Household Utility Robot

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Abstract—*Dozens of smart tools and devices have been produced to make ease of the tasks which cannot be done otherwise. The matter is more crucial when children, elderly persons or differently able persons are faced with such situations. Our hypothesis is that the above issue can be addressed to a great extent by developing a small scale robot with vertical and horizontal movements. The robot is essentially portable, about 8 inches, and can be connected to a rod to gain extended length up to desired limit. The robot head consists of an IR camera which undergoes two degrees of freedom, generally horizontal and vertical. The vertical and horizontal displacements of the head of the robot are measured by rotation of two stepper motors. The displacements of the robot head is confined to end points of the two sliding guides through the signals coming from four IR sensors in those ends. The robot is able to scan its proximity, locate any object in the region, and display the information on a portable device such as a laptop, a smart phone or a tablet. The robot has been implemented by 16F877A microcontroller and shown promising results in accurate vertical and horizontal movements. This robot can be introduced as a smart device for a household toolbox.*

Keywords: utility robots, horizontal movement, vertical movement,

I. INTRODUCTION

Technology has changed the way people do things in work places and at homes (Kim & Jung, 2007). The consumer markets are more prioritized in selling such devices with the increasing customer demand day by day. The paper is based on a household utility robot, which can be used to reach unreachable places, where people can't reach and having a risk (Hinze & Huang, 2002) in attending to do so. The robot will be able to give real time feed of its surrounding. The house chores are becoming more and more complicated than the early ages due to the influence of modern architecture. So, in order to overcome those problems the house-hold utility robot is much helpful.

The robot that we have developed is a portable device (Robot) with horizontal and vertical movement to address the above issues to a great extent by developing a small scale robot with vertical and horizontal movements. The robot is more portable and easy to handle due to its simpler design and ease of use. The capability of reaching heights and spaces which are difficult to reach easily by a normal human may help to succeed the day today household activities easily and more efficiently in shorter time with absolutely no cost.

According to the research done previously, the portable devices which can be used easily without much effort always considered buying by customers well ahead of those not. So the portability is much more important in this design in order to maintain the household utility robot's standards. Other than the portability, the ease of use of the utility is also a main consideration in modern world. So the robot is made to meet those major requirements while fulfilling the main objectives of horizontal and vertical movement. Developing a horizontal and vertical moving household utility robot have resulted in achievements in productivity, by lowering cost and enhancing customer satisfaction for engineered systems in most of the developed countries (Warszawsky & Rosenfeld, 2004). Therefore, countries all around the world are now trying to reap the benefits of modern technology through the products similar to this.

II. DESIGNING THE ROBOT

The hypothesis is to design and develop a horizontal and vertical movement device, which can be more portable than the previous researches done by

others in this research area. The two degrees of movement of the robot was the key consideration when in the design phase. It was very vital to consider the most suitable design to fulfil the desired objectives without any unwanted fuss. Several ideas came up on how to implement the two directional movements of the robot.

- To use a slider, mounted on two thin cylindrical metal bars connected with a stepper motor, for the directional motion.
- To use a threaded strip of hard plastic connected to a stepper motor and the camera mounting bay in the device.
- To use a threaded metal rod connected to a stepper motor, the rotation in the rod may lift the connected platform up or down while moving through the threads.

The above three ideas were the ones we most considered in selecting a design for the horizontal and vertical moving parts of the robot. Here the major objectives that was to be fulfilled by the above ideas were:

- To move the platform with least vibrations so it may provide the best viewing experience through the mounted IR camera.
- To reach a reasonable speed in the directional motions which may provide fast reach and ultimately save operator time.

The structure of the sliders where horizontal and vertical moving parts of the robot fixed are made out of aluminum to provide light weight and reasonable strength for the robot. Using of aluminum resulted in easy mounting of the vital and additional parts to the robot. The robot's electronic circuitry is attached to the bottom part of the device providing close access to the sensors and motors of the robot increasing the amount of clarity of the work. Small, but powerful motors with higher torque used in the horizontal and vertical motions facilitating powerful motion capability and good control over it. Use of the small motors affect directly to the weight of the robot finally providing ease of use. The platform providing horizontal movement has a bay to accommodate an Infrared camera.

III. THE TECHNIQUE

The choice of the technique depends mainly on the objectives or the results expected from the method. Conventional methods used in related work have mainly focused on one directional motion, either moving along the plain up and down or the horizontal plain. The manual horizontal motions has also been used (Kim, 2004), Moving only in one direction may not always a very productive way compared to two directional movement. So they carry drawbacks such as lower productivity, safety, value for money etc.

The horizontal arm consisting the Infrared Camera, consists of Infrared sensors to identify any obstacle in the moving path and sends a signal to the controller unit in order to take necessary actions. Detection and Avoidance of oncoming objects can be done through this method. The rate of extending of the horizontal arm can be used to find the distance travelled in that direction, using a simple mathematical calculation, with the use of time taken and rate of extending of the horizontal arm. This technique is simple to use and very effective. Availability of the distance travelled as an output from the robot is a unique addition compared with the other related researches (Grassi, Naticchia & Giretti, 2007). Here the user can receive live updates of distance travelled.

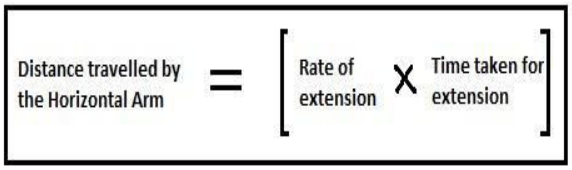


Figure 3. Calculation of the distance travelled by the horizontal arm

a. Measuring the distance travelled

In the sense of fulfilling most of the house-hold needs in reaching target places, it is very essential to know the distance where we want to reach. So we would know the dimensions of the place where we are accessing. The horizontal arm is extendable using the motor support, it facilitates a reasonable extension away from the device's body. The extendable arm is powered by a motor, which is similar to that of an extendable vehicle antenna. The rate of extension can be measured and through the data obtained, the robot can output the distance travelled by the horizontal arm. The calculated distance can be feed back to the operator.

b. Obstacle detection and identification

One of the main objective of the robot is to detect and identify obstacles in an unreachable place to the operator. Obstacle detection can be done easily by using the Infrared camera attached to the camera bay at the end of the horizontally extensible arm. The camera will give the live feed to the portable electronic device with the operator (e.g. - mobile phone, tablet computer, etc.).

IV. BASIC ARCHITECTURE

Motion in the two directions implemented using a 16F877A microcontroller which is pre-programmed according to the requirements of the objectives to be accomplished. The Programmable Integrated Circuit (PIC) 16F877A is controller, which is widely used for experimental applications because of its low price, wide range of applications, high quality, and ease of availability. It is ideal for applications such as machine control applications, measurement devices, study purpose, and so on. Two PWM (Pulse Width Modulation) ports have been used to maintain the speeds of the two motors used to facilitate horizontal and vertical motions.

The robot is made mainly out of a slider connected to the extendable horizontal arm together with using two stepper motors with the ability to move along the directions desired. The control board consists of microcontroller, motor drivers, resistors, voltage controller and the required circuitries. The robot is generally taken the shape of a cross when it is fully extended, but it will be in an initial position until it is extended by the signal given by the operator.

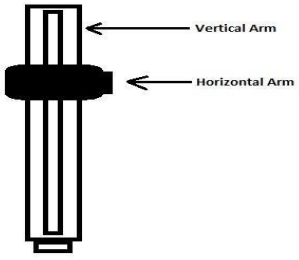


Figure 2. Front view of Utility Robot

The robot's horizontal arm is equipped with two IR sensors on the upper and lower sides of the arm in order to keep track of the position of the moving arms. The Horizontal Arm moves along a rail on the Vertical Arm placed in order to keep the Horizontal Arm in accurate position to facilitate correct movements. The Vertical arm consists a place to fix an extending pole.

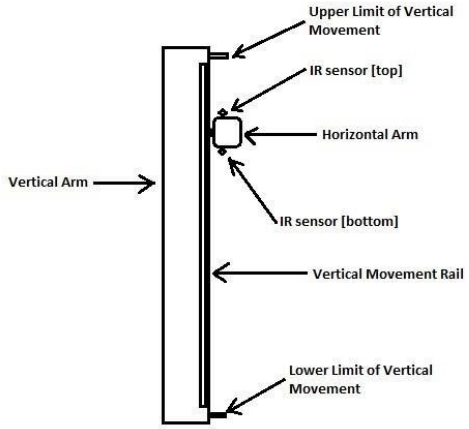


Figure 3. Side view of Utility Robot

A. Parts of the Robot

As in the above diagram, the robot consists several vital parts important for the actions carried out by the robot.

- Horizontal arm
- Vertical arm
- Lower and Upper limits
- IR sensors

B. Dimensions of the Robot

The robot has been made with the below dimensions and those should be kept in sensible manner in order to maintain the correct and efficient movement of horizontal and vertical movements. The approximate measurements of the robot are set as follows:

- Vertical arm - Height = 8 inches approx.
- Horizontal arm – Length (compact) = 4 inches approx.
- Horizontal arm – Length (extended) = 35 inches approx.

The dimensions of the robot have kept in a limited frame in order to maintain the objective of portability. As this robot is a house-hold device, portability is a major concern.

The Horizontal arm is initially at contracted state,

when the user signals the Horizontal arm can be extended with the camera bay mounted to the end of the arm. The mechanism for the extension of the Horizontal arm is the use of tubular extension method allowing much efficiency along with little space requirement.

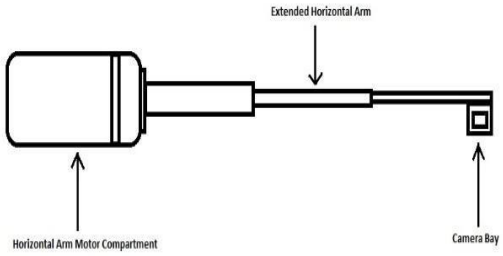


Figure 4. Mechanism of horizontal arm

Extendable part of this is made out of several tubular parts, which are not identical in their sizes. So they may fit into larger tubes making one tube containing all the smaller tubes than it. The motor inside the motor compartment drives the tubular horizontal arm forward and backward as instructed by the user.

V. RESULTS

The House-hold utility robot has several main features which are unique to itself. Weight of the device, 360 degree rotation around the vertical axis, compact design and unique tubular horizontal extension of the arm are those features which are contrasting to other similar devices.

Table 1. Comparison of main features

Main Features	House-hold Utility Robot	Other similar devices	
Weight of the device	Reduced weight for increased portability	Some devices are too heavy to operate	
360 degree rotation along vertical axis	Manually	Achieved with a separate motor	
Compact design		Design is compact due to the auto-retractable horizontal arm and 360 degree rotation along horizontal axis	Design is compact, but lacks features
Unique tubular horizontal extension arm	Easy to move through smaller areas and compact		May need more room. Limited reaching ability.

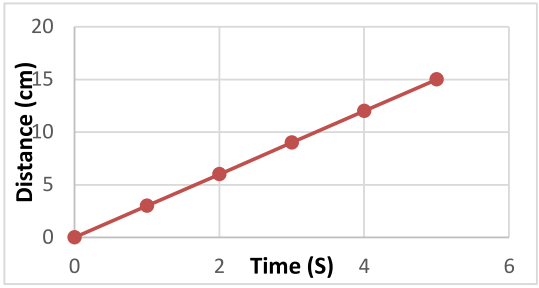
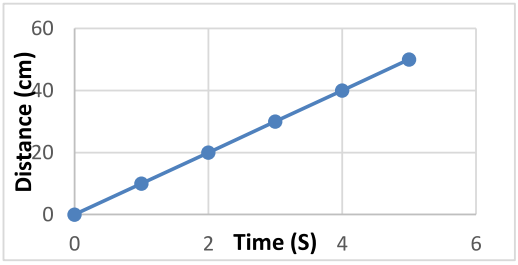


Figure 5. Variation of Distance travelled by horizontal arm with Time

The graph's X- axis represents the time in seconds while the Y- axis represents the distance travelled by the horizontal arm in centimetres.

Figure 6. Variation of Distance travelled by vertical arm with time



The graph's X- axis represents the time in seconds while the Y- axis represents the distance travelled by the vertical arm in centimetres.

VI. CONCLUSION

In this technology centric world, every device we use a product of many technology combinations. Such devices are playing a vital part in today's human life. Many high-end devices have been made to simplify day today house-hold activities. In that

sense a house-hold robotic device to reach horizontal and vertical directions to fulfil the objective of reaching unreachable places to human and avoid risk in reaching heights while enabling multiple uses, may get much productive and needy in today's world.

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