A location of robots proposal in collaborative environments

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Abstract

This paper proposes a method to localize a robot in a collaborative enviroment when it can not do itself. In a enviroment is possible that a robot crashes with an object and breaks any of its sensors or something works wrong. In this case, this robot will use the others to find its location. Distances and power signals will be used to locate the robot inside the environment. In this way, a robot may be triangulate from the position of other robots to achieve the objective of this paper.

1 Introduction

Nowadays, communication technologies exist between devices on a small scale that they allow exchange information between them, as WiFi, Bluetooth, ZigBee or Wibree.

From this technologies, a group of robots that has some of them, can interact for execute a common task or simply establish organisational criteria of collaboration for execute small task individually that it takes to get an global goal.

We start of premise that robots that belong a group generate a map of the enviroment from laser sensors, ultrasounds or other technologies for know their location, and from this information, they execute a series of operations that carry out to obtain the goal according the program algorithm.

But, what would happen if one of the robots of group was not able to locate his location in the map? That is, what would happen if we replace one of the robots of group for other that unknown the process for locate in it? In this case, the global goal can not reach to get because the tasks that was delegated to it would never obtain. More serious it would be the case of one robot that must execute a own task.

In this paper we focus in the behavior of a robot that is helped by others for obtain its location in the map for carry out the program task. For this, we will analyze the possible solutions of some communication technologies and the sensors that the robots have to interact with the enviroment. After, we extend the study to the possibility that more of one robot exist without previous knowledges of their location in the map.

Finally, we reflect about the possible problems that will confront. One of them can be the loss signal in the communication device or robots with a wrong operation in their sensors.

2 Collaborative enviroment

A collaborative environment between robots is an environment in which the participation of more than one robot is needed to achieve perform a global task shared by all.

In this environment, robots receive different instructions that must be completed in a rigorous order to make the overall task is not compromised and can be carried out. This arrangement contains a dependency between subtasks that must do only if the above were carried out. Each subtask must achieve a subgoal that will be the starting point for the next subtask.

Normally, these subtasks require the mobilization of the robot in a given environment by a map that may be generated by them or may be instilled so static. This map contains physical objects such as walls and objects alien to the group of robots that do not change their situation along the entire process of execution of subtasks.

Based on the need for possession of the map, it is necessary to locate the robot in introducing the coordinates of the point of departure or scheduling an algorithm of location from sensors which provided the robot. This is the most important point, since it makes no sense to take all necessary and not knowing the location of departure.

3 Location methods

The methods used in this paper to locate a robot are based on the triangulation from other robots that know their location. We need an interaction between them and the calculus of algorithms under certain parameters predefined to achieve this goal.

These calculations are continuous in order to correct the error that might occur to acquire information regarding robots such as the position of each of them and the distance or the signal strength emitted and received.

At first, the robot is located in any collaborative environment of space robots and unknown location within the map generated.

Through the only means of communication available, this robot emits an aid signal that will be received by a group of robots around the environment. The greater the signal strength of communication, more robots can communicate with him to provide the data needed.

The following are two methods of location based on the interaction between robots in which one of them does not have sensors. It will need the help provided by the robots of environment that can interact with him and convey the necessary information.

3.1 Distances

This method is based on the distance that separates the robot without sensors and the need for direct contact with the rest of robots through sensors which have them.

When the robot interacts or falls within the scope of one of the robot that has sensors it can obtain the distance that separates from it and has a circumference of positions in which they can be.

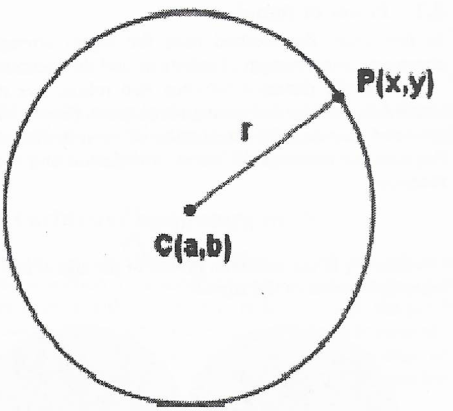

Figure 1: points situacion for one robot.

Unfortunately, the robot can be placed in an infinite number of positions. Since we have a initial position $P1(x_1, y_1)$ and a distance of separation $d(P1, P) = r$, the points where it can fall can be obtained from the following equation and its solution.

$$r = \sqrt{(x - x_1)^2 + (y - y_1)^2}$$
$$r^2 = (x - x_1)^2 + (y - y_1)^2$$
$$x^2 + y^2 - 2x_1x - 2y_1y + x_1^2 + y_1^2 - r^2 = 0$$

The equation becomes reduced in the case of the robot with sensors is at the point of origin,

$$x^2 + y^2 = r^2$$

As you can see, there are countless points that meet this equation and it is now when it requires action by another robot to reduce the number of possible cases.

Proceeding from the premise that we have two robots in the environment of the robot misplace, we now have two initial points $P1(x_1, y_1)$ and $P2(x_2, y_2)$ and two separation distances $d(P1, P) = r$ and $d(P2, P) = s$. Developing the above equation independently to find common points in two equations, we have the following.

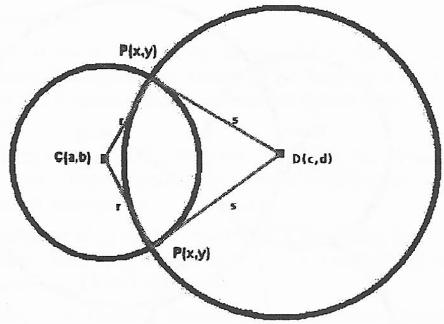

Figure 2: points situacion for two robots.

$$x^2 + y^2 + D_1x + E_1y + F_1 = 0 \quad (1)$$

$$D_1 = -2x_1$$
$$E_1 = -2y_1$$
$$F_1 = x_1^2 + y_1^2 - r^2$$

$$x^2 + y^2 + D_2x + E_2y + F_2 = 0 \quad (2)$$

$$D_2 = -2x_2$$
$$E_2 = -2y_2$$
$$F_2 = x_2^2 + y_2^2 - s^2$$

If we subtract the equations (1) and (2) and work out the value of x, for example, we get the following.

$$x = My + N \quad (3)$$

$$M = \frac{E_2 - E_1}{D_1 - D_2}$$
$$N = \frac{F_2 - F_1}{D_1 - D_2}$$

We replace (3) in (1) and have

$$Ay^2 + By + C = 0$$
$$A = M^2 + 1$$
$$B = 2MN + D_1M + E_1$$
$$C = N^2 + D_1N + F_1$$

In this case, if we assume that the three points $P1(x_1, y_1)$, $P2(x_2, y_2)$ and $P(x, y)$ are not located in the same line, we have two possible solutions of location.

Finally, if we have three robots in the environment of the robot misplace, we now have three initial points $P1(x_1, y_1)$, $P2(x_2, y_2)$ and $P3(x_3, y_3)$ and three separation distances $d(P1, P) = r$, $d(P2, P) = s$ and $d(P3, P) = t$. If we resolve the previous system of equations for two pairs of circles, we can get the common point between the two resolutions.

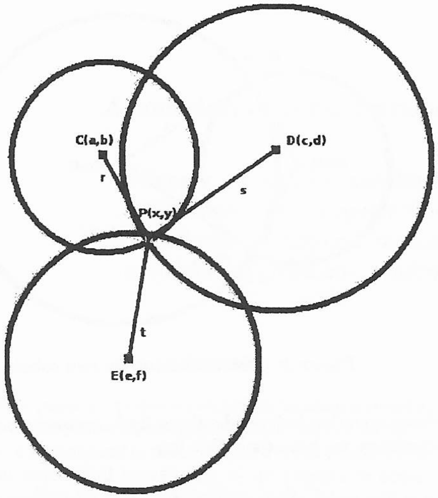

Figure 3: points situacion for three robots.

$$x^2 + y^2 + D_1x + E_1y + F_1 = 0 \quad (4)$$

$$D_1 = -2x_1$$
$$E_1 = -2y_1$$
$$F_1 = x_1^2 + y_1^2 - r^2$$

$$x^2 + y^2 + D_2x + E_2y + F_2 = 0 \quad (5)$$

$$D_2 = -2x_2$$
$$E_2 = -2y_2$$
$$F_2 = x_2^2 + y_2^2 - s^2$$

$$x^2 + y^2 + D_3x + E_3y + F_3 = 0 \quad (6)$$

$$D_3 = -2x_3$$
$$E_3 = -2y_3$$
$$F_3 = x_3^2 + y_3^2 - t^2$$

Resolving the system of equations (4) and (5) as before, we have:

$$A_1y^2 + B_1y + C_1 = 0 \quad (7)$$

$$A_1 = M_1^2 + 1$$
$$B_1 = 2M_1N_1 + D_1M_1 + E_1$$
$$C_1 = N_1^2 + D_1N_1 + F_1$$
$$M_1 = \frac{E_2 - E_1}{D_1 - D_2}$$
$$N_1 = \frac{F_2 - F_1}{D_1 - D_2}$$

Resolving the system of equations (4) and (6) as before, we have:

$$A_1y^2 + B_1y + C_1 = 0 \quad (8)$$

$$A_2 = M_2^2 + 1$$
$$B_2 = 2M_2N_2 + D_1M_2 + E_1$$
$$C_2 = N_2^2 + D_1N_2 + F_1$$
$$M_2 = \frac{E_3 - E_1}{D_1 - D_3}$$
$$N_2 = \frac{F_3 - F_1}{D_1 - D_3}$$

From (7) and (8), we know that the solution must match, so just stay with the common point of two systems of equations.

3.2 Power of signals

In this case, the method uses the signal strength in the communication system of robots to find the location.

To find the distance between two robots, we must have some data such as emission and reception power. From these data and knowing the attenuation of enviroment, we can get the distance between the point of emission and the point of reception

$$dB = 10log\frac{P_1}{P_2},$$

where P_1 is the emission power of the signal and P_2 is the reception power of the signal.

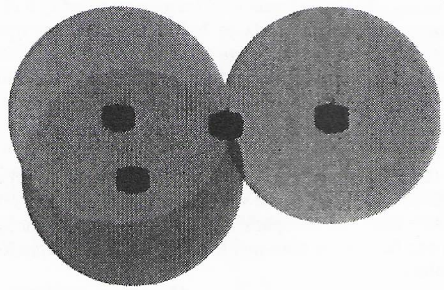

Figure 4: common area of the three areas of coverage of the signals.

The difference with the method 3.1 is that is not necessary the direct visualization between robots. It is possible to locate in space with an altitude sensor as well, extending the equations (4), (5) and (6) to three dimensions.

$$x^2 + y^2 + z^2 - 2ax - 2by - 2cz + a^2 + b^2 + c^2 - r^2 = 0$$

The peculiarity of this location method is that measuring the signal strength, it may fluctuate due to interference from other signals. Therefore, the values obtained in the measurements are not accurate. They always contain a mistake α to regard the distance obtained.

$$x^2 + y^2 + z^2 - 2ax - 2by - 2cz + a^2 + b^2 + c^2 - r^2 + \alpha = 0$$

3.3 Resourceful calculation

Once the robot that does not have location sensors is located, now there are no problems in executing the subtask it deserves. To work with greater precision we creates the need for calculating the position for short periods of time that it can be programmed into the location algorithm.

At this point, we affirm that it can rely on to obtain the location of other robots from the latter in an instant of time, always considering that there is an error that it will add. If in an instant of time so we get recursive location of a robot from others, we must spread the error shall be as follows:

$$\varepsilon_0 = \alpha_0$$

$$\varepsilon_1 = \alpha_1 + \varepsilon_0$$

$$\dots$$

$$\varepsilon_n = \alpha_n + \varepsilon_{n-1}$$

This instant error is not always the same, since as mentioned earlier, the calculating position of the robot is done every so often, so the error will fluctuate within a range.

4 Conclusions and future work

Owing to the fact that the different methods of location present in section 3 are subject to errors, the location of robot covers an area with a maximum radius fixed by the precision of measuring. For each of the methods, the existence of such errors depend of the different factors as the existence of objects in the straight line that connects them or interference from other signals.

For each of the methods, we show some of its most outstanding features.

- **Distances**:
  - Greater accuracy in measuring.
  - Inefficient in environments with obstacles.
  - Need for direct visualization.
- **Power of signals**:
  - Less accuracy in measuring.
  - Useful in environments with obstacles.
  - Problems with interference from other signals.

These methods of location have not been tested and have not been achieved experimental results to verify its operation, so this task remains as future work to determine the reliability of them.

Once we have located all the robots in need of collaboration among themselves to perform a task, the following steps are guided situations and coordination between robots with sensors and without them. This aspect will be important, because anything worth locate a robot in an environment if it can not fulfill its task.

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