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AUTONOMOUS LAND MINE DETECTOR AND DIFFUSER

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ABSTRACT

The aim of the land mine sensing or detecting robot is to see and cover the most area feasible, display the landmines, and map the remaining region with millimeter accuracy on a visual map. This study offers a prototype land mine detection robot that is easy to manage, powerful yet affordable, and equipped with a visual interface for mapping landmines, PID tuning, and camera alignment. Emphasis is placed on controlling the differential drive robot in manual, semi-auto, and auto modes. Robotics uses image analysis to pinpoint its exact location, providingreal-time data to its dead reckoning servo control. The sensor that finds landmines is called a beatmetal detector. The robot can be controlled by the user with ease thanks to the graphical user interface on the remote terminal PC. Ultimately, the system aims to give the user a robust, economical, and easily understandable interface.

Keywords: Land Mine Detection, GPS (Global Positioning System), Image Process, Graphical User Interface (GUI), PIC Controllers.

I. INTRODUCTION

Societies are quickly destroyed by the calamity of war. Land mines need to be removed in order to rebuild societies that have been devastated by conflict. Eliminating land mines isa very expensive and time-consuming process. The borders can become more safer place to livewith the help of science. Land mines can beidentified and mapped by robots.

The first stage in demining is mapping land mines after they are discovered. To complete the task, numerous automated and semi-automated robots have been designed. These robots located themselves using Global Positioning System, optical encoders with GPS, or image processing. This profession requires a high degree of accuracy. A few inches of offset may prove to be fatal.

The main goal of a landmine detection robot is to be undetectable to landmines, which and only can be accomplished by lightening the robot's weight. It is not a feasible solution to identify the beginning of the land mine field as. Researchers have utilized large, always-porn machinery to fall victim to landmines.

Poor nations whose economies are damaged by war sometimes struggle with demining. They lack the money to purchase pricey demining supplies. Researchers have employed control rooms and engines to power vehicles, forcing some nations to revert to manual demining techniques .

Low literacy rates necessitate the implementation of user-friendly land mine detection equipment in impacted lands. The robot's user interface ought to be easy enough even for inexperienced individuals to operate. Researchers own a system that requires appropriate training to use. In land mine areas, robot repair and maintenance are challenging. The inability to transfer technology to landmine-affected countries makes it impossible to manufacture these systems locally.

The demining robot described in thisresearch has a lightweight construction that makes it nearly imperceptible to land mines. It is an inexpensive robot. The local market has all of the parts needed for this robot readily available. Because of the robot's extremely straightforward user interface, even a beginner user may readily control it. In order to facilitate the demining crew's easy identification and removal of landmines, this research aims to precisely detect and plot landmines as well as the region visited by the robot.

Periodic absolute position updates are required for improved dead-reckoning procedures, as they lead to an increase in inaccuracy. GPS can be used in conjunction with other location sensors to obtain a global map of a mine field, but it is not accurate enough for mapping due to its poor signals in dense foliage and buildings. Image processing and an active beacon system can be used to determine the position of the robot [8]. The robot's true positioncannot be determined in either of these scenarioswithout a clear line of sight.

This work describes a robot position-finding method using image processing. When two cameras are positioned at specific angles, a stereoscopic open vision mechanism is utilized todetermine the robot's location. The robot's true position is computed using the trigonometric formulas. An environment program is developed for the purpose of aligning cameras. The cameras are positioned at the precise angles needed with the aid of this program.

Lightweight, differential drive robots are the foundation of this concept. Drive motors with DC gearing are connected to both wheels. The addition of two caster wheels lowers the weight on each wheel and ensures stability. For the robot's motion control, PID control is used to bothwheels. Robot speed is lowered to minimize wheel slippage. To make PID tuning easier, a visual environment is used to construct a PID tuner application. The electronically vanishing, code able, read-only memory can (EEPROM) of the controller Micro stores the values of Kp, Ki, and Kd.

The servomotors and metal detector values are read by the PIC 18F4550 microcontroller. The robot displays motor control commands and metal detector values on an LCD. With a baud rate of 115200, the microcontroller and computer interact via the RS232 serial protocol. Modules for wireless serial communication are used to facilitate this serial connection. The microcontroller handles computer tasks, and it decides what feed the drive motors should receivenext.

Gain equilibrium A metal and metallic detector uses a combination of beat frequency operation and induction balancing to locate land mines. It is more sensitive and resilient to variations in temperature, voltage, and ground mineralization.

The user can choose to operate the robot in manual, semi-automated, or auto modes thanks to the creation of a graphical user interface. A robust mechanism for detecting landmines is provided to the user via these modes.

The Microsoft C# visual environment displays a map of the region the robot has covered as well as any landmines that have been found. Figure 1 depicts the control scheme.

As tensions with India increased in 2001, the Pakistani army planted land mines along its eastern border. Pakistan and India have a 2912- kilometer border. As a defensive tactic, the Pakistani army planted field mines. Demining began as soon as peace negotiations got underway. Demining cannot be completed to 100% since there are no worldwide landminefield maps. There are still landmine warning signs in some locations. Landmine fields should be cleaned as soon as possible because of the dense population in the surrounding areas. By hand, the land mines are placed. There is little flora, a dusty surface layer, and a primarily dry environment in these regions. The dead reckoning servo mechanism becomes ineffective when the terrain causes the robot wheels to occasionally skit. The Pakistani army has to remove a lot of existing mine fields from the terrain using a mobile robotic device. A cheap cost, quick, accurate, and user-friendly interface are all desirable qualities for this technology.

An early mobile robot that can locate and locate landmines is created using this as a case study. This robot's easy-to-use interface, differential drive, and affordable cost are among its additional qualities.

Image process is used and employed to determine the precise location of the Robot in order to compensate for wheel slippage. Thisstudy discusses a number of system features, withparticular emphasis placed on the system's simple user interface and image processing-based robot position location. It is talked about controlling and interacting with a robot from a distance.

Providing an efficient yet strong system is the overarching goal of the effort.

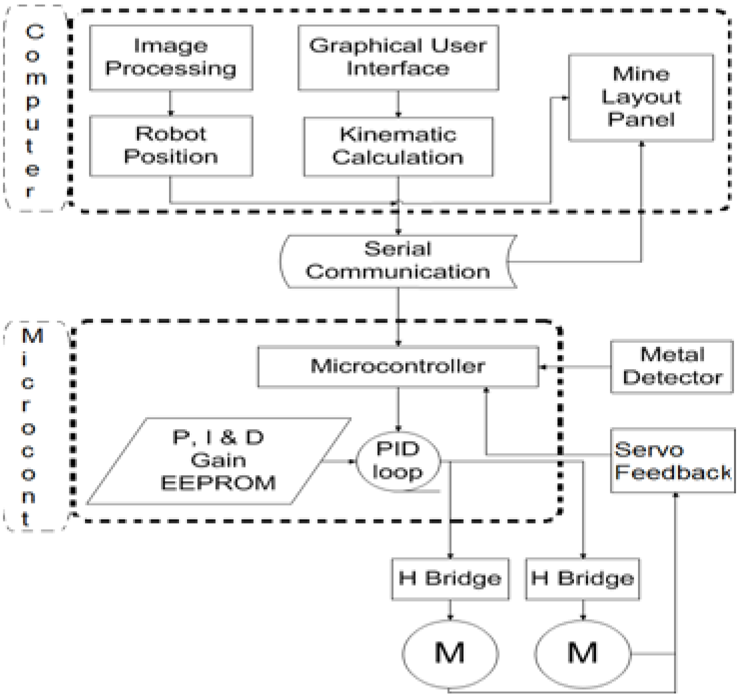


Figure 1: Robot and remote terminal programming scheme displaying their serial interface

II. THE ROBOT

To make the robot lightweight, fiber glass is employed in its construction. Each of the robot's two wheels is connected to a 12V DC geared servomotor through a differential drive system. Acceleration encoders are found in motors. Five hundred and four pulses per revolution is the resolution of the encoders.

Figure 2 depicts this robot system with two casterwheels, a metal detector, and a differential drive.In order to reduce the weight on wheels, two caster wheels are used, even though one caster wheel can be sufficient to stabilize the robot. About 10 kilograms of weight are distributed over the robot's four wheels, allowing it to move through a landmine field without setting off any landmines. Antipersonnel landmines often have a minimum weight requirement of 25 to 40 kgbefore activating. To find landmines, a metaldetector is attached to the robot's front.

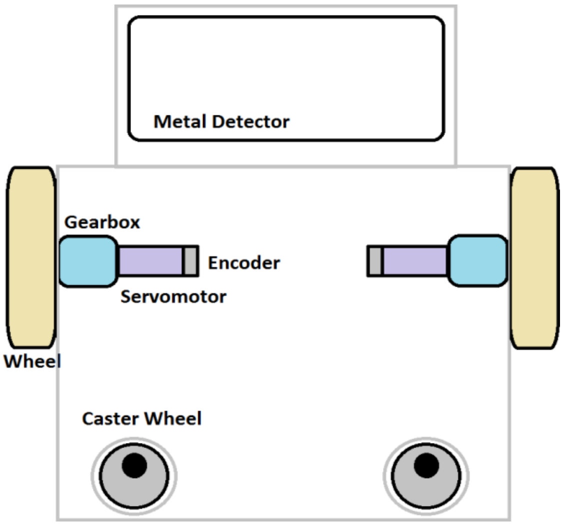


Figure 2: Landmine Detecting RobotScheme with Differential Drive

III. ROBOT CONTROL

Robot movement commands originate from a computer and are applied through PID control on the motors in a PIC 18F4550 Microcontroller.Figure 3 illustrates this method.

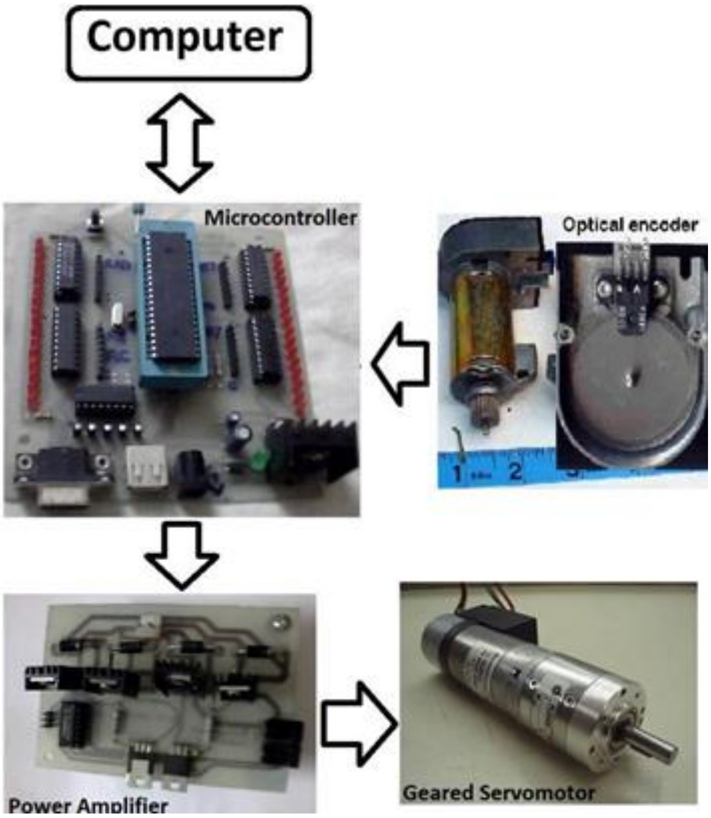


Figure 3: Microcontroller-controlled servomotordrive and feedback encoders connected to a computer interface.

3.1 Microcontroller

The remote station computer sends out motion orders via serial communication. The pwm of the microcontroller's built-in channels ischanged to implement PID. When in normal mode, the devise works in an open loop. Incremental in encoders supply feedback to the closed loop system. Since a single pwm channel can only drive one device, a mux is added to the power amplifier cards.

Robot's LCD (liquid crystal display) shows the metal detector reading, motion orders,and the robot's mode of operation thanks to a microcontroller. In order to perform orders and transfer the metal detector values to the remote computer, the microcontroller interfaces with it. Figure 4 explains this communication and control architecture.

3.2 PID Gains Storage

The electrical vanishable programmable and code able read-only memory, or EEPROM, of the microcontroller contains thevalues for the proportional, integral, and derivative gains of the two motors.

3.3 Communication Protocol

An RS232 serial protocol with a 115200 baud rate is used for communication between the microcontroller and computer.

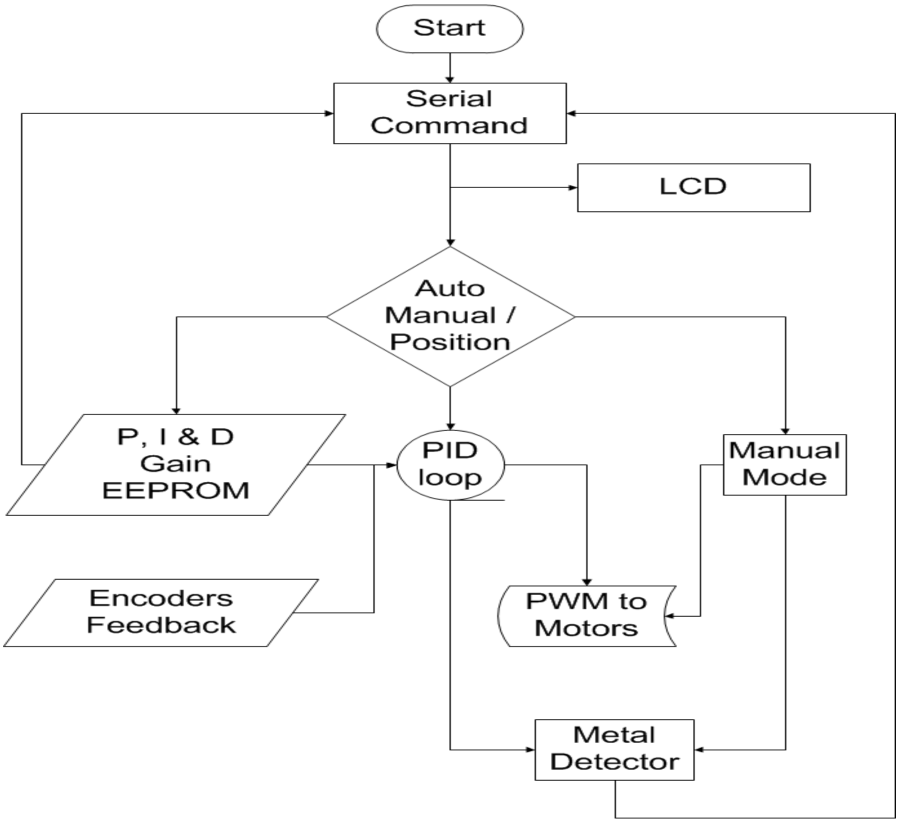


Figure 4: Program Shema For

3.4 Wireless Serial Communication

Robot and computer serial communication is accomplished by wireless serial modules. With the help of these modules, the robot is cordless and mobile.

3.5 Synchronization

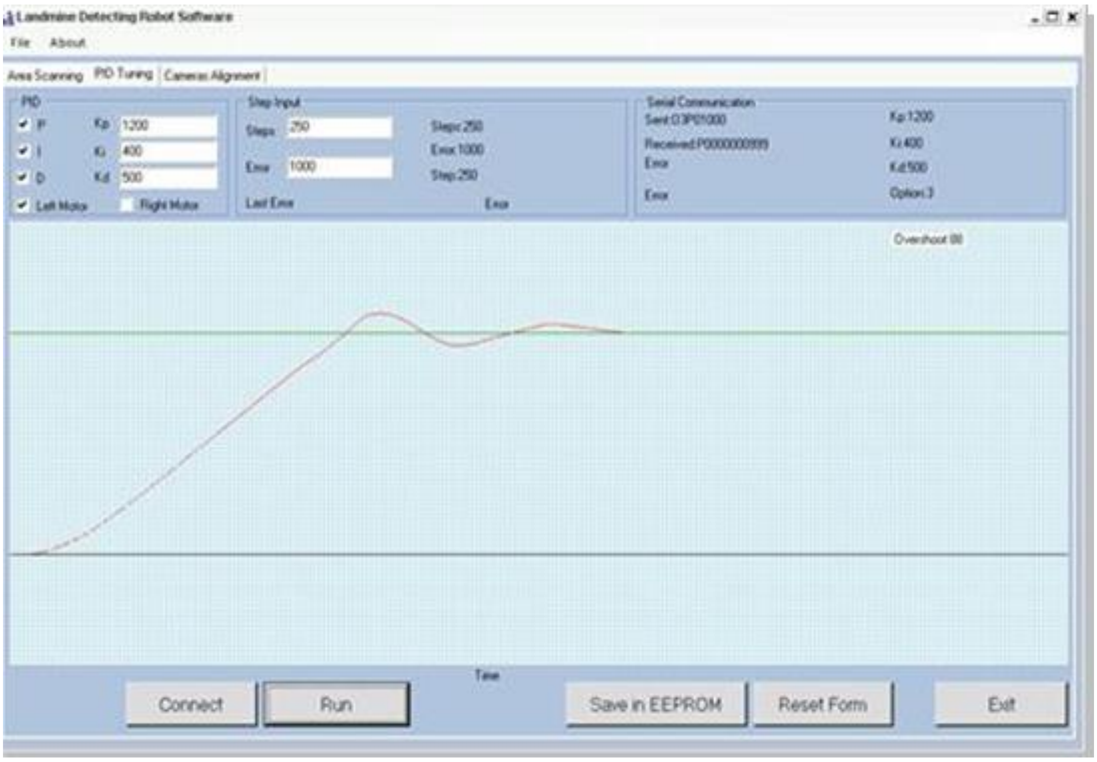
The Systems execution speed is greater than the robot's gearmotor’s, thus the microcontroller and computer need to be in sync. The microcontroller and computer programs synchronize when the microcontroller delivers a signal to indicate that an operation has been completed and the System waits for the controller to execute operations. Next, the following command is sent by the computer.

3.6 Visual Tuning Interface

In the Microsoft Visual C# visual environment, agraphical user interface is provided for motor PIDadjustment. By reading the gain values from the microcontroller's EEPROM using the "Connect" button, one may verify that the robot and computer are connected serially.

Using the "Save EEPROM" button, the P, I, and D gain values can be stored in EEPROM. ForP, PI, PD, and PID, step response for the designated user Once the motor has been chosenfrom the left or right motor checkbox and the corresponding P, I, and D checkboxes have been clicked, you may view the error and the steps by clicking the "Run" button.

The graphical user interface displays a curve that represents the encoder values along the y-axis and the number of steps along the x-axis. The system's overshoot, rise time, settling time, and error band are all visible to the user. Figure 5 depicts this user interface. This graphical user interface makes servomotor tuning incredibly simple.



☑ P Kp 1200
☑ I Ki 400
☑ D Kd 500
☑ Left Motor ☐ Right Motor

Steps 250
Error 1000
Last Error
Error
Steps: 250
Error 1000
Step 250

Sent 03P01000
Received P000000999
Error
Error
Kp 1200
Ki 400
Kd 500
Option 3

Overshoot 08

Figure 5: Visual C# GPU Interface

IV. ROBOT KINEMATICS

The differential drive robot's mobility is controlled by the software using the following kind of kinematics.

4.1 Forward Kinematics

Calculating the robot's end position while knowing its start point and both wheels' velocities is the forward kinematics of a differential drive robot.

To determine the robot's end point, utilize the following equations.

$$x' = \frac{v_l + v_r}{2} \sin\theta \qquad (1)$$

$$y' = \frac{v_l + v_r}{2} \cos\theta \qquad (2)$$

$$\theta' = \frac{v_r - v_l}{B_w} \qquad (3)$$

x', y', and θ' represent the robot's linear and angular velocities. The velocities of the differential drive wheel are Vr and Vl. The two wheels' distance is denoted by Bw. Robot orientation is denoted by θ.

4.2 Inverse Kinematics

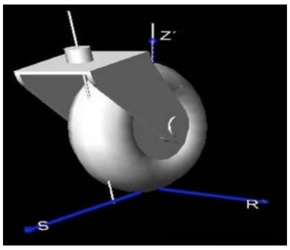


Figure 6: Caster Wheel

The calculation of wheel motion to achieve a predetermined robot motion is known as inverse kinematics. Given that this is a two-DOF problem, two parameters—the robot's orientation (θ') and its velocity in the x axis (x')—are supplied. The left wheel's (Vl) and right wheel's (Vr) velocities can be found using the following formulae.

$$= \frac{x'}{\sin\theta} + \frac{B_w}{2}\theta' \quad \text{........ (4)}$$

$$= \frac{x'}{\sin\theta} - \frac{B_w}{2}\theta' \quad \text{..........(5)}$$

4.3 Error of Differential Drive For Contorller

The following presumptions form the basis of the differential drive mobile robot kinematics, which in practice leads to odometry inaccuracies.

Errors in differential drive robots are caused by the following factors. Uneven floors, excessive acceleration, rapid turning (skidding), external forces (interaction with external bodies), internal forces (e.g., castor wheels), misalignment of wheels, uncertainty regarding the effective wheelbase (due to non-point wheel contact with the floor), limited encoder resolution, limited encoder sampling rate, and so forth are some of the factors that can result in wheel slippage.

The offset mistake in figure 6 indicates that although the caster wheel axis should be vertical to the ground, it is not because of constructional imperfection.

In a lab setting, the robot can be adjusted to achieve a minimally acceptable inaccuracy, as explained by [15], but in a real-world setting, tiny stones or slight gradients in the soil may cause the robot to veer. Odometry systems are unreliable for charting land mines because they require precise position systems.

The mechanical construction inaccuracies, electrical characteristics, and control loop flaws mentioned above demonstrate the necessity of a live reckoning feedback for the differential drive odometry in order to eradicate robot position mistakes.

Robot location is determined by the use of image processing.

V. IMAGE PROCESSING

Land mine mapping errors are eliminated by the use of stereoscopic vision systems in image processing. A stereoscopic vision system uses a single, marginally different image from each camera to perceive depth.

5.1 Scheme

Robot location is detected using a front view camera technique. Figure 7 depicts this plan. The robot is visible to both cameras.

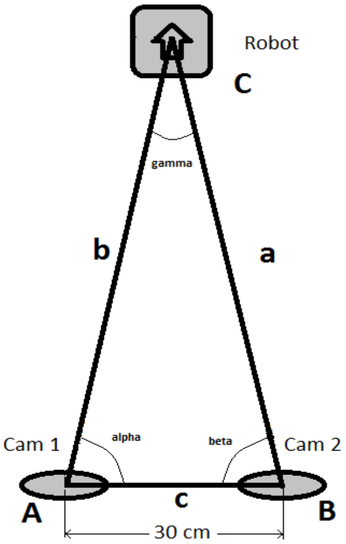


Figure 7: Stereoscopic Cameras Arrangement Scheme for the Robot Location

The distance between the cameras is preset. The cameras are positioned at different angles in relation to the target robot. The cameras' field of vision and resolution should be understood in order to compute the distance utilizing cameras as measuring sensors.

Proper Camera

42.25 degrees is the horizontal field of view.

35.79 degrees is the vertical field of view.

Camera on the left

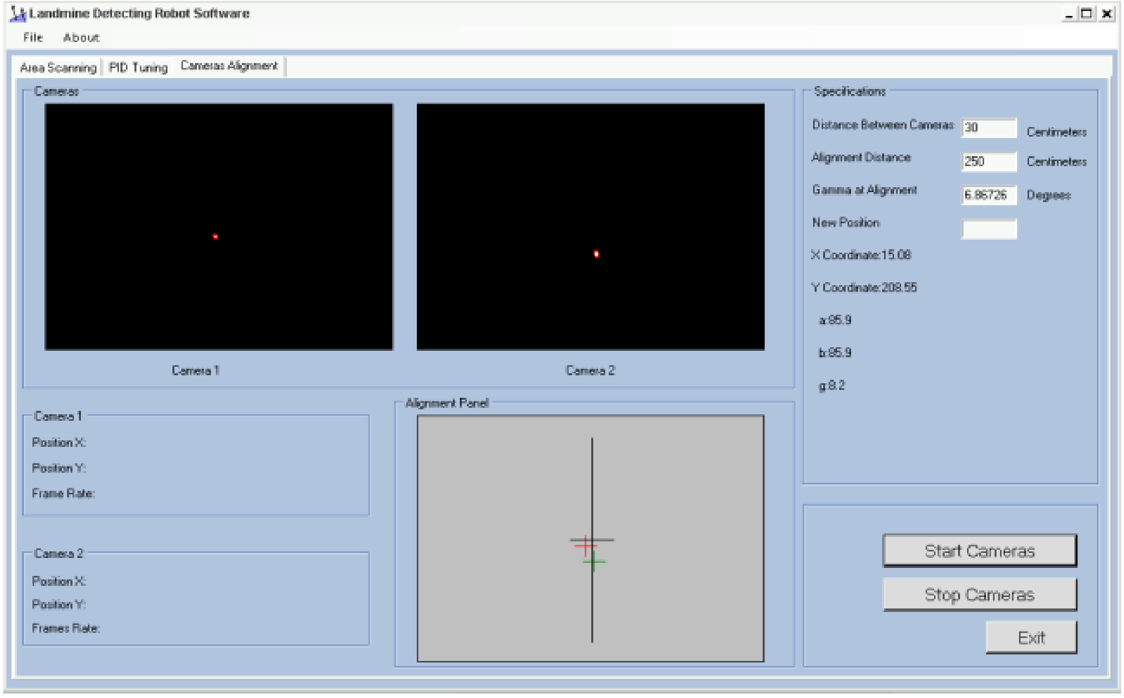
41.73 degrees is the horizontal field of view.

34.92 degrees is the vertical field of view.

The separation between the cameras is mentioned. At particular angles, the cameras are positioned. The robot's position is determined byprocessing its coordinates from both cameras andapplying trigonometric rules.

5.2 GUI for Camera Alignment

A graphical user interface is made in Microsoft Visual C# to align the cameras at the specified angles. The cameras may be precisely positionedat 86.5663 degrees thanks to this interface.Its operation is demonstrated in Figure 8.



Distance Between Cameras 30 Centimeters
Alignment Distance 250 Centimeters
Gamma at Alignment 6.86726 Degrees
New Position
X Coordinate:15.08
Y Coordinate:208.55
a:85.9
b:85.9
g:8.2

Figure 8: GUI for cameras

The robot is positioned at 250 cm on the line thatperpendicularly divides the line between the twocameras in this interface, after both cameras are positioned 30 cm apart. Therefore, the two robotblobs in the picture should be in the middle. Boththe camera's output marks and the panel's center are marked. Rotating cameras to align their crosses with the center cross while maintaining a30-centimeter gap between each camera is the challenge of camera alignment.

VI. LANDMINE DETECTION

A metal detector with a balance beat is used to locate land mines. There's a new breed of metal detector out there. It recognizes that it is a combination of beat frequency operation (bfo) and induction balance (ib) by calling it "Beat Balance" (bb). acknowledging the influence of both concepts. Ultimately, this leads to a fairly straightforward design that offers excellent discrimination, high immunity to voltage mineralization, and sensitivity that is higher than that of a bfo detector.

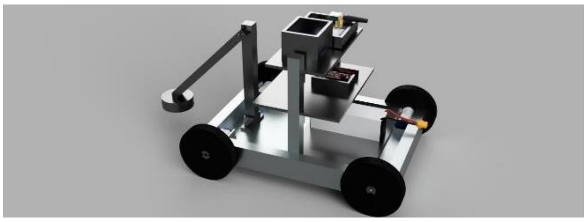


Figure 9: 3D Model Of The Robot

VII. MOTION COMMANDS

The graphical user interface for the computer station equipped with cameras uses the following commands for moving the robot:

7.1 Auto Mode

The robot in this instance scans the region using a rectangle path. Figure 11 illustrates this plan. The aim of this technique is to detect landmines over the biggest area possible. The landmine position is kept and displayed on a visual map onthe computer upon receipt of any signal from thelandmine detecting sensor via serial protocol.

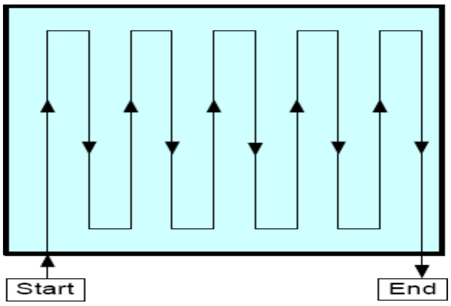


Figure 10: Scanning Ground Area

VIII. MAPPING OF LANDMINES

Microsoft C#'s visual world is mapped with the land mines that are recognized when the robot is moving. An region measuring 60 by 90 centimeters is scanned in Figure 10.

An area in centimeters is displayed in the little square on the map, while an area in ten centimeters is displayed in the huge square. The robot has identified the green area as its scan area, while the red circle indicates landmines. The robot was able to detect and plot only two land mines that were positioned during the test sessions.

IX. RESULTS

The goal of the study was accomplished by precisely identifying and mapping the land mines as well as the robot's visited area, enabling the demining team to locate and demine the landmines with ease.

The secret to this landmine detecting robot's success is its low weight, which allows it to remain undetectable to landmines. The cost of this robot is cheap. The graphical user interface and mapping system on this robot are extremely primitive. Even for novices, operating the robot is simple. The robot's parts are easily obtained from the local market. The robot was able to work in three different modes: manual, semi-auto, and auto. The user has access to a very powerful system thanks to all three control modes being present on a single graphical user interface.

Image processing makes it possible to plot landmines by compensating for flaws in dead reckoning. In order to counteract the dusty places where robot wheels are prone to skidding, the user of this research must prioritize this feature. The visual map's landmine plots are inaccurate to the millimeter level. The metal detector with balanced rhythm proved quite good at finding landmines. A visual map makes it simple to spot landmines.

Servomotors with PICmicrocontrollers have successfully used PID.A visual environment is used for servomotor tuning. Time was saved by the visual environments used for PID adjustment. The user can easily adjust any parameter's value to obtain the required result thanks to the control response displayed in a visual environment.

Quick system setup in any remote location was made possible by the visualenvironment application for camera alignment. In order to assess the robot's comprehensibility, inexperienced people piloted it and discovered that the controls were incredibly simple to handle.

The PIC microcontroller and remote terminal computer were able to establish successful handshaking via a wireless serial link. At all times, this communication was trustworthy and safe.

X. CONCLUSION

An effective tool for controlling a differential drive robot is the interface that was created. The mapping and control modes make the device a practical robotic demining solution. It is possible to improve landmine detecting robots by implementing the concepts and methods discussed in this study. Many robots can be employed to update the map simultaneously, increasing productivity.

Robots equipped with many sensors can identify landmines more accurately. The cameras can be turned with high resolution servos to follow the robot. This will contribute to expanding the robot's working area. A global map of landmines can be obtained by adding GPS to the remote station. Graphical and simulation tools are available in modern robotic systems. Users may be able to receive training from the simulation of this system.

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