

How to Built a 5-DOF Servo Robot

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The servo robot is not a new idea, but because of its simplicity to make and control so I decided to make one for student project in my robotics class. The book PIC Robotics by John Iovine also describes how to make a similar servo robot but with 4 degree of freedoms (DOF). This robot is also made by ETT, the microelectronics company, for its showcase as shown in Figure 1. The company does not make this robot available for sale, however, it makes most of the robot components ready off the shelf. The base of this robot is the only part that we have to find our own material. ETT even make a servo motor controller, which receives user commands through serial port (RS232), which make it convenient because ETT already takes care of all the electronics work. The 4-DOF kinematics used by Iovine and ETT allows the robot to place the gripper in a desire position (x,y,z) and rotate the gripper around. But I want the robot to be able to grab object from the ground at right angle. So I decided to go with 5 DOFs with kinematics structure similar to the Rhino robot, the first robot I used in my robotics class at Case Western Reserve University.

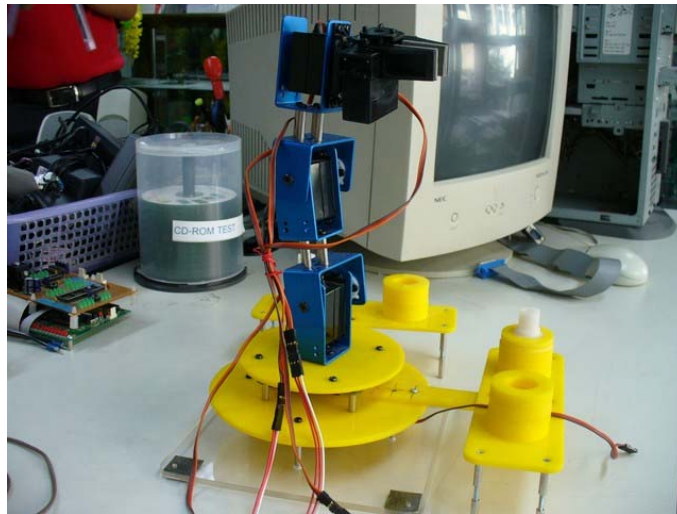


Figure 1 The 4-DOF servo robot made by ETT

This document will describe how to build the 5-DOF robot by using servo motors. Figure 2 shows the 5-DOF servo robot that we made. It has ability to rotate around 5 joints, and to open/close its gripper at the end of the kinematics chains. The robot has 6 servo motors. In this instruction, I will call the servo motor nearest to base to be servo motor #1, and the next one will be #2, #3, #4, #5, and #6 respectively. Thus, the motor #6 is the one that is used to open/close the gripper, and does not count as a DOF of this robot.

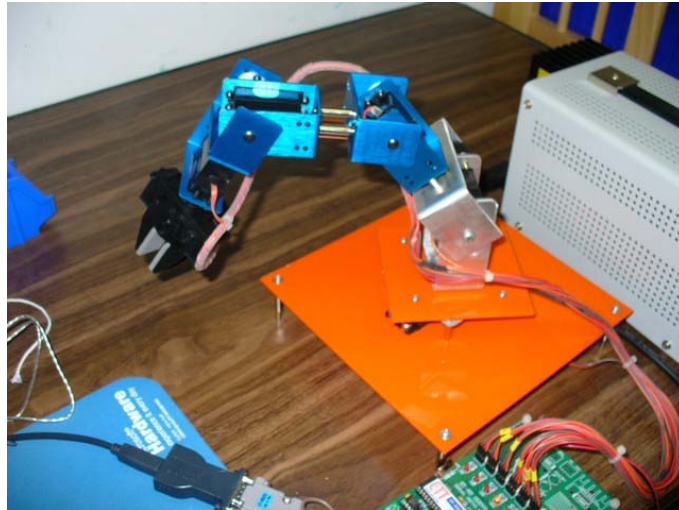


Figure 2 The 5-DOF servo robot that we made

Components

1. Servo motor, GWS S03/2BBMG/JR, brass gear, 4 sets, 890 baht ea. (3560 baht)
2. Servo motor, GWS S04/BBM/JR, brass gear, 2 sets, 990 baht ea. (1980 baht)
3. R-joint servo (for servo motor S03), ETT, 3 Sets, 140 baht ea. (420 baht)
4. R-servo gripper, ETT, 1 sets (390 baht)
5. Serial servo controller, ETT, 1 board (1,390 baht)
6. Metal PCB stand, 10 mm long, with M3 female thread on both ends, 4 pcs (13 baht)
7. Metal PCB stand, 20 mm long, with M3 female thread on both ends, 4 pcs (14 baht)
8. Metal PCB stand, 40 mm long, with M3 female thread on both ends, 4 pcs (37 baht)
9. Metal PCB stand, 18 mm long, with M3 female and male thread on each end, 4 pcs (22 baht)
10. 3mm-thick acrylic board, 2 pcs of 1ft x 1ft is sufficient, 65 baht ea. (130 baht)
11. 3-inch ball bearing rotation plate (25 baht)
12. Servo joint, similar for the ETT's R-joint servo, but sizing for servo motro S04. This one is not available in store, so we have to make it ourselves. The part drawing is available.
13. M3 nuts and bolts, various sizes

Total Budget: 7,981 baht

Building Instructions

Two parts, arm (part A) and base (part B) are built separately and will be put together after each part is complete.

Part A: Instructions for Building the Arm

1. Unscrew the horn set piece (white plastic disk) out from the servo motor #5 (Item 1). Make sure that the servo motor is in the center position by using the servo controller (Item 5). Please refer to the

servo controller for instructions. Attach the gripper into the servo motor. The gripper should have position as shown in Figure 3. Put on the screw to lock the gripper with the motor.



Figure 3 The servo motor #5 that used to rotate the gripper is installed

2. Unscrew and remove the horn set piece out from the servo motor #6 (Item 1). Make both the servo motor and the gripper in their center positions. Then insert the servo motor into the position. Make sure that the gripper can fully open and close. Put the screw back in place. Figure 4 shows the gripper after the servo motor #6 is installed.

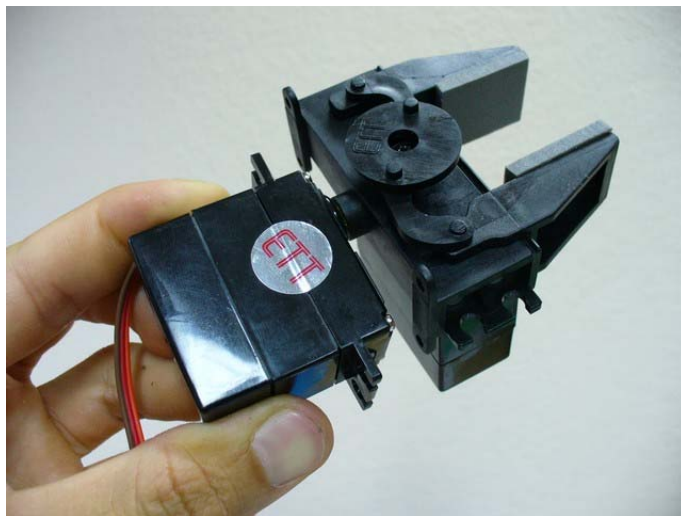


Figure 4 The servo motor #6 that used to open/close the gripper is installed

3. Connect a pair of R-joint servo (Item 3) with 4 pairs of nuts and bolts as shown in Figure 5.



Figure 5 Two pieces of R-joint servo is connected with 4 pairs of nuts and bolts.

4. Attach the servo motor #5 to the U-shape part of the R-Joint Servo as shown in Figure 6.

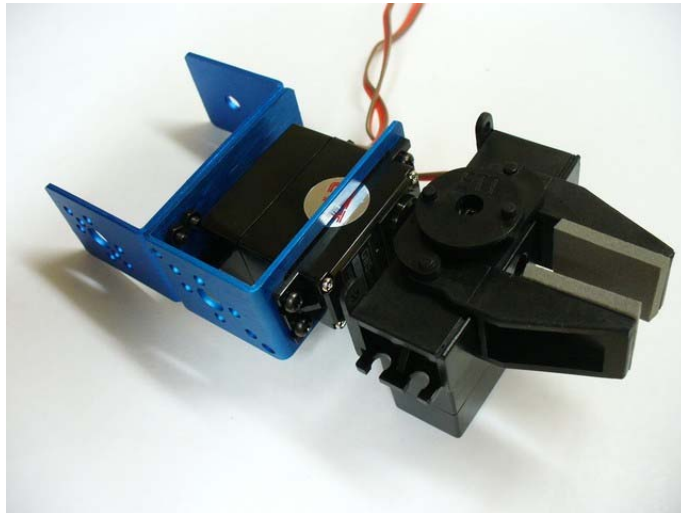


Figure 6 The servo motor #5 is attached to the connected R-joint servo.

5. Connect another pair of R-joint servo (Item 3) with four 20-mm PCB stands (Item 7) as shown in Figure 7. Put in a brass boot, and then attach the servo motor #4 (Item 1) to the U-shape of the R-joint servo.

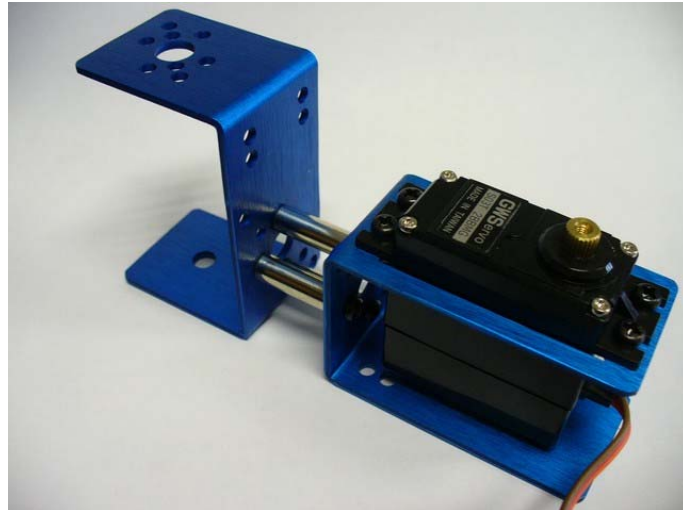


Figure 7 The servo motor #4 is attached to the connect R-joint servo.

6. Unscrew and remove the horn set piece out from the servo motor #4. Drill 4 holes with diameter 3 mm on the horn set piece as shown in Figure 8. Attach the horn set piece to the first C-shape part with 4 pairs of nuts and bolts.

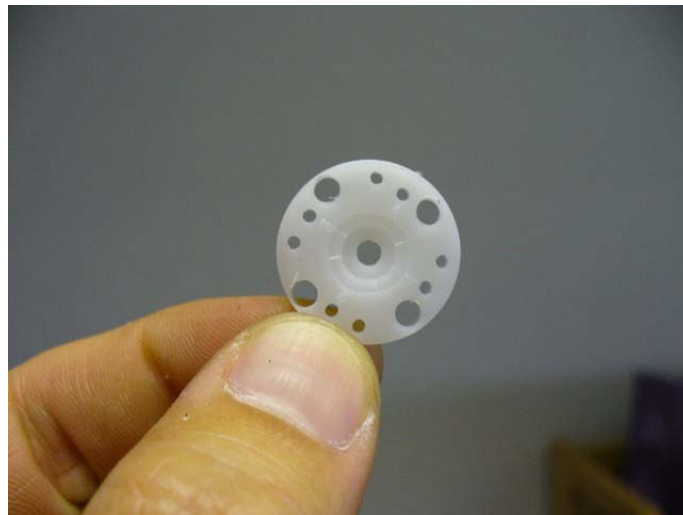


Figure 8 Drilled horn set piece

7. Center the servo motor #4 with the servo controller. Install the motor with its horn set piece in the straight position as shown in Figure 9. Put the screws to lock the horn set piece and the brass boot.

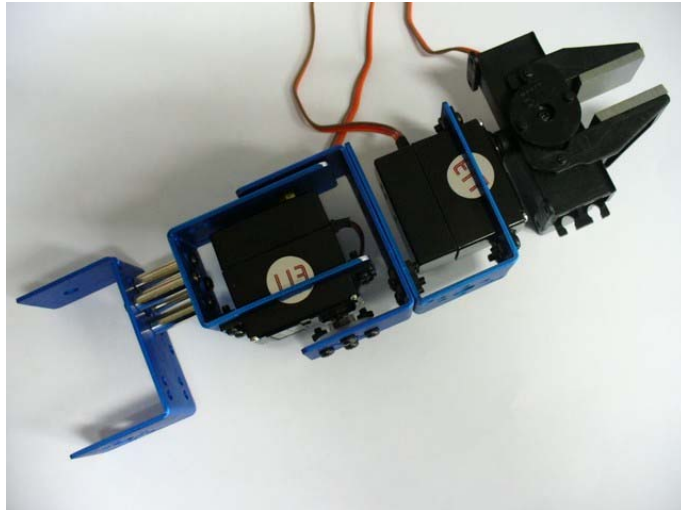


Figure 9 Position to install the servo motor #4

8. Connect 2 new pieces of R-joint servo with four 10-mm PCB stands (Item 6) as shown in Figure 10. Note that the U-Shape part is the small sized R-joint servo (Item 3 - from ETT), and the C-shape part is the large sized R-joint servo (Item 12 - homemade). Put in a brass boot, and then attach the servo motor #3 (Item 1) to the U-shape of the R-joint servo.

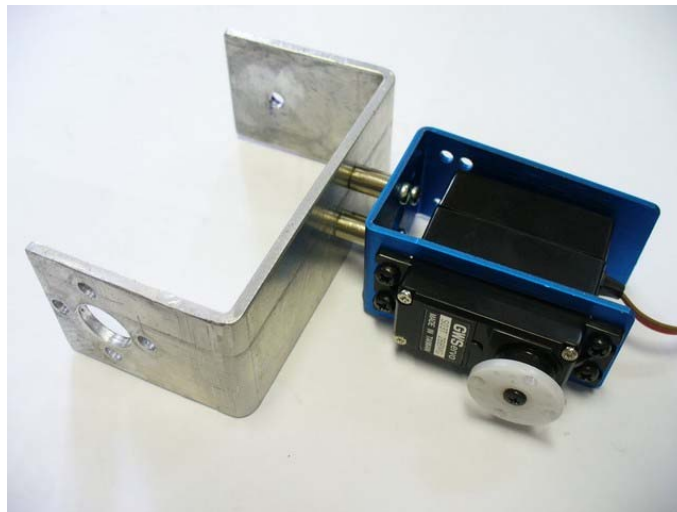


Figure 10 The servo motor #3 is attached to the connect R-joint servo.

9. Repeat steps 6-7 for connecting Servo Motor #3 with the arm. Figure 11 shows the robot arm after the servo motor #3 is installed. In this position, the servo motor #3 must be in the center position.

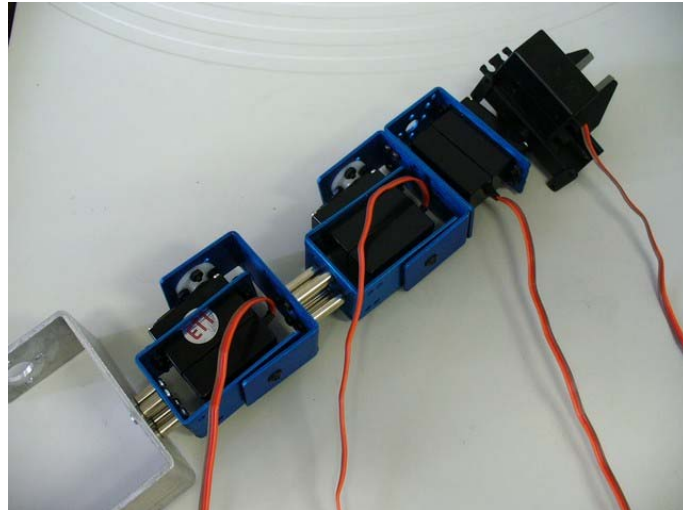


Figure 11 Position to install the servo motor #3

10. Now we just finished building the arm. We will put it aside and start working on the base. We will put the base and the arm together later.

Part B: Instructions for Building the Base

1. Cut 3 pieces of acrylic boards by using dimensions from the given drawings.
2. Attach the servo motor #1 (Item 2) on to the large acrylic board. Lock the motor in place with four pairs of M5 nuts and bolts as shown in Figure 12.



Figure 12 The servo motor #1 is attached to the acrylic board.

3. Install four 18-mm PCB stands (Item 9) on to the large acrylic board. Install the 3-inch ball bearing rotation plate on the four PCB stands. Insert four screws to fix the rotation plate to the board as shown in Figure 13.



Figure 13 The ball bearing rotation plate is attached to the acrylic board.

4. Turn the horn set piece of the servo motor #1 with lathe to the diameter of 33.5 mm. Drill 4 holes with diameter 3 mm at the second holes from center as shown in Figure 14.



Figure 14 The drilled horn set piece after attached to the acrylic board

5. Attach the horn set piece with the small acrylic board and the U-Shape of the servo motor #2 with four pairs of nuts and bolts as shown in Figure 15.



Figure 15 The horn set piece, the acrylic board and the U-Shape are attached together.

6. Center the servo motor #1 before installing the horn set piece. Insert four pairs of nuts and bolts at the corners of the rotation plate, and a screw at the center of the Servo Motor #1 as shown in Figure 16.

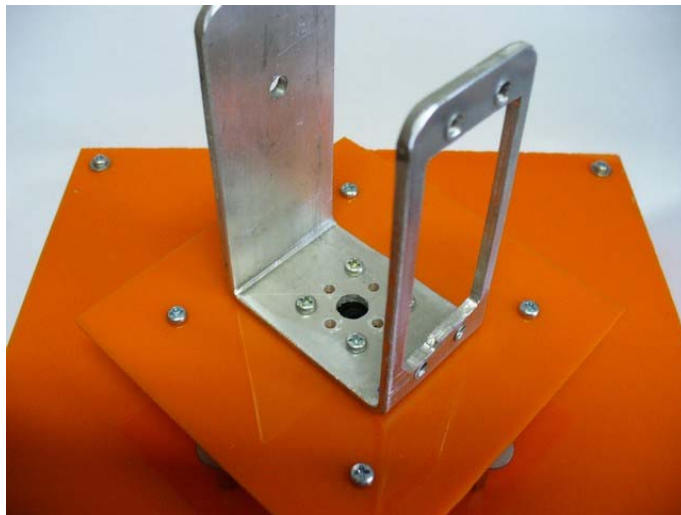


Figure 16 The horn set piece of the servo motor #1 is inserted to its motor.

7. Install the servo motor #2 (Item 2). Lock it in place with four screws. Center the servo motor #2. Insert its horn set piece and lock it with a screw as shown in Figure 17.



Figure 17 The servo motor #2 and its horn set piece are installed.

Assemble Arm (Part A) and Base (Part B) Together

1. Put the arm and the base together as shown in Figure 18. Put in the screw at the horn set piece and the brass boot. We are almost done.

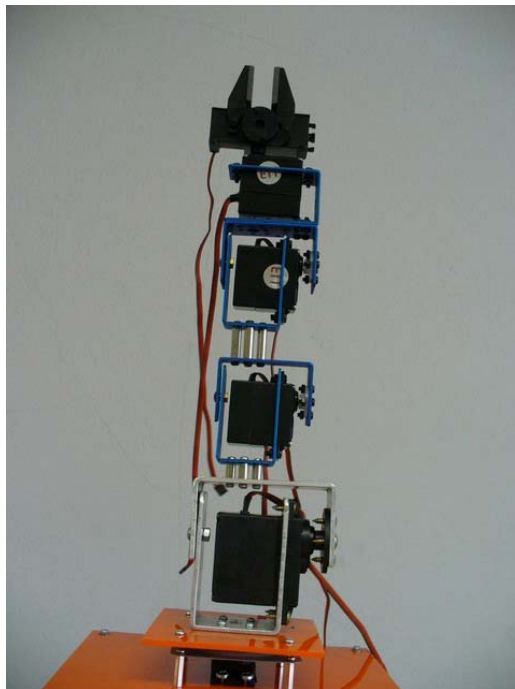


Figure 18 The arm and the base are connected.

2. Install four 40-mm PCB stands (Item 8) at 4 corners of the large acrylic board. Extend the servo motor cables to appropriate lengths and wrap them up. Connect the connectors of the servo motors to the servo controller as shown in Figure 19.

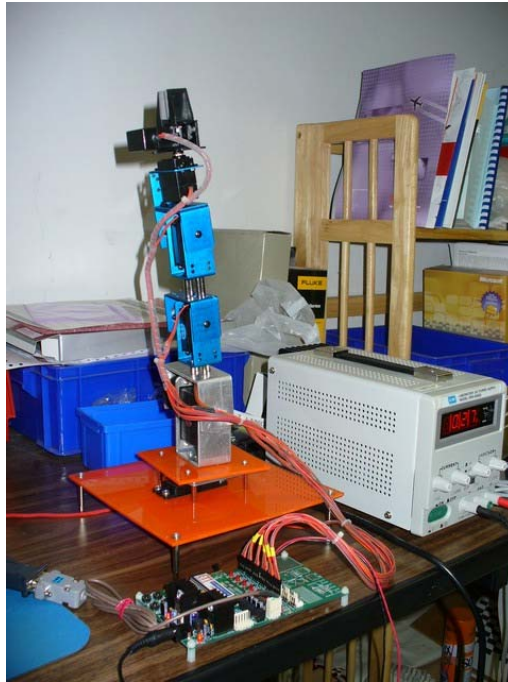


Figure 19 The robot after wrapping up all the wires

3. Attach the servo controller board on to the bottom acrylic board as shown in Figure 20. Put four screws to fix the bottom acrylic board with the PCB stands. There we have the complete robot.

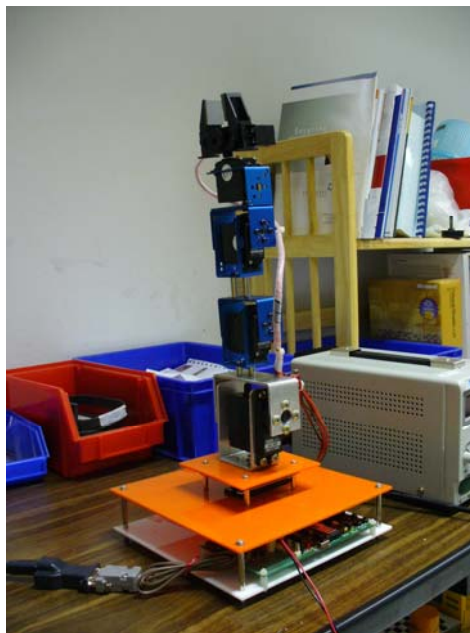


Figure 20 The complete robot