Prediction of Fault Tolerance in Automatic Manufacturing Process Based on Robotics Control System

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ABSTRACT

In this paper we modified the process of fault tree analysis in automatic manufacturing industries. The automatic production system fulfils the high rate of customer demand and supply. The working of high speed robot occurred some fault and error problem in production process. These fault and error process effect the rate of production and deceases the reliability factor of industries. For the improvement of reliability and diagnoses of fault various model and methods are used such as fault analysis tree, fault analysis and management and Markova model process of production. Failure of the robot results in production line down-time and, in some cases, damage to the product that is being processed.

Keywords: - FTA, Robotics, automatic production, Tree, ACO

INTRODUCTION

Manufacturing systems consist of human workers, automation, and various material handling technologies, configured in ways that create specific manufacturing system typologies. More specifically, a manufacturing system is a collection of integrated equipment and human resources, whose function is to perform one or more processing and/or assembly operations on a starting raw material, part, or set of parts. Our focus in this unit is upon manufacturing systems that are said to be automated, and so concentration will be put upon the types of integrated equipment that is used and arranged in a manufacturing cell. This can range from production machines and tools, material handling and work positioning devices, to the use of various computer systems that facilitate automation in the production environment. [1]. In the rest part of this research paper, in the section we described fault path selection based on ant colony optimization, in this section III discussed the proposed model, in the section IV simulation & result analysis its model and finally discussed the conclusion of our research.

II. FAULT PATH SELECTION BASED ON ANT COLONY OPTIMIZATION

The idea for motion planning in Cspace is to ‘grow’ C-space obstacles from physical obstacles while shrinking the industrial robot robot down to a single point. In the cell decomposition approach to motion planning, the free C-space in the robot environment is decomposed into disjoint cells which have interiors where planning is simple. The planning process then consists of locating the cells in which the start and goal configurations are and then finding a path between these cells using adjacency relationships between the cells. Fault Detection and Avoidance plays a vital role in industrial robot robot applications. Algorithms are used to achieve this. This Fault Detection and Avoidance is also employed in various other applications like simulated computer games, unmanned vehicle guidance in military based applications, etc. In these applications the Fault detection strategy is achieved by checking whether the objects overlap in space or if their boundaries intersect each other during their movement. The obstacle avoidance problem for robotics can be divided into three major areas. These are mapping the world, determining distances between manipulators and other objects in the world, and deciding how to move a given manipulator such that it best avoids contact with other objects in the world. Unless distances are determined directly from the physical world using range-finding hardware, they are calculated from the world model that is stored during the world mapping process. These calculations are largely based on the types of objects that are used to model the world. GJK supports mappings for reading the geometry of an object. A support mapping fully describes the geometry of a convex object and can be viewed as an implicit representation of the object. The class of objects recursively constructed are • Convex primitives

- Polytopes (line segments, triangles, boxes and other convex polyhedra)
- Quadrics (spheres, cones and cylinders)
- Images of convex objects under affine transformation
- Minkowski sums of two convex objects
- Convex hulls of a collection of convex objects
- Convex Polyhedra and Fault Detection

ANT PATH SELECTION PROCESS

Suppose ants find data points of similarity in continuous root. Every ant of data points compares their property value according to initial data point set. When deciding data is noise and outlier, we should consider two factors: importance degree and easiness degree of noise and outliers. While walking ants deposit pheromone on the ground according to importance of the outlier and follow, in probability pheromone previously laid by other ants and the easiness degree of the noise.

Let D be the fault section and m be the number of ants, importance degree $a_1, a_2,\ldots, a_n$ is c_1, c_2 ,c_3 ……………..c_n, the appetency of solutions searched by two ants is defined as

$$\text{App (i, j)} = \frac{1}{Ci-Cj}\text{………………………..(1)}$$

where c_i and c_j is the importance of noise and outlier path. The concentration of the solution (1) is defined as

$$\text{Con (i+j)}=\frac{\delta i+\delta j}{m}\ \text{……………………….(2)}$$

where δ_i and δ_j is the number of ants whose appetency with other ants is bigger than α; α can be defined as m/10, then the incremented pheromone deposited by ants is

$$\Delta\tau_i = Q.\beta_i\ /\text{Con (i+j)……………………(3)}$$

where Q is constant.

Each level of pheromone modeled by means of a matrix τ where $\tau_{ij}(t)$ contains the level of pheromone deposited in the node i and j at time t, ant k in node i will select the next node j to visit with probability,

$$p_{ij}^k(t) = \begin{cases} \dfrac{[\tau_{ij}(t)]^\alpha.[\eta_{ij}]^\beta}{\sum_{l\in J_i^k}[\tau_{il}(t)]^\alpha.[\eta_{il}]^\beta} & if\ j \in J_i^k \quad (1) \\ 0 & otherwise \end{cases} \quad \text{….(4)}$$

where η_{ij} represents heuristic information about the problem which can be defined as the easiness of the path. The heuristic desirability of traversal and edge pheromone levels are combined to form the so-called probabilistic transition rule is given in equation (4), denoting the probability of an ant at data point i choosing to travel to data point j at time t.

Direct search in the best solution need global update rule applied as:

$$\tau\,(t+1) = (1-\rho).\ \tau_{ij}\,(t) +\ \rho.\Delta\ \tau_{ij}\text{…(5)}$$

where, $\rho(0 < \rho \leq 1)$ is a parameter that control the pheromone evaporation.

The steps of the proposed ACO based data preprocessing procedure for fault (FAULT-ACO) are as follows:

Step 1: Initialization of ants and degree of importance for the acceptance of data point selection: The appetency of solutions searched by two ants is defined as

$$\text{App (i, j)} = \frac{1}{Ci-Cj}\text{……………………..(1)}$$

where c_i and c_j is the importance of noise and outlier path.

Step 2: Find the acceptance solution on given parameter of degree of acceptance: The concentration of the solution (1) is defined as

$$\text{Con (i+j)} =\frac{\delta i+\delta j}{m}\ \text{……………………….(2)}$$

where δ_i and δ_j is the number of ants whose appetency with other ants is bigger than α; α can be defined as m/10, where m is the number of ants.

Step 3: Check the acceptancy of the data point and update the value of pheromone with amount of $\Delta\tau_i$: the incremented pheromone deposited by ants is

$$\Delta\tau_i = Q.\beta_i\ /\text{Con(i+j)……………………….(3)}$$

where Q is constant.

Step 4: Generate the data point selection matrix after the increment of pheromone value and selected data points: Each level of pheromone modeled by means of a matrix τ where $\tau_{ij}(t)$ contains the level of pheromone deposited in the node i and j at time t, ant k in node i will select the next node j to visit with probability,

$$p_{ij}^{k}(t) = \begin{cases} \dfrac{[\tau_{ij}(t)]^{\alpha}.[\eta_{ij}]^{\beta}}{\sum_{l \in J_i^k}[\tau_{il}(t)]^{\alpha}.[\eta_{il}]^{\beta}} & if\ j \in J_i^k \quad (1) \\ 0 & otherwise \end{cases} \quad …….(4)$$

where η_{ij} represents heuristic information about the problem which can be defined as the easiness of the path (η_{ij} is the heuristic desirability of choosing data point j when at data point i), J_i^k is the set of neighbor nodes of node i which have not yet been visited by the ant k. $\alpha > 0$, $\beta > 0$ are two parameters that determine the relative importance of the pheromone value and heuristic information, and $\tau ij(t)$ is the amount of virtual pheromone on edge (i,j).

Step 5: Iterate and check data point matrix for processing of FAULT mapping: Direct search in the best solution need global update rule applied as:

$$\tau(t+1) = (1-\rho).\ \tau_{ij}(t) + \rho.\Delta\ \tau_{ij}……(5)$$

Where $\rho(0 < \rho \le 1)$ is a parameter that controls the pheromone evaporation?

Step 6: Finally, data point matrix is passed to FAULT algorithm for obtaining final clustering results.

III PROCESS MODEL

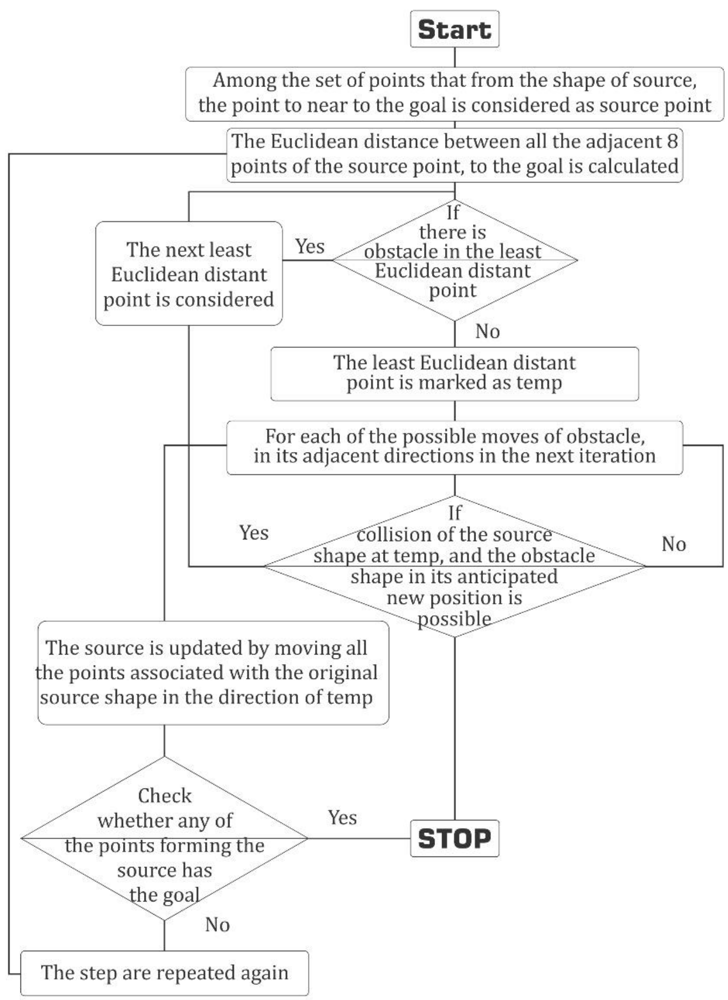

Figure 1: shows that path selection process of fault analysis.

IV SIMULATION & RESULT ANALYSIS

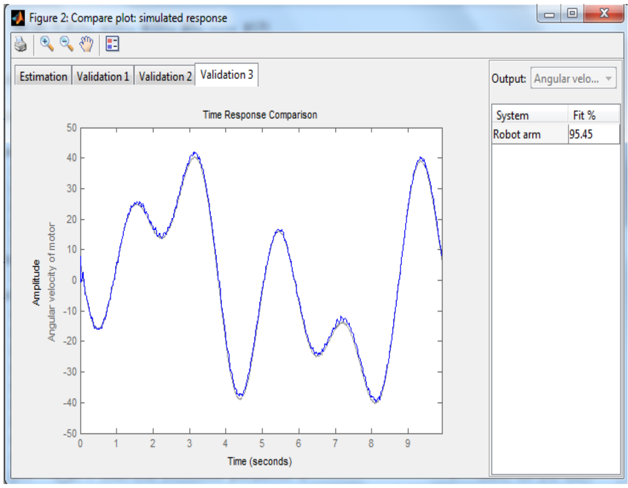

Figure 2 : shows that the data amplitude and time respone of robot arm for validation of fault occured in the process of automatic manufacturing and the change the value of fault path with certain amount of constant.

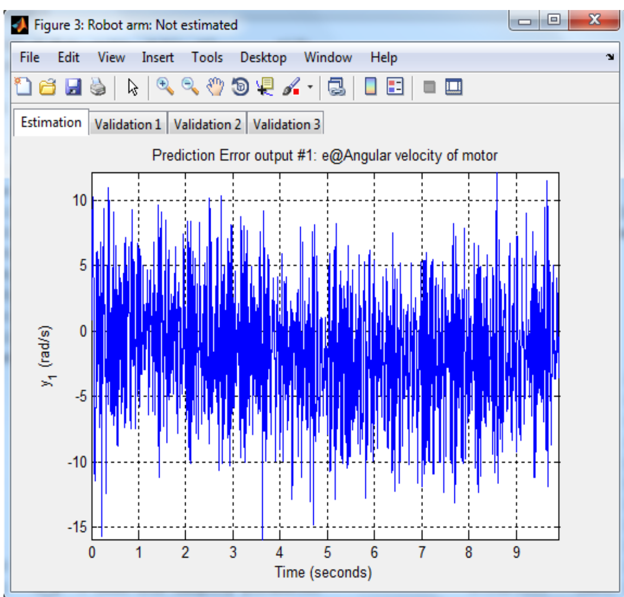

Figure 3: shows that the data of angular radiation of robot arm with fault time process in automatic robot process.

METHOD OF FAULT ANALYSIS	PATH SELECTION	PATH LOSS
FTA	13	9.0567
FTA-ANT	13	7.890
FTA	9	8.670
FTA-ANT	9	6.789

Table 1: show that the comparative analysis of path selection and path loss.

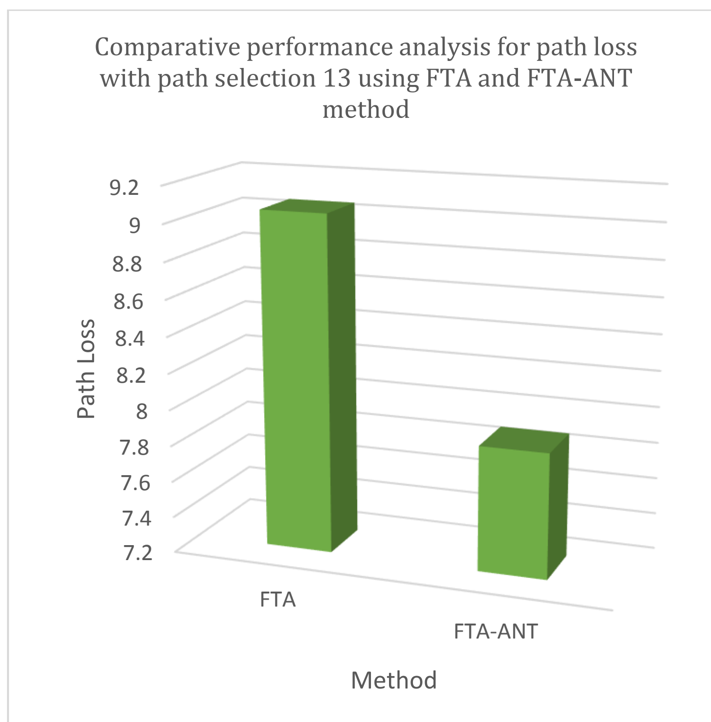

Figure 4: shows that comparative result analysis for fault analysis using FTA and FTA-ANT. The loss of fault path decreases in ant process in compression of FTA.

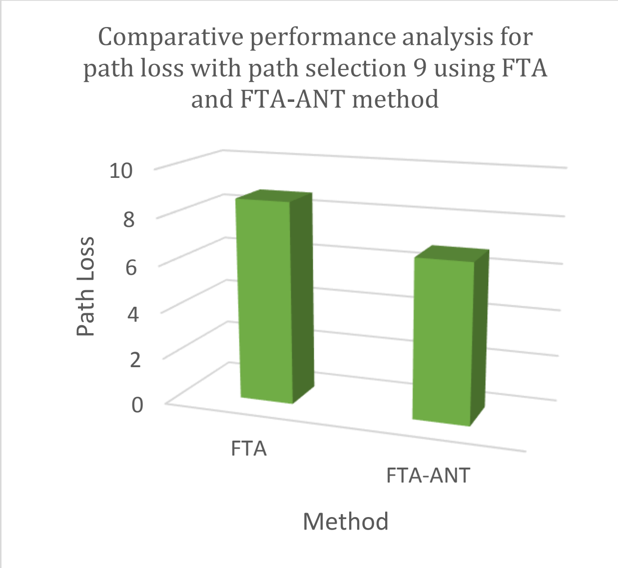

Figure 5: shows that comparative result analysis for fault analysis using FTA and FTA-ANT. The loss of fault path decreases in ant process in compression of FTA.

V CONCLUSIONS & SUGGESTIONS FOR FUTURE WORK

In this paper we applied ant colony optimization analysis in the pre-processing of data used in the fault diagnostics of industrial robots. The output of FTA was then used as the input of an Ant Colony System classifier whose output predicts the state of the industrial robot. As states we considered the normal operation and 5 faulty conditions which are: brake drag (high &medium), collision (hard & soft) with external obstruction and incorrect motor commutation (phase angle). Verification of the proposed algorithm was performed off-line using experimental data obtained from an industrial robot used in the semiconductor manufacturing industry. The FTA was excellent for data reduction and capturing the required features of the signal needed for the Ant Colony System training. The experimental results showed that the Ant Colony System classifier had a very high fault detection success rate (around or above 90%) for all faults. However, it showed difficulty distinguishing between the hard and soft collisions. Combining these two relevant faulty conditions into one fault that of just "collision" the Ant Colony System based classifier achieves a high rate of success for that fault too. Now in current scenario growth of automatic manufacturing industries is increase. The high-speed production for customer demand supply and reliability of manufacturing need a fast process of fault analysis for starting a process of production.

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