

Automated and Specific Bridge Deck Crack Inspection and Mapping

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Abstract-

The most important task for bridge maintenance is bridge deck crack inspection. Traditionally, a human inspector detects cracks using his/her eyes and marks the location of cracks manually. However, the accuracy of the inspection result is low due to the subjective nature of human judgment. We propose a crack inspection system that uses a camera-equipped mobile robot to collect images on the bridge deck. In this method, the Laplacian of Gaussian (LoG) algorithm is used to detect cracks and a global crack map is obtained through camera calibration and robot localization. To ensure that the robot collects all the images on the bridge deck, a path planning algorithm based on the genetic algorithm is developed. The path planning algorithm finds a solution which minimizes the number of turns and the traveling distance. We validate our proposed system through both simulations and experiments.

Keywords - Mobile robotic systems; Bridge deck inspection; Image Stitching; Nondestructive evaluation.

1. Introduction

The condition of bridges is critical for the safety of the traveling public and economic vitality of the country. There are many bridges through the U.S. that are structurally deficient or functionally obsolete. Condition monitoring and timely implementations of maintenance and

rehabilitation procedures are needed to reduce future costs associated with bridge management. Application of nondestructive evaluation (NDE) technologies is one of the effective ways to monitor and predict bridge deterioration. A number of NDE technologies are currently used in bridge deck evaluation, including impact echo (IE), ground penetrating radar (GPR), electrical resistivity (ER), ultrasonic surface waves (USW) testing, visual inspection, etc. For a comprehensive and accurate condition assessment, data fusion of simultaneous multiple NDE techniques and sensory measurements is desirable. Automated multi-sensor NDE techniques have been proposed to meet the increasing demands for highly-efficient, cost-effective and safety-guaranteed inspection and evaluation. Automated technologies have gained much attention for bridge inspection, maintenance, and rehabilitation. Mobile robotic inspection and maintenance systems are developed for vision based crack detection and maintenance of highways and tunnels. A robotic system for underwater inspection of bridge piers is reported in [3]. An adaptive control algorithm for a bridge-climbing robot is developed. Additionally, robotic systems for steel structured bridges are developed. In one case, a mobile manipulator is used for bridge crack inspection. A bridge inspection system that includes a specially designed car with a robotic

mechanism and a control system for automatic crack detection. Similar systems are for vision-based automatic crack detection and mapping to detect cracks on the bridge deck and tunnel. Edge/crack detection algorithms such as Sobel and Laplacian operators are used. Difference to all of the above mentioned works, our paper focus on the bridge deck data analysis which is collected by our novel robotic system integrated with advanced NDE technologies. The developed data analysis algorithms allow the robot to build the entire bridge deck image and the global mapping of delamination and elastic modulus of the bridge decks. These advanced data analysis algorithms take into account the advantages of the accurate robotic localization and navigation to provide the high-efficient assessments of the bridge decks. The paper is organized as follows. In the next section, we describe the robotic data collection system and coordinate transformation. In Section III we present the image stitching algorithm and bridge deck viewer/monitoring software. In Section IV, we present



Fig .1. The bridge robotic inspection system with the command center built in the transportation van. the IE and USW data collection and analysis. Finally, we provide conclusions from the

current work and discuss the future work in Section V.

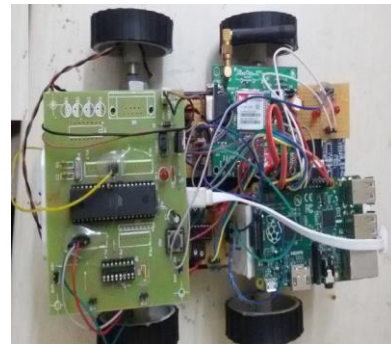


Fig.2. Hardware section of Robot

2. EXISTING SOLUTION

In the existing solution, the robot is equipped with a camera for processing the bridge. It uses histogram evaluation, and fault recognition algorithms for image processing. Thereby, the time taken to inspect the robot will be increasing rapidly. The robot is traversed from start point to end point through an autonomous line following algorithm. Thereby, the data read to navigate the robot is becoming complicated.

3. PROPOSED SOLUTION

In the proposed solution, the robot is equipped with a GSM module to intimate the place of cracks/holes occurred to the manager with the simple SMS technology. The robot is also equipped with a RFID Reader to navigate from start point to end point, advanced step of autonomous line following algorithm. The entire bridge was divided into zones; if a crack is occurred in zone1 then a simple SMS is sent to the manager for speedy recovery. The place of identification is not done in the existing solution, but it is done in the proposed solution. Cracks were identified with the help of ultrasonic waves. Sensor Systems were used for identifying the cracks/holes of a bridge.

Raspberry Pi is used as a processor for this robot, which is also best alternative used than the existing one. Zone identification is done with the help of slave 8051 controller, processing and intimating the manager is done with the help of Raspberry Pi.

4. IMPLEMENTATION

Raspberry Pi is booted with a Linux OS Distribution of named Wheezy Raspbian and the robot is interfaced to Raspberry Pi via Motor Driver (Current Amplifier). Ultrasonic sensor is also interfaced to Raspberry Pi for detecting cracks with echo algorithm, and a GSM Module is interfaced to UART port of Raspberry Pi. As the GPIO Hedar of Raspberry Pi is having only one UART port, the RFID Reader is interfaced to slave 8051 controller UART port. The slave lines of 8051 were connected to Raspberry Pi for zone identification.

A status LED's were also connected to the Raspberry Pi for user understanding, what's happening at Raspberry Pi. The three programs (Robot Running, GSM Sending SMS, Ultrasonic Detection) were written in Python and they were executed automatically upon a boot.

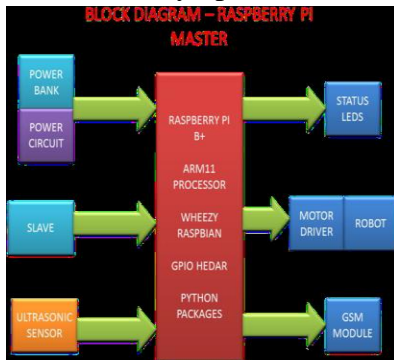


Fig.3. Block Diagram of Raspberry PI Master

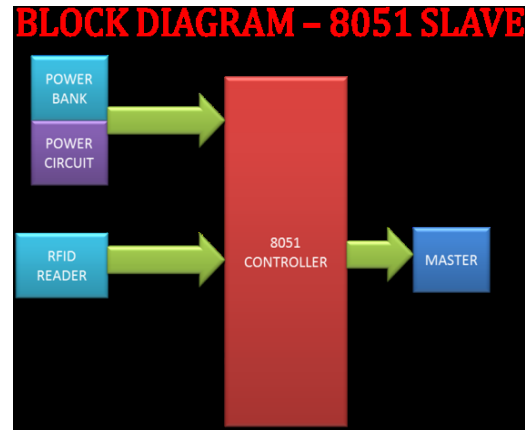


Fig.4. Block Diagram of 8051 Slave

A. Raspberry Pi B+

The Below is Raspberry Pi model B will help you to find out what peripherals present on Raspberry pi board. With help of this we are going to start the Raspberry Pi.

Before going to start it first find out what we want to connect to Raspberry Pi and what we need to boot the OS into Raspberry Pi.

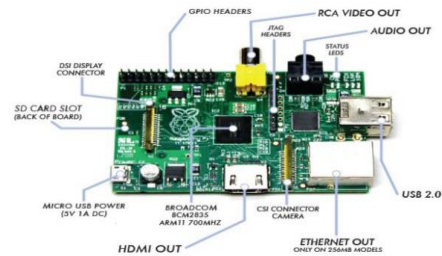


Fig.5. Raspberry Pi

Requirements:

- HDMI Cable (For display purpose, it can be connected to LCD display or desktop)
- Micro USB power (it contains 5V,1A DC)
- SD Card and followed by its adapter for Operating System

- For Input devices like KEYBOARD and MICE is connected to the USB Ports
- Ethernet Cable (for option you can connect WIFI Modem instead of Ethernet cable)

INSTALLING OS INTO SD CARD:

For installing here I used two software's and one operating system called Wheezy Raspbian.

1. SDFormatterv4 (for format your SD card)
2. Win32DiskImager-0.9.5(to install OS into your SD card)
3. Last Operating System is Wheezy Raspbian newest version (2014-09-09)

First two are must be installed on your PC or Laptop and additional you must download this Operating system on your Laptop and it is open source

The following steps are will show you how to boot the OS

BOOT THE OS:

Step 1:

Insert your SD card into Adapter like below and put it in your laptop.

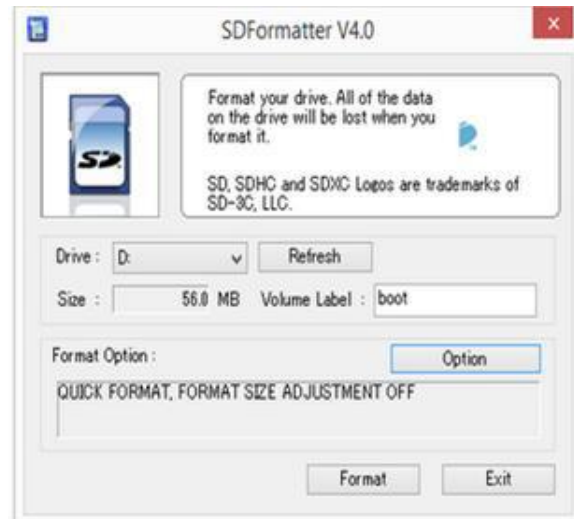
Note: 4GB of SD card is minimum but I prefer 8GB SD card



Fig.6. SD Card and Adapter

Step 2:

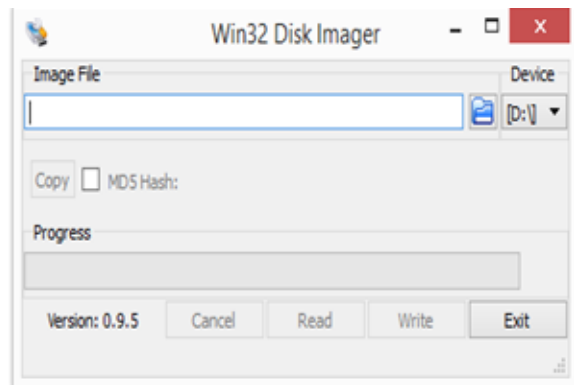
Open SDformatter and format your SD Card after inserting into your laptop or PC. That will look like below.



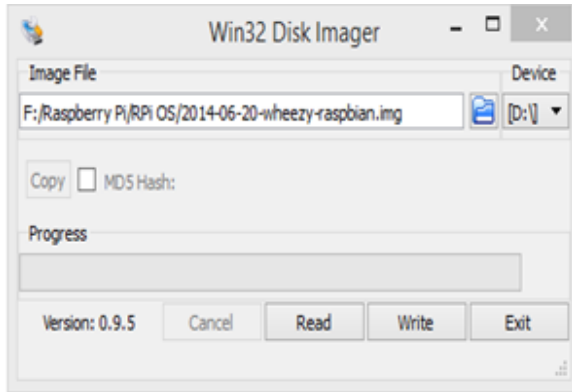
Press Format button over there then it will automatically format.

Step 3:

Next open Win32DiskImager that look like below



There you will find folder icon click over there then select Wheezy Raspbian that have already downloaded into your laptop.



Now click on Write button you can find there. Then it will automatically install into the SD Card. You must wait until it has finished.

Step 4:

After writing OS into the SD Card then take it off from your laptop and put it into the Raspberry pi directly if it is Model B, or if it is Model B+ then just insert your small SD card without adapter. I'm showing you below on Model B

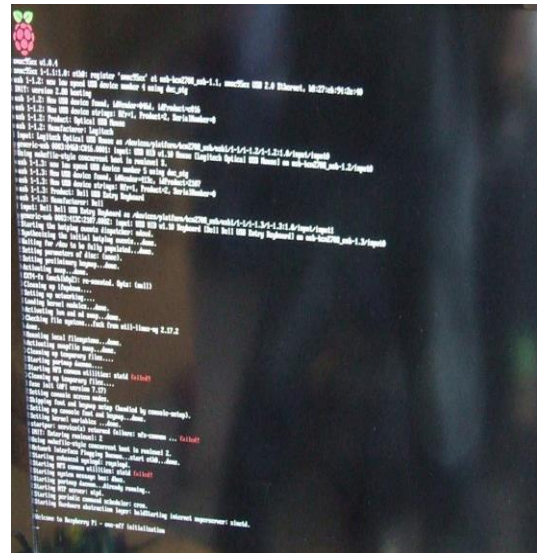


Step 5:

Next connect Keyboard and Mice in USB slots and Ethernet cable and also micro power.



After connecting all then you will get Linux shell on your display like below.



Then you will get pop up window of raspberry pi configuration, you just use up and down arrows on your keyboard and press finish there then you will get entry level there you reboot your system. For reboot type sudo reboot then it is automatically rebooting your system then you will get the window there you need to enter the username and password.



After that enter startx command that will entering you into raspberry pi GUI. This is how you are booting OS into the Raspberry Pi.

5. RFID READER

In a basic RFID system, tags are attached to all items that are to be tracked. These tags are made from a tiny tag-chip, sometimes called an integrated circuit (IC), that is connected to an antenna that can be built into many different kinds of tags including apparel hang tags, labels, and security tags, as well as a wide variety of industrial asset tags. The tag chip contains memory which stores the product's electronic product code (EPC) and other variable information so that it can be read and tracked by RFID readers anywhere.

An RFID reader is a network connected device (fixed or mobile) with an antenna that sends power as well as data and commands to the tags. The RFID reader acts like an access point for RFID tagged items so that the tags' data can be made available to business applications.

An RFID reader, also known as an interrogator, is a device that provides the connection between the tag data and the enterprise system software that needs the information. The reader communicates with tags that are within its field of operation, performing any number of tasks including simple continuous inventorying, filtering (searching for tags that meet certain criteria), writing (or encoding) to selected tags, etc.

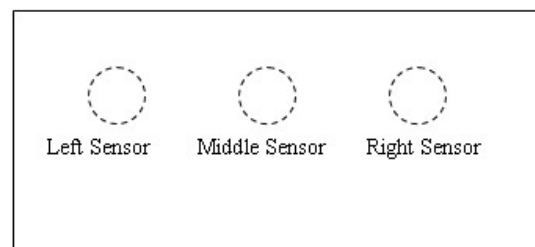
The reader uses an attached antenna to capture data from tags. It then passes the data to a computer for processing. Just like RFID tags, there are many different sizes and types of RFID readers. Readers can be affixed in a stationary position in a store or factory, or integrated into a mobile device such as a portable, handheld scanner. Readers can also be embedded in electronic equipment or devices, and in vehicles.

6. GSM SIM900 MODULE

The SIM900 is a complete Quad-band GSM/GPRS solution in a SMT module which can be embedded in the customer applications. Featuring an industry-standard interface, the SIM900 delivers GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. With a tiny configuration of 24mm x 24mm x 3 mm, SIM900 can fit almost all the space requirements in your M2M application, especially for slim and compact demand of design. ” SIM900 is designed with a very powerful single-chip processor integrating AMR926EJ-S core ” Quad - band GSM/GPRS module with a size of 24mmx24mmx3mm ” SMT type suit for customer application ” An embedded Powerful TCP/IP protocol stack ” Based upon mature and field-proven platform, backed up by our support service, from definition to design and production.

7. ROBOTICS

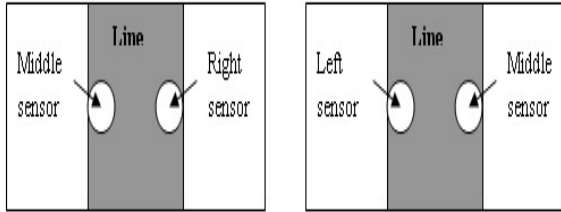
For this project, we will be using three pairs of IR sensors which will be attached to the bottom of the robot. These 3 sensors will be classified as left sensor, middle sensor and right sensor. A view of the placement of the sensors is as below:



View from the top of the robot

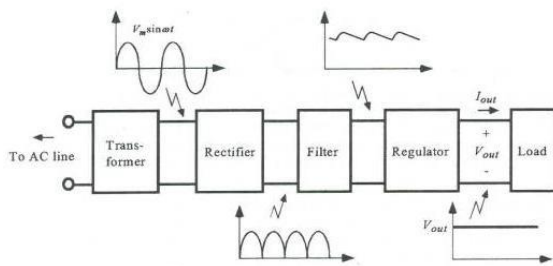
The distance between the two sensors depends on the width. The sensor should be placed in

such a way that maximum distance of two sensors is equal to the width of the line as shown in figure below.



8. POWER SUPPLY

The input to the circuit is applied from the regulated power supply. The a.c. input i.e., 230V from the mains supply is step down by the transformer to 12V and is fed to a rectifier. The output obtained from the rectifier is a pulsating d.c voltage. So in order to get a pure d.c voltage, the output voltage from the rectifier is fed to a filter to remove any a.c components present even after rectification. Now, this voltage is given to a voltage regulator to obtain a pure constant dc voltage.



Components of a regulated power supply

Transformer:

Usually, DC voltages are required to operate various electronic equipment and these voltages are 5V, 9V or 12V. But these voltages cannot be obtained directly. Thus the a.c input available at the mains supply i.e., 230V is to be brought down to the required voltage level. This is done by a transformer. Thus, a step

down transformer is employed to decrease the voltage to a required level.

Rectifier:

The output from the transformer is fed to the rectifier. It converts A.C. into pulsating D.C. The rectifier may be a half wave or a full wave rectifier. In this project, a bridge rectifier is used because of its merits like good stability and full wave rectification.

Filter:

Capacitive filter is used in this project. It removes the ripples from the output of rectifier and smoothens the D.C. Output received from this filter is constant until the mains voltage and load is maintained constant. However, if either of the two is varied, D.C. voltage received at this point changes. Therefore a regulator is applied at the output stage.

Voltage regulator:

As the name itself implies, it regulates the input applied to it. A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. In this project, power supply of 5V and 12V are required. In order to obtain these voltage levels, 7805 and 7812 voltage regulators are to be used. The first number 78 represents positive supply and the numbers 05, 12 represent the required output voltage levels.

9. APPLICATIONS

- Distance measurement.
- Distance Ranging.
- Robotics for mapping.
- Colored Line sensing
- Object/obstacle detection
- RFID Navigation for Autonomous Robots

- Detection of mines in Forest Areas
- Robotics in Military Applications
- Robots in Emergency Cases

10. RESULT

In this project design and implementation of robotic crack inspection for bridge deck maintenance based secure system for monitoring and control of accidents on bridge's using Raspberry Pi and sensor ultra-sonic was proposed implemented and deployed that successfully detected accidents in bridges and roads.

11. CONCLUSION

The project "DESIGN AND IMPLEMENTATION OF ROBOTIC CRACK INSPECTION FOR BRIDGE DECK MAINTAINCE." has been successfully designed and tested. It has been developed by integrating features of all the hardware components and software used. Presence of every module has been reasoned out and placed carefully thus contributing to the best working of the unit. Secondly, using Raspberry pi, 8051 Controller and with the help of growing technology the project has been successfully implemented.

12. REFERENCES

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