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Cooperative Approach navigation for autonomous Mobile Robots (Application on a building Site)

Benmachiche Abdelmdjid ^{a,*}, Bouhadada Tahar^{*,b}, Makhlouf Amina^{a,*}, Zekri Meriem ^{a, +},
Maatallah Majda ^a

^a Département d'Informatique – Université Chadli Bendjedid El-Tarf, BP 73, (36000) – Algérie.

^{*} Laboratoire LRI Université Badji Mokhtar-Annaba BP. 12 Annaba – Algérie

⁺ Laboratoire LISCO Université Badji Mokhtar-Annaba BP. 12 Annaba – Algérie

^b Département d'Informatique – Université Badji Mokhtar-Annaba BP. 12 (23000) – Algérie.

Informations	Résumé
Mots clés : Mobile Robots, building Site, Genetic algorithm, multi-agents system *Correspondance : benmachiche- abdelmdjid@univ-eltarf.dz Reçu le 12 avril 2018, Révisé le 13 juin 2018, Accepté le 14 juin 2018.	This paper deals with the problems of co-operative navigation of autonomous mobile robots focusing on a type of specific system and application: building site; it is about creating an environment of robotics specific to a building site where mobile autonomous robots must cooperate to deal with the functions related to this building site. According to the theory of multi-agents system (MAS), our suggested approach, which is composed of several autonomous mobile robots, must ensure the fundamental properties of this theory (communication, cooperation, negotiation, sociability ...) to carry out the common objectives of the various agents assigned to the function of the application.

1. Introduction

Co-operation in robotics [1, 2] is a very important problem of optimization in autonomous robotics, it is a topic widely investigated in high level laboratories. Based on decomposing robot mission into many tasks then decomposing these tasks into secondary ones until we get the elementary task (directly achievable by a robot) according to a mechanism of repartition of the functions so that the multi-robot system [3], is more efficient according to the following characteristics: Execution time, complexity of the algorithm, the robustness and the tolerance of the failures. Finding the shortest path in the multi-robot environment is a complex and important task, which is described as an optimization problem. The aim is to find the shortest way by avoiding the obstacles for a robot from the starting point up to the arrival point. The aim is to find the shortest way by avoiding the obstacles for a robot from the starting point up to the arrival one. There are several methods which deal with this problem such as the potential field in [4], bio-inspired approaches of artificial

intelligence [5], neural networks in [6], the genetic algorithms presented in the articles [7], [8] fuzzy logic [9], [10].

Collective navigation has interested researchers in the last decades compared to the single robot navigation because of its effectiveness, its speed, its robustness and its capacity to achieve complex tasks.. This topic has become more and more interesting over recent years, therefore an increasing number of researches is carried out today in the field of robot cooperation. A good summary of the reasons behind our choice of multi-robot systems over a single robot can be found in [11, 12, 13].

2. Architecture of our system

Our work is on two main axes:

Control of the Robots: this axis gathers the sets of themes related to the planning of the way, the generation of trajectories, and robots command in a general way. In this part we tried to propose a new model of planning for the autonomous navigation of the mobile robots, in

other words, to manage several robots in a dynamic environment in an optimal way where they choose the shortest ways by using 2 types of algorithms, the first type is A* algorithm which gives very good results [8] in a limited environment for determined missions. But if the 2 starting and arrival points are distanced, the complexity of the algorithm increases, and for this reason we tried to use the power of the biological inspiration, to be very precise, the genetic algorithms can solve the problems of the path with a random generator of trajectories. The randomly generated obstacles are located in unknown places; the robots must avoid them by

using the 2 algorithms mentioned above. The robots must avoid the collisions whether with the obstacles or between themselves.

The Inter-robots Communication: one can find here all the works related to the cooperation between robots and the robots flotillas control. In this part we did an in-depth study about the types of cooperation and the techniques of communication between the intelligent autonomous entities (agents or robots) distributed, and here is the general Architecture of the system (Fig. 1):

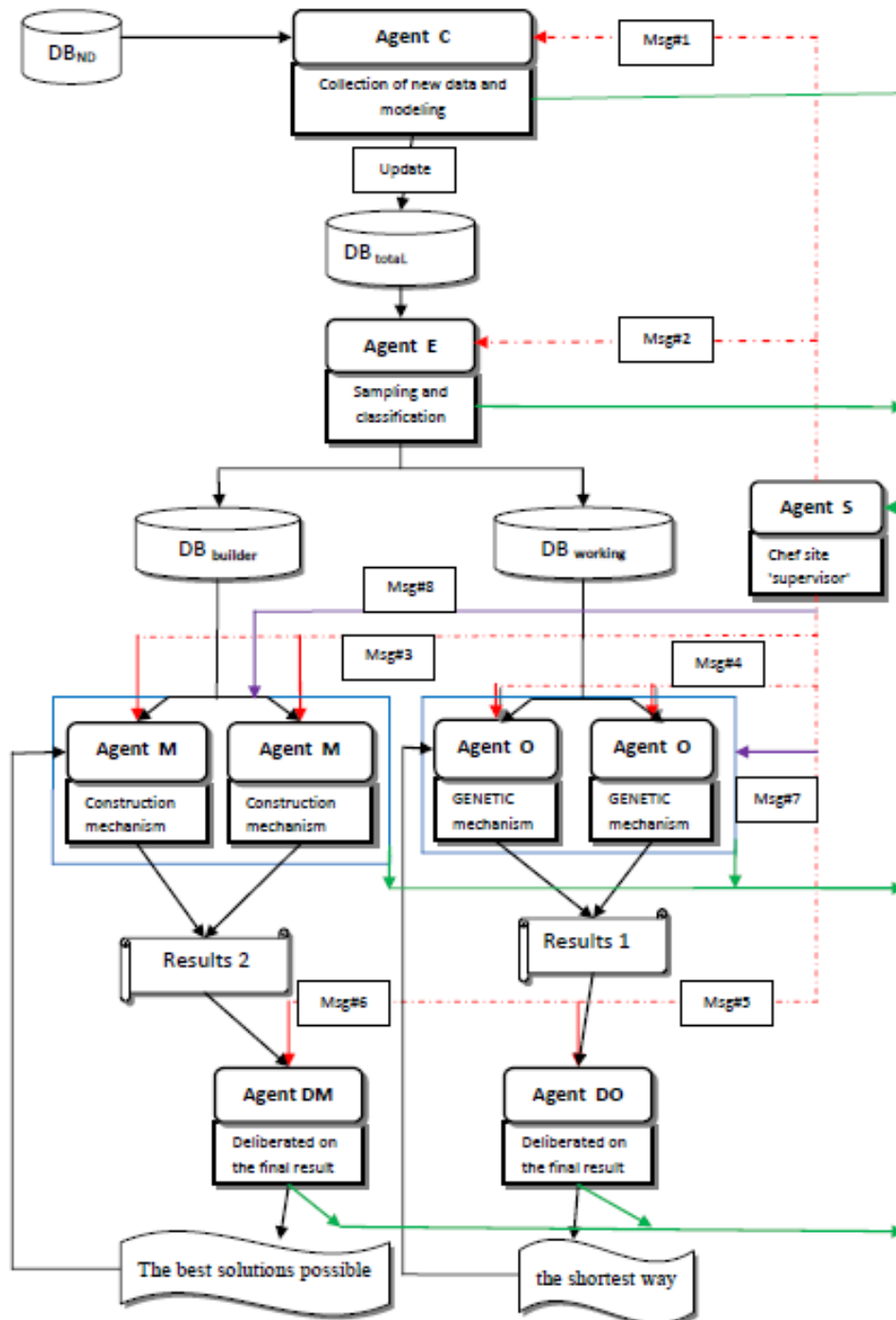


Fig. 1: The General architecture of the system

2.1 Stage of Collection of the New Data

This section shows the interaction between two agents in the collection stage; it is a communication scenario between the supervisor agent (Agent S) and collector agent (Agent C).

1. Detection of the new data by Agent S.
2. Sends msg#1 calling Agent C.
3. Access to DB by Agent C.
4. Aggregation and adaptation (coding) of the new data.
5. External juncture between the new DBND and the DB total.
6. Insert the new data and update the evolved existing data.
7. Send a message of completion of the Agent C to Agent S and sleeps.

Each new information encoded in a table contains **(Table. 1)**:

1. *Num*: represents the order of execution of the action.
2. *Action*: the requested task.
3. *Actor*: it was he who does the action.

Num	Action	Actor
1	Take a brick.	Builder
2	Break a brick.	Builder
3	Put a brick.	Builder
4	Find a tool.	Worker

Table.1: The result of collection of the new data

2.2 Stage of sampling and classification

This section shows the interaction between two agents in the sampling and classification stage; it is a communication scenario between the supervisor agent (Agent S) and classifier agent (Agent E).

1. Detection of the new updates with the total DB by Agent S.
2. Sends a msg#2 calling Agent E by Agent S.
3. Label the data according to their types of activity.
4. Classification and partition of the total DB into 2 under- DB (mobile activities 'DB working' /activities of construction 'DB builder').
5. Sends a message of completion of the Agent E to Agent S and sleeps.

Give a sample that corresponds exactly to its own actor in order to separate the activities and to divide the work between the 2 categories of the employing robots. Then, create 2 databases DB builder and working DB **(Table. 2)**, finally, to insert in each database the suitable sample.

Num	Action	sample	Class
1	Take a brick.	B	DB _{Builder}
2	Break a brick.	B	DB _{Builder}
3	Put a brick.	B	DB _{Builder}
4	Find a tool.	O	DB _{Working}

Table.2: The result of classifying step

2.3 Stage of Calculation

In this section, the interaction between three agents in the Calculation stage; it is a communication scenario between the supervisor agent (Agent S), builder agent (Agent M) and worker agent (Agent O).

1. Detection of the new updates to DB working by Agent S.
2. Sends a msg#3 calling Agent O by Agent S.
3. Detection of the new updates to DB builder by Agent S.
4. Sends a msg#4 calling Agent M per Agent S.
5. If (1) is true then Each Agent O calculates its proposal according to mechanisms of calculation the shortest way and the strategy of navigation, to gather the results of calculation of the agents "Agent O" in table 'Results 1'.
6. If (3) is true then Each Agent M calculates its proposal according to the rules of construction, gathering the results of calculation of the agents Agent M in table 'Results 2'.
7. Sends a message of completion of the Agent M towards Agent S and sleeps.
8. Sends a message of completion of the Agent M towards Agent S and sleeps.

2.4 Stage of Decision

In this section, the interaction between three agents in the Decision stage; it is a communication scenario between the supervisor agent (Agent S), decision maker for builder agent (Agent DM) and decision maker for worker agent (Agent DO).

1. Detection of the new updates in table 'Results 1' by Agent S.
2. If (1) is true then sends a msg#5 calls Agent DO by Agent S.
3. Access to table 'Results 1' by Agent DO.
4. Agent DO deliberates the best proposal starting from the results stored in 'Results 1' according to its knowledge.
5. Stores the best solution (proposal) in 'the shortest way' by Agent DO.
6. Detection of the new updates in table 'Results 2' by Agent S.
7. If (6) is true then sends a msg#6 calls Agent DM by Agent S.
8. Access to 'Results 2' by Agent DM.

9. Agent DM deliberates the best proposal starting from the results stored in 'Results 2' according to its knowledge.

10. Stores best the solution (proposal) in 'the best solutions possible' by Agent DM.

11. Sends msg of completion by the agents (Agent DO/Agent DM) to Agent S.

12. Agent DO sleeps

13. Agent DM sleeps.

2.4.1. Mechanism of Deliberation of Best Proposal of the Builder Robots (Agent M)

The construction of wall for the cell: to build one wall without breaking bricks (except in special cases), In order to make this operation successful: calculate the length of wall, Calculate the length of the bricks, Length of the wall /length of bricks, the robot "Agent DM" traverses the walls brick after brick, and each mal-positioned one. The counter of the builder robot responsible for this construction increments it to 1, the robot "Agent DM" counts the broken bricks and store the ID of the builder robot which proposes the best strategy, the robot "Agent DM" store the best strategies in "the best possible solutions" and finally Agent DM sleeps.

2.4.2. Mechanism of Deliberation of Best Proposal of the Working Robots (Agent O)

The working robots start the genetic mechanism to calculate the shortest way. Every working robot calculates the distance 'd1' between its current location and the position of the required tool, Each working robot calculates the distance 'd2' between the position of the tool and the position of the builder robot, the robot "Agent DO" selects the results 'd1' obtained by the working robots according to an ascending order and stores the ID of the robot which calculates the shortest way, the robot "Agent DO" selects the results 'd2' obtained by the working robots according in an ascending order and stores the shortest way, le robot "Agent DO" calculates the total "dt" distance by a simple operation of addition 'dt =d1+d2' (in our simulation the way is a list of (X, Y). So, concatenating the 2 lists d1 and d2), the robot "Agent C" updates the table "the shortest way" and insert the "dt" list.

2.5 Stage of Construction

1. Detection of the new updates in 'the shortest way' by Agent S.

2. If (1) is true then it sends a msg#7 calls Agent O and Associated with the best proposal by Agent S.

3. The Agent O carries out the solution sequentially.

4. Agent O sends a message of completion to Agent S and sleeps.

5. Detection of the new updates in 'the best solutions possible' by Agent S.

6. If (5) is true then sends a msg#8 calls Agent M and Associated with the best proposal by Agent S.

7. The Agent M carries out the solution sequentially.

8. Agent M sends a message of completion to Agent S and finally Agent M sleeps.

3. Conclusion

In this study we exposed our approach of co-operative and autonomous navigation of the mobile robots in a building site, in order to build the plan of navigation in an environment with obstacles. The robots are able to move from initial to final position in an environment of dynamically moving obstacles without collision. The path chosen is optimum. The performance of the proposed Genetic Algorithm based approach is tested on environments with increasing complexity. The results obtained by this approach show the effectiveness of GA's, these algorithms can find the optimal path in a very short time and has the capacity to enrich the configuration space by a different set of eligible movements by using the selection, crossover operator and mutation. This technique can be used to enable the movement of many robots together in a common place. This example proposes the dialog between the robots with the aim of cooperation and responding to the initial objective. As future works, we would like to extend this approach to multiple cooperating robots and mobile manipulators.

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