International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 09, September-2015

Review of Anfis Tool used in 5 Dof Robotic Arm

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Abstract: **In this paper modeling and control of 5 degree of freedom robotic arm is the presented. It consists of forward and inverse kinematics is derived based on Denavit-Hartenberg (DH) representation. Main of this paper is to design the robotic arm by using D-H representation. The kinematics issue is identified as the advance from the Cartesian position to the mixed position and the other way around. This papers is developed to design the forward and inverse kinematics of a 5 DOF robotic Arm for simple select and position system. A typical D-H representation of forward and inverse matrix is obtained.**

Keywords: Forward kinematics, Inverse kinematics, robotic arm, degrees of freedom (DOF), Denavit-Hartenberg representation, ANFIS, Artificial neural network

1.INTRODUCTION TO ROBOTICS

Over the last 45 years, robotics research has been focused at discovering answers to the technical requirements of used robotics. The enhancement of system places and their complexness have impacted research topics in the robotics team. This enhancement has been protected with personal requirements. In the starting 1960s, the professional pattern put professional robots in the maker to produce the individual proprietor from risky and risky tasks. The later growth of professional robots into other types of production techniques involved new requirements that known as for more flexibility and intelligence in professional robots. Currently, the growth of new needs and market segments outside the original production automated market (i.e., cleaning, demining, growth, shipbuilding, agriculture) and the aging world we reside in is complicated position and service robots to be existing at to the newest market and to personal public needs.

1.1 Kinematics

It is the department of traditional methods that describes the game of methods (objects) and methods (groups of objects) without issue of the causes that cause the activity. Kinematics is the procedure of identifying the positioning in position of the finish of a linked structure, given the viewpoints of all the mixed places. This technique may be incredibly useful in robotics. You could have a robotic arm which needs to get products. If the application form knows where the merchandise is in relation to the throat, it really needs to figure out the viewpoints of the mixed places to accomplish it. The most convenient system of kinematics is for substance activity, translational or rotating [8]. The next level of complexness arises from enhancement company methods, which are choices of pollutants having time invariant varies between themselves. Firm methods might undergo presentation and rotating or an assortment of both. A more difficult situation is the kinematics of a system of company methods, which can be linked together by technical mixed places. It is of two types [19].

- Forward Kinematics
- Inverse Kinematics

1.1.1 Forward Kinematics

The fundamental concept of forward kinematic animation is that the positions of particular areas of the model at a specified time are calculated from the positioning and orientation of the thing, together with any informative data on the joints of an articulated model. So for instance if the thing to be animated is an arm with the shoulder remaining at a fixed location, the location of the tip of the thumb could be calculated from the angles of the shoulder, elbow, wrist, of the tip of the thumb could be calculated from the angles of the shoulder, elbow, wrist, thumb and knuckle joints. Three of those joints (the shoulder, wrist and the root of the thumb) have more than one amount of freedom, that must be used into account. If the model were a whole human figure, then a location of the shoulder would also need to be calculated from other properties of model [20].

1.1.2 Inverse Kinematics

It will enable us to calculate what each joint variable must be if we desire that the hand be located at particular point and have a particular position. The positioning and orientation of the conclusion effector in accordance with the base frame compute all possible sets of joint angles and link geometries which may be properly used to attain the given position and orientation of the conclusion effector [20].

1.5 Degree of freedom (DOF)

The Levels of freedom, or DOF, are a critical term to understand. Each amount of freedom is a joint on the arm, a place where it can bend or rotate or translate. You are able to typically identify the number of quantities of freedom by the number of actuators on the robot arm. When building a robot arm few quantities of freedom is allowed for the application form, because each degree requires a motor, often an encoder, and exponentially complicated algorithms and cost [24].

1.6 Robotic Arm

A robotic arm is a robotic manipulator, usually programmable, with similar functions to an individual arm. The links of such a manipulator are connected by joints allowing either rotational motion (such as in a articulated robot) or translational (linear) displacement. The links of the manipulator can be considered to form a kinematic chain [22]. The business enterprise end of the kinematic chain of the manipulator is called the conclusion effector and it's analogous to the human hand. The end effector may be designed to execute any desired task such as for instance welding, gripping, spinning etc., with respect to the application. The robot arms may be autonomous or controlled manually and can be used to execute many different tasks with great accuracy. The robotic arm may be fixed or mobile (i.e. wheeled) and may be designed for industrial or home applications. It is assume that most joints rotate no more than 180 degrees, because most servo motors cannot exceed that amount.

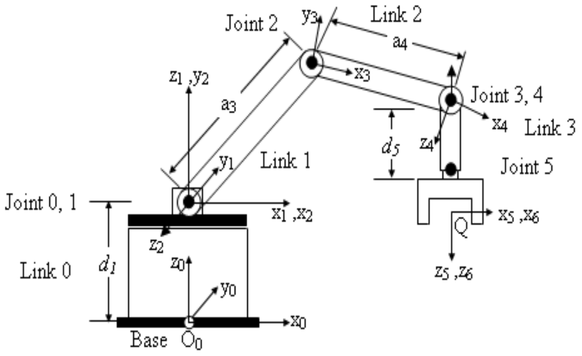

Fig 3.1 AL5B Robot Arm Frame Assignment

2. LITERATURE REVIEW

De Xu et al.[6] proposed an analytical solution for a 5-DOF manipulator to check out certain trajectory while keeping the orientation of just one axis in the end-effector frame. The forward kinematics and inverse kinematics for a 5-DOF manipulator are analyzed systemically. The singular problem is discussed after the forward kinematics is provided. For any given reachable position and orientation of the end-effector, the derived inverse kinematics will provide an accurate solution. Put simply, there exists no singular problem for the 5-DOF manipulator, which has wide application areas such as for example welding, spraying, and painting.

Baki Koyuncu et al.[8] Presented the theoretical background for the analysis of the 5 Dof Lynx-6 educational Robot Arm kinematics.The kinematics problem is defined while the transformation from the Cartesian space to the joint space and vice versa. The Denavit-Harbenterg (D-H) type of representation is employed to model robot links and joints in this study. Both forward and inverse kinematics solutions for this educational manipulator are presented, An effective method is suggested to decrease multiple solutions in inverse kinematics. An aesthetic software package, named MSG, can be developed for testing Motional Characteristics of the Lynx-6 Robot arm. The kinematics solutions of the program package were found to be identical with the robot arm's physical motional behaviors.

Mohammad Amin Rashidifar et al.[17] proposed the Modeling and control of 5 degree of freedom (DOF) robot arm is the topic of this article. The modeling problem is important before applying control techniques to guarantee the execution of any task according to an ideal input with minimum error. Deriving both forward and inverse kinematics is an essential step in robot modeling based on the Denavit Hartenberg (DH) representation. Proportional integral derivative (PID) controller is employed as a guide benchmark to compare its results with fuzzy logic controller (FLC) and fuzzy supervisory controller (FSC) results. FLC is applied as another controller because of the nonlinearity in the robot manipulators. We compare the consequence of the PID controller and FLC results with regards to time response specifications. FSC is really a hybrid between the prior two controllers. The FSC is useful for tuning PID gains since PID alone performs not satisfactory in nonlinear systems. Hence, comparison of tuning of PID parameters is utilized using classical method and FSC method. Based on simulation results, FLC gives better results than classical PID controller with regards to time response and FSC is better than classical methods such as for example Ziegler-Nichols (ZN) in tuning PID parameters with regards to time response.

Vivek Deshpande et al. [21] proposed that the control of an automatic arm is a huge challenge since earlier days of robots. The kinematics problem is defined while the transformation from the Cartesian space to the joint space and vice versa. This paper aims to model the forward and inverse kinematics of a 5 DOF Robotic Arm for quick pick and place application. A general D-H representation of forward and inverse matrix is obtained. An analytical solution for the forward and inverse kinematics of 5 DOF robotic arm presented, to analyze the movement of arm from one point in space to a different point. The 5 DOF robotic arm is a vertical articulated robot, with five revolute joints. It's a trustworthy and safe robotic system created for educational purpose. This versatile system allows students to achieve theoretical and practical experience in robotics, automation and control systems.

C.A. Acosta Calderon et al. [20] proposed that the main problem in trajectory generation and tracking of robotic manipulators is to plan the trajectory and compute the required joint angles. Inverse kinematics modelling is usually adopted, though sometimes other approaches are needed due to the lack of reliability and accuracy of analytical methods. This paper presents a comparison between an analytical inverse kinematics based hybrid approach and a Resolve Motion Rate Control method for controlling the Pioneer Arm mounted on the Pioneer mobile robot.

Himanshu chaudhary et al. [26] presented two approaches to generating such trajectories: straight lines in joint space and straight lines in Cartesian space have been discussed. This is one of the most common requirements in robotics for moving the end-effector smoothly from initial location to goal location. These are known respectively as joint space and Cartesian space tracking. Two user defined algorithms are developed for Joint space as well as Cartesian space trajectory tracking. The algorithm has been tested in simulation yielding fair results, which have also been compared with those provided by another important trajectory planning technique methods.

3. TECHNIQUES USED

3.1 Adaptive Neuro-Fuzzy Inference System (ANFIS)
ANFIS are a part of evolutionary computing, which is a rapidly growing area of artificial intelligence. Adaptive Neuro-Fuzzy Inference System is a feed forward adaptive neural network which implies a fuzzy inference system through its structure and neurons. Jang was one of the first to introduce ANFIS. An adaptive neuro-Fuzzy Inference System (ANFIS) is a cross between an artificial neural network and a fuzzy inference system (FIS). Based on the ability of an ANFIS to learn from training data, it is possible to create an ANFIS structure from an extremely limited mathematical representation of the system. In sequel, the ANFIS architecture can identify the near-optimal membership functions of FLC for achieving desired input-output mappings. The network applies a combination of the least squares method and the back propagation gradient descent method for training FIS membership function parameters to emulate a given training data set. The system converges when the training and checking errors are within an acceptable bound. The ANFIS system generated by the fuzzy toolbox available in MATLAB allows for the generation of a standard Sugeno style fuzzy inference system or a fuzzy inference system based on sub-clustering of the data.

3.2 Artificial Neural Network
Artificial neural network (ANN) is a parallel-distributed information processing system. This system is composed of operators interconnected via one-way signal flow channels. ANN stores the samples with a distributed coding, thus forming a trainable nonlinear system. It includes hidden layer(s) between the inputs and outputs. An artificial neural network is designed to mimic the characteristics of the human brain and consists of a collection of artificial neurons. An adaptive network is a multi-layer feed-forward network in which each node (neuron) performs a particular function on incoming signals. The form of the node functions may vary from node to node. In an adaptive network, there are two types of nodes adaptive and fixed. The function and the grouping of the neurons are dependent on the overall function of the network. The network applies a combination of the least squares method and the back propagation gradient descent method for training FIS membership function parameters to emulate a given training data set. The system converges when the training and checking errors are within an acceptable bound. A back propagation neural network with sigmoidal activation function is used to solve inverse kinematics problem. Firstly, some points in the work volume of manipulator are taken to use in the cubic path planning to generate the ($\theta 1$, $\theta 2$, $\theta 3$) joint angles according to different (x, y, z) cartesian coordinates. These values were recorded in a file to form the learning set of the neural network. We obtained the angles ($\theta 1$, $\theta 2$, $\theta 3$) from a certain cubic by sampling 6000 for orbit trajectory a given job.

3.3 Sugeno-Type Fuzzy Inference The fuzzy inference process we have been referring to so far is known as Mamdani’s fuzzy inference method, the most common methodology. In this section, we discuss the so-called Sugeno, or Takagi-Sugeno-Kang, method of fuzzy inference. Introduced in 1985 [Sug85], it is similar to the Mamdani method in many respects. The first two parts of the fuzzy inference process,fuzzifying the inputs and applying the fuzzy operator, are exactly the same. The main difference between Mamdani and Sugeno is that the Sugeno output membership functions are either linear or constant.[20]

4.METHODOLOGY USED

4.*1 Methodology Applied*
I have used MATLAB. Firstly I have to install MATLAB. I have used MATLAB Version 7.10.0.499 (R2010a). There ifferent tool box in MATLAB, I have used ANFIS (Adaptive neuro–fuzzy inference system) TOOL in MATLAB for the implementation of the technique of my research work.

4.2 Proposed Work
The proposed work is based on finding finding the value of inverse kinematics solutions. In the MATLAB we use ANFIS tool to find the inverse kinematics solution of 5 DOF robotic arm. Artificial Neuro-Fuzzy Inference Systems (ANFIS) is a class of adaptive networks that are functionally equivalent to fuzzy inference systems. ANFIS represent Sugeno e Tsukamoto fuzzy models and it uses a hybrid learning algorithm. The fuzzy logic are little used in limnology, and almost completely ignored by classical statistics textbooks, and by standard statistical packages. The only pre-requisite is to have access to the MATLAB basic package plus the MATLAB Fuzzy Logic Toolbox, but no expertise with this software is required. we wrote codes in MATLAB language, to take advantage of the ANFIS functions present in the MATLAB Fuzzy Logic Toolbox. System modelling based on conventional mathematical tools (e.g., differential equations) is not well suited for dealing with ill-defined and uncertain systems. By contrast, a fuzzy inference system employing fuzzy if then rules can model the qualitative aspects of human knowledge and reasoning processes without employing precise quantitative analysis. This fuzzy modelling or fuzzy identification, first explored systematically has found numerous practical applications control prediction and inference .However, there are some basic aspects of this approach which are in need of better understanding.

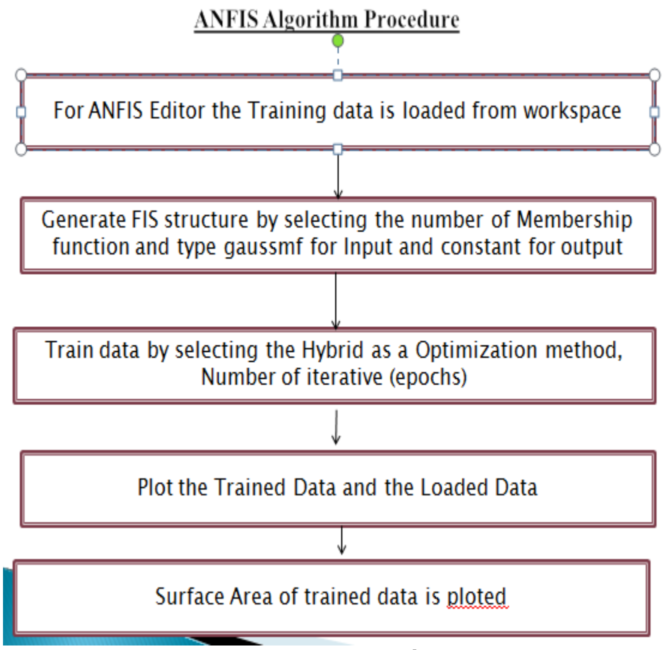

Figure 5.1 ANFIS Procedure

4.3 Tool Used

4.3.1 Introduction to ANFIS TOOL

The acronym ANFIS derives its name from adaptive neuro-fuzzy inference system. Using a given input/output data set, the toolbox function anfis constructs a fuzzy inference system (FIS) whose membership function parameters are tuned (adjusted) using either a back propagation algorithm alone, or in combination with a least squares type of method. This allows your fuzzy systems to learn from the data they are modeling.

4.3.2 ANFIS Editor GUI

The basic structure of the type of fuzzy inference system that we have seen thus far is a model that maps input characteristics to input membership functions, input membership function to rules, rules to a set of output characteristics, output characteristics to output membership functions, and the output membership function to a single-valued output or a decision associated with the output. We have only considered membership functions that have been fixed, and somewhat arbitrarily chosen. Also, we have applied fuzzy inference to modelling systems whose rule structure is essentially predetermined by the user's interpretation of the characteristics of the variables in the model. In this section we discuss the use of the function anfis and the ANFIS Editor GUI in the Fuzzy Logic Toolbox. These tools apply fuzzy inference techniques to data modelling. As you have seen from the other fuzzy inference GUIs, the shape of the membership functions depends on parameters, and changing these parameters will change the shape of the membership function. Instead of just looking at the data to choose the membership function parameters, we will see how membership function parameters can be chosen automatically using these Fuzzy Logic Toolbox applications.

4.3.3 Model Learning and Inference through ANFIS

The basic idea behind these neuro-adaptive learning techniques is very simple. These techniques provide a method for the fuzzy modeling procedure to learn information about a data set, in order to compute the membership function parameters that best allow the associated fuzzy inference system to track the given input/output data. This learning method works similarly to that of neural networks. The Fuzzy Logic Toolbox function that accomplishes this membership function parameter adjustment is called ANFIS. The anfis function can be accessed either from the command line, or through the ANFIS Editor GUI. Since the functionality of the command line function anfis and the ANFIS Editor GUI is similar, they are used somewhat interchangeably in this discussion, until we distinguish them through the description of the GUI.

5. CONCLUSION

In this paper, complete analytical solution to the forward and inverse kinematics of 5 DOF Robotic arm is discussed . The forward kinematic analysis of 5 DOF robotic arm is investigated. A strategy based on geometric projection was done to resolve the inverse kinematics of 5 DOF robotic arm. A review from various kinematic modeling methods has been taken using denavit-hartenberg representation

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