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Predict the Inverse Kinematic Solution to Manipulate Duplicate Using Anfis

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ABSTRACT:

The way forward and analysis of inverse kinematics 1 DOF 5 O7- We suggest duplicate DOF handler. Get started and calculate Joint top DOF corners of which the manipulator robot is required is one of the important concerns of Robot control kinematics. When the automated system has more degrees of freedom And it is called (DOF) that required to perform a specific manipulator duplicate task. The Difficulties in the resolution of inverse kinematics (IK) Equations This redundant robot Conflicts arise because it is not uncertain, different and over time the nature of non-linear Equations that have transcendental functions. In this thesis, the capacity of ANFIS (Adaptive Is used Neuro System Fuzzy Inference) to the data that has been created to solve the inverse kinematics Issue. The proposed fuzzy hybrid nervous system that combines learning capabilities Neural networks with diffuse reasoning for the nonlinear system approximation function. and single output Sugeno was modeled from the Islamic Salvation Front type (fuzzy inference) using a split network system In this work. Denavit- Hartenberg (D-H) representation of model and robot links Solution arrays pass from each subscriber. The oriented-and-reverse movement And the kinematics analysis of the DOF 5 and 7 DOF manipulator regularly. ANFIS successfully used to predict SIC of 5 DOF O7-Finance Department Redundant need manipulator in this business. After comparing the output, he concluded that ANFIS expect excellent capacity as this approach provides a general framework for action NN combination of logic and diffuse. ANFIS efficiency may conclude by observing The plot surface, conspiracy and conspiracy remaining regular perspective. This current study in the use of Nonlinear models to predict different indigenous knowledge systems l DOF 5 and 7 duplicate DOF Manipulator will provide a valuable source of information for the authors of the other models.

INTRODUCTION:

1.1.Introduction to Robotics Word robot was coined by a Czech novelist Karel Capek

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in 1920. The term robot derives from the Czech word robota, meaning forced work or compulsory service. A robot is reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks [1]. A simpler version it can be define as, an automatic device that performs functions normally ascribed to humans or a machine in the form of a human.

1.2. History of Robotics The first industrial robot named UNIMATE; it is the first programmable robot designed by George Devol in1954, who coined the term Universal Automation. The first UNIMATE was installed at a General Motors plant to work with heated die-casting machines.

Figure 1. The first industrial robot: UNIMA'

In 1978, the Puma (Programmable Universal Machine for Assembly) robot is developed by Victor Scheinman at pioneering robot company Unimation with a General Motors design support. These robots are widely used in various organisations such as Nokia corporation, NASA, Robotics and Welding organization.

Then the robot industries enters a phase of rapid growth to till date, as various type of robot are being developed with various new technology, which are being used in various industries for various work. Few of these milestones in the history of robotics are given below. 1947 — The first servoed electric powered teleoperator is developed. 1948 — A teleoperator is developed incorporating force feedback. 1949 — Research on numerically controlled milling machine is initiated. 1954 — George Devol designs the first programmable robot. 1956 — Joseph Engelberger, a Columbia University physics student, buys the rights to Devol's robot and founds the Unimation Company. 1961 — The first Unimate robot is installed in a Trenton, New Jersey plant of General Motors to tend an die casting machine. 1961 — The first robot incorporating force feedback is developed. 1963 — The first robot vision system is developed. 1971 — The Stanford Arm is developed at Stanford University. 1973 —

The first robot programming language (WAVE) is developed at Stanford. 1974 — Cincinnati Milacron introduced the T3 robot with computer control. 1975 — Unimation Inc. registers its first financial profit. 1976 — The Remote Center Compliance (RCC) device for part insertion in assembly is developed at Draper Labs in Boston. 1976 — Robot arms are used on the Viking I and II space probes and land on Mars. 1978 — Unimation introduces the PUMA robot, based on designs from a General Motors study. 1979 — The SCARA robot design is introduced in Japan

Figure 2. Puma Robotic Arm

Laws of Robotics Asimov [2] proposed three "Laws of Robotics", and later added a 'Zeroth law'. Zeroth Law: A robot may not injure humanity, or, through inaction, allow humanity to come to harm.

First Law: A robot may not injure a human being, or, through inaction, allow a human being to come to harm, unless this would violate a higher order law.

Second Law: A robot must obey orders given it by human beings, expect where such orders would conflict with a higher order law. Third Law: A robot must protect its own existence as long as such protection does not conflict with a higher order law [3].

LITERATURE REVIEW:

Obtaining the inverse kinematics solution has been one of the main concerns in robot kinematics research. The complexity of the solutions increases with higher DOF due to robot geometry, non-linear equations (i.e. trigonometric equations occurring when transforming between Cartesian and joint spaces) and singularity problems. Obtaining the inverse kinematics solution requires the solution of nonlinear equations having transcendental functions. In spite of the difficulties and time consuming in solving the inverse kinematics of a complex robot, researchers used traditional methods like algebraic [14], geometric [15], and iterative [16] procedures. But these methods have their own drawbacks as algebraic methods do not guarantee closed form solutions. In case of geometric methods, closed form solutions for the first three joints of the

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manipulator must exist geometrically. The iterative methods converge to only a single solution depending on the starting point and will not work near singularities [17]. In other words, for complex manipulators, these methods are time consuming and produce highly complex mathematical formulation, which cannot be modelled concisely for a robot to work in the real world. Calderon et al. [18] proposed a hybrid approach to inverse kinematics and control and a resolve motion rate control method are experimented to evaluate their performances in terms of accuracy and time response in trajectory tracking. Xu et al. [19] proposed an analytical solution for a 5-DOF manipulator to follow a given trajectory while keeping the orientation of one axis in the end-effector frame by considering the singular position problem. Gan et al. [20] derived a complete analytical inverse kinematics (IK) model, which is able to control the P2Arm to any given position and orientation, in its reachable space, so that the P2Arm gripper mounted on a mobile robot can be controlled to move to any reachable position in an unknown environment. Utilization of artificial neural networks (ANN) and fuzzy logic for solving the inverse kinematics equation of various robotic arms is also considered by researchers. Hasan and Assadi [21] adopted an application of ANN to the solution of the IK problem for serial robot manipulators. In his study, two networks were trained and compared to examine the effect of the Jacobian matrix to the efficiency of the inverse kinematics solution. A Kinematically redundant manipulator is a robotic arm posses extra degree of freedom (DOF) than those required to establish an arbitrary position and orientation of the endeffector. A redundant manipulator offer several potential advantages over a non-redundant manipulator. The extra DOF that require for the free positioning of manipulator can be used to move around or between obstacles and thereby to manipulate in situations that otherwise would be inaccessible [22],[23],[24]. Due to the redundancy the manipulators become flexible, compliant, extremely dextrous and capable of dynamic adaptive, in unstructured environment [25]. . The redundancy of the robot increases with increasing in DOF and there exist many IK solutions for a given end-effector configuration for this type of robot. So various researcher have proposed many methods to solve the IK equation of redundant manipulator. L. Sciavicco et.al. [26] used inverse jacobian, pseudo inverse jacobian or jacobian transpose and solve the IK problem of 7-DOF redundant manipulator iteratively. But the main drawback of this method are, these are slow and suffer from singularity issue. Shimizu et.al. [27] proposed an IK solution for the PA 10-7C 7-DOF manipulator and considered arm angle as redundancy parameter. In his study, a detailed analysis of the variation of the joint angle with the arm angle parameter is considered, which is then utilizes for redundancy resolution. However link offset were not considered in his work. An analytical solution for IK of a redundant 7-DOF manipulator with link offset was carried out by G.K Singh and J. Claassens [28]. They have considered a 7-DOF Barrett whole arm manipulator with link offset and concluded that the possibility of in-elbow and out-elbow poses of a given end-effector pose arise due to the presence of link offset. They also presented a geometric method for computing the joint variable for any geometric pose. Dahm and Jublin [29] used angle parameter as redundancy and derived a closed-form inverse solution of 7-DOF manipulator. They also analysed the limitation of the parameter caused by a joint limit based on a geometric construction. The analysis has its own drawback as priority is being given to one of the wrist joint limit. Based on the closed-form inverse solution and using angle parameters by Dahm and Joublin in his work, Moradi and Lee [30] minimised elbow movement by developing a redundancy resolution method. Due to the presence of non-linearity, complexity, and transcendal function as well as singularity issue in solving the IK, various researchers used different methods like iteration, geometrical, closed-form inverse solution, redundancy resolution as discussed in above theory. But some researchers also adopted methods like algorithms, neural network, neuro fuzzy in recent year for solving the non-linear equation arises in different area such as in civil engineering for constitutive modelling [31], for structural analysis and design [32], for structural dynamics and control [33], for non-destructive testing methods of material [34] and many disciplines including business, engineering, medicine, and science [35]. Liegeois [36] first introduced a gradient projection algorithm to utilise the redundancy to avoid mechanical joint limit. In his work, he obtained a homogeneous solution by considering the pseudo inverse method and projected it on to the null space of jacobian matrix but selection of appropriate scalar coefficient that determine the magnitude of self motion and oscillation in the joint trajectory are the main drawback of this algorithm. One of the main drawbacks to utilize redundant manipulators in an industrial environment is joint drift. The well known Closed-loop inverse kinematics (CLIK) algorithm was proposed by Siciliano [37], to overcome the joint drift for open-chain robot manipulators, by including the feedback for the end-effector's position and orientation. Wampler [38] proposed a least square method to generate the feasible output around singularities, by utilising a generalised inverse matrix of jacobian, known as singularity robust pseudoinverse. Due to the adapting and learning nature, ANN is an efficient method to solve non-linear problems. So it has a wide range of application in manufacturing industry, precisely for Electro discharge machining (EDM) process. Various authors had adopted ANN with different training algorithms namely Levenberg-Marquardt algorithm, scaled conjugate gradient algorithm, Orient descent algorithm, Gaussi Netwon algorithm and with different activation finction like logistic sigmoid, tangent sigmoid, pure lin to model the EDM process. Mandel et.al. [39] used ANN with back propagation as learning algorithm to model EDM process. They concluded that by considering different input parameters such as roughness, material removal rate (MRR), and Tool wear rate (TWR) are found to be efficient for predicting the response parameters. Panda and Bhoi [40], predicted MRR of D2 grads steel by developing a artificial feed forward NN model based on Levenberg-Marquardt back propagation technique and logistic sigmoid activation function. The model performs faster and provides more accurate result for predicting MRR. Goa et.al. [41] considered different algorithm like L-M algorithm, resilient algorithm, Gausi-Newton algorithm to established different model for machining process. After several training of models and comparing the generalisation performance they conclude that L-M algorithm provides faster and more accurate result. Despite of the NN approach by different authors as discussed above, some authors have also adopted neuro fuzzy (NF) method for solving non-linear and complex equation. Although ANN are very efficient in adopting and learning but they have the negative attribute of 'black box'. To overcome this drawback, various author adopted neuro fuzzy method like ANFIS. This can be justify as ANFIS combines the advantage of ANN and fuzzy logic technique without having any of their disadvantage [42]. The neuro fuzzy system are must widely studied hybrid system now a days, as due to the advantages of two very important modelling technique i.e. NN [43] and Fuzzy logic [44]. Malki et.al. [45] adopted adaptive neuro fuzzy relationships to model the UH-60A Black Hawk pilot floor vertical vibration. They have considered 200 data of UH-60A helicopter flight envelop for training and testing purpose. They conducted the study in two parts i.e. the first part involves level flight conditions and the second part involves the entire (200 points) database including maneuver condition. They concluded from their study that neuro fuzzy model can successfully predict the pilot vibration. LI ke et.al. [46] applied ANFIS to solve the forecast problem of microwave effect by adopting microwave parameters and its threshold as variable. Then they develop an ANFIS model to study its forecasting ability. By comparing the output of ANFIS with training and testing data, they concluded with good forecasting ability, small error and low data requirement are found with ANFIS. Srinivasan et.al. [47] applied ANFIS based on PD plus I controller to the dynamic model of 6-DOF robot manipulator (PUMA Robot). Numerical simulation using the dynamic model of 6-DOF robot arm shows the effectiveness of the approach in trajectory tracking problems. Comparative evaluation with respect to PID, fuzzy PD+I controls are presented to validate the controller design. They concluded that a satisfactory tracking precision could be achieved using ANFIS based PD+I controller combination than fuzzy PD+I only or conventional PID only. Roohollah Noori et.al [48], predicted daily carbon monoxide (CO) concentration in the atmosphere of Tehran by means of ANN and ANFIS models. In this study they used Forward selection (FS) and Gamma test (GT) methods, for selecting input variables for developing hybrid models with ANN and ANFIS. They concluded that Input selection improves prediction capability of both ANN and ANFIS models and it not only reduces the output error but reduces the time of calculation due to less input variable. U. Yüzgeç et.al., [49], investigates different modelling approaches and compares for drying of baker's yeast in a fluidized bed dryer based on ANN and ANFIS. In this work they investigates four modelling concepts: modelling based on the mass and energy balance, modelling based on diffusion mechanism in the granule, modelling based on recurrent ANN and modelling based on ANFIS, to predict the dry matter of product, product temperature and product quality.

CONCLUSION:

In this study, the inverse kinematics solution using ANFIS for a 5-DOF and 7-DOF Redundant manipulator is presented. The difference in joint angle deduced and predicted with ANFIS model for a 5-DOF and 7-DOF Redundant manipulator clearly depicts that the proposed method results with an acceptable error. The modelling efficiency of this technique was obtained by taking three end-effector coordinates as input parameters and five and seven joint positions for a 5-DOF and 7-DOF Redundant manipulator respectivly as output parameters in training and testing data of NF models. Also, the ANFIS model used with a smaller number of iteration steps with the hybrid learning algorithm. Hence, the trained ANFIS model can be utilized to solve complex, nonlinear and discontinuous kinematics equation complex robot manipulator; thereby, making ANFIS an alternative approach to deal with inverse kinematics. The analytical inverse kinematics model derived always provide correct joint angles for moving the arm end-effector to any given reachable positions and orientations. As the ANFIS approach provides a general frame work for combination of NN and fuzzy logic. The efficiency of ANFIS for predicting the IK of Redundant manipulator can be concluded by observing the 3-D surface viewer, residual and normal probability graphs. The normal probability plots of the model are also plotted. The normal probability plot of residuals of training and testing data obtained from ANFIS shows that the data set of ANFIS are approximately normally distributed. The methods used for deriving the inverse kinematics model for the these manipulators could be applied to other types of robotic arms, such as the EduBots developed by the Robotica Ltd, Pioneer 2 robotic arm (P2Arm), 5-DOF Lynx 6 Educational Robot arm. It can be concluded that the solution developed in this paper will make the PArm more useful in application with unpredicted trajectory movement in unknown environment

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