Wall-Painting Robot-Paintbot

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Abstract-This report is based upon a robot which will help you in painting your houses and buildings, all indoor and outdoor environments. This robot is developed using Altera DE2 board and its implementation is done in Quartus II and NIOS II with the help or C language. The development of hardware in this project includes making the chasis, motor, circuit diagrams and all pneumatic controls for the air brush which will be used in painting and IR sensors. The implementation in the software includes converting the MATLAB code to C code so as to generate the area dimensions of the workspace which is provided. There is a string which will be used to change the direction. I have used a path planning algorithm to determine the required z-path and u-path, which were taken in considerations from the MATLAB. The GUI workspace in MATLAB helps to plot the area. So, this robot will be able to paint all the walls excluding windows and doors and all the gaps.

Keywords—wall painting robot, IR sensor, Altera DE2 board.

I. INTRODUCTION

Wall Painting Robot is a household type of robot which can be useful in our day to day work also. It can help you to clean your house too. The job of painting the wall is very tedious and hectic and required labour work, so these types of robots are developed mostly in Japan to improve the life quality of people.

The main aim is to reduce man labour and to develop a multi-tasking machine. Also, there is a chance of human life as risk.

Painting is not a dangerous task but it can be risky when you have to paint heighted walls. And these robots ensure safety and security both and also consistency during the work environment. We should maintain a friendly workspace with our machines so that they can be controlled easily. The tasks can be accomplished by robots are well organised.

II. LITERATUREREVIEW

A. SupportSystem

Construction of the support system is the most important part of this robot. For making a stable support system many alternatives were taken into consideration like kinematics mechanism, planning of path and motion tracking. Few alternatives also include string to follow path and sliding frames. The string mechanism require negative pressure as adhesion but to ensure the vertical movement of the robot, sliding frames are used to correct errors. In addition, if the adhesion system uses pneumatics, and complicated structures.

For a robot to be of low complexity and low price a system should be chosen of a very simple configuration, and an expandable workspace. However, the first support system was considered and modified in Japan which used the vertical rail system installed on other side of the building so that it can slide through it. So, this concept in not more suitable for indoor environments.

Some other support system was also considered and research were done on such Robo climber to study their movement like how they move in land slides areas. Also, the inspiration for this design has been taken from roboclimber only.

B. Area Coverage andPatterns.

This robot is designed systematically to cover the area and to see whether it overlaps the area or workspace or not. There are many robots which have a random covered area coverage and distinct features which includes obstacle detection and avoidance as well. But the main thing in this robot which needs to be taken care off is that it does not over coats the wall, if there are un even layer of paint in the wall the shades will come out to be different and resulting in a disaster which we could not bare . So, the main motive is to supervise one thing that it does not destroys the shades of paint which we have selected and which has to be painted. It doesn’t require accurate

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movement although but if the approximate movement patterns are equal then it will cover the whole workspace completely. And we have to design the patterns in such a way that it covers the whole area and also maintaining the quality of work.

C. Sensor Integration, Obstacle avoidance and Navigation Properties.

This wall painting robot can detect and avoid windows panes while painting. There are some sensors which can help in detecting and avoiding the area which are not to be painted, for example the reflective object sensor which consists IR diode and NPN phototransistor.

The sensor that we are using has a daylight filter too. But, due to shortage of resources I have used only IR sensors to help in differentiating the background black and white.

III. SYSTEMDESIGN

The software and hardware systems are shown in below figure, and also the major subsystems.

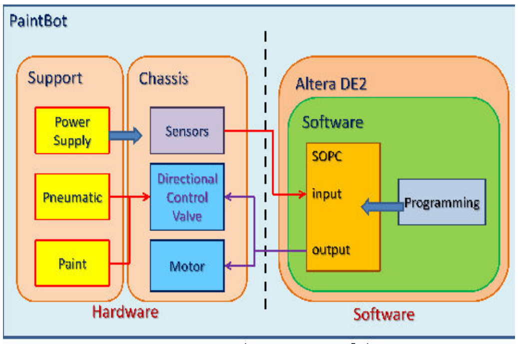

Figure 1 Overview of the system

IV. DESIGN OF HARDWARE MODULES

Major hardware modules of the robot are shownbelow:

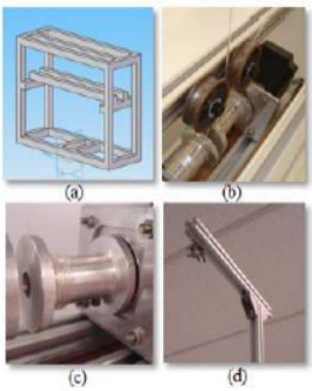

Figure 2 a) Chassis design b) Guiding pulley c) Spindle d) Static support point

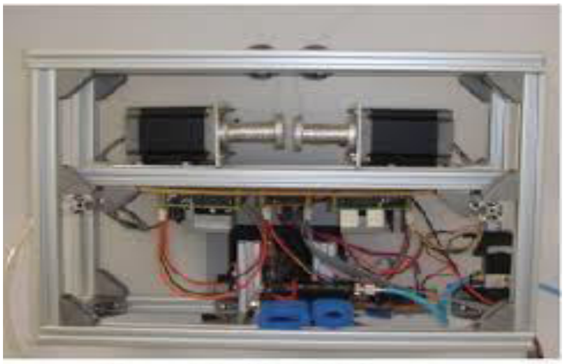

Figure 3 Robot prototype

A. ChassisDesign

The above diagrams shows the layout of chassis. Aluminium profiles of dimensions 20x20mm were used to build the chassis. The base of the design is made solid so that it can bear the weight of other hardware which is to be placed upon it.

B. Suspension SupportSystem

The support system of this robot includes two static support point and two guiding pulleys to guide the cable windings. The two stepper motors are connected with two spindles to wind the other cables.

C. Stepper Motor and Driver Modules

There is 1-pulse mode used in this robot, where two inputs are needed. One input is used for pulse signals and other for guiding the directions and motor rotation and cables L1 and L2 are used which is shown below. And the motor are bounded on chassis. These motor help to drive the pulley support system. The changes in length of the cables results in desiredlocomotion.

D. Hardware Modules andInterfaces

1). IR SensorModules

While doing the paint job the obstacle and no paint zones are detected by IR sensor modules. In this modules we have fixed the code like if there are wall then the background will be shown white means the paint job has to be done there and the black background for places where there is no paint zone of windows ordoors.

We have used two IR sensors modules one in the left and one in the right side of the air brush. These sensor set a certain threshold value for detection of range. The range of this system ranges from 2 to 20cm . The threshold voltage to differentiate between white and

black background is 3.1V. Since dark surfaces cannot be highlighted easily, there are two states for the sensors as 'high' and 'low'.
Output 0 for low- black colour and 1 for high- white colour.
The logic operations are below:

Robot's status	Sensor's state		Detect	Task
	R sensor	L sensor		√= Paint, X= Stop Painting
Moving right	1	1	Wall	√
Moving right	0	x	Window	X
Moving right	1	0	Window	X
Moving left	x	0	Window	X
Moving left	0	1	Window	X
Moving left	1	1	Wall	√

Table 1 IR sensors operation

2). Pneumatic PaintingSystem
The system is maintained by a processor which receives feedback from the IR sensors. Directional Control Valve is used to control the air in the air brush. Power of 24V is supplied to DCV.

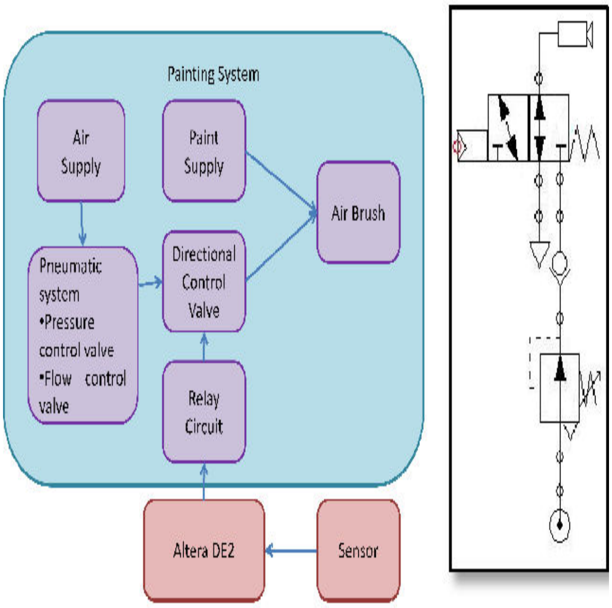

Figure 4 Painting system and Electro Pneumatic circuit.

3). Altera DE2 DevelopmentBoard
This board is used to implement bothhardware and software systems. It operates on Cyclone II 2C35 field programmable gate array (FPGA). It consists of a array of logic blocks And programmable I/O arrays that are configured with software. This board can also be used for real time communication between many programs with some additional configurations.

V. DESIGN AND DEVELOPMENT OF SOFTWARE MODULES

The whole system is configured in 3 phases:
a) Pathplanning
b) MATLABsimulation
c) Real worldimplementation

A. PathPlanning
The motion of the robot depends on the cable length. L1 an L2 is the change in cable lengths.

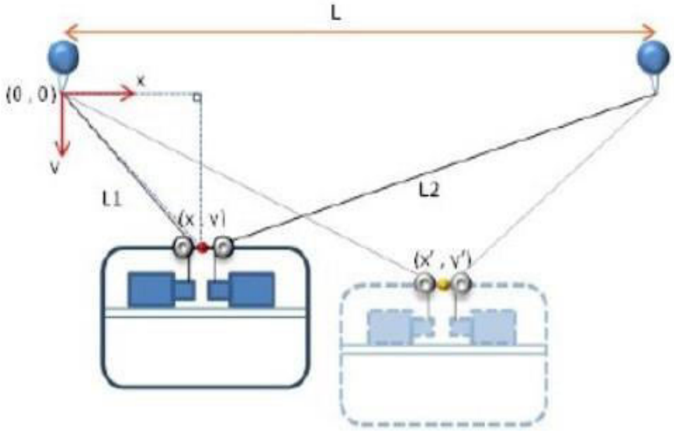

Figure 5 Robot's motion

To move the robot from initial position to final position L1 and L2 vary continuously.
By calculating the change in length of cables we can wind up the stepper motor accordingly. The below equations are to calculate both the lengths on the basis of Pythagoras theorem:

$$L1=\sqrt{(x^2+y^2)} \quad (1)$$

$$L2=\sqrt{(L1^2+L^2-2Lx)} \quad (2)$$

B. MATLAB Simulation Environment The interface is created using MATLAB GUIDE toolbox. This GUI helps user to select their own workspace area, which comprises of length and height inmeters.
The simulation shows the path it covers while performing the task. For Z-path, the robot moves horizontally along the length of workspace and vertically down at the edges.
The codes that we are providing will generate the x and y coordinates depending on users input of height and length. L1 and L2 are calculated based on supporting cable lengths. Above equation 1 and 2 are responsible for calculating the robot position.

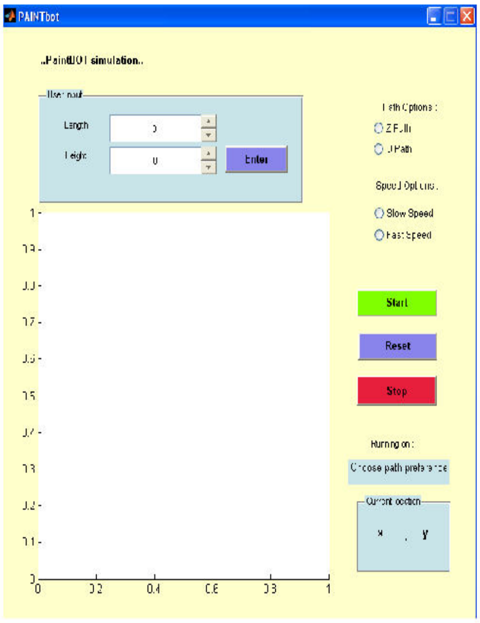

Figure 6 Screenshot of MATLAB GUI

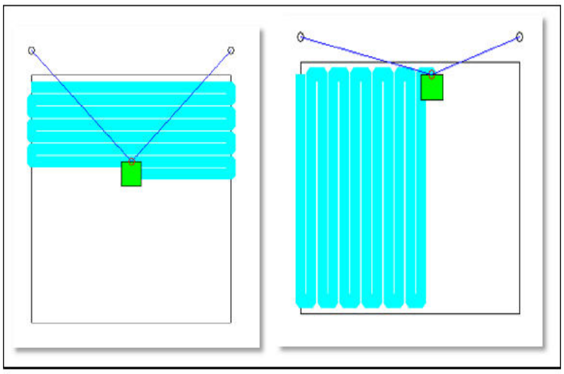

Figure 7 Plotted results of moving pattern

C. Real World Implementation NIOS II ide consists a source code editor, a compiler, a debugger and building tools. Itis
more suitable for software implementation of system and all modification can be done in a single program.

1). Main Program

We have created a flow chart for the code that is been used and this flow chart shows the sequences of the callback of the primitive functions in the robots coding.

2) StartupFunction

So this function is used to make the robot automatic without any user interference. So, 4 switches that are in the DE2 board are used for manual mode.

3) Motor Pulses GeneratorFunction

$$Rev = Deg * 2\pi \quad (3)$$
$$Pulse = 400 * Rev \quad (4)$$

This function finds out how many pulses are required for each theta value.

4) ObstacleAvoidance

So, we have set a count of 200 counts after every 200 counts the sensor will be called in the motor function. If any door or windows or no paint area is detected the data is been sent to the DCV to turn it off. Only specific sensor is turned onn like during right movement right sensor is checked and during left movement left sensor ischecked.

5) Path GeneratorFunction

There are 4 types of movements in this robot,
i.e. left movement, right movement, moving down at right and moving down at left side. Value of angular displacement is calculated using the below flowchart which will be given to the motor function.

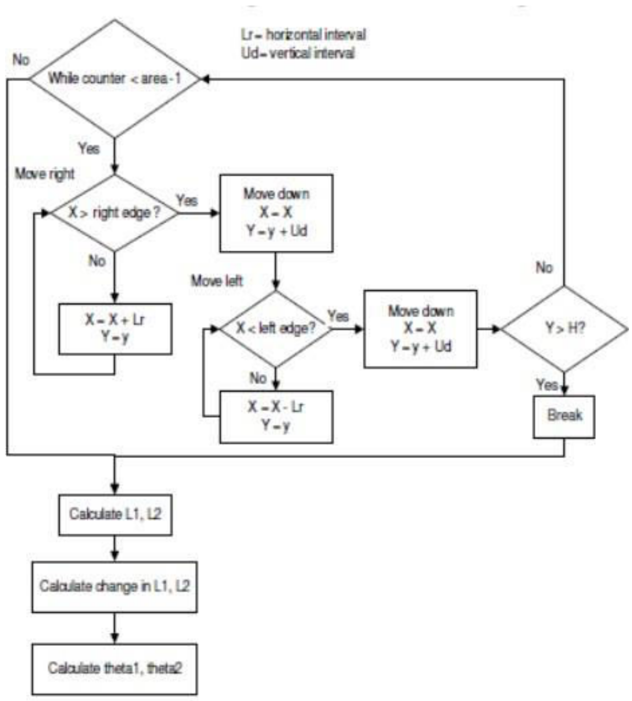

Figure 9 DFD for generator function

6) Motor PrimitivesFunction

This function helps to give signal to the stepper motor and takes the data from pulse generator and produces that data in the form of pulses and give to stepper motor. There is a variable delay which is added to the loop of function so that there should be adjustment in the motor speed according to theneed.

The pulses from the pulse generator function Is given to motor drivers respectively.

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VI. RESULTS AND ANALYSIS

Comparison of simulation and practical implementation, the horizontal movementdid not went straight. With the help of MATLAB gui simulation we got to find out that the painting path is straight and more similar to the pathresult.

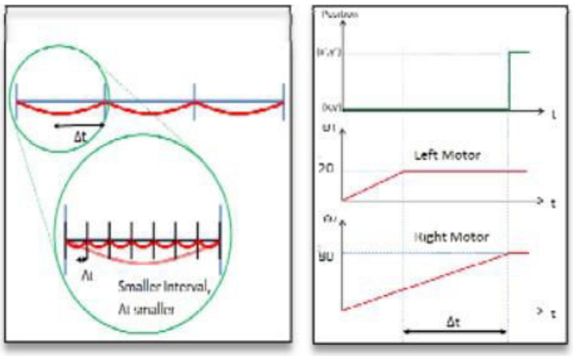

Figure 10 a) Actual path b) Motor's operation time

As we can see that change in L1 and L2 is very different in every point, so in this casethe stepper motor will receive different pulses so might possible the motor stops at different stages, also as the movement depends on change of supporting cable so the robot is slightly unstable and this affects the sensor range andaccuracy.

VII. FUTURESCOPE

1). DynamicModelling.
2). VelocityProfiling.
3). Modification to the new walldesigns. 4). Fully automatics.
5). Real timecommunication.
6). Artificial Intelligenceapproach.

VIII. CONCLUSION

This robot worked well as we planned and it will be a great help and is very user friendly , affordable.

My objective was to make it fully functional and without any human interference and it turned out to be working properly. Some more features that are been added into the system is for control purpose. Also MATLAB gui is used for its path planning for the PAINTbot. The simulation results were compared with real movements and are observed carefully.

And this robot prototype will be more helpful in future and will perform the task more efficiently and with accuracy. It satisfies all the reuirements that are specified and the hardware and software subsystems.

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