Solving Indirect Kinematic Problem Using Clonal Selection

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***Abstract*—The problem of articular angles' estimation for serial manipulators comprises the study of the relations between joint variables and Cartesian variables. We distinguish two problems, commonly referred to as the direct and kinematic problems. The former reduces matrix multiplications, and poses no major problem. The inverse kinematic problems, however, is more challenging, for it involves intensive variable-elimination and nonlinear-equation solving. In this work,we have used the Artificial Immune System to solve the inverse problem on a manipulator arm, to determine its various articulations. The results of simulation are presented to show the validity of the approach suggested above.**

Keywords- Artificial Immune System; estimation; articular angles' Problem; manipulator.

INTRODUCTION

In robotics, to determine the various articulations of arm is significant and essential, which is even used for prediction of Protein's structures [1]-[9]. The problem consists in finding the parameters which bring the final point to a wished situation, being given a configuration of the arm with chains series and the final point. The problem is so difficult because it requires resolution of a system of nonlinear equations, and the difficulty increases with the number of bonds in the chained structure. There is not a general analytical method to circumvent this problem.

Numerous solution strategies have been proposed for the Inverse Kinematic Problem, such as Distance Matrix Completion [10], Characteristic polynomial, Dyalitic elimination, Genetic Programming, Intelligent Algorithm, and Wavelet Networks [2]. We present a new approach, Artificial Immune System, to solve this problem without constraint or restrictions on structure of the arm.

This work is organized as follows. Some concepts of the robotic are given first, after we construct the Artificial Immune System and finally we discuss the results of the application.

ROBOT MANIPULATOR

A robot is a combined mechanical, electronic, and computer system that follows a simple cycle of commands and task execution for operation. First, the computer learns environmental information from its sensors. Based on this iThese commands are sent to the mechanical system, which executes the task, and the cycle repeats, all actions of the robot have to be continually monitored to correct deviations from the planned trajectory formation and the task to be accomplished, computer algorithms calculate appropriate commands for the motors.

The range of motion of each manipulator is called working space. The manipulator is normally connected to a base (floor, ceiling, operating table, etc) and composed of a succession of joints and links (appendages). The instrument with which the robot performs the desired task is attached to the last link of the arm and is referred to as the end-effector. An end-effector can be a needle, grasper, scalpel, etc.

Our model of robot is PUMA560 with 6 joints angles Q(Q1, Q2, Q3, …,Q6), and we must find them for a given position M(x,y,z) in Cartesian space[8]. Here is the pseudo code of it:
Input: position to be reached (M)
Output: values of the parameters of the articulations
Q= vector of model parameters
Q = (Q1, Q2, Q3, …,Q6) Find Q subject to:
f(Q)-M=0
which brings back us to min ||f(Q)-M||.

ARTIFICIAL IMMUNE SYSTEM

Artificial Immune System AIS is a model of the immune system that can be used by immunologists for explanation, experimentation and prediction activities that would be difficult or impossible. This is also known as ‘computational immunology’. The study and design of artificial immune systems (AIS) is a relatively new area of research.

That tries to build computational systems that are inspired by various aspects of the immune systems of mammals. Who protect the body from attack of foreign or non-self organisms (called antigens), it has the ability to distinguish between self and antigens [4]. The various algorithms developed in are Negative Selection, Immune Network, and the Clonal Selection, which we employed in this paper.

3.1 Innate immunity

Innate immunity, which is also known as nonspecific immunity, refers to the defense mechanism against foreign invaders that individuals are born with [5].

3.2. Adaptive Immunity

Adaptive immunity, also called acquired or specific immunity, represents the part of the immune system that is able to specifically recognize and selectively eliminate foreign microorganism and molecules (antibodies) [6].It is important to note that the acquired immunity does not act independently of the innate immunity; on the contrary, they work together to eliminate foreign invaders.

3.3 Clonal Selection

The Clonal Selection principle describes the basic features of an immune response to an antigenic stimulus. It establishes the idea that only those cells that recognize the antigen proliferate, thus being selected against those that do not.

The main features of the Clonal Selection theory are that
The new cells are copies of their parents (clone) subjected to a mutation mechanism with high rates (somatic hypermutation);

- Elimination of newly differentiated lymphocytes carrying self-reactive receptors;
- Proliferation and differentiation on contact of mature cells with antigens [7]-[11].
- Our algorithm is based on the clonal selection modeling the fact that only the highest affinity antibodies to the antigens will proliferate. Our algorithm uses it to perform a function approximation.

Here is the algorithm :
Antibody: $\mathbf{x}=\{\mathbf{x_1, x_2, ..., x_N}\}$ (x_i structure representing solution)
Initialize the population of **Ab**(random);
Repeat
For every antibody **Ab**
Evaluate the function of adjustment **f**;
End;
Sort population **Ab** according to adjustment;
Choose **n** (n<N) the best antibodies from population **Ab**
to a new population **Abn**
For every antibody **Abn**
Cloning;
Hypermutate;
Evaluate the function of adjustment **f;**
End;

Sort population **Ab** according to adjustment; Choose **N-n** (new individuals) from population **Abn** and replace individuals with low adjustment in population **Ab** by them;
While (the maximum number of iterations OR the smallest error is not reached)
Solution= the best antibody from **Ab** [12]-[13].

IV. Results And Discussion

Simulation on the PUMA560 arm was made with Pentium 4 processor given 1.8GHz frequency, with 40GO HDD, 1GB of RAM, and under Mat lab 7. Above all, we present the result found with Wavelet Network in 2006[4]:

TABLE I. TABLE TYPE STYLES MEAN SQUARE ERROR WITH WAVELET NETWORKS

Error	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6
$*10^{-3}$	0.276	0.144	0.029	0.259	0.198	0.151

We implemented Artificial Immune System AIS under parameters shown Table II:

TABLE II. AIS PARAMETERS

Parameter	Generation	Mutation Probability	β
Value	400	0.001	0.1

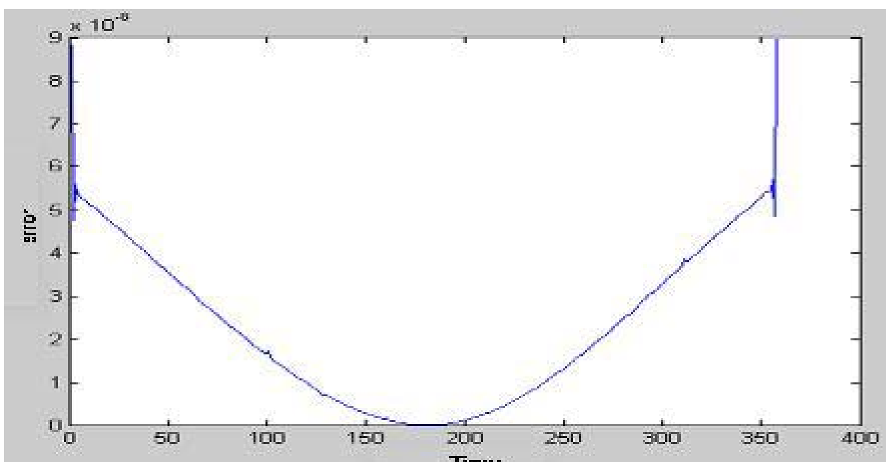

Figure 1. Test of AIS on Q1

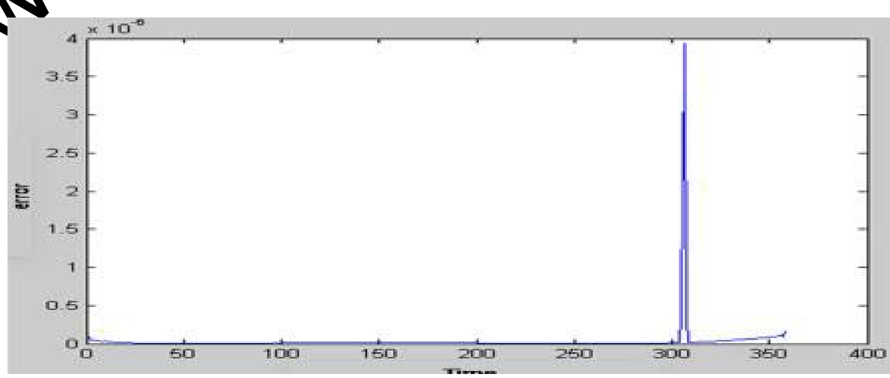

Figure 2. Test of AIS on Q2

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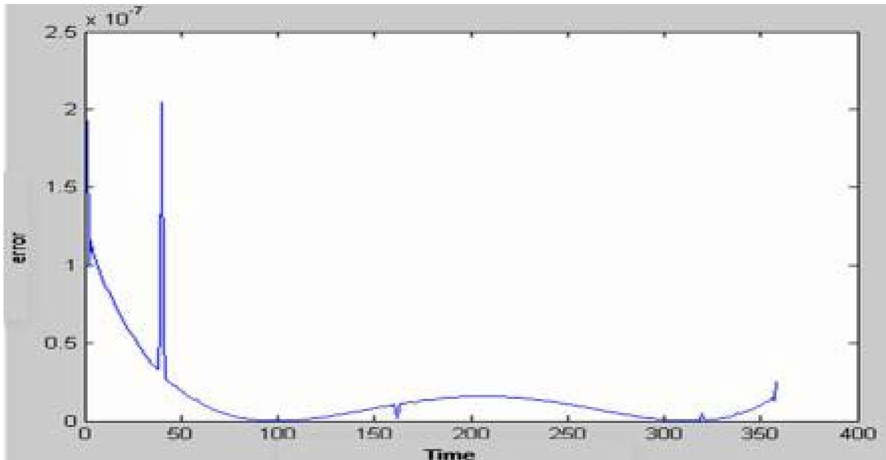

Figure 3. Test of AIS on Q3.

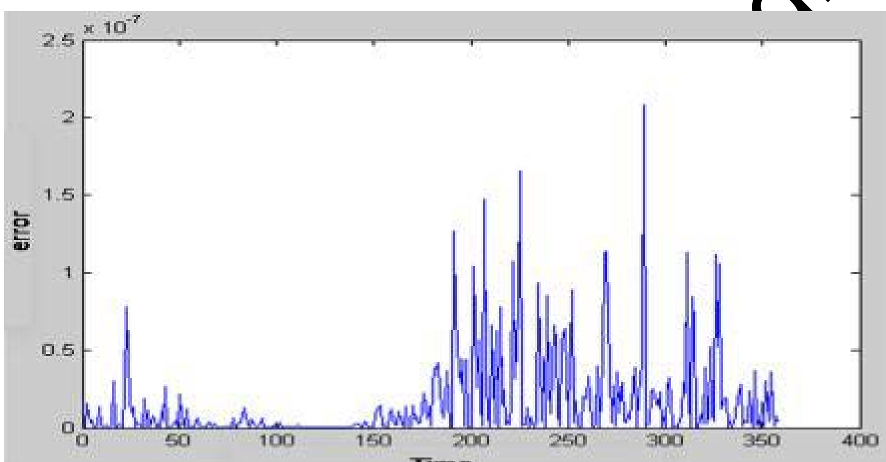

Figure 4. Test of AIS on Q4

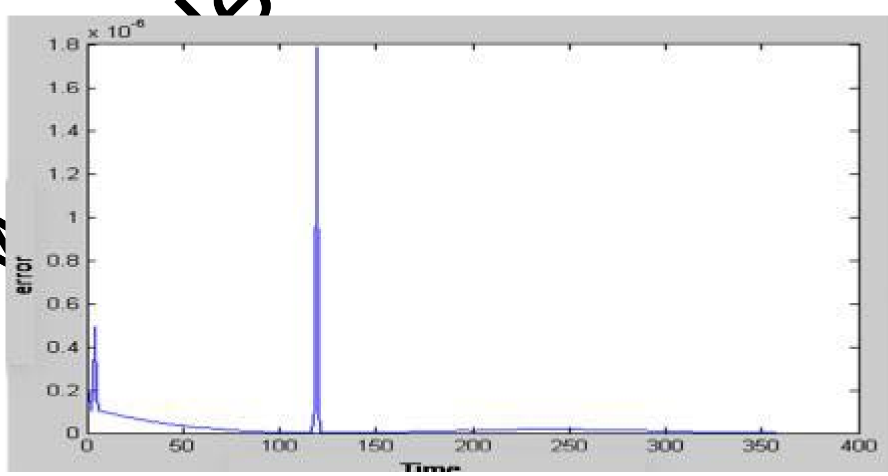

Figure 5. Test of AIS on Q5.

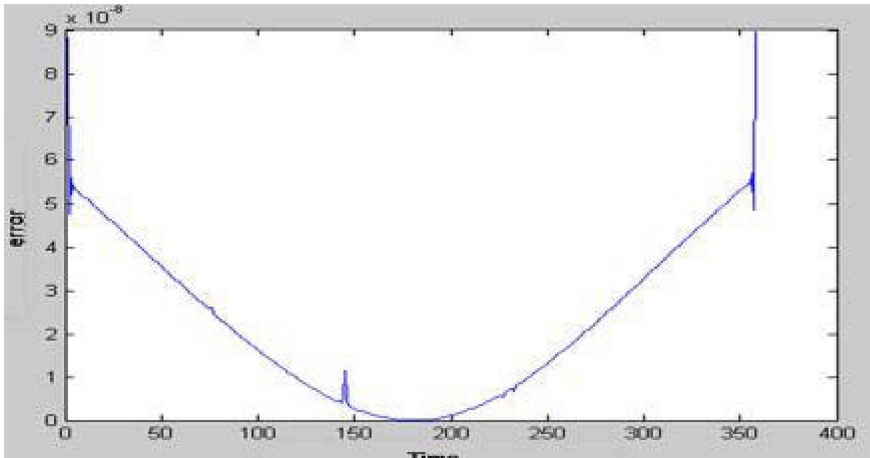

Figure 6. Test of AIS on Q6

At first sight, all errors are between 10^{-7} and 10^{-8}, which is satisfactory compared to the method seen up.

For Q_1 and Q_6 there is a reduction in error before time=200 but after it starts went up, while for Q_2, Q_4 and Q_5 it has almost stabilization for the error.

CONCLUSION

According to experimentation made on PUMA 560, we notice that AIS used previously gave satisfying results comparing it with Wavelet Network. As a prospect, we suggest to implement it in the robot controllers.

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