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Multipurpose Robotic Arm

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Abstract: The need for a robotic arm is increasing in areas such as food industries, consumer goods manufacturing industries, plastic goods manufacturing industries and electronics industries. However, it is still more concentrated in automotive industries. For a robotic arm to perform human tasks, it not only needs to have the arm like form but also features like accurate motion, proper communication and even intelligence. Although the usage of robotic arm is a difficult task for a layman i.e. only a learned person can operate it. Through our project, we propose its usage for household applications, for students to do simulations, etc. Using our robotic arm prototype people can do household chores and learn its operations and working day by day. Also students can learn its programming and kinematics and also upgrade accordingly. It has numerous software and hardware interactions and expansion interfaces in order to maximize the student's freedom to create. Through building, students can learn how a robotic arm and its mechanics work. Our project aims to develop a robotic arm of lightweight materials such as acrylic or aluminium and stepper motors to perform various application like stirring, pick and place and many more. Its lightweight will increase its portability so that it can be carried around anywhere for some applications or demonstrations.
Keywords: Robotic Arm, Lightweight, Stepper Motors, Portable, 3D printer.

I. INTRODUCTION

A robotic arm is a type of mechanical arm, usually programmable, with similar functions to a human arm; the arm may be the sum total of the mechanism or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement. The terminus of the kinematic chain of the manipulator is called the end effectors and it is analogous to the human hand. The end effectors, or robotic hand, can be designed to perform any desired task such as welding, gripping, spinning etc., depending on the application. Our endeavour is to confect a robotic arm which is first in class to incorporate multiple applications whilst having a compact design. Robots have been the workhorse of the automotive and the manufacturing industries, it have proven its might along the years. The robots have evolved and have become far more capable and versatile, but there is much more to explore in this technology. We believed that exposure to this technology at an earlier point in life can spark the light into young minds. The robot is developed around the concept of affordability, compactness and interoperability.

The end effector is designed in such a way that multiple attachment can be attached to it, we offer the user to design custom end effectors. It is capable of 2-Dimensional plotting, the user can either use a sheet of paper to sketch on, or copper clad board to transfer a PCB sketch. It can also be used for pick and place applications, the end effector can be swapped by a jaw which can hold and object. The robot is easy to program, the user just has to generate the g code and upload it to the robot, the robot offers a good repeatability which is necessary for such applications.

II. THEORY

This robotic arm is based on an open-loop control system, the robotic arm can be divided into three main components the Control unit (the mind of the robot), Actuators, and the foremost end effectors. The robotic arm follows a certain set of instructions to perform an operation.

The instructions are in the form of numerical control (CNC) programming language, in this case, the robot is controlled by G-code. The instructions are then decoded by the control unit and converted to signals, to control the stepper motors. The G-code is generated by a CAM (computer-aided machining) software on a desktop computer, the generated G-code is then transferred serially to the robot via a USB cable. The flow of control is described below.

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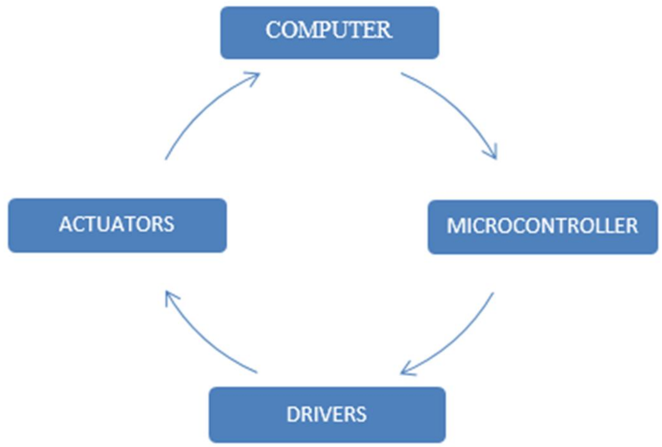
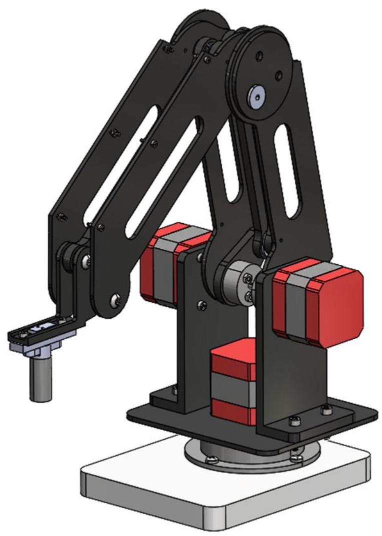


During the entire process, at all times the user has control over the process, at any stage, the user can authorize a stop procedure or any other precautionary options. The control menu offers the user the options to locally control the robot movements, the G-code is uploaded to the control menu. The robot consists of two links, the end effector is connected at the end of the second link. The links are controlled by two stepper motors. The end effector operates on the principle of 2 bar parallel mechanism, it stays parallel with respect to the base of the robot at all times. The robot has 3 degrees of freedom. The robot uses a spherical coordinate system to calculate the kinematics for a motion.

III. DESIGN

One of the most important step in making a robotic arm is its designing part. It is the most essential as the kinematics of the robot depends on the design. It requires a lot of mathematical calculation. One can also proceed with the built by skipping this part but it may require a lot of trial and error which may take a lot of time. Hence designing it with the help of computer aided designing software might just lower the work load. Now, coming back to our build, we first visualized and had a discussion on different design forms and the flaws followed by them. Once we were on the same platform we started designing each individual part in Solidworks software. Once done with designing individual parts the next step is assembly of the designed parts. The final assembly file came out to be pretty good.



Now the next step is to make those parts in real. There are many options open for making those parts such as we already have the 3d design of each and every part so we can 3d print those parts or make them out of light metals such as aluminium by simply CNC routing it but here the 3d printing filament cannot provide us with the optimum strength and CNC routing is a much expensive option. We came up with an idea of taking the 2d view of the parts and cutting those parts on acrylic or aluminium sheets of desired thicknesses. The next stage is the assembly of those parts and the associated electronics. It is well described in the later subsection.

IV. HARDWARE

Structure: The major parts such as the base, links, end effector, and the 3 bar parallel mechanisms were built using 3mm acrylic, it was the choice of material because weight saving, and cost were the major design goals of this project. Acrylic also has a smooth surface gives the robot a professional look finish while providing desirable strength, also acrylic can be laser cut effortlessly.

1) *Actuators:* The choice of actuator were stepper motors, as they are less expensive and have some added benefits such as:

a) The motor has full torque when at rest.
b) Measuring the same position and repeatability of movement since great stepper motors have a precision of 3–5% of a step and this mistake is non-cumulative from one point to another.
c) The motors reaction computerized input pulses which provide an open-loop control, making the motor simpler and less costly to control.
d) It is possible to accomplish a low-speed synchronous revolution with a load that is directly coupled to the shaft.
e) An extensive variety of rotational speeds can be realized as the speed depends upon the frequency of the input pulses.

The motor used is a standard bipolar NEMA 17-45 N/cm motor.

2) *Stepper Drivers:* The microcontroller cannot drive the stepper motor, a dedicated circuit is needed to drive the stepper motors. The driver circuit must decode the signals and drive the stepper to a precise angle. The stepper driver of choice was A4988, the key features of so are listed below. Size of the driver was a major reason for choice.

a) Simple step and direction control interface.
b) Five different step resolutions: full-step, half-step, quarter-step, eighth-step, and sixteenth-step.
c) Adjustable current control lets you set the maximum current output with a potentiometer, which lets you use voltages above your stepper motor’s rated voltage to achieve higher step rates.
d) Intelligent chopping control that automatically selects the correct current decay mode (fast decay or slow decay).
e) Over-temperature thermal shutdown, under-voltage lockout, and crossover-current protection.
f) Short-to-ground and shorted-load protection.

A4988 allows higher resolutions by allowing intermediate step locations, which are achieved by energizing the coils with intermediate current levels which is an added benefit. Wiring for full step mode is minimal.

Microcontroller: To perform matrix transformations and other mathematical operation on matrices, a minimum of 16-bit calculations were required. The Atmega2560 chip was chosen for this project. The Atmega2560 chip is available as a single board microcontroller commonly known as the Arduino mega2560. The Arduino Mega 2560 is a microcontroller board based on the ATmega2560.It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller.

V. SOFTWARE SUBSYSTEM

Using Pronterface: When you're done setting up Printrun, you can start pronterface.py in the directory you unpacked it. Select the port name you are using from the first drop-down, select your baud rate, and hit connect. Load an STL (see the note on skeinforge below) or GCODE file, and you can upload it to SD or print it directly. The "monitor printer" function, when enabled, checks the printer state (temperatures, SD print progress) every 3 seconds. The command box recognizes all pronsole commands but has no tabcompletion. If you want to load stl files, you need to install a slicing program such as Slic3r or Skeinforge and add its path to the settings. Slic3r integration: To invoke Slic3r directly from Pronterface your slicing command (Settings > Options > External Commands > Slice Command) should look something like slic3r $s -o $o. If Slic3r is properly installed "slic3r" will suffice, otherwise, replace it with the full path to Slic3r's executable.

If the Slic3r integration option (Settings > Options > User interface > Enable Slic3r integration) is checked a new menu will appear after application restart which will allow you to choose among your previously saved Slic3r Print/Filament/Printer settings.

VI. ALGORITHM

A. Start
B. Switch ON the power supply of ARM
C. Connect Robotic ARM to computer.
D. Open Arduino IDE
E. Upload GRBL Firmware to the microcontroller.
F. Open Universal Gcode sender software.

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G. Select proper COM port of Robotic ARM.
H. Select baud to 115200.
I. And Choose GRBL in Fireware.
J. Set up the Step Size Of X, Y and Z Axis.
K. Set up the Max rate of each axis.
L. Define the acceleration (mm/sec^2).
M. Enter the maximum travel in mm of X, Y and Z axis.
N. Now enter the desire path to follow by using command G0 X_ Y_ Z_
O. And press Enter.
P. Open Ponterface Software.
Q. Select Robotic ARM COM Port.
R. At @ block enter standard baud rate used in Universal Gcode Sender.
S. Click Connect
T. If facing any issues, Click Reset.
U. Click Load File.
V. Select the Gcode generated by Universal Gcode Sender.
W. And click Start/Print.
X. End

VII. RESULT AND DISCUSSIONS

The inferences from the above study were successfully constructed practically, the physical model was constructed as per the above design. There were arrears present in the model which were not found in the initial stages of the design. A few are them are as follows.

A. There were physical limitation to the movement which were different to that of calculated theoretically.
B. There were restrictions to the speed of movement of the robot.
C. It was later discovered that the robot is not scalable in size.

The practical model was working and apart from all the above arrears, the robot could 3d print and 2d plot. The power consideration were under the limits of 500 watts, the robot used 300watts of power to be precise. The movement speeds and the physical reach of the robot values were off by few values. The precision tolerance was in range of 2-4mm off. The repeatability of the robot was around. The robot was physically stable while in motion. The weight of the robot was more than calculated value around 1200grams, 300 grams more than expected. The image of the robot are below.

VIII. APPLICATIONS

The aim is to make the robotic arm mainly for three applications i.e. 3D printing, 2D plotting and pick and place applications. However a lot can be done in the future scope of this project.

Robotic Arm over traditional 3D Printers: The traditional 3D printers occupy a large space and are bulky. They are heavy and lack portability. They have high energy consumption. They have limited printable object size. On the other hand, the robotic arm occupies less space and is portable i.e. it can be set up anywhere. The robotic arm of the same dimensions of a traditional 3D printer can print an object of a larger size.

2D Plotter: The end effector can be equipped with a pen stand or a holder. This setup will be able to draw images on plane surface with high accuracy.

Pick and Place Robot: The arm will be fitted with a gripping mechanism. Then the arm will be trained with the software. Once programmed the robotic arm will perform the action and will continue to do it in a loop.

IX. FUTURE SCOPE

This project has a wide range applications that can be used in future. The 2D plotter can be modified to plot points on a curved surface in future. The 3D printer can be made more precise and the printing speed can be speed up. It can be programmed to be manually trained to perform actions without any software interventions making it more user friendly. It can also be used for educational purposes to teach robotics to students and learn the kinematics behind it.

X. ACKNOWLEDGEMENT

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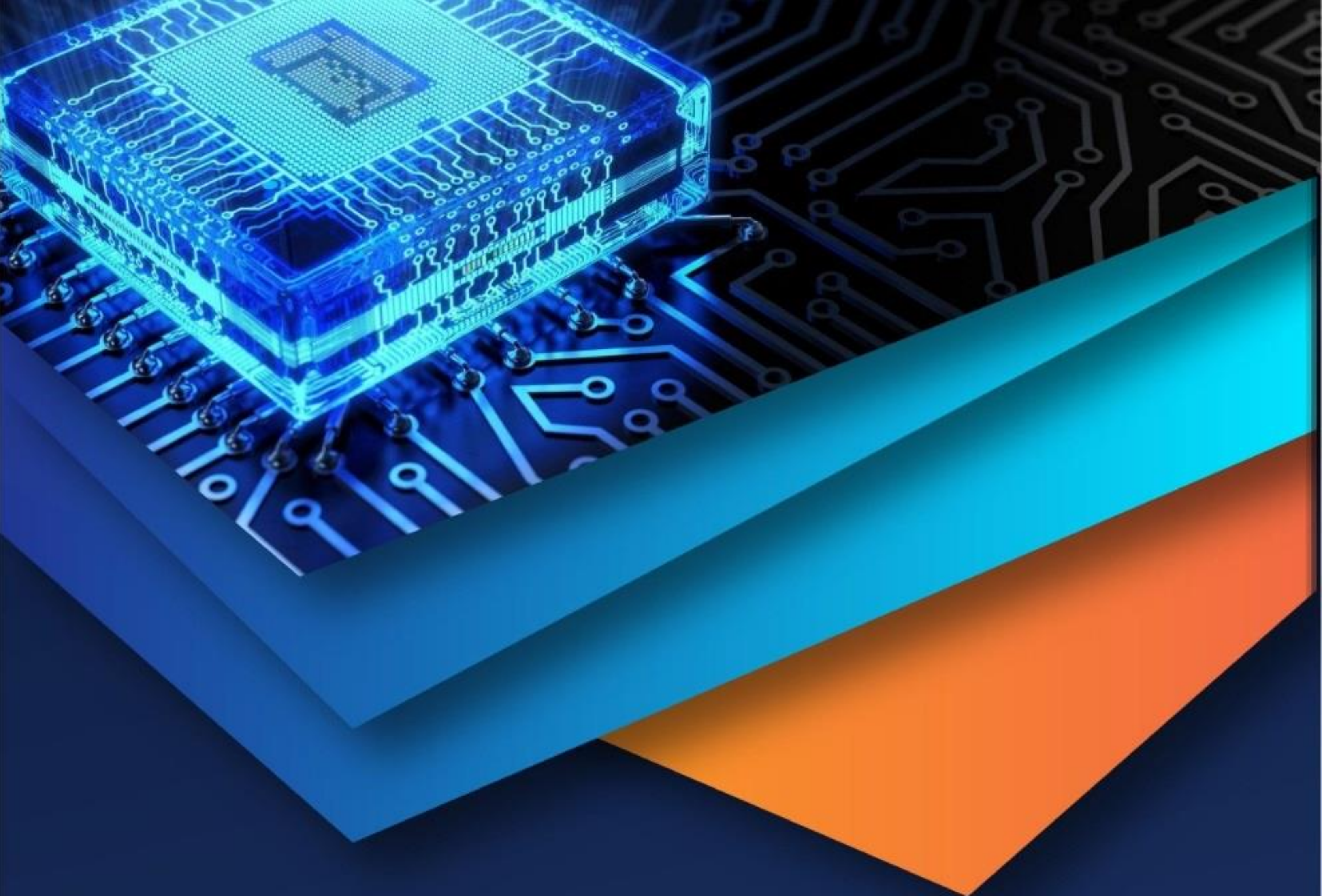

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