Simulating a Robotic Flexible Assembly System with Petri Net and Fuzzy System

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Abstract— The integration of design and planning of flexible assembly system (FAS) has been recognized as a tool for achieving an efficient model in a production environment that demands assembly with a high degree of flexibility. For this design and planning a concurrent intelligent approach and framework must be the propose for design of robotic flexible assembly system. The principle of the proposed approach is based on the knowledge of Petri net formalism by incorporating Petri net with artificial intelligent or fuzzy net. The complex assembly systems are modeled and analyzing by adopting a formal representation for dynamic behaviors of the system through knowledge on using the Petri net modeling for the analyzing of simulations. A template is first define for a knowledge Petri net model, and then the models for assembly system individual are established in the form of instance of the template. The design of assembly system is implemented through a knowledge based Petri net –function-behavior-analysis and evaluation, as well as the layout optimization of the flexible assembly system in an integrated intelligent environment. The integration of assembly design and planning process can help to reduce the processing time of assembly system.

I. Introduction

Quality characteristics, such as surface finishing of a produce manufactured by a CNC milling machining center are important aspects in order to accept or reject the product. The inclusion of the product quality specification in the machine control algorithm would be advantageous. Quality is a measured quantity and usually can be described by linguistic variables such as high, medium, or low. This implies that it can be modeled and controlled by fuzzy roles. In essence, then, fuzzy logic controllers can be considered as an algorithm that converts the fuzzy rules into an output control action. Fuzzy logic controllers are capable of maintaining vague and uncertain situation in an efficient manner. Thus, fuzzy logic can be incorporated with Petri net has been used to model imprecise and uncertain situation that can arise within automated manufacture system. [1],[2],[5].

Petri net has the capacity for the modeling and planning of FAS. The place, transition, and token movement together provide the specification of resource constraints and graphical representation of serial and concurrent events for assembly systems. Petri net can overcome the problems stated above. However, the major difficulty with ordinary Petri nets is that industrial applications are likely to result in large system consisting of many places and transitions. There have been many reports of Petri nets applications in the representation, analyze and control of FAS [3].Petri nets have been used to model robotic or assembly processes so that sequence of operation is generated based on the Petri net model.

Clearly explain the nature of the problem, previous work, purpose, and contribution of the paper.

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II. Primary Knowledge About Petri net

By incorporating the ordinary place/transition Petri net model into a knowledge-based system through object-oriented programming techniques, knowledge embedded Petri net model can be defined as, KPN=(P,T,I,O,K),where (P,T,I,O) is a finite Petri net. $k = K_P \cup K_T$, where $k_P : P \rightarrow k(P)$ the mapping from place set P to place knowledge is set K (P). $k_T : T \rightarrow k(T)$ Mapping from transition set T to transition knowledge set K (T).K (p) and K (t) are the set of knowledge associated with place $p \in P$ and transition $t \in T$. P is a finite set of places and T is the finite set of transition.

III. FAS Modeling and Analyzing Knowledge Petri Nets

It is known that the dynamic behaviors of FAS can be modeled by petri net [4].during the assembly system development process, the description of FMS is completed by specifying the confections between resource, and merging behavioral rules between interconnected resources, synchronizing transition from the petri net viewpoint. Therefore, the procedure for concurrent modeling and analysis of assembly systems can be outline as:

(i) Model abstraction and specification for isolated entities; (ii) merging isolated entities to create a complete model; (iii) inclusion of job or operation priority rules; and (iv) the model verification and validation. Following these step, the designer can use the rule-petri net integration approach [6] to create the petri nets for FAS.

IV. GENERATION OF KNOWLEDGE PETRI NET MODEL FOR FAS

As it was similarly explained, main object to take advantage of petri net modeling the process and reel of a system for perception matter in hand and examination problems and good points in the modeled system. By utilize this modeling we can control different point of system from the view point of process time, how to work and etc; and take a good decision.[7]

This work wants to model a robot that contains several machines and works simultaneously. Robot can choose a special part of job between many parts by paying attention to special condition and send this part to machine that have high compatibility with chosen part. Some of this condition includes is: a) waiting time of part to machinery, b) machine idle time, c) the number of line in the input gate and d) the importance of quality and structure of part.

Fig 1 shown a robot with several machine and tree input line. Fig2 show petri net model of a robot that consider above.

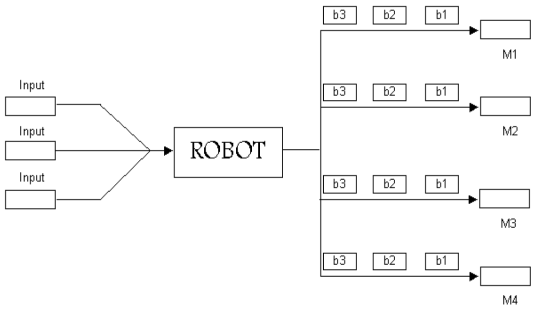

Fig1. Robot with several machine and tree input line

P1, p2, p3: part come and wait for choice by robot, p5, p6… p16: buffers. T1, T2, T3: parts sending to robot, T4, T5… T15: parts sending to buffers and T16, T17, T18: parts sending to machines. In fig 2 robot can not choose a part by consider compatibility between part and machine. When robot sense that one input buffer is empty, immediately send one part to empty buffer. Consequent chosen part maybe no compatible with machine and cause failing in machine or broken in machining process. In order to avoid these problems, robot must be able to consider several parameters to choice best part to suitable machine for machining.

V. FUZZY LOGIC IN THE FAS SYSTEM

In order to reduce the probability of part failure and machine corrosion, we can define several criteria for robot to choose the best part type for the best machine. Robots can choose part by paying attention to special criteria that are defined by user. These criteria contain compatibility part with four machines (cpwm), rate of part value (rpv) and etc. in this work we define 5 type of part by rpv= [.9 .65 .45 .25 .65], compatibility part1 with machine(cp1wm)= [.8 .5 .4 .3], cp2wm= [.8 .6 .6 .4], cp3wm= [.8 .5 .6 .4], cp4wm= [.3 .4 .6 .8]. cp5wm= [.4 .4 .6 .6]. The rpv vector indicates that part type 1 has an excellent value, part type 2 and 5 has a good value, part type 3 has a middle value and part type 4 has a bad value. The cp1wm shows that part type 1 has the excellent compatibility with machine1, good compatibility with machine 2, middle compatibility with machine 3 and bad compatibility with machine 4.thus if part type 1 send to machine 1, we have excellent machining work and conversely if send to machine 4, may be fail and damage machine. Now by attention this 4 vector can define 16 rules for selecting parts for sending to machine:1) if part value (p.v) excellent and compatibility (comp) very high then select machine1, 2) if p.v excellent and comp high then select machine 1,3) if p.v excellent and comp low then select machine 2, 4) if p.v excellent and comp very low then select machine 4, 5) if p.v good and comp very high then select machine 1, 6) if p.v good and comp high then select machine 2, 7) if p.v good and comp low then select machine 2, 8) if p.v good and comp very low then select machine 4, 9) if p.v middle and comp very high then select machine 2, 10) if p.v middle and comp high then select machine 4, 11) if p.v middle and comp low then select machine 4, 12) if p.v middle and comp very low then select machine 3, 13) if p.v bad and comp very high then select machine 4, 14) if p.v bad and comp high then select machine 3, 15) if p.v bad and comp low then select machine 3 and 16) if p.v bad and comp very low then select machine 3. For example if part value 0.71 and compatibility 0.25, by number 3 rule, machine 3 is the best choice. In this work consider very important point in simulation that helps me to simulate system in the best condition. In the simulation we consider that when each machine start to machining for a long time, compatibility with part type reduce and they need to servicing .this reduce in compatibility simulated in model and help me to obtain the best consequence.

VI. THE ACCOMPLISHMENT SIMULATION WITH PETRI NET AND FUZZY NET

In execution program primarily was defined a matrix of machining time (m.t) for different part type that used in simulation and vector of part expense (p.e) for accounting expenses.

$$m.t = \begin{bmatrix} 0.9 & 1.1 & 1 & 1.3 & 1.2 \\ 1.2 & 1.4 & 1.3 & 1.6 & 1.5 \\ 1 & 1.2 & 1.1 & 1.4 & 1.3 \\ 1.5 & 1.7 & 1.6 & 1.9 & 1.8 \end{bmatrix}, \quad p.e = \begin{bmatrix} 1 & 0.9 & 0.3 & 0.6 & 0.9 \end{bmatrix}$$

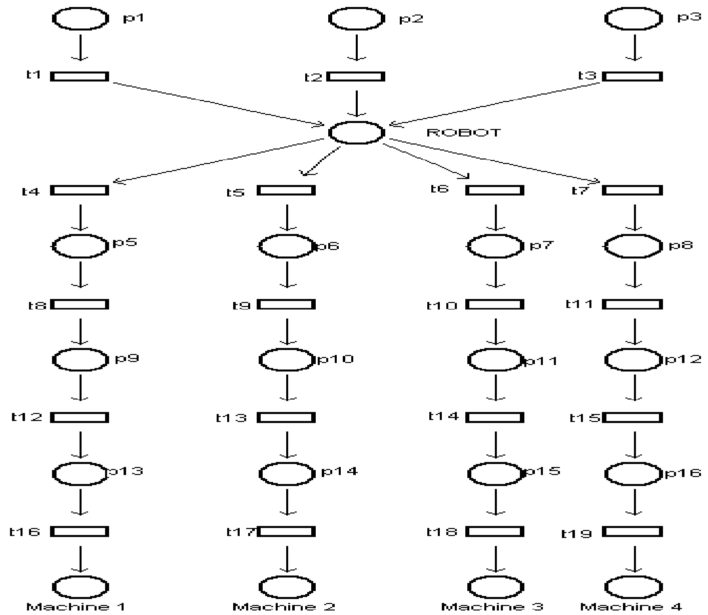

Fig2. Petri net model of a robot

Where each row of matrix m.t is the number of machine and each column is the number of part.

The FAS system simulated by 1000 different part types in tree states: a) robot has not buffer and when part entered, immediately send to machine, b) robot has buffer but can not decision to select proper part and c) robot consider rules to select proper parts (fuzzy).

Fig3. Petri net model of a robot with fuzzy system

The 3rd state was shown in fig 3. By paying attention to fig.3 robot exchange with fuzzy robot that can be abele to choice the parts by considering the rules that describe previously.

A. *Manner of Accounting Disadvantage*

a) If a part before gets into machine scraps then only accounting disadvantage related to parts.

b) Idling machine causes disadvantage that must be accounted for each machine.

c) If part after entering to machine escapes, it causes the machine corruption and must be accounted both part and machine scraps.

B. *Compare States and Conclusion*

By paying attention to consequences that shown in fig4 (part wait time), fig5 (wait time of machine), fig 6 (mean cost of part product), fig7 (mean cost of part scraps), and Fig8 (mean cost of machine damage).

The mean cost of machine damage can point to several consequences as: 1) as shown in fig 3, wait time of parts in first state less than the other states, because in this state the first input part, the first out parts. 2) As shown in fig 4, mean cost of part machining in 3rd state very little, because in 3rd state part was sent to machine by consider the special rules

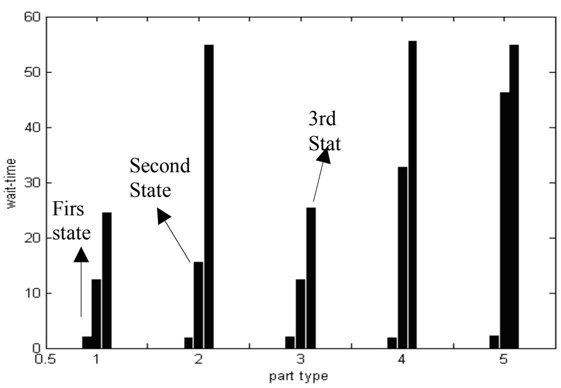

Fig4. Part wait time

that describe previously in this work. 3) In first and second state, part scraps risk is high, because parts selected without any criterion. 4) By attention to 3, cost of maintain and repair machines is very high. 5) In fuzzy state, part scraps risk is very low, thus probability of part scraps in machine reduced. 6) By attention to 5, cost of maintain and repair is very low.

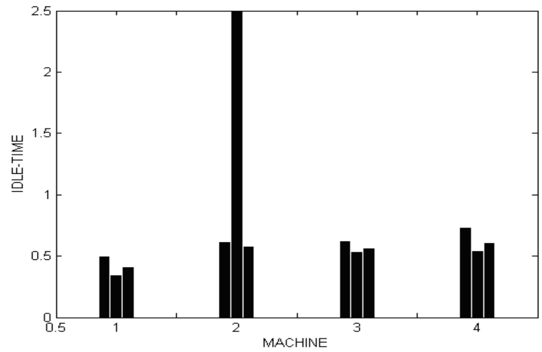

Fig5.Wait time of machines

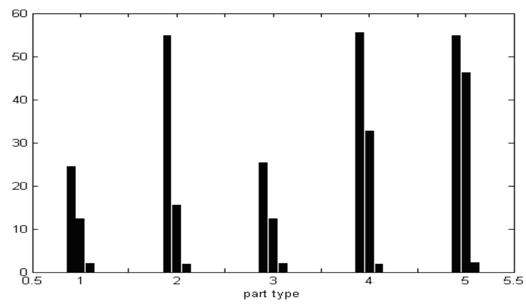

Fig6. Mean cost of part product

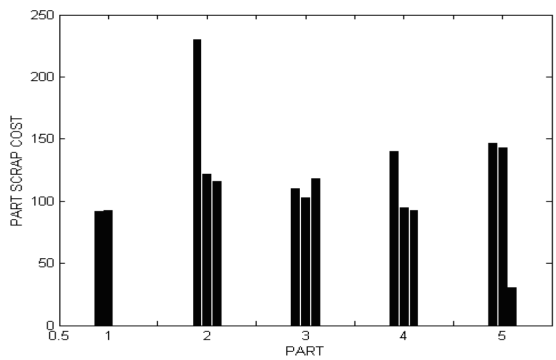

Fig7. Mean cost of part scraps

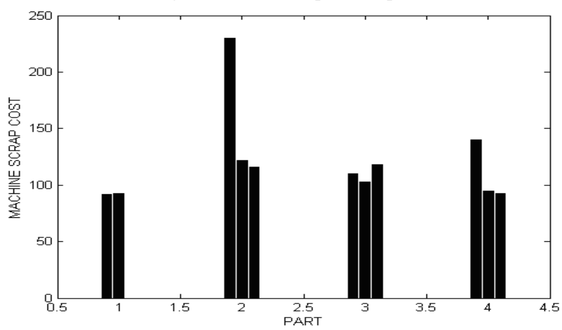

Fig8. Mean cost of machine damage

VII. Conclusion

these days, simulation science by paying attention to development of computer sciences and available efficient instrument, very important rules in FAS systems. In these paper trying to use computer instrument and simulation software (such as matlab, Petri net toolbox and fuzzy toolbox) to present usage model for simulation FAS system. We first model the simple system by Petri net and see that this model not good for real work and Then change model by defining 3 buffers in entrance robot and run again by Petri net and finally use fuzzy logic to obtain good result in simulation.

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