Robotic Crack Inspection and Mapping System for Building Maintenance

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Abstract— One of the important tasks for building maintenance is building deck crack inspection. However, the inspection result in human analysis is lower accurate in nature. A crack inspection system that uses a camera-equipped mobile robot to collect images on the building 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 clarify that the robot collects all the images on the building deck, a path planning algorithm based on the genetic algorithm is developed. by simulations and experiments, We validate our proposed system through both simulations and experiments. This work addresses crack detection and mapping on a building deck using a robotic system. Several challenges including coordinate transformation, robot localization and complete coverage path planning for the proposed robot system are tackled. This paper focuses mainly on the overall framework for such a robotic inspection system, therefore some of the techniques for handling shadows, paints, patches on buildings are not addressed. In real-world applications, these issues should be carefully incorporated into the design of the image processing algorithm. Also, there may be vibration caused by the passing traffic, which should be dealt with as well. The positioning of the ROCIM system is critical to crack mapping, hence more accurate robot localization techniques fusing various sensors such as differential GPS, Inertial Measurement Unit (IMU), etc. should be developed. It is also worth noting that the depth and severity of the cracks can be measured by employing advanced nondestructive evaluation (NDE) sensors, such as impact echo and ultrasonic surface wave.

Key words: robots, mapping systems, ROCIM system

I. INTRODUCTION

An autonomous robot is a robot that performs behaviors or tasks with a high degree of autonomy, which is particularly desirable in fields such as space exploration, cleaning floors, moving lawns, waste water treatment and delivering goods and services. Some modern factory robots are autonomous within the strict confines of their direct environment. It may not be that every degree of freedom exists in their surrounding environment, but the factory robot's workplace is challenging and can often contain chaotic, unpredicted variables. The exact orientation and position of the next object of work in the more advanced factories even the type of object and the required task must be determined. This can vary unpredictably at least from the robot's point of view. One important area of robotics research is to enable the robot to cope with its environment whether this be on land, underwater, in the air, underground, or in space. A fully autonomous robots behavior can be explained. Gain information about the environment, Work for an extended period without human intervention, Move either all or part of itself throughout its operating environment without human assistance, Avoid situations that are harmful to people, property, or itself unless those are part of its design specifications.

An autonomous robot may also learn or gain new knowledge like adjusting for new methods of accomplishing its tasks or adapting to changing surroundings. Like other machines, autonomous robots still require regular maintenance.

II. RELATED WORKS

Whenever structural cracking and movement appear significant or significantly worsen, a qualified & licensed Structural Engineer should be consulted for further advice. Cracks occur when forces either externally, internally within a building, or as a result of chemical changes within the building's materials are greater than it can withstand. Cracking and movement can be structurally dangerous. Differential movement throughout a building may be a consequence of poor design, ageing or changing environmental conditions to which a rigid building cannot adapt without fracturing. The form and positioning of cracking depends upon the building's weak points, particularly around doors and windows and where floor and roof connect to walls. Other factors are the size, shape, and position of the crack, the age of the crack indicating repetitive movement, and crack widening suggesting settlement or support failure.

Full depth cracking in external rendered surfaces occurs when the backing material has fractured due to movement of masonry walls on expansive soils or foundation failure. Cracking may also be due to rusting of embedded material or the growth and expansion of salt crystals in mortar joints. Crazing and surface cracking results from long term weathering and defective finishing techniques e.g. excessive trowelling or where the finishing coat is cement-rich compared to the undercoat.

Major failure in solid internal plaster is associated with movement of backing material causing loss of adhesion and cracking. Minor cracking and crazing occurs with age. Internal plaster sheeting problems are the result of the sheet itself - old plaster sheeting suffers from sagging caused by poor fixing, the effects of long term loading and deterioration in the bonding. Cracks develop at joints caused by insufficient support for the sheet, shrinkage of pointing material or movement of backing. Cracks in plasterboard are caused by shrinkage and warping in buildings as they age and adjust to new environmental conditions.

III. PROPOSED WORK

Crack monitoring should be started as soon as possible. The longer the crack monitoring period, the more data will be available for diagnosing the cause. The monitoring should continue throughout the data gathering, the investigation and the remedial work. It should continue beyond the completion of the remedial work in order to validate the performance of the remedial measures. Monitoring is important because a local authority was sued for the cost of foundation underpinning, but was held not liable because the structural engineer who recommended the under pinning had not monitored the cracks to establish if the movement was progressive.

To ensure that the robot collects all the images on the buildings 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. Several challenges including coordinate transformation, robot localization and complete coverage path planning for the proposed robot system are tackled. Currently, building decks are inspected with very rudimentary methods in the form of visual inspection by a trained engineer. The inspectors usually walk through the buildings and measure the crack sizes and locations. This manual approach has several disadvantages.

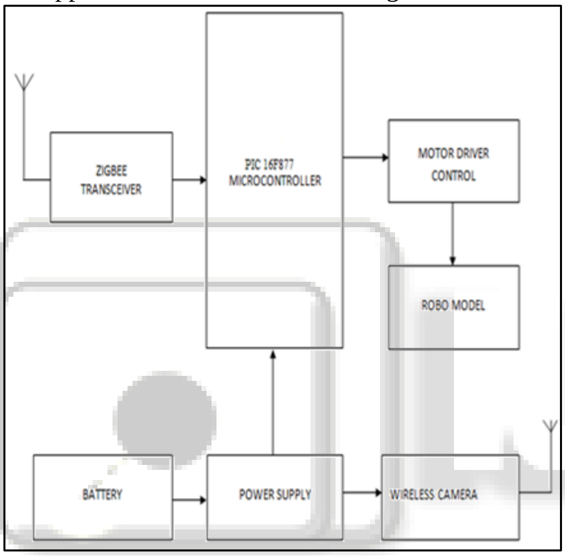

Fig. 1: Block diagram of crack detection robot unit

Fig.1 shows that the block diagram of the crack detection robot unit. The inspectors usually walk through the bridges and measure the crack sizes and locations. This manual approach has several disadvantages. Crack detection is to detect cracks on the bridge deck using computer vision, using MATLAB platform we need to develop an effective edge detection algorithm to distinguish cracks and no cracks.

Since the cracks are detected in the image coordinate system, and have to map the crack locations from the image coordinate system to the global coordinate system. First fixed the Robot model to wall or pillar. In that Robot model having a wireless camera for detect the crack in the wall or pillar. Robot model drive with motor driver circuit and driver control is control via personal computer using Matlab tool. Matlab tool using for Robot control and taken images and compare the crack image via wireless sensor module Zig-bee. AM transceiver for receive the crack images from Robot model to pc and pc point out the crack images from which location. Zig-bee transceiver is sent the data's to controller for Robot model movements e.g. up, down, right, left, stop.

Fig 2 shows the Motor driver circuit using the l293d motor driver. In the diagram, can see that there is a microcontroller (MCU). Now, this MCU may/may not take in inputs as in from sensors, other digital inputs, etc. Next, as per our programming, the MCU will generate control signals. Please note that the MCU will generate signals in form of HIGH (Vcc = 5v) or LOW (zero). But this voltage is insufficient to drive a motor.

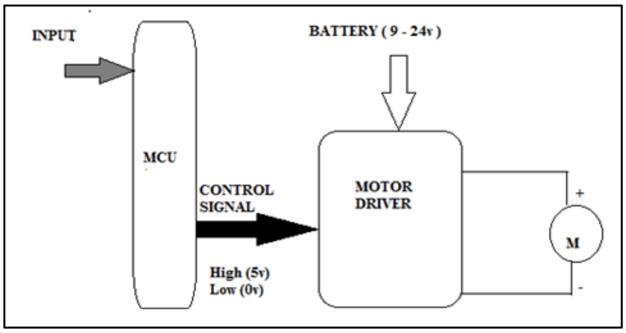

Fig. 2: Block Diagram – Motor Control

A motor driver always has a battery input Vs . In simple terms, what a motor driver does is that it directs the Vs voltage to the motors connected to it. Thus, the motors behave as per the control signals generated using the MCU with the excitation from the external battery voltage.

Microcontroller (MCU) may/may not take in inputs inputs as in from sensors, other digital inputs, etc. The MCU will generate control signals. A DC motor is an AC synchronous electric motor that from a modeling perspective looks very similar to a DC motor. Sometimes the difference is explained as an electronically-controlled commutation system, instead of a mechanical commutation system, although this is misleading, as physically the two motors are completely different. Three sub types are given as

- The three-phase AC synchronous motor type has three electrical connections
- The stepper motor type may have more poles on the stator.
- The reluctance motor has all its poles on the stator, and a magnetic core on the rotor.

Mono wireless ptz color camera complete 3 lux minimum illumination and it focus manual adjustable from 30 mm to infinity, it view 50 degree horizontal ngle. it support 8v dc – 12v dc or 9 volt single battery and it has 20gram weight,it has 1.2ghz operation frequency and 1.2 watt power consumption.

ZigBee is a low-cost, low-power, wireless mesh network standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications. Low power-usage allows longer life with smaller batteries. Mesh networking provides high reliability and more extensive range. ZigBee chip vendors typically sell integrated radios and microcontrollers with between 60 KB and 256 KB flash memory.

PROTEUS VSM brings you the best of both worlds. It combines a superb mixed mode circuit simulator based on the industry standard SPICE3F5 with animated component models. And it provides an architecture in which additional animated models may be created by anyone, including end users. Indeed, many types of animated model can be produced without resort to coding. Consequently PROTEUS VSM allows professional engineers to run interactive simulations of real designs, and to reap the rewards of this approach to circuit simulation.

PICs are microcontrollers, PIC's are a large range of microcontrollers manufactured by Microchip Technology Inc. The 8-bit range, also known as the PIC16 range is a popular microcontroller range for beginners and students. Especially the PIC16F84 and PIC16F877. Then starting with PIC16F877 they may be intimidating at first, but after you studied its datasheet and learned some basic assembler or ANSI C, you can get started. There are MSC51 standard Atmel 89C51 or 8051 family and then there is Atmel AVR, like the ATMEGA8. The nice part about the ATMEGA8 for instance is that if you feel comfortable with this device and probably started using C language to make life easier. You find it very easy to move up to ATMEGA128 which is a more advance microcontroller.

The best approach to microcontrollers is not to commit to quickly to a particular one or brand name, play the field a bit. Once you are more experienced it's best to use your experience and choose a nice microcontroller that can do most of what you will need and try stick with it or a very few variations at least. It takes very long to study and learn a particular make or model very well and you really do not want to go through all that every time you do a new project.

IV. EXPERIMENTAL RESULTS

Simulations and experiments to validate the proposed ROCIM system and the associated algorithms. In the first experiment, the crack detection algorithm which can detect the crack in the building pillar easily with the help of an PTZ camera. It can capture the clear image of every side of the camera. The cracks are finding three types they are

- No Cracks.
- Small Cracks.
- Large Cracks.

Server can send the image to MATLAB tool and analyse whether the cracking image is small or large elsewhere no cracks occurred.

A. No Cracks:

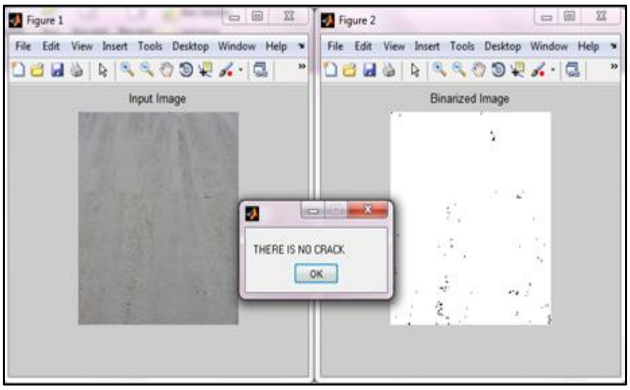

Fig. 3: Crack In a Building Pillar, Figure (1) Input Image, Figure (2) Binary Image

Fig. 3 representing the building pillars without any cracks and it mentioning the input image and with the binarized image. In a binary image which given the value as 0 and 1,here the value 0 representing the black colour and the value 1 representing the white colour. In that Figure (1) shows the input image and converting into binary image which shows in Figure (2). The binary image representing black and white pixel, if the black pixel value is lesser than 600 then there is no crack in the building pillars.

B. Small Cracks:

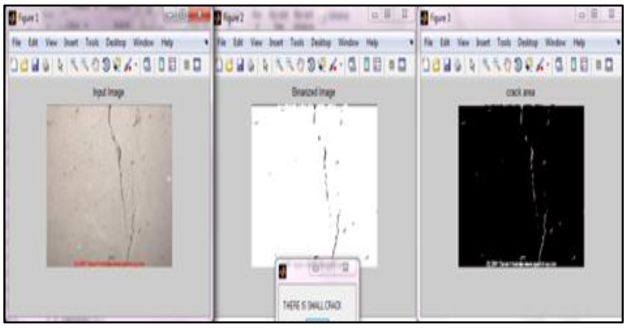

Fig. 4: Small Cracking Image Of The Building Pillar, Figure (1) Input Image, Figure (2) Binarized Image, Figure (3) Crack Area

Fig. 4 representing the different ways of small cracks occur in the building pillars, and converting the input image as the binarized image as per the previous explanation .In this Figure(1) and Figure(2) shows the input and binary image , here the black pixel is large and so the crack area image is shown in Figure(3).If the black pixel is less than 1000 then there is an small crack occur in the building pillar.

C. Large Cracks:

Figure 5 representing the different ways of large cracks occur in the building pillars, and converting the input image as the binarized image as per the previous explanation .In this Figure(1) and Figure(2) shows the input and binary image , here the black pixel is large and so the crack area image is shown in Figure 3. If the black pixel is above 1000 then there is an large crack occur in the building pillar.

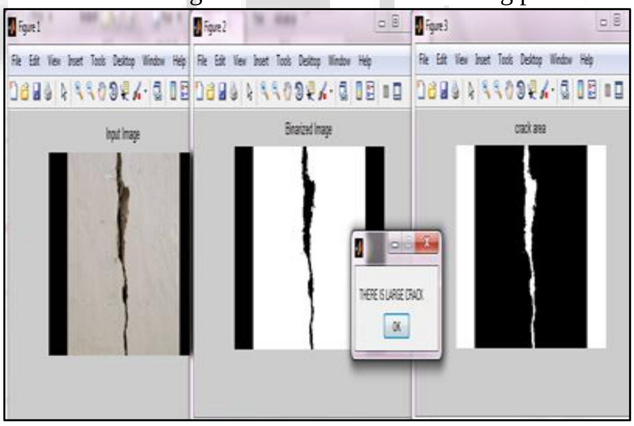

Fig. 5: Large Cracking Image Of The Building Pillar (1) Input Image, Figure (2) Binarized Image, Figur (3) Crack Area

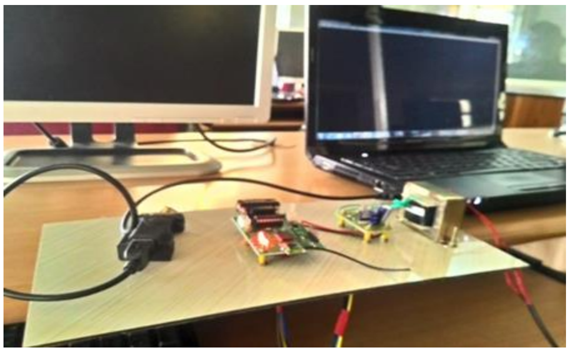

Fig. 5: mapping system hardware in server side

Figure 5.5 shows the mapping system hardware, the system which is ready to check the crack in the building and it can give the comment to the receiver side for movement of robotics.

V. CONCLUSION AND FUTURE WORK

The aim of this project is to detect the crack which occur in the building, in this phase robotics which moves overall building pillars with the help of tracks which fixed in the wall, the robotics can have the PTZ camera on the top. Through the camera, it can detect the crack which occur in the building pillars and it store the detected image. Finally transmit the image through the ZIGBEE transceiver to the server. Server can send the image to MATLAB tool and analyze whether the cracking image is small or large elsewhere no cracks occurred. implementing the simulation by the use of hardware tools and server can detect the cracks and monitoring the building pillars. From this the cracks can identified easily and so the image can useful to modify the building pillars in a particular place, it can be helpful for workers to maintain the building and also provide good safety for the people who are living in the building.

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