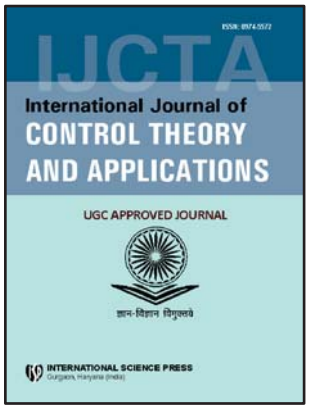

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Design and Development of an Unmanned Ground Vehicle for Defense Applications

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Abstract : This work is based on a new design and Development of Unmanned Ground Vehicle (UGV) for defense applications. In this developed UGV three different military applications were designed in a single robot platform namely, Surveillance using image processing, Land mine detection using metal detector and these two applications can be possible in any unstructured path. Face detection technique is implemented in Night vision camera for surveillance. RF is used as a communication network to send the audio and video output of camera to the receiver. For Land mine detection metal detector which can detect 0.1g of metal is implemented. Tracked Robot wheels and high torque motors are used to climb any unstructured path. To locate the UGV Global Positioning System (GPS) is used. ZigBee is used as wireless communication for UGV to send land mine data and GPS data to the receiver. Simulation of UGV is designed in Solid works software.

Keywords: *UGV, surveillance, landmine detection, Zigbee, GPS, solid works.*

1. INTRODUCTION

In military war fields, many human losses occur regularly, in order to avoid these human losses an unmanned ground vehicle (UGV) is developed. UGV consist of several defense applications that can be replaced by robot instead of humans in war field. Defense applications such as surveillance, search and rescue, climbing any unstructured path, bomb or land mine detection and hospitality can be performed by UGV. In existing methods all the above applications are developed by individual UGV. In our proposed method three applications namely surveillance, climbing any unstructured path and land mine detection are developed in a single UGV.

Surveillance of a specific region is manipulated by several CCTV cameras namely, Dome CCTV Camera [1], Bullet CCTV Camera [2], C-Mount CCTV Camera, Day/Night CCTV Camera, Infrared/Night Vision CCTV Camera [3], Network/IP CCTV Camera [4], Wireless CCTV Camera and High-Definition HD CCTV Camera [5]. This Histogram based human and pedestrian detection system [6] uses two stages namely training stage and detecting stage to detect the humans. But histogram images shows number of pulses where the human moving within the interval, not the actual pulses of movement. [7] This dynamic unconstrained facial recognition system uses Bayesian network to detect fast and free moving objects accurately Here they uses three different cameras to capture three different views of moving objects, even this paper is also not very accurate in view of free moving objects.

Landmines are three types namely Anti-tank, Anti-personnel and Anti handling devices. Anti tank mines are large in size and heavy weight [8]. It also requires more pressure to detonate. Hence this anti tank mines is used for huge vehicles. Anti personnel mines are small in size and weight [9], when compared to anti tank mines. It requires less pressure to detonate. Anti personnel mines are made for human detonation [10]. Anti-handling devices detonate the mine if someone attempts to lift, shift or disarm it [11].

Climbing the wall or staircase or terrain is a challenging task for the robot. For climbing those structured and unstructured path high torque motors are required. Structured and unstructured path with movement is proposed by passive complaint joints [12]. Hence this robot can only able to carry low weights, high torque motors are required. There are several robots which is used to examine gas pipelines [13], but those robots should be accurate in shape and size according to the pipelines they inspect. Stair climbing of several robots is executed using successive perching methodology [14]. Structure of this successive perching robot denotes that these robots used where less loads are required and this robot fails to climb when stair height is more.

Combination of all the above three applications, in the paper an unmanned ground vehicle is developed for defense purposes. Here a patrol course is being developed for surveillance using night vision camera [15]. By developing the patrol course for camera, focusing upon enemies and their tank can be examined in programmed direction.

Land mine detection using metal detector is implemented. [16] In this method, magnetic materials especially 0.1g of metals can be detected in any soil conditions. Climbing of robot is performed by eight dc motors with huge torque. Hence the robot is designed by rocker-bogey mechanism; each two motors are connected to movable aluminum shaft. This aluminum shaft acts as suspension for robot.

2. SYSTEM DESIGN

In this multifunctional Unmanned Ground Vehicle two sections are there, they are Robot section and user or receiver section. Devices in receiver section are static.

2.1. Robot section

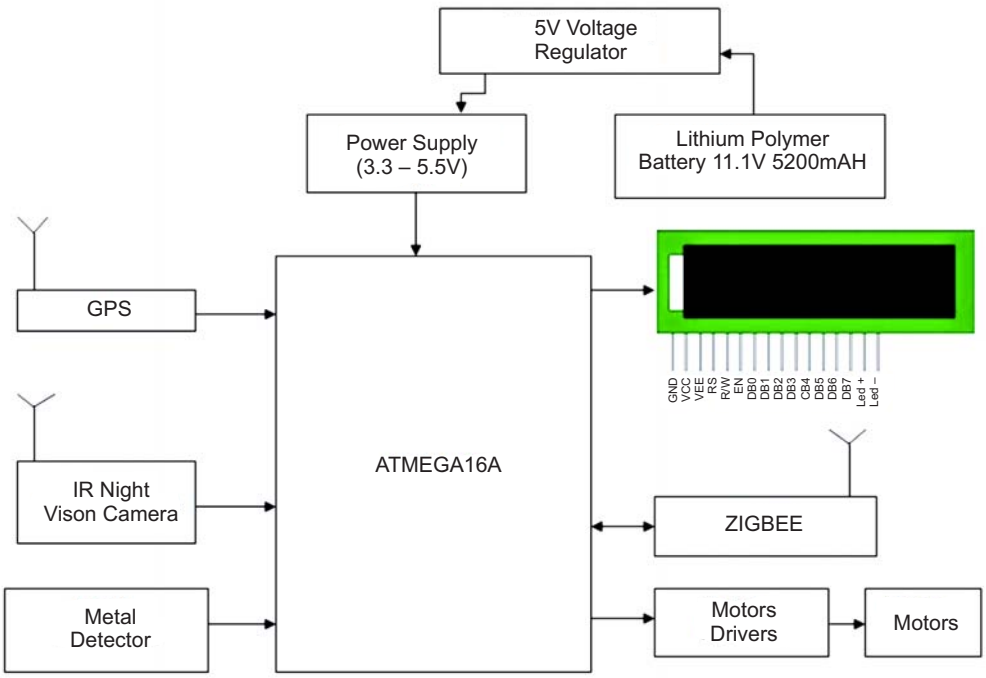

Figure 1: Robot section

ATMega16A is used to control all the devices that are connected to it as shown in Figure 1. The developed robot is completely autonomous, so robot movements are controlled by programming. By specifying interrupt priority, all three applications can be operated at a specific time**.** ATMega16A controls the GPS receiver signal and programs zigbee to send GPS data to the receiver or user.

Metal detector is used to detect the metals which is more than or equal to 0.1g. 2*16 Alphanumeric LCD display is used to display the presence of metal and for displaying robot movements. Night vision camera is used for surveillance. It is also used to analyze the intruders for unauthorized entry. Power management circuit and signal conditioning circuit are used in our system for power control and signal amplification. Here lithium polymer battery of 11.1V 5200mAH is used as a power source.

2.2. Receiver section

Receiver section shown in the figure 2 explains about the hardware with the receiver. Zigbee in receiver side receives the signals from the robot and process those signal using ATMega16A microcontroller. Further the output signal from microcontroller consists of land mine detected data and GPS signal.

Using the GPS a signal is received to find the exact latitude and longitude of the robot. Wireless audio and video of surveillance camera will be received in receiver and AV displayed in any kind of display. Robot can be operated according to priority interrupts.

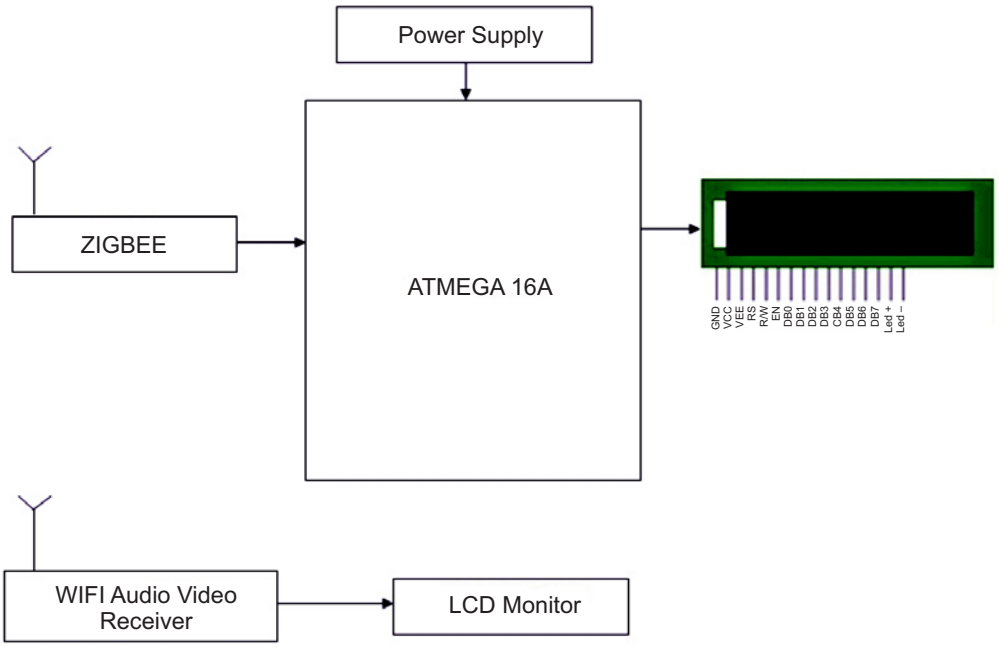

Figure 2: Receiver section

3. SOFTWARE DESIGN

Using Solid works software static modeling of unmanned ground vehicle is developed. Solid works simulation with all applications was developed. Robot base having 50cm length, 25cm width and 10 cm height was developed. Overall robot base thickness is 2mm.

Base clearance shaft in this robot is 120cm height with 2mm thickness Robot designed in our proposed was based on rocker bogey technique. Rocker bogey technique uses a simple screw type which acts as suspension for shaft. At the corners of the shaft, motors are connected.

3.1. Front view

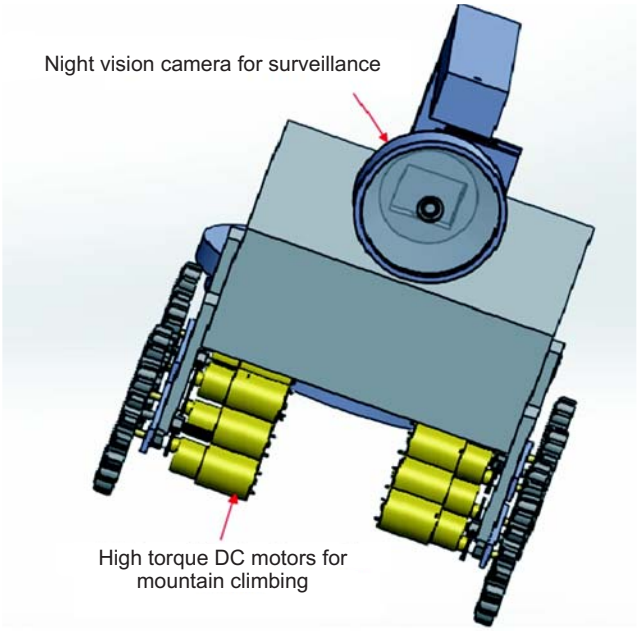

Figure 3: Front view

In this figure 3, shows a simulation of the developed surveillance hardware using night vision IR camera. High torque motors with mountain climbing wheels were selected. Gear wheels give more friction for robot to climb any unstructured path,

3.2. Side view

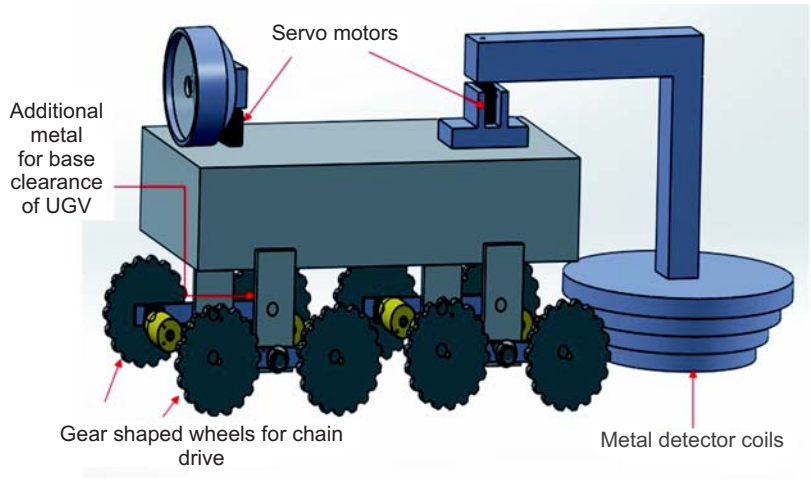

Figure 4 : Side view

Base clearance shafts are also shown in figure 4. In this paper two servo motors are being used. One servo is used for the movement of surveillance camera, another one for the movement of land mine detection. Here metal detector coil is selected, with coil windings of nearly 100 turns to generate less frequency namely 100 KHz. In this side view, pulley like geared wheels is shown.

3.3. Isometric view

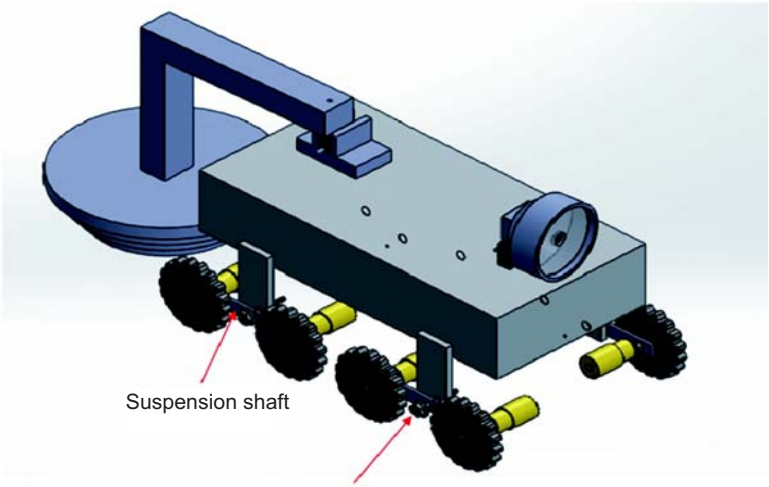

Figure 5: Isometric view

In this figure 5 it is possible to view suspension system of this rocker bogey technique. Suspension shaft and lengthy screws are displayed.

4. HARDWARE DESIGN

4.1. Material design

Here an aluminum material is used to build the robot base, base clearance and suspension shaft of the robot as shown in figure 6. Aluminum is typically not as strong as steel, but it is also almost one third of the weight. This is the main reason why aircraft are made from Aluminum.

Aluminum has a high oxidation and corrosion resistance mainly due to its passivation layer. Passivation is the protective material such as metal oxide, which is used to shell against corrosion. It has a much better thermal conductivity (conductor of heat) than stainless steel.

Aluminum is very easy to cut and form the necessary shapes than any other metal. Cost wise aluminum is cheaper than stainless steel. Aluminum metals are lightweight can be able to carry anywhere anyplace.

Figure 6: Base of the Robot

4.2. Microcontroller

In this UGV, to control all the hardware with the software microcontroller is used. ATMega16A is used in our system. It is a High-performance, Low-power AVR 8-bit Microcontroller with Advanced RISC Architecture. 16K Bytes of In-System Self-programmable Flash program memory, 512 Bytes EEPROM, 1K Byte Internal SRAM. AT Mega 16A having write/Erase Cycles of 10,000 Flash/100,000 EEPROM. Data retention up to 20 years at 85°C or 100 years at 25°C. In-System Programming by On-chip Boot Program with True Read-While-Write Operation and Programming Lock for Software Security. It consists of 131 Powerful Instructions, 32 x 8 General Purpose Working Registers and Fully Static Operation. JTAG (IEEE std. 1149.1 Compliant) Interface with Boundary-scan Capabilities According to the JTAG Standard, Extensive On-chip Debug Support and Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface. Crystal Oscillator Up to 16 MHZ can be used. Other features are AT Mega 16A includes Real Time Counter with Separate Oscillator Four PWM Channels; mainly it has 8-channel 10-bit ADC.

Byte-oriented Two-wire Serial Interface, Programmable Serial USART, Master/Slave SPI Serial Interface, Programmable Watchdog Timer with Separate On-chip Oscillator and On-chip Analog Comparator. Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby ATMega 16A have several I/O Packages they are 32 Programmable I/O Lines 40-pin PDIP, 44-lead TQFP, and 44-pad QFN/MLF. Operating Voltages 2.7 - 5.5V for AT mega16A. Speed Grades 0 - 16 MHz for ATmega16A. Power Consumption of AT Mega 16A at 1 MHz is 3V, and 25°C.

4.3. Mechanism

Rocker-bogie mechanism in our robot uses only screws as the suspension system. Using these screws suspension shaft moves free according to the obstacle. These rocker bogie robots are famously known as mars rovers. Hence the planets mars consist of many rocks, this rocker bogie robot climb those rocks automatically.

When Power supply is given to all the eight motors our unmanned ground vehicles start its movement. Our robot consists of high torque motors which help the robot to climb any horizontal and vertical obstacles having height of 15 cm. base clearance of our robot is 12cm, thickness of our suspension shaft is 2.5 - 1 cm. For horizontal movement front wheels of each suspension shaft climbs the rock with the back lift of rear wheels.

4.4. Surveillance

Night vision is a vision which is used to view in low light conditions. There are two types of ranges of night vision camera they are sufficient intensity range, sufficient spectral range. Intensity range uses photo detectors, histogram etc. spectral range uses near infrared or ultraviolet spectral radiations for the vision.

A night vision IR camera of 3megapixel, 360 degree viewing angle and HD camera as shown in figure 7, is used in our system. There is an automatic control for camera rotation. For manual operation a servo motor is employed of 360 degree movable is used for manual camera angle and rotation adjustment.

Figure 7: Night vision camera

4.5. Land mine detection

A metal detector is an electronic instrument which detects the presence of metal nearby. Metal detectors are useful for finding metal inclusions hidden within objects, or metal objects buried underground. They often consist of a handheld unit with a sensor probe which can be swept over the ground or other objects. If the sensor comes near a piece of metal this is indicated by a changing tone in earphones, or a needle moving on indicator.

A metal detector circuit as shown in figure 8, is being used along with the coil which can be able to detect 0.1g of metals. Usually metal detector of lower frequency (100KHZ) has more accuracy than maximum range (500KHZ). This circuit will help to create frequency for metal detection.

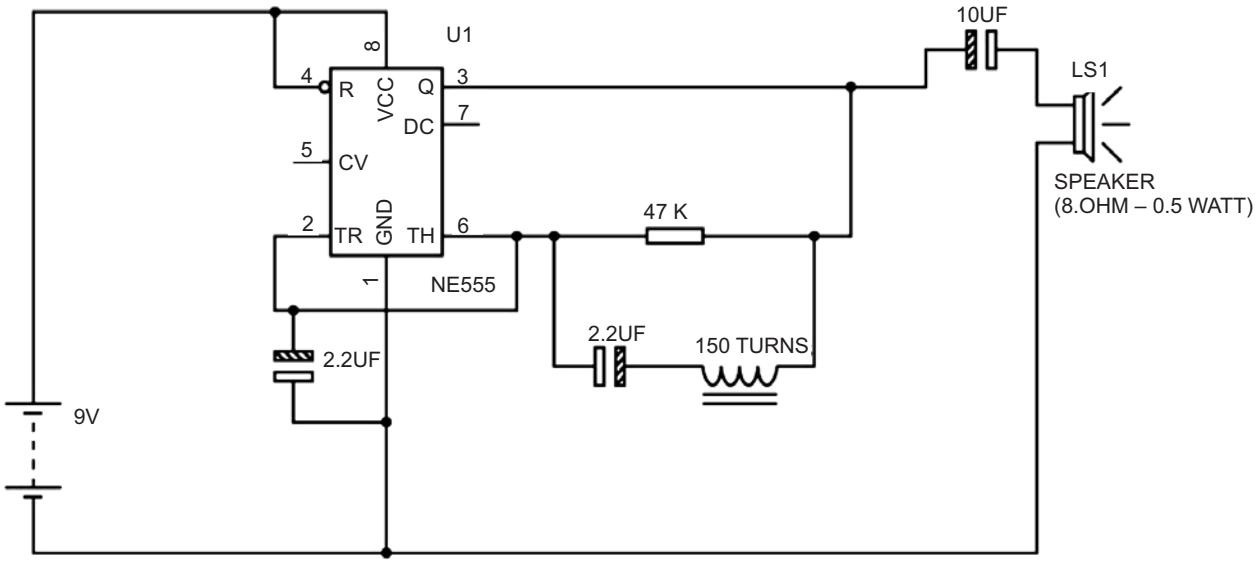

Figure 8: Land mine detection

5. RESULTS AND DISCUSSIONS

Finally the hardware output for the proposed unmanned ground vehicle for rocker-bogie mechanism is given in the below figure 9.

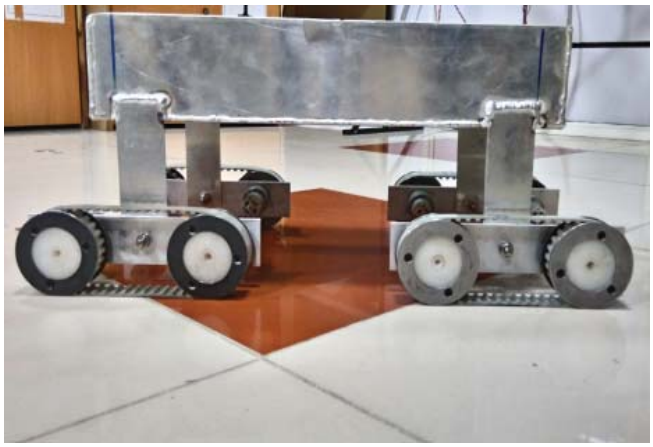

Figure 9 : UGV with Rocker-Bogie mechanism

6. CONCLUSION

An unmanned ground vehicle is the only system developed to control all the three applications namely land mine detection, surveillance using night vision camera, and climbing unstructured path. This developed UGV successfully does the sensing of obstacles and do the terrain climbing having height less than 15 cm.

Land mine detection with high accuracy coil windings with 100KHZ is used for detecting any metals of 0.1g with very high efficiency. Climbing in any unstructured path is performed by high torque dc motors. Hence to design an unmanned ground vehicle for defense applications has been developed.

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