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# Design and Implementation of Autonomous Robot for Military Applications Using Artificial Intelligence for Performance Management

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**ABSTRACT**
The emergence of autonomous machines is debated in the media. The progression of innovation in the field of autonomous route for robots is one of the main patterns these days, where we have to experience tremendous measure of eccentrics that is normal in military conditions during the defusing unexploded bombs or salvage tasks. Autonomous robots work in various types of condition, and it is essential for them to move and avoid obstacles around it. So as to explore the robot in an impact free way, way arranging calculations have been introduced. A human recognition calculation running on an indoor versatile robot needs to address difficulties including impediments because of jumbled situations, changing foundations because of the robot's movement, and restricted on-board computational assets. Earlier human detection was mainly done on images taken by visible light cameras. These methods take the detection process that humans use. We centre on continuous human-location and following in tumultuous and dynamic conditions and furthermore featuring the hugeness of fusing mechanical technology, correspondences and data examination in the field of land mine disclosure.

***Keywords -*** Autonomous Robots, Balancing, Collision Avoidance, Human Detection, Landmine Detection.

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## I. INTRODUCTION

We realize that a soldier's living includes chance taking and working in a risky domain. The undertaking included are strolling in a zone containing mined fields and defusing unexploded bombs or cleaning threatening structures are a portion of the models. Innovation is advancing regular making our lives simpler and agreeable, so imagine a scenario where we send robots to carry out the responsibility of a warrior. Along these lines, in the event that anything turns out badly, rather than losing a human life we would just lose the cash that was put resources into building the robot in spite of the fact that we can generally assemble more robots.

Today, most frameworks utilize a versatile robot with a camera for observation. The camera mounted on the robot can go to better places. Robots of this sort are increasingly adaptable. It expresses that the most generally utilized observation robots are wheel robots. Wheel stage robots are progressively reasonable for level stages. This robot has 6 leg structures (semi-round metal) which help it to move in any unfriendly conditions. Despite the general awareness on the number of landmines laid down around the globe, end-user's needs for new technologies must be properly assessed in order to avoid the wastage of financial funds.

Robotics is bringing innovatory changes in the world by introducing new technologies. The basic aim to employ a robotic method is to ascertain human safety and lessen human efforts. With the advancement and development of wireless and Internet communications, videos captured by this robot can be viewed remotely on any computer or laptop. During the war, it very well may be utilized to assemble data from the adversary's territory and screen that data in a protected region, and securely devise an arrangement for counter assault [6]. Follow the areas of foes' associations and afterward plan the assault at the correct time [7]. Screen any territory influenced by a fiasco where people can't go [9].

In the past few decades there has been a great interest in the problem of motion planning for autonomous mobile robots. To define motion planning problem in a better way, we can decompose it into path planning and trajectory planning. Path planning is taking care of the generation of obstacle free path taking into consideration geometric characteristics of obstacles and the kinematic constrains of the robot. Trajectory generation deals with the robot's dynamics, moving obstacles or obstacles not known priori which are time dependent constrains [6].

Considering the robot condition movement arranging can be either static or dynamic. We have static condition when the area of the considerable number of hindrances is known priori. Dynamic condition is the point at which we have halfway data about snags earlier the robot movement. The way arranging in a unique situation is done first. At the point when the robot follows its way and finds new obstructions it refreshes its neighborhood guide, and changes the direction of the way if essential [6].

Robot way arranging is tied in with finding an impact free movement starting with one position then onto the next. By speaking to engineered, reproduced people as robots, we can utilize movement arranging calculations to create persuading PC produced activity. There are numerous conventional procedures utilized in past in robot control, for example, PID. Issue with PID control is that they perform process effectively over restricted scope of condition. It is hard to have profoundly precise execution particularly at fast of procedures. The primary accentuation of the paper is to investigate the effective and precise method dependent on delicate figuring calculation to give the internet learning component which performs better in powerful, unstructured condition of robot [16,17].

The growing interest in autonomous mobile robot lead to the development of various types of mobile robot control methods and algorithms. The ability of mobile robot to navigate autonomously has improved tremendously due to the improvement of various path planning and obstacle avoidance algorithms developed by recent researchers. In the area of artificial intelligence (AI), Fuzzy Logic is often used in autonomous mobile robot for obstacle avoidance [9].

In ongoing decades, extraordinary intrigue has emerged in the issue of traffic getting ready for self-ruling portable robots. To describe this issue of movement arranging, we can partition it into way arranging and heading arranging [1]. Way arranging manages the age of a way without obstructions, pondering the characteristics of deterrents and the restrictions of the robot [2]. Direction age oversees robot components, snags in development or obscure deterrents from the earlier, which depend upon time [4, 5].

Detection of human individuals in video data is an essential need in the field of video surveillance. One is often interested in derived information from these detections, such as human tracks or the count of humans in the scene. Multiple humans in the observed scene can lead to challenging problems. Segmentation of human individuals close to each other, potentially overlapping each other is one example [7].

This problem is often encountered when a traditional camera setup is used under a 2D side view. In this context robust human detection and separation becomes an extremely difficult task especially when dealing with crowded scenes. Illumination changes in scenes are another burden when trying to develop a reliable human detection algorithm. Especially color data captured by traditional color cameras is sensitive to these illumination changes since the pixel values can change drastically in consecutive frames over a short period of time. Furthermore, shadows and reflection scan lead to spurious results of a detection algorithm [7].

Human identifiers running on self-sufficient indoor versatile robots experience a few difficulties. The apparent movement of the earth because of the movement of the robot itself makes it hard to seclude moving people. People are seen in an assortment of stances relying upon whether they are sitting or standing, the kind of furniture they are perched on, and the edge from which they are seen. Moreover, people collaborating with the robot may just be somewhat noticeable to the robot. Versatile robots have restricted computational assets which are shared among different procedures required for independent activity, so the human locator must have a little computational impression [18].

This paper clarifies the advantages of utilizing automated technique for the location of disguised mines. Mechanical technology is bringing innovatory changes on the planet by presenting new advancements. The essential expect to utilize an automated strategy is to find out human wellbeing and reduce human endeavors. Pakistan and some third world war nations require a state-of-the-art and skillful innovation, in this manner, to expel these mines the manual techniques are being utilized that carries fiasco to human life and property According to ICBL (International meeting to boycott Landmines) report, there were 5700 causalities in 2006 in various nations [10].

This robot will be associated with the control room utilizing either the neighbourhood or Wi-Fi. It will send continuous pictures that will be caught by means of the camera through the system [10]. Wi-Fi or a PDA are associated with a server, these gadgets could be utilized for face following and item qualification [13]. This system is appropriate in encased spaces. Mines are typically positioned beneath the ground surface and they are intended to detonate in light of the heaviness of the vehicles or troops that are moving over it [17]. Metallic items can be effortlessly recognized by the metal locator sensor utilizing electromagnetic fields [15]. Dynamic and Passive are the two essential methods of metal finders to identify metals utilizing electromagnetism [14].

This paper main focus is to develop an autonomous robot, keeping in mind the path planning it need to follow, obstacle avoidance algorithm the robot needs to implement. The collision avoidance algorithm is also taken into consideration. There is also a part of the robot that will focus on human detection and finding the enemies for the soldiers. It will also be detecting mines that have been buried and laid out for the soldiers by the enemy. The metal detector will detect the mines and warn the controller via signals. A robot with automatic balance is very similar to an inverted pendulum [3]. The robot is powered by six DC motors and is equipped with a Raspberry Pi 4 Model-B board, a single-axis gyroscope and a 3-axis accelerometer to determine the attitude [3,4].

The rest of the paper is organised as follows. Section II describes the related work, section III describes proposed Methodology, section IV describes system implementation and experimentation and section V concludes the paper.

## II. RELATED WORK

In the developing era wireless and internet connectivity, the videos filmed by this robot can be viewed remotely on any computer or laptop. The main objective of this paper is to create a robot to provide military support against the enemies. This robot will also serve us to spy on the enemy. It can detect underground mines and help prevent or destroy them. A camera is embedded in the robot and displays video or photographic images taken while traveling to remote areas. You can also store data or video and broadcast live from the camera, which is included in some subscriptions. During wartime, it can be used to get information from enemy positions and to search for information in a safe location, as well as attack planning. Know their enemy location and plan the attack in a timely manner. The robot connects to the control room via a local network or Wi-Fi. It transmits real-time images that are captured on camera through the network. Wi-Fi or smart phones are connected to a server that is used to track face and object recognition. This network is suitable for closed spaces. Landmines are usually placed under the ground and are designed because they carry the weight of a vehicle or army above it. Metal detectors can detect metal objects through electromagnetism.

### 1. Path Planning

Path planning can be portrayed as the errand of exploring a versatile robot around a space in which various deterrents that must be dodged to locate the ideal ways that limit the measure of turning, the measure of slowing down or whatever a particular application requires. Way arranging requires a guide of the earth and the robot to know about its area as for the guide. A dependable route calculation must have the option to recognize the current area of the robot, maintain a strategic distance from any impacts, and decide a way to the item.

1.1 Particle Swarm Optimization (PSO):

Particle Swarm Optimization (PSO) is a computational technique that upgrades an issue by iteratively attempting to improve an applicant arrangement with respect to a given proportion of value. It improves an issue by having a populace of up-and-comer arrangements, with named particles, and moving these particles around in the hunt space as indicated by straightforward numerical formulae over the molecule's position and speed. Be that as it may, metaheuristics, for example, PSO don't ensure an ideal arrangement is ever found. PSO can hence additionally be utilized on advancement issues that are in part sporadic, uproarious, change after some time.

1.2 Visibility Graph:

In visibility graph method obstacles on the way are considered of the shape polygon. The vertices of the polygon are joined in a way such that the optimal paths are found by avoiding the obstacles in best possible way. The main disadvantage of this method is that there is a possibility that the robot can hit an edge of the obstacle if the size of the considered graph is same as the obstacle.

1.3 Generalized Voronoi Diagram:

This method is similar to the visibility graph method only difference is the size of the graphs being increased for the robot not to hit an edge of the obstacles. This uses simple graph search techniques. Therefore, this method can be used effectively in area with more obstacles [6].

1.4 Tabu Search:

Tabu Search is a nearby quest technique utilized for numerical enhancement to permit slope moving to conquer neighbourhood optima. Neighbourhood search techniques tend to get stuck in problematic locales or on levels where numerous arrangements are similarly fit. Unthinkable hunt depends on the reason that critical thinking, so as to qualify as shrewd, must join versatile memory and responsive investigation [3,5].

1.5 Genetic algorithm (GA):

It is a heuristic search that emulates the process of natural evolution. It proceeds by creating an irregular introductory populace and afterward makes a succession of new populaces and finally uses the individuals in the present age to make the next populace. When this algorithm was tested it generated a few test cases that found optimal paths. With varying iterations that were done, the optimal paths that were produced were based on the minimum cost factor. The algorithms ends when a most extreme number of generations is produced or either satisfying fitness level has been accomplished for the population. If the algorithm is terminated because of maximum number of generations, an agreeable solution could possibly be created [15, 16].

1.6 Ant Colony Algorithms:

This algorithm was created dependent on the manner in which an ant discovers its path and follows it back to its source path. It follows back from its goal to its source by the utilization of a compound called as Pheromone. Similar thought has been used to make the Ant Colony Algorithm. It finds the shortest navigational route for the portable robot keeping up a vital good way from deterrents to show up at the objective station from the source station. At the point when an insect experiences a hindrance in its way it will occupy its way and make another way. Another ant may make another way for a similar obstruction. How ants discover that a path is wealthy in pheromone is by sure properties of pheromone which are dissipation, maturing and pheromone smoothing. The thickness and to what extent the pheromone takes to dissipate until the ant follows back to its source, figures out which way is the ideal one. To execute this in ACO calculation, which will likewise discover different ways yet the way that is shorter for example time compelling will be picked as the ideal way. What's more, a way that is shorter will likewise be less financially savvy. [14,15].

## 2. Obstacle Avoidance

For maintaining a strategic distance from the snags the portable robot needs to get information about its general condition. For speed case, the robot speed varies on how away snag are recognize from the current position. On the off chance that impediments are perceived near the robot, license speed for example speed order will be send by the FIS. Utilizing this technique to coordinate, the robot moves safely and arrives at its goal point.

2.2 Fuzzy Logic Approach:

Fuzzy logic approach is utilized which depicts how to manage a hindrances, in the event that they are identified in various ways. It utilizes fluffy rationale method which is depicted underneath. Fuzzy logic control technique is utilized in this paper to accomplish reactive obstacle avoidance, which has the advantage of rapid response and can make the robot react to unknown environment effectively.

Fuzzy logic technique: It has Fuzzy Interface System (FIS). It has inputs include Distance Information from left, right &front. And Output consists of Left and right motor speed. Fuzzy control rules for mobile robot:
If (F.O.D. is close and L.O.D. is close and R.O.D. is close) Then (L.M.S. is low and R.M.S. is fast)
If (F.O.D. is close and L.O.D. is close and R.O.D. is medium) Then (L.M.S. is medium and R.M.S. is low)
If (F.O.D. is close and L.O.D. is close and R.O.D. is far) Then (L.M.S. is fast and R.M.S. is low)
If (F.O.D. is far and L.O.D. is medium and R.O.D. is medium) Then (L.M.S. is fast and R.M.S. is fast) [6].

2.3 The Obstacle-Restriction Method (ORM):

The ORM strategy was utilized which tells the conduct or reaction of the robot when it is tried in various and troublesome conditions and moreover the time taken by the robot to show up at the last goal. This technique centres around the conduct of the robot when nature turns out to be more bunches. It utilizes a calculation which encourages it to find the various deterrents present in the earth.

Algorithm:
Let L_ be the list of points of L that is in the rectangle with height the segment xa xb and width 2R.
Let A and B the two semi-planes divided by the line that joins xa and xb. If for all the points of L_, d (xLj, xLk) > 2R(with xLj ∈ A and xLk ∈ B) then return: POSITIVE else return: NEGATIVE.
The algorithm returns:
• POSITIVE: there exists a path joining xa and xb, i.e. the Final location can be reached.
• NEGATIVE: within local portion of the space the final location cannot be reached (a rectangle that we call the tunnel of width the robot diameter 2R, and the height of the segment that combines both the locations). This indicates that in the given local area there is no path (although it could exist a global one) [7].

Various Obstacle Avoidance techniques are used which tells how to deal with the same obstacles in a different way. The techniques included are mentioned below.

2.3.1 Virtual Force Field:

This technique includes the utilization of histogram grid that speaks to robots work zone and furthermore partitioning it into cells framing the grid. Any of these cells have a "Certainty Value C (i, j)" demonstrating the proportion of certainty that an obstacle is situated in the cell.

2.3.2 Vector Field Histogram:

VFF method performs quickly, it has its inadequacies. The implemented test-bed shows that the robot frequently would not move between obstacles to near one another due the repellent impact from the two sides, causing the robots to repel away. This issue is likewise knowledgeable about the Potential Field method.

2.3.4 VFH+:

The VFH+ strategy is like the VFH however presents a few curiosities by utilizing "threshold hysteresis" to improve the state of the trajectory, and the utilization of a cost function. The cost function is utilized to pick the best location among all candidate addresses (which are liberated from obstacles) provided by the polar histogram. The chosen address is the one with the most minimal expense.

2.3.5 Dynamic Windows Approach:

The dynamic window approach is another method that can be used to avoid reactive obstacles by managing the kinematic and dynamic constraints of the vehicle, in contrast to the VFF and VFH methods.

2.3.6 Nearness Diagram:

The nearness diagram (ND) technique utilizes the "divide and conquer" approach by separating the environment into segments to represent the area of the obstacles. Tests show that the ND strategy can maintain a strategic distance from local minimum traps in particular on the off chance that it is totally noticeable by the sensors.

2.3.7 Elastic Band Concept:

The Elastic Band Concept referenced in [13] works by deforming the main deterrent free way gave by a way organizer. The clarification is that consistently the way organizer figures a way that has sharp turns, making it hard to control the robot. The way balanced using the Elastic Band thought is shorter and smoother than the main way if new obstructions are recognized, staying away from the requirement for another way pre-arranging. This procedure can conform to dynamic changes.

2.4 Adaptive neuro fuzzy inference system (ANFIS):

The ANFIS is the mix of two procedures, neural frameworks and fluffy rationale. In the event that both brilliant methods are united, better reasoning will be gotten with respect to quality and sum. Toward the day's end, both diffuse reasoning and the figuring of the neural framework will be open at the same time. An ANFIS (Adaptive Neuro Fuzzy Inference System) approach is utilized to manage the hindrance utilizing ultrasonic and different sensors in various condition. It gets the data for instance FOD (Front Obstacle Distance), ROD (Right Obstacle Distance) and LOD (Left Obstacle Distance) from various sensors. These sensor signals are dealt with to the commitment to the ANFIS framework to give the yield Steering Angle (SA) control orders for the flexible robots [10]. Methods like Fuzzy Logic and ANFIS manages the deterrents in a superior manner, and hush up savvy. Thus, it is smarter to utilize these methods which will bring about better yield.

## 3. Human Detection

Using three stage structured method, for detecting humans is shown using 2 techniques, Histogram of Height Difference (HOHD) and Joint Histogram of Color and Height (JHCH) [10]. There is an algorithm that successfully detects humans under challenging conditions. The algorithm has 3 phases: Depth image segmentation, Region filtering and merging and Candidate classification [12]. Humans can also be detected using background subtraction method, they used motion as the criteria for differentiating the background and the subjects [13]. Detecting of humans from top view (i.e. head detection) using an algorithm which consists of following steps: Local maxima search, Head localization algorithm, Head detection and finally the Tracking algorithm [14]. Detecting of humans can also be done based on activities. For doing this Feature extraction and Learning methods can be used [7,9].

Some of the methods and algorithms which can be useful in detection and analysis of humans are studied and discussed below.

3.1 Histogram of Height Difference (HOHD):

The state of human's upper part is for all intents and purposes unquestionable from various items. The height of the head-crown is greater than near to focuses and significantly greater than shoulder domains.

3.2 Joint Histogram of Color and Height (JHCH):

Both shading conveyance and tallness (or profundity) structure have wind up being effective in human distinguishing proof and following. The shading insights of the head is on a very basic level assembled from hair and face or solo hair (if human is seen from the back) and are arranged at different stature levels.

JHCH can work honorably regardless, while overseeing people with different hairdos and head presents.

Utilizing JHCH Model: Different people may have particular shading, tallness transports. To normally follow obscure number of people, the JHCH model is used here. JHCH better researches the association among shading and stature.

2D JHCH: is sufficient and powerful in depicting the presence of human head.

3D hue-saturation-height histogram: Divide the hue range into 9 intervals, saturation range into 5 intervals, and height range (0.6m-2m) into 5 intervals [10].

An algorithm that effectively distinguishes people under testing conditions, for example, impediment, mess, and various stances using the following:

Depth image segmentation: Segmenting each watched depth image into "regions" relating to geometrically distinct objects.

Region filtering and merging: These regions are then filtered into a lot of "candidates" in light of a progression of parametric heuristics.

Candidate classification: The candidates are then utilized to figure histograms of oriented depth (HOD) and HOD descriptors are classified as a human or not human by a support vector machine (SVM) [7].

3.3 Background Subtraction for Motion Detection:

There are different sorts of calculations that can be used for development recognizable proof, for instance, optical stream and edge assessment. One of the principle kinds of development recognizable proof is using foundation deduction. Moving things inside a given foundation are as often as possible contemplated from the qualification of the current arrange framework and an encourage structure, routinely called the "foundation picture". Challenges in most by far of these computations are the light changes and handling speed [10].

A calculation depicts following and checking which involves a couple of algorithmic advances which are as per the following:

Local maxima search: Aim of this algorithmic step is to make an adequate number of introductory head candidates for the following step.
Head localization algorithm: The centers of the head candidates are found in this step and handed over to the classification based head detector.

Head detection: The head detector predicts if the head candidate is a legitimate head (utilizing depth feature descriptor)
Tracking algorithm: A tracking algorithm totals the detections after some time and computes trajectories for every head [9].

3.4 Feature extraction:
Acceleration: Motion of the humans.
Environmental variables: For instance, the qualities from air pressure and light intensity are useful to decide whether the individual is outdoors or indoors.
Vital signs: 1) Number of heart beats 2) Time domain features for heart rate, respiration effort, SaO2, ECG, and skin temperature.
Feature selection: Some of the features in the processed information set may contain repetitive or superfluous data that can adversely influence the perceived precision.

3.5 Learning:

Supervised learning: Labeling sensed information from individuals performing various activities (Decision trees, Bayesian methods, Instance based learning, etc.)

Semi-supervised learning: Having part of the information without labels.

Machine learning tools: Waikato Environment for Knowledge Analysis (WEKA) is certainly the best known tool in the machine learning research community [15].

The techniques examined [7] can viably recognize people yet for more exactness we can utilize strategies determined in [9] for example utilizing action acknowledgment and furthermore we can consolidate the piece of foundation deduction as indicated in [10]. Distinguishing people in testing condition likewise can't be overlooked [7], so we join every one of the characteristics determined to make a precisely working calculation which can recognize people in any conditions.

## 4. Landmine Detection

Landmine are the military weapons which are put just underneath the outside of the ground and are organized so that it detonates when the heaviness of vehicles or people disregards it. There are three sorts of mines which are:

Anti-Tank Mine (ATM) which detonates when the soldiers vehicles disregard it. Anti-Personal Mine (APM) which detonate when human disregards it. Unexploded Ordinance (UXO) is ordinarily a bomb which gets terminated and don't detonate and they deal with the two vehicles and people.

In the military mining, the objective is to make the protected way for the soldiers or military vehicles against these mines/bombs. A portion of the landmine discovery procedures are referenced underneath.

4.1 Metal detector sensor:

It is an electronic gadget which can distinguish the covered metal. This sensor comprises of loops. At the point when the AC current went through this loop it makes the electromagnetic field. At whatever point the metal comes in the scope of the curl the whirlpool current instigated in metal and makes its own attractive field. Be that as it may, distinction in electromagnetic field in metal can identify the nearness of covered metal [11].

4.2 Ground Penetrating Radar:

GPR is an instrument utilized for distinguishing underground items. This gadget consistently emanates the electromagnetic waves. At whatever point this waves are experienced on a metal/objects it reflected back. This reflected waves helps the sensor in distinguishing the articles. This wave well spreads in dry condition [11].

4.3 Ultrasound sensor:

It is quite similar to the GPR but this sensor emits sound waves. This wave well propagates in water, so it is used to detect underwater landmine [20]. Concluded that method used in [11] are quiet effective for detecting the landmines.

4.4 Balancing

Balancing is capacity to keep up the line of gravity of the body. For the adjusting reason we require different sorts of readings/calculation. For readings different sensors/materials like Gyroscope, Accelerometer Encoder are utilized. These together they use for adjusting the bike robot [20]. Whirligig quantifies the precise speed that is keeping up rotational movement and can foreseeing the fall of robot. Encoder that gauges the rotational edge and can ascertain separation went by robot. In light of these computation of Torque required to address the robot from tilt point. Engine control board is utilized for giving current to the engine. Accelerometer is the electronic-mechanical gadget that can gauge speeding up powers. Increasing speed is estimation of progress in speed partition by time [19].

## III. PROPOSED METHODOLOGY

The various methods that can be used for implementing an autonomous robot have been proposed here. This robot will move around using path finding algorithm. Its micro-controller will make use of the camera and the sensors to sense its surroundings. There are various different sensors that it will make use of such as Gyroscope and Accelerometer for balancing and mine detector for detecting mines. It sends the information it receives from the camera and the sensors to the microcontroller. The microcontroller then sends these responses to the user and user will act upon if necessary.

Using path finding algorithm, robot will find the best path based on the information gathered by its sensors (Camera, Ultrasonic, and Metal Detector) and will move towards its destination. For obstacle avoidance, ultrasonic sensors are used to calculate the distance of the surrounding objects using some method in obstacle avoidance technique. If the object is within the specified range, then robot will change its path otherwise it will continue along the path specified by the path finding algorithm. A spy agent camera is fused in the recipient segment where it will show the recordings or depictions taken while voyaging onto far off territories. Furthermore, can likewise store the information or recordings and give live gushing of what is been recorded by the camera fused on the recipient segment.

A buried landmine can be detected using the metal detection sensor [20] that is installed in the bot. This mine recognition robot is expected to recognize the covered mines, make an imprint on their areas and afterward keep searching for another mine without upsetting the denoted mine. Software that are being used are NOOBS OS, Python for IOT and hardware are Raspberry Pi 4b, Metal detector sensor, Camera sensor, Ultrasonic Sensor, L298N Motor Drivers, Li-po Battery (3000 mAH), Johnson Geared Motors and ACP Material for the Chassis.

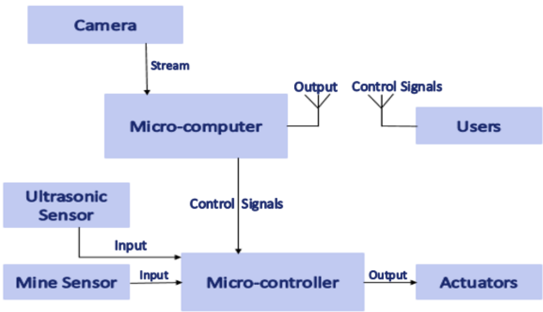



**Fig 1:** Block Diagram of the Robot

The above functional diagram (Fig 1) represents an autonomous robot with specific sensors. Based on sensors, the methods described above can be used to generate movements and detections of various obstacles or humans. The various methods that can be used for implementing an autonomous robot have been proposed here. This robot will move around using path finding algorithm. Its micro-controller will make use of the camera and the sensors to sense its surroundings.

The robot's built-in camera helps detect enemies in the environment and can be used to capture details of the environment. Thus locating the enemies. There are various different sensors that it will make use of such as Gyroscope and Accelerometer for balancing and mine detector for detecting mines. It sends the information it receives from the camera and the sensors to the microcontroller. The microcontroller then sends these responses to the user and user will act upon if necessary.

| Algorithm | Time Effective | Tools & Techniques | Efficiency | Cost Effective | Advantages | Disadvantages |
|---|---|---|---|---|---|---|
| Ant colony optimization | Yes | Ai techniques | Optimal | Yes | Finds path faster in dynamic environment | For each iteration probability can vary. |
| Fuzzy logic technique | No | Fuzzy technique | Moderate | Yes | Obstacle of any size can easily be avoided | Steering of right wheel & calculating angle is time consuming |
| Adaptive neuro fuzzy inference system(ANFIS) | Yes | ANFIS system | Effective | Yes | Obstacles in clustered environments are easily avoided | Small obstacles will also be detected and avoided |
| Histogram of Height Difference (HOHD) | Yes | Joint Histogram of Color and Height | Effective | Yes | Works well even when dealing with people with different hairstyles and head poses | Difficult to detect when in motion |
| Human Detection and Tracking in Top-View Depth Images | Yes | • Local maxima search<br>• Head localization algorithm<br>• Head detection<br>• Tracking algorithm | Optimal | Yes | Multiple humans can be detected | Doesn't detect whole body |
| Metal detector | No | Mine Detector sensor | Optimal | No | Can detect the buried metal. | Cannot detect plastic landmine. |

**Table 1:** Overview of all the algorithms used for the robot

## IV. EXPERIMENT AND PERFORMANCE ANALYSIS

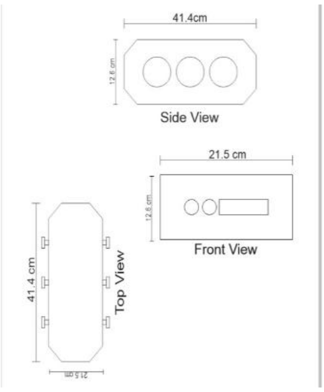



**Fig 2:** Structure of the robot

Fig 2 represents the structure of the robot. The robot was built in such a way that it can traverse in any condition. It is fully structured and compact.

Thus using this robot performance was tested by placing it in various environment condition and noting it down its completion time. Meaning, the time taken by it in order to reach its target. Along with it various experiments was performed. The robot was dropped from a certain height and checked it lasting power, was also made to travel in muddy and sandy areas in order to check its performance reliability.

*A. Implementation of Path Planning and Obsctacle Avoidnce*

The implementation of the proposed algorithm on path planning problem is demonstrated in this section. We consider ACO (Ant Colony Optimization Algorithm) for path planning and Fuzzy Logic Technique for obstacle avoidance.

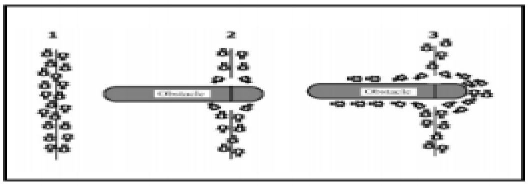


**Fig 3**: Ants and obstacles

ACO is modelled on the behaviour of the ants. Fig 3 shows how ants find the shortest path possible to reach the destination when they encounter any obstacles on their way. Once a shortest path is found the remaining ants follow the trail.

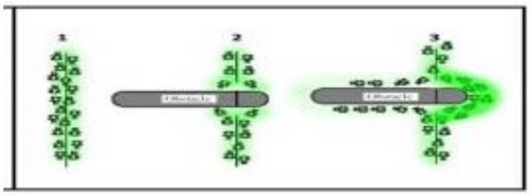
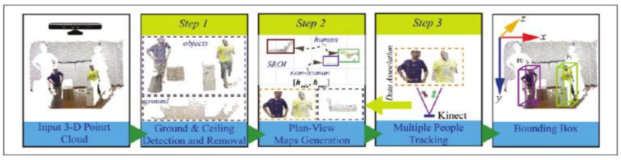


**Fig 4:** Pheromone build-up allows ants to re-establish the shortest path.

How the ants know which path is the shortest is based on the special chemical called pheromone, it leaves in its path. The aging factor of this chemical is what tells the ants which path to follow as shown in figure 4. It clearly shows that ants follow the path which is rich in pheromone and avoid the path that is not. As a result creating a shorter path. Taking into consideration of these special factors of the ACO algorithm to find the shortest path, it has been used for building this robot [21].

Simulation is performed using MATLAB Fuzzy Logic Toolbox and programming. Figure. 5, 6 and 7 shows simulation and experimental results of the movement of a robot as it navigation from start point to destination point through various static obstacles in different positions. The environment information acquired by the robot with the help of sensors (measure obstacle distances) is the inputs to the FIS which control the speed of the motor (wheel speeds) of a robot as it two outputs (left motor speed and right motor speed). The FIS continuously collect the input sensor information and gives an output data until the mobile robot reaches its destination. Thus the obstacles are detected the speed of the mobile robot is reduced and hence it tends to move to left or right directions. However if the destination point and obstacles are near to the robot then the robot takes appropriate action by turning its heading angle and moving at low speed for obtain collision free path. Fuzzy logic control method is developed to move the robot to reach collision free path while obstacles is presence in environment. Simulations developed on different obstacles with various shapes and sizes are conducted and the effectiveness of proposed method is verified. In simulation the robot is successful reach the destination without any collisions.



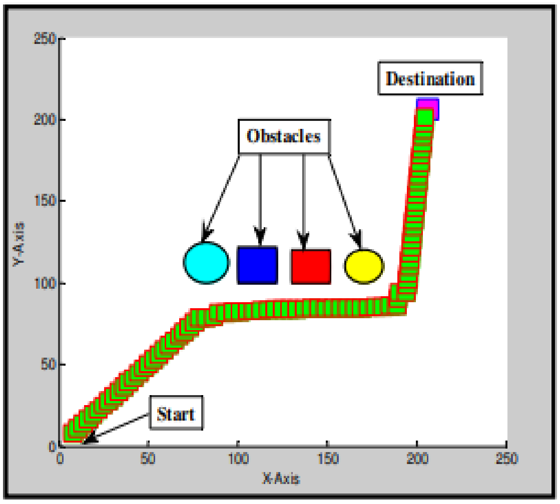




**Figure 5:** Navigation path for obstacles avoidance of mobile robot using fuzzy controller.

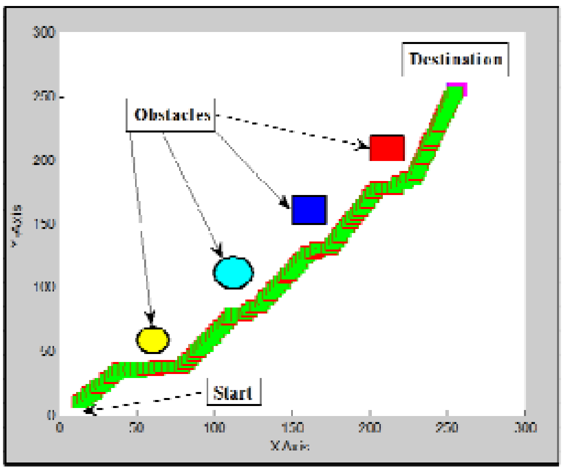



**Figure 6:** Navigation path for obstacles avoidance of mobile robot using fuzzy controller

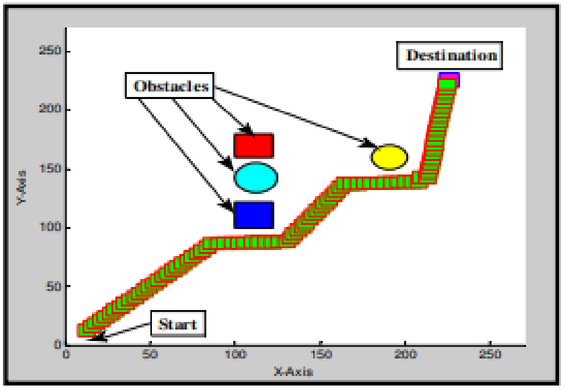



**Figure 7:** Navigation path for obstacles avoidance of mobile robot using fuzzy controller.

All the graphs in the above figures 5, 6 and 7 clearly shows that, Fuzzy Logic Technique is an efficient technique and precisely more accurate. It shows that the obstacles are avoided that is a collision free algorithm is established [9].

*B. Human and Object Detection*

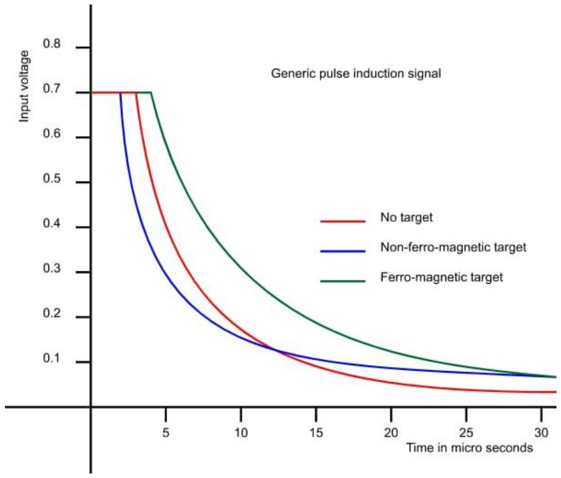
**Fig 8:** Human and objects detected

For human detection we have used tensorflow framework, openCV libraries and pre trained dataset by google for object detection. Using all these technologies an algorithm is made which is capable of detecting humans and other objects which are visible to the camera and using GUI it can show the results to the user.

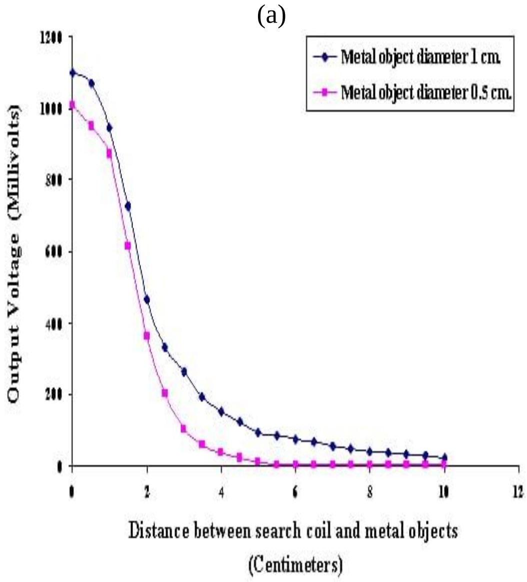
Fig 9 shows human detection and tracking framework. The major procedures are listed as follows; a) Group detection and ceiling removal, b) Human detection using modified plan view map generation, c) Multiple person tracking [22].

Fig 9: Human detection and tracking framework

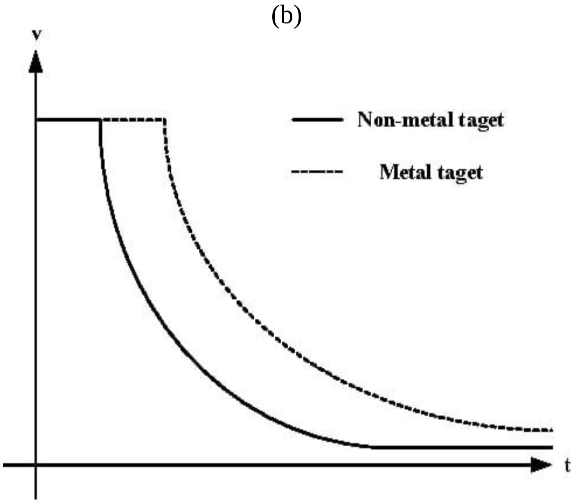
*C. Mine Detection*




(a)




(b)




(c)

Fig 10, (a), (b), (c): Metal detection graphs

Fig 10, (a), (b) and (c) shows various graphs of metal detection and detection range of it. The discovery pattern of heartbeat enlistment metal locators begins directly after the attractive field has been killed. This is cultivated by shutting the bipolar force transistor or MOSFET that interfaces the loop with the force gracefully. The release diagram of the loop can be partitioned in three areas:

- Stage 1: Breakdown effect over the driver MOSFET.
- Stage 2: Current decay over the dampening resistor with high coil voltages.
- Stage 3: Final current decay and eddy currents.

A potential chart of the release bend (Fig 10(a)) at the information side of our identification gadgets can be found in the following picture. The red bend is the release bend with no objective present, the other two bends show the distinction when an objective is in the compass of the attractive field.

During the initial five microseconds when the discharge bend is in stage 1 and stage 2, the sign is clasped by the security diodes in the information circuit. After that the bend gradually rots, with the rot speed subject to the presence of an objective and the conductivity of that target. In the head of the bend, ferro-attractive metals will make a little postponement of the sign dip under 0.7 Volt, where non-ferrous metals will move that change point somewhat prior. Profoundly conductive materials like gold, silver and copper will have a precarious bend and rot quickly to zero. We see that after around 30 microseconds, separation between various objective sorts is practically incomprehensible. By investigating some of these bends it is conceivable to make an informed supposition about the material of an objective identified by the beat enlistment metal locator. Similarly as with every single metal finder it is an informed supposition and not a clear answer, since size, profundity, encompassing targets and soil reaction may adjust the sign so that legitimate segregation is beyond the realm of imagination.

## V. CONCLUSION

The main purpose of this paper is to build a robot that is non-detectable by the enemy and serve us to spy on the enemy. It also has the ability to detect underground mines. The camera mounted onto the robot is connected to the Wi-Fi module allowing live streaming of the path the robot is travelling. We also have a balancing factor induced into the robot making the robot flexible in its movements.

After reviewing all the above mentioned methods and techniques we conclude that there are few ways to build such a robot. For each of the techniques there are few advantages and disadvantages leading us to conclude that through further research we can improve the scope of the existing researches.

To implement best path finding algorithm we found that the ACO i.e. the Ant Colony Algorithm serves the purpose of finding the optimal path compared to the other algorithms that have been proposed. It additionally ends up being a decent calculation that could be utilized in a static and dynamic condition. ACO takes motivation from the searching behavior of ants [2,15].

The Fuzzy Logic and ANFIS techniques were concluded to be the more efficient way to avoid obstacles in the path of the robot. Both Fuzzy Logic and ANFIS are a good choice since it can be used in static and dynamic environment as well in changing destination points for multiple autonomous robots simultaneously. Both these techniques effectively and efficiently create a smooth travelling path for the robots till its destination [16].

As the robot detects enemies i.e. it detects humans, we use cameras that satisfy a certain type of algorithms or technique that helps us detect humans even during the dark. For this we concluded that the technique based on activity recognition and background subtraction together overcomes the problem of human detection. Sensors working on these two techniques could make the job of detecting humans easier for the mobile robot.

For detection of mines we found that the GPR i.e. Ground Penetrating Radar and Ultra Sound are the best sensors to detect mines in various conditions. Detecting the mines from multiple candidates is done by GPR. This has reduced the efforts of the humans.

As for balancing factor for the robot we concluded that gyroscope, accelerometer and encoder for predicting the angular momentum and acceleration forces and torque respectively are the efficient techniques to be used for the building of this robot. Even if the obstacle avoidance algorithm doesn’t work for some reasons and the robot encounters an obstacle or hits it, then the balancing techniques or sensors that have been installed into the robot will help the robot not to toss over and avoid it from being damaged majorly.

Eliminating or overcoming any limitations to the mentioned algorithms could be the further research that could be made on these algorithms. Moreover, other advanced features can be implemented and tested to optimize the algorithms to get better results. For each type of techniques discussed above we can further improve on its limitations and provide a better technique than the already existing one.

The existing path planning algorithms that has been mentioned above might create some limitations in some way after further researching on it we can find a better algorithm or improve the existing one. As for the obstacle avoidance techniques the existing method can be enhanced by optimizing with the help of optimization algorithms. Similarly, for human detection a further enhancement of the computation performance of our algorithm could be achieved by utilizing several processor cores for algorithmic parts, e.g. the gradient climbing computation in the head localization step could be done in parallel for every seed point [9,10].

When we use sensors in the robot, like the mine detector and balancing sensors, they might drain the battery of the robot faster than expected. So, in future work we can make use of small solar panels instead of batteries which could be proved more efficient for the robot [11].

## VI. FUTURE WORK

For the detection of objects and humans, we used part of the Opencv library and framework, metplotlib provided by tensorflow. And also the object training data set provided by Google. Instead of using a mine detector, we used a metal detector, once this detector comes into contact with metal, it triggers an audible alarm. Some hardware changes have also been made for the efficiency of the robot. When we use sensors in the robot, like the mine detector and balancing sensors, they might drain the battery of the robot faster than expected. So, in future work we can make use of small solar panels instead of batteries which could be proved more efficient for the robot.

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