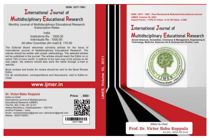
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A REVIEW ON DESIGN AND ANALYSIS OF ROBOTIC ARM WITH 6 DOF

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ABSTRACT: In the 21st century, the automotive industry is booming. This paper consists design of robotic arm which simulates the movement of human hand to grip different objects be it in lab or industry or toxic environment with 6 D-O-F.

The robotic arm is controlled with Arduino so it can be implemented to a robot which can analyze hazardous area to carry out the task. In order to examine those torque characteristics, we consider a model of humanoid robot arm and simulate typical object lifting and transferring tasks by using the robot arm. The majority of current robotic hands does not completely replace the functionality of a hand and cannot be used in environments which are designed for the use of human hand. This paper concludes with some possible applications of 6 D.O.F robotic arm mechanism based on type of end effector attached to the robotic arm.

Keywords: Arduino, D-O-F, End Effector, Robotic Arm.

1. INTRODUCTION

Nowadays, robotic arms are mostly employed in industry automation and hazardous environment operations. Due to their complexity, many robotic controllers are prohibitively expensive. Custom machining of high-precision actuators components. We believe that robotic control research should be pursued. If valuable robotic arms are developed, progress can be made more quickly [1,2]. If it provides heavy discount in price. Affordability increases can lead to a greater level of acceptance, which can lead to speedier advancement. However, extreme cost-cutting will necessitate design compromises. as well as compromises There are a variety of dimensions on which to base your decision. Backlash, payload, and other characteristics of robotic arms can be assessed. Speed, steadiness, adherence, human safety, and expenditure. Some of these dimensions are more important in robotics research. More vital than others: for gripping and manipulating objects. The importance of great repeatability and low reaction cannot be overstated. If the manipulator is to be humane, it is difficult to maintain human safety. utilised in close proximity to people The Arduino UNO A000066 is utilised as a controller. Force sensors are positioned at the robotic arm's brain. Gripper for determining the force that has been exerted to the object, and, At the joints, potentiometers are utilised to detect position of the motor shaft. We employed the earlier used model of the produced robotic arm, which was made of aluminium due to its light weight, resistance to wear, low cost, and ease of machining. Most industrial robots utilize six axes, which give them the ability to perform a wide variety of industrial tasks compared to robots with fewer axes [3]. Six axes allow a robot to move in the x, y, and z planes, as well as position itself using roll, pitch, and yaw movements.

LITERATURE REVIEW

[1] Ankur Bhargava conducted a survey on the Arduino Controlled Robotic Arm. A robotic system with five degrees of freedom (DOF) is used in his work. An Arduino Uno is used to control it. A microcontroller is a device that accepts input signals from a user. use a set of potentiometers The arm is made up of four pieces. Termination effect and rotary joints alternatively, where there is a rotational motion A servomotor is used to provide this. Each link has been meticulously crafted. Solid works Sheet Metal Working Toolbox is used first, followed by A 2mm thick aluminium sheet was used in the fabrication. As a result, fasteners were used to assemble the servomotors and linkages. The arm's ultimate shape was created. The Arduino has been programmed to supply rotation to each servo motor in proportion to the potentiometer shaft's rotation. The nature of the relative movements of the links that make up a robot can be used to characterise it.

[2] Rahul Gautam's review on the development of an industrial robotic arm, this type of selective robotic control is required to solve problems such as placing or picking objects that are far away from the worker. The robotic arm has been successfully produced because the robot's movement can be accurately controlled. Because changing the cable is costly, it is critical to design to reduce friction on the table in order to extend the duration between maintenance.

[3] Ashraf Elfasahany conducted a survey on the design and development of a competitive low-cost robot arm with four degrees of freedom. The design, development, and implementation of a robot arm capable of performing simple tasks such as light material handling are shown in this study. Acrylic material was used to design and manufacture the robotic arm, where servo motors are used to perform links between arms. The encoder in the servo motors eliminates the need for a controller. However, the motor's rotation range is less than 180 degrees, limiting the area that the arm can reach and the positions that can be taken. The robot arm was designed

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with four degrees of freedom in mind. Because it is much easier and more cost-effective to use a commercial gripper, the end effector is not taken into account when developing.

[4] Mahanta G.B., Deepak B.B.V.L., Dileep M., Biswal B.B., Pattanayak S.K. (2019). In this paper the use of soft computing approaches to determine the inverse kinematics of a Kawasaki RS06L 6-DOF robotic manipulator for a pick and place operation was presented by the authors. A comprehensive analysis was conducted among techniques such as artificial bee colony (ABC), firefly algorithm (FA), invasive weed optimization (IWO), and particle swarm optimization to validate and check the efficacy of the proposed approaches (PSO). Before the actual experiments, a detailed analysis was undertaken in a simulation environment to determine the inverse kinematics of the proposed system, and the results were fed into the Kawasaki Controller for the pick and place job, demonstrating efficient reversibility.

[5] Jamshed Iqbal, Raza ul Islam, and Hamza Khan has done a paper on kinematic model of 6 DOF robotic arm. The research creates kinematic models for a six-degree-of-freedom robotic arm and examines its workspace. In an unstructured environment, the suggested paradigm allows the manipulator to be controlled to any attainable position and orientation. Denavit Hartenberg (DH) parametric system of robot arm position placement underpins the forward kinematic model. The achieved inverse kinematics model offers the required appropriate joint angles given the desired position and orientation of the robot end-effector. The forward kinematic model was tested in MATLAB using Robotics Toolbox, and the inverse kinematic model was implemented on a real robotic arm. The end-effector of a robotic arm can point at the target coordinates with a precision of 0.5cm using the proposed model, according to experimental results. The loom given in this paper can be used to tackle the kinematics problem of other robot manipulators of similar types.

[6] N.G. Adar and R. Kozan of Sakarya University, Mechanical Engineering Department, Sakarya, Turkey has performed a paper- A two-degree of freedom PID controller method for a six-degree of freedom rigid robotic manipulator is presented in this study. Because of its simple control structure and ease of application in industry, traditional PID controllers are frequently employed. However, load disruptions and parametric fluctuation have an impact on the controller's robustness. The proposed two-degree of freedom PID controller is compared to traditional PID controllers in terms of performance. The proposed method is implemented in real-time using the Matlab-Simulink application. In real-time manipulator control, experimental data show that two-degree of freedom PID control outperforms standard PID control.

[7] Won-Bum Lee and Sang-Duck Lee School of Mechanical Eng., Korea University, Seoul, Korea. The paper was published in 2017 IEEE ICRA. The paper proposes a six-degree-of-freedom collaborative robot with a multi-degree-of-freedom CBM. For a small and long-lasting multi-DOF CBM, a double parallelogram linkage and a slider-crank mechanism are used. The suggested CBMs can be incorporated into the robot linkages, unlike prior prototypes where some pieces of CBMs protruded out of the robot body due to their enormous volume. Simulations employing dynamic simulation software were used to verify the performance of the designed CBM and collaborative robot. The proposed CBMs can effectively lower the joint torques required to operate the robot, according to simulation results. Because of the reduction in torque, low-power motors can be employed in collaborative robots, greatly enhancing crash safety and energy efficiency.

[8] Dino Dominic Ligutan Levin Jaeron S. Cruz Michael Carlo D. P. Del Rosario Electronics and Communications Engineering Department, De La Salle University Science and Technology Complex, Biñan Laguna, Philippines has published a paper in 2017 computing conference. The paper presents Design, simulation, and implementation of a fuzzy logic-based joint controller (FLJC) on a six-degrees-of-freedom (6-DOF) robotic arm with machine vision feedback capable of picking and placing an object in a preset position. The FLJC is implemented on a four-degree-of-freedom M100RAK robotic arm with a two-degree-of-freedom gripper. The robotic arm system's control is a closed-loop system. The FLJC receives joint angles, gripper coordinates, and target object coordinates as inputs. The MPU6050 Six-Axis (Gyro+Accelerometer) sensor is used to measure the input joint angles. To extract the coordinates of the gripper and the target from the image of the workstation, a machine vision system comprised of a Kinect camera and opensource Processing software is employed. FLJC computed joint angles are sent to the Arduino microcontroller via network protocols packets for servo control.

[9] Pragathi Praveena Daniel Rakita and Bilge Mutlu Department of Computer Sciences, University of Wisconsin–Madison, Madison, USA. They describe an offline method for generating smooth, viable motion for robot arms such that the end-effector posture goals of a 6-DoF path are matched within the user-defined acceptable limitations. Their method seeks to match the position and orientation goals of a given path as closely as possible, while allowing divergence from these goals if self-collisions, joint-space discontinuities, or kinematic singularities are a risk. Their method generates a number of alternative trajectories and chooses the optimal one based on

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sparse user input about the types of deviations that are acceptable. They demonstrate that their method yields solutions that accomplish smooth, achievable motions while closely approximating the provided posture goals and complying to user specifications by applying it to a variety of demanding pathways.

[10] Hwi-Su Kim and Jae-Bok Song of School of Mechanical Engineering, Korea University, Seoul, Korea. They presented a new counterbalance system that can totally offset the gravitational torques caused by the robot mass. It suggests a 3-DOF counterbalance system based on the double parallelogram mechanism, in which reference planes are provided to each joint for proper counterbalancing, because most 6-DOF robots include three pitch joints that are vulnerable to gravitational torques. To show the performance of the suggested mechanism, a 5-DOF balancing robot arm was created. The proposed mechanism successfully reduced the torque required to maintain the robot mass, enabling for the future usage of low-cost motors and speeds, according to simulation and experimental data.

[11] Mahmoud Abdelaa Ramy M.A.Farag Mohamed S.Saad M.Emarayman El-Dessouki of Mechatronics Department, Helwan University, Cairo, Egypt. This research provides a unique method for estimating object posture in six degrees of freedom for robot arm pick and place applications. It works by using a stereo vision technology that doesn't need to be calibrated. The object's four corner points are recognised using both cameras. From the four detected corner points' coordinates in each image of both cameras, a deep-neural-network (DNN) is trained to estimate the object's 6 DOF pose. A low-cost vision system was employed in a custom-made arrangement for stereo vision. The robot is designed to automatically gather data in a predetermined workspace before the DNN training phase. This workspace is determined by the robot arm's spatial capability and the stereo vision system's shared field of view. Images of a 2D marker attached to the robot arm gripper are included in the data. To make detecting the four corner points easier, a 2D marker is employed for data collecting. The proposed method is successful in predicting the object's six degrees of freedom pose without the necessity to determine the stereo vision system's intrinsic or extrinsic characteristics. After analysing alternative activation functions and optimizers connected with the DNN, the optimum design of the proposed DNN is obtained.

[12] Jeong-Seob Kim Seul Jung and Hyo-Won Jeon of Department of Mechatronics Engineering, Chungnam National University, Daejeon, South Korea. The FPGA implementation of a nonlinear PID controller for humanoid robot arms is presented in this study. Nonlinear functions, as well as the traditional PID control technique, must be implemented by the hardware description language in order to create the nonlinear PID controller on an FPGA device. Nonlinear functions like trigonometric and exponential functions are therefore constructed on an FPGA chip. The findings of simulation tests on position control of humanoid arms are compared. When disturbances are present, the nonlinear PID controllers' superior performance is validated. Experiments with humanoid robot arm control tasks are being carried out in order to verify our design and simulation results.

[13] Austin Gregg-Smith and Walterio W. Mayol-Cuevas of Department of Computer Science, University of Bristol, UK. They demonstrate a unique 6-degree-of-freedom cable-driven manipulator for handheld robotic applications. The arm is designed using a linked tendon technique to increase movement speed and configuration space while lowering overall arm mass. They suggested a space carving method for designing optimal link geometry that maximises structural strength and joint limitations while reducing link mass. The design improves on similar non-handheld tendon-driven manipulators by reducing the number of actuators required per degree of freedom to just one. We provide a 5-DoF inverse kinematics solution for the end effector pose because the manipulator includes one redundant joint. The inverse kinematics problem is solved by dividing the 6-DoF problem into two connected 3-DoF problems and combining the results. For scenarios where the desired end effector posture is outside the configuration space, a method for elegantly degrading the output of the inverse kinematics is provided. This is important in situations where the user is part of the control loop and can assist the robot in approaching the intended destination. The handheld robot's design is available as open source. While our findings and tools are geared toward handheld robotics, the design and methodology are applicable to non-handheld applications as well.

[14] Fenglei Li, Zexin Huang and Lin Xu of Institute of Robotics and Automatic Information Systems, Nankai University, Tianjin, China. The actuator of the venipuncture system in this paper was a compact 6 degree-of-freedom (DOF) robot arm. They reduce the model of the robot arm and obstacles according to the geometry of the robot arm and obstacles in the environment, aiming at the robot arm's requirements for speed and smoothness and considering that the robot arm may collide with impediments in the course of movement. Then they proposed an improved A-star algorithm and a three-dimensional (3D) collision detection algorithm that can plan a collision-free optimal path for the blood taking needle fixed in the robot arm's end, allowing the blood taking needle to penetrate into the target point of the venous vessel continuously, smoothly, and accurately driven by the robot arm. The proposed path planning method is successful and practicable, according to simulation and real-world path planning studies.

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[15] Ferenc Lombai and Gabor Szederkenyi Faculty of Information Technology, Pázmány Péter Catholic University, Budapest, Hungary. This study describes the trajectory tracking control of a rigid robot arm with six degrees of freedom (DOF). The joint variables' trajectories are constructed in third-order spline form using general constrained nonlinear optimization, with the joint position, velocity, acceleration, jerk, and overall current consumption constraints all taken into account. A discrete-time linear controller scheme is used to solve the trajectory tracking of the individual joints. Oriented bounding boxes and related separation axis theorem tests are used to check the generated trajectories for collisions. In the Mathematica computing environment, the whole inverse kinematics of the arm is symbolically calculated and implemented in C++. The proposed method's applicability is demonstrated through simulations and observations.

[16] Guo-Shing Huang, Chiou-Kou Tung, Hsiung-Cheng Lin and Shun-Hui Hsiao Department of Electronic Engineering, National Chin-Yi University of Technology, Taichung, Taiwan. This work offers a 6-DOF robot arm system, proposes a strategy for solving the inverse kinematics equations, and sets up the robot's coordinate system with the D-H notation approach, using the robot arm assembled by seven AI servos (RX-64). The geometric analysis is used to calculate the motion trajectory of a robot arm. In the entire system, it was taken into account as the length of the robot arm and the motion angle. To precisely locate the direction for all axes of the robot arm and obtain the optimal motion path, adjust and drive the robot arm to the coordinates of the folder and place between one and the target object, make the angle of the shaft position can accurately locate the direction for all axes of the robot arm, and make the angle of the shaft position can accurately locate the direction for all axes of the robot arm. Finally, the findings of the inverse kinematics equations analysis were verified and compared to the experimental data using Matlab software. We position the object using the camera that was put on the robot arm, operate the robot arm using the analytical result of the inverse kinematics equation, and make the robot arm achieve the action of exact grabbing the object in the experimental test. Finally, the food service robot will employ the robot arm system to serve customers.

2. PROBLEM STATEMENT

The following are the project's problem statements:

i. A robot is a sophisticated system. The mathematical modelling reveals a higher order, requiring the derivation of large equations. As a result, a CAD model can be employed as a different technique.

ii. Linear controllers must be linearized before being used in robot systems, and the controller does not account for parameter uncertainty. To address this issue, a non-linear controller will be utilised.

iii. The hybrid controller comprising two non-linear controllers, the fuzzy and neural-network controller, can improve the non-linear controller's transient response and steady-state response.

3. SCOPE

This model and controller is mainly for six (6) degree of freedom of industrial robots by using CAD design. Controller development will be based on arduino controller. The simulation platform will be Matlab/Simulink, ansys, and SolidWorks.

4. METHODOLOGY

i. Begin with literature review to study previous paper and come up with problem statement.
ii. Secondly, design the CAD model until the desired position and orientation are achieved.
iii. Then the CAD model is converted to physical model by using Sim-Mechanics Simulink.
iv. In the fourth stage, arduino is programmed
v. Next, observation of result is done through simulation study.

4.1 Design of CAD Model

Computer-aided layout (CAD) is using pc structures to useful resource inside the introduction, amendment, analysis, or optimization of a layout. The CAD software program software is used to growth the productivity of the clothier, decorate the wonderful layout, enhance communications via documentation, and create a database for manufacturing. CAD output is frequently in the form of digital documents for print, machining, or different manufacturing operations. The CAD model is design by using SolidWorks, the assemblies' window of SolidWorks can be referred to Figure 1 The purpose of creating CAD model in assemblies' window is to make sure the position and orientation of each part is correct.

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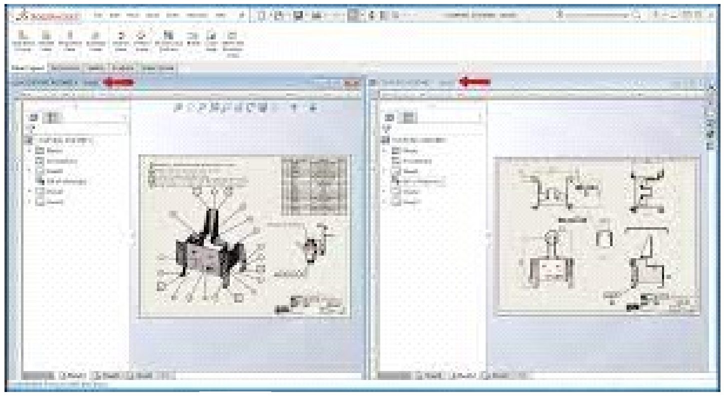

Fig:1- Window of SolidWorks

5. WORKING PRINCIPLE

The robotic arm operates on the premise of electrical input energy to efficiently accomplish mechanical tasks using automation and program-based operations. Major hardware components of the pick and place robotic arm are strips & motors, arm gripper, switches, battery, piece of metal, and other discrete mechanical and electrical components. The goal of this project is to create a pick-and-place robotic arm with a soft catching gripper. This soft catching gripper is used to properly handle and place an object while capturing it. The servo motor in the robotic arm is utilised for angular rotations of the arm to capture items (to hold items, release items, rotate, and position). This servomotor is controlled by an Arduino circuit board and works on the premise of Fleming's left-hand rule.

6. COMPONENTS

6.1 Mechanical Gripper

A mechanical gripper is used to grip and hold objects while transporting them from one spot to another. The gripper features a built-in micro servo that allows it to open and close its jaws to grip objects. The gripper is created using a LASER cutting procedure on acrylic. The servo's shaft is attached to the end of the first jaw, and it meshes with the gear on the second jaw. The gear turns as the motor rotates, and the jaws open and close to release or grip the objects as the gear rotates in mesh. A servo motor is connected to a gear link, which meshes with another geared link to give a smooth gripping motion for various objects of various sizes.

Fig:2- Mechanical Gripper

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6.2 Base with Bearing

The base is designed to sustain the entire assembly while also balancing the entire arm's centre of gravity. The base enables the arm to perform faultless motions in the required directions, allowing the arm to cover the entire hemispheric volume. The bearing is fixed in the base and takes on the entire load of the base; it also delivers rotational movement from the base to the robotic arm.

6.3 Servo Motor

In the robotic arm, there are three major servo motors: one for the base motions and two on the side of the base plate that send motion to the arm's numerous linkages. The servo motor is fastened to the base plate, which maintains it stable and prevents vibrations during use.

A rotary actuator is made consisting of a suitable motor and a position feedback sensor. It also necessitates a complex controller, which is frequently a separate module created exclusively for servomotors.

6.4 Controller

A servo control can be acquired by delivering servo signals, which are a sequence of variable-width repeating pulses in which the width of the pulse (most common in modern hobby servos) or the duty cycle of a pulse train (less frequent today) defines the position to be achieved by the servo controller. The controller incorporates the digital command signal into analogue parameters such as servo motor shaft movement. We can upload the software for the servo motions with the help of the controller. We can control a large number of servos at once and synchronize their operation for -operation of any servo in any sequence and to synchronize the actuation of four servos consecutively in a loop programme utilizing the controller.

6.5 Connectors

Electrical connectors are the devices that are used to connect electrical terminations and produce an electrical circuit. These are electromechanical devices that are made up of male and female ending plugs and jacks. The connection may be temporary, such as for portable equipment, or it may act as a permanent electrical union between two wires or devices, requiring the use of a tool for assembly and removal. For the connections in our project, we solely used male to male connectors or plugs.

7. MECHANICAL LINKS

The different linkages convey the movement from the servo motor to the tool holding assembly or gripper. The linkages are designed in such a way that the power is conveyed with the least amount of load on the servo motor. By employing the correct material, the linkage design is produced incredibly light weight. The main idea behind employing links instead of rigid pieces is to save energy by reducing the amount of energy necessary to conduct the arm motion. Aluminium alloy 6061 will be used to make the arm links.

8. Conclusion

The design and development of a robotic arm capable of performing modest tasks such as light material handling are shown in this article. Servo motors were used to make arm movements on the robotic arm, which was designed and fabricated from aircraft grade aluminium. The robotic arm's design is limited to six degrees of freedom. This method would make it easier for humans to avoid the dangers of handling suspicious objects in their current environment and workplace. With this approach, complex and difficult tasks might be completed faster and more correctly.

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