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Vehicles and MultiAgents Systems

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Abstract :

In this paper, we deal with MultiAgents systems devoted to collisions avoidance within road traffic network. We can in fact define an agent within each vehicle. We have thus designed a simulation tool in order to study agents behaviours when faced with dangerous situations. The results were a reactive MultiAgents system and a Mid-level cognition agents system. We also show hierarchical aspects within MultiAgents systems that allow concurrent design.

1 Introduction

MultiAgents systems [3, 1, 6] distribute intelligence, by defining within each agent which part of the problem to solve or by defining a particular behaviour of agents. This approach is of great interest in multiple fields such as geographically distributed systems, for instance electric distribution[10], or systems where applications deal with dynamic evolution, for instance road and aerial traffic systems[7, 8, 5, 4].

The presented work, is involved with distributed management of collision avoidance within road traffic network. MultiAgents systems fit then our goals. Indeed, we can define within each vehicle an agent with embeded capabilities.

We study agents according to the following points:

1. **Grain level** that could be associated with the environement in which agents do evolve.

2. **Agents complexity level** as the cognitive capabilities of agents.

3. **Agents interactions modes** representing relationnal mechanisms involving agents to agents and agents to universe relationship.

4. **Autonomy of agents** which is tightly coupled with points 2 and 3 and can be analysed through robustness and flexibility aspects.

All these points can be used to characterize a "road traffic system" seen through three different grain levels. These levels are presented in section 2, while in sections 3 and 4, we particularly focus on the coarsest grains.

2 Road traffic system

Within a road traffic system, we can note the following four organizations each one defining a MultiAgents society. These organizations are presented according to their grain level.

2.1 First organization

This is a coarse grain system representation. Agents in this society are vehicles, and road network is their universe. Agents, in this system, have minimum cognitive capabilities. They are just able to perform simple task as a response to particular events. Agents to agents interactions mode is achieved by reactive coordination of actions. Such organization is studied in section 3.

2.2 Second organization

Agents in this society differ from those described above by their mid-level cognitive capabilities. These agents can dynamically modify their intentions: for example, an agent can cancel its initial overtaking intention. Agents to agents interactions mode are augmented with communications capabilities. This allow that more elaborate mechanisms take place among agents: for example, negociations mechanisms. Section 3 deals with such organisation.

2.3 Third organization

This mid-level grain representation follows naturally the previous developements. It constitues a deeper representation where agents do evolve within the vehicle in the way that a vehicle is the agents universe. The conductor is considered as member of this society of agents. The other agents are the AI on-board system and potentially external agents. AI agent has high cognitive capabilities enabling him to exchange informations with external agents (signs), and to interact with the conductor by use of hierarchical collaboration mechanisms. An expert system devoted to collision avoidance can be such AI agent.[2]

2.4 Fourth organization

This is a fine grain representation. The intelligent system is the agents universe. Agents of this organization are dedicated processes and they deal with resources of the system they are to evolve in. In order to meet their goals, agents have the ability to interact with each others by collaboration, coordination mechanisms. They can also interact with users of the system they elaborate.[9]

Following to which organization they belong to, agents behave differently. Agents of the first and second organizations deal with external (real world) features. Agents in the other organizations interact with intra-vehicles resources. We can also note that among the first and second organizations there exists concurrency that does'nt allow implementation of the two organizations within a same frame.

2.5 Concurrent engineering

We are interested in the study of the coarse grain organisation. However, a complete system may take care of all aspects required: real world events and internal resources managements. Fortunately, the implementation within a complete system of the previous organizations should be made easier thanks to the complementary relationship that exist between the organizations.

MultiAgents vision allows the integration of developements that are made at each grain level. As the agents functionalities (within each grain level) remain valid, the full system gains complete capabilities but this is conditionnal to the design of well suited interactionnal mechanisms among the differents grains.

The ability to integrate in a final stage the efforts made by other teams corresponds then to our concurrent engineering scheme.

3 Coarse grain MultiAgents level

Within MultiAgents systems of sub-sections 3.1 and 3.2, our main interest remains in collisions avoidance mechanisms that are to be integrated within each agent of each system. Thus, the more important is agents behaviours, not their internal design. A behavioural description in the design of each agent is thus sufficient for our purpose.

The road traffic system exhibits also a hard constraint, agents cannot evolve outside road traffic network.

In the reactive system, agents avoid obstacles by calculating by a reactive manner their next displacement by using protagonist agents displacement. Such mechanisms have been already implemented [5, 4]. The technics was shown robust for their case.

In the cognitive Mid-Level system described in subsection 3.2, agents integrate reactive capabilities, behavioural abilities and also communications mechanisms.

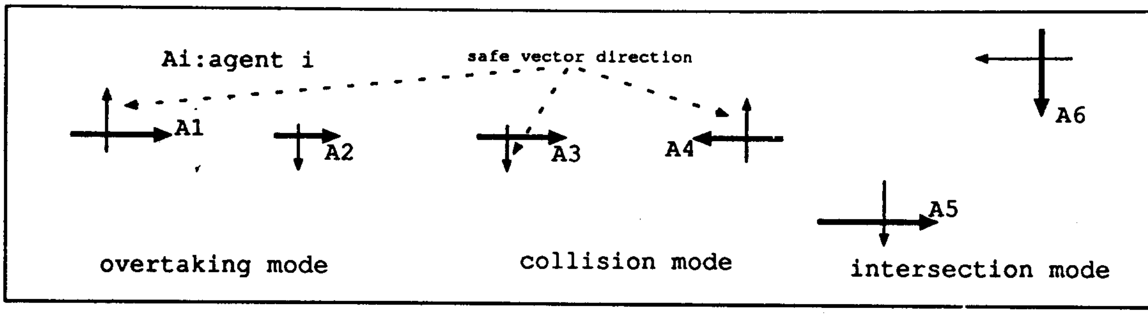

Fig 1:dangerous situations and safe vector directions

3.1 Coarse grain Reactive agents system

Reactive agents have two integrated mechanisms in order to evolve. The first mechanism is an integrated navigation system that allows the agent to receive next locations to reach from an external system[1]. The second mechanism is the reactive mechanism that performs, on obstacles detection, a new displacement in the safe direction.

In our simulation system, we have mainly studied three possible dangerous situations, we have thus the three following modes, that are:

head-on collision mode;

intersection collision mode;

overtaking collision mode.

For each mode, the agent elaborates the displacement direction in order to avoid collision, that we name safe vector direction as in fig 1.

3.2 Mid-level cognition agents system

Mid-level cognitive agents integrate reactive capabilities for collision modes. They use communications among agents on overtaking modes: before heading, each concerned agent seeks if there is any received message about a possibly critical situation. The agent do not perform overtaking on the occurence of such message. In intersection mode, agents follow priority rights, that is, agent with less priority waits at the intersection until the agent with highest priority has passed its route.

[1]GPS Navigator is an example of such system

4 Simulations results

The simulations (see fig 2.) starts with agents parameters initialisation. For each agent, we initialise:

- Initial and final destination.
- The maximal velocity.
- The perception distance at which an agent can scan.

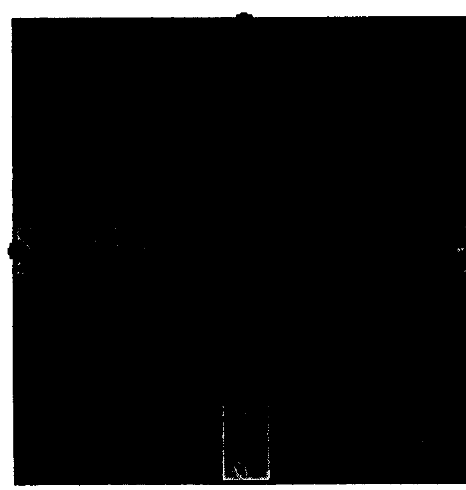

Fig 2: Simulation system

Agents trajectories are choosed so that all the previously defined modes will occur in the same simulation session. They are also estimated so that agents will meet in a same area, increasing thus the number of interactions among agents.

At the end of each session, the number of failed missions (related to the number of collisions), and the number of interactions that occured are stored.

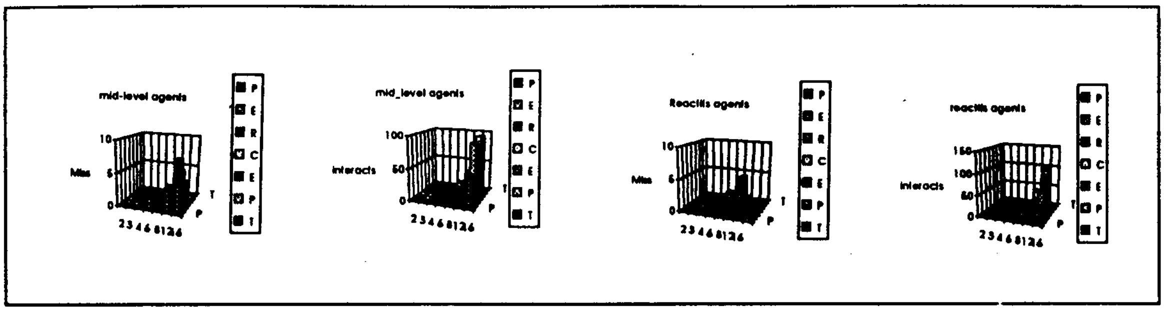

Fig 3: simulations results

The obtained results (see fig3) show what we can expect, that pure reactivity does'nt fit robustness. In our case, this is due to hard spatial constraints and thus, when a great number of agents evolves in a reduced area, safety positions decrease in the same order.

Mid-level cognition agents behave badly than reactive one, when perception distance is small (a small distance corresponds to the near positions reached in the very next future). This is due to the fact that these agents are less reactive and a better behaviour is expected from them specially by setting greater perception distance.

However, although mid-level cognition agents are more robust than reactive ones, they are still unable to fully avoid collisions and this because of spatial constraints.

To increase robustness, new abilities must be embeded within agents That are:

- More elaborated intra-vehicles communications so that informations about road traffic fluidity could be propagated.
- road planning to deal with such informations.

5 Conclusion

In this paper, we have studied different grain levels that concern on-board Intelligent system for road traffic collision avoidance. It has been shown that at a coarse grain pure reactive agents are not suited for our case. Mid-level cognition agents at the same grain level behave better but they remain inefficient in some specific situations. These situations can be avoided by planing mechanisms.

In order to realise an efficient system we propose one that should comprise:

- **reactive agent** to deal with situations that are time constraints.
- **mid-level cognition agent** that can manage operation such as enabling overtaking mode, intersection mode and collision avoidance.
- **a planning agent** that has to estimate the impact of current decisions that are made by the other agents, on future evolution and that can change these decisions.

The development of such system although it can be simulated at a coarse level for behavioural analysis, has to be developed at a mid-level grain for inter-agents interaction analysis, and at fine grain level for the detailed processes of the system.

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