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Aunthenticating the Motions (Angular Velocities) Of Simulated Automaton Arm of Five Joints and a Real Human Arm

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Abstract: This paper work is aimed to model and simulate an automaton arm using MATLAB in simulink software to accomplish the duplication of the automaton arm that behaves similarly with functionality and control of the reference human arm. The prime objective of building the automaton arm is to replicate capability of real human arm to achieving tasks by armless people in the society. The usual fundamental challenges such as ability to determine the basic characters of the automaton arm, evaluating the positioning in simulation, the model cost, production cost, robotic application and maintenance cost, and the suppleness of the manipulator (easiness to adjust or modify) were considered in the modeling, building and operating program of the automated robot arm. The objective of the research was attained by simulating already modeled automaton arm using MATLAB in software environment (simulink software). In the process of achieving the objective, an automaton arm was foremost modeled given a model name, ISO18E, and then the key trajectory parameter (angular velocity) of the automaton arm at all joints were simulated in line referencing the real human arm. The resulting trajectory dynamism of automaton and human arms were compared which show the reproducibility of an efficient automaton arm successively simulated to have similar angular velocity at each joint of the real human arm. The simulated automaton was encrypted with five joints (joint1 to joint5) considering the real human arm of five joints. The successful simulation indicates that ISO18E robot arm was simulated with capability of moving with similar (same) speed as the real human hand undergoing a motion. Therefore, with evolution of robotics the armless and other limb deformed communities can freely and easily accomplish a task without nervous tension.
Keywords: Automaton, Arm, Simulation, Angular Velocity and Simulink Software.

1. Introduction

In the present day, robots make efficient influence in various perspective of modern life in areas like manufacturing industries, medicals, transportation and exploring the deep spaces and seas. In the future, robots would be expected to be pervasive and personal as personal computers we have today. The human dream is to manufacture proficient and intelligent device and this has been invariably a concern to humanity from the onset. This dream is already in line with the world’s striking efforts and reality today [8, 14]. The great challenge of robots is to create robot hands that have efficient grasping capabilities. The reason is that robot gripper is very important component of robotics in robot manipulator. In particular, the technology of humanoid robot is useful in robot grippers and has created attention publicly. Researchers have studied valued existence of robotic grippers thereby explaining how important is the universal gripper in achieving normal gripping tasks of different working parts [2].

The evolution of robot deals with procedure production of automated and autonomous robots [7]. This was attained by selecting the fittest reproduction stated by Darwinian principle in algorithmic evolution. The concept describes how robots could create a system that controls their body configuration when closely interacting with the environment with no intervention by human and this makes robots regarded as autonomous artificial inanimate. They are being inspired by the principles of biological self organization evolutionary robotics which talks about elements of evolutionary, neural, developmental, and morphological systems. This principle brings the idea of how evolutionary process has driven the control system procreation that existed since 1950s [15] which explicitly appear midyear of 1980s with the brilliant experiments on vehicle driven neural by a neuroscientist named *Valentino Braitenberg* [4].

Today many successful works have produced couples of oscillators’ neural system controllers that overcome high unstable motion issues with biped gait. Some works have described affirmation which says that accurate physics simulating process using physics-engine software have been useful in developing controllers able for generating successful bipedal walking pattern [5, 11,]. Integration of neural networks oscillations have been produced for the controlling of swimming of articulated, snake-like and beneath the water robots by physics oriented simulations [3, 8]. Kinematics is inevitably regarded as the motion of robots with no consideration to the force causing it. The kinematics results of robot end-effectors are separated into two solutions as the first solution is the frontward kinematics and the next solution is the converse (backward) kinematics solution [9, 16]. The purpose of frontward kinematic study is to decide the collective consequence of the joint changeable. Converse (inverse) Kinematics (CK or IK) study establishes the joint viewpoint for preferred point and direction in Cartesian liberty.

Motion in this context is an activity or procedure of constantly changing position or moving of object (anything) from one place to another. Velocity is a vector measurement of the rate and direction of motion. Velocity is simply defined as the rate of change of speed in a particular direction. In calculus terms, velocity is the first derivative of position or displacement with respect to time. The most common way to calculate the angular velocity of an object is the formula in equation 1:

$$w = \frac{\theta}{t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 1$$

Where w is the velocity (angular), θ is the angular position of the object and t is the time it takes to undergo the motion. The angular velocity is measured in radian per second (rad/sec).

2. Limitations

In development of robot simulation software there were difficulties posed by programming categorized into graphical user interface (GUI) and control software [13]. Starting with the use of structure programming language which is followed by use of third party package, object programming language, web-programming tools, and artificial intelligence programming language, the challenges have created a lot of concern amongst software developers in order to develop software better than RSS which can cover the two components. In addition, many tools can be used for programming the simulators but MATLAB Virtual Realty toolbox in Simulink was used as the excellent tool for this research.

3. Materials and Method

The materials used in accomplishing simulation task in this research were selected and outlined in cost-effectiveness of the research work concerned with the software cost shown in table 1.

Table 1: Cost effectiveness of the research software

Materials	**Prices ($)**
Window Operating System	110
CB280 Microcontroller	180
MATLAB 7.1	200
Microcontroller interface kit	100
Computer	465
Total	**1055**

The robot arm was simulated in MATLAB - Simulink software. In order to simulate robot motion (controlled or uncontrolled) differential equations of motion are meant to be set up. In Simulink one can basically set up equations and solve them via 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 [1, 13]. To avoid that there are two solutions to apply in which the first is to model equations of motion in MATLAB symbolically and then to generate function blocks directly in simulink. The Second solution is to use Sims cape toolbox and model the robot arm similar to 3D modeling in Solid works and the equations of motion are calculated by Sims cape so you do not have to worry about them. However, the ISO18E automaton arm was modeled having five joints of the arm embedded in a serial order configured from base (shoulder) to the phalange of rotating motion. Each joint has a degree of wrist rotation angular freedom covering the range of -90 degree to 90 degree about the articulated joint axis. Axis of the joint and normal of joint have the design of coordinate system. In the simulation a connection was made between robot and personal computer (PC) to accomplish a total control of the robot arm in computer. This is a connection known as interface connection which is achieved by microcontroller. Microcontroller is a device though inexpensive usually applied and commonly used in computing secured applications that makes all parameters of the devices in the software environment smart in decision making. Microcontroller is designed to have interference and interaction with electrical and electronic systems, sensors and relay of control, and high technology gadgets. The complete control process can be divided into two categories, namely, hardware and software. In this research the suitable environment for the automaton arm control is software environment [6]. The software environment is categorized into the following parts: the CUBLOC microcontroller program and MATLAB Program. CUBLOC program used a code in making interfacing between PC and ISO18E arm. The

MATLAB program comprises of a code for serial communication and a graphical user interface (GUI) [10, 12]. The complete system functions consist of three parts which are forward kinematics, trajectory planning and the controller.

4. Results and Analysis

From the behavioral dynamism it can be inferred that the simulation representation of angular velocity of each of the five joints of the real human arm and that of the automaton arm against the time resembles the a velocity-time graph for a body undergoing a motion. Therefore it can be affirmably said that the automaton arm was effectively simulated using simulink software in MATLAB to behave dynamically as the real human arm joints at each instant of motions. The simulation results at the five joints of the automaton (robot) are shown in figure 1 to 5 as in below. Usually the graph of velocity versus time represents acceleration but in this research we are not interested in the gradient of the graph that would have given us the physical quantity, angular acceleration, as the case maybe in the figures below. Since the objective of this research is to authenticate (compare) the angular velocity of the simulated automaton arm having five joints with a real human arm at different and equivalent five joints. The angular velocity of the automaton and real human arm were verified at same time intervals in checking the similarity in functionality and degree of angular position and displacement at each joint.

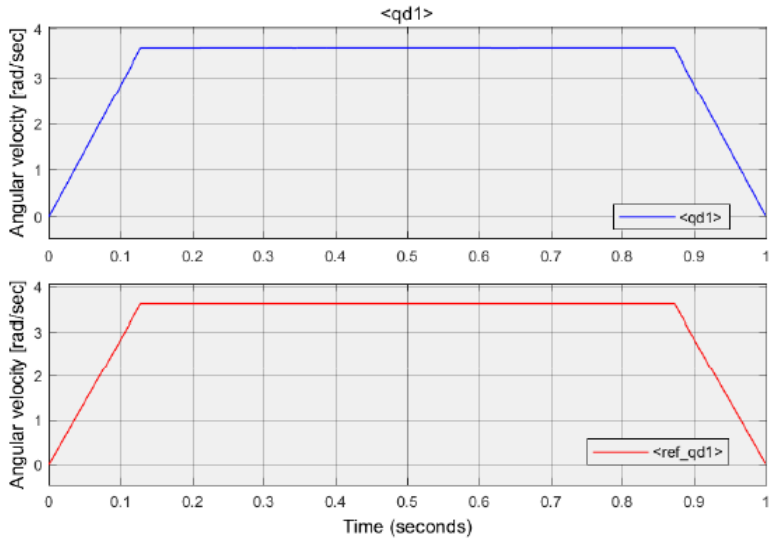

Fig. 1: Result of simulating joint 1 of human arm (reference arm) and the automaton arm

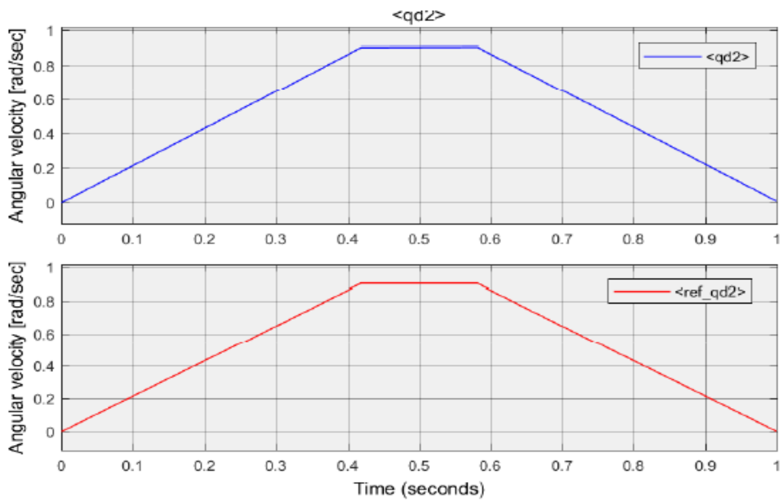

Fig. 2: Result of simulating joint 2 of human arm (reference arm) and the automaton arm

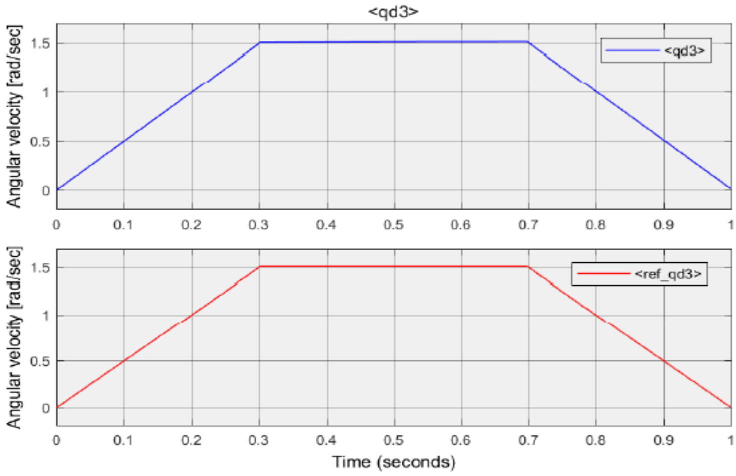

Fig. 3: Result of simulating joint 3 of human arm (reference arm) and the automaton arm

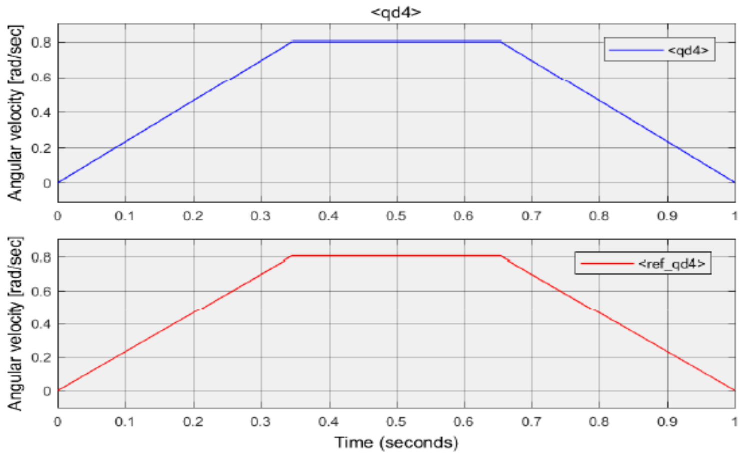

Fig. 4: Result of simulating joint 1 of human arm (reference arm) and the automaton arm

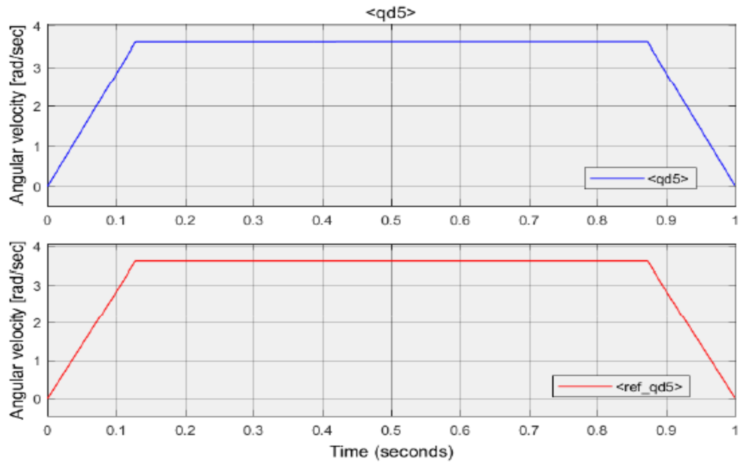

Fig. 5: Result of simulating joint 5 of human arm (reference arm) and the automaton arm

The results at each joint of real human arm is represented by ref_qd values (ref_qd1, ref_qd2, ref_qd3, ref_qd 4 and ref_qd5) as the reference work while the simulated results of the automaton arm at each joint is represented by qd values of links (qd1, qd2, qd3, qd4 and qd5). It can be observed that the trajectory dynamism of the real human arm at all joints and the joints of automaton arm are same from the starting point to the ending point. The angular velocity is measured in radian/sec. The links of both arms joints (i.e joints of real human arm and joints of automaton arm) started their dynamism from zero rad/sec (0 rad/sec) to a point where they maintained a constant angular velocity and later traveled back to rest of zero rad/sec (0 rad/sec).

These results show that evolution of robotics in this dispensation has the potential of solving so many human challenging tasks of control and grasp. The human arm functionality depends majorly on axial movement and control which this research was able to discover and hence, attaining a high response of the dynamic parameters in simulating the automaton arm of model ISO18E. This automaton arm is graded to have the efficiency of control of the human arm. This is to say that the automaton arm was effectively simulated to behave as the reference human arm in its control.

5. Conclusion

The simulation of an automation (robot) arm in simulink software (MATLAB) was successfully achieved in reproducing a replica of a reference human arm with five joints. The simulation was performed across the five joints regarding the dynamical parameter, the angular velocities at the time variations. The simulation trajectory is the trapezoid path of velocity-time graph of motion with the time starting from zero second to one second. The kinematics of the simulated automation arm started from zero rad/sec and still returned to zero rad/sec. This simply means that the referencing arm (human arm) underwent a motion starting from its rest point and returned to the same rest point after the motion that lead to exudation of the velocity-time graph. The authentication of motion of the simulated automaton arm and real human arm as regard to angular velocities at different joints was graphically shown to have been same after the simulation process. However, the automaton arm of model, ISO18E, behaves dynamically as the real human arm considering five joints of the real human arm which are shoulder, elbow, wrist, interphalangeal and metacarpophalangeal. Therefore, it is concluded an automaton arm could be simulated to in MATLAB to effectively do equivalent duties of real human arm.

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