SIMULATION OF A ROBOT ARM THAT MIMICS THE ANGULAR MOVEMENT AND CONTROL OF AN AUTHENTIC HUMAN ARM

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Abstract- This paper contains the research report of the simulation of robot arm of model ISO18E using Simulink software to achieve reproducing a robot arm that will mimic the functionality and control of an authentic human arm at different joints. There were challenges encountered during this research which would have hampered the processes and results. The challenges that were considered here were the major limiting factors regarded as the fundamental problems encountered in the course of simulating operating program of automated robot arm. The challenges were found to be the ability to determine the basic characters of the robot arm including evaluating the positioning in simulation and the model cost. The method used to get the results was simulation of a modeled robot arm ISO18E in a software environment (Simulink software). In the research the modeled robot arm, five joints were simulated referencing the authentic human arm and its joints. The human joints taken into considerations were the shoulder, elbow, wrist, Meta carp phalangeal and the inter phalangeal joints. The results of controlling effects of the simulated robot arm were compared with the prototype of real human arm and from the comparison it was found that the robot arm was able to be simulated to have same angular rotation per instant time at each joint as the real human arm. This research will proffer a reasonable assistance to the armless and deformed community to accomplish a task without stress and constraints in gripping, manipulating and controlling with the aid of this robot arm.

Keywords: Simulation, Robot Arm, Movement and Control, Human Arm, Simulink Software

1. Introduction

Robot has become a significant piece of equipment due to its increasing use in engineering and production. Providing robot hands with acquisitive capabilities is one of the immense confrontations of robotics [12]. Robots today are making a substantial impact on many aspects of contemporary existence from industrial and manufacturing engineering to healthcare services, transportation and exploration of the unfathomable legroom and sea. In the future robots will be as insidious and private as today's personal computers. The vision of creating pieces of equipment (machines) that are skilled and smart has been part of mankind from the beginning of time [14].

In exceedingly controlled environments robot are simulated to develop into controllable as regards to its angular implications. Robots can be helpful for acquisition of real world objects with a robot arm especially in the object's location and orientation. Different application areas can benefit the progress in this field of research. Currently, a large number of robots are engaged in manufacturing purposes to perform grasping tasks by utilizing simple two-fingered or three-fingered grippers. Most of them are integrated in an automated production line and hence repeat a succession of motions while performing only one kind of movement for opening and closing the gripper [3].

In this dispensation a number of sophisticated multi-fingered artificial hands have been developed, which have the essential perfunctory dexterity to carry out a large diversity of everyday tasks. To provide these more or less anthropomorphic robot hands with algorithms that realize such arm capabilities and a promising approach is used to mimic human arm [6]. Supporting this approach, previous work [4, 5] has demonstrated the promise of the evolutionary approaches to enable dynamic behaviour creation in independent robots.

Many industrial robot arms are built with simple geometries such as intersecting or parallel joint axes to simplify the associated kinematics computations [9]. However, their costs are high for research workers. AL5B is a good alternative for such robot manipulators, because it is inexpensive, flexible and similar to industrial robot arms. Papers that developed software for modeling 2D and 3D robots arm such as [2, 15], forward and inverse Kinematic are analyzed. According to the model a computer simulation is generated, a simulation and testing characteristics of this robot arm is prepared by programming languages. Two and three dimensional (2D and 3D) visualization are used to build GUI (graphical user interface) friendly for users as educational tool. The software is incomplete, because it did not investigate anything about the path and trajectory planning. V-Realm Builder 2.0 and Simulink were used for virtual reality prototyping and testing the viability of designs before the implementation phase for the industrial SCARA robot, located in the Control Robot Lab of the University of Oradea. In addition, they illustrated the use of the 3D Joystick for manipulating objects in a virtual world [7].

Martin and Arya developed Robot Simulation Software for forward and inverse kinematic using VRML and MATLAB Simulink [10, 1]. The output of the system had good graphic capability and flexibility in terms of 3D representation. However, the system was not able to run as stand-alone application and was not user friendly. Muhammad and his research colleagues in 2008 reported the development of the Robot Simulation Software (RSS) where a Mitsubishi RV-2AJ robot was taken as a case study [13]. The project adopted the virtual reality interface design methodology and utilized MATLAB / Simulink and V-Realm Builder as tools. A robot model was developed and a RSS software life cycle was implemented.

It is clear from a popular view that the function of the cerebellum within the motor control loop is to represent a forward model of the *skeletomuscular* system. As such it predicts the movements of the body, or rather the perceptually coded (e.g., through muscle spindles, skin-based positional information, and visual feedback) representation of the movements of the body. With this prediction a fast control loop between motor cortex and cerebellum can be realized and motor programs are played before being sent to the spinal cord.

Kinematics is the motion without regard to the forces that cause the study of position, velocity, acceleration, and higher derivatives of the position variables. The kinematics solutions of any robot manipulator are divided into two solutions. The first one is the solution of Forward kinematics and the second one is the inverse kinematics solution. Forward kinematics will determine where the robot's manipulator hand will be if all joints are known while the inverse kinematics will calculate what each joint variable must be if the desired position and orientation of end-effector is determined. Hence, Forward kinematics is defined as transformation from joint space to cartesian space, where the Inverse kinematics is defined as transformation from cartesian space to joint space [8]. Since each joint has a single degree of freedom the action of each joint can be described by a single number (i.e θ_1, $\theta_{2,}\ldots$, θ_n) and the angle of rotation in the case of a revolute joint. Suppose a robot has n_{+1} links numbered from zero to n starting from the base of the robot, which is taken as link, the joints are numbered from 1 to n, and z_i as a unit vector along the axis in space about which the links i-1 and i are connected [11].

A robot arm ISO18E is controlled angle wise and manufactured by simulating the robot arm with reference to a prototyped human arm. This robot arm was simulated to perform all the angular movements (motions) of a real human arm.

2. Specification of the robot arm

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Robot ISO18E Arm	**Dimensions in (mm)**
Base (foot)	Diameter 70,hight 35
Shoulder (carriage)	Diameter 110,hight 30
Upper Arm	Length 135, Thickness 45
Forearm	Length 100, Thickness 45
Wrist	Length 55, Thickness 45
Manipulator	Length 48, Gripper size 40

Table 1: showing specification of robot arm of model ISO18E

3. Materials and Method

The materials used for the angular control were the simulated ISO18E robot arm and the simulink software in MATLB programming. There are many ways for designing a graphical user interface, for drawing 3D models and developing real time software simulators for robotics manipulators. So many other tools can be used for programming the simulators but MATLAB Virtual Realty toolbox with Simulink was used as the excellent tool in this research. Robot Simulation Software (RSS) and on-off line programming were used for evaluating and predicting the behaviour of ISO18E robot. The programming trends and challenges in the development of the RSS are divided into two components such as the graphical user interface (GUI) and the control software. The procedure started with the use of structure programming language, followed with the use of third party package, object programming language, web-programming tools, and artificial intelligence programming language. The Simulation proper was done in MATLAB - Simulink software. In order to simulate robot movement (controlled or uncontrolled) differential equations should be set up which are solved through block diagram representation. But for robot arm or any other mechanism with more than two degrees of freedom (DOF), setting up equations with block diagram representation becomes cumbersome and to avoid that there are two solutions used in this work as it concerns robot arm. The first solution is modeling equations of motion in MATLAB symbolically and then to generate function blocks directly in simulink. Second solution is to use Sims cape toolbox and model the robot arm similar to 3D modeling in Solid works. Here the equations of motion were calculated by Sims cape there was worry about them. Simplifications were made to robot arm as robot segments are considered as long thin rods and damping coefficient is empirically chosen by implementing control law.

4. Results and discussion

It can be seen that from fig. 1-5, the angle at the joints (joint 1-5) of the human arm is compared with the prototype of selected human five joints which is shown in the representations. The joints of the robot arm were categorize as joint 1 , joint 2 , joint 3 , joint 4 and joint 5. The q sequences (q1, q2, q3, q4 and q5) represent the angles of each of the five joints of the ISO18E robot arm and the ref_q sequences (ref_q1, ref_q2, ref_q3, ref_q4 and ref_q5) represent the angles of each of the five joints of the prototyped human arm which served as the reference angles of comparison. The joint 1 of human arm has maximum angle of rotation of approximately 0.5 radians in one second as well as the simulated robot arm joint 1. Also the result of joint 2 of the human arm displaced showing 3 radians as maximum angle was similar to the simulated robot arm joint 2 at same time (one second). The maximum angle of joint 3 for both prototyped human arm and robot arm had same value of 1 radian at one second. The maximum angular values of joint 4 and joint 5 of both real human arm and robot arm were 0.5 radian and 3 radians at one second respectively. These results also show that the control of angles motion of the prototyped human arm at each joint correspond to the angular motion of the ISO18E. However, what the human arm could perform an automated machine (robot arm) simulated in a monitored and controlled environment (software) can as well accomplish it with no fault and error.

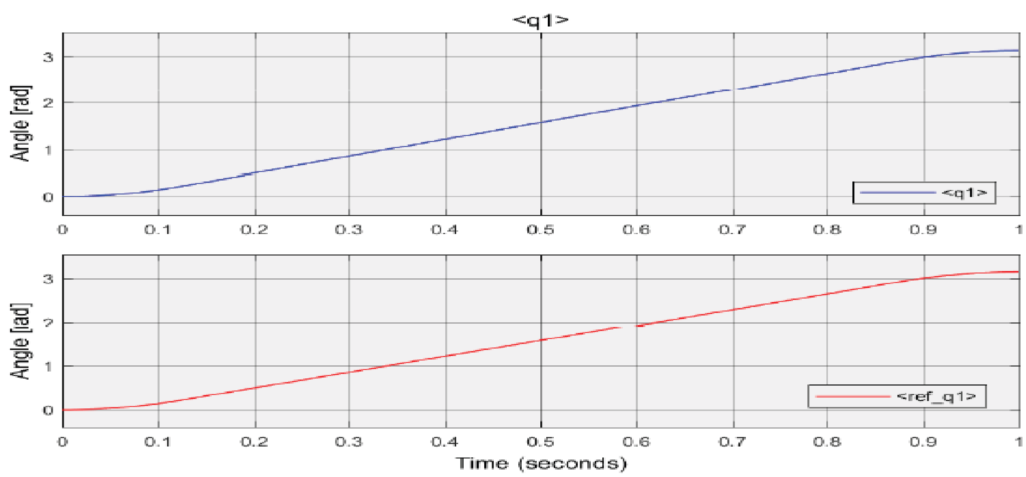

Fig 1: Comparison of angle of joint 1 of robot arm ISO18E with the prototyped human arm shoulder joint

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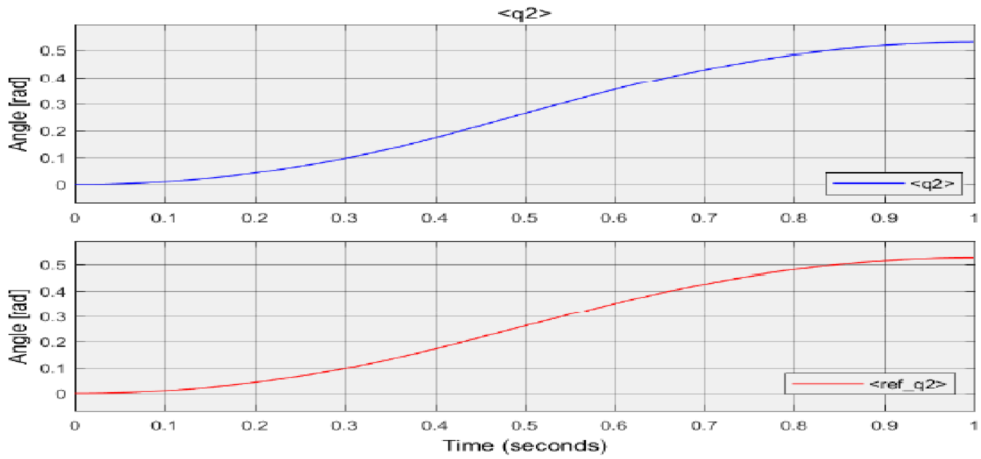

Fig. 2: Comparison of angle of joint 2 of robot arm ISO18E with the prototyped human arm metacarpophalangeal joint

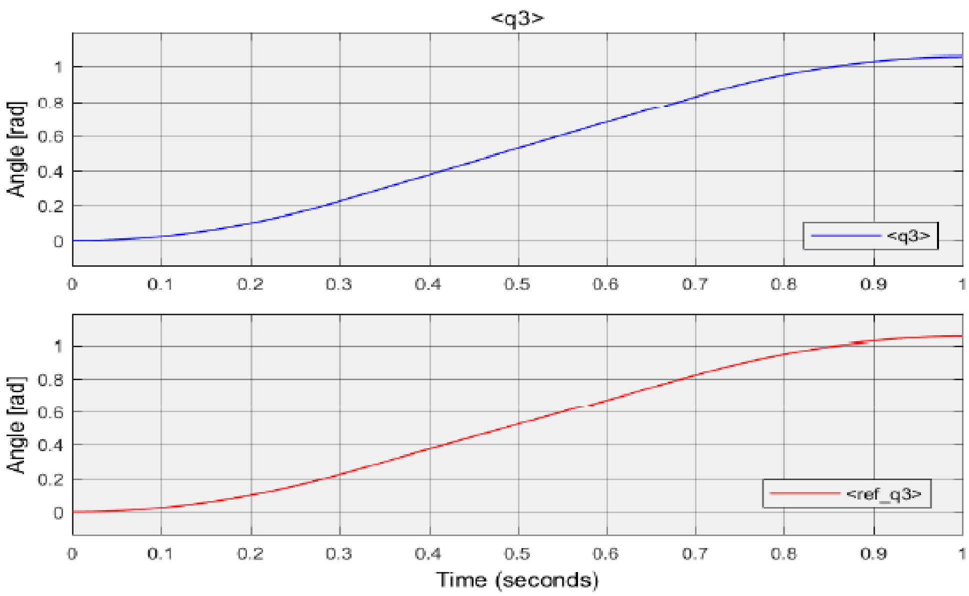

Fig.3: Comparison of angle of joint 3 of robot arm ISO18E with the prototyped human arm joint elbow joint

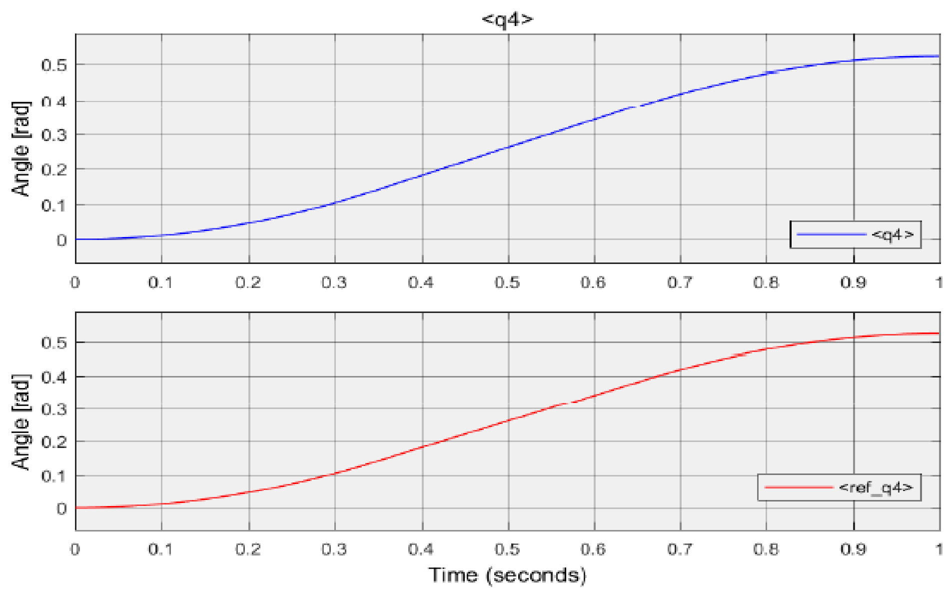

Fig. 4: Comparison of angle of joint 4 of robot arm ISO18E with the prototyped human arm interphalangeal joint

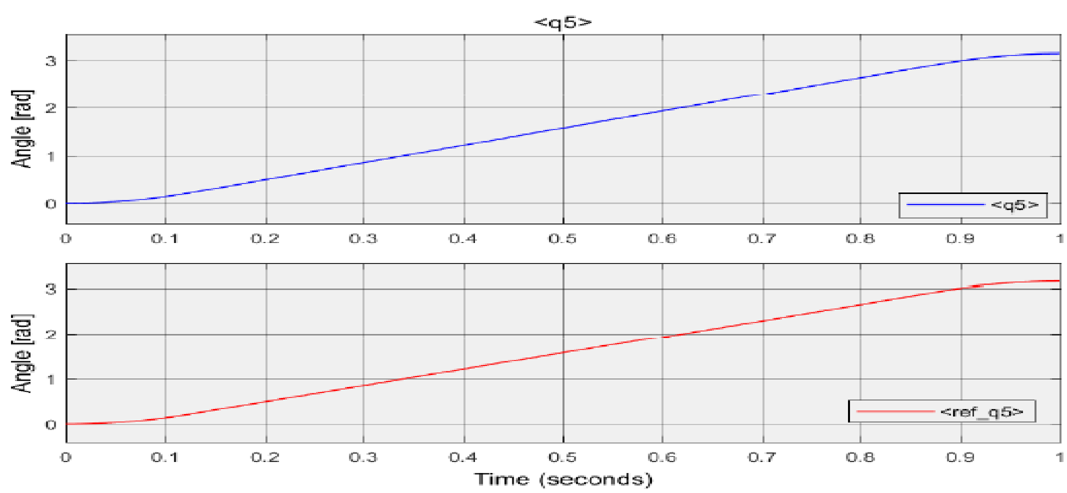

Fig. 5: Comparison of angle of joint 5 of robot arm ISO18E with the prototyped human arm wrist joint

5. Conclusion

The results shown in the figures above had revealed that the robot arm ISO18E was successfully simulated to have same angular displacement at equal time interval with the prototyped human rotational angle at all joints. The robot hand was properly simulated to have similar interactions with the prototyped human arm joint at same angles. At each angle per time both results were same with no angular deviation depending on the viewer angle. But for the software result both are same and they coincide at each instant. By so doing this simulated robot arm can effectively mimic the angular control of a human arm. Hence, simulink software is an appropriate software environment to simulate and control articulated robots. Therefore, the ISO18E is a robot arm with broad specifications and capabilities of replacing human hand in achieving tasks. More so, the armless individuals should not worry much about the difficulties they face in working with their arms. This is because physics and engineering are researching often to solving the problem of wasting time in accomplishing a simple task and providing alternative piece of instrument to enable work done by armless people by control in all axial displacement.

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