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Artificial Neural Network Based Inverse Kinematics solution 2-Link Serial Chain Manipulator

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Abstract*—*In this paper artificial neural network is applied to find the solution of inverse kinematics problem of robotics. The algorithm used here is feed forward backpropagation algorithm. Logistic function is used as activation function. A set of datasets were generated by inverse kinematics equation. The network is trained, tested and validated by using inverse kinematics equation. The performance and regression graphs are plotted in this study.

1. INTRODUCTION

A robotic manipulator is a mechanical device. It has one or more links that are connected by joints. It consist of actuator and sensor to perform its task. A programmed software is used for controlling purpose of manipulator.

Kinematics of manipulator is described as the relationship between the joint variables and position and orientation of the manipulator. The modeling of kinematics of robot is categorized into two parts: forward kinematics and inverse kinematics. If the joint link parameters are given then finding the position and orientation of end effector with respect to known reference frame is termed as direct kinematics of robot whereas, if the position and orientation of the robot is known then finding the joint link parameters is known as inverse kinematics of robot. There is no systematic procedure exist for the solution of inverse kinematics problem, so it is more difficult problem than forward kinematics.

Analytical and numerical methods are the two main solution exist for inverse kinematics Problem. Geometric and algebraic solution are the two approaches in analytical method. In analytical method joint variables are solved by the given Configuration data whereas when the joint variable are obtained based on numerical technique then it is termed as numerical method.

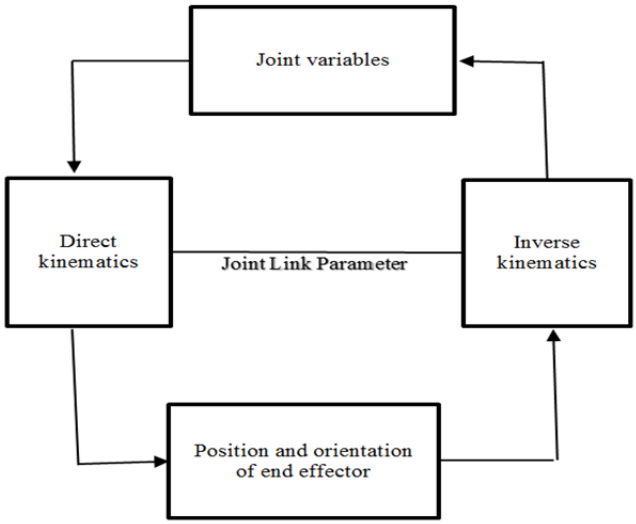

Fig. 1*:* Direct and Inverse Kinematics Model

2. LITURATURE REVIEW

In [1] the author describe the relationship between link parameters and position and orientation of manipulator, forward and inverse kinematics are described. In [2] the author describe the neural network and fuzzy logic approach for solving inverse kinematics. In [3] the author used functional link artificial neural network (FLANN) to solve the inverse kinematics. In [4] author uses minimum configuration MLP for solving Ex-OR problem. In [5] the author used artificial neural network and knowledge based technique for intelligent robotic control. In [6] the author describe intelligent control system, here system has to deal with complex system. In [7] Werbos describe the bachpropagation algorithm in detail. In [8] the author describes the solution of Ex-NOR gate using

minimum configuration MLP. In [9,10] the author present neural network based inverse kinematics solution. In [11] the author present the LabView simulation of inverse kiinematics soluion of robot. In [12] the author gave solution of inverse kinematics problem by using artificial neural network. In [13] the author gave the force control of robotic manipulator by using neural network.

General Approach of solving Inverse Kinematics Problem

Inverse kinematics is defined as finding link and joint parameters by the help of known position and orientation. The relationship between the end-effectors position x (t) and joint angle θ (t) can be represented by forward kinematics equation,

$$x(t) = f(\theta(t)) \qquad (1)$$

Here, f is nonlinear, continuous and differentiable function. The joint variable in inverse kinematics problem can be solved by,

$$\Theta(t) = f(x(t)) \qquad (2)$$

The equation (2) is not unique, nonlinear and time varying in nature.

In kinematics of manipulator we consider the motion of link without considering the force and torque. A manipulator is classified into serial and parallel manipulator. In serial manipulator one end is fixed which is called base, and another end is free which is called end effector. There is no closed loop in serial manipulator.

An artificial neural network can be trained to perform a particular function by adjusting the value of connection that is weighing coefficient between processing nodes. In general artificial neural network adjusted to reach from a particular input to a specific targe outputusing suitable learning method until the network output matches the target. The error between desired output and network uotput is minimized by modifying the synaptic weight and bias value.

In this paper, we present the inverse kinematics solution of two link serial chain manipulator. A 20Link serial chain robot is shown below:

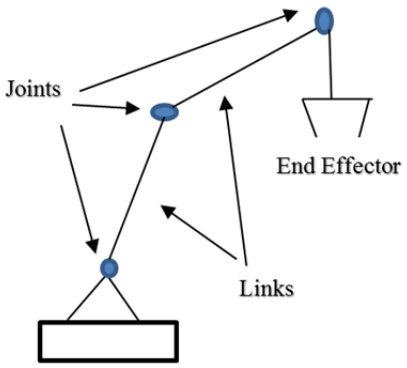

Fig. 2*:* Planar Manipulator with 3 revolute joint

In palnar 3-R robot the link parameters are represented by l_1 and l_2 and joint angles are represented by$\theta_1 and\ \theta_2$.

The position and orientation of end effector in terms of joint parameters are represented as,

$$X = l_1 \cos\theta_1 + l_2 \cos(\theta_1 + \theta_2) \qquad (3)$$

$$Y = l_1 \sin\theta_1 + l_2 \sin(\theta_1 + \theta_2) \qquad (4)$$

By the help of equation (3) and (4) we can find the joint angles of the manipulator.

When the kinematics equations are coupled, then multiple solution and singularities exist, this leads to difficulty in solving inverse kinematics problem.

3. ARTIFICIAL NEURAL NETWORK

Artificial neural network is a parallel and distributed processor which mimic the working of human brain. Unline conventional computers, a neural network adapt differenct approach for solving problems. A computer executes a set of instructions to perform its task, it cannot perform its task without set of predefined set of instruction of algorithm. A neural network process information similar to the human brain. It composed of highly interconnected set of processing units which is called neuron. A neural network learns its task by example. It cannot programmed to perform specific task. The disadvantage of artificial neural network is that sometimes its operations are unpredictable.Brian learns from experience.

An artificial neuron is a processing unit, which receives input signal from environment then process it and sends it as output in environment. The three basic elements of ANN are: neuron, learning rule and network topology which is used to connect the neuron. We can represent the artificial neural network by using block diagram, signal flow diagram representation and architectural graph. Supervised learning, unsupervised learning and reinforcement learning are the the three basic category of learning algorithm. We use linear and non linear neuron depend on the ttype of activation function used in it.

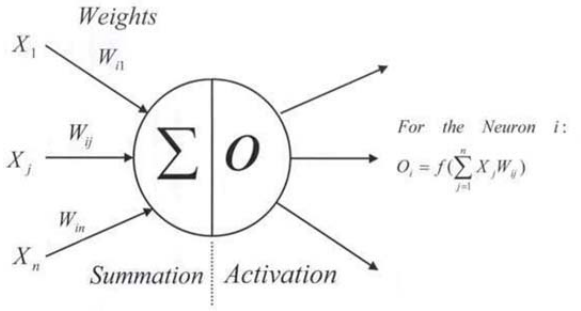

Fig. 3: Artificial Neuron

SOLUTION OF INVERSE KINEMATICS PROBLEM USING ARTIFICIAL NEURAL NETWORK:

We find the solution of inverse kinematics of two link serial chain manipulator in Matlab using aritificial neural network toolbox. The procesure to train the neural network in Matlab is as follows:

- Data collection
- Network creation
- Network configuration
- Initialization of weights and biases
- Network training
- Network validation
- Use the network

The stages of learning using neural network includes training of data, testing of data and validating it. The firstly, datasets is created by using inverse kinematics equation. Then seventy five percent of data are used for training, fifteen percent data used for testing and fifteen percent data used for validating it.

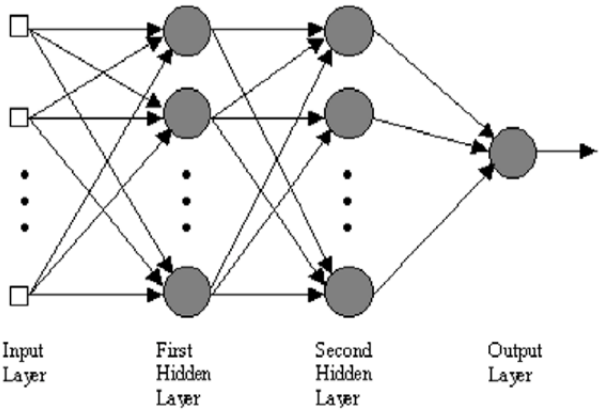

Fig. 4*:* Multilayer Feedforward Neural Network Model

The Fig. 4 shows multilayer feedforward neural network model. It consist of one input layer, an output layer and one or more than one hidden layers. Input layer receives signal from the environment, then it is passed to hidden layer, where the processing of signal is performed, it is transferred to output layer. The activation function used here according to linear and nonlinear activation function.After input/output mapping a desired result is generated.

4. TRAINING/LEARNING FUNCTION

We used 'trainlm' function for training of two link serial chain manipulator. Feedforward backpropagation algorithm is used here. 15 neurons are used in the hidden layer. Two layers are used in the network. The logistic function is used as trnsfer function.

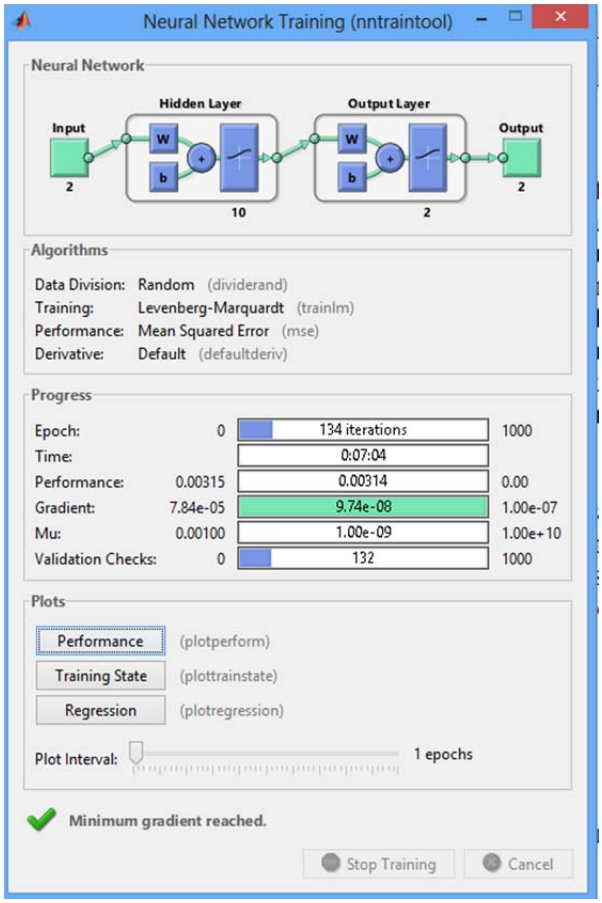

Fig. 5*:* Neural Network Training State

5. RESULT

Here, neural network is used in MATLAB for the training of two link serial chain manipulator. The network is trained usin input data, which results in performance plot, regression plot. The neural network training state shown in this paper. The maximum number of epoches used for training is 1000, whereas the minimum gradient reached at epoch 134. The whole data is devided into three parts that is training purpose, tesing pupose and valiidation.

6. CONCLUSION

Inverse kinematics problem is one of the most complex problem in rel world calculation. The artificial neural network is based on input and output maping that is used to determine the structure and parameters of the model. Aritifical nerual network updated itself to achieve better result.

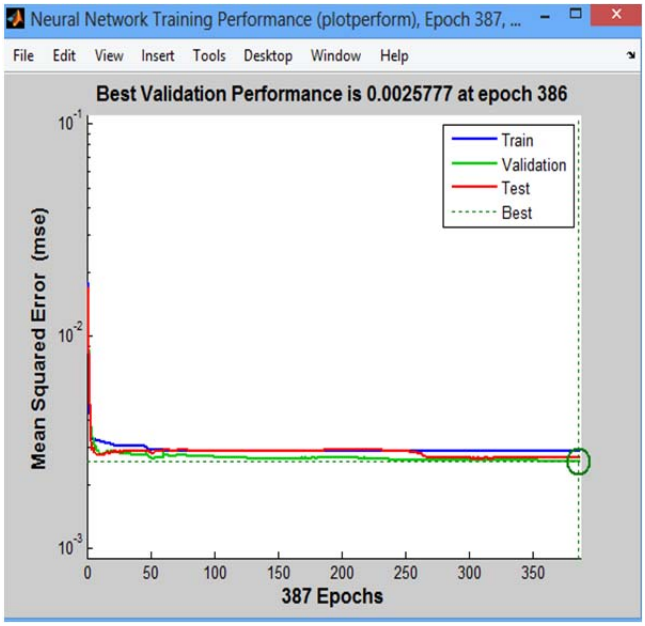

Fig. 6*:* Performance Plot

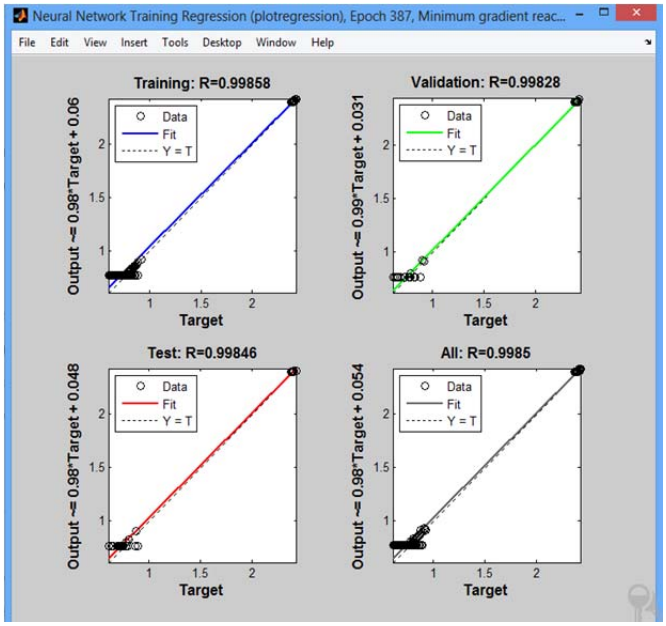

Fig. 7*:* Reggression Plot

7. FUTURE WORK

There are many methods available for solving inverse kinematics problem in aritificial neural network. In this paper, trainlm is used as a training function but there are many soft computingmethods available to train the two link serial chain manipulator. Application of fuzzy inference system, adaptive network basd fuzzy inference system, evaluation compution are the methods that author will use in fututre to train two link serial manipulator.

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