OPENCV based TRACKING and MANEUVERING VEHICLE (OTMV)

Mrs. Monali Chaudhari, Amit Kadam, Dhairya Thakkar, Gauresh Vanjare, Malay Shah, Gaurav Mulani.

***Abstract*— With the growth in the technology, better security and surveillance systems emerged. We aim to develop a low cost Unmanned Ground Vehicle (UGV) which can be modular to provide us the video feed and shoot the enemy with face tracking algorithm. This budget friendly UGV is made using Arduino Uno, Ultrasonic Sensors, IP Camera and Gun Control Mechanism (GCM) consisting of two servo motors. UGV is maneuvered in the field with the help of ultrasonic sensors. Camera is used to provide live feed of the field. This camera serves as an input device for image processing to track the face on the base station side and send the coordinates of the 2D mapped face to the Arduino on the UGV side. The Arduino commands the GCM to track the face and shoot it or give a visual indication to the operator to manually shoot the target. The base station communicates with UGV wirelessly using Zigbee. This system can prove handy in several military and rescue operations.**

***Index Terms*— Face detection and tracking, Gun Control Mechanism (GCM), Obstacle avoidance, Unmanned Ground Vehicle.**

I. INTRODUCTION

With world growing at such fast rate lot of advanced technologies have been evolved, which are used every day in life. One of the intriguing technologies is the unmanned vehicles. The unmanned vehicle finds its use in military, civil and commercial sectors as described by the Association for Unmanned Vehicle System Internationals (AUVSI). Various types of unmanned vehicles are Unmanned Ground Vehicle (UGV), Unmanned Air Vehicle (UAV), Unmanned Undersea Vehicle (UUV), Unmanned Surface Vehicle (USV) and Unmanned Spacecraft. Each type of these Vehicles has its own special purposes.

The Unmanned Ground Vehicle (UGV) is land-based vehicle used for different applications like military, surveillance, security service, border patrol, hostage situation, etc. UGV's can be used to augment the human capabilities in several life threatening activities. As demonstrated by Abdelhafid B. [1] all UGV's can be applied in security as well as in civilian operations. Various implementation techniques have been developed [2] to run UGV's on different surfaces such as flat, rough terrain, etc. *UGV's can be operated in two modes*[1,3,4,5]: *Autonomous mode*, in which the vehicle itself intelligently performs the operation without human intervention and *Remote Controlled Mode* in which the vehicle sends the various sensor readings to Base Station and human present at Base Station decides to perform a particular operation. The proposed work is based on the Foster-Miller TALON robot [6], DRDO Daksh robot [7] and [8] and the face detection and tracking algorithm developed Viola and Jones. Our aim is to develop a vehicle that can autonomously find its path by the obstacle avoidance algorithm and to use it in border patrol as well as in rescue operation to effectively track and target the intruder using Image Processing, specifically a face detection algorithm and Gun Control Mechanism

II. SYSTEM OVERVIEW

A. *Vehicle Block Diagram*

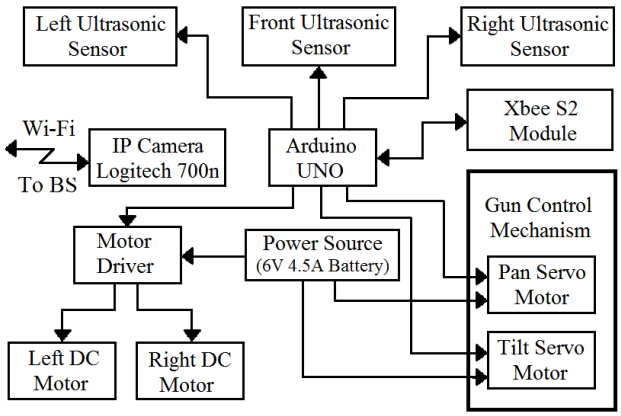

Fig. 1 Block Diagram of UGV-Hardware

Hardware system of UGV consists of 7 major sections as shown in Fig. 1:

1. Arduino UNO:

Arduino UNO is the heart of the system which consists of Microcontroller IC Atmega 328. It receives signals via Zigbee and accordingly commands various sensors and motors connected to it as well sends various reading received by the Ultrasonic sensor to the base station via Zigbee.

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2. Ultrasonic sensors:

In order to maneuverer our robot autonomously in the field we have used an Ultrasonic sensor HC-SR 04. Three Ultrasonic sensors are used for front, left and right directions. If any obstacle is detected by the Ultrasonic sensor, it accordingly changes its path, thus acting as an obstacle avoider. It can detect obstacles in range of 3cm to 3m.

3. Motor Driver:

Motor Driver consists of L293D IC used to drive the DC motors. Motor driver receives command from the Arduino and accordingly drives the DC motors which are used to run the UGV.

4. Gun Control Mechanism (GCM):

GCM which consists of a turret which can be moved in X and Y direction i.e. pan and tilt motion respectively with the help of two Servo motors. Depending upon the co-ordinates received by the Arduino, it accordingly rotates the pan and tilt servo motor in order to shoot the target.

5. IP Camera:

Logitech 700n IP camera is used to capture the live feed and send it to the base station over wireless network using Wi-Fi which is used to detect the intruder using face detection algorithm.

6. Zigbee Module:

Two Zigbee Modules are used as trans-receiver for wireless communication between Base station and UGV. Zigbee module is used to transmit the Ultrasonic sensor readings to base station and used to receive the signals from base station to maneuver the vehicle.

7. Power Source:

UGV has a 6V 4.5Amp NiCd rechargeable battery. It is used to power DC motors used to run the UGV as well as Servo motors used for Pan and tilt motion in GCM.

B. Base station and Vehicle

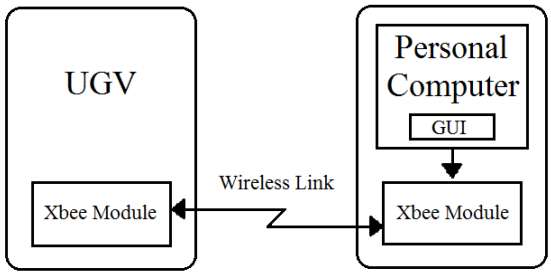

Fig. 2 Block Diagram of Base Station

Fig. 2 shows the controlling mechanism for the UGV. The Base Station includes a personal computer with JRE 1.8 to compile the java sketch. The java sketch has a graphical user interface for easy tele operation control. Zigbee S2 in Router AT mode is used at Base station. On the other side, UGV with another Zigbee S2 is configured with same PAN ID as that of Router. UGV side Zigbee is operated as Coordinator AT for point to point wireless communication with Zigbee in Router AT mode.

C. Communication between Base station and UGV

The data for telemetry is sent in the form of a frame by the base station. Fig shows the frame structure.

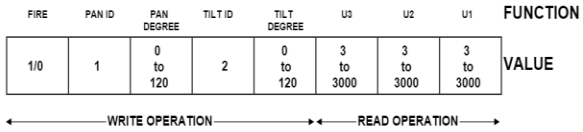

Fig. 3 Frame structure of the data

Fig. 3 pictures the format in which the data is transmitted or received from the Base station.

- U1, U2, U3 are the ultrasonic sensor reading that are transmitted by the UGV to the Base station. These reading are used for maneuvering the UGV.
- TILT ID and PAN ID are to uniquely identify the two servo motors of GCM.
- PAN DEGREE and TILT DEGREE are used to rotate the servo motor with rotation value ranging from 0 to 120 degree. These servo movement values are set by the target's location x-y coordinate .
- FIRE is set manually to 1 to hit the target.

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III. DESIGN OF UGV

A. *Vehicle Design*

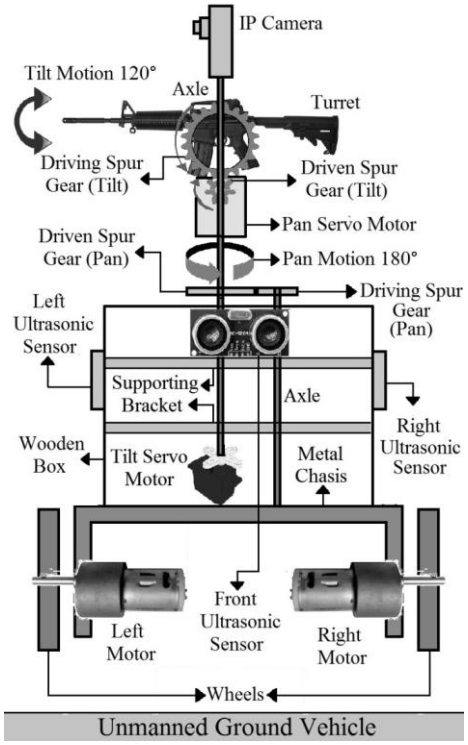

Fig.4 Hardware Design of UGV

Fig.4 is the hardware design of UGV which consist of a gun controlled mechanism, vehicle, IP camera and Ultrasonic sensors. UGV can be moved manually as well as automatically which is done with the help of Ultrasonic sensors. Three Ultrasonic sensors are used for front, left and right direction in order to maneuverer the UGV in the field. In autonomous mode, UGV automatically maneuverers in the environment with the help of readings received from all the Ultrasonic sensors. While in manual mode readings of the Ultrasonic sensors are sent to base station by the Arduino using Zigbee S2 module. With the help of these values person sitting at the base station manually moves the UGV. Gun controlled mechanism consist of a turret used to shoot the intruder and a pan and tilt mechanism used to move the turret using two servo motors. One servo motor is used for pan motion used to rotate the turret horizontally in 180 degree while other is used for tilt motion used to rotate the turret vertically in 120 degree. Gun controlled mechanism is placed on a vehicle consisting of two 10 kg torque 200 rpm DC motors at the rear end and two dummy motors at the front end. IP camera is used to send wireless live feed of the field using Wi-Fi to the base station as well to detect the intruder using face tracking algorithm in order to find the co-ordinates of the intruder in the frame which is sent to the Arduino. Once the intruder is detected and tracked, it can shot manually as well automatically. In autonomous mode turret automatically shoots once face is detected while in manual mode person at base station decides to shoot or not. Thus in manual mode it allows the person at base station to know whether the person detected is foe or friend. Fig is the prototype structure of the UGV.

Fig 5. Prototype of UGV

B. *BASE STATION DESIGN*

Base station is the key element to control the functioning of the UGV as shown in Fig.6. It has 5 major sections:

1. **Live Feed Screen:**

   Logitech 700n IP camera and the personal computer are connected to the same Wi-Fi network. This enables us to retrieve the live video from the camera and display it onto a PFrame inside GUI.

2. **Vertical movement mode selection switch**

   It is used to select manual and automatic movement of the tilt mechanism.

3. **Vehicle movement control**

   On click button events trigger the movement of the bot in left, right, forward, backward motion. There is stop button to make the robot standstill.

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Fig.6 GUI on the Base station side

4. Shooting mode

This slider switch gives an autonomous fire triggering control based on the position of the face being tracked. Along with this, the GCM can be controlled manually.

5. Ultrasonic Distance meter

It adds second level of intelligence in the Robot control by sensing the environment around it. Three ultrasonic sensors are used to detect the obstacle and send the obstacle range reading to the Base station. These readings help the operator to maneuver the robot in the arena

IV. ALGORITHM

Face detection is done using Haar cascade using OPENCV. Adaboost algorithm is used for fast detection [8]. Based on the difference in the intensity level of the nose and eyes a contour is formed round he face as shown in Fig. 6

A. System Algorithm

1. Power on the UGV Circuits, GCM, Zigbee, H-bridge and the wireless camera.
2. Connect Zigbee which is configured in router AT mode to the Personal Computer (PC).
3. Load the haarcascadefrontalface.xml in the processing sketch folder on the Personal Computer
4. Run the java sketch.
5. The java sketch loads up with the live feed screen from the camera on UGV side. The PC then sends the data frame to the UGV wirelessly with Zigbee.
6. For autonomous mode of GCM, slide the shooting mode to the right. This controls the GCM and points the gun to the target using face detection. It then shoots the target with the gun.
7. For manual mode of GCM, the operator controls the vertical tilt with the help of vertical slider switch.
8. For manual Vehicle movement, ultrasonic sensors are used to get numerical indication of the distance from the obstacles (LEFT, RIGHT, CENTER FORWARD)
9. For autonomous Vehicle movement, the Arduino takes the decision to move the UGV based on the ultrasonic sensor reading.
10. Buttons are used for movement of the UGV.

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V. RESULTS AND DISCUSSIONS

Movement of the UGV was based on the following ultrasonic sensor readings:

Table 1: UGV movement

CASES	U1 LEFT	U2 CENTER	U3 RIGHT	OERATION PERFORMED
1	0	1	0	Move left or right (random)
2	1	0	0	Move right
3	0	0	1	Move left
4	1	1	1	Move back
5	0	0	0	Move forward
6	1	1	0	Move back and then right
7	0	1	1	Move back and then left

Here 1 indicates the values read by ultrasonic sensors are less than 15 cm and 0 for value greater than 15 cm. On the other hand the GCM is based on the face detection algorithm. The tracked face coordinates are sent to the Arduino. Arduino then rotates the servo motors with the help of received coordinates.

VI. CONCLUSION

We have successfully built a vehicle that can be controlled manually and autonomously using camera and obstacle avoidance algorithm. The vehicle can move in all environmental conditions by avoiding all obstacles in its path and effectively track and target the intruder using face detection algorithm and the gun control mechanism. The vehicle could be controlled manually as well as autonomously depending upon the situation. The UGV can be used in several rescue operations and during wars in border areas. The system could be further developed using a Global Positioning System (GPS) and a robotic arm for Improvised Explosive Device (IED) detection.

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BIOGRAPHY

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