SOME RECENT DEVELOPMENTS OF NEXT GENERATION'S MARINE TRAFFIC SYSTEMS

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Abstract: Some recent developments of next generation's marine traffic systems from Marine ITS project in Japan are roughly introduced. One is marine traffic simulation utilizing automatic collision avoidance system. It can simulate marine traffic simulation for any interested area based on a given OD tables etc. The safety assessment in congested area and utilization for planning of on-land AIS stations are shown as examples of its applications. The other is automatic berthing system utilizing artificial neural network. A proposal of automatic teaching data creation is introduced. A result of a model ship experiments is shown.

Keywords: ship control, traffic control, automation, path planning, expert systems, artificial intelligence, neural control.

1. INTRODUCTION

Systemisation of automation of ship operation has started already in 1960s in Japan. It has started from labour-saving, power-saving to safing. The first national project named "Highly Reliable Intelligent Ship" (to be abbreviated as "*Intelligent Ship*") (Ohshima et al. 1989-90) (J.SNAJ) has targeted automation for safety, including collision/aground avoidance and berthing, which were not treated before. These days are coincident with the boom of the research on artificial intelligence or soft computing such as fuzzy theory and artificial neural network. This kind of automation is a kind of neural and cognitive automation apart from the automation of muscle treated by the conventional automation. The system is realized by expert system combining rule-base or knowledge-base with several sensors.

As the second phase of this national project, national research institutes, universities or companies who participate this project continue research and development individually.

In this paper, some of these researches done by the author's group after the project will be introduced. Similar researches are continuing by other groups in Japan.

2. MARINE TRAFFIC SIMULATION SYSTEMS

2.1 Automatic Collision Avoidance System.

The system called *SAFES* (Ship Auto-navigation Fuzzy Expert System) (Hasegawa *et al.*, 1989) is an automatic collision avoidance system with multiple-ship environment. The fundamental study was done by various researchers in the "*Intelligent Ship*" project. In the project several methods to solve the multiple-ship environment were proposed, but in *SAFES*, the combination of expert system and fuzzy theory was implemented. It was originally written in OPS83, an expert system language based on another basic system called *ACAS* (Automatic Collision Avoidance System) (Hasegawa, 1987) written in FOTRAN, which solves two-ship encounter problem.

2.2 Intelligent Marine Traffic Simulation System.

SAFES is not only a system to be implemented for real ships, but also a system applicable for various applications such as:

- *Evaluation of automatic system.*
- *Safety assessment for harbour and waterway design.*
- *-Implementing for background traffic in ship handling simulator.*

The system originally named *SMARTS* (each-Ship-with-captain MARine Traffic System) (Hasegawa 1990) was developed as an application of *SAFES* to assess harbour and waterway design. It uses *SAFES* as decision-making engine for each ship. It contains automatic traffic flow generation according to the statistically given OD (Origin-Destination) tables for each port or gate in the gaming area. It also include data logger to be analyzed on-line and/or off-line.

The system was originally written in OPS83, and rewritten in G2, but now is completely implemented in C++ both for a PC and a workstation.

An example of the simulation result applied for Tokyo Bay, one of the most congested areas in the world, is shown in Fig. 1. The window provides system information, including the bird-eye-view of the present gaming area in any scale. For reader's convenience, the zoomed area is shown in Fig. 2, where each ship represented by a circle mark in different colour with velocity vector, which means the status of the motion such as normal and avoiding, although the colour cannot be appeared in the print. The trajectory of each ship can be traced as shown in Fig. 3, which might be useful to design the navigational lanes or regulations. The analysed result of near-miss is shown in Fig. 4 to demonstrate how it will be used to assess safety.

The system was recently utilized to plan AIS station in land. Japanese Coast Guard Agency is planning to construct AIS stations in congested area such as Tokyo Bay, Ise Bay and Osaka Bay. The system could provide useful data to predict the area distribution of AIS reports as shown in Fig. 5. We are now expanding the system fot predicting the slot confliction in AIS slot reservation in realistic way.

The system can now handle various areas, just replacing a set of input setting files such as OD tables and an area map and configuration. Fig. 6 shows such an example done for Ise Bay, Japan, where Nagoya, the third biggest city in Japan exists. For the comparison an example for Osaka Bay done in the previous version of the system (Hasegawa *et al.* 2001b) is shown in Fig. 7, which was coded in G2.

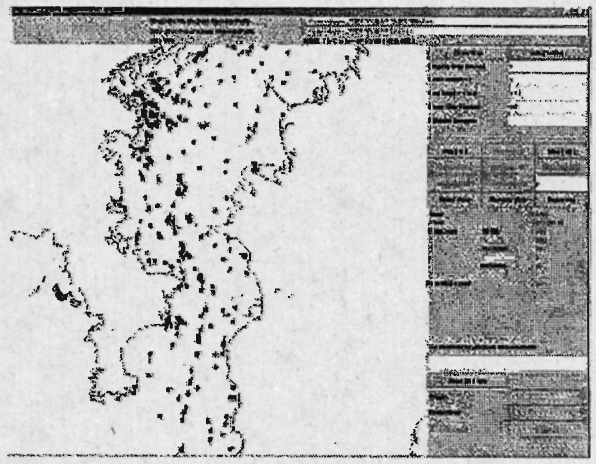

Fig. 1. Marine traffic simulation (Tokyo Bay)

The system can not only handle fully simulated traffic flow, but also any externally given ship movements. It means that the system can simulate certain modification with existing traffic flow. In the next stage the system is planning to be connected with ship path recorded by VTS (Vessel Traffic Service).

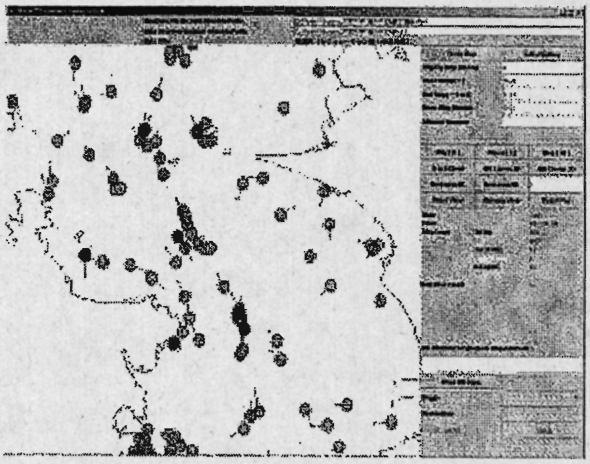

Fig. 2. Marine traffic simulation – zoomed (Tokyo Bay)

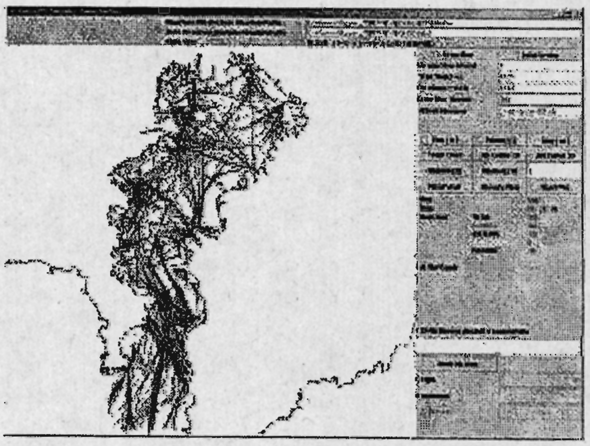

Fig. 3. Marine traffic simulation – trajectories (Tokyo Bay)

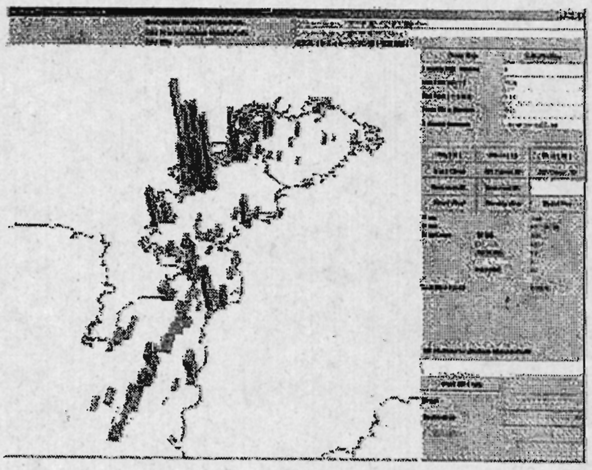

Fig. 4. Marine traffic simulation – near-miss points (Tokyo Bay)

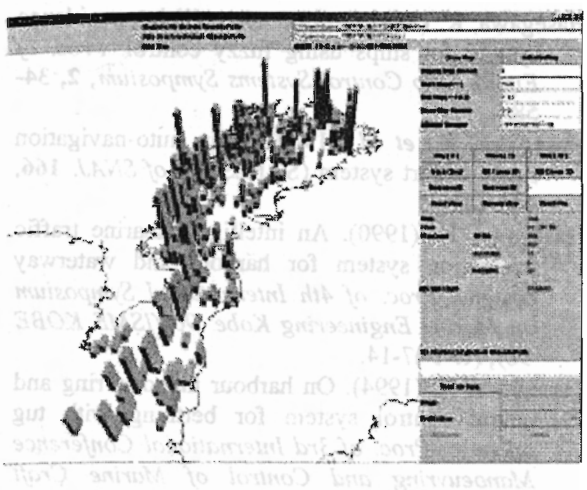

Fig. 5. Marine traffic simulation – AIS reports (Tokyo Bay)

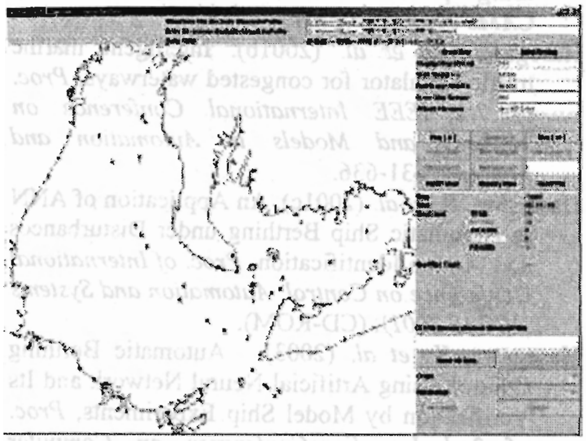

Fig. 6. Marine traffic simulation (Ise Bay)

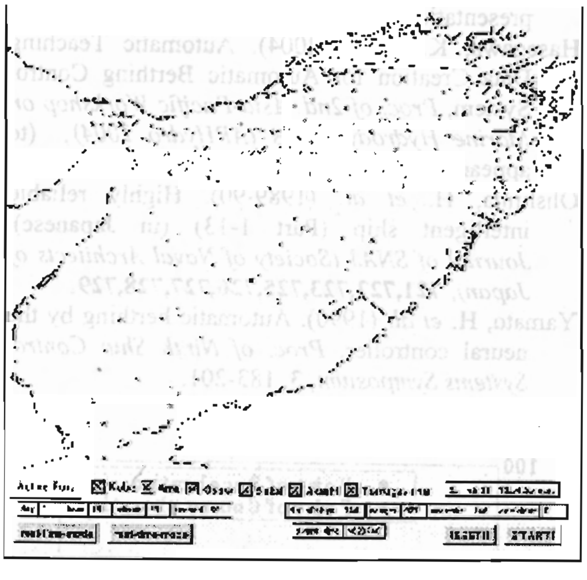

Fig. 7. Marine traffic simulation (Osaka Bay) (Hasegawa *et al.* 2001b)

3. AUTOMATIC BERTHING SYSTEM

Berthing is one of the most sophisticated manoeuvres in the various ship operations. A ship is normally not stable enough or sometimes unstable in low advance speed and much affected by disturbances such as wind and current. The effects of the depth of the sea bottom, bank and even the near-by ships are not ignored sometimes. Thus certain feed-forward or future-prediction is necessary. Therefore it is normally assisted by tugs, bow- and/or stern thrusters(s) as well as physical or electrical navigational aids. It will requite cautious judgement secured by long-term on-job experience. However with the decrease of number of skilled pilots and captains, it is highly requested to provide certain guidance or support system.

Several attempts of automation of berthing were done by several researchers under the "*Intelligent Ship*" project and others. The author has engaged in this problem using artificial neural network (ANN), which was first proposed by Yamato *et al.* (1990). By several researches (Hasegawa 1994, Hasegawa *et al.* 2001a, 2001c), it is verified that the artificial neural networks will work fairly for berthing control. The automatic berthing system was verified by experiments. Fig. 8 shows the teaching data obtained by manually-radio-controlled model ship and Fig. 9 shows the result of ANN controller learned from the teaching data thus obtained. In most cases it works fairly well, but several problems are also found. One is the effect of wind or current effect is not small and controller design for such disturbances is important for robustness. To improve these faults, parallel structure of the network is proposed. However, the most important factor for ANN controller design is to provide consistent teaching data. In the previous works all teaching data were provided by manual control results. Even if the operators are fully trained by themselves, human operators have various uncertainties. They will directly affect on inconsistency contained in teaching data.

Therefore teaching data is automatically created (Hasegawa, K. *et al.* 2004) based on the method proposed by Endo and Hasegawa (2003). Fig. 10 shows such results, where the origin is the berthing point with various starting points with different positions and heading angles and Fig. 11 shows the ANN controller results learned using these automatic created teaching data. It is verified that the ANN controller works consistently according to the various starting points.

The research is still undergoing for further developments such as practical tolerance against wind and current disturbances.

4. CONCLUDING REMARKS

The paper summarizes some recent developments of author's work aiming the next generation's marine traffic system or support system. There are still many things to be fixed or solved before going to the real-world application. However, the efforts or attempts to the collaboration between VTS or model ship experiments are continuously done. The detail of the works are mostly in the references listed below, although some of the work is still undergoing or somewhat confidential.

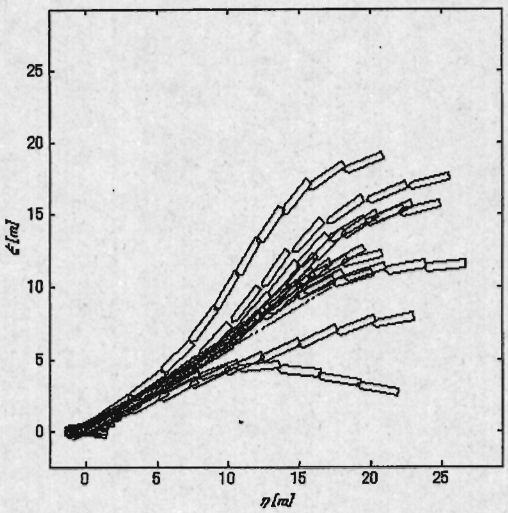

Fig. 8. Berthing manoeuvres provided for teaching data obtained by model ship experiments (Hasegawa 2003)

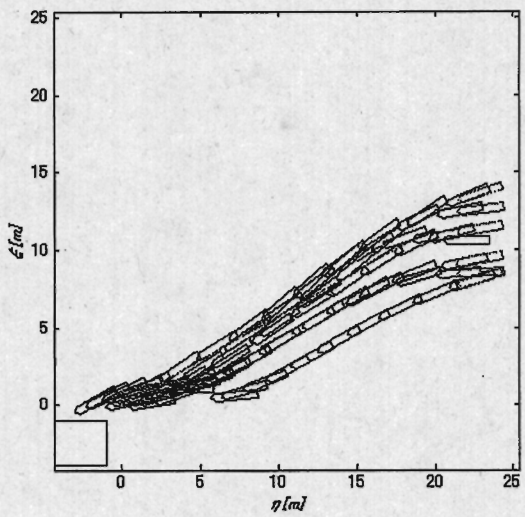

Fig. 9. Results of automatic berthing by ANN controller by model ship experiments (Hasegawa 2003)

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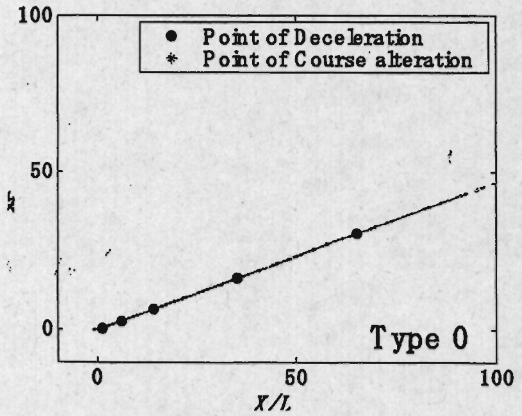

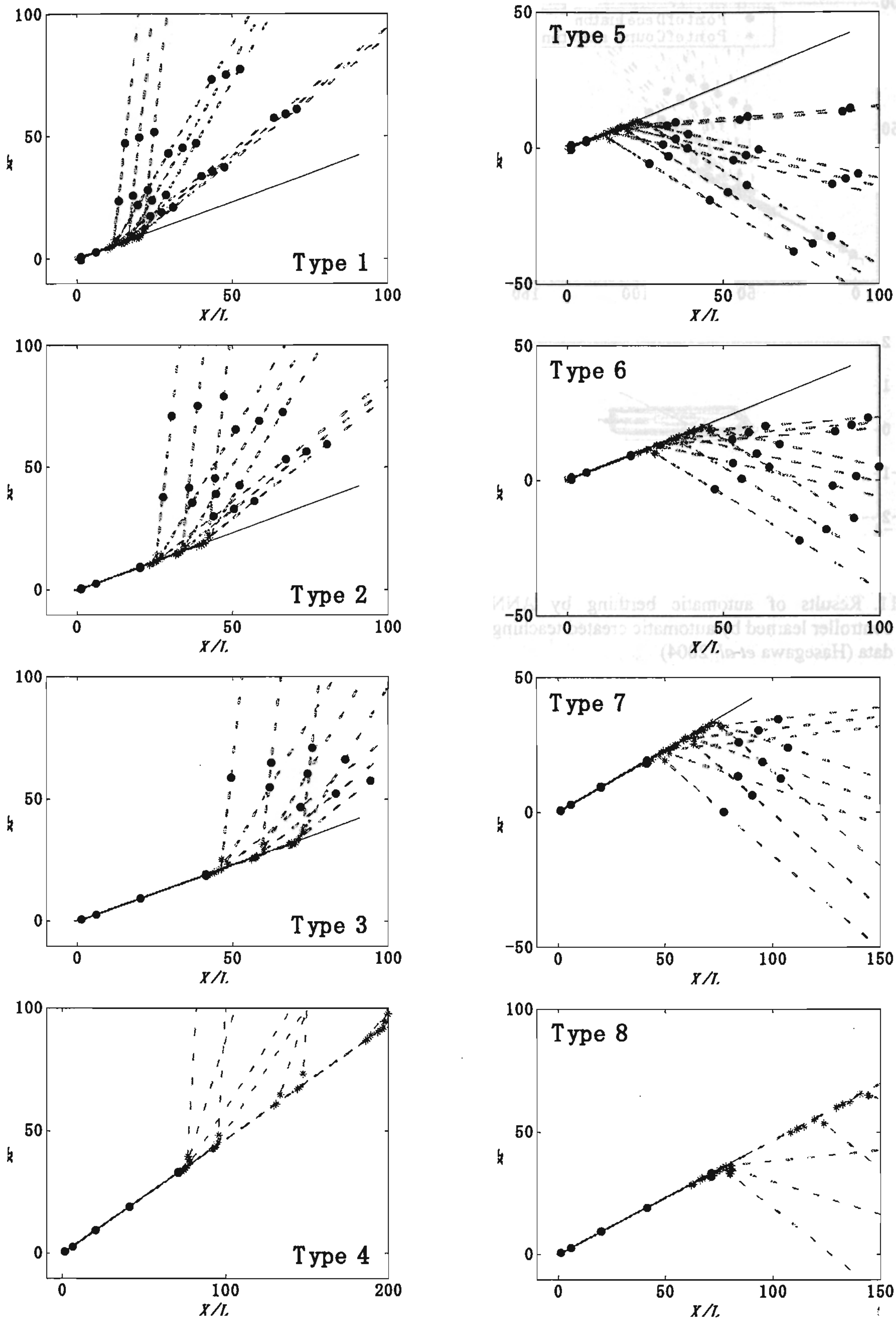

Fig. 10. Automatic created teaching data provided for ANN berthing controller (Hasegawa *et al.* 2004)

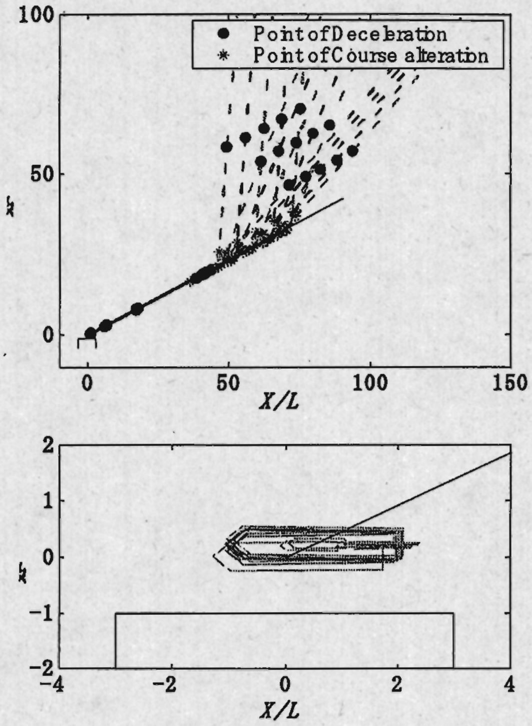

Fig. 11. Results of automatic berthing by ANN controller learned by automatic created teaching data (Hasegawa *et al.* 2004)