause mental strain and in some cases can be fatal. At present there are various ways to detect the potholes either manually or automated. The main aim of our project is to detect the pothole automated and also repair it without us being present there. Along with that, our system is quite cheaper than other proposed systems. To reduce the potholes we have decided on a mechanism where it could simultaneously detect and store the data of the pothole in the database. For transmission of data we use LoRaWan module which can send data of the pothole in the database. Then it would send a robot without any manual assistance to that place to correct it.. This reduction of manual labor will also lead less in time consumption for the correction of pothole. In our system, Image Processing is an integral part of the detection of Potholes. Plus, for the transmission of the images and data we are using LoRa instead of zigbee, as LoRa can transmit data over longer ranges i.e. 10 kms. Also the project deals with the filling of potholes which hasn't been attempted earlier on, here instead of asphalt we are using chip filling which can greatly reduce the recurring of the filling. Also by using chip filling techniques we can reduce the carbon emission by the production of asphalt resulting in a greener world and environment. The project will improve the efficiency of road maintenance and reduce the labor requirement for the same.

3.1 What is a pothole?

A pothole is generally a depression or a crater on any type of road caused by the various extreme weather conditions and the continuous usage of the same road without any regular maintenance. The official Cambridge Dictionary defines a Pothole as "a hole in a road surface that results from gradual damage caused by traffic and/or weather". In other words, it is a depression formed in a road that could be a asphalt or a mud road

or any pavement.
A Pothole formation usually requires two factors to be present at the same time: water traffic.
The main reason behind the formation of pothole is water within the underlying soil structures and traffic passing over the affected area. Water weakens the soil layer beneath the road/pavement surface while traffic applies a huge pressure that stress the road surface past breaking point. Potholes can grow up to several feet in width, but they usually develop depths up to few inches. But when they grow deeper due to more and more tension from the load emerging from traffic) damage to tires, wheels, vehicle suspensions, etc. are liable to occur. Moreover, in some cases they can lead to serious road accidents, especially when to those roads where vehicles speeds are greater, say Highways.

3.2 Types of Pothole

i) Fatigue cracks:
It is one of the most common types of asphalt road potholes seen on the road. It is often presented in a cracking pattern which can have figure similar to the that of a crocodile scale or a spider web. This type of pothole is often the result of insufficient support in the underlying base structure and that is due to either insufficient design and construction or water penetration that has resulted in a weakened base.
When the crack is considered non-severe and remains relatively stable, a thin coat of crack reflection treatment is applied which is followed by an asphalt overlay of the cracked area.
The cases when the crack is more severe i.e exhibiting larger spaces between the cracks suggesting more movement, the area should be sawcut, excavated or milled. The base structure should be repaired and then the asphalt be replaced.
The overlay repair is the least costly, but tends not to last as long as the removal and replacement option.


Fatigue Failure

ii) Blowout: This type of pothole is created when in an extreme case, the whole of the base structure is blown or destroyed. These types of failures suggest an underlying lack of support within the base structure itself.
Blowouts often requires extensive base repair or reconstruction. Given the seriousness of the pothole, it is crucial to ensure that the main cause is identified and repaired along with the failed area. More often than not, these types of failures are "fixed" without the main cause being addressed, only to fail again.
Therefore we can see that there is always a lack of underlying base support within the base structure itself. So more often than not the entire base of the road is to be reconstructed again
and is often subject to various sub-grade stabilization techniques, such as cement sub-grade stabilization and/or Geogrid placement.

 Blowout Failure

iii) Reflection Pothole:
It is caused when a fresh new road is made above the underdeveloped or the cracked existing road. This causes an existing weak base of the new road and thereby accelerating the speed of the process of erosion and pothole formation very fast. This is typically the result of the original pavement structure and the overlay moving relative to each other. It tends to wear on the underside of the new asphalt and work its way upward to the surface, resulting in a crack in the new asphalt that is identical to the crack underneath. The severity of the pothole can be reduced by using BST treatment or certain types of geo-Fabrics. We can also change the rate of the reflection by adding various substances like Bituminous Surface Treatment (also called chip-fill), applying a bitumen non-woven geo-textile fabric, or replacing the worst areas of fatigue prior to an overlay. Thus we can say that the greater the thickness of the asphalt layer, the longer it takes the reflection to take place

Crack and Reflectiont Failure

iv) Sink Hole:
Sink Hole generally occurs in the places where there is a lot of drainage system or any underwater or underground body. The sink hole is caused when the base is fully eroded by drainage or other various underground processes. It is also observed that these type of sinkholes are also found in the places where there is a sharp change in the elevation of the surface. It is more serious as it can be totally caved in overnight. It is also seen that sink holes are created in places where there is heavy traffic as thee bitumen experiences a lot of pressure from the vehicles and these vehicles continuously erode the rode creating a sink hole. It is crucial to ensure that root cause is properly identified and repaired while repairing the sinkhole itself. Often times these types of failures can be caused by plumbing, sewer, or drainage leaks. Additional causes may be drainage avenues opening along laid utility lines underground.


Sinkhole Failure

v) Block Cracks:
These are also called as shrinkage cracks and present themselves in a linear fashion and at very different angles. These types of cracks are often present in the older asphalt roads and the roads where there is light traffic. It is because the asphalt shrinks horizontally and little to no stress is applied in the vertical way. The simplest way to correct is to fill it with and sealed with a hot pour crack filler material to prevent

water penetration.

 block Failure

vi) Rutting:

It is one of the basic types of potholes. It is caused due to the road being not able bear the weight of the cars and slowly corroding itself from the base. It most often occurs in fatigued drive lanes, or close to overly stressed areas such as at stop signs, or in front of dumpster pads.

 Rutting Failure

xvii) Linear Cracking:

It is caused when the water gets absorbed by the cracks present in the road. The absorption causes the road to be weakend from the base, therefore making the surface asphalt to bear most of the weight of the automobiles and greatly reducing the load bearing capabilities of the road. The combination of these factors result in the faster erosion of the surface asphalt. Generally, these areas typically present cracking that is often referred to as alligator cracking or spiderwebbing as they show spider web or alligator scale type cracks.

 Linear Cracking Failure

xviii) Raveling:
They tend to occur in the places where the roads are old and the asphalt gets oxidized so that it starts to separate itself from the bed of rocks present underneath the road. As more and more the contact between the asphalt surface and the road gets reduced, the surface asphalt bears most of the weight of the automobiles and after some time cracks and deformities start to appear on the road. The basic type of repair for this type of situation is to overlay the raveling asphalt with a new layer of fresh asphalt. Generally, a 1.5" to 2" of new asphalt is recommended.

 Raveling Failure

ix) Slippage Cracks:
When fatigued areas are continuously exposed to raid, runoff, traffic, etc. the trand between the cracks increases, which leads to loose pieces of asphalt being forced out of the failure areas which further exposes the underlying surface and creates a pothole.

This further perpetuates the problem because it exposes more of the bottom to more water and thus allows a better amount to flow underneath the pavement, weakening a bigger area of base and thus it spreads the general fatigue throughout the lot

 Slippage Failure

x) Shoving/Corrugation:
The corrugations where the surface asphalt has been "shoved" or bunched up are known as Shoving or Corrugation. It's more often the resultant of extreme horizontal stress that is caused when having traffic loads typically start or stop.
The most common way to repair these areas is to perform full-depth repair. This exposes the bottom, with any base weakness to be repaired

 shoving and Corrugations Failure

xi) Seam cracks:
Cracks that are developed along the joints of asphalt where difficult paving pulls come together, is known as a Seam. These cracks usually exhibit themselves as long linear cracks that should regularly be crack-filled.
If these cracks are left unsealed of unfilled, they can become central points for fatigue as water steeps under pavement. Once a seam crack open wider into a fatigued area, it should be treated as a fatigue area because adequately sealing these types of cracks is quite difficult.

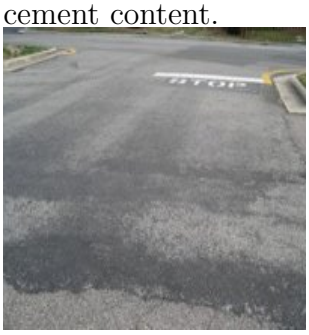
 Seam Cracks Failure

xii)Peeling:
Pavement that had previously been overlaid with asphalt and the asphalt layer has begun to fail as a result of underlying fatigue "reflecting" up through the overlay layer results in peeling.
Peeling usually occurs many years after the overlay has been installed. This overlay layer oxidizes and then becomes brittle and much more susceptible to the underlying fatigue cracking throughout. When the fatigue failure has reflected through more and more, the overlay then exhibits the identical fatigue failure as that of the underlying asphalt.
The overlay pieces tend to break free, which exposes the original, fatigued asphalt beneath it.
The best way to permanently repair these cracks is a complete removal and replacement of the entire failed area along with the underlying fatigued asphalt.

 Peeling Failure

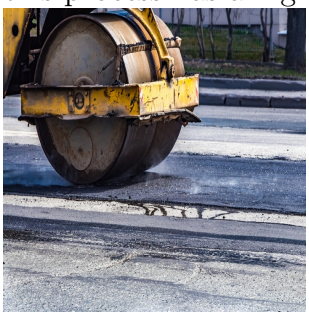
xiii) Bleeding:
When the asphalt contains too much asphalt cement relative to the aggregate, it results in Bleeding. The asphalt cement, in these cases, tends to "bleed" thorough the surface. These issues are typically still in function but they have an unsightly appearance to the pavement. Typically, these areas are repaired either by applying a chip seal application using absorbent aggregate or by milling the top layer of asphalt and then

applying a new course of hot mix asphalt that contains a lower asphalt cement content.

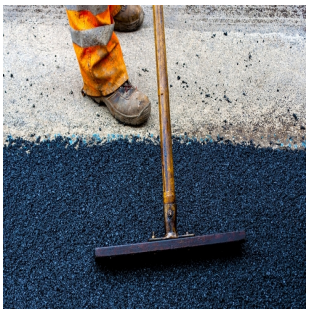
 Bleeding Failure

3.3 Types of existing pothole repair methods:

i) Throw and roll repair:
It is one of the basic methods of reconstruction of road. In this the the pothole is filled with the asphalt and then it's being rolled over by heavy vehicles/automobiles. This is generally a temporary pothole relief but this process has a high failure rate.

 throw and roll repair

ii) Throw and Go Method:
This is also one of the most common type of pothole repairing as it is very easy to implement. Along with that it is the cheapest method. In this, the pothole is filled with the asphalt and a person with the help of a shovel levels up the pothole. The main disadvantage of this process is that it is a temporary solution and it can be easily eroded with strong winds and rains.


Throw and Go repair

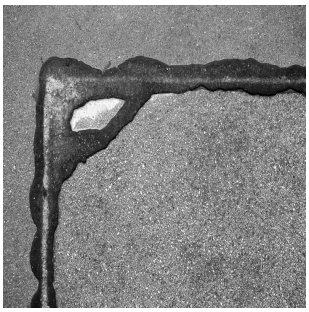
iii) Semi Permanent Pothole Repair method:
It is generally one of the better methods of pothole repairing techniques. In this, the first step is to remove the debris, water, sand and gravel from the pothole to make it clean. The next step is to clean and trim the sides of the pothole so that there is no sharp wedge in it. Now, we have to put the patch (filling substance such as asphalt). Now after putting the patch, it is to be pressed by using vibrating plates or rollers. It is important that the patch area should be greater than the vibrating plates as due to the pressure the patch gets compressed and shrinked.


Semi Permanent Pothole Repair

iv) Spray Injection Hole Repair:
In this the first step is to clean and clear all the debris present in the pothole by blowing out. Next is to spray the sides of the pothole with a substance called binder tack coat. Next is to blow and put the aggregate and the asphalt on it and then covered the repair section, after sometime again coat it with a layer of aggregate.


Spray Injection Hole Repair

v) Using Edge seal to repair the pothole:
This method involves using the throw-and-roll repair and then filling the pothole. Once the hole is fully filled then it is compressed with the help of a heavy machinery. Once this is done, done a asphalt tack ribbon is used to connect and join the road and pavements so that there is no gaps present in between them and this material overlaps the border. Next put some sand on the tack so as to prevent the tracking of wheels of the car.


Using Edge seal to repair the pothole

vi) Full Depth Roadway Hole Replacement:
It is the best type of pothole repairing techniques for the old roads. It is uses both, the old asphalt as well as the new asphalt as the filling of the pothole. It is involves pulverizing of the old asphalt and then mixing it with the water and cement. Next it is compressed and compacted to produce a base for the new concrete and asphalt block.
The most important thing of this process is that we have to fully remove the old road and then replace it with the new one.


Full Depth Roadway Hole Replacement

vii) Using the Cold-lay Pothole Repair Method:
It involves applying a cold-lay material by gradually layering it into the pothole. As every layer is formed and compressed the durability and the strength of the pothole is increased. One of the merits of these type of repairing is that it can be used immediately after the repairing is complete.


Using the Cold-lay Pothole Repair Method

viii) Hot-work Repair method:
This is a permanent pothole repair method that's exceptionally durable. It uses heavy machinery to heat and compress it. As it cools, it hardens and solidifies its bond with the liquid asphalt in the surrounding area.


Hot-work Repair

4 OBJECTIVES

i) The objective of this study is to firstly create a completely autonomous robot which can be deployed unmanned and automatically to the specific position.
ii) The second thing is that it should be able to work hassle free and without it being a nuisance to other vehicles.
iii) The idea is that the bot is able to detect and correct the pothole alongwith updating the database continuously.
iv) Another objective is to create a bot which can be used to review and analyze the road and predict when the road's condition might deteriorate.
v) The CCTv cameras installed will also help us detecting criminal activities or accidents more clearly.
vi) Next it would check the depth and the width of the pothole using image sensors and finally fill it up with thermosetting plastics (chip fill) that will be heated by a heating object like blowtorch.
vii) Using of a material that is not a non-renewable source.

5 LITERATURE SURVEY

noindent
We know that the potholes are a nuisance to the society and well being of the humans. Several measures have been taken in reducing the number of potholes or detecting it to make the driver aware of the potholes aware of it beforehand. In one such case, a camera was used to detect any erosion on the roads by using various image processing techniques like Canny Edge detector, dilation and contouring. It was quite portable as there was a reduction in non-portable objects as computers were used. Since image processing was used it was relatively faster than any other previous processes. The system produced an average accuracy, sensitivity, and specificity within the expected output and the success rate of sending reports of detection was found to have no errors. The value of the accuracy achieved during the testing showed that the systems was excellent in terms of the overall performance[1]. Another idea was presented with an integrated approach to road distress identification. In this the most important thing was a set of multiple algorithms working synergistically for a common goal. By adjusting and changing various functions like pixel, sub-image or object and the number of signals to be processed, they were able to achieve robust performance and computational tractability[2]. For another paper suggested the use of 2D LiDAR and camera for a pothole detection system. It used specifically 2 LiDARs so as to scan the wide road more accurately. After that they developed the system algorithm including filtering clustering, line extraction and gradient of data function. Error rate of pothole detection system shows the performance of developed system. One of the novel things was that 3D pothole detection can be performed using 2D LiDAR. Pothole detection using video data is combined with that of 2D LiDAR, and combined data gives more accurate pothole detection performance[3]. In another paper the problem was tackled by designing a Wi-Fi based infrastructure enabling application data transfer to the vehicles moving on the roads. In this method the driver is given early notifications on the roads condition so as to assist the driver in making strategic and real time tactical decisions in varied environments. The architectural design and system support for the pothole detection and warning system ensured that the driver gets information about potholes well in advance and has sufficient time to take decision according to the prevailing road conditions[4]. In another paper,it countered the problem by using a ultrasonic senor for the pothole detection and Zigbee mod-

ule pair for communication. The proposed model uses NXP LPC1768 microcontroller for taking decisions about controlling the speed of the vehicle. It's main aim was to achieve proper and efficient detection of pothole and communication between multiple vehicles. Zigbee was used for multi-vehicular communication establishment. Pothole detection is an important feature of the autonomous vehicles and this idea can be extended to detect vehicles in the vicinity and any type of obstacles on the road[5].Another method describes accelerometer data based pothole detection algorithms for deployment on devices with limited hardware and software resources and their evaluation on real world data acquired using different Android OS based smart-phones. The evaluation test resulted in optimal setup for each selected algorithm and the performance analysis in context of different road irregularity classes show true positive rates as high as 90 percent[6].

Thus, we have seen all these papers that Image Processing is an integral part of the detection of Potholes. Plus, for the transmission of the images and data we are using LoRa instead of zigbee, as LoRa can transmit data over longer ranges i.e. 10 kms. Also the project deals with the filling of potholes which hasn't been attempted earlier on, here instead of asphalt we are using chip filling which can greatly reduce the recurring of the filling. Also by using chip filling techniques we can reduce the carbon emission by the production of asphalt resulting in a greener world and environment. The project will improve the efficiency of road maintenance and reduce the labor requirement for the same.

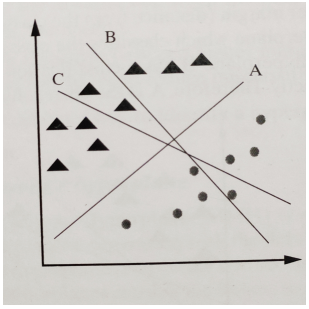
Author/year	Applications used	Merits
Mae M. Garcillanosa /2018	RPi, image processing, cloud storage	Image processing very fast, very portable and efficient
David H. Gill/1997	Detectors ,line trackers, hough transform	integrated approach to road distress identification, robust performance and computational tractability
Su il-Choi/ 2017	2D LiDAR, camera, OpenCV	wide area of the road scanned efficiently, more accurate pothole detection performance
Sudarshan Rode/2009	Wi-Fi based architecture, GPS module	assist in making strategic and real-time tactical decisions
Artis Mednis, Girts Strazdins /2011	Android OS, accelerometer sensors,GPS module	Detects different road irregularity classes show true positive rates as high as 90%

Comparision

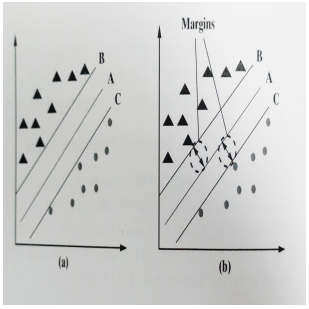
6 METHODOLOGY

6.1 Support Vector Machine

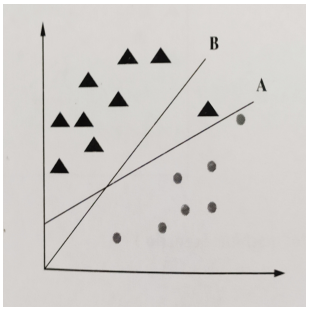
SVM(Support Vector Machine):SVM is a model that can do linear classification as well as regression. SVM is based on the concept of a surface called hyper plane which draws boundary between data instances plotted in the multi dimensional feature space. The output prediction of an SVM is one of two conceivable classes which are already defined in the training data.
Classification using Hyper Plane:In SVM a model is built to discriminate the data instances belonging to different classes. We are doing binary classification in pothole detection. So we have only two labels .pothole or not a pothole. In this case when mapped in two dimensional space the data instances belonging to different classes fall in different sides of a straight line drawn in the two dimensional space. In other words the goal of SVM is to find a plane or rather a hyperplane which separates the instances on the basis of their classes. In Summary, in the overall training process, SVM algorithm analyses input data and identifies a surface in the multi dimensional feature space called the hyperplane.
Support Vectors: Support vectors are the data points (representing classes) the critical component in the a data set, which are near the identified set of lines (hyperplane).
Hyperplane and Margin: For an N dimensional feature space hyperplane is a flat subspace of dimension(N-1) that separates and classifies the set of data. Mathematically in a two dimensional space a hyperplane can be defined by the equation: c0X+c1X1+c2X2 = 0 which is nothing but an equation of straight line.
Identifying the Correct HyperPlane in SVM : There are 4 major scenarios to be considered for identifying the correct hyperplane in SVM.
Scenario 1:
we have three hyperplanes A, B, C. Now we need to identify the correct hyperplane which better segregates the two classes represented by triangles and circles . As we can see hyperplane A has performed this task well.



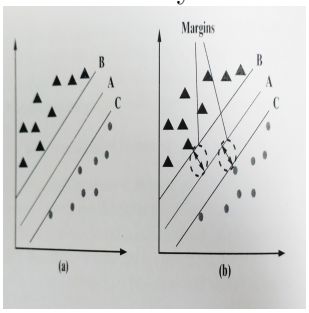
Scenario 2:
we have three hyperplanes A, B, C. Here maximizing the distances between the nearest data points of both the classes and hyperplane will help us decide the correct hyperplane. This distance is called as margin. You can see that margin of Hyperplane A is high as compared to those of B and C. so Hyperplane A is a correct hyperplane.



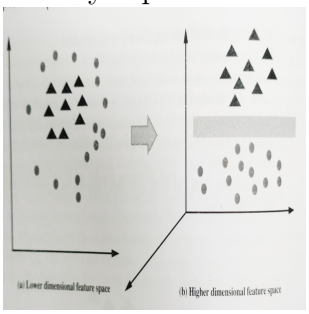
Scenario 3:
Here it seems that B is a correct hyperplane due to higher margin than A . But here is a catch, SVM selects hyperplane which classifies classes accurately before maximizing the margin. Here B has the classification error and A has classified all data instances correctly so A is the correct hyperplane.



Scenario 4:
In this scenario it is not possible to distinctly segregate the two classes by using a straight line as one data instance belonging to one of the classes lies in the territory of the other class as an outlier. SVM has the feature to ignore outliers and find the hyperplane that has maximum margin. So we can say SVM is Robust to outliers.



Kernel Trick: The data can also be non linear sometimes. SVM has a trick to deal with non linearly seperable data .There are functions which can transform lower dimensional input space to a higher dimensional space. In the process it converts linearly non separable data to a linearly seperable data . These Functions are called Kernels.



There are 4 main common types of kernels:
1.Linear Kernel: it is in the form $K(xi, xj) = xi.xj$
2.Polynomial Kernel: It is in the form $K(xi, xj) = (xi, xj + 1)^d$
3.Sigmoid Kernel: It is in the form K(xi,xj) = tanh(kxi.xj-eta)
4.Gaussian RBF Kernel: It is in the form K(xi,xj) = e(-xi-(xj)^2)/(2(A)^2)

6.2 SVM Algorithm

Step 1: selection of two classes on which classification has to be done.
Step2: Boundary plane is drawn between the two classes .(Hyperplane)
Step3:Find the Optimal hyperplane.
Step4: Data is classified using the correct hyperplanes and Input training data
Approach:
Step 1: Features of pothole are obtained by using Open CvLibrary in Python through corners and their histograms
Code Snippet:

```
defHarris_Corner_Detection(image):
gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
gray = np.float32(gray)
dst = cv2.cornerHarris(gray,2,3,0.04)
dst = cv2.dilate(dst,None)
image[dst>0.01*dst.max()] = [0,0,255]
return image
deffd_histogram(image, mask=None):
    # convert the image to HSV color-space
    image = cv2.cvtColor(image, cv2.COLOR_BGR2HSV)
    # compute the color histogram
hist  = cv2.calcHist([image], [0, 1, 2], None, [bins, bins,
bins], [0, 256, 0, 256, 0, 256])
    # normalize the histogram
    cv2.normalize(hist, hist)
hist.flatten()
```

Step 2: Now a dataset of images is created and by that dataframe is

created using pandas library in Python.
Step 3: The whole dataframe is used for SVM Classifier's Training.
Step 4: After the model is trained we get SVM classifier for pothole detection.This SVM model will detect pothole if any found through the camera attached to the Bot.
Step 5: Once the Pothole is detected the Bot will approach towards the pothole and then by detecting depth through LIDAR the pothole will be filled by the Bot to that depth .
Step 6: After repairing the Pothole the Bot will move from that site and keep looking or searching for other Potholes using Servo Motor(Tracker) and Camera attached to it .
Step 6: After repairing the Pothole the Bot will move from that site and keep looking or searching for other Potholes using Servo Motor(Tracker) and Camera attached to it .

6.3 Why SVM when there are many machine learning Algorithms?

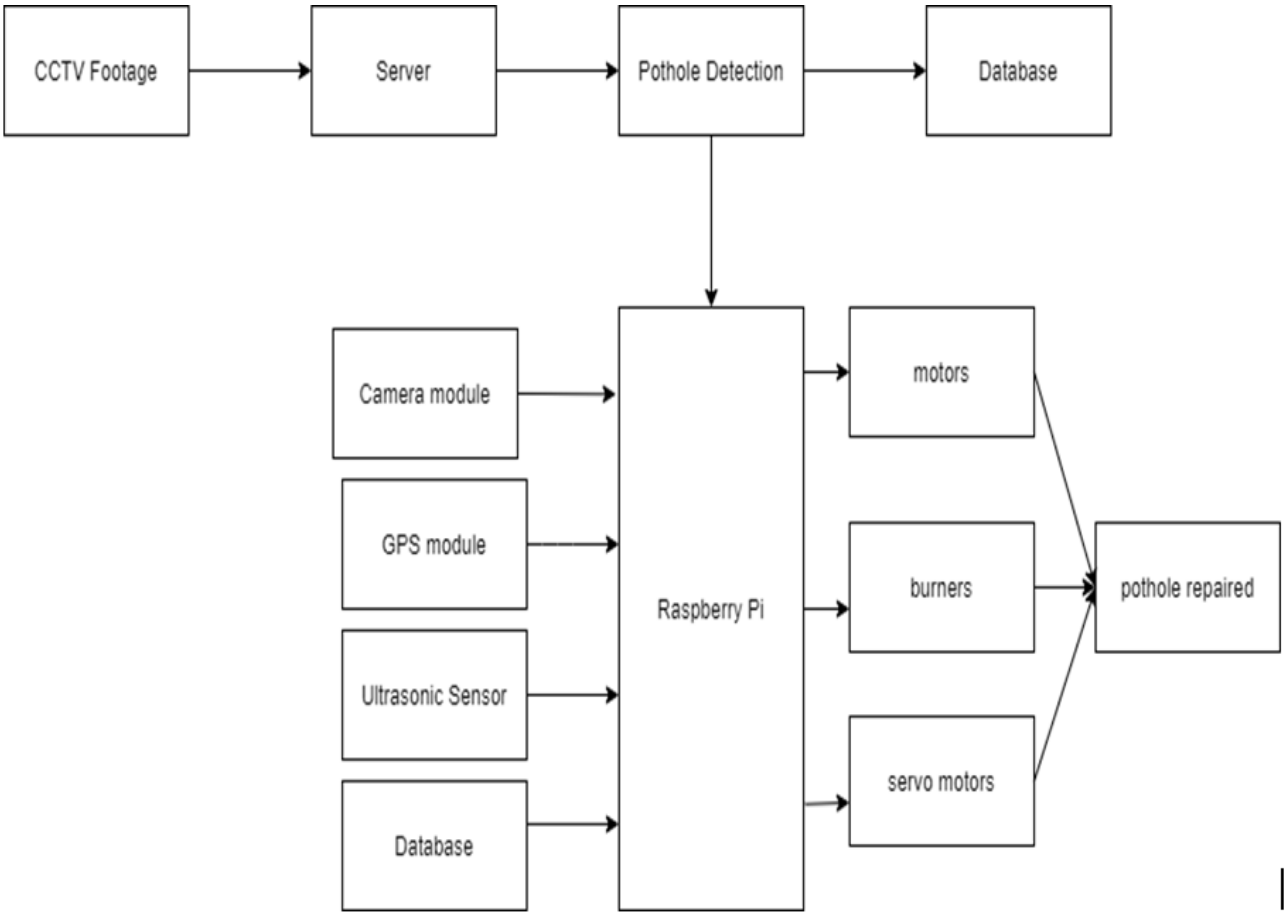
There are 4 major Reasons for this:
1. The image of a pothole is very complicated .Roads are usually dark gray in color or almost similar to black. It is very difficult to track a black object in a black coloured road by image processing algorithms .so basically in short there are many outliers in a pothole Image and data is non Linear. SVM is Robust and is not much impacted by data with noise and outliers. Due to this SVM excels among all the other machine learning algorithms.
2. It is very accurate compared to other Algorithms. The predictions results using this model are very promising.
3. Pothole detection is a binary classification problem. SVM excels in Binary classification.
4. For detecting a pothole accurately on the Road, the dataset for training should be huge. SVM runs efficiently on large and expensive Datasets.

6.4 Flowchart of the bot

Explanation
Step 1:The bot monitors the area around it in search of Potholes with the help of camera mounted at the top of servo Motor.
Step2:The frames from the camera are captured real time using Open CV image processing Library. This images are passed through SVM model. As soon as an image of pothole is passed the model predicts it accurately and gives the feedback that the image is of pothole. If the image is not

pothole then again the Bot starts monitoring.
Step3: After the image is detected then the distance of the pothole from the bot is calculated using simple mathematics and image processing operations. After that the Bot approaches the Pothole.
Step4: After reaching the spot Bot calculates the depth of pothole using ultrasonic Sensor. After that it fills the pothole upto its depth and process is complete. This whole process is repeated when another pothole is detected

7 SYSTEM ARCHITECTURE



System Architecture

Steps:
1. CCTV Footage:- A CCTV takes the footage of the surrounding area, i.e a specific part of the road. It sends images of the section of the road in specific intervals to the server via LoRA.
2. Server:- The main server where the pothole detection model is, so basically it gets the video fro the CCTV and runs it in the SVM model to see if there is a pothole in the sent video.
3. Pothole detection:- It is done using trained SVM model. Once the pothole is detected, it is updated in the real-time database so that the bot can go to the desired location.
4. Database:- This is the real-time database of the whole system. It gets updated with the location and size of the pothole by the server.

5. Camera module:- The camera module on the bot is used to detect the pothole at the exact location when the bot is on the field. It is used for distance calculation and depth calculation.
6. GPS module:- It is installed in the bot to get the general location of the bot, also so that the bot finds its way to the exact location of the pothole.
7. Ultrasonic Sensor:- It is used for collision detection and depth detection. Ultrasonic sensors are cheap and can be used fairly easily for collision detection. For depth detection like of a pothole, which has an irregular surface, LiDAR can be used but it is an expensive alternative.
8. Raspberry Pi:- It is the heart and brain of the system. It's the main controller.It runs the bot and has the image processing model in it for pothole detection. Also, it helps in the maneuvering of the bot from one place to another, i.e, collision detection and moving the bot to exact coordinates. It also calculates the distance of the pothole from the bot. It also, the amount of material needed for filling the hole and the depth of the hole.
9. Motors:- It is used for the movement of the bot. These are high power, high RPM, High torque motor so that the bot can move around with its weight at a fair speed.
10. Burners:- These are used to heat up the thermosetting plastic, heat, and the flame is regulated by the Raspberry Pi.
11. Servo motor:- These are used for controlling the valve of the material container so that the exact amount of material can be used.

8 CHIPFILL THERMOPLASTIC

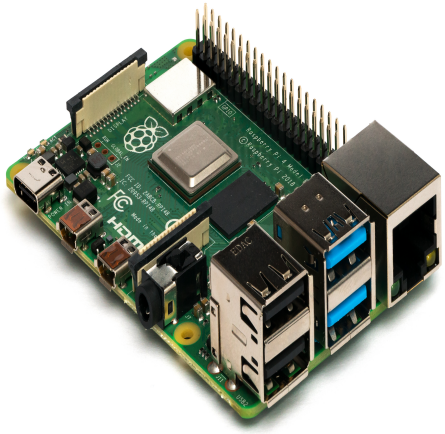
A thermoplastic, is a plastic polymer material that becomes pliable or moldable at a certain elevated temperature and solidifies upon cooling. They form polymers form when repeating units called monomers link into chains or branches. ChipFill is a specially developed thermoplastic for repairing road surface defects. The thermoplastic in the form of granules is poured into a clean and dry pothole and melted. Hot thermoplastic flows even into the smallest cracks just like water. Whether the surface is asphalt or cement-concrete, the material adheres to it perfectly. The road can be used by traffic after approximately 15 to 20 minutes. The advantage is it can be applied all year round. Features:

- Year-round application
- Quite Eeasy to use
- It has excellent fluidity so hot thermoplastic flows into the smallest joints.
- After applying the chip fill it takes around 20 mins for the road to be used.
- Without the use of heavy equipment (just a broom, burner and 2 hands)
- Minimal risk of further surface degradation
- Better adhesion to the road (thermoplastic bonds with asphalt)
- Effectively prevents further water penetration
- Conventional gravel can be applied on top of this to increase grip
- Especially recommended for repairing defects where different materials connect eg drainage channel
- Tidy job
- Lightness of material
- Ecological

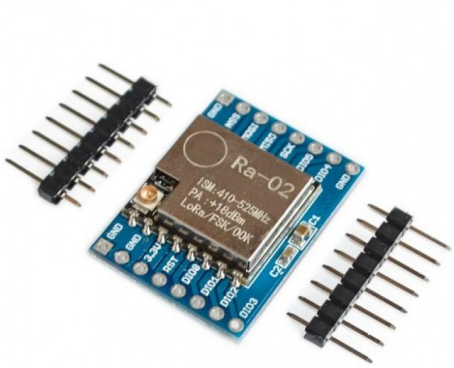

Geyeko Markings

9 HARDWARE REQUIREMENTS

1. RASPBERRY PI ZERO:
The RaspberryPi Zero is a largely reduced size of only 65mm long by 30mm wide. With the addition of wireless LAN and Bluetooth, the Raspberry Pi Zero W is ideal for making embedded Internet of Things (IoT) projects. The Pi Zero is designed to be as flexible and compact as possible with mini connectors and an unpopulated 40-pin GPIO.At the heart of the Raspberry Pi Zero W is a 1GHz BCM2835 single-core processor with 512MB RAM.Raspberry pi zero will be the brain of the pothole repairing Robot. It will receive inputs from LoRa , motor driver and sensors and will control the robot based on the inputs from the devices.

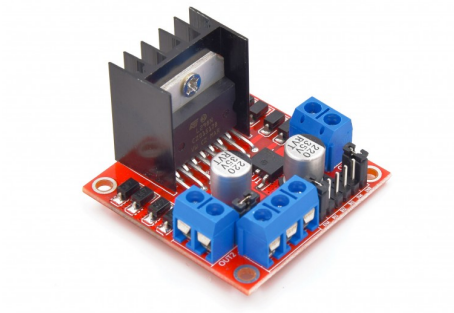


2. LoRa MODULE:
LoRa is a 'Long Range' low power wireless standard intended for providing a cellular style low data rate communications network.
The LoRa modulation and radio interface has been designed and optimized to provide exactly the type of communications needed for remote IoT and M2M nodes.LoRa module will used for wireless communication between the raspberry pi and the data transceiver.LoRa module will receive the data from the data transceiver (camera) and will supply it to Raspberry pi.



3. MOTOR DRIVER:

The Motor Driver is a module for motors that allows you to control the working speed and direction of two motors simultaneously. DC motors requires 9v and more current that raspberry pi is not able to provide . Due to that motors cannot be controlled just by raspberry pi. So motor driver will be used to drive the motors that supplies enough current to them.



4. DC MOTORS:

DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common

types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electro-mechanical or electronic, to periodically change the direction of current flow in part of the motor. DC motors will be used to drive the robot.

5. SERVO MOTOR:

As we know that an electric motor can be utilized as servo motor if it is controlled by servomechanism. Likewise, if we control a DC motor by means of servomechanism, it would be referred as DC servo motor.The motors which are utilized as DC servo motors, generally have separate DC source for field winding and armature winding. The control can be archived either by controlling the field current or armature current. Field control has some specific advantages over armature control and on the other hand armature control has also some specific advantages over field control. Which type of control should be applied to the DC servo motor, is being decided depending upon its specific applications.This motor gives angular control of the shaft. So this will used to control the movement of burner that will be used to repair the pothole up and down.

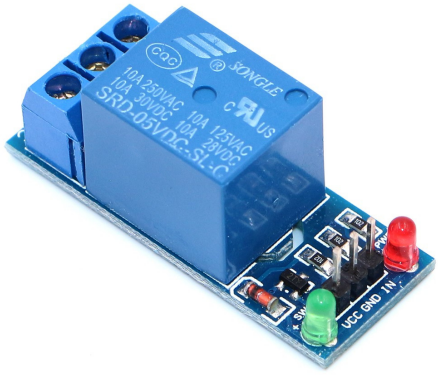
6. CAMERA MODULE:
The Pi camera module is a portable light weight camera that supports Raspberry Pi. It communicates with Pi using the MIPI camera serial interface protocol. It is normally used in image processing, machine learning or in surveillance projects. It is commonly used in surveillance drones since the payload of camera is very less. Apart from these modules Pi can also use normal USB webcams that are used along with computer.. This Module will be used to detect a pothole on the road. Camera module will supply the necessary data required to detect a pothole.

7. BURNER MODULE:
This module will be used to melt the chip fill and fill the pothole.

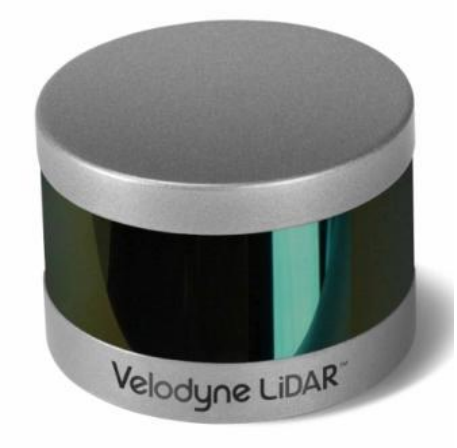
8. RELAY MODULE:

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof.

Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal. Relays were first used in long-distance telegraph circuits as signal repeaters: they refresh the signal coming in from one circuit by transmitting it on another circuit . This module will be used to drive the burner as Rasberry pi would not be able to supply sufficient current to the burner to drive it.



9. LiDAR:
which stands for Light Detection and Ranging, is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. It is used here to detect the depth of the pothole.



10 SOFTWARE REQUIREMENTS

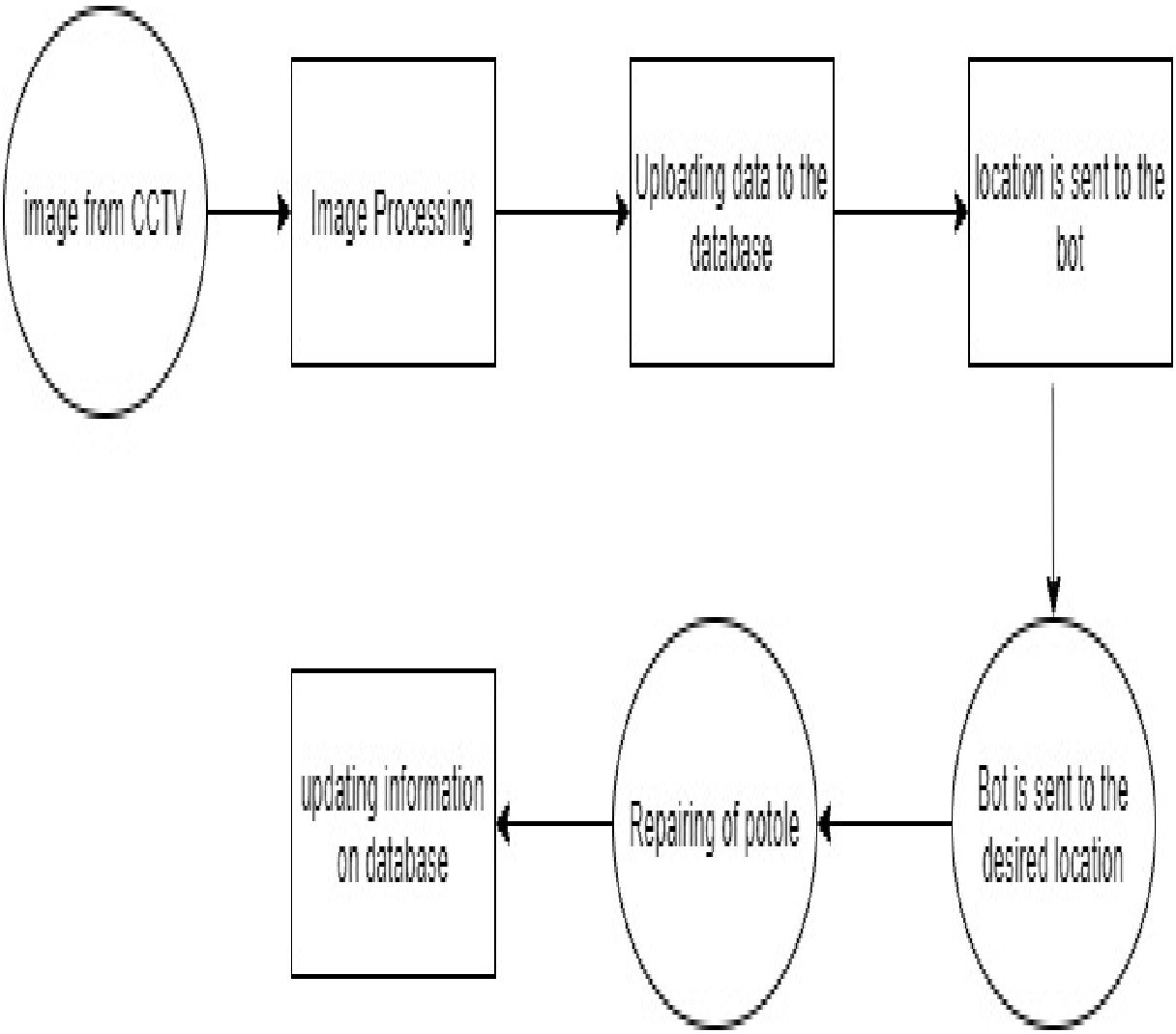
1. PYTHON IDLE 3.7.4
IDLE (Integrated Development and Learning Environment) is an integrated development environment (IDE) for Python. IDLE can be used to execute a single statement just like Python Shell and also to create, modify and execute Python scripts. IDLE provides a fully-featured text editor to create Python scripts that includes features like syntax highlighting, auto-completion and smart indent. It also has a debugger with stepping and breakpoints features.

2. JUPYTER NOTEBOOK
The Jupyter Notebook is an open source web application that you can use to create and share documents that contain live code, equations, visualizations, and text.
Jupyter Notebooks are a spin-off project from the IPython project, which used to have an IPython Notebook project itself. The name, Jupyter, comes from the core supported programming languages that it supports: Julia, Python, and R. Jupyter ships with the IPython kernel, which allows us to write our programs in Python, but there are currently over 100 other kernels that we can also use.

3. PANDAS LIBRARY
This is library for making different sorts of dataframe from data. Rows and Collumns of dataframe and database can be easily accessed using this Library.

4. OPEN CV
This library is used for image Processing and machine vision . In our bot this library will be used to extract Features from Array of Images.

11 BLOCK DIAGRAM OF THE WHOLE MODEL



12 RESULTS

It can be inferred that:
Robot can successfully detect the pothole by Image Processing. So we can say SVM has been successfully Trained.
Robot can successfully calculate the distance of the pothole from it by mathematical equations and image processing.
Robot can successfully repair the pothole in fast and accurate manner.
Robot successfully monitors the area by an angle of 360 degrees in 3D space .so at any an angle pothole is located the bot will be able to find and repair it.
Robot works in fully Autonomous Mode . That means there is no human interference while Robot is operating . Robot spots the pothole goes to it and then repairs it.
Robot Operates in 5 Steps :
1. Robot identifies the Pothole
2. Robot calculates the distance of the pothole and goes near to it.
3. Robot calculates the depth of the pothole using LIDAR sensor
4. Robot then starts filling the Pothole until its completely filled upto its depth
5. Then Robot starts moving randomly in autonomous manner in order to look for other Potholes. It also has ability to randomly stop moving sometimes and keep scanning in order to accurately identify a pothole.

13 CONCLUSION AND FUTURE SCOPE

13.1 Conclusion

The proposed system is a completely autonomous vehicle capable of traversing through streets, it can detect road signs and can detect obstacles in its path LiDARs and react accordingly. Irregularities on the road i.e. the potholes are detected and Cold Lay Asphalt Material is dispensed on the affected area thus making the road smooth and pothole free. This is whole process is fully automatic. This will also result in the decrease of heavy machinery used for repairing and will also reduce the expenditure.

13.2 Limitation

Although there are a lot of significant upgrades wit the current system,our system has a few limitations associated with it. At first, the total cost of setting up of various CCTV cameras is very high. The battery consumption of the RPi, LiDAR and various other instruments is quite high. So to change that solar powered batteries must be used which is quite scarce. Proper security of the bot is not present as, since the bot is quite small in size many vehicles might overrun it and destroy. As our budget is limited, we cannot make use of various modern and expensive instruments which could enhance the detection and improve the motion of the bot.

13.3 Future Scope

With advancements in the field of autonomous vehicles and road surfacing materials, the cost of such a vehicle can be reduced which will enable them to be widely used for road maintenance everywhere. Since we are also using CCTV cameras, accidents on the road can be identified. The data can be further used to analyze traffic patterns and lay new roads. The data can be used to understand the wear of roads and plan a total renewal of roads. It can also be used in the industrial sector to perform tasks in hazardous environments.

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