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PAAMS, the International Co
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change their experience in the deve
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This volume presents the pape
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Abstract. This work
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1 Introduction

Injuries or disabilities contra
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* Corresponding author.

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Multi-Agent Systems Platform for Mobile Robots Collision Avoidance

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Abstract. This paper presents a multi-agent platform to simulate a new methodical approach to the problem of collision avoidance of mobile robots, taking advantages of multi-agents systems to deliver solutions that benefit the whole system. The proposed method has the next phases: collision detection, obstacle identification, negotiation and collision avoidance. In addition of simulations with virtual robots, in order to validate the proposed algorithm, an implementation with real mobile robots has been developed.

Keywords: Avoiding collision method, robotic agents, mobile robots, avoidance collision method, jade platform.

1 Introduction

As it is well known, the main theme of AI is the concept of intelligent agent defined as an autonomous entity which observes through sensors and acts upon an environment using actuators [9]. This definition is very close to features that a robot can provide, so the concept of agent often is related with robots [3], [14].

On the other hand, detecting and avoiding a collision is a previous step for overcoming the motion planning problem in mobile robots. Collision-detection techniques can be divided into discrete collision detection (DCD), and continuous collision detection (CCD). The DCD algorithms involve stepping the motion of both the mobile robot and the mobile obstacle at a time sampling rate and some problems like tunneling can occur [10]. The CCD techniques are more effective because motions are not stepped. CCD algorithms basically make a return if a collision between the motion of two given objects is presented or not; and if it is going to occur then, the instant in time of the first contact is returned [5], [12] and [1].

In this paper, a multi-agent systems platform for collision avoidance for mobile robots is proposed. Strategies of collision detection of autonomous mobile robots based on [2] are combined with strategies based on artificial intelligence to offer a new method of avoiding collision management. The platform for the implementation and management of the multi-agent system is based on JADE [6].

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2 Main Purpose

This platform expects to present a new
sion avoidance of mobile robots taking
deliver solutions that benefit the whole
concepts: obstacle detection by a mob
agent as a software agent within MA
method of communication and negotiati

The aim of the avoiding collision met
thodology for obtaining the instant in tin
located at their maximum-approach posit
tories. If the involved robots do not col
Otherwise, their maximum penetration is
[4]. A very remarkable aspect is both the
separation or maximum approach are com

The methodology used for the collisi

Detection: In this phase, the local sy
be a threat of collision at some poin
the global scenario. This position is
tem in MAS to manage the threat.
Obstacle identification: When an a
the local system it represents must i
ject or a static object. In order to c
know who is located within that are
area, the threat is identified as a thre
Time to talk, negotiate and resolv
threat have been identified, the com
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Collision detection algorithm app
position coordinates of detector-age
it returns the probability of collisio
detector-agent the time of maximum
Negotiation: To decide the load per
sion avoidance, the two agents com
meters such like priority, the weigh
neuvering, speed… This informatio
agent offers to change its trajectory a
Solve the collision: The detector-a
robot should be achieve at correct t
ives the avoidance position and th
reached, the collision is resolved, an

The platform allows simulated and re
LEGO Mindstorms NXT systems [7] pr
four SHARP IR proximity sensors [11]
nected to their software agents (compu
part of a network that forms the overall
platform control architecture.

2 Main Purpose

This platform expects to present a new methodical approach to the problem of collision avoidance of mobile robots taking advantages of multi-agents systems (MAS) to deliver solutions that benefit the whole system. The method is divided into three basic concepts: obstacle detection by a mobile robot, the concept of abstraction robotic agent as a software agent within MAS, and distributed artificial intelligence as a method of communication and negotiation between these software agents.

The aim of the avoiding collision method used in this platform is to implement a methodology for obtaining the instant in time when two robots or agents in motion will be located at their maximum-approach positions while they are following straight-line trajectories. If the involved robots do not collide then their minimum separation is returned. Otherwise, their maximum penetration is computed as a minimum translational distance [4]. A very remarkable aspect is both the instant in time and the corresponding minimum separation or maximum approach are computed without stepping any involved trajectory.

The methodology used for the collision avoidance platform has the next phases:

Detection: In this phase, the local system of the robot detects an obstacle that may be a threat of collision at some point and calculates the position of threat-object in the global scenario. This position is sent to the agent who represents the local system in MAS to manage the threat.

Obstacle identification: When an agent receives a position of a threat-object by the local system it represents must identify what kind of threat it is, a moving object or a static object. In order to do this, the agent consults the other agents to know who is located within that area of threat. If there isn't any agent within that area, the threat is identified as a threat of static object.

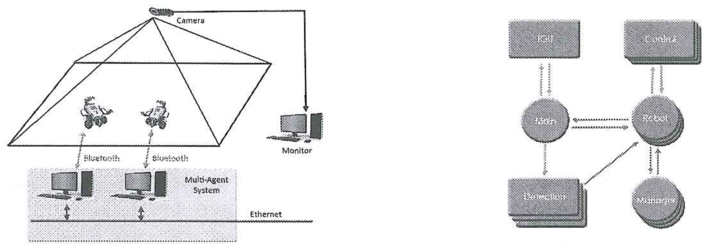
Time to talk, negotiate and resolve: When the two involved agents in a possible threat have been identified, the communication between the two agents is used to obtain the information needed to apply the detection algorithm.

Collision detection algorithm application: This algorithm requires the current position coordinates of detector-agent and threat-object and their destinations, and it returns the probability of collision. In case of collision, the method informs to detector-agent the time of maximum penetration to be produced.

Negotiation: To decide the load percentage that each robot will have in the collision avoidance, the two agents communicate with each other and exchange parameters such like priority, the weight of the transported load, the difficulty of maneuvering, speed… This information defines the easiness or availability that each agent offers to change its trajectory and avoid collision.

Solve the collision: The detector-agent computes the two new positions that the robot should be achieve at correct time to avoid collision. The threat-agent receives the avoidance position and the time in which must be achieve. Once it's reached, the collision is resolved, and each robot continues its original path.

The platform allows simulated and real robots. The real robots are based on the LEGO Mindstorms NXT systems [7] programmed with LeJOS [8] and equipped with four SHARP IR proximity sensors [11] connected by a I2C bus. The robots are connected to their software agents (computers) via Bluetooth and those computers are part of a network that forms the overall MAS through JADE. Figure 1 (a) shows the platform control architecture.



(a) (b)

Fig. 1. Platform Control architecture

In Fig. 1 (b), purple circles represent agents, and blue rectangles represent execution threads. Each robot has a control module for following trajectory, a detection module that manages the IR sensors and a manage module that obtain the data and solve the collisions.

Figures 2 and 3 shows two executions obtained with the proposed platform. In the first one four robots (circles green, blue, black and pink) are considered. The robot initial positions are the corners of the arena, and they must arrive to the opposite corner (marked by a star). The figure also shows the detection area (a trapezoid in front of each robot), and the final path described by the robot.

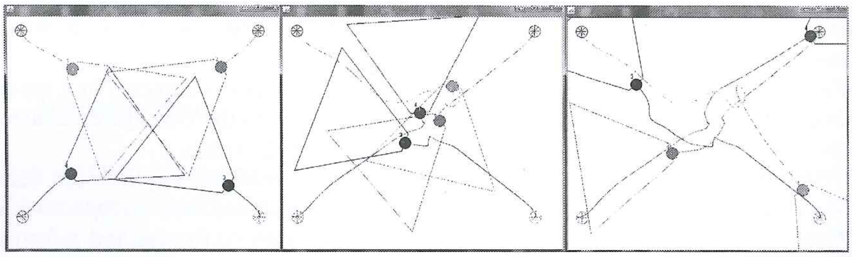


Fig. 2. Simulation 1: 4 robots without static obstacles

Figure 3 shows a similar situation but in this case there are four static obstacles, marked with black squares.

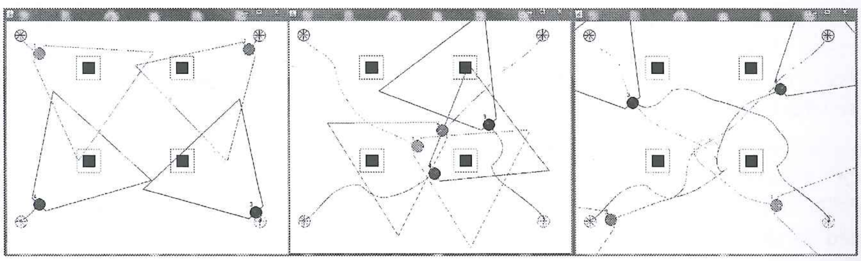


Fig. 3. Simulation 2: 4 robots with static obstacles

A video demonstration o
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3 Conclusions

A collision avoidance metho
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A video demonstration of practical experiment with Lego robots and two compiled versions of the platform that allow the simulation with robots can be obtained in http://idecona.ai2.upv.es/ (multimedia gallery and Resultados at Proyect menu)

3 Conclusions

A collision avoidance method that takes advantages and benefits of MAS has been presented in this work. This method is located one level above the traditional methods of obstacle avoidance where the management is performed locally and the possible communications between the local systems are solved functionally. The application of techniques provided by the area of artificial intelligence to the robotic area opens a wide range of possibilities that offers more natural results and gives human characteristics of communication like negotiation between robots. This work has succeeded in unifying concepts of agent theory with concepts from the area of mobile robotics, providing more intelligence to robots and offering solutions that otherwise can't be provided.

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