Advanced Engineering Technology and Application
An International Journal

http://dx.doi.org/10.1857/aeta/120102

Accident Avoiding Detection Support System Using Multi Agent System (MAS)

*K. C. Ranjan, H. Kumar, S. K. Mahato, R.Prakash and S. Gupta**

Department of Computer Science and Engineering, UIT, Burdwan University, Pin:713104, West Bengal, India

Received: 22 Oct. 2022, Revised: 22 Nov. 2022, Accepted: 6 Dec. 2022.
Published online: 1 Jan. 2023.

Abstract: The aim of this study is to increase the road safety and the quality of the entire road network, especially in case of congestion, accidents and jams, considering traffic information in real-time. Traffic crowding is a problem in most large cities globally. It occurs when the capacity of the road is exceeded, that results in reducing the speed. It can be caused or increased by various conditions like weather, road work, road traffic incidents. To deal with these problems, we developed a Multi Agent System (MAS) for Road Traffic Decision Making. Accident avoiding systems are studied on the basis of overall planning on how many types of accidents can happen and design a multi-agent system (MAS) structure and intelligent and information processing mechanism based on the target detection and recognition are proposed. The multi-agent operation process is analyzed deeply and designed in detail. In the specific agent construction, the information fusion technology is introduced to define the embedded agents and their interrelations in the system structure, and the intelligent processing ability of complex and uncertain problems is emphatically analyzed from the aspects of freedom and collaboration. The aim is to avoid the accident as much as possible. Analyzed that when the relative angle between the vehicles is greater than zero degree (when the vehicle is coming from the front) and when the relative speed of the vehicle is negative then the collision will occur.

Keywords: Target Detection, Detection Recognition, Intelligent Information, Multi-Agent System.

1. Introduction

Due to recent rapid urbanization, road traffic congestion in many large cities and suburbs in the world has increased. The traffic congestion causes longer trip times, slower speeds and increased vehicular queuing. The events like vehicle crashes, the unplanned works in the road, special events, etc. negatively affect drivers, obliging them to multiply their planned travel time to attain their destination in due time. The used solutions to congestion handling, such as systems of adaptive traffic signal control and route guidance on the basis of the local traffic information collected in real time, is likely to enhance each intersection's throughput of the urban traffic in usual conditions. However, they do not have any mechanism to detect and notify the route events. With the advancements in wireless communication technologies in the past few years, MAS is considered as one of the efficient solutions to make smart decisions to avoid accidents. Road traffic accidents are a leading cause of death globally. [1]In India, more than 1 million are injured annually and about 0.1 million are killed in road traffic accidents. [2]It causes the country to lose around many people yearly which is 2–3% of Gross Domestic Production. A road traffic accident can be defined as, an event that occurs on a way or street open to public traffic resulting in one or more person being injured or killed, where at the minimum one moving vehicle is involved.

A road traffic accident is any injury due to crashes originating from, terminating with or involving a vehicle partially or fully on a road. [3] It is projected that road traffic injuries will move up to the third position by the year 2020 among leading causes of the global disease burden. There are millions of deaths from traffic accidents each year, besides severe economic, social, and environmental consequences.There are so many ways that accidents can happen on the road. The most unfortunate thing is that we are not learning from our mistakes on the road. Most of the road users are well aware of the general rules and safety measures while traveling on roads but it is only the carelessness on part of road users, which causes accidents and crashes. Main cause of accidents and crashes are due to errors done by humans.
Learning models and the second approach is the hyper selective ensemble pre-learning model. The two approaches are based on pre-learning models which are training on the ImageNet dataset. These models are fine-tuned to use on the brain tumor dataset. The best results came from three selective models based on fine-tuning a pre-trained which achieved a recognition rate of 97.77%.

*Corresponding author-mail: skgupta.81@gmail.com

2. Structures of Target Detection and Recognition

2.1 Scene Analysis and Mathematical Description

At present we are generally focusing on the two types of collision named frontal collision and rear collision.

[4] For a frontal collision, the two vehicles that are relatively driven are generally not in a straight path, when the horizontal distance between the two vehicles is greater than the average of distance vehicles, even if the distance between the two cars is already very close, there is no possibility of getting a collision. Therefore, only when the distance between the two vehicles perpendicular to the traveling direction is less than the average value k of the two vehicle widths (the A vehicle width is WA and the B vehicle width is WB), that is, when $k \leq |\ d \times \sin\theta_1|$, a frontal collision will occur. The general vehicle width is about 1.5 meters to 1.8 meters, so here k takes 1.7 meters. The distance d between the two vehicles can be derived from the vehicle coordinates received by the Dedicated Short-Range Communication (DSRC) module in meters as follows:

$$d=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$$

The self-vehicle speed is VA, the adjacent car speed is VB, and the unit is km/h. For the frontal collision shown in Figure1, the time required is as follows:

$$t=4.3\times\frac{(d\times|\cos\theta_1|-5)}{(V_A+V_B)}$$

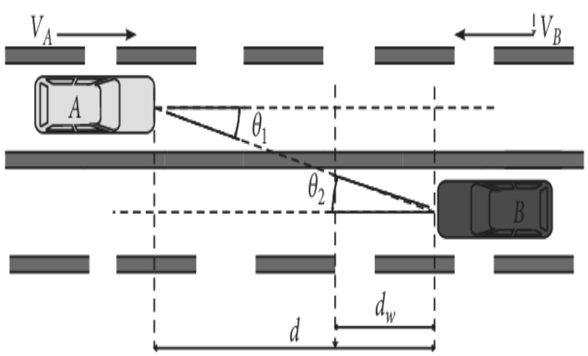

Fig. 1. Frontal collision Algorithm Model

When $|\theta_1| \leq 90°$and $|\theta_2| > 90°$, the calculation of the collision time is performed; if it is $|\theta_1| \geq 90°$and $|\theta_2| \leq 90°$, the processing is not performed.

[5] For the rear-end collision model, most of the rear-end collisions occur in the same lane. Hence, when we study the rear-end collision model, we are no longer considering the heading angle problem but only consider the relative motion of the vehicles. In the rear-end model, the variable is the relative speed and relative distance of the two cars.

For the rear-end collision model shown in Figure 2, when the vehicle is actively rear-ended, if $V_A > V_B$, the time required for collision is as follows:

$$t=\frac{d}{(V_A-V_B)}$$

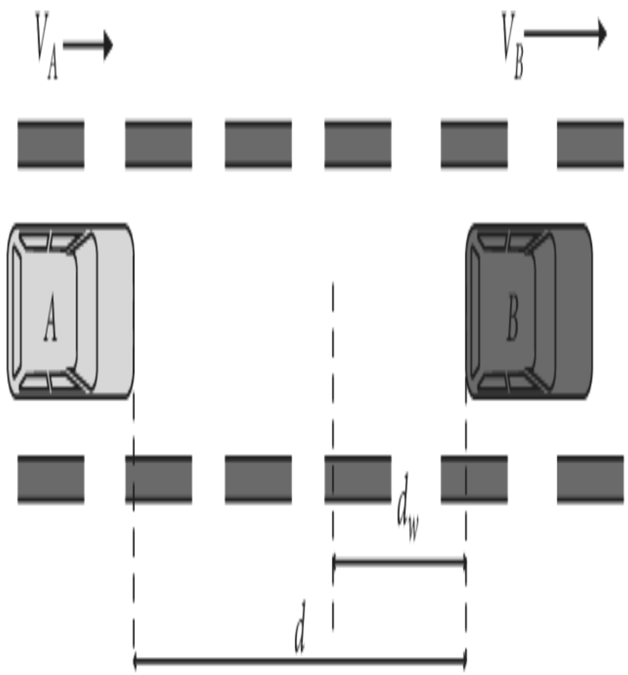

Fig. 2. Rear-end collision Algorithm Model

If $(V_A < V_B)$, the collision avoidance algorithm is not processed. When the car is passive rear-end collision, if $(V_A > V_B)$, the time required for collision is as follows:

$$t=\frac{d}{(V_A-V_B)}$$

If $(V_A - V_B)$, the anti-collision algorithm is not processed.

Through the analysis of the above mentioned scenarios, it can be seen that the calculation method of collision occurrence time is the same whether it is a head-on collision or a rear-end collision, and the unified calculation method is useful to enhance the adaptability of the algorithm in the complex scene.

3. MAS Architecture

On the specific Multi-Agent System structure, thesystem is distributed as a remote multi-agent target detection and recognition system. [6] This comprises mainly three parts: detection subsystem agent, recognition agent and management decision agent, and is divided into three layers according to the degree of data abstraction and main functions. It uses the idea of role-based task decomposition. On the one hand, each role is built by different hard and soft components to accomplish different functions; on the other hand, each role has different functions, which can communicate and coordinate information according to different system task requirements, and jointly complete complex tasks, so as to achieve the overall optimal system performance. Moreover, the structure model reflects the advantages of open design and modular system, which is conducive to system upgrade, and improves the system flexibility and scalability.

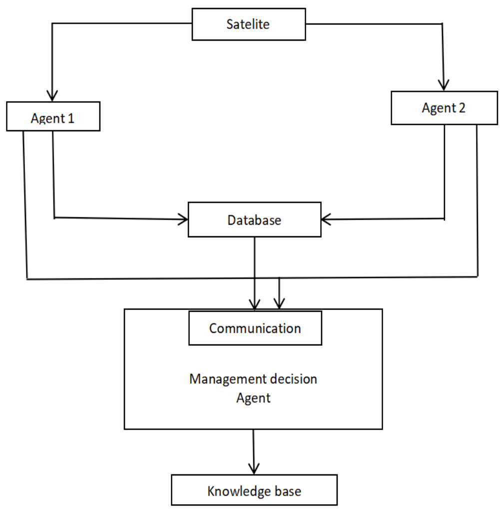

Fig. 3. Communicating with different agents.

In the process of task execution, the system firstly uses sensors in different detection subsystem agents to detect the targets. After they are found, the recognition agent makes fusion judgment according to the initial identified results for each hypersonic target; the management decision agent makes decisions according to situation recognition, understands and decomposes the combat tasks, assigns the corresponding tasks to the recognition agent or the detection subsystem agent, and exerts its characteristic or changes its working mode to further recognize the key target. At the same time, it is considered whether another detection subsystem agent or recognition agent is needed for collaboration. In the process of executing combat tasks, each agent realizes the cooperation andcommunication with other agents through the communication interface.

4. Function and construction of agent

The detection subsystem agent mainly collects processes and stores the data from several similar sensors, unifies multi-sensor information into a common space time reference system, and gives a unified, clear and reliable description of the battlefield environment. When the abnormal situation is found, the report will be submitted to the management decision agent in time, the target local characteristic data after the associated registration and fusion will be sent to the recognition agent, and the management and dynamic scheduling of sensor-level tasks will be accepted by the management decision agent. Since the research content in this paper is mainly in the recognition stage, no further discussion is made on the sensor measurement stage, and the initial recognition results are directly simulated by the sensor. The recognition agent mainly carries out information fusion based on the local characteristics of targets detected by one or several similar sensors through various information fusion algorithms, and establishes the recognized target linked list to provide command and decision-making basis for the management decision agent. At the same time, the change of the target state and the urgency of attack are analyzed. Once a conclusion is reached, it is timely released to other agents. Its functional structure is shown in the above image. Because there is no perfect algorithm to solve all kinds of problems, each method has its advantages and disadvantages. Therefore, by combining various methods and making full use of their respective advantages, when processing the fusion information, appropriate algorithms can be selected according to the various factors in the representation form of the information of target characteristics and changes, so as to achieve better results. A number of fusion agents with different algorithms are embedded in the recognition agent. When identifying the target, the results are compared with other nested fusion agents through the messaging passing mode. When the results are consistent, the credibility or weight of the fusion agents is increased; when the recognition results are inconsistent, they are directly submitted to the decision agent for final fusion judgment.

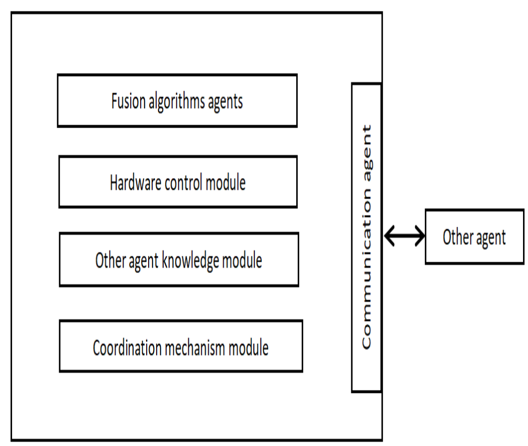

Fig. 4. Communicating with agents using different algorithms and tools.

[7] The remarkable feature of the recognition agent is that it can combine multiple target characteristics with information relevance, such as radiation intensity characteristic, temperature change rate characteristic, heat capacity difference characteristic, etc., all of which are the realization of target infrared characteristics, so they can constitute the target local comprehensive feature. Then it can maximize the role of information correlation, improve the information utilization, and

reduce the characteristic dimensions and the overall calculation amount, and it is organized to coordinate and manage similar sensors with similar characteristics.

The management decision agent mainly synchronizes the asynchronous information of each recognition agent to generate the consistent description of the targets. Considering the different characterizations of target group characteristics of each detection subsystem agent and the limited ability of a single recognition agent, it is necessary to minimize the impact of singular results on fusion results, and increase tolerance of the system and the certainty of the results. The management decision agent can choose the reasonable fusion algorithm and complete the final goal, or make a quick response to the emergency according to the existing knowledge and scheme. At the same time, the target information stored in the database is compared with the sensor information, and the recognition process and result are stored in the knowledge base, or relevant experience and knowledge are called out from the knowledge base for auxiliary decision-making. It is responsible for the initiation, coordination and termination of the task, as well as the management of the sensors, and forms the task list of each decision and writes them into the blackboard model. In addition, the structures of the management decision agent and the recognition agent are roughly the same. The only difference is that there is more database and knowledge base, and no embedded agents.

5. Multi-Agent Coordination Planning Workflow

The cooperation among agents is mainly in the form of dynamic driving cooperation based on various characteristics changing in daily vehicle driving. Therefore, each sensor member shall implement the plan according to their own capabilities and the task distribution, cooperate with other sensor members as required, and solve the existing conflicts through negotiation after the formation of the initial operational plan.[8] The decision-making body is responsible for centralized planning of the inconsistencies among sensors. Therefore, our project suggests a coordinated planning method of target detection and recognition systems based on MAS combining distribution and concentration. It comprehensively solves the system task decomposition and assignment from three aspects of function, structure and flow, and the main steps are as follows:

Step 1 According to the task assignment of the management decision agent, the detection subsystem agent is responsible for early warning and monitoring of target launch in its responsibility area.

Step 2 When a certain detection subsystem agent discovers the suspicious target emission, it will report the situation to the recognition agent and the management decision agent, and inform other similar sensors in the detection subsystem to cooperate in the detection.

Step 3 The detection subsystem agent coordinates the internal sensors for data-layer information fusion and error correction, and obtains high-quality target information to improve the target recognition performance.

Step 4 The recognition agent conducts fusion recognition according to the target information. Since the recognition agent holds the information of sensor capability in the detection subsystem agent, the target characteristic information obtained by them will be given corresponding weight before fusion. Within the recognition agent, an embedded agent will send the target classification recognition results that it considers to be of greater reliability to other embedded agents in the form of message passing.

Step 5 After other embedded agents compare their own results with them, if the conclusions are consistent, the credibility of the recognition results will be increased, and the consistency results of the recognition agent will be sent to the management decision agent; if the results are inconsistent or uncertain, all the information will be directly sent to the management decision agent, which will coordinate the rest of the recognition agents for fusion identification.

On this basis, other recognition agents reduce the scope of target recognition with the elimination method to improve efficiency. On the other hand, if the recognition agent obtains satisfactory identification results at a certain fusion level, the management decision agent can directly make the final identification judgment and threat ranking. In the process of fusion recognition, the corresponding knowledge source (such as database and knowledge base) can be immediately started to deal with the uncertain results. Each recognition agent dynamically adjusts its weight according to the working state of the sensor, and the management decision-making agent adjusts the weight of the recognition agent according to the recognition results embedded in the recognition agent.

Step 6 According to the target characteristics and operating conditions, the management decision-making agent selects and coordinates different detection subsystem agents and recognition agents in time to allocate and combine tasks according to the characteristics assessment and optimization combination knowledge, dynamically determines whether the system achieves the best fusion result, and controls the timing sequence of the system and the start-stop operation of task instructions.

Step 7 When the target goes out of the responsibility area[9]of the detection subsystem agent, the management decision-making agent will transfer the target according to the situation, and start the next detection subsystem agent. The task of the original detection subsystem agent is completed, and then it exits the plan.

Step 8 After the target is recognized and intercepted; the detection subsystem agent and the recognition agent will evaluate the interception effect. If the target is destroyed, the coordination planning will be finished.

6. Results and Analysis

The overall result is described below when the vehicle is at a certain stage. The detection and recognition system uses many technical approaches to measure and extract the dimension, type, speed, etc. of the target vehicle. Here, we are assuming the coordinates and speed of the vehicle will be taken from the satellite.

Table 1: Different scenarios of frontend movement of vehicle where collision can or cannot happen.

Coordinates		**Distance**	**Degree**	**Speed**		**Time**
(x_1, y_1)	**(x_2, y_2)**			**V_A**	**V_B**	
0,0	20, 20	28.284	60	50	60	0.35 h
0,0	20, 20	28.284	95	50	60	0h(collide)
10,10	15, 15	7.071	60	30	20	0h(collide)
10,10	15, 15	7.071	95	30	20	0.5h
5,5	15, 15	14.142	30	10	30	0.67 h
5,5	15, 15	14.142	120	10	30	0.05 h

(For frontal collision)

Table 2: Different scenarios of rear movement of vehicle where collision can or cannot happen.

Coordinates		**speed**		**Time**
(X1, Y1)	(X2, Y2)	V_A	V_B	
0,0	20,20	60	50	2.82h
0,0	20,20	50	60	0h(collide)
10,10	15,15	60	30	0.235h
10,10	15,15	30	60	0h(collide)
5,5	15,15	30	10	0.707h
5,5	15,15	10	30	0h(collide)

(For rear collision)

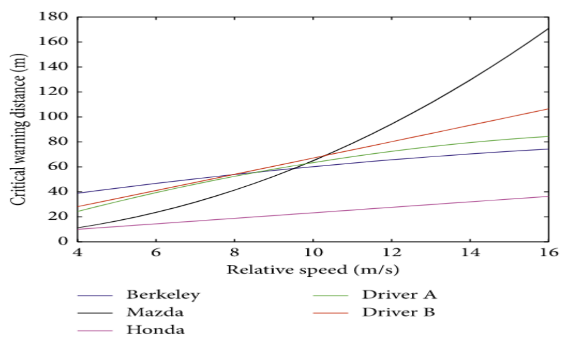

Fig. 5. Comparison Analysis Diagram

7. Conclusions

Concluding at the problem of target detection and recognition, our work proposes the MAS structure based on the combination of distribution and concentration, and mainly designs the information fusion intelligence and processing mechanism.

The steps of coordinated planning and multiple intelligent information processing and application are expounded, and the effect is demonstrated. This scheme changes the solidified state of the information processing structure in the previous target detection and recognition system, which does not change with the sensor and the target state. It can enhance the adaptability and cooperation of information fusion and make target detection and recognition more intelligent.

The innovation of this scheme is mainly provided in the following aspects of intelligence:

I) Multi-intelligence is expressed in the multi-agent co-operation and competition based on the evaluation and selection of target characteristics, and the overall information fusion presents multi-level intelligent optimization.

II) Advanced intelligence is embodied in the cognitive closed loop of the information processing model and can self-adjust the system detection and recognition strategy according to the target and sensor states.

In the future, the scheme will be further improved on effective integration and performance evaluation.

Conflict of interest

The authors declare that there is no conflict regarding the publication of this paper.

References

[1] Whom Collaborating Centers for Neurotrauma. World Health Organization; Geneva: 1995.

Prevention, Critical Care and Rehabilitation of Neurotrauma

[2] World Health Organization; Geneva: 2004.

[3] WorldReportonRoad Traffic Injury Prevention: Summary; pp. 1–52.

[4] S. Gopalakrishnan” A Public Health Perspective of Road Traffic Accidents”,2012 Jul-Dec; 1(2): 144–150.

[5] Y. J. Zhang,1 F. Du, 1 J. Wang, 1 L. S. Ke, 2 M. Wang,1 Y. Hu,1 M. Yu, 1 G. H. Li,1 and A. Y. Zhan1, “A Safety Collision Avoidance Algorithm Based on Comprehensive Characteristics”, Volume 2020.

[6] Y. J. Zhang,1 F. Du, 1 J. Wang, 1 L. S. Ke, 2 M. Wang,1 Y. Hu,1 M. Yu, 1 G. H. Li,1 and A. Y. Zhan1, “A Safety Collision Avoidance Algorithm Based on Comprehensive Characteristics”, Volume 2020.

[7] WU Xia, LI Yan*, SUN Yongjian, CHEN Alei, CHEN Jianwen, MA Jianchao, and CHEN Hao, “Investigation of MAS structure and intelligent information processing mechanism of hypersonic target detection and recognition system”, Journal of Systems Engineering and Electronics Vol. 31, No. 6, December 2020, pp.1105 – 1115.

[8] Dongya Wu, Huanzhang Lu, Moufa Hu, Bendong Zhao, “Independent Random Recurrent Neural Networks for Infrared Spatial Point Targets Classification”, 30 October 2019, 9(21), 4622.

[9] Xia Wu, Jianwen Chen, Kun Lu, “Investigation of system structure and information processing mechanism for cognitive skywave over-the-horizon radar”,Journal of Systems Engineering and Electronics27(4):797-806.

[10] Eric Bonabeau, “Agent-based modeling: Methods and techniques for simulating human systems”, May 14, 2002,99 (suppl_3) 7280-7287.

[11] Doi,A., Butsuen, T. Niibe, T., Takeshi, T.,Yamamoto,Y. and Seni, H., 1994, Development of a rear-end collision avoidance system with automatic brake control. JSAE Review, 15, 335–340.

[12] Abdel-Aty, M.A. and Radwan, A.E., 2000. Modeling traffic accident occurrence and involvement. Accident Analysis & Prevention, 32(5), pp.633-642.

[13] Xiao, F., Ligteringen, H., Van Gulijk, C. and Ale, B., 2013, October. Nautical traffic simulation with multi-agent system for safety. In the 16th International IEEE Conference on Intelligent Transportation Systems (ITSC 2013) (pp. 1245-1252). IEEE.

[14] Dvořák, Z., Raždík, J., Soušek, R. and Sventekova, E., 2010. Multi-agent system for decreasing risk in road transport. Transport means, pp.100-103.

[15] Bhumkar, S.P., Deotare, V.V. and Babar, R.V., 2012. Accident avoidance and detection on highways. International Journal of Engineering Trends andTechnology, 3(2), pp.252.

[16] Cobeanu, I. and Comnac, V., 2014. Multi-agent systems: Traffic control application. Bulletin of the Transilvania University of Braşov, 4(53), pp.107-114.

[17] Aguirre, H.R.O., Lopez, M.Q., Salas, S.L. and Moreno