DESIGN OF A ROBOT TEAM FOR SEARCH IN CENTRAL EUROPEAN FORESTS

Santi Esteva, Antoni Martorano
Institut d'Informàtica i Aplicacions, Girona University, C/ Santaló S/N, Girona, Spain

Albert Figueras
Institut d'Informàtica i Aplicacions, Girona University, C/ Santaló S/N, Girona, Spain

Keywords: Autonomous robots, Surveillance, Robot exploration, Robot team design.

Abstract: Security incidents are a new topic for the autonomous robot task. Robots, sensors and intelligence make a great combination to achieve specific goals in this area. This paper proposes a methodology to design the size and the exploration form for a group of robots in the typical Central European forest. The objective is to find victims hidden into the fallen leaves. A statistics of the trouble situations is the starting point to design the team to displace at the objective. The robots are autonomous but is necessary one human supervisor to solve some critical situations. The results show the partition and the area covered by a simple group of equal robots.

1 INTRODUCTION

In the last years, security incidents, like terrorism, have raised new research areas focused in surveillance issues, the automation of these tasks is an important research area using robotic platforms and sensors. The use of a team of robots and sensors is an approach that has many advantages and difficulties over a single robot platform. In this paper it is proposed a framework to develop a multi-robot surveillance platform (Caballero D., 2010), (Caballero D., 2009). Surveillance is the act to close watch kept over someone. Robotic surveillance is the topic to refer at close watch on the relevant events. The automation of the surveillance task are the approaches oriented to the formalization of the problem (Everett H. R., 1999), (Everett H. R., 2003).

Related works to segment the space to explore for a multi-robot teams, several authors uses Voronoi diagrams of the space exploration to assign rectangular polygons strategies to segment the space exploration (Matcovschi M. H., 2008). Other works uses the agent entities and discuss the ability of the agent to explore determined area (Rybski P. E., 2000). And other determine an algorithm to achieve optimized region partition and coverage according the energy and some constraints (Hao Wu, 2008).

This work analyzes the optimum partition of the space exploration according probabilistic information of the abnormal situations for the robot, which is necessary a human operator support. Optimizing the efficiency of the whole team, robots and support and also taking information from the biological communities (Martorano, 2010) is the objective of the presented work.

2 THE TERMITES

The Termites colonies are groups of social insects composed by a social organization to share tasks in a specialized form. The Workers, the Soldiers and Reproductives elements are a self-organized system in a decentralized form for a common collective behavior.

The Caste system of the Termite cologne depends on the environmental scenarios and depredators, from a 2% of soldiers in Africa zones to 12% of soldiers in a Formosa Island.

Genetic information characterizes the Caste, size and composition. Also stress situations can adapt the system to the new changes, as temperature, depredators, etc. The biological process into the live of the Termite insect evolves the colonies adapting at the evolution phase of the group. The differences of the Caste proportion are justified to improve the colony survival at different conditions; the analysis of this in-

Esteva S., Martorano A. and Figueras A..
DESIGN OF A ROBOT TEAM FOR SEARCH IN CENTRAL EUROPEAN FORESTS.
DOI: 10.5220/0003570603250328
In *Proceedings of the 8th International Conference on Informatics in Control, Automation and Robotics* (ICINCO-2011), pages 325-328
ISBN: 978-989-8425-75-1

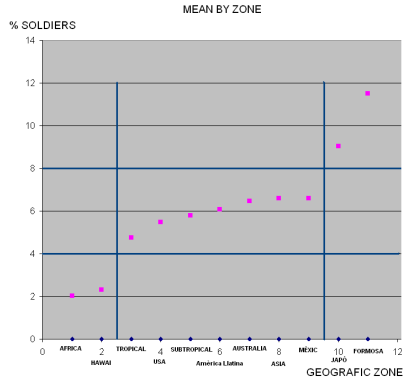

Figure 1: Proportion of soldiers depending on the geographic area.

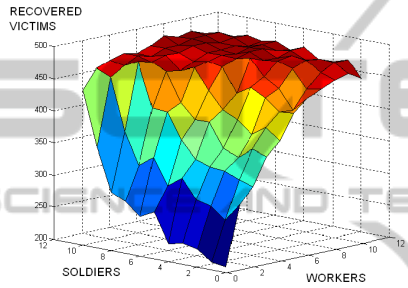

Figure 2: Graph of efficiency as the number of workers-soldiers.

formation induces to propose different size and Caste of a team of robots for each scenario.

Some experiments for one defined scenario with different Castes show the result of the improvement for the colony survival. The improvements are done when the size of the colony is small and the Caste ratio is at the lower rates. From these results is transformed to other representation the improvement at interchanging the role between one Worker to a Soldier.

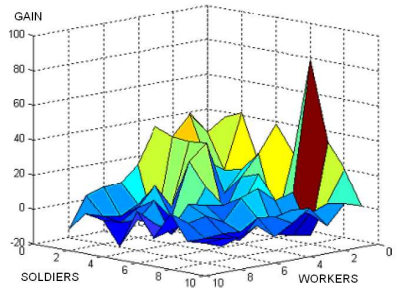

Figure 3: Gain performance by the number of workers-soldiers.

In this representation indicates the minimum size and composition of the team to gather these best improvements.

3 TEAM OF ROBOTS

The robot team can be similar to the Termite colony taking account several similarities or equivalences in order to transport the termite results to the robot team:

The different role of the termite elements can be viewed as robots specialization. Depredators in Termites are the blocking situations in the robot area. Nest of termite is the operation centre on the robots field.

There are also several aspects with big differences, as size of the colony, objectives, movement, etc. The main result of this comparison is: there exist one Caste relation and size that will be optimal for a one defined task and area.

4 THE ROBOT

The team of robots are composed by several units of a specialized robot to autonomously navigate in forest areas, coordinated by an operation center, where a human operator controlled all the system, the positions, the finding targets, the stopped or blocked robots.

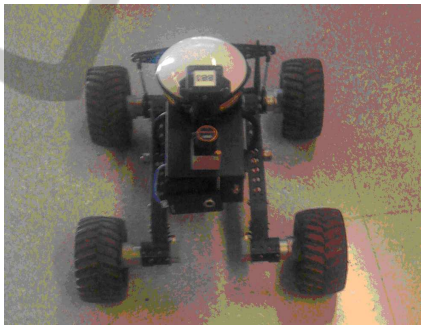

Figure 4: Unit of our autonomous robot.

The robot characteristics are:

Size: 51cm x 58 cm x 32 cm.
Weight: 5 Kg.
Batteries: 12V 14 Ah.
Autonomy: 2 hours.

The robot is equipped by:

- DGPS with 15 cm. global position accuracy.
- Laser Range Finder with 240 and 4m range obstacle detection.
- Inertial Measurement Unit, which combines 3 gyros and 3 accelerometers.
- Thermal sensor with 1m. range measure.
- Methane sensor.
- Digital camera.

- WI-FI communication.
- Four-Wheeled Driver 60W.

5 EXPLORATION

The robot ability to explore unknown areas is demonstrated, using D-GPS in outdoor scenarios and equipped by four strong wheeled drive, and the robot can easily navigate by typical Central European forest, due by their characteristics.

Some handicaps can be found in this kind of terrains, holes, climbs, obstacles, water, etc. and cannot be over passed by the robot.

Four typical blocking situations for the robot:

Figure 5: Lateral climbing.

Figure 6: Obstacle not detected.

A 2D Laser range sensor is useful to detect and predict some of these troubles, the others can cause problems to the robot and will be necessary the use of other kind of support to solve these handicaps.

To define the support for the robots according the number of the explorers will be defined according the obstacle proportions for the exploring area.

Figure 7: Hole and slipping situation.

Figure 8: Changes in the field.

6 EXPERIMENTATION

One forest is necessary to be explored to find a victim, dead or alive. The area is divided in circles or squares where the robots are working, jointly with one human operator to restore the robot at blocking situations. Each area where the robots are moving is organized to be covered in 2 hours of autonomy batteries for a group of N robots. The velocity of the robot is 1 m/s and during this time is covered 1 square meters of exploration. The objective is to configure the surfaces to cover by a group of N robots, maintained by only 1 human operator. The probability of the blocking situation is 1 over 400, this means during 400 sec. one abnormal situation appears. And the operator needs the distance in time to arrange the situation.

With all this premises the analysis over square areas or circular is the following:

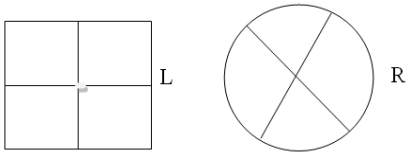

Figure 9: Square or circular areas.

The gravity center of a circular sector is 2/3R, and

over Diagonals of the square is L/$\sqrt{2}$, and in Vertical or Horizontal lines is L/2, the mean result 0.6 L. Assigning this distance for same surface covered result R=L/$\sqrt{\pi}$, and combined with the gravity center, resulting the distance for circular areas 73% less than square areas. This means the time to recover the robot improves using areas limited by circles.

Once the shape of the areas is defined, is also necessary to define the number of the robots working in and the size of the area.

The number of robots is defined by the working limit of the human operator, as much robots much work to restore the operability of the robot front a blocking situations.

Time between abnormal situation appears each 400 sec/ N , and during this time the operator uses 2/3 R in time to restore the robot:

$$400 / N = 2/3\ R$$

And using the other formula to solve the problem, the time to cover this area is 2 hours:

$$R2/N = 2 * 3600$$

Resulting a N = 8 robots and R = 135 m

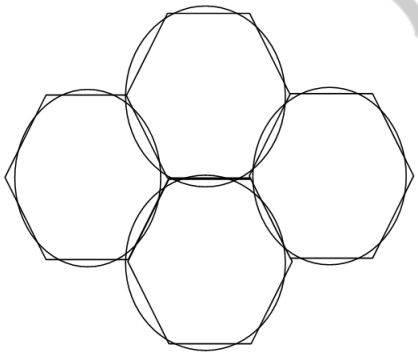

Figure 10: The areas can be rearranged at hexagonal forms maintaining the results.

7 CONCLUSIONS

The ability of the robot for this subject is the accurate measure of the Methane or Thermal information and their interpretation, the persistence and the working journey. The humans have ability on the movements, but not at the inspection and data interpretation, and also are affected by the fatigue.

This article try to import some information from the evolution process over the adaptation of the termites at different mediums in millions of years, and incorporate any information as improvements for a team of robots designed to exploring a forest area.

The characteristics of the distribution, and the caste particularities of the termites colonies are the principal focus where this work is centered, and the results show one possible characterization of the team of robots specialized on search in a forest area.

REFERENCES

Caballero D., Esteva S., e. a. (2009). *Designing The Size Of a Robot Team For Search And Rescue*. ISSN1454-8658.

Caballero D., Esteva S., e. a. (2010). *Fleet size of robots for rescue missions.* Proceedings of IEEE International Conference on Automation, Quality and Testing, Robotics.

Everett H. R., e. a. (1999). *From Laboratory to Warehouse: Security Robots Meet the Real World.* The International Journal of Robotics Research 1999, DOI: 10.1177/02783649922066448.

Everett H. R., e. a. (2003). *Robotic Security Systems*. IEEE Instrumentation and Measurement Magazine.

Hao Wu, Guohui Tian, X. L. (2008). *Research on optimized partition algorithm for multi robots collaboration coverage.* Intelligent Control and Automation, 2008. WCICA 2008. 7th World Congress on.

Martorano, A. (2010). *Required to incorporate SWARM intelligence into the equipment design of robot rescue teams.* Master Tesis, Mster MIIACS, University of Girona, Director: Santi Esteva.

Matcovschi M. H., P. O. *Stability and Set-Invariance Testing for Interval Systems.* Journal of Control Engineering and Applied Informatics, Vol.10, No.3 , pp.18-26, 2008, ISSN: 1454-8658.

Rybski P.E., e. a. (2000). *A Team of Robotic Agents for Surveillance.* AGENTS '00 Proceedings of the fourth international conference on Autonomous agents, ACM New York, NY, USA 2000., isbn: 1-58113-230-1 edition.