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Enhanced Robotic Surveillance & Inspection System Innovations for Versatile Terrain Exploration

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Abstract

Robotic control has demonstrated a positive impact on various segments ranging from forest patrolling to industrial inspection, drainage inspection, and pipe inspection. These versatile robots typically feature up to six wheels and run through rugged terrains with ease. By using night vision cameras, live video feeds may be accessed on laptops and smartphones, allowing for remote monitoring and photo taking. Robotic gadgets become more autonomous when night vision technology is integrated into them. Control and automation play a major role in robotics, which is a disruptive technology and essential to our system. The cameras utilized for these sorts of inspections must have specialized technologies to fulfil their purpose effectively. Moreover, the conventional cameras fall short in detecting industrial deformities, leakage issues, heating abnormalities, or potential harmful weapons, etc. To address these challenges, our developed robot operates on a tracked mechanism, allowing it to traverse rough terrain akin to a tank's mobility. Additionally, the remote-controlled (RC) robot boasts a control range of over 100 meters and is equipped with both night vision capabilities and object detection technology, enhancing its surveillance and inspection capabilities significantly.

Keywords: Robot, night vision, surveillance, raspberry Pi, video feeds.

INTRODUCTION

The aim of this work is to ensure comprehensive security in the designated area. In case of any detected faces, the system captures images for potential identification and assistance. Utilizing night vision cameras, live video feeds are accessible via smart phones and laptops, enabling remote monitoring and image capture. The integration of night vision technology enhances the autonomy of robotic devices [1]. Robotics, a transformative technology, relies heavily on control and automation, making it integral to our system. These robotic units, akin to computers, are easily controlled via remote access. Patrolling involves continuous monitoring of designated areas by these robots, ensuring constant surveillance and movement within their allocated zones. Images captured by the robots are transmitted in real-time to users for evaluation, enabling prompt action if any issues arise. Equipped with camera motors, these robots can gather data from multiple angles, enhancing surveillance capabilities [3]. Utilizing a predetermined path, the robots navigate and patrol the area efficiently.

LITERATURE SURVEY

In response to the imperative for a device capable of detecting and signalling activities in a designated area, a spy robot system was developed utilizing the Raspbian operating system, complemented by a control algorithm and remote monitoring capabilities [1]. The system comprises three key

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components: an Arduino board, a camera, and a night vision sensor. Information pertaining to activities captured by the camera is relayed to users via a web server, simultaneously displayed on a dedicated webpage.

The groundwork laid by Qunqun Xie, Cheng Tang, Yongsheng Ou, and Guolai Jiang in their 2013 study on planar reflection models for road surveillance inspired diverse concepts for road detection and monitoring. Effective road and street surveillance is pivotal for various activities such as identifying new individuals and detecting suspicious behaviour. While numerous methods have been devised for daytime surveillance, nocturnal monitoring remains largely unexplored. The advent of new technologies facilitates night time identification. However, vision-based devices face challenges distinguishing between desired objects and extraneous elements such as vehicles or birds. Introducing a planar reflection model with an infrared camera could enhance pixel classification, ensuring accurate lane identification.

The development of a remote-controlled spy robot capable of traversing up to 125 meters exemplifies the multifaceted applications of this technology. The compact design enables ease of transportation, while smartphone compatibility facilitates remote control [2]. Utilizing radio frequency technology, the robot communicates between a radio frequency receiver onboard and a transmitter at the base station. This design paves the way for the integration of wireless cameras for monitoring purposes. Equipped with an 8051 series microcontroller, the robot employs surface detection algorithms to navigate effectively.

Research by David Beymer and Kurt K focuses on real-time face tracking amidst background clutter and occlusion, emphasizing the importance of continuous detection [3]. Similarly, Harsha Nanda and L Davis have developed optimization techniques to enhance implementation speed, catering to diverse hardware requirements [4]. The "Night Rider" system, employing visual odometry with headlights, facilitates relative motion estimation using camera images [5]. While cheap sensors offer extensive data collection capabilities, the system's reliance on external lighting sources presents challenges in varying conditions. Exploring alternative lighting solutions and addressing complexities such as visibility and speed remain crucial areas for further advancement [6].

CIRCUIT DIAGRAM AND METHODOLOGY

Block Diagram

The below block diagram as shown in Figure 1 gives us the knowledge of components used in the circuit for hardware specifications along with the VNC viewer.

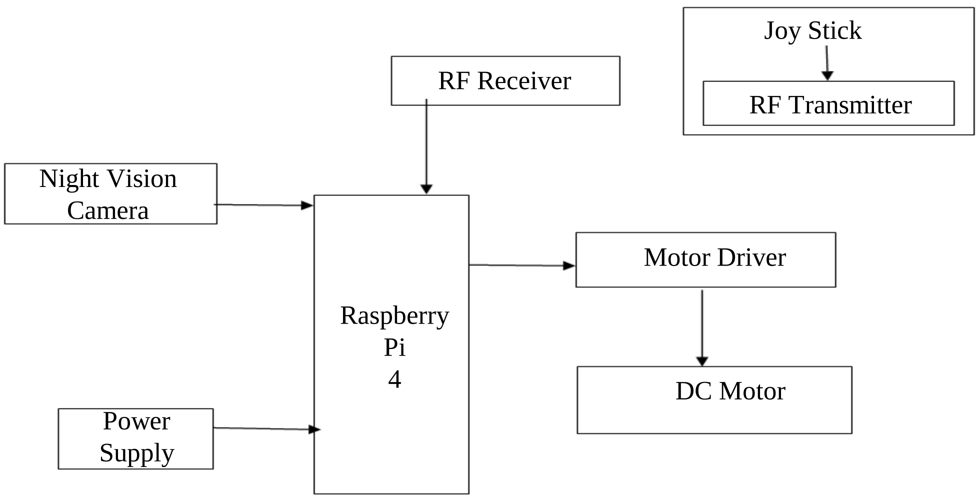

Figure 1. Block diagram of Night vision RC tracked robot.

Working Process

According to the block diagram Figure 1, the robot consists of the main component raspberry pi which is equipped with a night vision camera that helps the user to monitor the surrounding area during the daytime as well as at night time. And that captures the face of the person and gets saved in a folder so that the user can check at any time and detects the different objects and gives names of the objects. The robot has the ability and intelligence to protect the greater region. This robot moves in four directions and can be controlled using a joystick as well as with four keywords on the keyboard.

Once the power supply is given to raspberry pi it gets activated and it needs wifi to connect wirelessly and then the night vision camera connected to it also gets activated. Then the user can watch the live streaming in the Virtual Network connect viewer app by typing the IP address and connecting both the raspberry pi and laptop to the same wifi network. After opening and connecting the app there a window will be displayed in which there are some folders on the desktop. In one of the folders we have to run the programmed code then we can see the live video of surrounding areas, the IR lights on the night vision camera allow us to get complete and clear vision even in daytime and night time. After that, we can move the robot by using a joystick or by using keywords on the laptop. The robot moves in different directions with the help of dc motors and a motor driver connected to it and has four wheels with track linkages. The motor driver needs a power supply to move the robot.

The robot can move with the help of a joystick because the HC12 transceiver is connected to both ends of the raspberry pi and the joystick. This transceiver helps in sending and receiving the signals for the movement of the robot. The HC12 at raspberry pi acts as the receiver and the HC12 at joystick acts as a transmitter.

SOFTWARE IMPLEMENTATION

In our paper python language is used. The reason for using this language is because of its versatility, power, and easy use. Python has easy programming with simple syntaxes. Python comes pre-installed for Raspbian, so it is easy for programming and interfacing with other components.

VNC Viewer is used to run the code and enable the robot to move. In the VNC Viewer, first we should write the IP address of the Raspberry pi which is visible in the Wireless Network Watcher Tab. We require authentication to the VNC Server, where we type the user id and password. The next step is to write the username and password. All the files are opened and we need to open the required code. Now, we need to run the code which enables the robot to start. And the live streaming from the camera can be seen even at night times [7].

Raspberry Pi 4

Raspberry Pi stands as a formidable and compact computing solution, roughly the size of a standard debit card. Since its inception, the open-source community has contributed numerous operating systems, applications, and similar computing solutions. Powered by the Broadcom BCM2711 processor, it boasts a quad-core Cortex-A72 (ARM v8) 64-bit architecture and 8 GB of RAM. Additionally, it features built-in WiFi and Bluetooth capabilities, enabling seamless connectivity. With 2 USB 3.0 ports and 2 USB 2.0 ports, it offers versatile peripheral connectivity options. Data storage is facilitated through a MicroSD Card Slot, providing expandable storage solutions. The device operates on a 5.1V power supply, ensuring reliable performance.

HARDWARE & SOFTWARE IMPLEMENTATION

Night Vision Camera

The Raspberry Pi Night Vision Camera is compatible with all revisions of the Pi. It offers impressive capabilities, including capturing static images at a resolution of 2592 × 1944 pixels. Additionally, it supports video recording at various resolutions and frame rates. Connecting the camera to the Raspberry Pi is straightforward, as it utilizes one of the two small sockets on the upper surface of the board. This connection is facilitated through the dedicated CSI (Camera Serial Interface) interface, specifically designed for camera interfacing. The CSI bus boasts high data transfer rates, enabling seamless transmission of pixel data between the camera and the Raspberry Pi [8].

Joystick

Joysticks serve as integral components in numerous industrial applications, facilitating precise control over the direction of machines in two dimensions: forward, backward, left, and right. To relay this full range of motion to the computer, a joystick employs a mechanism to measure the stick's position along two axes—the X-axis, spanning from left to right, and the Y-axis, moving from up to down. By capturing X-Y coordinates, the joystick accurately pinpoints the stick's position, akin to basic geometry's coordinate system [8, 9]. The commands which are given by Joystick is shown in Figure 2.

Motor Driver

The L293D motor driver is a versatile solution capable of powering two DC motors using a single IC. It offers both speed & direction control functionalities. With a motor voltage (V_{CC}) range of 4.5V to 36V, it accommodates various motor types. The maximum peak motor current is 1.2A, ensuring efficient motor operation within specified limits. The supply voltage (V_{SS}) ranges from 4.5V to 7V, providing stable power to the motor driver circuitry. One notable feature of the L293D is its automatic thermal shutdown mechanism, which safeguards against overheating, enhancing overall reliability. Operating on the principle of a half H-bridge, the IC enables bidirectional motor control, allowing motors to rotate in both clockwise and counter clockwise directions. This capability makes it suitable for a wide range of applications requiring precise motor control and directionality.

Arduino Pro Mini

The Arduino Pro Mini is a compact microcontroller board built around the ATmega328P chip. It boasts 14 digital I/O pins, with 6 of them capable of functioning as PWM (Pulse Width Modulation) outputs. Additionally, it features 6 analog input pins, providing versatility for various sensor applications. The board is equipped with an onboard resonator and a reset button for easy programming and debugging. The mounting holes accommodate pin headers, facilitating secure installation onto other devices or surfaces. The ATmega328P chip, at the heart of the Arduino Pro Mini, offers 32KB of flash memory for storing program code. This ample memory capacity allows for the implementation of complex and feature-rich applications, making the Arduino Pro Mini a versatile and powerful tool for embedded systems development [10].

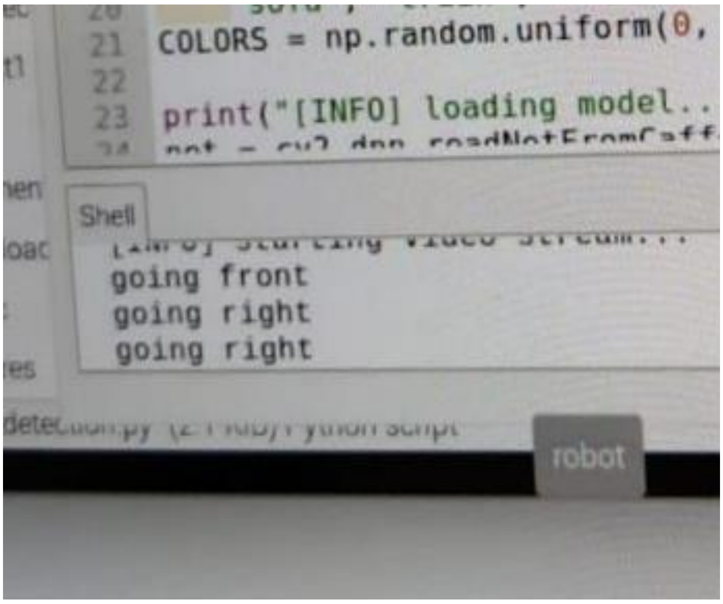

Figure 2. The commands which are given by Joystick.

RESULT

Step 1: Switch ON the kit by connecting the battery and raspberry pi to the laptop or powerbank.

Step 2: Connect the raspberry pi with the laptop and run the code. The robot starts moving by controlling the joystick as shown in Figure 3.

Step 3: Now, different Objects are detected by moving the robot in different directions as shown in Figure 4, 5, 6, 7, 8 and 9.

Step 4: The detection of objects during night time.

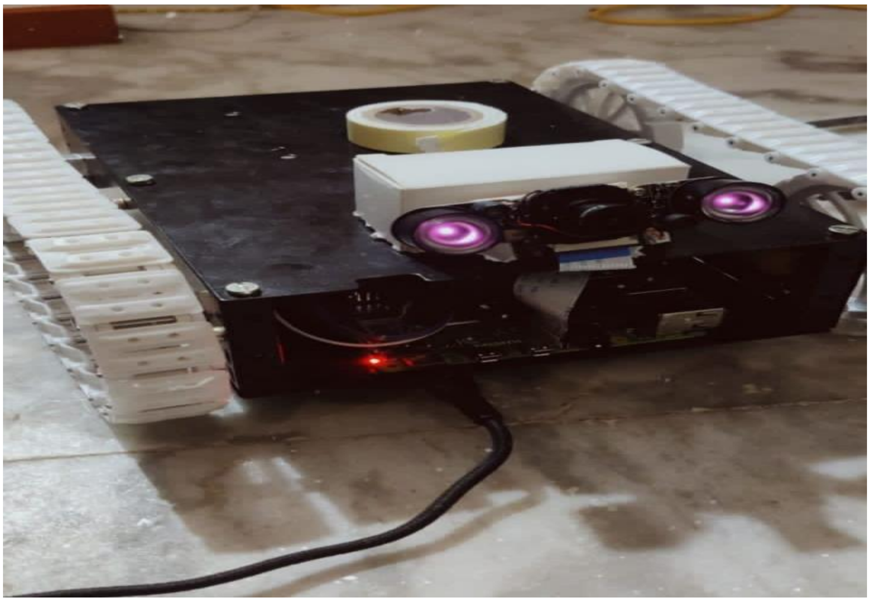

Figure 3. Front View of the Robot.

Figure 4. Face detection(Case 1).

Figure 5. Face detection (Case 2).

Figure 6. Object(Bottle) Detection (Case 1)**.**

Figure 7. Object(Bottle) Detection (Case 2).

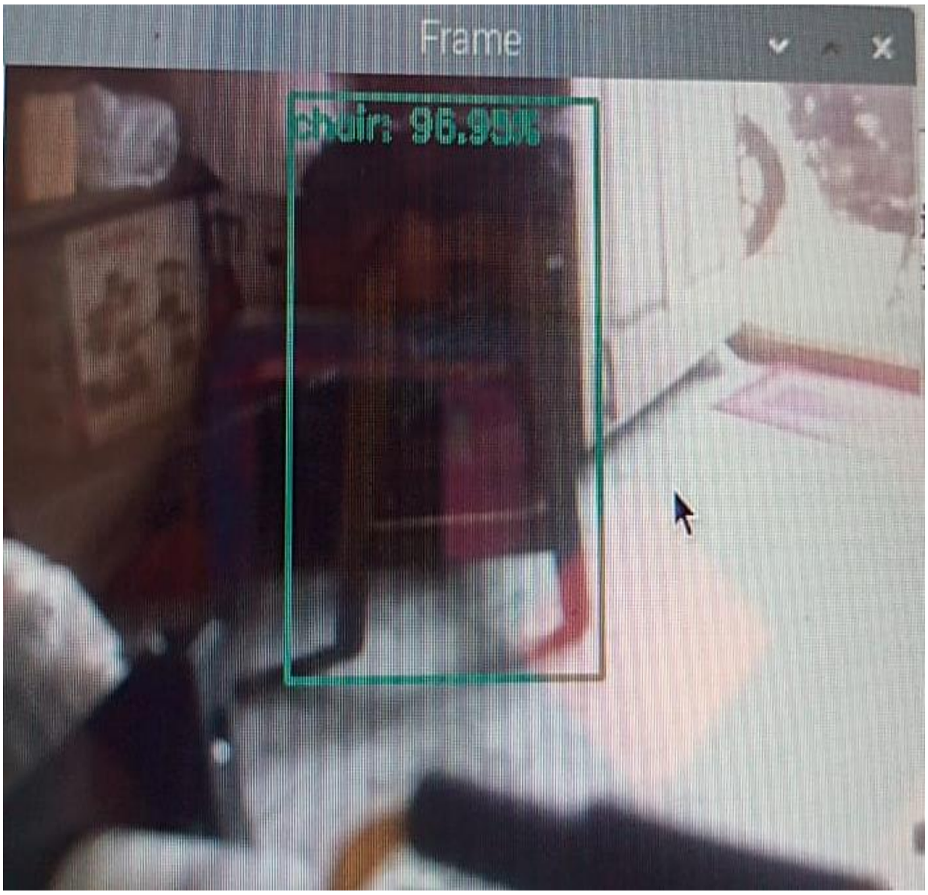

Figure 8. Object (Chair) Detection (Case 1).

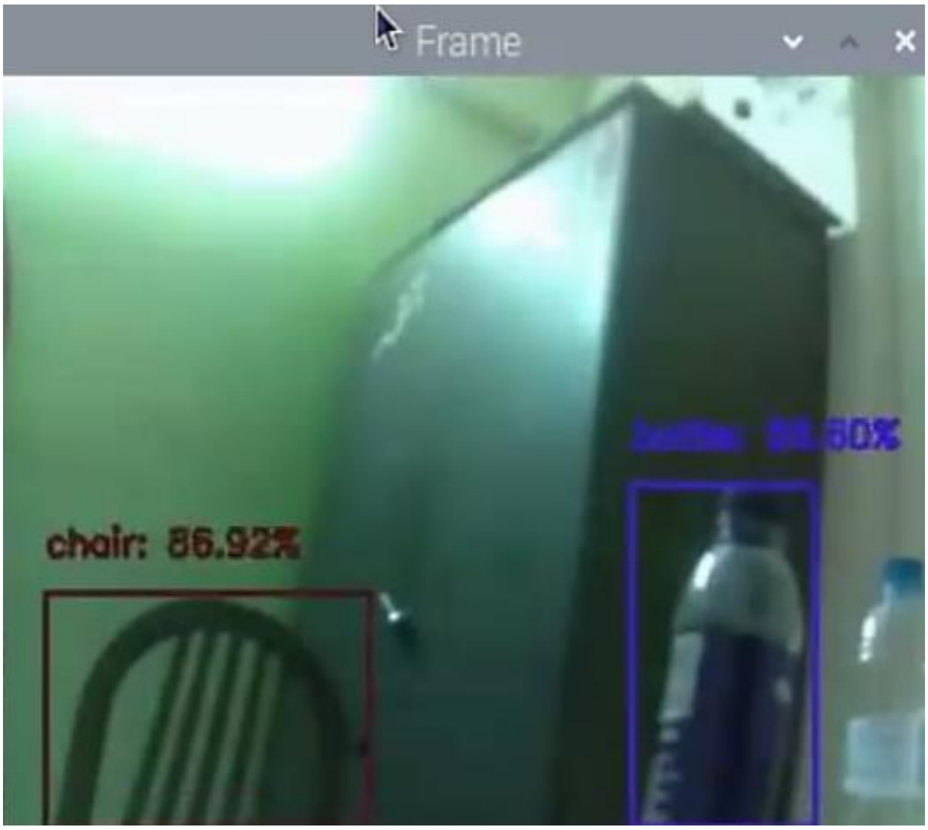

Figure 9. Object(Chair) Detection (Case 2).

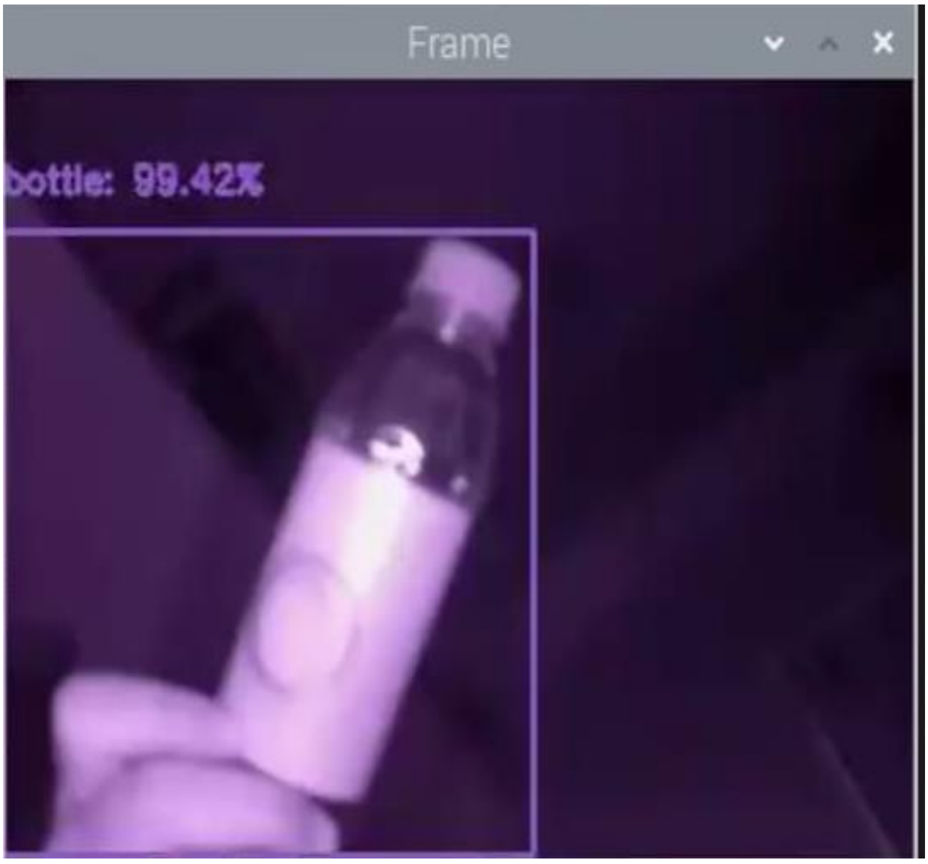

Figure 10. Objection Detection(Bottle) during night time.

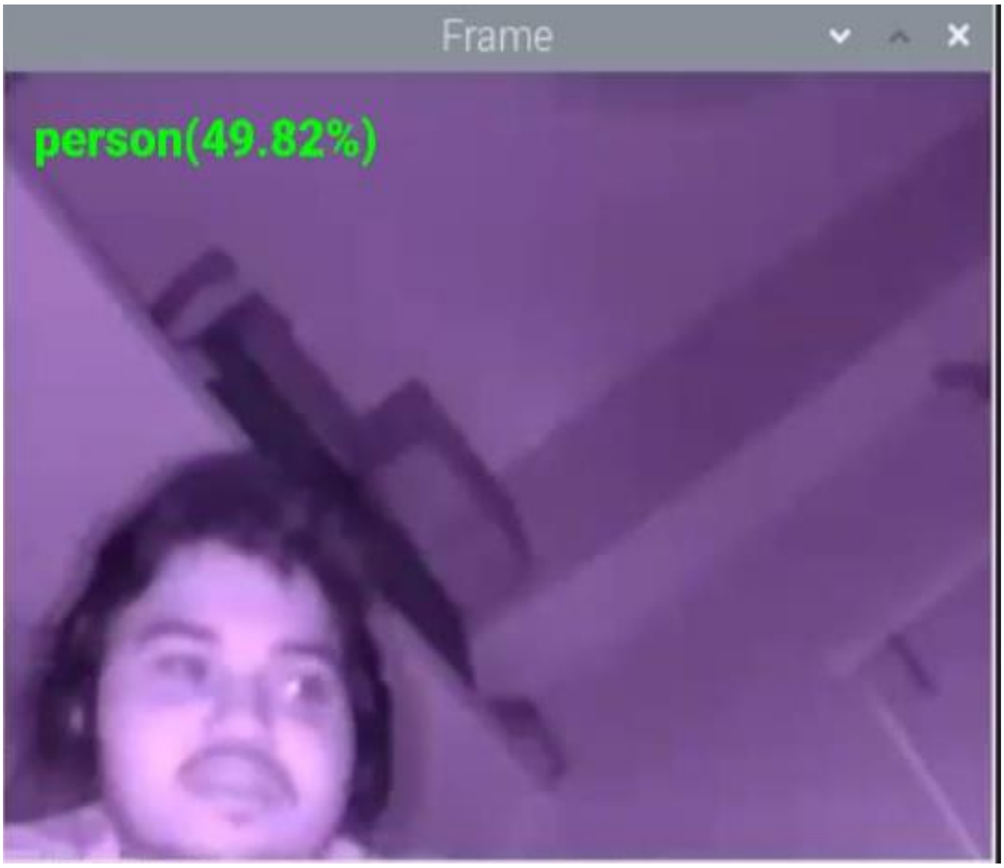

Figure 11. Face detection during night time as shown in Figure 10, 11, 12, 13.

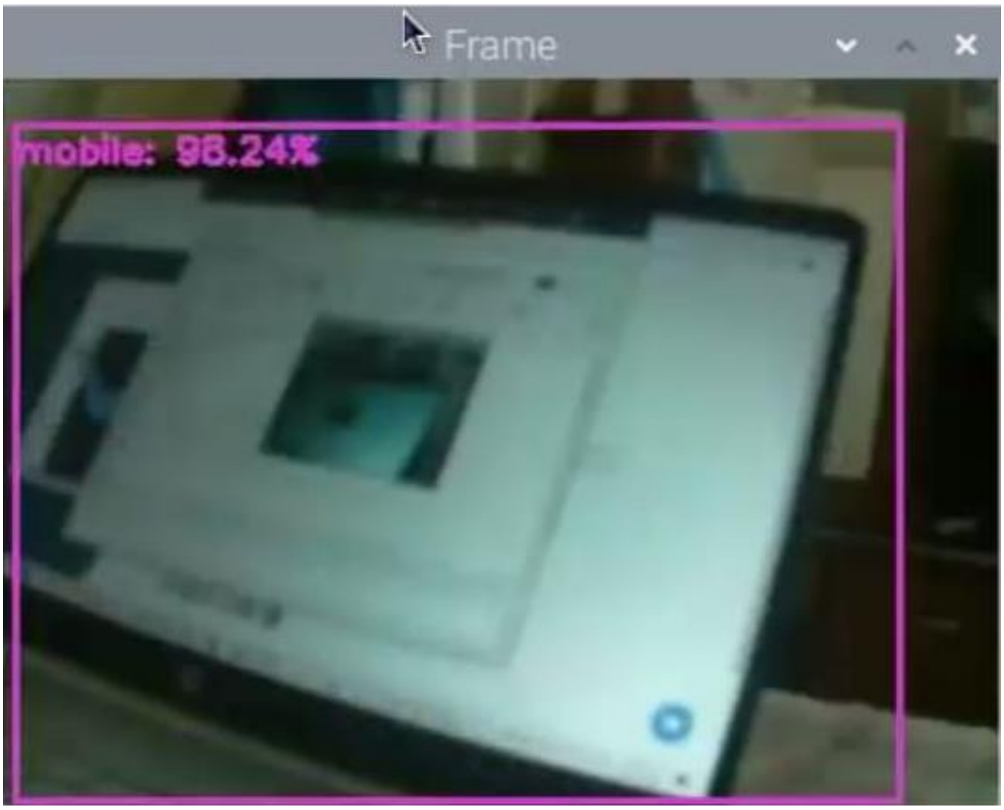

Figure 12. Wrong Object detection(Case 1).

Figure 13. Wrong objection Detection (Case 2).

CONCLUSION AND FUTURE SCOPE

The paper concludes by introducing a novel concept of a night vision RC tracked robot designed to enhance security measures. This robot traverses along a predefined route, continuously patrolling the area under surveillance. Equipped with a night vision camera, it captures images of any detected individuals, storing them for further examination and action.

Utilizing the night vision camera, the robot enables comprehensive monitoring of the designated area, with the capability to capture live video streams. Leveraging this feature, the security system can benefit from real-time video streaming via VNC server integration. The fabricated robot represents a cost-effective solution, utilizing readily available components from the market.

Looking ahead, the paper proposes the potential addition of a fire-detection module to the robot, enabling it to autonomously detect and approach fires, extinguishing them from a safe distance using water or other extinguishing agents. Furthermore, future advancements could involve enhancing the night vision camera's object recognition capabilities through additional training data, thereby improving result accuracy. Additionally, upgrading to a higher-specification camera could further enhance the robot's surveillance capabilities and overall performance.

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