Vehicle Guidance System using Local Information Assistants

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Summary. In this paper, we propose a vehicle guidance system using local information assistants. The information assistant device which is embedded into the environment, realizes to exchange and manage local information related to the environment and the situation. Therefore, proposed system can realize to provide the information without direct communications among the vehicles and global communications. We develop local information device for vehicle guidance and attempt experiment using the electrical vehicle. Also, we discuss a simple guidance method based on local information manaement such devices.

1 Introduction

In recent years, AGVs (Automated Guided Vehicles)[1] are introduced to products transportation system in the factory and so on. Such technologies are expected to apply and extend to general environment. Practically, in the golf course, the AGV technologies are utilized as human transportation system. For example, towards barrier free society, ITS(Intelligent Transportaion Systems) technologies are also applying to construct safety and comfortable transportation for the elderly and handicapped people. In most case of transportation system using AGVs, supervisory management approach is utilized based on global communication. However, such system has the problems related to high calculation load because the amount of information increases according to the number of the vehicles. Therefore, practical guidance systems of AGV utilize the guidance line (magnetic, electrical and so on) and fixed command devices (magnet and so on) that are distributed at the side of the guidance line. The devices realize to send control command to the vehicles, locally. In such systems, the fixed information is handled by such distributed signal devices and it is hard to correspond to change the course layout and the traffic situation.

On the other hand, it is developing that the research related to the technologies for autonomous AGVs using on-mount sensors without the guidance line. However, in such system, the system should equip plural sensors to realize to improve the reliability of the recognition in general environment[2]. The control system of such vehicle becomes highly complex and the cost also becomes high. Therefore, it is required to develop a new guidance system that introduces distributed information management and realizes flexible course construction. Chiba *et al* proposed a method for classifying the transportation route of AGVs[3]. Higashi *et al* proposed a self-organizing control method for AGV system[4]. Moreover, in conventional technologies of AGV, the main scope is to transport the object in the factory with small number of AGVs and it is not the scope to apply to the general traffic road enviroment.

In this research, we are developing a guidance system for applying AGV to human transportation on the general road. Our system realizes to construct un-supervised vehicle control system based on local infomrmation management. In this paper, we develop an electrical outdoor vehicle guidance system with local information devices. Also, we examine to extend the system for realizing effective guidance and propose simple guidance algorithm based on combining distributed information.

2 Conventional Vehicle Guidance System

Generally, in AGV guidance system, the tape or electric wire for the guidance is on the ground and each AGV equips the sensor to detect such guidance line. Figure 1 shows a commercial electric vehicle and we utilize this platform in this research[5].

Standard guidance system for this commercial electric vehicle utilizes the electric wire as the guidance line and the permanent magnets for the control

Fig. 1. An Electric Vehicle

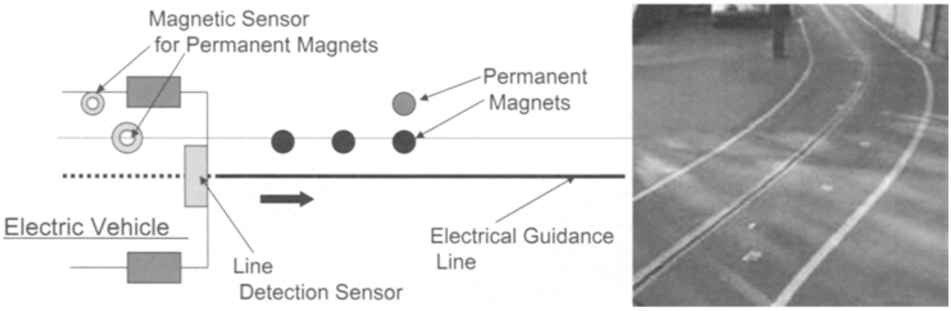


Fig. 2. Conventional Guidance System

command are placed on the side of the guidance line(Figure 2). The arrangement pattern of permanent magnets expresses the control command to the vehicle utilizing the combination of S and N pole (moving speed change, stop and so on.) However, such conventional guidance system only manages fixed information and operates small kinds of the control commands. Therefore, flexibility for system construction is acquired to extend this system to the other applications. In next section, we explain our local information management devices and to apply them to vehicle guidance system.

3 System Configuration

Here, we explain our developing vehicle guidance system based on Intelligent Data Carrier.

3.1 Intelligent Data Carrier (IDC)

In our current work, we proposed and are developing *Intelligent Data Carrier* (IDC) system. Figure 3 shows the concept of the IDC system. IDC tag is a portable electronic data carrier device with functionality of information storage (rewritable nonvolatile memory), information processing (MPU), local wireless data exchange (RF-ID weak radio communication), power supply (battery - optional), and external ports (I/O interface, optional).

As shown on Figure 3 , IDC system consists of a number of IDC tags embedded in the environment(wall, floor, obstacles, objects, etc) and reader/writer devices. Each IDC tag manages and processes local information depending on specific place or objects. The agents can communicate with the IDCs via a reader/writer device provided with each agent, and extract/add/update the local information in IDC tags through local radio communication. Or, the IDC tags inform the agents of the necessary local information for guidance or task execution, and mediate the knowledge or commands stored by an agent to the other agents. With IDC system, it becomes possible to make the environment

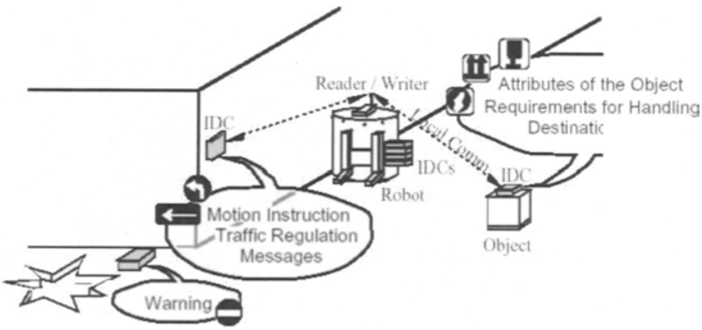


Fig. 3. Concept of the IDC system

intelligent and implement information structure in the environment, namely the infrastructure for mobile agents to acquire the necessary information. In other words, the IDC system facilitates realization of a ubiquitous computing environment [6], which makes autonomous operation of mobile robots feasible and task execution efficient and flexible. Moreover, with the interactions between robots and the environment, the agents can share knowledge via environment without mutual direct communication. Consequently, the IDC system provides not only the utility for agents as their infrastructure, but also means for emergent adaptiveness of cooperating agents constructing active and dynamic affordance[7]. The global order of the intelligent system is expected to emerge through the local interactions by using IDC system [8].

In this research, we developed an IDC system for electric vehicle control. Table 1 indicates the speccification of the developed system. Figure 4 shows IDC tags and IDC Reader/Writer, respectively.

3.2 Guidance Experiments using IDC system

Our developing system is shown on Figure 5. The vehicle equips the computer(PC) for its own controller, the antenna and IDC Reader/Writer(IDC R/W) which communicates with the control PC via RS-232C(serial communication).

Table 1. Specifications of IDC system

media	electromagnetic wave
communication	RF-ID
communication rate	read:4.8[kbps]/write:0.96[kbps]
communication range	150[mm]
memory capacity	110[byte]

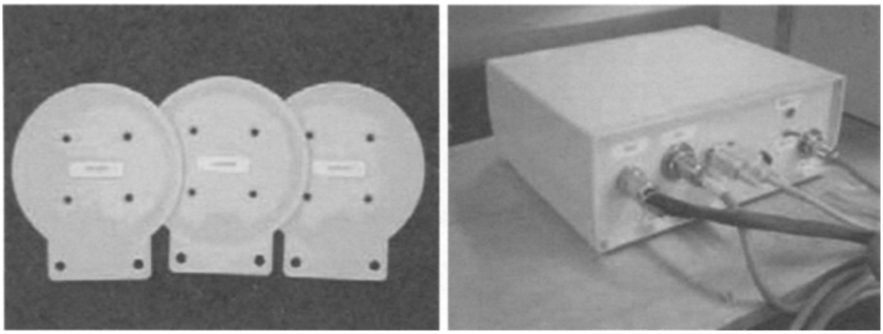


Fig. 4. IDC Tags and IDC Reader/Writer

Figure 5 also shows IDC R/W with antenna and it works to read/write the information from/to IDC tags on the road(Figure 6). Using developed system, we have some basic experiments related to running speed control, branching off control and so on. The control commands are stored in each IDC tag and the tags are placed on the side of the guidance line. We confirmed that the vehicle can adjust its own running speed from 1.0[km/h] to 8.0[km/h] at every

Fig. 5. Overview of the Electrical Vehicle and Communication Antenna

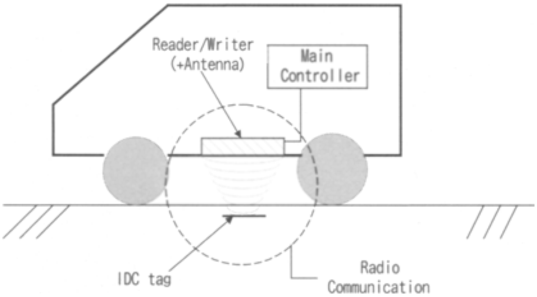


Fig. 6. Communication between IDC tag and Vehicle System

Fig. 7. Overview of Running Experiment

1.0[km/h] based on information on IDC tags. Also, the vehicle can branch off to right or left blanch line, and run through the junction of two branch lines. Figure 7 shows the overview of running control experiments using developed system. In this experiment, the vehicle starts at 3.0[km/h] and accelerates to 8.0[km/h] after passing first IDC tag. Passing the second IDC tag, the vehicle slows down to 2.0[km/h] and finally stops after passing the third tag.

As the result, we can confirm that developed system can work to guide and control the vehicle. Although the system can locally manage static or semi-static information based on RF-ID communication, it can not treat dynamic information. Here, semi-static information include the map information, vehicle control command and the data which are stored when previous vehicles passed at that point.

We must consider to improve our system for effective guidance system based on the distributed manner.

4 Guidance Method with Local Information Assistant and IDC

In this section, we examine a vehicle guidance method based on local information management using Information Assistant(IA) which is a sort of extended IDC system. IA equips simple calculation capacity and local communication (based on like a wireless LAN devices) with the other IA. At each intersection, there is one IA and plural IDC tags. IDC tags are utilized to provide semi-static infomation as velocity command, map and so on to the vehicle. IAs also support to provide dynamic situation change including traffic condition. IAs support that the vehicles decide the path based on mutual information exchange.

4.1 Environment Setup and Selection of Path Candidate

We assume a simple road layout as Figure. 8. and it consists of straight roads and the intersections. The intersections are connected to straight roads(bi-directional paths) each other and the distance between the intersections is equal to the road length.

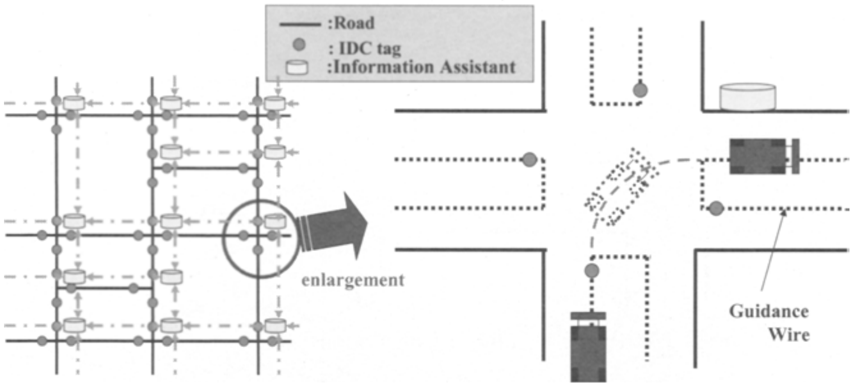


Fig. 8. Experimental Setup

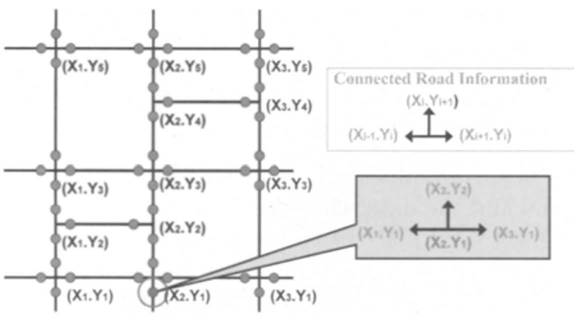


Fig. 9. Stored Information in IDC Tags

The guidance line is set up to the road part and IDC tags are placed at every branches of the intersection. As guidance at the intersection, we proposed a laser guidance system using Information Assistant (IA)[9]. IA can communicate to the IAs at the neighboring intersections, locally. IDC tags, which are placed at the intersection, supervise semi-static information including the map, command and so on. The example layout is shown on Figure 9 and there are IDC tags at each intersection in proportion to the number of the roads. Each intersection is identified using the position in the world coordination and it is stored in IDC tags.

For example, when the vehicle arrives at the intersection $P_{ij} = (X_i, Y_j)$, the vehicle can read the position of the neighboring intersections $P_{(i-1)j}$, $P_{(i+1)j}$, $P_{i(j-1)}$ and $P_{i(j+1)}$ from IDC tag at the intersection P_{ij}. Therefore, the vehicle has the destination position $P_{dst} = (X_{dst}, Y_{dst})$ and can calculate each path length to the destination based on IDC information. Each IDC tag, which is placed at the intersection, has the local map information related to the position of connected branches. Here, the distance $L_{\alpha\beta}$ between the destination P_{dst} and the next branch position $P_{\alpha\beta} = (X_\alpha Y_\beta)$ is calculated by following equation.

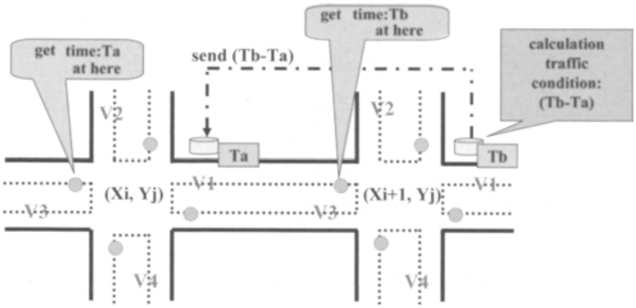


Fig. 10. Traffic Condition Calculation Scheme

$$L_{\alpha\beta} = P_{dst} - P_{\alpha\beta} \\ = ||X_{dst} - X_{\alpha}|| + ||Y_{dst} - Y_{\beta}|| \quad (1)$$

Next, the minimum of $L_{\alpha\beta}$ is selected as the candidate of the path. As the natural result, there is possibility that plural candidate paths are selected. In the next discussion, we discuss that path selection method with considering the traffic condition.

4.2 Path Selection based on Traffic Condition

Using local stored information, the candidates of the path can be selected. Here, in order to realize efficient guidance, time which takes to get to the destination should be considered for the path selection. It means that traffic condition of near area should be referred. Therefore, we introduce a path selection method utilizing traffic condition information. Figure 10 shows the overview of our proposed scheme. . As Figure 10, the vehicle passes the intersection P_{ij} at time T_a and also reaches to the next intersection $P_{\alpha\beta}$ at time T_b. The vehicle sends T_a to IA at $P_{\alpha\beta}$ when IDC tags at $P_{\alpha\beta}$ is detected and IA calculates the time difference. Thus, IDC tags at the intersection are the sort of trigger for IA. Here, we set the traffic condition coefficient ${}^{P_{ij}}V_k$ which means the value for path V_k at the intersection P_{ij}.

$$^{P_{ij}}V_k = \frac{T_b - T_a}{T^{reg}} \\ = \frac{^{P_{\alpha\beta}}T - ^{P_{ij}}T}{^{P_{ij}}T_k^{reg}} \quad (2)$$

Here, ${}^{P_{ij}}T_k^{reg}$ indicates the regular time for passing through k path from the intersection P_{ij}, These traffic condition coefficients are supervised by each IA at the intersection. IA at $P_{\alpha\beta}$ sends the traffic condition coefficient to IA at P_{ij} The vehicle refers these value to select better path from the candidates. Figure 11 shows the path selection flow based on the distance value and the traffic condition.

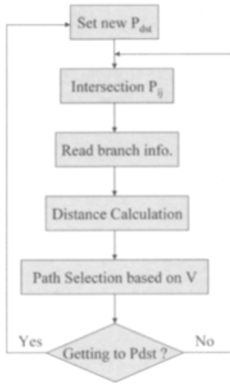
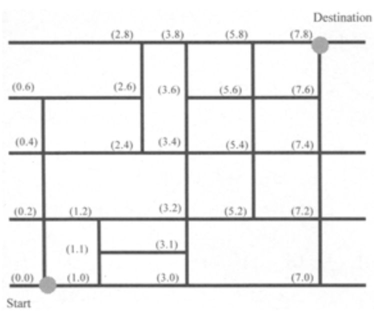


Fig. 11. Path Selection Flow

5 Computer Simulation

In this section, we confirm how our guidance method can work effectively. Here, we compare the result of utilizing only IDC tags and utilizing IDC tags and IA. Figure 12 (1) shows the simulation environment. In this environment, there is 22 vehicles and they set their initial position and destination at random. One of them is the target vehicle and its initial position and destination is set as [0,0] and [7,8](the unit in this map is 10[m]), respectively. Here, the vehicle moves at the speed : 1.8[km/h](the vehicle can pass the unit length:1.0[km] at 20[sec]) and takes 15[sec] at the intersection for local traffic management. Figure 12 (2) and Table. 2 show the simulation result. In figure 12, black bars in the graph indicate navigation time by using proposed method. Gray bars show navigation time by using only IDC tags. We can confirm that the advantage of our method for effective guidance based on local information management(approximately 22[%] improved).



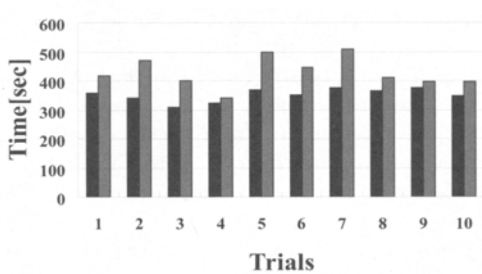


Fig. 12. (1)Simulation Environment (2) Simulation Result

Table 2. Average Time

condition	average time[sec]
only IDC tag	351
IDC tag and Assistant	429

6 Conclusion

The purpose of this research is to apply AGV technologies to flexible new traffic system for human transportation. In this paper, we developed a vehicle guidance system using local information assistants. The system consists of magnetic guidance line and distributed information devices on the running course. We had some experiments to confirm that developed system Also, we proposed a simple algorithm for utilizing our development guidance system. In our future work, we examine and discuss more effective guidance scheme based on a distributed manner with real-time local information, some part of global broadcasted information and so on.

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