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Development of Intelligent Robotic System for Scouting and Surveillance

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***Abstract* - This paper covers the design and implementation of an Intelligent Robotic System [IRS] for full filling the Scouting and Surveillance needs of military operations. The aim of the robot is to aid soldier into special mission on urban and non – urban areas. The robot works both in autonomous and semi-autonomous mode and remotely alerts the user for the presence of Metallic Object, Human, Poisonous or Flammable Gas and Water. In semi-autonomous mode, robot transmits a live video feed to the operator. In autonomous mode, robot uses sensors and follows dead reckoning method with an occupancy grid map to navigate within a certain region.**

Keywords – autonomous robot, semi-autonomous robot, scouting robot, military robot, robotics

I. INTRODUCTION

The aim of IRS vehicle is to assist human soldiers in complex battle scenario and save resources. In simple battle terrain, the existence of sharp corners, vegetation screen, fox holes are very common and any enemy personal can hide themselves and suddenly mount an attack. The problem in this case is the reaction time [2]. After identifying the threat, the soldier usually does not have enough time to react. Sometimes in a second the decision is to be made and soldiers needs to react within this time frame. Another danger is hidden improvise explosive devices and traps. Usually the explosive contained into metal frame and activated remotely or by some signal produce by the soldier; such as foot pressure, proximity etc [1]. Also sometime enemy uses poisonous gas and the gas attack is so sudden that a complete group of soldier can be affected [3]. So in order to reduce surprises or in pre-emptive attack planning, there is a necessity of identifying the threat first. IRS vehicle is designed to identify the threats mentioned above and warns the user remotely.

II. PROPOSED SYSTEM

IRS is low cost, light weight, intelligent robot vehicle. It is designed to move over moderate level of obstacle. Water sensor placed at lower frontal part of robot for sensing the presence of water and activates the propeller at rear, when necessary. In that way, the robot can easily move with the soldier in land and water and supports them in doing their mission. In semi-autonomous mode, the wireless camera transmits live video for the ease of driving and hazard identification. The size of the robot is relatively small compare to human. Thus a less chance for the robot to be identified by the enemy, where the robot can identify enemy by using camera zooming. Gas sensor on robot, detects poisonous and flammable gases and alert the operators. In same way the metal sensor and PIR sensor detects hidden explosive and presence of human.

III. SYSTEM DESIGN

Body Frame

The frame of the robot must able to carry the payload of the equipments and also be lightweight. So a body mount approach is followed. The aluminum is light weight and provide enough strength against deformation when goes under cold work process. Another reason for choosing aluminum is the metal got natural protection against rust. The chassis of the robot is chosen from off shelf RC vehicle. It is understood that, the track with timing belt pulley provides better traction and advantages in longer when crossing gaps, higher when climbing vertical obstacles and more compact when in storage [4]. The problem found that the skid steer driving system is prone to produce large error while robot uses dead reckoning system. So the design continued with Ackermann steering style driving.

Weight

The weight of the IRS was measured using a weighing scale with accuracy of 100g. The weight of the IRS is 6.000kg including the batteries.

Maximum Volume of IRS = 40 x 30 x 10 = 12 000 cm3

Estimated Maximum Mass of IRS (S.F =2) = 2.69 x 2

= 5.37 kg = 6 kg (rounded to nearest whole number)

The IRS's able to move easily with an additional weight of 2kg on it on a horizontal flat surface. However, adding more weight affects the robot's efficiency of maneuverability and obstacle climbing ability

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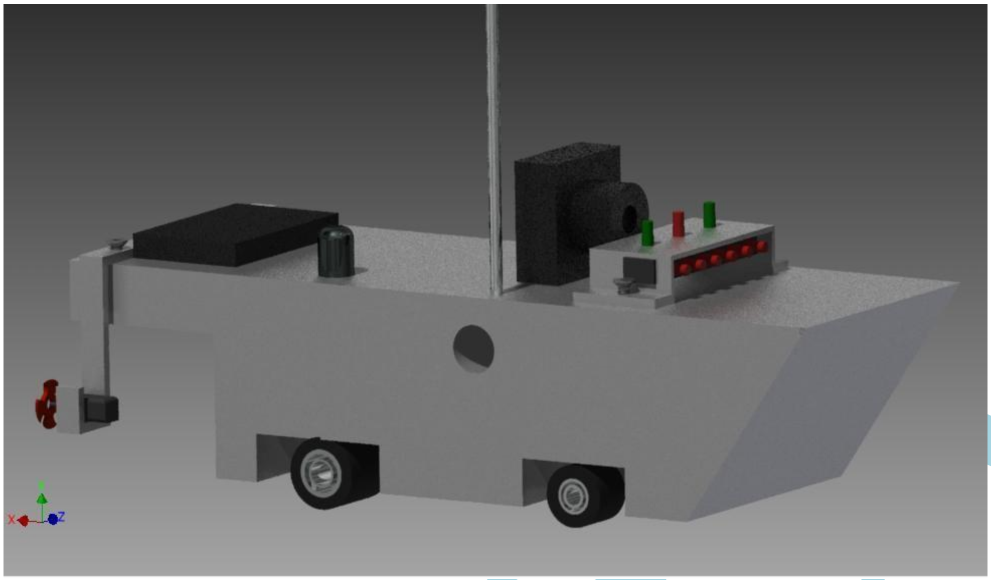

Figure 1 CAD Model of IRS Robot

Obstacle Clearing

The obstacle clearing test was carried out by using a horizontal obstacle of flat surface that had top surface height 6.5cm above the ground. This test was conducted 5 times and the IRS passed every attempt. However, the vehicle faces difficulties in climbing the obstacle over 6.5 cm.

Incline Climbing

The Incline Climbing test was conducted for measuring IRS's climbing capacity. IRS's incline climbing was tried by placing 1:2 wooden slopes in front of the vehicle path. Four wheels of the vehicle provide enough traction with wooden surface for climbing without engaging full throttle.

It is understood that the co-efficient of friction can be different with other terrain such as loom, concrete and grass

Figure 2 Working Model of IRS Vehicle

The technical specification of the robot is given in below.

General Specification	
Dimension	400 mm (L) x 300 mm(B) x 100 mm (H)
Mass	6 Kg Fully Loaded
Speed	3 km/h
Type of Control	Radio Controlled [27 MHz]
Range	750 m Maximum [Open Ground]
Type of Steering	Frontal Steer
Power Source	7.2 V R/C Battery Pack
Battery Power	Rechargeable 7.2V [1], Non – rechargeable 9V [4], Non – rechargeable 12V
Charging power	220 V, 50Hz
Obstacle Avoidance	6.5 cm
Water Depth	7.5 cm

MCU

IRS uses ATMEL 8051 microcontroller as MCU. This MCU works in both automated mode and also in semi-automated mode. This segment incorporates with all the sensors and display unit, while vehicle is running on manual mode. On autonomous mode, the MCU uses the sensorial and occupancy grid map for implementing dead reckoning method.

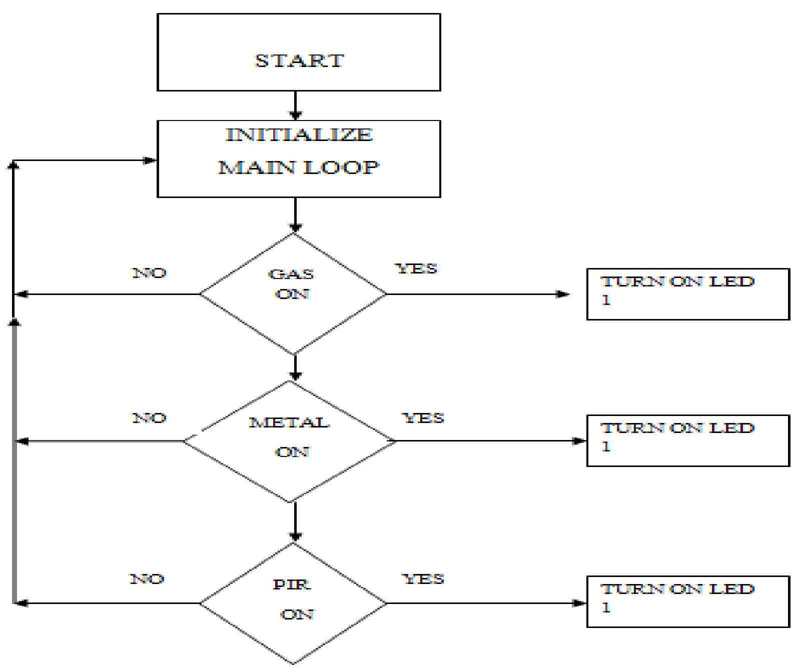

Figure 3 Sensor's Work Model Flowchart

Water sensor

Water sensor senses the existence of water along the robot's path. The sensor is placed in such way that it only activate when water reaches in certain height. In case of reaching threshold value, the sensor activates the propeller and makes it easier for the robot to move along the water bodies.

Metal Detector Sensor

Most metal can be detected by using its magnetic properties. The initiative was taken to design and implement the metal sensor. Metal detector sensor were tested to detect metal with 11 ft radius around the sensor and also ½ ft below earth.

Gas Sensor

Off shelf gas sensor was collected from the market and attached with the system. The gas sensor got an inbuilt heater, which needs to be heated for 24 hours before first time use. The heater heats up the coil of the sensor and makes the chemical layer soft. This chemical layer will react with the incoming gas and generates the output. This sensor detects poisonous and flammable gases.

Human Detection Sensor

Our human body radiates infrared waves. The sensor detects radiated wave from human and other living bodies as well. In IRS robot, a PIR sensor was used for this purpose. However, some problem found related to PIR sensor. The PIR sensor also gets the data from the ambient environment such as from sunlight. As most living warm blood animal generate the infrared wave, so the PIR detects the infrared frequency and generates output [4]. This is how the PIR can tell if there is a human present in the room. This method is very effective into the air conditioned room where the environment is cold and human body generates relatively high temperature. The problem occurs when PIR is used in non air conditioned room and in summer time. Then PIR gets signals from everywhere and remain high all the time. PIR isolated from the ambient sunlight with a ceramic cup and light exposure controlled installation solve this problem.

Remote Control Circuit

Remote control used to control the robot in semi-autonomous mode. The remote controller attached with the robot is 27 MHz frequency radio. In semi-autonomous mode, robot will be controlled by a radio frequency generator remote control. The remote control will generates radio frequency and the receiver section of the radio control will receive and decode the frequency. According to the received code the robot will perform some specific functions. The flowchart of the functions is given below.

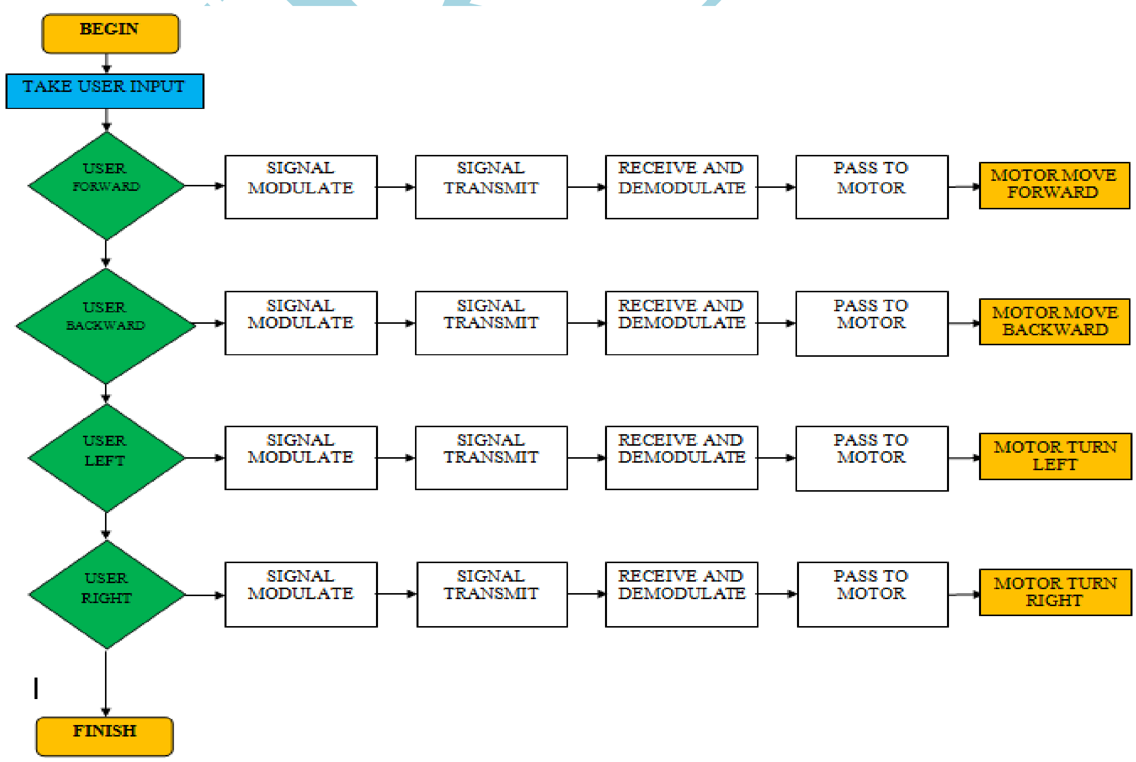

Figure 4 User Control Model Flowchart

Power Source

Standard 7.2V battery packs used in radio control System. Parts like the radio receiver that require a 6V voltage will be powered by the same battery packs using a voltage regulator. A 12V battery will be used to power the camera and video transmitter.

IV. AUTONOMOUS MODE

Usually autonomous mode used for scouting and map building purpose. An optical encoder is placed on the rear shaft of the wheel and the output of the encoder is connected with the MCU. MCU counts the number of ticks from the encoder and also collects the data from the directional sensor. Based on received data, the MCU calculates location and direction of vehicle on occupancy grid map by using dead reckoning method. The user can also activates the camera on autonomous mode and thus view the surrounding environments.

Program for the Robot

A program is written for the microcontroller. By using the program microcontroller controls the sensors and shown the output. The program is written in Keil C programming language.

Robot's Program

Program for the robot is written on C language. MCU controls the intelligent behaviors of the robot by using the program. Occupancy grid uses MCU memory, due to its smaller size. In order to use bigger size map in future, additional memory can be attached with the MCU. Sample screen shot of the program is given in below.

```
#include <REG51.H>   //Adding the Library File

#define ON 1          //Define the On and off
#define OFF 0

sbit GAS = P1^0;      //Define the Pin for the Gas Snesor
sbit METAL = P1^1;    //Define the Pin for the Metal Snesor
sbit PIR = P1^2;      //Define the Pin for the PIR Snesor

/*void delay(void);

void delay()
{
    int i;
    for(i=0;i<50;i++);
} */


void main(void)                     //Main Function starts here
{

unsigned N=00000001;
P0=000000000;
P0=N;

    for(;;)                      //Infinite Loop begins here.
    {
        if (GAS==ON)        //If Gas Sensor is On - Turn on the first LED
```

```
} */


void main(void)                     //Main Function starts here
{

unsigned N=00000001;
P0=000000000;
P0=N;

    for(;;)                      //Infinite Loop begins here.
    {
        if (GAS==ON)        //If Gas Sensor is On - Turn on the first LED
        {
        P3^0 = 0;
        }

        if (MAGNET==ON)     //If MAGNET Sensor is On - Turn on the second LED
        {
        P3^0 = 0;
        }

        if (PIR==ON)        //If PIR Sensor is On - Turn on the third LED
        {
        P3^0 = 0;
        }


```

V. FUTURE ENHANCEMENT

The project is complete according to the specifications. There are few recommendations were made that would help the project extend its capabilities in future.

The body of the robot is made by aluminum sheet. This gives the body a metallic signature which can be detected by the enemy's magnetic sensor. So the robot's body can be replaced by using the Kevlar or other non-magnetic material will reduce the metallic signature, so as the chance of being detected by the enemy.

The battery pack of the robot can be increased in such way that the robot can run longer time period and have the shorter recharge period. If the robot is reequipped with military grade battery then the robot can run longer time period and the battery will be safe from dust, water, humidity, temperature, leakage and other environmental issues.

VI. CONCLUSION

The IRS has performed well on ground testing. The robot got a good rate of inclination and also the speed test. As it has performed well in all the tests, it means that the IRS has satisfied the performance criteria that were presented at the initial point of the project. All the functions of the IRS are working well and the camera is giving about 100 ft work range without blurring the picture.

VII. REFERENCES

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