Modeling and Implementation of a Mobile Robotic Arm for Industrial Tasks

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Abstract. Mobile Robotic Arm is a key of many new applications of robotics in industry, construction, nuclear tasks, even in space. The essential part of the mobile robotic arm is a programmable microcontroller based brick capable of driving basically two gear motors and three stepper motors. An advanced model and implementation of a mobile robotic arm are presented in this paper. This paper presents the method of interfacing the robotic arm, stepper motors and gear motors with the programmed ATmega8 microcontroller which is used to control the robot operations. A simple mobile robotic arm can grab an object and transfer it from one place to another successfully and fulfill the requirements of industrial tasks.

Keywords: Manipulator, Mobile robot, MCU, I/O.

1 INTRODUCTION

Robot is a mechanical device which can be programmed to perform some task of manipulation or locomotion under automatic control. Programs can differ in their nature (Sandier B. Z., 1999). The fact that a robot can be reprogrammed is important; it is definitely a characteristic of robots. To perform any useful task the robot must interface with the environment, which may comprise feeding devices, other robots, and most importantly people.

A mobile robot system has the ability to grab an object and transfer it from one place to another. In this way mobile robotic arm has many advantages over manipulator. There is demand for mobile robotic arm with in industrial purpose, subsea and in space because of the potential presented their application for complex tasks compared to a ‘handicapped’ robot system.

It was not late after the emergence of robotics technologies that mobile robotic arm began to be interested in by some of robotics researchers. The concept of placing a manipulator on a mobile platform to increase the workspace and improve the quality of the manipulator or to enhance the usefulness of the moveable platform dates back several decades (Pavlov and Timefeyev, 1976). The reason was apparent, that is, due to many limitations in applications of the robotic arm or manipulator. Manipulator is a mechanism, usually consisting of a series of segments, jointed or sliding relative to one another, for the purpose of grasping and moving objects usually in several degrees of freedom (Sandier B. Z., 1999). Therefore, robotic arm or manipulator in not suited for applications in unstructured environments. So, mobile robotic arm could be useful in every field. Research works in the early days include that by Khatib (Khatib, 1999); Singth (Singh, 1997); Stentz, Bares, Singh, Rowe (Stentz et al., 1999), and Monta, Kondo, Shibano (Monta et al, 1995).

Nowadays, mobile robotic arm is a widespread term which refers to robots built form a robotic arm mounted on a mobile platform (Cardenas et al., 2003). Both locomotion and manipulation abilities of this kind of robots allow them to do all types of industrial tusks (Arai T., 1996; Khatib 1997). Actually, such systems combine the advantages of mobile platforms and robotic arms; and reduce their drawbacks. For instance, the mobile platform extends the workspace, while the arm offers much operational functionalities. So, they seem particularly suited for field and service robotics. Although not new in the robotics history (Pavlov and Timefeyev, 1976) this concept has mainly been studied not more than 15 years (Dobowsky and Tanner, 1998; Liu and Lewis ,1990; Pin and Culioli,1990).

The primary use of robotics in industrial applications is to reduce the dependence upon manpower. They are widely used in industry to perform dumb, dangerous, dull and dirty tasks. Furthermore, robots-based manufacturing increases product quality, improves work conditions, and leads to an optimized use of resources. Therefore, robotics plays a vital role to improve the quality of life of European citizens (EUROP, 2009). However, the industrial robots of these days are rather inflexible as they are often dedicated and/or fixed (Hvilshoj and Bogh, 2011). Its, either autonomous or tele-operated, are particularly well suited for human-like tasks. In big industries a large number of workers have been employed in order to accomplish the necessary task. By using mobile robotic arm the number of workers is minimized, this in turn creates many additional saving including a reduction on the quantity of protective clothing needed and decreased administration.

Moreover, they have applications in many different areas like manufacturing, mining, space mission, military purpose, house hold tusk, hospital deliveries (Alfaro et al., 2004). Requirements of important elements for building a simple high quality mobile robotic arm have been presented in this paper. Modeling and implementation of such kind of robotic arm have been presented with the aim of obtaining the changes of functionality of a robot, reduction of the cost and complexity to the earlier invention.

2. METHODOLOGY

The development of advanced technology requires both a study of economic feasibility and an assessment of available technology. The identification of the required capabilities that a robotics system should have not is an easy task. To support the development and to extend the application, it is rational to combine locomotion capabilities with manipulation abilities, to create mobile robotic arm. With respect to the traditional industrial robot it is easier for mobile manipulators to adapt to changing environments and perform more manufacturing tasks (Hamner et al., 2009). The conventional model of these types of robots is a robot manipulator mounted upon a mobile platform, extended with tooling system (Hentout et al., 2010). The adoption of a process needs the use of an appropriate development model, which takes into consideration the unique nature of the particular tasks (Bakari et al., 2007).

The method employed in designing and constructing the robotic arm are based on the operational characteristics and features of the microcontrollers, stepper motors, gear motors, the electronic circuit diagram and most importantly the programming of the microcontroller and stepper motors. The block diagram of the work is as shown in Fig. 1.

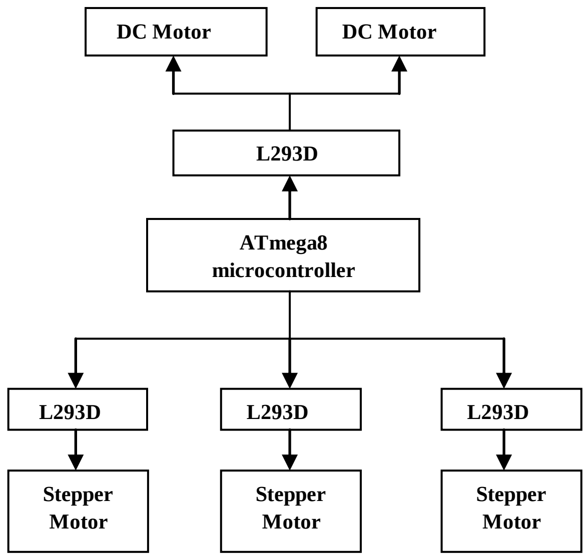

Fig. 1. Block diagram for modeling and implementation of a mobile robotic arm.

Seven steps have been used to complete the whole structure as (i) microcontroller testing, (ii) motor testing, (iii) base implementation, (iv) mobile platform implementation, (v) wrist and gripper implementation, (vi) elbow implementation and (vii) combining all parts.

A detail study is performed on the robotic arm, mobile platform and the ATmega8 microcontroller. The built robotic arm, stepper motors and the gear motors have been tested at the loaded condition. The C language is use to program the microcontroller and associate software to write the code is 'AVR STUDIO' and compiler is "WinAVR". AVR lib and PonyProg also used as the Library and the Programmer respectively. The C language codes converted to hexadecimal codes and transfer it to the ATmega8 microcontroller by a burner circuit.

The mobile robotic arm used for modeling and test purposes. A typical prototype is as shown in Fig. 2. There is a stepper motor at the elbow, which allows to upward- downward movement of the arm; another stepper motor of the wrist cause the movement of the arm forward; and the last stepper motor of the gripper allows to grab an object (Olawale et al., 2007).The gear motors which moves the movable platform from right to left (or vice versa) and forward or backward. ATmega8 micro-controller takes robot's motor signal as I/O and controls the robot operation programmatically.

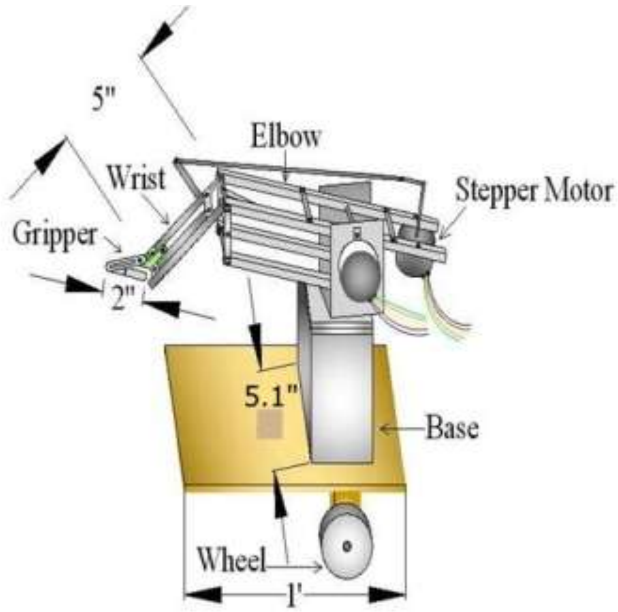

Fig. 2. Symbolic design of mobile robotic arm.

3 DESIGN OF A MOBILE ROBOTIC ARM

Mechanical and electrical designs for implementing a mobile robotic arm are presented as follows:

3.1. Mechanical design

This work is able to accomplish the defined functionality. A sample robot which can move, grip an object, lower and raise its arm, by being controlled by the ATmega8 microcontroller is built successfully. The main attraction is in the wrist and the gripper. The movement of wrist is completely a unique method. The traditional gear is not used in here. A folding stick is attached with the ring of the wrist motor and connected to the wrist arm, which moves precisely by the direction of the stepper motor. It is very available and also cost efficient. That is as shown in Fig. 3(b). The motor is situated in the back side of the arm which also balancing the weight of the structure. A clip device is used in the gripper that is for holding an object firmly. It is very much suitable for unstructured condition to take an object from one place to another. The ATmega8 development board is soldered and the required procedure has been used for the correct operation of the controller. The ATmega8 development board has been interfaced to the stepper motors and gear motors such that the structure can be controlled by a switch.

(a)

(b)

(c)

(d)

Fig.3. (a) Movable platform, (b) Robotic arm, (c) Combination of base and arm, and (d) Mobile robotic arm

Fig. 3 presents the steps for implementing a mobile robotic arm. For designing the structure of the mobile robotic arm the design parameter values are presented in table 1 and table 2.

Table 1. Length and weight of the robotic arms and wooden board

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Components	Length	Weight	Height	Width
Wooden Board	12 inch	800 gm		9.1 inch
Base		550 gm	7.5 inc	5.1 inch
Elbow	5 inch	15 gm		
Wrist	5 inch	15 gm		
Gripper	2 inch	5 gm		

Table 2. Diameter and weight of the motors and wheels.

Components	Diameter	Weight
Elbow Motor	2.1 inch	300 gm
Wrist Motor	1.5 inch	122 gm
Gripper Motor	2.3 inch	300 gm
Gear Motor	1.0 inch	300 gm
Wheel	3.5 inch	220 gm

3.2 Electrical design

Control circuit is the heart of electrical design. It is the control panel of the system as it oversees the operations of the mechanical arm, and the mobile platform. The ATmega8 microcontroller acts as the brain of the control panel as it coordinates all the activities of the other devices. When power (+5V) was supplied to the control unit, the MCU started off by loading the program, interpreted and executed the instruction codes through the various operational principles.

ATmega8 sends signal to the gear motor which moves the mobile platform from right to left (or vice versa) and forward or backward. Signal also goes to the stepper motor which moves 7.5^o per step. The stepper motor at the elbow moves six times (45^o) and cause upward-downward movement of the hand. The stepper motor of the wrist moves next stepping twelve times (90^o) and cause the movement of the arm 90^o forward or backward. Both elbow and wrist works simultaneously. Then the stepper motor of the gripper moves four times (30^o) to grip an object and moves five times (37.5^o) to leave an object. The control circuit diagram of the development board and the flowchart are shown in Fig.4 and Fig.5 respectively. In Fig.4 the connection of the identified components and devices are shown also. The components are ATmega8 microcontroller, L293D, stepper motors, DC gear motors. This components work together to achieve the set goal of controlling the arrangement of the stepper motors and gear motors. The microcontroller is the processing device that coordinates all the activities of all the components for proper functioning.

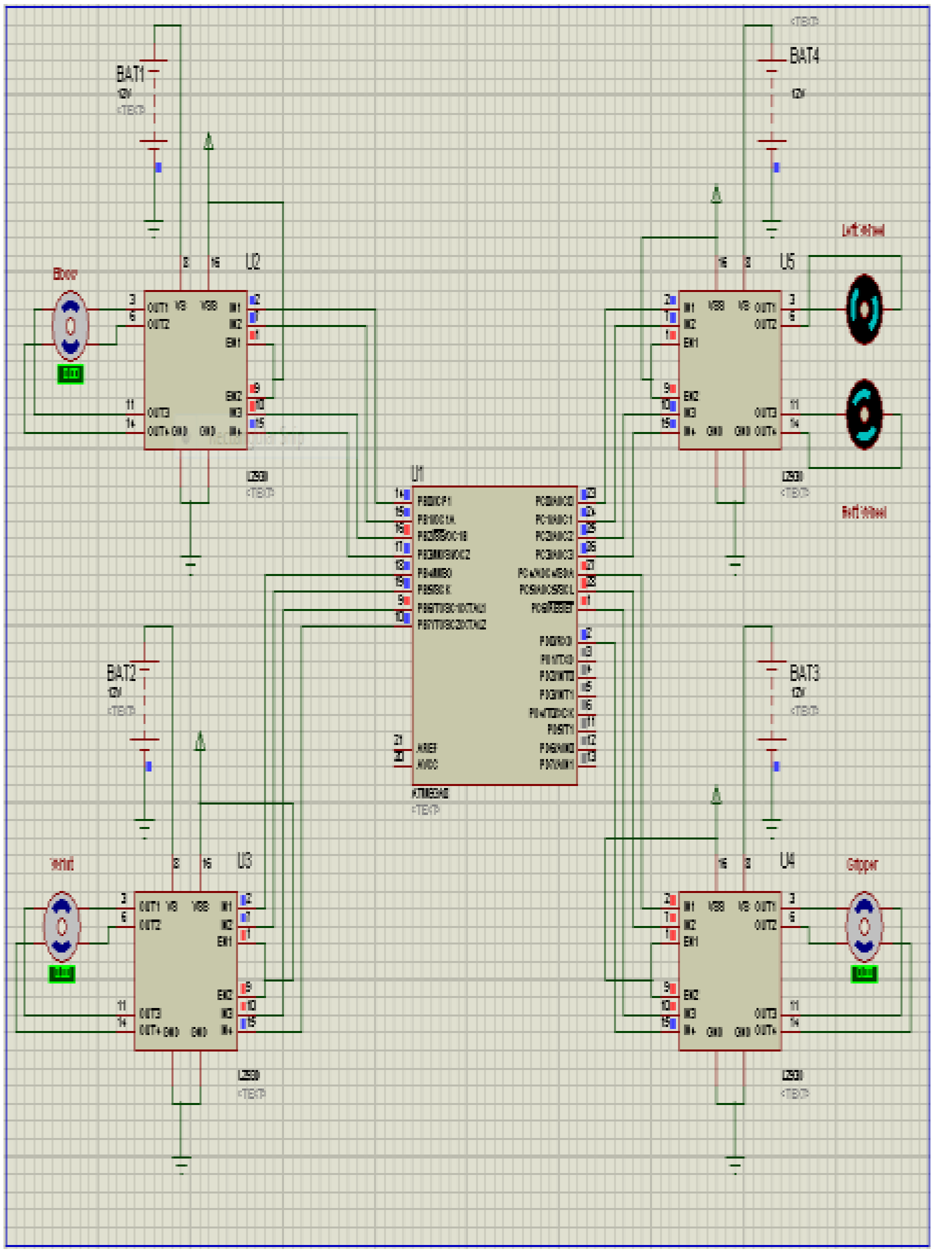

Fig. 4. Control Unit of a mobile robotic arm.

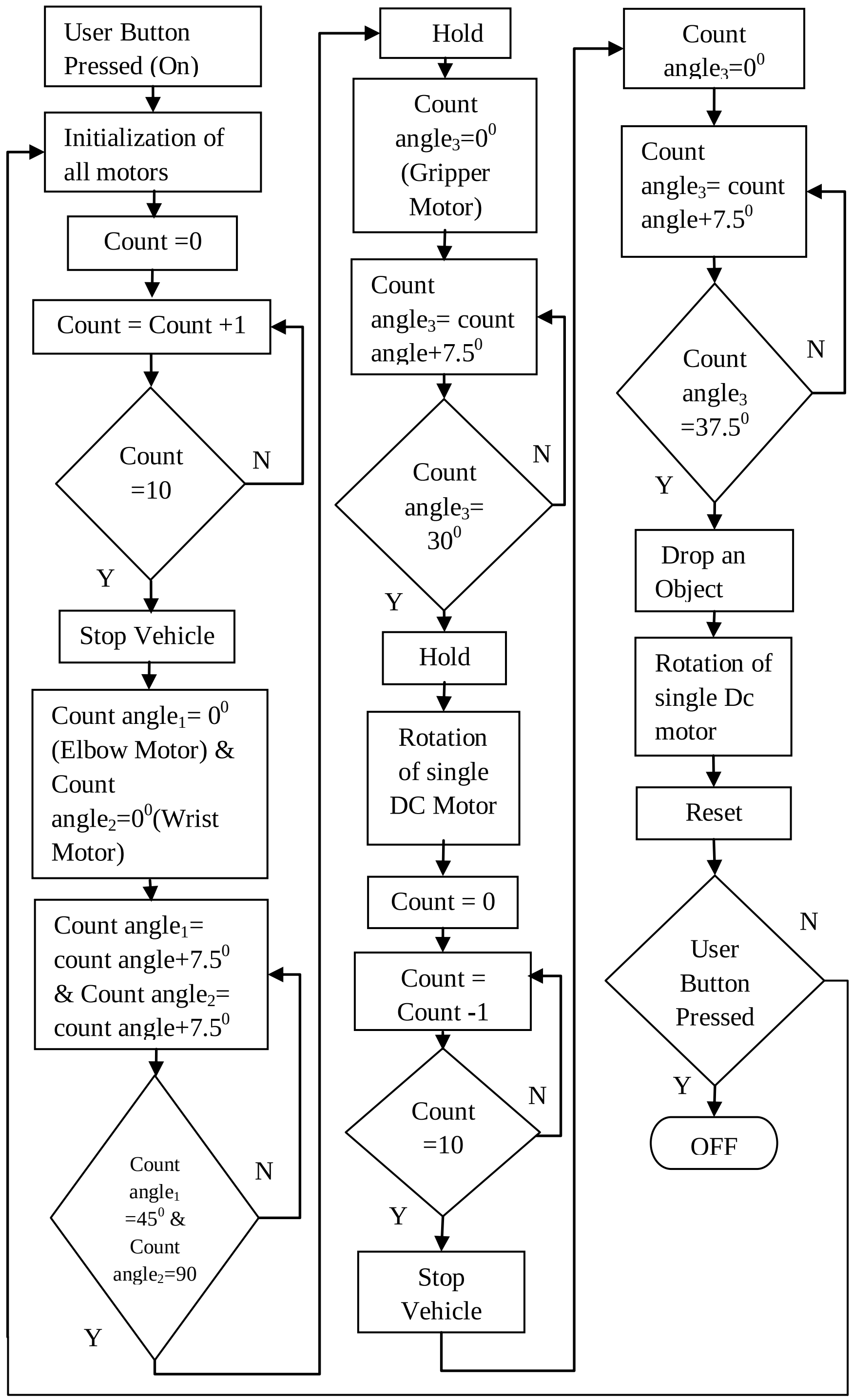

Fig. 5. Flowchart for Mobile Robotic Art

4 CONCLUSIONS

This paper introduces a new model of a mobile robotic arm which is designed and implemented for industrial tasks. This model minimizes the complexity of wrist and gripper with respect to the earlier version. The structure is not packed so easy to maintenance and maintenance cost is very low. Elbow, wrist, gripper, mobile platform are not permanently attached with one another. So, easy to replace any mechanical parts due to the reason of mechanical fault. It has been interfaced with different kinds of I/O devices and also deduces that a mobile robotic arm can be much efficient, stronger and therefore able to lift heavier weights and extra large forces. It can be very precise in their movements, reduce labor costs, material wastage and improve working conditions and product quality also. Actually, the implemented mobile robotic arm introduces additional issues that are not present in mobile manipulator and also tried to show the new techniques by a cost efficient method.

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