Mini-Bot: a Patrol Robot with Multi Mechanical Joint and Swap Algorithm

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Abstract- The main contribution of this paper is an improved method for charging the patrol robot, without human machine interaction. The robot retains their charging position as per the commands stored in the memory. The other feature in this patrol robot is design of a track wheel, which helps to move in the rough terrain surface with high precision. A single folded mechanical joint is set up with the base for the site surveillance and which is rotated 360 degree. For the real time visuals a camera is mounted on the top of the mechanical joint. All the control commands are exchanged between the base station and robot through zig bee module. A battery monitoring mechanism is also attached with the system. As the battery charge reaches the threshold level, drive the robot to the charging panel with the proper command which is stored in the memory of the microcontroller.

Index Terms- robotics, locomotion, arm, charging

I. INTRODUCTION

Robot is a machine to execute different task repeatedly with high precision. Thereby many functions like collecting information and studies about the hazardous sites which is too risky to send human inside. Robots are used to reduce the human interference nearly 50 percent. Robots are mainly in different types like fire fighting robot, metal detecting robot, rescue robots, patrol robots other humanoid robots etc. Mostly used in industrial purpose, military, defense, research and development etc. The focus for the patrol robot applications are on difficult surfaces and simple smooth platforms. Some patrol robots use their small size model, for the easy site assessment. However the small size robots will have a problem while climbing over the steps higher than their height and want to move fast. There are some jumping patrol robots which try to move over the high obstacles by using a pneumatic cylinder, which also having the problem of gravity and stability. For the better surveillance of the vital environment visual sensor must be placed at certain height. Hence a camera is fixed on the tip of the joint. such as the mini bot will equipped with the track wheeled method along with the charging option to overcome this problem.

This paper focuses on the systems of hardware and software which control robot locomotion and mechanical arm movement. It gives the details to the hardware and battery monitoring system as well. Section two and three gives literature survey and limitations and idea of new methodology. In section four, the robot mechanical design and hardware parts are explained. Section five gives the methodological design. And section six gives basic software aspects. Section seven shows the result and discussion last section gives the conclusion and the future work of the robot.

II. HARDWARE CONCEPT

The main design concept is using the simple method but highly effective and reliable. The block diagram of the patrol robot system is shown in fig 1 and fig 1.1. All of controlling commands are sent from the base station computer to robot via zig bee. The controlling commands compose of the locomotion control, robot’s navigation path and multi-joint mechanical arm control. In order to monitor video in real time, a wireless surveillance camera is mounted on the mechanical joint. The controlling commands are generated from the base station. The codes are transmitted with the help of terminal window. On the receiver side zig bee is configured as receiving purpose. A separate power station is setup for the independent power delivery to the motors and to the on board. A secondary back up power source is also arranged. All the control commands are received and compared with the help of predetermined program which is loaded in the microcontroller. A battery monitoring mechanism is setup along with the board for the awareness of the current charge level. Whenever the voltage level reaches the threshold value, the driving motors will get the power to drive the robot to the charging station. The movement of the robot is based on the commands stored in the memory during the real time. Commands are executed in last in first out, will be executed by swap algorithm.

A stepper motor is fixed at the base of the mechanical joint. This will help to rotate the arm up to 360 degree. This takes 8 steps to complete one rotation. Thus the surveillance became easier. DC gear motors are also attached to other mechanical joints for several purposes like stretching the arm, tilting the camera and one at the charging terminal for rotating the flap to make the contact with the charging station.
III. LITERATURE REVIEW AND LIMITATION

The major criteria for the patrol robots are the navigation path. Several methods are implemented for the path following purposes like developing a sensor packages and algorithms [14]. Such a robots designed on these aspects should lack on the simplicity of the hardware. This will also increment the software complexity. Other approaches like stereo vision based obstacle avoidance and visual servings, both follows algorithms and image recognition methods [15]. Hence high end processors and modules are needed to compute the path. In order to overcome this difficulty some map creation as well as artificial route mapping approaches are used [18][20][21][23]. But the mathematical computation becomes much more complex. Especially by locating the position of the robot using the markov localization method, bayes approach. This will take large amount of time to fix the position of the robot and also the next goal positions. All of these executions will drain too much power and it will affect the system performance.

IV. NEW METHODOLOGY

In order to reduce the complexity in both the hardware and software, we are introducing a robot with a swap algorithm along with track wheel. By this we can reduce the power consumption and it will lead to minimize the software as well as hardware complexity. Thereby the cost of the robot should be an economical one. With the usage of swap algorithm the robot can easily driven to the charging panel without any other human machine interactions. Mostly we can reduce the computational time.

V. MECHANICAL DESIGN

Robots are several types wheeled, tracked, and legged, multi robots, vibration types. The simplest are wheeled robots, while tracked wheels are used because of their ability to move in rough terrain surface and their greater stability. The mini bot is tracked wheel vehicle. They are relatively lightweight about 10 kg. They are quite active and fast in unstructured environments and they also perform well on uneven terrain. The whole robot structure is constructed in mild steel and the mechanical joints are effectively works with gears.

A. Body and Driving System

Thick aluminum sheet is folded to be the base frame. The locomotion driving system, all motors and mechanical joint sets and the batteries are placed in this frame in order to have the low level centre of gravity. Two 12V DC motors are used for driving base wheels separately. Both are controlled bi-directionally. Mechanical joint is fitted at the centre of the robot. With suitable commands from the operator the joint moves.

When a solid body slides over a rough or smooth stationary surface, a force is exerted at the surface of contact by the moving body. This force is frictional force and is always acting in the opposite direction [25]. Consider a simplified model of the system as shown in Fig. 3. The minimum torque required for climbing a surface with slope of 20° is calculated by second law of Newton. The mini bot can be covers the steps up to 20°, because the height of the wheel is 8cm.

\[
F = Ma
\]

Assume the linear acceleration and thus the rotational acceleration of the wheels to be zero.

\[
a = 0
\]

\[
F_t = mg \sin \theta
\]

Let \( m = 10 \text{kg} \)

\[
F_t = 33.5 \text{N}
\]

The torque becomes,

\[
T = F_t r = 10 \text{Nm}
\]

The locomotion system consists of two separate sides connected to the main body while a motor independently drives the track at each side. So the desired torque is obtained by dividing the \( T/2 \) [3].

\[
T = 5 \text{Nm}
\]

B. Flipper and Driving System

The flippers (dark color flap) are created in order to raise the charging terminal up for better connectivity, which is shown in the fig 3. Another 12V DC motors and transmission chains are required for flipper driving. Separate commands are generated for this action.
and its tracks whenever it needs to close vision algorithm. Charging the battery is a challenging task in and that need on a permanent. Let "h" be the height from base to the.

\[ y \]

s high end processors are used. A monolithic

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work having the deviation as shown in fig.7, halts and

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the robot to exp

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wheel rotates leads to rotate the wheel also.

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It consists of a large diameter worm wheel with a worm screw

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meshing with teeth on the periphery of the worm wheel. The

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vital sign of the victims like camera [23]. The second

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For a large speed reduction worm gear is used as shown in fig.4.

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Fig. 4 worm gear

For the patrol robot navigation several methods are used like

esensing the paths, graphical user interface, map following

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methods[1][2][3][14][20]. All these approaches are somewhat

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complex. This can be overcome by using the EEPROM of the

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microcontroller. PIC16F877A has 256 bytes of EEPROM inside

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it. So memory can use it to store data t

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microcontroller. There by the driving wheels get the power and

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remaining motors are disabled. The movement of the robot

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depends up on the commands stored on the memory during the

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running process. These commands are then executed by a swap

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algorith. The robot is then driven to the charging panel. This

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will executed in last in first out manner. The charging of the

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robot can be held at the charging panel.

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Fig. 5 Mechanical joint

\[ y \]

unsigned short Eeprom_Read(unsigned int address);

\[ y \]

void Eeprom_Write(unsigned int address, unsigned short data);

Most of the robot will navigate with different

algorithm.[22][24][18][19]. The robot will navigate with respect

to the commands from the user. All the running commands are

stored in the memory and also a timer is set to determine how

long the commands are executed. Now the current position of the

robot is at B after starting from A. Whenever it needs to return,

the last stored command will execute first (LIFO). If the last

executed command is forward, that swaps it into backward

command at the same time the timer starts decrements the value.

If the path having the deviation as shown in fig.7, halts and

proceeds to the left and move forward. At the time of returning,
initially the command is fetched and checked which command is executed last. Let the last executed command is forward. Then it swaps it in to backward command by calling the forward function in the program. Similarly,

Backward \approx Forward
Left \approx Left
Right \approx Right

**Fig. 7 Navigation path**

**VII. SOFTWARE ASPECT**

Onboard software is mainly developed with micro C. This software interfaces between the operator station software and the robot by receiving operator’s command to control all robot functions. Simulations have been executed both in Mat lab and PIC simulator. In Mat lab the approaches were implemented under ideal hypothesis, more realistic settings. The commands are sends through serial communication with the help of terminal window to zig bee module. Zig bee module is configured as a transparent mode for the normal transmission. On recharging and navigation of the robot swap algorithm is executed. Real time visuals can be captured and displayed on the window with the help of surveillance camera. A tunable receiver is connected to the base station for proper reception.

**VIII. RESULT AND DISCUSSION**

The proposed robot was successfully designed and implemented. With the help of swap algorithm the navigation operation was also effective. Thereby the power consumption is reduced. Battery monitoring system is also worked well. The limitation of this robot is obstacle detection, far objects cannot be detected. Instead of IR we can use ultrasonic sensors.

**IX. CONCLUSION AND FUTURE WORK**

The mini bot robot was designed and implemented. The patrol robotic system with track wheel type and gearing, driving method has been briefly described. Its performances were observed to be excellent in unstructured environments. The development of this mini-bot robot can be adapted to fit many other applications easily by changing the top part of the robot. Single stretched mechanical arm is designed and implemented. It cannot stretch not much longer. This can solve with the design and implementation of robot with more degree of freedoms mechanical arm which can stretch to 150 cm or more. For better the access of the robot instead of zig bee we can choose WIFI/internet. Instead of using the internal memory, SD card can be implemented. Hence large amount of information can be stored.

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