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ANALYSIS KINEMATICS GRAPHICALLY OF THE HASTOBOT ROBOTIC ARM

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ABSTRACT

Hastobot was a robotic arm developed by Electrical Engineering Study Program Sanata Dharma University to assist undergraduate students in studying robotic. Students experienced difficulties mainly on the mechanism and kinematics robot arm. This paper will discuss analysis kinematics graphically of Hastobot Robotic arm. Software used for 2D analysis was AutoCAD and SketchUp for 3D visualization. The Hastobot Robot arm consists of a base, shoulder, elbow, and a gripper. The length of arm approximately 14 cm and 15 cm forearm. The robot arm can reach 30cm. From the graphical analysis of the movement of the robot arm can be known and the robot arm working area.

Keywords: Hastobot, robotic arm, kinematics, mechanism, graphically.

1. INTRODUCTION

The robotic arm is one of the robots that are often found in the industry. The industrial robot arm shape is quite large. For educational purposes in studying the robotic arm designed a robotic arm that resembles a miniature robot arm on the industry. We design the Hastobot an ABB robot arm miniature pick and place and can place it on the table. Because of its small and controlled by servo motors then the Hastobot be interesting to learn. This paper will discuss the design and analysis of kinematics Hastobot robot arm graphically.

There are two types kinematics analysis : forward kinematics and inverse kinematics. In the forward kinematics analysis, the position of the end effector is calculated as a result of driving on the arm angle. In the inverse kinematics analysis of the position of the end effector has been determined and calculated angles forming.

Rehiara [1] conducted an analysis of the type SCARA robot; Kurfess [2] provides a theoretical basis for kinematics analysis of robots in general. Coskun [3] analyze the kinematics of the robot arm with 3D freedom. uFactory Inc. [4] made a robotic arm called uArm and is designed for educational and robot enthusiasts (hobbies).

2. DESIGN OF HASTOBOT

The Hastobot is 4D freedom robot arm driven by servo motors. The first servo motor moving the base, the second servo motors move the shoulder, three servo motors to move the elbow and the fourth servo motors drive the gripper as an end effector. The Hastobot robotic arm shown in the Figure-1.
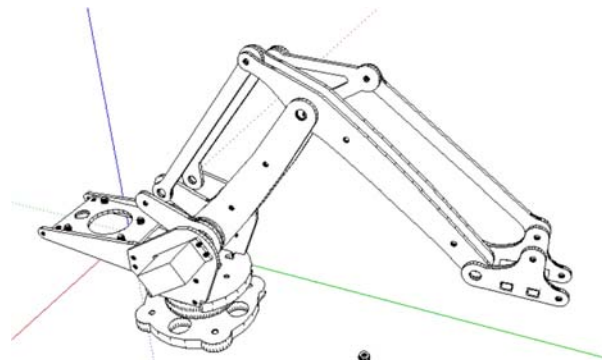

Figure-1. The Hastobotrobot arm.

The servo motors for elbow and shoulder placed between servo base functioned to strengthen the robot. The structure of the elbow and the shoulder is a parallel structure to make the end effector remains fix orientation. Plastic cap used at the bottom base to stick to the surface.

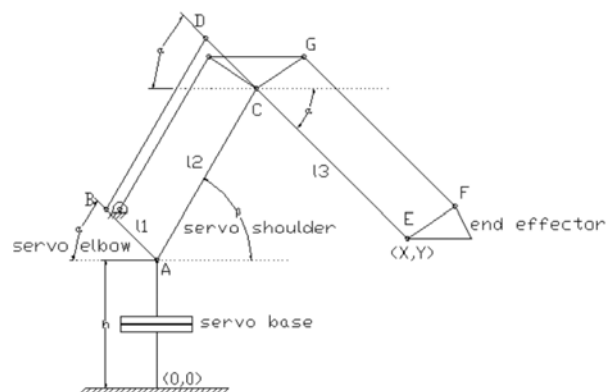Simplified structure of the Hastobot robot arm shown in Figure-2.

Figure-2. Simplified structure of Hastobot robot arm.

The Hastobot robotic arm mechanism uses parallel structures. The joint AB parallel with joint CD.

Joint CE is extended of joint CD. Joint CE parallel with GF.

In two degree of freedom with fix angle base, XY Position of end effector calculated using Equation (1) and Equation(2).

$$X = l_2 . \cos(\beta) + l_3 . \cos(\alpha) \qquad (1)$$

$$Y = h + l_2 . \sin(\beta) - l_3 . \sin(\alpha) \qquad (2)$$

Where X, Y is position of end effector
α: Angle between horizontal and line AB (in degree)
β: Angle between horizontal and line AC (in degree)
L1 is link between joint AB (servo elbow)
L2 is link between joint AC (servo shoulder)

The end effector also functions of servo base position.

The elbow link is driven by servo motors and motion is shown in Figure-3. The elbow motion changes the angle α in Equation (1) and Equation (2).
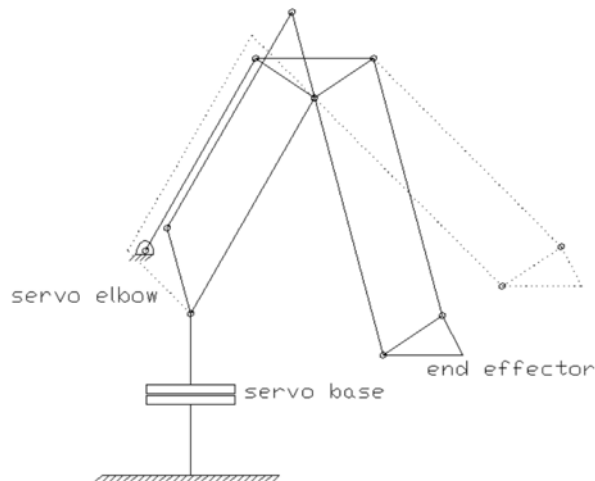

Figure-3. Elbow motion on the Hastobot Robot arm.

The shoulder link is driven by servo motors and shoulder motion is shown in Figure-4 the shoulder motion change the angle β in Equation (1) and Equation (2). In Figure-3 and Figure-4 shows an end effector orientation remains fix.

The elbow and shoulder link can move independently of each other as shown in Figure-5 Servo for elbow motion and servo for shoulder motion places opposite site to other. The axle of servo elbow is in line with servo shoulder. The servo base is placed in the middle of servo elbow and servo shoulder.
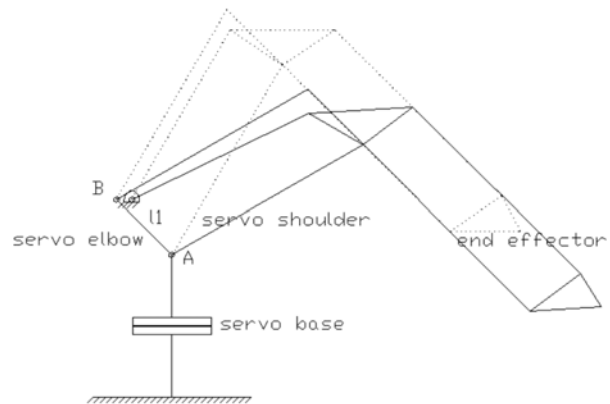

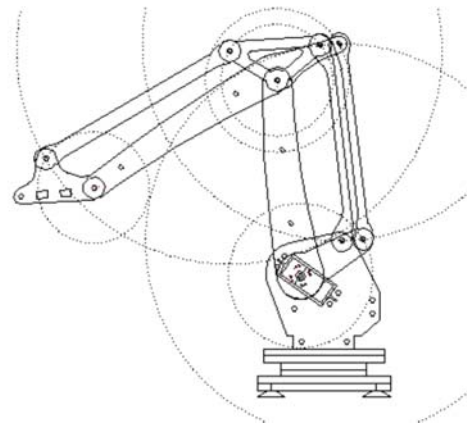**Figure-4.** Shoulder motion on the Hastobot Robot arm.

Figure-5. Elbow and Shoulder motion.

Torque on link elbow as shown in Figure-6 is calculated using Equation (3).

Figure-6. Torque analysis at elbow joint.

$$\tau = R_1 . F_1 = R_2 . F_2 \qquad (3)$$

Where

τ is torque driver (kg.m)
R1 is radius driver force (m)
F1 is driver force (Kg. m/s2)
R2 is radius driven load (m)
F2 is driven load (kg.m/s2)

The robotic arm is moved using servo motors. The angle of servo motor can be controlled using the pulse width modulation (PWM) signal as shown in the following Figure-7.

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The coverage angle on servo motors ranging from 0 degrees to 180 degrees. The center angle of the servo motor is 90 degrees, and pulse width of signal control at 1.5 ms.The minimum angle of servo motor at 0 degrees performed on the PWM signal 0.9ms. The maximum angle of servo motor at 180 degrees performed on the PWM signal 2.1ms.

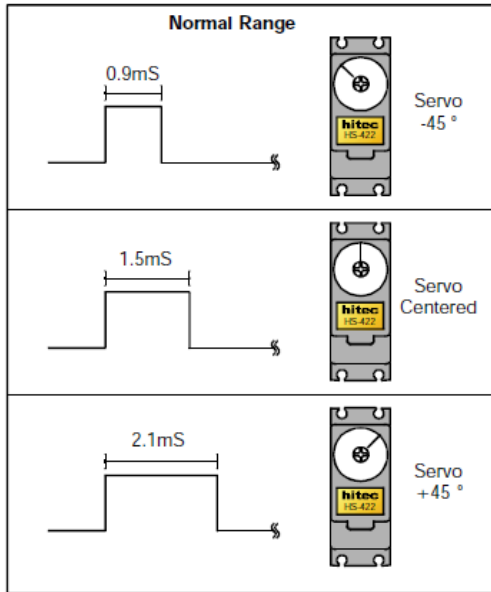Motor servo often used in Remote Control airplane and robotics.

Figure-7. Signal control for RC servo motor.

3. RESULTS AND DISCUSSIONS

Servo motors used in this robot arm are RC servo motor standard with 2Kg cm torque. Servo motor placed on each side of the robot arm. Calibration of the servo motors is done by placing a central angle of 90 degrees to the position servo shown in Figure-8.
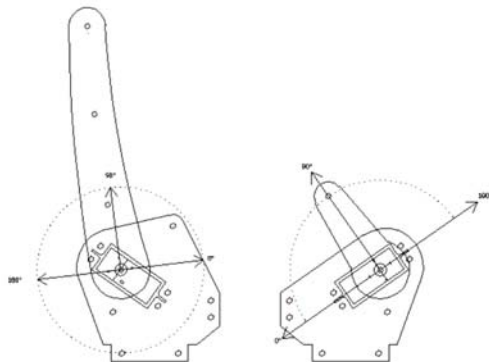

Figure-8. Elbow servo and Shoulder servo calibration at 90° position.
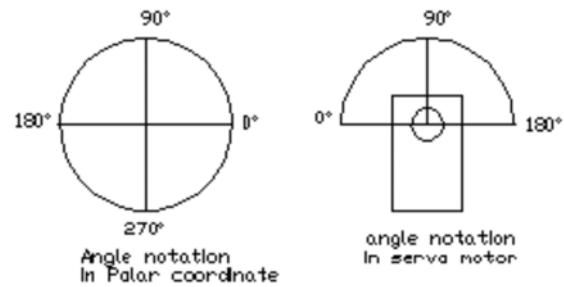

Figure-9. Angle notation in Polar coordinate and degree notation on servo motor.

There is a difference between the coordinate system of angle notation used in servo motors as shown in the following Figure-9. Position servo motor is aligned causing zero degrees of servo motor different from zero degrees of the coordinate. Offset angle is required when programming the servo motor. In Figure-10 shown range motion of servo elbow. Minimum motion for servo elbow before a collision with another object in the structure is 55 degrees. Maximum angle is 180 degrees.
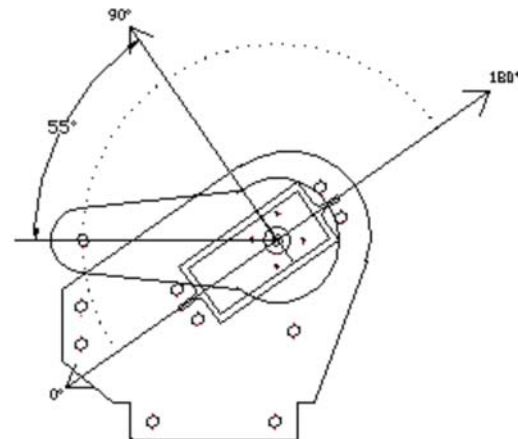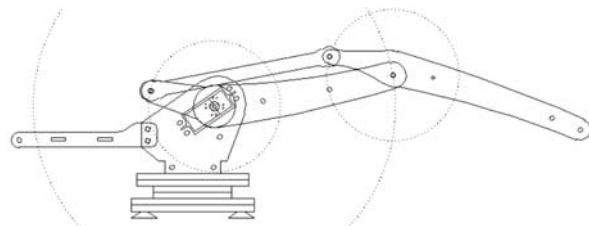

Figure-10. Range motion of servo elbow.

Figure-11. The maximum range of end effector.

In Figure-11 shown the maximum range of the end effector by 30cm. The back of the robot arm serves as a counterweight. A. plastic cup that was in the bottom of the base serves adhesives to strengthen the robot and the robot. The Robotic arm can rotate with the z-axis at 0 degrees to 180 degrees. Torque calculation at elbow links

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shown at Figure-12. The maximum load that can be carried on the end effector that is less than 700gr
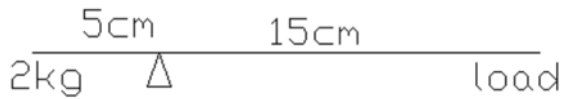

Figure-12. Torque calculation at elbow link.

4. CONCLUSIONS

The analysis kinematics graphically of Hastobot robot arm has been done. The maximum load that can be lifted by Hastobot robot arm for 700gr and the maximum range of 30 cm

REFERENCES

[1] Rehiara A. B. 2011. Kinematics of Adept Three Robot Arm.INTECH Open Access Publisher.

[2] Kurfess T. R. 2005. Robotics and Automation Handbook-CRC Press.

[3] YetimCoşkun. 2009. Kinematics Analysis for Robot Arm, Senior Project, Yildiz Technical University, Istambul.

[4] uFactory. 2014. Assembly Instruction uArm version 1.0.www.ufactory.cc.