Design and Implementation of Adaptive Jamming Gripper

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Abstract

The existing work depicts the design of simple jamming gripper, comprised of a flexible membrane filled with a mass of granular material that can passively adapt to the shape of the target object. By modulating the air pressure namely positive and negative pressure within the membrane, a jamming gripper can rapidly harden or soften to grip and release a wide range of objects irrespective of their size and shape. The major challenges in the flexible gripper are based on size, nature and object with complex geometries. The gripper passively confirms to the shape of a target object, and creates vacuum- hardens to grip it rigidly, later utilizing positive pressure to reverse this transition releasing the object and returning to a deformable state. Also this work describes the implementation of gripper and analyzes its performance by conducting different testing situations. By using both positive and negative pressure, gripper performance increases of up to 85% in reliability, 25 % in error tolerance, with the added capability to shoot objects by fast ejection. In addition, multiple objects are gripped and placed at once while maintaining the relative distance between the object and its arrangements. Finally by comparing the performance of the proposed gripper with various testing object in the field.

Keywords—Flexible gripper, Granular material

I. INTRODUCTION

Flexible robot grippers are robotic end effectors that can grip a wide variety of arbitrarily shaped objects. Proposed Flexible grippers have ranged from vacuum-based suction grippers to multi fingered hands, and these can be divided along a spectrum from active Flexible grippers to passive flexible grippers. Passive flexible grippers require minimal grasp planning. They often have ten or more degrees of freedom (DOF) per actuator and include components that passively confirm to unique object geometries, giving them the ability to grip widely varying objects without readjustment. For example, a gripper design in which many independent telescoping pins could each passively slide in or out to confirm to the shape of a target object, before pinching from the side to grip the object. Simpson was likely the first to suggest adding pockets of granular materials to gripping surfaces for this purpose, and later designs that allowed vacuum hardening of similar grain filled pockets to produce a custom gripper jaw shape, while describing a similar idea, went so far as to speculate that a single membrane filled with granular material might be able to grip an object on its own and function as a passive Flexible gripper. One research report focuses on strategies to achieve versatile and cost-effective gripping [1]. The three main sections of the paper cover existing techniques for making grippers more flexible, a strategy for minimizing the required number of grippers through part-family grouping, and a strategy for selecting and using grippers based on knowledge-engineering methodology. A passive universal gripper includes a mass of granular material encased in an elastic membrane [6]. Using a combination of positive and negative pressure, the gripper can rapidly grip and release a wide range of objects that are typically challenging for conventional universal grippers, such as flat objects, soft objects, or objects with complex geometries [2-5]. The gripper passively conforms to the shape of a target object, then vacuum-hardens to grip it rigidly; later using positive pressure to reverse this transition-releasing the object and returning to a deformable state. The apparatus and method enable the fast ejection of objects from the gripper, as well as essentially instantaneous reset time between releasing and gripping [7].

II. PROBLEM DESCRIPTION

The development of universal grippers able to pick up unfamiliar objects of widely varying shape and surface properties remains, however, challenging. Most current designs are based on the multi fingered hand, but this approach introduces hardware and software complexities. These include large numbers of controllable joints, the need for force sensing if objects are to be handled securely without crushing them, and the computational overhead to decide how much stress each finger should apply and where. Here we demonstrate a completely different approach to a universal gripper. Individual fingers are replaced by a single mass of granular material that, when pressed onto a target object, flows around it and conforms to its shape. Upon application of a vacuum the granular material contracts and hardens quickly to pinch and hold the object without requiring sensory feedback.

III.SYSTEM DESIGN AND ARCHITECTURE

A. System Architecture

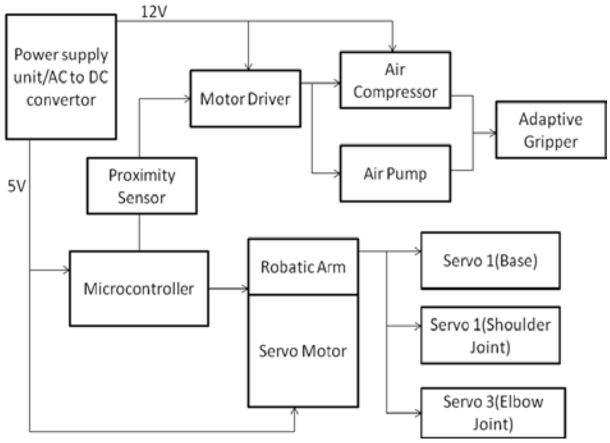

Figure 1.1: Block diagram of the proposed system

In figure 1.1 the detailed architecture of the proposed system. The basic function is used to pick and place the object. The microcontroller is programmed to produce pulse width modulation (PWM) signals. This pulse width modulation signals rotates the servo motors of the robotic arm based on time delay provided. Once the object comes in contact with gripper, the compressor unit sucks the air to create a negative pressure so that granular materials become intact and grips the object. The object is placed by creating a positive pressure, granular materials are broken and the robotic arm drops the object.

B. Arduino Board:

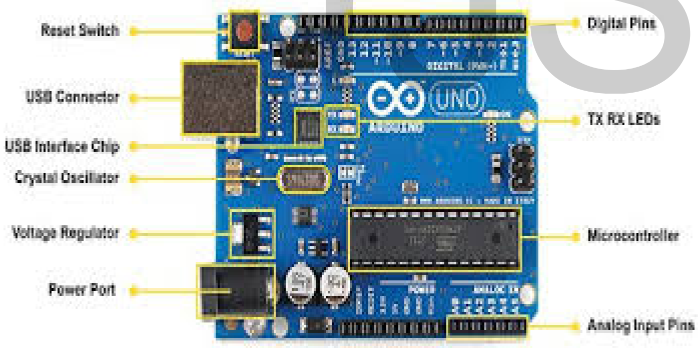

Figure 1.2: Arduino ATMEGA328 microcontroller board.

The embedded controller is the central controller for the whole unit which is shown in figure 1.2. Here, ATMEGA328 controller is used, which is an open source electronics prototyping 8 bit micro-controller board running at a frequency of 20 Mhz.

C.Servo Motor

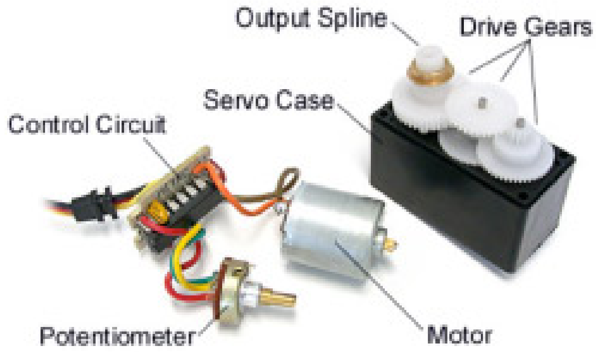

Figure 1.3: Servo Motor

In this work three servo motors are used to move the robotic arm which is shown in figure 1.3. Servos are controlled by sending an electrical pulse of variable width, or pulse width modulation (PWM), through the control wire. There is a minimum pulse, a maximum pulse, and a repetition rate. A servo motor can usually only turn 90° in either direction for a total of 180° movement. The motor's neutral position is defined as the position where the servo has the same amount of potential rotation in the both the clockwise or counter-clockwise direction. The PWM sent to the motor determines position of the shaft, and based on the duration of the pulse sent via the control wire; the rotor will turn to the desired position. The servo motor expects to see a pulse every 20 milliseconds (ms) and the length of the pulse will determine how far the motor turns. For example, a 1.5ms pulse will make the motor turn to the 90° position. Shorter than 1.5ms moves it in the counter clockwise direction toward the 0° position, and any longer than 1.5ms will turn the servo in a clockwise direction toward the 180° position.

D. ***Motor Driver (L293D)***

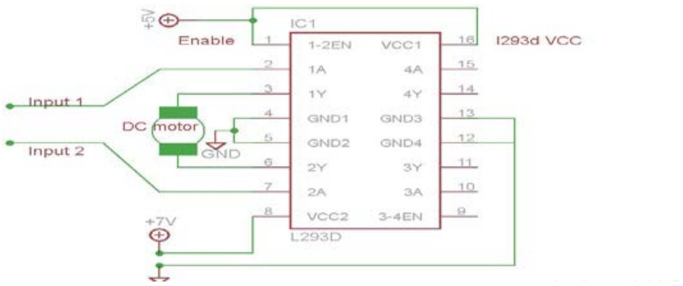

Figure 1.4: Circuit Diagram for motor driver IC controller

The above figure 1.4 describes the detailed circuit for motor driver controller unit which activates the motor in all directions based on the condition programmed in the microcontroller. There are 4 input pins for l293d, pin 2,7 on the left and pin 15,10 on the right. Left input pins will regulate the rotation of motor connected across left side and right input for motor on the right hand side. The motors are rotated on the basis of the inputs provided across the input pins as LOGIC 0 or LOGIC 1.

E. Reciprocating pump

A reciprocating pumps is class of positive displacement pumps which includes the piston pump, plunger pump and diaphragm pump. When well maintained, reciprocating pumps will last for years or even decades; however, left untouched, they can undergo rigorous wear and tear. It is often used where a relatively small quantity of liquid is to be handled and where delivery pressure is quite large. In reciprocating pumps, the chamber in which the liquid is trapped, is a stationary cylinder that contains the piston or plunger.

IV. SOFTWARE AND ENVIRONMENT

F. Arduino Software:

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. The Arduino programming language (based on Wiring), and the Arduino Software (IDE) platform .The design of the robotic arm flow chart is shown in the figure 1.5.There are many ways to design a robotic arm but several questions needed to be pointed out before designing it such as what is the object to be lift, how heavy is the object to be lift , how far can be the arm stretch, how many degree of freedom is the robotic arm and what is the material used to build the robotic arm and its composition. These questions are compulsory in order to build a reliable and efficient robotic arm. After these measurements have been taken the robotic arm can now be constructed and assembled together with the microcontroller chosen.

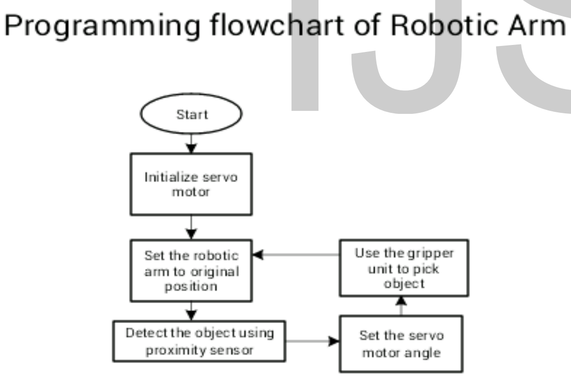

Figure 1.5: Flowchart of the Robotic Arm

Based on the designed robotic arm, a suitable programme is being constructed using the programming language chosen to be written into the microcontroller used. This program is built to suit with the application of pick and place robotic arm. During this stage, simulation is also being conducted through simulation software to verify that the programme written is working perfectly in order to protect the components and microcontroller from being damaged in case of any error.

The Arduino microcontroller is connected to the computer through USB. The text editor in software is used to write and edit the program in C/C++ environment. After the compilation if any error present it should be corrected before it is embedded in the board. In the arduino programming environment there is a possibility of monitoring the data movement through serial monitor.

V. EXPERIMENTAL RESULTS

G. Experimental Setup:

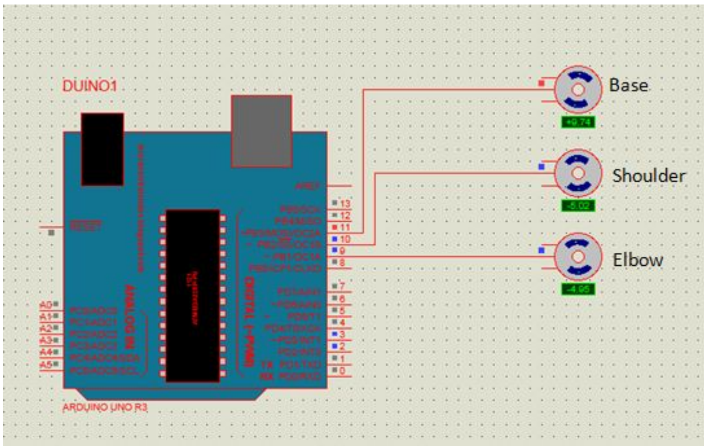

Figure 1.6: Simulation circuit in proteus environment

In figure 1.6, proteus simulation of robotic is described here. Once the power supply is given to controller ATmega328P the three servo motors namely base, shoulder, elbow goes to on state, initially all the servo motors will be at 90 deg respectively. After a delay of 500ms base servo motor move right by 45 deg, at delay of 1000ms shoulder servo move down to pick the object by 55 deg and it will wait to pick the object. Once object is picked up a small delay of 100ms is given to stop the operation. Now the base servo move left with the object by 90 deg and after delay of 20ms shoulder servo move down to place the object. The object elbow servo drop the object after delay of 1500ms. The angle of motor movement is noted and tabulated in table 1.1.

I. Degree of rotation of robotic arm

S.No.	Base Servo	Shoulder Servo
1	90	110
2	45	110
3	45	55
4	90	55

Table 1.1 Robotic arm degree of rotation

Figure 1.7: Adaptive Jamming Gripper picking a object

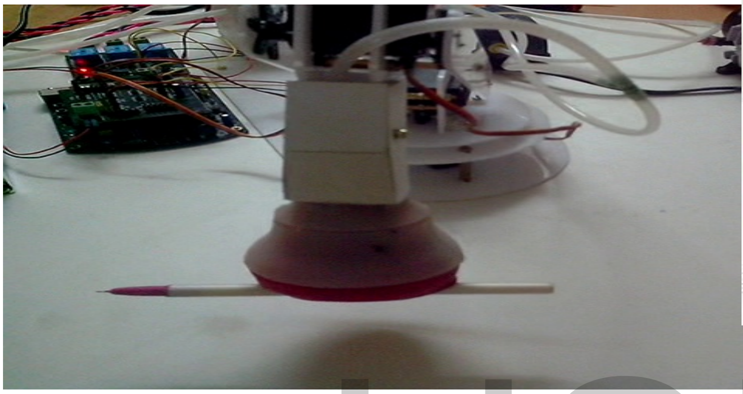

Figure 1.8: Adaptive Jamming Gripper placing a object

VI. CONCLUSION AND FUTURE SCOPE

The positive pressure gripper proved capable at gripping objects of different size and shape, and when compared with a version without positive pressure, it showed an increase in reliability of up to 85% and an increase in error tolerance of up to 25%. The positive pressure gripper also applied up to 90% less force on target objects, demonstrated an increase in placement accuracy. With this jamming gripper, objects of very different shape, weight, and fragility can be gripped, and multiple objects can be gripped at once while maintaining their relative distance and orientation. This diversity of abilities may make the gripper well suited for use in unstructured domains ranging from military environments to the home and, perhaps, for variable industrial tasks, such as food handling. The gripper's airtight construction also provides the potential for use in wet or volatile environments and permits easy cleaning. Its thermal limits are determined only by the latex rubber membrane, because of the temperature independence of the jamming phase transition.

H.Future Development:

The future work involves the integration of image processing to detect the specific object shape and color. To make the effective gripping of the object more reliable and durable latex membrane can be employed at different stages to pick and place the material without involvement of any human beings.

Figure 1.9: Various applications of Grippers

- This type of grippers are employed in the department of Nuclear science to move things remotely when the things dealt with are dangerous for body health.
- Astronauts can manipulate remote controlled grippers in space within the safety of the spacecraft when they are building the space station.

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