Analysis of Multi-Robots Transportation with Multi-objective PSO Algorithm in an Artificial Capital Market

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ABSTRACT
In this paper, to analyze the transport of autonomous robots, an artificial Capital market is used. Capital market is considered as a pier which loading and unloading of cargo is done. Autonomous robots load and unload from the ship to the warehouse wharf or vice versa. All the robots have the ability of transporting the loads, but depending on loads and the location of unloading (or loading) and position of robots, robots have different role in unloading tasks. The role of robots and their number is decided, planned, and managed by the partial swarm optimization (PSO) algorithm. The main goal of the paper is to optimize a multi-object function (MOF) which is a combination of total work time and fuel cost functions. In this paper, a new method of transporting from ships to warehouses and vice versa was developed and presented considering the cost of fuel and the shortest possible time.

KEYWORDS: PSO algorithm, Multi-object function, autonomous robots, artificial capital market, market mechanism

1. INTRODUCTION

Far away in time, labor was used for loading and unloading ships at the ports. Sometimes in loading certain hazardous cargo, personnel and staff faced problems and accidents and they were not careful enough in handling goods In 1957, the first semi-automatic robots alongside humans were used to carry the loads [ ]. In recent years group of robots to transport the loads were used in a more sophisticated form [55.56]. Robotic systems used in industries for transferring material have various types. However, in terms of the physical structure there are two: mechanical arms and moving robots. Mechanical arm are made in different kinds and can perform a variety of pre-programmed actions in different industries, some of these arms are designed for a specific job, but others are programmable [34, 37]. Moving robots are robots that can move on a specific shift mechanism and displace themselves from one point to another. These groups of robots now are not widely used in the industry, but in the not too distant future, a lot of mechanical work in factories and many other industries will be given to the robot [40]. The group robots include a large number of robots that their main inspirations are from observations of creatures such as ants, bees and social flock [11, 12]. This is a simple example of collective behavior working to achieve an ultimate purpose. This method is most effective than acting individually. In such communities each of the creatures, have relatively simple structure, however, their collective behavior is extremely complex or in other words, there is a very complex relationship between collective behavior and individual behavior of a community. The collective behavior of society is not just related to individual behavior but it depends on the interactions among individuals. Interaction between human will increase the experience of human about the environment and lead to development of community.

In this paper to analyze the problem of transportation in docks, autonomous robots have been used. Autonomous robots participate for carrying goods, which are unloaded from ships to warehouses or vice versa. A MOF is defined combining an objective function of time and a function of fuel costs. An intelligent algorithm based on PSO algorithm firstly determines the place of the loading or unloading with respect to the number of goods, the number of robots and dimensions of the berth, or in other words where should the ship anchor for loading. In the second stage of the algorithm according to the priority of each of the two targets (the total time and cost of fuel), it determines how many robots can work for the loading (or unloading). Each robot automatically will move in any direction as the algorithm determines and its controls fuel. If the fuel gets lower than limit, after unloading, immediately goes to the fuel station.

2-AUTONOMOU SROBOTS SYSTEMS AND TRANSPORTATION

Autonomous robots are group moving robots that with artificial intelligence and efficiently fulfill their duties without human operators. Any robot that works in a group has an autonomous robotic system. In this system, robots according to their understanding of the environment as well as the information about the location of other robots, attempts to do something. The advantage of this system is the ability of robots in deciding, thus each robot can alone or with other robots move objects or do not take part in the duty. Each robotic group has the same basic structure resulting in a relatively low cost to build the robots. Transportation is a major issue, which is developing fast in the industry. Today's robots play an important role in the delivery of raw materials to factories;

Interior automation of factory, transportation of products and their packaging. Moving objects by robotic science every day reduces the number of labors in factories and on the other hand reduces the hazard to workers. In (Fig. 1) the coordinates of objects, robots, fuel supplies and central warehouse have been put in MATLAB programs in which everyone has the different coordinates.

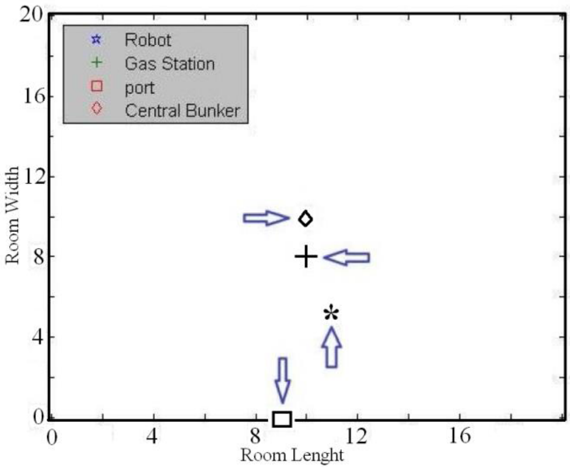

Fig.1. The coordinates of objects, robots, storage and the fuel supply

3 - APPLICATION OF AUTONOMOUS ROBOTS

Autonomous robots can do activities that involve the transportation of dangerous cargo operation, handling or carrying objects, and rescue services [1, 2, and 3]. Finally, using autonomous moving robots or multi robotic systems on important and sensitize scientific and practical issues and other industrial applications, have many advantages [4, 5], which the most important cases are:

1. Performing activities that humans are incapable of doing
2. Increasing the accuracy of operation
3. Reducing the time
4. Reducing the cost

4-PARTICLE SWARAM OPTIMIZATION ALGORITHM

Particle swarm optimization is an algorithm for social search that is modeled on the social behavior of bird flocks. Initially the algorithm was used in order to discover the governing patterns of birds flying along with each other and sudden changes in their directions. Result of modeling the social behavior is a search process that the particles move towards the regions of success. PSO is based on the principle that at any given moment, each particle adjusts its location in the search space considering the best place so far it has been and the best place in the whole neighborhood.

5 – TRANSPORTING OBJECTS BY ROBOTS USING AN INTELLIGENT PSO ALGORITHM

To analyze the issue of an artificial capital market has been used. The artificial market environment is considered as a pier. The pier includes robots, goods, and the fuel as well as central warehouse that ships load and unload will be conducted there. The proposed model, length and width coordinates can vary depending on the user's environment and given number of robots. A pier (an assumed environment) are shown in Fig. 2

Fig.2.A pier Assumed Environment

Every robot according to its condition calculates and decides what to do at any given time. It can independently move objects as well as getting fuel at any fuel supply that can be found nearby. In the proposed model number of can vary robots. In addition, two-dimensional coordinates of the robot can be identical or different. Since the decision by robots is distributed, robots themselves decide how many of them will participate in transferring objects. Robots make decisions according to the distance to the target object and the distance to the fuel

source. In the proposed model algorithm several decentralized robots attempt to carry one or more objects within an environment to specified targets with the help of intelligent algorithm. In this paper, it is assumed that the autonomous robots have a limited amount of fuel (energy) and their every move will reduce the fuel. Fuel of each robot, must not be less than a certain amount, and if it happens, refueling fuel should be done.

The objective function used is a MOF. This function is a combination of two functions. The first function is a function of time that shows the total working time of the robots. The second function is a function of fuel costs; total costs include fuel costs of all robots. For any single function of time and fuel, a weighting coefficient is applied. Multi-object objective function and relationship between the weighting coefficients are:

$$F(t,H) = W_1 \times f(t) + W_2 \times f(h) \quad (1)$$

$$W_1 + W_2 = 1 \quad (2)$$

Where, W_1, W_2, $f(t)$ and $f(h)$ are, weight of time, weigh of fuel costs, function of time and fuel cost function, respectively.

Variables that are specified by intelligent algorithms include:

a) Where the ship anchor

b) Charging station robot

c) Selecting the number of robots that work

d) Weigh coefficient of objective function of time.

Algorithm with consecutive repetitions using PSO, regularly and purposefully alter the variables to obtain the best numerical values for the variables. The best numerical values of the variables are determined by the objective function. Cost and time spent on each robot independently and automatically at every movement is calculated, at any point, time and cost spent on robot motion can be seen. Calculation of fuel consumption of a robot on the move is in terms of distance traveled, but the consumption of robots in stillness (on) is in terms of time. The greater the number of objects, the greater the time required for the transfer, but as greater the number of transporting robots the shorter work time will be achieved. Calculation of the travel time of the robot from a primary station to delivery point of ship, and from the target point to the fuel supply, is done by fuel consumption coefficient of each single robot and the number of recharging. In addition, from the place of delivery of goods by ships to the target and vice versa is done by the fuel consumption coefficient of robotic group. Comparing similar articles with this paper, it is observed that many research conducted in objective functions, are used for a single purpose. For example, in papers [2-5] the objective function considered only fuel costs of robots and the robot's power source and place of portable objects, assumed to be constant. However, that was not the case in this paper and objective function is a MOF that contains combination of two independent objective functions of cost of fuel and time. Similar projects rarely used combined methods.

6 - SIMULATION RESULTS:

In a pier with coordinates of 20 in 20 meters in the port as presented in (Table 1) 10 robots are located in different coordinate. They Transport the unloaded goods from ships to warehouses in piers, or vice versa. First, location of ships or loading or unloading location which is at two sides of piers will be determined. In port there were 250 goods to transport by robots, and robots aim to transport them to the desired targets

Table 1.Position of the robot in all three layouts

Robot number	P_1	P_2	P_3	P_4	P_5
Robot coordinates	**(3,11)**	**(11,15)**	**(17,3)**	**(5,8)**	**(15,7)**
Robot number	P_6	P_7	P_8	P_9	P_{10}
Robot coordinates	(15,14)	(16,18)	(9,15)	(4,16)	(2,13)

Central warehouse, goods and fuel source have the coordinates as presented in the (Table 2).when more robots participate in the transfer of goods, fuel consumption increases. To illustrate how this algorithm works, three independent simulations have been conducted, in the first simulation, the objective function is only the time and in the second case the objective function is only the fuel. In the third case, the algorithm simulator tries to optimize the both to the maximum value.

Table 2.position of the fuel source, the target and the goods in three states

Simulation Mode	Position of Warehouse	Position of Good	Position of Station
Objective Function of Time	(10,10)	(9,0)	(9,6)
Objective Function of Fuel	(10,10)	(12,0)	(9,3)
Objective Function of Time and Fuel	(10,10)	(11,0)	(10,6)

In the first case, objective function assumes time. In pier, 250 goods are placed to be transported by robots. The aim is to make robots deliver the object to desired places. With these conditions, the system starts to work. The choice is shown by a binary number. This binary number is consisting of zero and one. Value of zero displays the robot at rest and one at work. The simulation is repeated in three modes for different layouts and the results are compared. In Fig. 3 after the robots began, results obtained from the algorithm are shown in binary code: 1111110111. It means 9 robots: 1, 2, 3, 4, 5, 6, 8, 9 and 10 are involved and the robot (7) does not work.

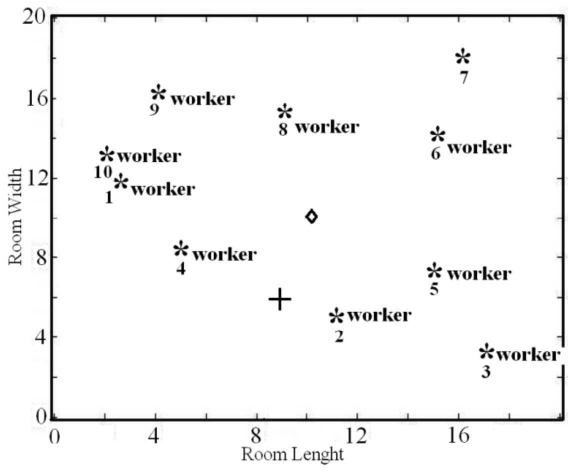

Fig. 3. Simulation responses to the objective function of time.

In the second case, the objective function is the fuel. 250 objects are in port to be transported by the robots. With these conditions, the system starts to work, In Fig. 4 at the beginning of work the pattern offered to move the robot by the proposed algorithm is in this way: 0100000000, which means only robot number 2 starts to work.

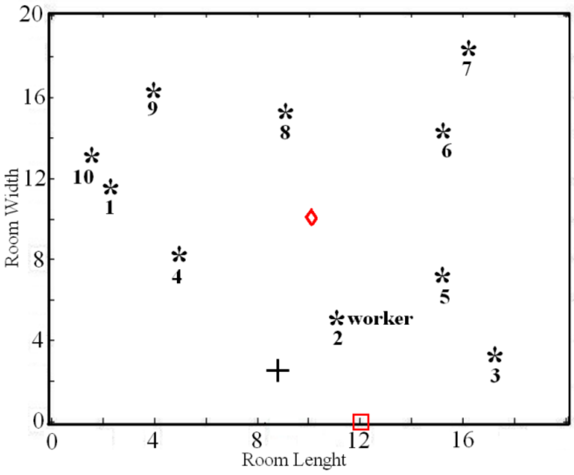

Fig. 4. Simulation response to the function of fuel

In the third case, the algorithm simulator tries to optimize both of them to the maximum value. 250 objects are in port to be transported by the robots, with these conditions, the system starts to work. Fig. 5 shows the arrangement of robots at work. The result obtained from our proposed algorithm is equal to 1111110000. It means robots 1, 2, 3, 4, 5 and 6 will participate. Simulation results for the three modes are shown in Table 5-3. Simulation results indicated that in all the arrangements for transportation robots had the best arrangement in the third stage and robots participate to transfer the objects with the arrangement of 1111110000.

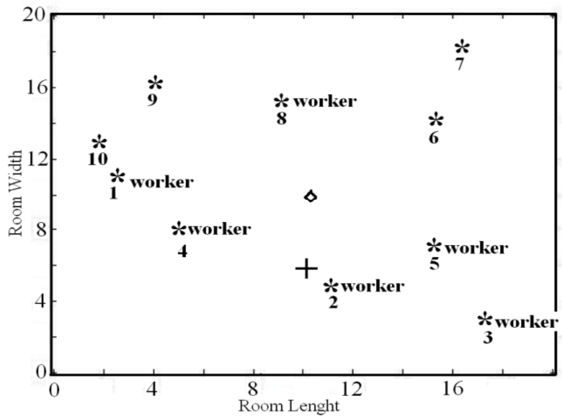

Fig. 5. Simulation response to the function of time and fuel

Table.3 Test results in three modes

Repetition	N of Robots	Weight of time	Weight of fuel	time	fuel	Objective function
Mode 1	9	1	0	429	397	429.84
Mode 2	1	0	1	4669	389	389.68
Mode 3	5	0.37	0.63	766	391	393.44
The final decision from the algorithm						1111100000
Fuel Consumption						391.0478
Optimized Function						393.447

Robot with respect to coordinates of the object, their number and target, as well as a fuel sources make decisions on how to participate in transporting of the objects.

7. CONCLUSIONS

In this paper the transport of objects from one point to another is carried out by autonomous robots. Robots in an artificial capital market transported the objects with the help of each other with a lower cost. Environment in which robots work, is a pier. The loading and unloading of cargo is done in that place and the robots can move goods of various shapes. A fuel source as a two-dimensional point is considered in the environments. Knowing the coordinates of fuel source, place of delivery of objects and central warehouse robots make decision about optimal route for transportation. A MOF has been used in this paper. This function is a combination of two functions of time and fuel costs. For each of the functions of time and the fuel a weighting coefficient was applied. Based on algorithm, which is an intelligent PSO algorithm, each robot independently performs its calculations and makes decisions about participation. In the proposed algorithm, one robot failure does not cause cuts and other robots carry out their work. The main objective of the program is to reduce labor time and cost of fuel of robots. According to the simulation results presented, the desired goals are achieved as well.

REFERENCES

[1] S. Zhiguo, H. Zhangzheng, L. Xu, Z. Fia; W., Zhiliang, 2010, ***Collaboration scenario of the mobile robot and household applicances based on IGRS protocol***, 2nd International Asia Conference on Informatics in Control, Automation and Robotics (CAR), Wuhan.

[2] F. Palacín, F. A. Salse, I. Valgañón, and X. Clua, 2004, ***Building a mobile robot for a floor-cleaning operation in domestic environments***, IEEE Trans. Instrum. Meas., vol. 53, no. 5, pp. 1418–1424, Oct.

[3] H. Wang, M. Zhang, F. Wang, 2010, ***Design and implementation of an Emergency Search and Rescue System based on mobile robot and WSN***, 2nd International Asia Conference on Informatics in Control, Automation and Robotics (CAR), Wuhan.

[4] D. Ding and R. A. Cooper, 2005, ***Electric-powered wheelchairs: A review of current technology and insight into future direction***, IEEE Control Syst. Mag., vol. 25, no. 2, pp. 22–34, Apr.

[5] S. Y. Oh, F. H. Lee, and D. H. Choi, 2000, ***A new reinforcement learning vehicle control architecture for vision-based road following***, IEEE Trans. Veh. Technol., vol. 49, no. 3, pp. 997–1005, May.

[6] R Zlot, A Stentz, "Market**-based multi-robot coordination for complex tasks**", The International Fournal of Robotics Research, 2006

[7]] Russell, S. F. and Norvig, P. (2003). Artificial Intelligence: a Modern Approach. Prentice Hall, Englewood Cliffs, NF, 2nd edition

[8] Sycara, K. (1998). ***Multiagent systems***. AI Magazine, 19(2):79–92.

[9] Cramton, P., Shoham, Y., and Steinberg, R., editors (2006). Combinatorial Auctions. MIT Press, Cambridge, MA.

[10] Kitano, H., Tambe, M., Stone, P., Veloso, M., Coradeschi, S., Osawa, E., Matsubara, H., Noda, I., and Asada, M. (1997). ***The RoboCup synthetic agent challenge 97***. In Proc. Int. Foint Conf. on Artificial Intelligence, Nagoya, Fapan

[11] M. Dorigo and E. Sahin. ***Special issue: Swarm robotics. Autonomous Robots***, 17:111–113, 2004.

[12] E. Sahin. Swarm robotics: From sources of inspiration to domains of application. In E. Sahin and William Spears, editors, Swarm Robotics Workshop: State-of-the-art Survey, number 3342 in Lecture Notes in Computer Science, pages 10–20, Berlin Heidelberg, 2005. Springer-Verlag.

[13] G. Caprari and R. Siegwart. Mobile micro-robots ready to use: Alice. In Proceedings of IEEE/RSJ International Conference on Intelligent Robots and Systems, pages 3295–3300, Edmonton, Alberta, Canada, 2005.

[14] Christopher M. Cianci, Xavier Raemy, Jim Pugh, and Alcherio Martinoli. Communication in a Swarm of Miniature Robots: The e-Puck as an Educational Tool for Swarm Robotics. In Simulation of Adaptive Behavior (SAB-2006), Swarm Robotics Workshop, Lecture Notes in Computer Science (LNCS), 2006.

[15] University of Stuttgart. Open-source microrobotic project, 2007.

[16] F. Mondada, G. C. Pettinaro, A. Guignard, I. Kwee, D. Floreano, J.-L. Deneubourg, S. Nolfi, L. M. Gambardella, and M. Dorigo. SWARM-BOT: a New Distributed Robotic Concept. Autonomous Robots, special Issue on Swarm Robotics, 17(2-3):193–221, 2004. September - November 2004 Sponsor: swarmbots, OFES 01-0012-1.

[17] J. McLurkin and J. Smith. Distributed algorithms for dispersion in indoor environments using a swarm of autonomous mobile robots. In 7th International Symposium

on Distributed Autonomous Robotic Systems, Framce, 2004.
[18] C. Ortiz, K. Konolige, R. Vincent, B. Morisset, A. Agno, M. Eriksen, D. Fox, B. Limketkai, J. Ko, B. Stewart, and D. Schulz. Centibots: Very large scale distributed robotic teams. In D. L. McGuinness and G. Ferguson, editors, AAAI, pages 1022–1023. AAAI Press / The MIT Press, 2004.
[19] A. E. Turgut, F. G¨ok¸ce, H. C¸ elikkanat, L. Bayındır, and E S¸ahin. Kobot: A mobile robot designed specifically for swarm robotics research. Technical Report METU-CENG-TR-2007-05, Dept. of Computer Engineering, Middle East Technical University, 2007.
[20] I.J. Cox and N.H. Gehani, Concurrent programming and robotics, Journal of Robotics Research 8 (2)
[21] T. Lozano-Perez, Robot programming, Proc. of the IEEE, Vol. 71, No. 7, (1983).
[22] C. McGillem and T. Rappaport. "An Infra-red Navigation Technique for Mobile Robots," Proc. 1988 IEEE lntnl. Conf on Robotics and Autornation, Philadelphia, PA, Apr. 26, 1988.
[23] Ray Jarvis, "A Tele-autonomous Heavy Duty Robotic Lawn Mower," Proc. 2001 Australian Conference on Robotics and Automation, Sydney, pp.157-161,2001.
[24] Masanao Koeda, Yoshio Matsumoto, Tsukasa Ogasawara. "Annotation-based Rescue Assistance System for Teleoperated Unmanned Helicopter with Wearable Augmented Reality Environment," 2005 IEEE International Workshop on Safety, Security and Rescue