The Seventeenth International Symposium on Artificial Life and Robotics 2012 (AROB 17th '12),
B-Con Plaza, Beppu, Oita, Japan, January 19-21, 2012

# AGVs' Control in Autonomous Decentralized FMS (AGVs' Mind with Neural Networks)

Hidehiko Yamamoto[1], Hiroaki Tashiro[2] and Takayoshi Yamada[3]

[1]Department of Human and Information Systems, Gifu University, Japan
[2]Graduate School of Engineering, Gifu University, Japan
[3]Department of Human and Information Systems, Gifu University, Japan
(Tel: 81-52-293-2550)

[1]yam-h@gifu-u.ac.jp

***Abstract***: This paper describes control of the moving robots in an autonomous decentralized Flexible Manufacturing System (FMS) by moving robots according to its mind change. We propose Experience based Stimulation Adjustment by NN (ESAN) that is the method of efficiently changing the mind of the automated guided vehicles. The mind changes by various stimulation. In ESAN, the stimulation sent to the mind is adjusted to an appropriate value by using the neural network. The effectiveness of ESAN is evaluated with production simulations in an autonomous decentralized FMS virtual factory.

***Keywords***: Autonomous decentralized FMS, Mind, AGV

## 1. INTRODUCTION

The purpose of our research is to improve the productivity of the Autonomous Decentralized Flexible Manufacturing System (FMS) factory. In Autonomous decentralized FMS, many moving robots called Automated Guided Vehicles (AGVs) are operated. In this research, we focused on the action control of AGVs.

In a past research as a method of evading the interference with the route of AGV, the mind of AGV is modeled and the action control that gave AGVs was tried. [1][2] As a result, each AGVs could perform various actions according to the change of mind.

However, in Autonomous Decentralized FMS that has many AGVs, it took much time to evade the route interference, and because of this, we had many cases that the productive efficiency of Autonomous Decentralized FMS dropped. Then we thought the change of mind cannot always correspond to various situations.

To solve this problem, we propose Experience based Stimulation Adjustment by Neural network (ESAN). ESAN stimulates the mind to efficiently change the mind of AGVs.

## 2. ESAN AND MODEL OF MIND

### 2.1. Past method and ESAN

Fig.1 shows the comparison between the method of stimulating the mind in a past research and the method by ESAN. In a past research, when AGV failed in the action, the mind of the AGV had been stimulated directly. In ESAN newly proposes this time, stimulation is adjusted by NN according to the situation at that time, and the mind of AGV is stimulated afterwards when AGV fails in the action.

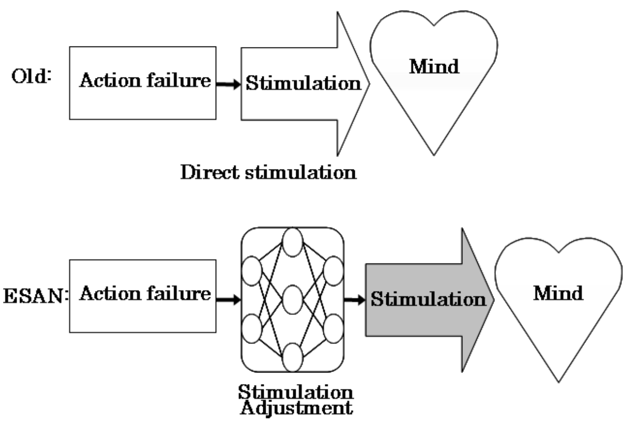


**Fig.1** Comparisons between past method and ESAN

### 2.2. Element of mind

The mind is defined to have combined three elements which are the unit, the stimulation vector, and the load. (Shown in Fig.2-Fig.4.) The stimulation vector is an element that is tied to unit the load. The unit is composed of two numerical values of excited degree [E] and threshold [T]. [E] is able to increase and decrease by the value of the load. [T] is an upper bound of [E]. [E] is lowered to [T] when [E] exceeds [T], and it makes a signal to the stimulation vector. The unit for [E] of the unit to reach [T] is called excited and the unit that excited, and doesn't reach [T] is called calm. The state of mind is decided by combining units that have been excited

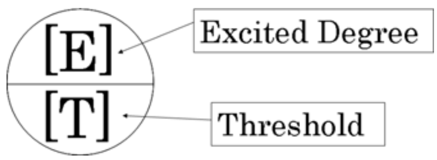


**Fig.2** Unit

**Fig.3** Stimulation vector


**Fig.4** Load

### 2.3. Model of mind that uses ESAN

Fig.5 shows the model of the mind that uses ESAN. This model is a model to unite the load α, β, and γ with two units A and B by the stimulation vector. This model is divided into two parts. It is in the part where stimulation is received from the outside of the part, β, and γ that decides the state of the mind of A, B, and α.

There are two states of mind, which are an arrogant mind and a modest mind. AGV acts while doing these two minds in switches.

When A gets excited, AGV becomes modest, and takes a modest action that transfers the load to others. Moreover, when A is calm, AGV becomes arrogant, and takes an action that advances forcibly on the load and is arrogant. When the action rails because the mind of AGV is arrogant, the mind is received as stimulation through β. Then, this increases A[E]. Unit A gets excited when A[E] reaches A[T]. When the action fails because the mind of AGV is modesty, the mind is received as stimulation through γ. Then, this increases B[E]. Unit B gets excited when B[E] reaches B[T].

### 2.4. Generation of NN and its working in ESAN

The new function of ESAN includes the stimulation adjustment function that is caused by the NN after some AGVs experiences. The NN in ESAN uses Backpropagation method (BP method). The instruction signal used for this is made by performing the FMS production simulation beforehand, and using the result.

At first, the FMS production simulation is made visible, and animation on the FMS factory is made. Next, the action of AGVs in the animation is analyzed. The analysis is to understand whether the route interference is generated easily under what situation in the animation.

That is, look for the case with route interference to which the route interference is quickly evaded and time-consuming route interference. The states of mind of AGVs in these cases request either arrogance or modesty. The result of such an analysis is used as a instruction signal of NN.

The BP method is done based on this instruction signal and NN is generated. The generated NN stimulates two values of the mind of AGVs. Whenever AGV causes route interferences, the NN of ESAN receives five kinds of information. The five kinds of information are the destination of the AGV, previous destination, other nearby AGV number, other AGV number in goal direction, own current location as shown in Fig.5. In other words, these are the input information of NN. And, NN decides the two values in the model of the mind as an output. The mind of AGVs receive the value of β and γ from NN every time AGVs causes route interference. There are two states of mind. One is arrogant mind and the other is modest mind. The arrogant AGV forcibly moves, and the modest AGV makes way for other AGVs. AGV moves while in these two states of mind by switching one after another. One of the AGV acts while in these two minds in switches. When A has gotten excited, the state of mind is modest. At this time, AGV takes a modest action that transfers the load to others. Moreover, when A is calm, the state of the mind is arrogant. AGV takes an arrogant action that advances forcibly on the load. If AGV failed action in arrogant, the mind receives stimulation by β. Then, mind's A[E] is increased by the value of β. A gets excited when A[E] reaches A[T]. If AGV failed action in modesty, the mind receives stimulation by γ. Then, mind's B[E]is increased by the value of γ.

## 3. SIMULATION RESLUTS

Fig.6 shows CG of applied Autonomous Decentralized FMS. The model of the mind that used the above-mentioned ESAN for each AGV was transplanted. At this time, the value of β and γ was set to the numerical value of 1～4. And, the production simulation that operated this Autonomous Decentralized FMS for eight hours was done.

The production simulation was performed for eight hours with the Autonomous Decentralized FMS. The production simulations of the number of AGV 3, 5, 7, and 9 were carried out 20 times respectively.

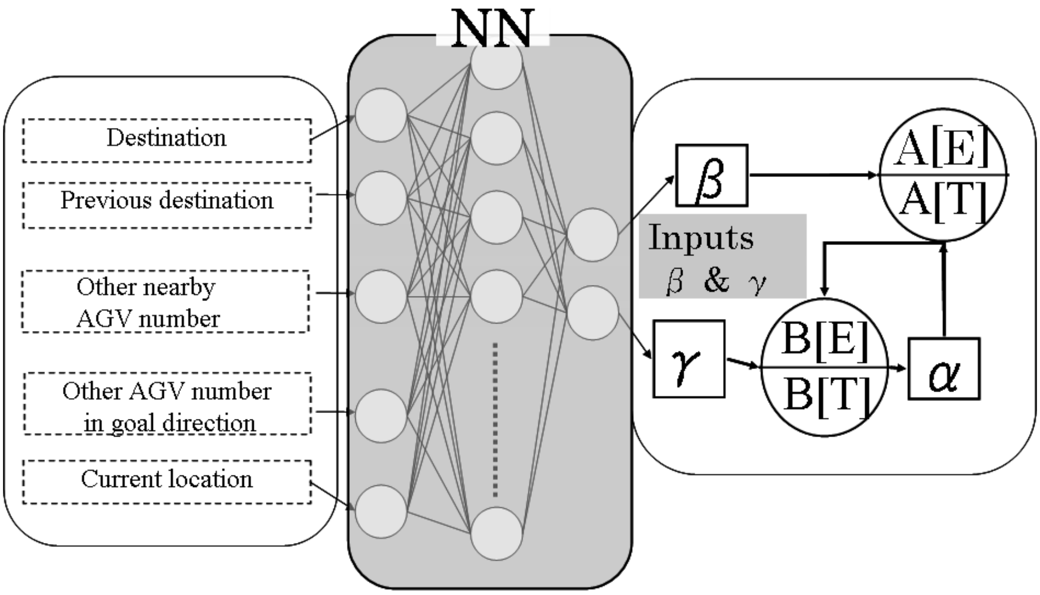


**Fig.5** Model of AGVs' mind for ESAN

**Table. 1** Average outputs and their increased rates

| Methods \ Number of AGVs | 3 | 5 | 7 | 9 |
|---|---|---|---|---|
| past research methods outputs | 111.7 | 162.15 | 199.65 | 228.6 |
| ESAN outputs | 115.3 | 171.2 | 215.25 | 249.4 |
| Increased rate (%) | +3.22 | +5.58 | +7.81 | +9.1 |

**Table. 2** Route interference number and its increased

| Methods \ Number of AGVs | 3 | 5 | 7 | 9 |
|---|---|---|---|---|
| past research methods | 943.2 | 2715.0 | 5034.1 | 7643.8 |
| ESAN | 735.7 | 2412.2 | 4671.3 | 7178.2 |
| Increased rate (%) | -22.0 | -11.15 | -7.2 | -6.1 |

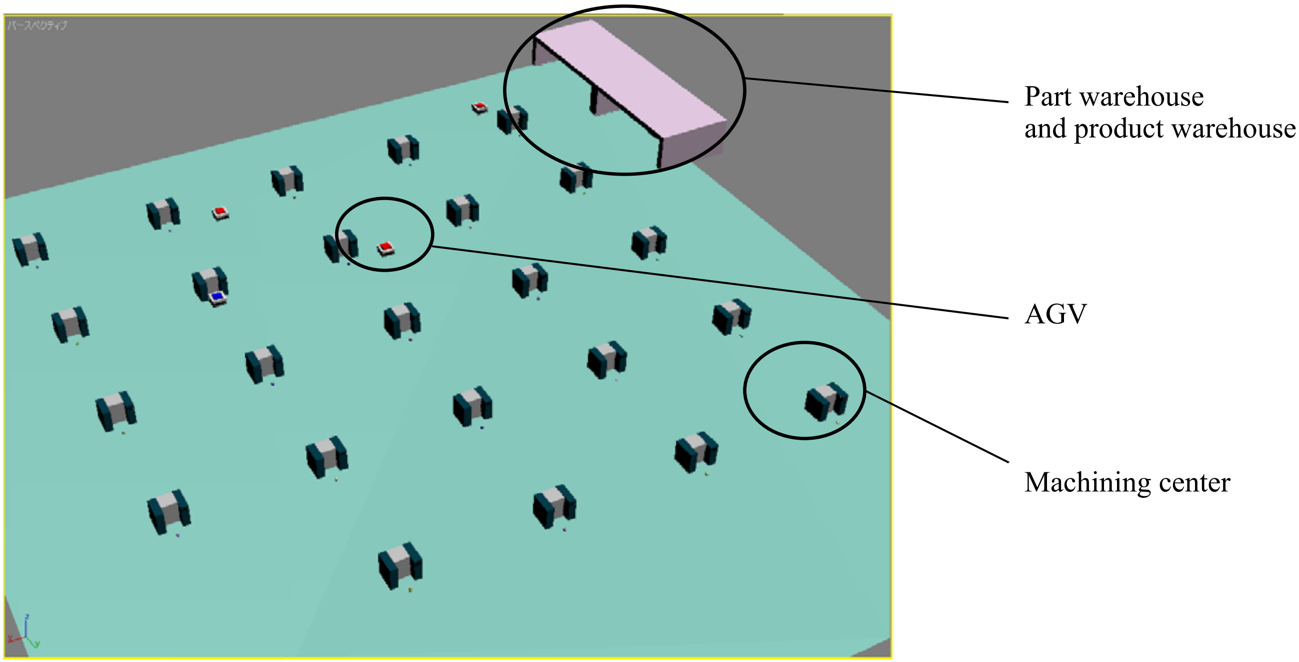


**Fig.6** Autonomous decentralized FMS

The average outputs are shown in Table.1 and the number of route interference is shown in Table.2. The simulation result under this condition of old methods is shown for comparison. The increasing rate of the average production based on earlier methods and the increasing rate of the number of route interference are shown respectively.

For example, when the number of AGV is 3, the average outputs were 111.7 in the case where the past research method was used. On the other hand, the average outputs are 115.3 in the case where ESAN is used, and the average outputs increased by 3.22%. Route interference number decreased by 22% in ESAN compared with the past research method. Moreover when ESAN was used, the average production increased in any conditions. Especially, if the number of operating AGVs increases, average outputs are increasing more and more. In the same way, the number of route interference decreases by 22% in ESAN compared with earlier methods when the number of AGVs is three. (as shown in table.2) When ESAN is used, the number of route interference decreases in other conditions.

Based on the above-mentioned, it has been understood that the productive efficiency of the factory improves by using ESAN.

## 4. CONCLUSIONS

In this thesis, ESAN is proposed as the method of adjusting the stimulation sent to the mind to an appropriate value as a method of changing the mind of AGVs more efficiently. The method of using ESAN as the method of adjusting stimulation to mind by NN is compared with the simulation result of the old method.

Under all conditions, it was achievable that the mind was changed more efficiently. Thus, ESAN was proven to be more effective than earlier methods..

## REFERENCES

[1]Hidehiko Yamamoto, Kikuchi Hiroyuki, Takayoshi Yamada and M. Anouar Jamali, Moving Robots' Mind of Autonomous Decentralized FMS and Mind Change Control, The Journal of Artificial Life and Robotics, Vol. 14, No.1, 34-38(2009), Springer

[2]Hidehiko YAMAMOTO, Takayoshi YAMADA and Shinsuke KATO, AGV Mind Model and its Usage for Autonomous Decentralized FMS by Change of Mind, Proceeding of Third KES International Symposium, KES-AMSTA 2009, Agent and Multi-Agent Systems : Technologies and Applications, Lecture Notes in Artificial Intelligence, Edited by Anne Hakansson, Ngoc Thanh Nguyen etc. , ISSN 0302-9743, Uppsala, Sweden, pp.744-753, June(2009), Springer.