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PICK AND PLACE HUMANOID ROBOT USING RASPBERRY PI AND ARDUINO FOR INDUSTRIAL APPLICATIONS

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ABSTRACT

Today pick and place robots are widely used in automobile and manufacturing industries to perform the repetitive and tedious jobs to increase the production cycle rates. In this paper, we have proposed a manually controlled, four wheeled pick place robot. Proposed robot has two robotic arms with 6 Degree of Freedom (DOF), with each arm having two fingered gripper controlled by high torque servo motors. We have used Raspberry Pi and arduino as the controller and other robot sensors, respectively, that are used for stable functioning and robustness. This design helps in both small scale and large scale industries, wherein various levels of torque capacities can be built based on grasping force required for an application. In small scale industries, manual control is incorporated where it eliminates computation required for motion planning of robot and it is also cost effective compared to the automated robots. For control of robot, android application is developed using MIT App Inventor.

Keywords *Industrial robot, Automation, End effectors, Servo-electric gripper*

I. INTRODUCTION

Robots are not made as simple machines, they are several steps ahead of a typical machine. It will perform totally different robust jobs. However, the advancement is that they can adapt with their own. Once programmed robots will perform needed tasks repeatedly in identical means. Robots play important role in repetitive jobs that are boring, stressful, or labor-intensive for humans.

Robots are progressively marching into our daily life activities. In the future, robots can act as caretaker, entertainers, medics, companions, troopers and even traffic police. At present, over 20 million household robots, and a further 2.7 million industrial robots, are operating worldwide[1]. There is a misconception with people that robot and automation eliminate manufacturing jobs but actually they create more desirable jobs, like engineering, management, programming, and equipment maintenance and also free up manpower critical constraints to let companies maximize workers skills in other areas like business. The humanoid robot with wheels which can perform skillful tasks using both arms with end effectors, could be treated as one of the ultimate robots, with applications not only on earth but also in space.

1.1 Industrial robot

An industrial robot is made of a collaboration of 3 fields namely Mechanics, Electronics and Computer science. Mechanics - This is nothing but the physical body what we see. This part is important for robot's payload, speed, and accuracy. Computer science - which makes the robot to be 'smart' enough by the combination of the robot environment information and the end user. Electronics - allows the control system to drive all motors and get environment condition from sensors. The industrial robot we worked on is a 'pick and place robot', which will do tedious and repetitive tasks at high cycle rates and speed.

There is a fast growth in the automation of manufacturing around the globe: 74 robot units per ten thousand labor is the new average of global robot density in the production industries (2015: 66 units). By regions, the average density of robot in Asia is sixty-three units, in the Americas eighty-four and in Europe is ninety-nine units [1]. The main reason behind this growing number of robots is drop in robot prices and hike in labor compensation in manufacturing industries.

At present industries are concentrating to increase production rates and consistency in quality of product delivered, for this 'pick place robot' is a perfect solution as majority of automobile and manufacturing industries have already started adopting it at large scales. In our proposed model the robot will perform loading, unloading, transporting parts or performing an operation on a work piece at fast rates with accuracy.

1.2 End Effectors

Industrial robots are used to perform precise, dangerous, or repetitive tasks. These tasks were traditionally performed by human hands, or by tools held by human hands. The robotic devices that accomplish the work of human hands are called end effectors. They are also called end of arm tooling (EOAT). It may be an end of arm tooling, gripper, tools or welding equipment. But the most common type of end effector is a gripper. A gripper is a type of end effector designed specifically for the purpose of grasping objects. The most basic way robots accomplish gripping is by having at least two moving fingers or jaws.

The robotic gripper is classified into 4 types: pneumatic grippers, vacuum grippers, hydraulic grippers and servo-electric grippers. Industries choose grippers based on which handling application is required and the type of material in use. In our model we are using a servo-electric based gripper since position and speed of jaw can be controlled. Unlike pneumatic based gripper cost for maintenance and power is eliminated in servo based. And also a wide range of objects can be grasped by applying minimum grasping force for objects based on weight. Friction Grip two jawed gripper is used at both the hands.

II. RELATED WORKS

There have been many attempts in the design of robot and end effectors for industrial applications. In 1961, Unimate was the first industrial robot developed and it was a simple robotic arm implemented for automation of die-casting in the factory [2]. In another approach, Abhinav Sinha et.al have proposed a mathematical model for the control method of mobile pick and place industrial robots using inverted pendulum concept and have proven it mathematically. But no real-time implementation is carried out to prove its efficiency [3]. Vojtech Vonasek et al. in 2017 proposed a technique for motion planning of robotic manipulators for a bin-picking industrial robot and the planner is called RRT-TS-MP (RRT with Task-Space Motion Primitives).They have tested it in simulation and also as a prototype. This technique RRT-TS-MP surpasses the existing TS-RRT method in many ways. But the main disadvantage is its accuracy and computational time [4].

A robotic gripper with variable stiffness using shape memory alloy (SMA) and a model for grasping force is proposed by Haibin Yin et al. in 2017. It is verified using a two jawed robotic gripper. The stiffness of gripper varied using the relationship between temperature and elastic modulus of SMA wires. Results show that the grasping ability increases by at least 30% of normal two fingered grippers but the drawback is, it is applicable for only small weights [4]. W. Gauchel has proposed a model individually movable two jawed pneumatic gripper using closed-loop position controller of jaws. But in pneumatic based approach cost and energy consumption is high [6]. Paul Glick et al. have designed a robotic gripper with a combination of fluidic and elastomeric actuators and gecko-inspired adhesives. This has increased the soft gripping property. But the drawback of this technique is position and speed of gripping is complex to control and needs more computation for lifting heavy parts. [7].

III. HUMANOID ROBOT DESIGN

In our proposed model we are building a manually controlled mobile pick and place robot with two jawed gripper controlled by servo motors. And the robot would be a humanoid robot with two robotic arms and a interactive face with a four wheeled base.

3.1 ROBOTIC ARM

To get 6 degree of freedom each arm is designed with 5 standard servos with angular rotation of 180^0 maximum and torque capacity of 6kg maximum. Servo brackets are used to create link between servo motors and to create joints of arm. All the servos of both the arms are connected to the servo driver .We are using pca9685 servo driver which is 16 channel and 12 bit/pwm. By using the driver the number of pin connection to arduino is drastically reduced. In accordance with the signal received by the Bluetooth module connected to raspberry pi, arduino controls the servo driver to drive all the servos. Each robotic arm is given a two jawed gripper. As shown in Fig.1 the robotic arm has an angular two- jawed gripper to open and close around a central pivot point, moving in an arcing motion. Since major application of robot is in automobile industries, dealing with soft material parts are not seen. Grasping occurs when the end effector wraps around an object. We have used a hard fiber with high coefficient for static friction to reduce the grasping force. Grippers are interchangeable. The same robot can perform a different type of task with a different gripper and its corresponding programming. The minimum gripping force for holding any object is given by

$F > m(g + a)/u$ *(safety factor) …(1)

F: Gripping force [N], *u*: Coefficient of static friction, m: Mass of the part [kg], g: Gravitational acceleration [9.81 m/s^2], a: Acceleration.

As in industries only some fixed parts and object is to be lifted, the minimum grasping force for individual object can be calculated and robot can be operated at different modes based on application. Pressure sensors are placed at jaws to calculate the gripping force. Safety factor depends on coefficient of static friction of the application.

Fig1. Robotic arm with two jawed gripper

3.2 FACE

We have placed two 8×8 LED Matrix to form the face of the robot. This is controlled using the raspberry pi placed behind LED matrix. It is easy get the face expressions using the matrix form in the programming. The robot is programmed in such a way that, it shows a face that continuously blinks eye with smile as an expression.

3.3 CONTROL AND POWER MANAGEMENT

As shown is fig.2, here raspberry pi is the main controller which control arduino, which in turn controls servo driver to drive all servo motors. Whole robot with body and head is placed on a 25cm x 13cm chassis with 4 wheels and it is made as a 2 wheel driven using 2 high torque dc motors driven by L239D IC controlled by arduino. The Bluetooth module incorporated is HC 05 which has a controlling range of 10 meters. Whole robot controlling is based on the signals sent by user application over Bluetooth and raspberry pi receiving it and controlling the all other components including arduino is based on the preprogramming done. Each servo is driven using the angle t, which in turn changes the position of the joints of arms and grippers. We have efficiently used the power between servo and DC motors by effective circuit design. Power source we are using is a 11.1V Li-Po battery of 2200mAh capacity. It will last maximum for 6 hours.

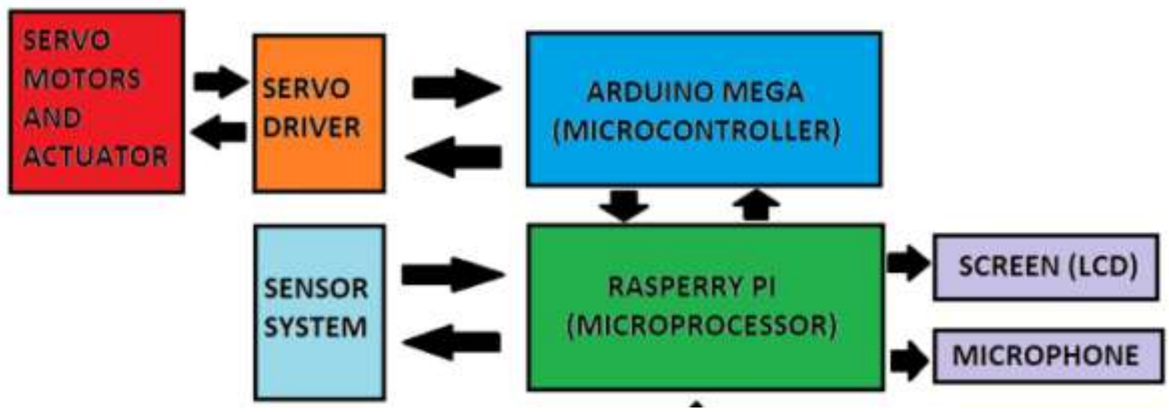

Fig.2 Control and Signal flow of Humanoid Robot

3.4 RESULTS AND DISCUSSION

As shown Fig.3 our robot prototype is tested to lift objects of varying size and shapes. Since our robotic arm is of 30cm in length, it can lift shapes with a maximum height of 25cm. And size of objects it can lift is of 2cm to 7cm in length. Fig.4 represents the GUI of android application developed using MIT App Inventor. It is interfaced with the Bluetooth module. Since our project is manually controlled, motion planning is not required, reducing the processing time, complexity, and power consumption.

As our robot is manually controlled, it always requires a skilled labor to operate it. But unlike fixed programmed robots, our robot will perform transportation, loading, and unloading within and outside the industry. When compared with automated ones, the safety issues while handling critical chemicals and other malfunctioning issues is solved in manually controlled ones. In our future work, we will be using Pi camera for adding autonomous mode feature of robot, for object detection we will be using image processing and background subtraction method.

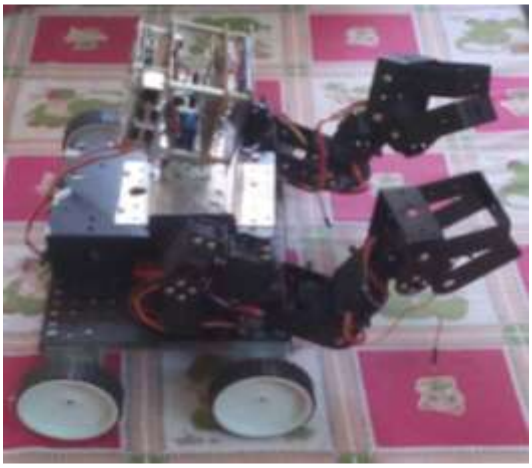

Fig.3 Side view actual robot prototype

Fig.4 GUI of application

V. CONCLUSION

We have successfully implemented and tested a manually controlled pick and place robot prototype with two arms and with humanoid features with height of 0.35m and weight 5kg. It can lift maximum weight of 4 kg from each of the arm. Our prototype can be implemented as a big model with high capacities of torque, grippers and power in small and large industries with manual control. This would cost very less compared to automated robot so it can be used by small industries for jobs requiring more man power.

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