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Wheelbot - An Integrated Robotic Rail Track Inspection and Surveillance System

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***Abstract* - Indian railway is existent for more than a century, but still safety is always a big concern. In this project, the track inspection and track surveillance is being automated, which will reduce the quality issues on track drastically. Though high end version of track inspection exists, they are very costly thus limiting the use on major railway stations alone and very less frequency of inspection in smaller stations. Smaller stations do manual inspection using trolley, which leads to human error and consumes much time. At the same time, the quality of the track has to be inspected periodically to avoid train accidents, this involves many lives.**

This project introduces the automation at affordable cost, which can be used by every small stations and thus avoiding the dependencies. It can also be employed for track surveillance, which is currently done manually. The above system is made possible by employing the high resolution night vision camera mounted on a wheelbot. This robot will move on the track and do the inspection. Wireless control is provided to robotic system, which can be operated from the remote station. Live video streaming is done to the remote control room at the base station. Video storage is provided for future reference. It is essential to track the location of the robot which is achieved through GPS (Global Positioning System) attached to the wheelbot. Live transmission is done through high speed 3G internet or 2G internet and the same is used to control the wheelbot also. The expert can monitor the entire process through the live stream and take a call on the track quality.

Using light sensors we adjust the brightness of the camera to achieve good video quality. To protect the wheelbot, obstacle detection sensors, emergency alarms are being provided to the robot to enhance the smartness of the system. In case of emergency the wheelbot can be setup within a short while thereby making it possible to be used in critical time.

The power utilized by the entire system is low due to intelligent algorithms that control the system. The principles of green computing and signal processing applied in the system help in the development of a green smart system. The total cost of the system is low hence most of the stations can have it and thus improving the safety standards and QoS of railways.

***Index Terms*—Wheelbot, Robotic rail track inspection system, Green Computing, Smart System.**

I. INTRODUCTION

Existing systems are getting automated to achieve accuracy and to reduce human efforts. Robotics is in existence for past four to five decades and latest technologies evolved in robotics highly promote the automation in very successful manner. Every field employs automation to improve the standard of living to next level. Developing countries including India are highly focused to get automated to be improved in all aspects.

India's Rail network is the fourth longest and most heavily used system in the world, transporting 7651 million passengers in the world and over 921 million tonnes of cargo annually, as of 2011. Indian railways are quite unique and distinctive in character, really a microcosm of India. To make it a safe and reliable system is an enormous challenge. Safety on the Railways is the end product of the cohesive fusion of its myriad parts. Single flaw in the route of 64,600 kilometers across country may lead to a serious train accident. Finding out that and fixing is a great challenge.

Even though the technology has improved a lot in safety aspects, the greater percentage of train accidents occurred due to the problem in track such as derailment, Central Railways statistics. In a study performed, it is an unfortunate fact that the reasons for accidents are many which include human error, long interval between successive track inspections, inability to afford very costly automotive gigantic machines. Hence, automotive machines to perform track inspection and surveillance at affordable cost will ensure more reliability.

Rail inspection is the practice of examining rail tracks for flaws that could lead to catastrophic failures. Surveillance is another very important area, where manual patrolling exposes employee's life at great risk. The project emphasizes to ensure safety of the passengers and railway assets by modernized method of rail track inspection and surveillance using wheelbot. It provides the inspector with a visual depiction of the track environment supported by quantifiable measurements to enable the inspector to quickly and accurately identify track problems. The inspector's time on the track infrastructure is minimized, providing more efficient revenue operations and minimizing the inspector's exposure to the hazardous environment. An autonomous deployment and integrated scheduling provides the railroad with the flexibility to carryout track inspection on a daily base. Recent development, communication and IT infrastructure has enhanced the capability of computing and intelligence which could again be used to make the system more friendly, affordable and more importantly improve the quality services of the Indian railways.

II. SYSTEM DESCRIPTION

Wheelbot is based on robotics telecommunication technology. It is a mobile system which moves on the track and does the inspection. Wheelbot has an inbuilt control system which controls the entire actions. The whole system is powered through the rechargeable battery. Wireless control is provided to robotic system, which can be operated from the remote station through a computer application and the same controls if necessary is provided over an android platform so that the person can be at ease and watch the process or control the operation.

High resolution night vision camera mounted on a wheelbot. Live video streaming is done to the remote control room at the base station. Video storage is provided in wheelbot for future reference and also for official records. Various parameters to be measured using transmitted video are, Ballast level, Bolts and nuts status, track interconnections, outer view of both the tracks, serious obstacles in track and temperature dependent deformations.

Apart from the video signals, various other sensors are placed in the system which provides the additional details as well as will be used for safety of the wheelbot. Instead of man on the track this system brings you the details better than the human vision to the base station itself. The specialist can inspect remotely.

Third generation (3G) wireless standards could be integrated with this system to provide a solution for mobile commands, video, and data. 3G capabilities include variable and asymmetric data rates, support for different bit error rates (BER), slotted ALOHA packet channels, and multiple connections. Hence the wheelbot uses the same technology to transmit video data to the base station.

GSM-R is an International wireless standard for railway communication. Indian railways occupy a 1.6 MHz wide range of the P-GSM band (900 MHz-GSM) in GSM-R. To improve data security the signalling and transmission in wheelbot can use the same after the successful demonstration and getting legal approvals from the government.

III. WHEELBOT

The wheelbot mainly comprises of the following,

- Data acquisition
- Transmission
- Server validation and processing
- Emergency data forward to specialist

Fig. 1 shows the integrated blocks of the above components.

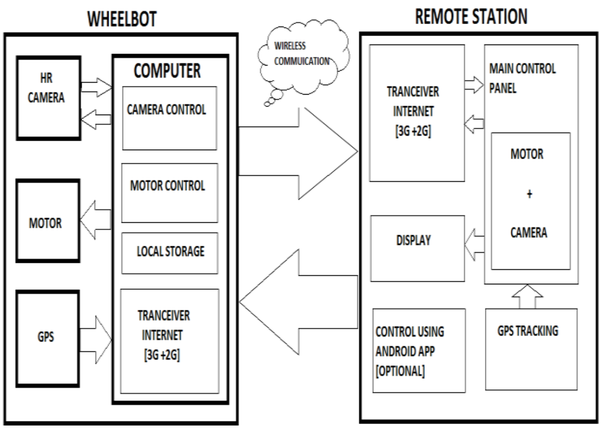

Fig. 1 Overall Block Diagram of the System

The track details are acquired using the hardware. It is done using the high resolution night vision camera. High resolution camera captures the maximum details of the track, which enables most exact inspection. Night vision featured camera is mounted on the system hence the system performs in a better way in low light areas such as tunnels and even during night times. Processor is the heart of the wheelbot, which controls the system and peripherals, such as Camera, motor and GPS. It controls the overall process of the wheelbot. The processor is powered with the lithium ion battery, which has the backup time around three hours. The camera is controlled using the server application installed in the processor. Live video streaming is done to the remote control room at the base station. Live stream integrates directly with Adobe Flash Media Live Encoder (FMLE) to broadcast live in high quality to live stream channel. In order to broadcast to live stream using FLME, will need to check the "Stream to Flash Media Server" box and configure the FMS URL and stream name. Depending on requirement specs and connection speed should adjust the encoding settings to provide best quality. It is recommended setting the output resolution to match the size of the embedded player (the standard player on live stream channel pages is 592x334). Use the pre-set profiles within Flash Media encoder or set own custom profile. Format options are H.264 or VP6. Results should be comparable using either codec in most cases, if plan to broadcast to mobile, will need to use H.264 and get the AAC Audio Codec plug-in. Frame Rate should ideally match the frame rate of the device.

Choosing a motor is an important step in creating an appropriate system for the robot. Brushless DC (BLDC) motors are the primary choice for a wide variety of applications. Compared to a typical DC motor, the BLDC motor implements an electric commutator instead of a mechanical commutator which, in effect, increases the reliability. Additionally, the rotor magnets in a BLDC motor generate the rotor's magnetic flux, in turn giving it higher efficiencies than a normal DC motor. To drive and control the BLDC motor, use of a motor controller was implemented. The motor controller is an essential device for any motor driven device. Of course, the applications of a motor controller vary based on the task that it will be performing. To drive the BLDC motor, the motor controller sends rectangular or trapezoidal voltage stokes that are coupled with the position of the rotor. voltage stokes applied with respect to the rotor position dictated by the Hall Effect sensor.

GPS do live transmission of position of the wheelbot, since it will not be in the line of sight during the operation. Hence to track the location of the robot , GPS (Global Positioning System) attached to the wheelbot will be used. GPS transmitter is placed on the wheelbot and it is tracked lively from the base station using the LabVIEW application. The GPS device placed in the wheelbot continuously transmits the co ordinates to the receiver in the base station. The following program receives the co ordinates and exactly maps the location of the wheelbot. This program access the Google map with th e help of the URL provided. The application has the options to zoom in and zoom out view of the map. Map width and height can be varied and also can obtain the road view, satellite view and terrain view in this application.

IV. DESIGN OF WHEELBOT

- Video Transmission Triggered from Remote Station

The application in Fig. 2 is to trigger the video transmission. It switches on the camera and start video transmission when the given condition is true The user can switch the transmission either on or off by using this LabVIEW application.

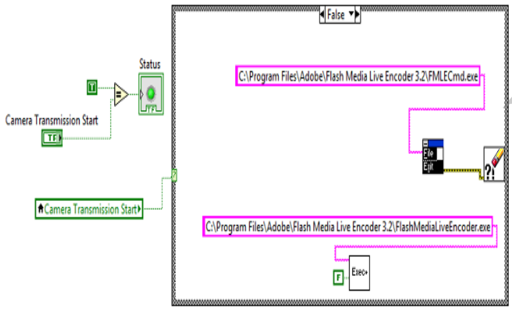

Fig. 2 Triggering video transmission from remote station

- Video Encoding using Flash Media Live Encoder

The video captured by the camera will be encoded before transmission. Here we are using the Adobe flash media live encoder to achieve encoding shown in the Fig. 3. In this application we can vary the video signal parameters such as bit rate, input image size, sampling rate, frame rate etc. at the input video side.

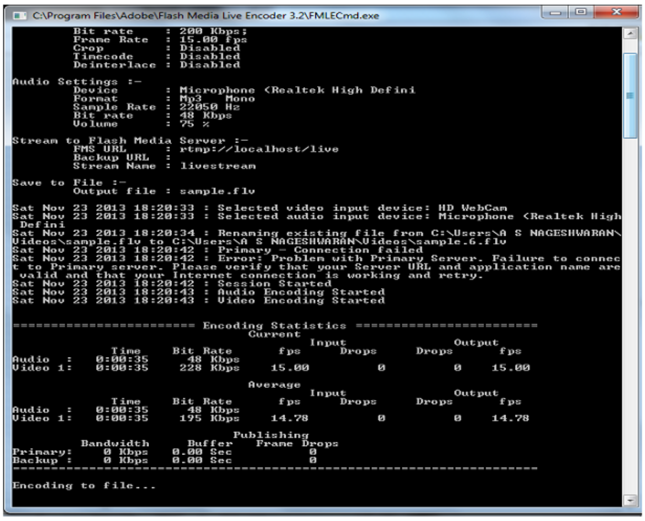

Fig. 3 Video encoding using Flash Media Live Encoder

- Communication established between microcontroller and system

Using MSP430G2553 microcontroller, the data is transmitted to motor driver from the system. The process involves Activation of Receiver and Transmitter pins of G2553, Configuring Timer for continuous Transmission and Reception, UART Activation, wait for data and Transmit data through COM when data received. The connectivity is verified using HyperTerminal shown in the Fig. 4.

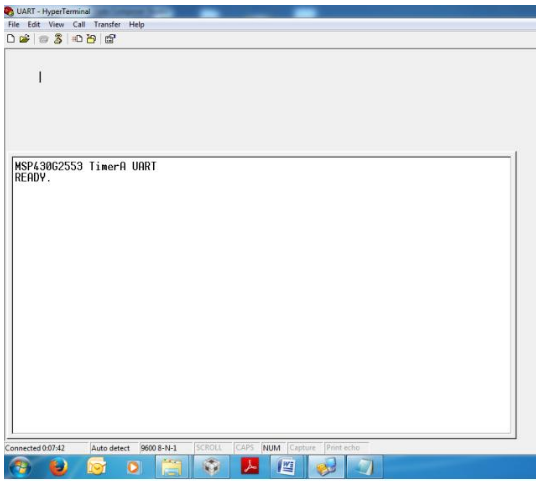

Fig. 4 Connection established between microcontroller and system

- GPS (Global Positioning System)

The position of the wheelbot has to be tracked because in its application it will not be in the line of sight. So, GPS transmitter is placed on the wheelbot and it is t racked lively from the base station using the LabVIEW application. The GPS device placed in the wheelbot continuously transmits the co-ordinates to the receiver in the base station. The following program receives the co ordinates and exactly maps the location of the wheelbot. This program access the Google map with the help of the URL provided. It has the options to zoom in and zoom out view of the map. Map width and height can be varied and also we can obtain the road view, satellite view and terrain view in this application.

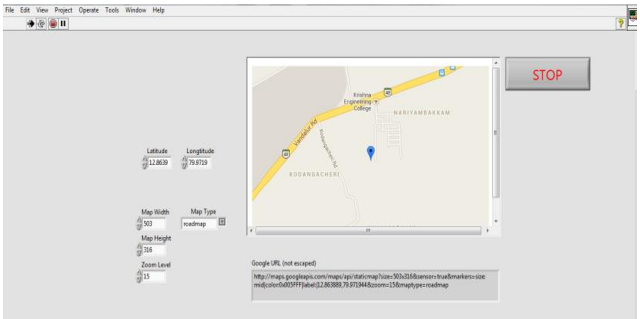

Fig. 5 Live GPS tracking using LabVIEW

The blue marker in Fig. 5 is provided to mark the exact location in the map area shown. Hence we can precisely track the location of the wheelbot.

V. DISCUSSIONS & CONCLUSION

The advanced, cost effective railway track inspection and surveillance robot has been designed for Southern Railways, Salem Division. Its application software and supporting softwares were realized and verified using LabVIEW. Microcontroller is coded and data flow verified to control the motor in the system. Video encoding is achieved through Adobe flash media live encoder. Position tracking of the wheelbot is developed and verified. The application bandwidth of Indian railways is keenly observed and the robot is developed to fulfill the quality requirements of the railway system. Hence all the stations of Railways can afford the system and thereby improve overall quality of track and finally the valuable lives of the passengers were secured.

In continuation to the completed modules, the future work includes,

- Assembling the hardware and integrating them with corresponding Software applications.
- Establish and Ensure communication between wheelbot and Remote station control.
- Finalizing the camera positions and its number.
- Development of Android application to enable comfort access (Optional).
- Finally the whole system will be tested in the Indian railways and fine tuning will be done.

Autonomous deployment and integrated scheduling provides the railroad with the flexibility to execute track inspection on daily basis. At the same time apart from the quality of the track, surveillance in the dark is done for improved security.

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REFERENCES

[1] Bing Jiang and Alexander Mamishev (2004), "Robotic Monitoring of Power Systems", IEEE Transactions on Power Delivery, VOL 19, No.3, pp. 912 -198.

[2] Chi-Cheng Cheng and Ying-Jie Zhao (2006), "A Telerobotic Manipulator System with Impedance Control", Proceedings of IEEE International Conference on Control Applications, pp. 193-198.

[3] Claudi Sacchi and Carlo S. Regazzoni (2000), "A Distributed Surveillance System for Detection of Abandoned Objects in Unmanned Railway Environments", IEEE Transactions on Vehicular Technology, VOL. 49. No. 5, pp. 2013-2023.

[4] Imad Elhajj1, Ning Xi, Wai Keung Fung, Yun hui Liu, Wen J. Li, Tomoyuki Kaga, Toshio Fukuda (2001), "Super media in Internet-Based Telerobotic Operations", Springer MMNS 2001, pp. 359-372.

[5] Moshe Kam, Xlaoxun Zhu, and Paul Kalata, (1997),"Sensor Fusion for Mobile Robot Navigation", VOL 85, No. 1, pp 108-119.

[6] Ted H. Szymanski and Dave Gilbert (2010), "Provisioning mission-Critical Telerobotic Control Systems over Internet Backbone Networks with essentially – Perfect QoS", IEEE Journal, VOL 28, NO 5, pp 630-643.

[7] The Times of India, "Articles about Rail Accidents - Times Of India",http://articles.timesofindia.indiatimes.com/keyword/rail-accidents.

[8] Indian Railways," Central Railway / Indian Railways Portal", http://www.cr.indianrailways.gov.in/view_section.

[9] Members reference Service, Lok Sabha Secretariat, New Delhi, No 1/FS/REF/2013.