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A Real Time Dispatching Rule for Shuttle Cars in Linear Motor-based Transfer Technology System Using Fuzzy Logic

Xianhui Song · J. H. Seo** · S. H. Han** · K. S. Lee****

*,**,*** *Department of Electrical Engineering, Dong-A University, Busan 604-714, Korea*

ABSTRACT : *LMTT (linear motor-based transfer technology) is horizontal transfer system in the maritime container terminal for the port automation. For LMTT system, shuttle cars are used instead of other types of cars. They are running on the routes which are stable on the terminal ground made of steel. The terminal scheduling complexity increases with the need of improving automation. It is necessary to make a good designed performance for the terminal system. This work presents a dispatching rule using fuzzy logic for the shuttle cars. It considers the actual status of terminals and takes decisions on real time. A simulation is done to validate the rule and two other dispatching rules to be compared.*

KEY WORDS : *Dispatching rule, LMTT shuttle cars dispatching, LMTT shuttle cars, Fuzzy systems*

1. Introduction

LMTT is recently been considered for cargo handling by Noell Company. The runways are pre-built, parallel and orthogonal one to another for the yard. On the runways shuttles are conducted fully automatically both lengthwise and crosswise.

They comprise a base frame and a loading platform and equipped with double wheel sets which can be rotated through 90 for the carrying and guiding functions and permanent magnet strips for the transmission of the driving power.

For a terminal, there are a high number of elements like: quay cranes, yard cranes, vehicles, etc. All the elements need to work on a synchronized way and having a common target. One of the most important elements is transport part of the terminal, using for example shuttles. There are a lot of requests given by different cranes and it is not easy to decide for a shuttle which request it should serve, mostly if we intended to achieve a defined performance.

The terminal scheduling contains a series of complex problems and vehicle dispatching is a classical one among them. There are some dispatching techniques using single rule and composed ones, where the main idea is to consider a good performance for the system. It is known that there is a considerable quantity of variables that can interfere to achieve a desired performance, like task distance, waiting time, traveling time, etc.

This work proposes a fuzzy dispatching rule using three variables for the shuttles' dispatching and validates the rule by simulations.

2. Proposed Fuzzy Dispatching System

The main purpose of this approach is to improve the efficiency and the productivity of the terminal. The proposed system is based on the Mamdani model and has the main elements or functions: Input variables definition; Fuzzy sets and membership fucnctions; Rule base; Input variable mapping or fuzzyfication; Inference; Defuzzification.

2..1 Input Variables

The variables of the proposed fuzzy dispatching system are:

- Waiting Time (W)
- Distance (D)
- Node Number (N)

W is the waiting time of the shuttle cars at the yard stacks before the yard cranes and it intends to minimize the whole process time. D is the distance between the shuttle cars and the quay cranes/ yard cranes, and it is for minimizing the travel time. N is the node quantity between the shuttle cars and the quay cranes/ yard cranes that need a transfer. Node quantity between the shuttle cars and the quay/ yard cranes. In [4], the authors employed node number for their dispatching rule. This variable is for penalizing a transfer where there are too many nodes in the path, because the shuttle car may stop at a node to wait for a free path. Here we adopt it in our dispatching rule. It is common in terminals that shuttle cars with different directions run for one crossover. At this condition in the LMTT system, only one shuttle car can go ahead at the time, others must wait until it passes the node. Through in the following simulation model the directions of the lanes are chosen, there also will be the condition given in Fig. 1. So we choose N as one variable of our rule.

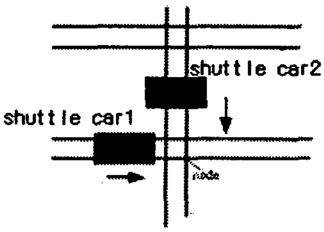
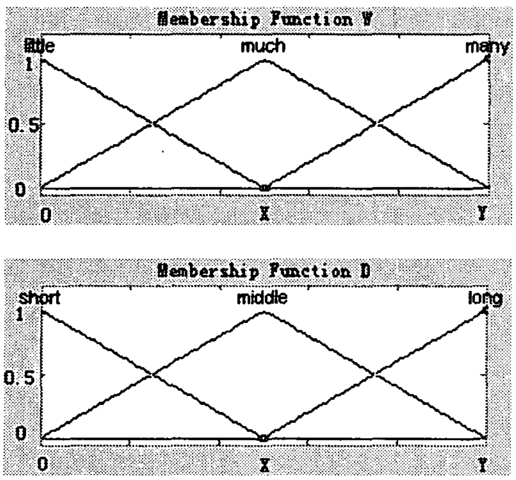


Fig. 1 Nodes, path, zones

2.2 Fuzzy Sets

The fuzzy sets are waiting time, distance, node number and priority. The membership functions (Fig. 2) are described as below:



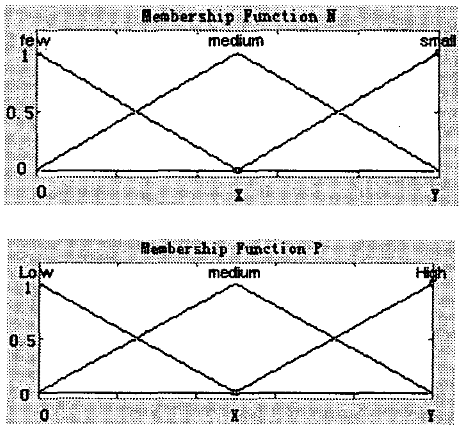


Fig. 2 Membership Functions of W, D, N and P

2.3 Rule Base

In order to combine the fuzzy values associated to each variable, it is necessary to construct a Fuzzy Rule Base composed of all combinations of the linguistic values. The rule sets were defined by experts and it is shown below:

Table 1 Rule Base:

Rule	W	D	N	P
1	little	short	few	high
2	little	middle	few	medium
3	little	long	few	medium
4	much	short	few	high
5	much	middle	few	low
6	much	long	few	low
7	many	short	few	medium
8	many	middle	few	low
9	many	long	few	low
10	little	short	medium	high
11	little	middle	medium	medium
12	little	long	medium	medium
13	much	short	medium	medium
14	much	middle	medium	low
15	much	long	medium	low
16	many	short	medium	medium
17	many	middle	medium	low
18	many	long	medium	low
19	little	short	small	high
20	little	middle	small	medium
21	little	long	small	low
22	much	short	small	medium
23	much	middle	small	low
24	much	long	small	low
25	many	short	small	low
26	many	middle	small	low
27	many	long	small	low

3. Applying Fuzzy Dispatching Rule

3.1 Simulation Model

In this paper, we consider the simulation model on the basis of the terminal layout given by [1]. we give out the ACT layout in Fig. 3.

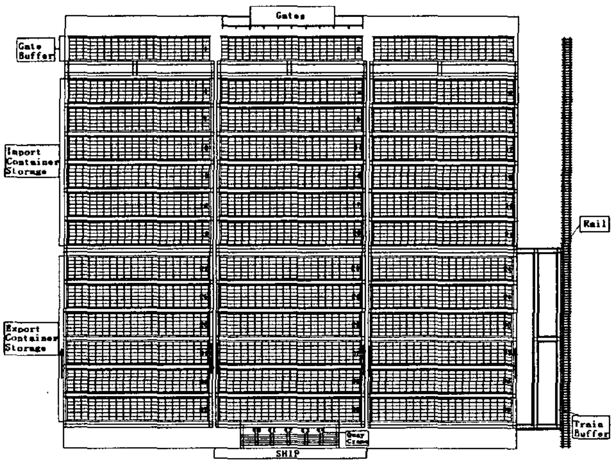


Fig.. 3 Layout of Automated Container Yard

The whole terminal layout contains gate buffer storage, import storage, export storage and quay crane buffer storage. There are all 18 stacks for the import and export storage area respectively, 3 stacks for gate buffer. For every stack in the yard there is one yard crane while two for every stack of gate buffer. There are all five quay cranes. Transit roads are just for transportation and are equipped either with 1 or 2 one-way guiderail(s). Loading/unloading takes place at the working roads which are equipped with a single one-way guiderail. This can avoid heavy congestion and blocking. Look at the arrows in the Fig. 3.

In [1], their consideration is that each stack has 216 containers when containers are stacked 3-high and 288 if stacked 4-high. There is no need for us to do the simulation with the whole layout model because our purpose is to validate our rule and compare it with other rule. We choose 2 stacks in gate buffer, 3 stacks in export and import respectively and 3 quay cranes to make our simulation model (Fig. 4). The numbers of the stacks in Fig. 4 are same with the numbers of stacks in Fig. 3.

3.2 Physical Characteristics of Simulation Model

Dimensions of the terminal: 1633*1875 ft^2
Storage Capacity: 22,464 TEUs
Number of Quay Cranes: 3
Capacity of quay cranes: an average of 90 seconds for one move (contain loading and unloading)
Number of yard cranes: 6
Capacity of yard cranes: an average of 60 seconds for one move
Speed for the shuttle cars: 10 miles/hour for empty and 5 miles/hour for loaded
Number of shuttles: 10
Shuttles' turning time at crossover: 5 seconds

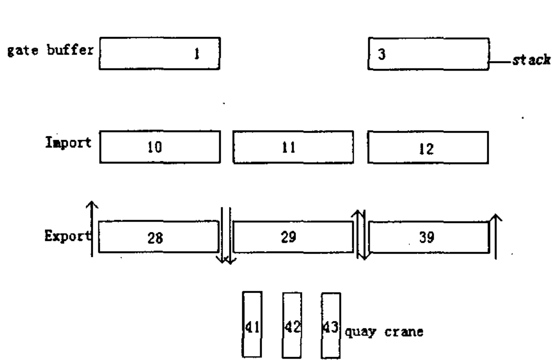


Fig. 4 Simulation Model

Our fuzzy dispatching rule here is called Rule1. Another Rule is called Rule2.
Rule 1: Fuzzy dispatching rule as described above
Rule 2: When the shuttle arrives at the quay/yard crane, it selects one of the quay/yard cranes by choosing randomly.

In our simulation, shuttles operate as follows: An export container loaded on a shuttle at the gate buffer is directly to a quay crane to be loaded on the ship or to an export stack in the yard. A shuttle loaded with an import container by a quay crane goes to the gate buffer or an import stack. We gave the initial status of the 15 shuttle cars to do the simulation. The result of the number of moves of all yard cranes by processing 3 hours is given. We choose the time to be the x-axis, the number of containers that are processed by all the yard cranes of the simulation model to be the y-axis and t=0 minute to be the initial point. Fig. 5 is the comparison of the number of moves of all yard cranes by two rules.

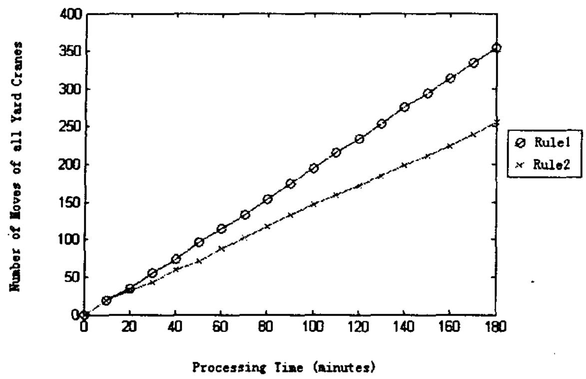


Fig. 5 Comparison of two Rules

4. Conclusion

In figure 5, we can see that Rule 1 is more efficient than Rule 2. The main result of the work is a definition of a new dispatching rule for LMTT shuttle cars that can be used in real time on a reactive way. A simulation is done and it was presented better results than Rule 2. The proposed approach for LMTT shuttles' dispatching in terminals considers actual terminal status and fuzzy logic. Some experts were consulted to help to define the variables to be considered, the membership functions and rules of the fuzzy system. We can use the automatic techniques for the generation of the rules and membership functions with the purpose of observing an eventual improvement in the obtained results.

후 기

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