SMART BORDER SURVEILLANCE SYSTEM

Sarvajit Tilve[1], Sohan Nageshkar[2], Shrihari Nair[3], Ambar Pednekar[4]

Devendra Sutar[5]

[1-4]*Electronics and Telecommunication Department, Goa College of Engineering, Goa, India*
[5]*Assistant Professor, Electronics and Telecommunication Department, Goa College of Engineering, Goa, India*

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Abstract - *Observation frameworks in India generally contains manual security guarding the lines or fences of significant locales. CCTV is one of the innovations utilized for surveillance yet that too needs a watchman observing every one of the screens to recognize dubious activities. There is a requirement for self-sufficient reconnaissance framework at different spots. This project proposes a surveillance framework that can identify activities close to the border or fences utilizing image detection and alert the control room. This will bring about an auto surveillance where guard will be alarmed when camera distinguishes action so guards don't need to patrol the territory or notice the screen consistently. The proposed strategy utilizes a bot that moves on the double rail structure and in the event that somebody gets detected, it alerts the control room. The smart fence will likewise alert the control room if the fence is contacted or on the off chance that somebody attempts to alter the fence structure. The bot comprises of a night vision camera which empowers it to recognize even in the dark, a DC motor, motor driver, distance sensor to help the bot in movement, LiDAR module interfaced with the Raspberry Pi which can give approximate distance of the individual that is detected. The robot can track the detected individual subsequent to cautioning the control room. Since live video recorded by the bot can be viewed on mobile, the guard will be able to track down the suspect more efficiently.*

Keywords: *Raspberry Pi 4 Model B, Smart fence, motion detection, Night vision camera, image processing, LiDAR*

1.INTRODUCTION

The requirement for an autonomous surveillance framework in India is ascending with expanding number of instances of unlawful migration, smuggling, dealing, interruption across borders and at critical destinations. Surveillance of such fences or boundaries gets intense with manual monitoring. Video observation frameworks are particularly in need for destinations that require high level security. The redesign on video observation is smart surveillance system that will alarm the control room just when some suspicious action is detected. This can lessen the need of steady observation by guards. This framework can be utilized at different locales for required discovery by few alterations. For instance, in forests to keep away from late identification of forest fire starting at fence, the bot can be outfitted with capacity to recognize fire and alarm the control room, which can fundamentally decrease the harm through fires. The automated reconnaissance has applications that can guarantee a general security and observation at different destinations against various problems.

2. LITERATURE REVIEW

Palagati et al. [1] propose a model to study videos captured by surveillance cameras and extract features from it after converting video to shots. Basic features are extracted by employing an object tracking method based on ROI. At last, semantic content extraction results in recognizing the intruder without any false matching. Sagar et al. [2] apply image processing techniques to implement a robotic smart home security system. The system is able to detect faces, signboards and provide notifications to the user if an intruder is detected. Raspberry pi is used to control the motion of the robot via Arduino and all the sensors are connected to it wirelessly. Singh and Khushwaha [3] propose a mechanism for smart border surveillance and automatic combat. It makes use of features extracted from optical flow information of the scene. Once the automatic detection of intruder takes place, suitable action is taken depending upon the relative position of the intruder with respect to the border fence. If the intruder happens to be behind the fence, mere tracking is followed. If the intruder is above the fence and trying to cross it, an alarm is raised. Auto-firing can be activated when the intruder has actually crossed the fence. Alkhathami et al. [4] investigate the performance of border surveillance simulation using WSN arrays. They provide experimental results for the OPNET (Optimized Network Engineering Tools) while using wireless sensor ZigBee nodes. Mesh and tree cluster are the two topologies for which experiment is performed and results are compared.

Zhang and Liang [5] propose a new method to detect moving human body based on the technique of background subtraction. Initially, a background image is obtained. To extract the moving regions from the current frame, difference between the current frame and the background image is obtained. At last, the shape features of the extracted regions are used to determine if the moving region is a human or not. Deshmukh at al. [6] proposes a system which is composed of three layers of lasers, cameras and a central monitoring system. The system heavily depends on extensive use of lasers and consists of three layer of lasers, running parallel behind each other. Background Subtraction, Frame differencing and threshold application are used for intrusion detection.

Finally, a Global System for Mobile communication (GSM) module is used for sending notification to the end user. Essendorfer et al. [7] describe the architecture of a project named SOBCAH (Surveillance of Borders, Coastlines and Harbors) which integrates the information gathered from heterogeneous sensors. All the information is first converted to a common standard data format. SOBCAH Shared Database (SSD) holds the data from all the sensors. Shivani and Kaur [8] propose a method in which CCTV cameras can be utilized for border intruder detection. Multiple events can be detected from a surveillance video using ROI (regions of interest) of the scene. A brief review of the existing work on the border security surveillance is reviewed.

Felemban [9] present a survey of experiments and the research work that has been done in the two fields of border surveillance and intruder detection. The main focus is on the use of WSN technology by placing a large number of small and low-cost nodes at the border areas to provide geographical and time-specific information. The challenges and technical requirements for such systems are discussed. Ferdoush and Li [10] describe their work which uses Raspberry Pi and Arduino for building a wireless sensor network. Both are open hardware platforms. The system architecture along with hardware and software requirements is discussed in detail. At last, some sample experimentations and their results are shown. The system is told to be cost effective as well as scalable.

3. PROPOSED METHODOLOGY

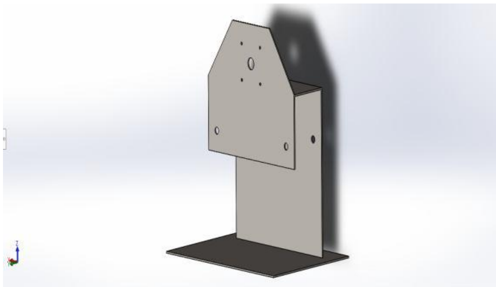
Considering all the current security frameworks for identification and avoidance of intrusion or other activities, we propose smart border surveillance system which will go about as a person on patrol to look for any interruption and different activities like illegal trafficking and smuggling. It will alert the control room when image detection program detects an individual and also stream the exercises around the border to the control room. It will enable us powerful coordination with security team in the control room and quicker response time from the security. We propose using a robot which will run on a double rail structure joined to the smart fence. The robot will be outfitted with the Raspberry Pi 4 module, a night vision camera, Distance sensors, motor driver, a 12V DC motor and a laser scanner (LiDAR). All the functioning of the robot, working of cameras and the laser scanner will be controlled by the raspberry pi module. The camera interfaced with raspberry pi will help in detecting the suspect using image detection with OpenCV library and also giving the control room live feed. The LiDAR will give us the approximate distance of the suspect from the bot.

We likewise propose a smart fencing framework which will expand the security if the robot can't identify exercises as the robot will be consistently moving across the edge. The fence whenever contacted by any subject will caution the control station. The robot will be running on a double rail structure appended to the fence by utilizing pulley's which will be turned with the assistance of a 12V DC engine powered by LiPo battery and controlled by raspberry pi 4 using motor driver. The distance sensors on the side of the bot will make sure that the bot does not crash onto the side pole of the fence. So, when it approaches the pole distance sensor will detect its distance from pole and when less than certain value, it will direct the bot to the opposite side. After the bot detects the subject and alarms the control room, the bot is likewise empowered with tracking program so it tracks the person until it is inside the cameras viewing reach. The live feed of the video recorded by the bot can be also viewed with a mobile phone connected to the same network.

4. SYSTEM DESIGN

A. Robot Body Design

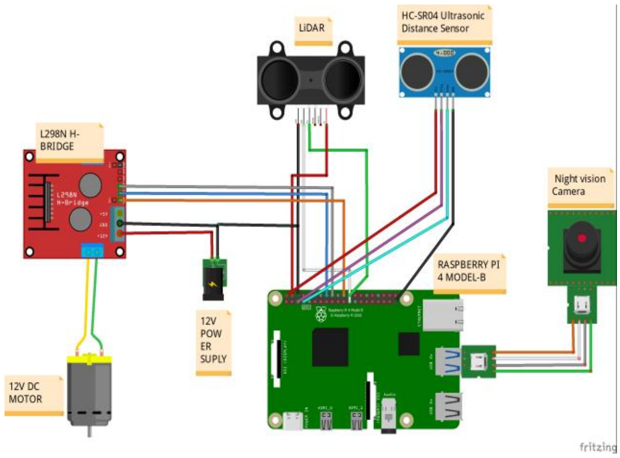
The 3-Dimentional Body of the bot was designed using SolidWorks software such that the robot body remains perfectly balanced on the rail and also made sure that the design is ideal for placement of other components inside the body.



The design of the bot body is in such a way that the bot slides over a dual-rail setup which was designed using SolidWorks. Pulleys are used to ensure smooth sliding of the robot body over the dual-rail structure.

B. Internal Circuitry

The internal circuitry of the Robot is shown below.



Raspberry Pi 4, Model B: Raspberry pi is the main computer used in the circuit. It uses a Broadcom BCM2711 SoC 1.5 GHz 64-bit quad-core processor. It has a standard 40-pin configuration which is used for various GPIO operations.

TFmini Plus LiDAR Module: This module is used to measure the coordinates of the intruder by measuring the accurate distance between the robot and the intruder.

Ultrasonic Ranging Module HC -SR04: This sensor is placed in a way that it senses the pole at the end of the rail and directs the robot to change the direction. This ensures that collision between the robot and the pole is avoided.

Orange 12V 300RPM Square Gearbox DC motor: Used for movement of the bot along the rail.

L298N Motor Driver: It acts an interface between the DC motor and the circuit. It supplies enough amount of current so as to drive the motor.

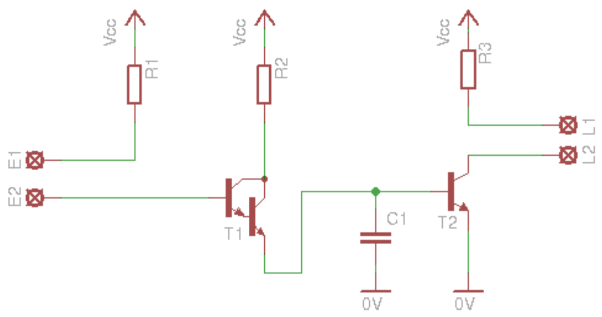
Ovonic 2200mAh 11.1V 3s 25C LiPo Battery: Used to power the circuit.

C. Electric Fence

E1 and E2 are the touch points of the fence circuit shown below. R1 (330 ohms ¼ Watt 5% Carbon) resistor acts as a protective resistor which is directly connected to Vcc. T1 (BC517 NPN transistor) is a transistor (Darlington pair) which is biased to active mode for amplification purpose. High current gain characteristics of Darlington pair is used to produce enough current to drive the load of the circuit even if the object touching the touch point is not wet. Resistor R2(1k ohm ¼ Watt 5% Carbon) is connected to collector terminal of T1. Emitter of Darlington pair is connected to base of transistor T2 which acts as a power switching amplifier. The base of T2 is also connected to a ceramic capacitor (0.1uF 50V) to eradicate noises. R3 acts as protective resistor for T2.

When the intruder comes in contact with these touch points, the circuit drives point L1 to high. L2 is connected to ground. This signal is then sent to control room. Each pole has a separate circuit and thus each pole has different output lines. Hence, depending on the output line, control room can figure out the instantaneous position of the intruder. Depending on the load, appropriate transistor T2 must be connected. In this case, 2N2222 switching NPN transistor is used which can handle up to 800mA of current. Value of R2 also depends on the load connected across L1 and L2.

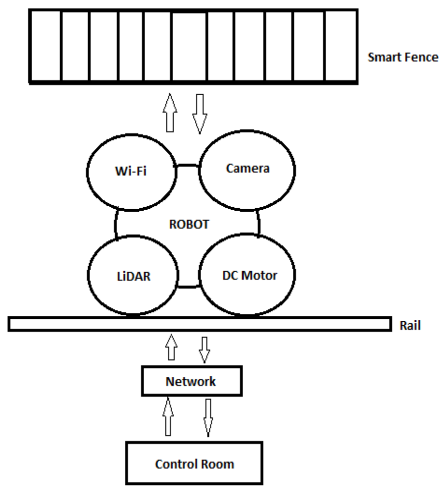
Circuit Diagram:



5. IMPLEMENTATION

SolidWorks software was used for designing of the 3-Dimensional Model of the robot body. The model was perfectly designed such that the robot body remains perfectly balanced on the rail for the entire course of tracking and made sure that the shape of the bot helps in perfect placement of the components.

A. Block Diagram



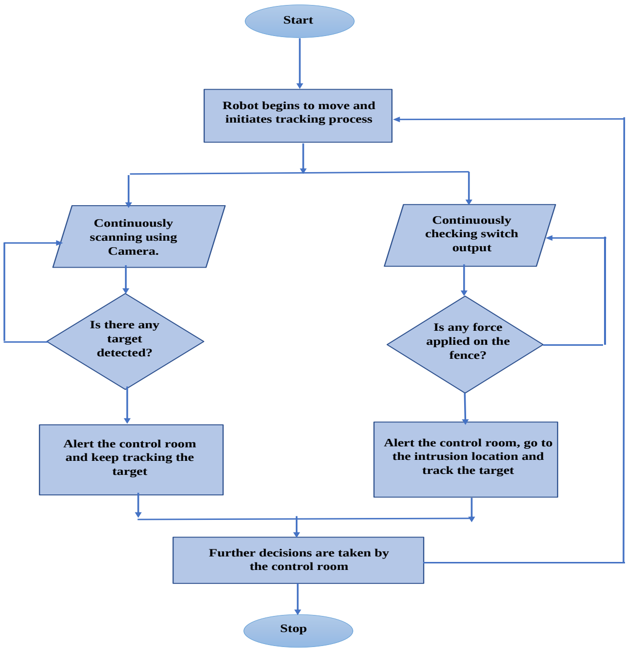
B. Working

The robot body is designed such that it keeps its posture as it moves along the rail which is in turn attached to the smart fence. The raspberry pi in the robot body is powered with help of a battery which is placed inside the robot body. The Wi-Fi module present inside the body ensures flawless communication between the bot and the control room. The camera connected to the raspberry pi checks for any intrusion with the help of Object detection algorithm designed using Haar-Cascade Classifiers uploaded into the raspberry pi.

The LiDAR assists camera in object detection by providing coordinates of the intruder with respect to the bot.

The Ultrasonic sensors connected to the bot body ensures that collision/derailing is avoided as the bot reaches the end of the rail. Smart fence is used to alert the control room when any sort of unauthorized intrusion takes place and control room then takes further measures to tackle the situation. The fence system is highly useful in situations where the bot is far away from the site of intrusion.

C. Flowchart



6. RESULT

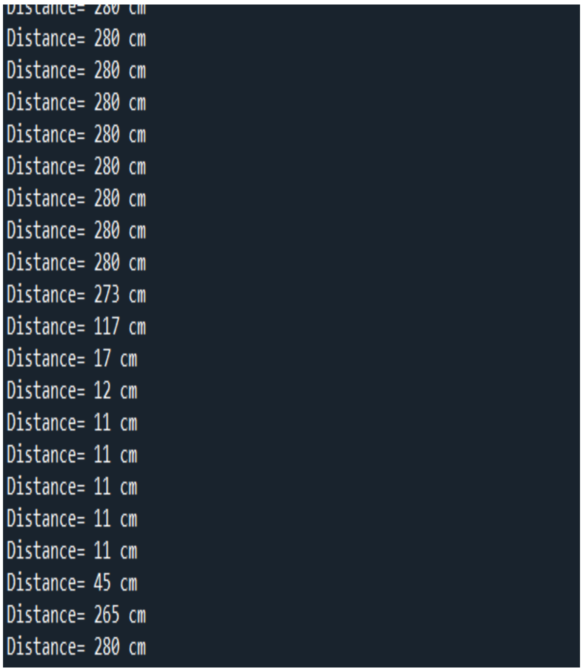
A. Movement
After interfacing the 12V DC motor with raspberry pi 4 using L298N motor driver, we could drive the pulley attached to motor's shaft, which in turn resulted in the movement of the robot.

B. Live Video Streaming
After interfacing camera with Raspberry pi 4, we could live stream the video to the control station.

C. Detection
Using image detection with OpenCV library we could detect any intruder in cameras viewing reach and save the video footage.

D. Tracking
Using the error between the initial x-coordinate value and x-coordinate value after the intruder moves, we could track the intruder movement.

E. Distance measurement using LiDAR
After the intruder is detected, we could calculate the distance of the intruder from the robot body using LiDAR module interfaced with the Raspberry pi 4. The distance is calculated based on the time the laser took to return from the object to the LiDAR module.



F. Smart Fence

After designing the touch circuit of the smart fence, we could send data to the control room whenever the fence was touched. As soon as the fence was touched current signal was generated which was transferred to the Control room.

7. CONCLUSIONS

An autonomous surveillance system was developed which runs on a double rail structure joined to the smart fence. The robot runs on the rail appended to the fence by utilizing pulley's which is turned with the assistance of a 12V DC engine powered by LiPo battery and controlled by raspberry pi 4 using motor driver. The camera interfaced with raspberry pi is used to detect the suspect using image detection with OpenCV library and giving the control room live feed. The robot also tracks the movement of the intruder until it is inside the cameras viewing reach. The LiDAR gives the approximate distance of the suspect from the robot. The smart fence whenever contacted by any subject cautions the control station. The designed system is applicable for surveillance purpose at borders and other critical destinations that require similar security. Thus, a smart border surveillance system was successfully designed and implemented to provide unmanned surveillance with intrusion detection and tracking.

ACKNOWLEDGEMENT

This project would not have been possible without the exceptional support of our project guide Prof. Devendra Sutar, Assistant Professor, Goa College of Engineering whose enthusiasm, knowledge and exacting attention to detail have been an inspiration for the development of this project. We also like to express our sincere gratitude to Dr Rajesh Lohani, Principal, Goa College of Engineering and Dr H.G. Virani, Head of Department, E&TC Dept for the continued support and for providing us the infrastructure and facilities for conducting our project. We take this opportunity to thank all our faculty for the help in this endeavor. We extend our regards for our family and friends for their unwavering support throughout our careers.

REFERENCES

[1] Palagati Harish, R.Subhashini, K.Priya, “Intruder Detection by Extracting Semantic Content from Surveillance Videos”, International Conference on Green Computing Communication and Electrical Engineering (ICGCCEE), pp. 1-5, IEEE, 2014

[2] Sagar R N, Sharmila S P, Suma B V, “Smart Home Intruder Detection System”, International Journal of Advanced Research in Computer Engineering and Technology (IJARCET), Vol:6 No:4, pp. 439-443, 2017

[3] Dushyant Kumar Singh, Dharmender Singh Kushwaha, “Automatic Intruder Combat System: A way to Smart Border Surveillance”, Defense Science Journal, Vol:67 No:1, pp. 50-58, 2016

[4] Alazzawi, Lubna, Alkhathami, Mosad and Elkateeb, Ali. "Border Surveillance and Intrusion Detection Using Wireless Sensor Networks," International Journal of Advances in Engineering & Technology, 8, pp. 17-29, 2015.

[5] Zhang, Lijing & Liang, Yingli. "Motion human detection based on background subtraction," 2010 Second International Workshop on Education Technology and Computer Science, pp. 284-287, 2010.

[6] R. A. Deshmukh, Shubham Kamdi, Mohak Pingle, Shivani Raje Bhosale, Asawari Bhosale, “Intelligent surveillance system using energy efficient intrusion detection and tracking techniques”, 2nd International Conference on Electronics, Communication and Aerospace Technology (ICECA), pp. 1214-1218, IEEE, 2018

[7] Essendorfer, Barbara, Monari, Eduardo & Wanning, Heiko. (2009). "An Integrated System for Border Surveillance," in Fourth International Conference on Systems, pp. 96, 2009.

[8] Shivani & Kaur, Lakhwinder. "A Brief Review: Border Intruder Detection System Based On Computer Vision," Imperial Journal of Interdisciplinary Research, 2(7), pp. 2454-1362, 2016

[9] Felemban, E. "Advanced Border Intrusion Detection and Surveillance Using Wireless Sensor Network Technology," International Journal of Communications, Network and System Sciences, 6(5), pp. 251-259, 2013.

[10] Ferdoush, Sheikh and Li, Xinrong. "Wireless Sensor Network System Design Using Raspberry Pi and Arduino for Environmental Monitoring Applications," Procedia Computer Science, 34, pp. 103–110, 2014.