

Autonomous Robot With Caterpillar

Vlad Vaduva, INCDMTM, Bucuresti, Romania
 Constantin Udrea, Universitatea Politehnica Bucuresti, Bucuresti, Romania

ABSTRACT

A robot with caterpillar it is useful in an environment in which a wheel based robot or a biped robot could not operate, for example in rough terrain or in crashes sites. The algorithms who command the robot should be capable to process the signals from three ultrasonic sensors and to generate autonomous movement accordantly with the environment. For this purpose are considered the potential vector field algorithms and bug algorithms (bug1 and bug2).

INTRODUCTION

Autonomy represents the ability of a mobile robot to move through the environment medium to execute tasks, with the possibility to adapt to medium changes. Functionary are robot is made of three modules: the sensor module, the orientation module and the lead module.

This autonomous robot uses caterpillar for navigating in hostile environments, in which the caterpillar helps to move above obstacles and climb out obstacles that the robot meets. The structure of the robot is represented in the figures below:

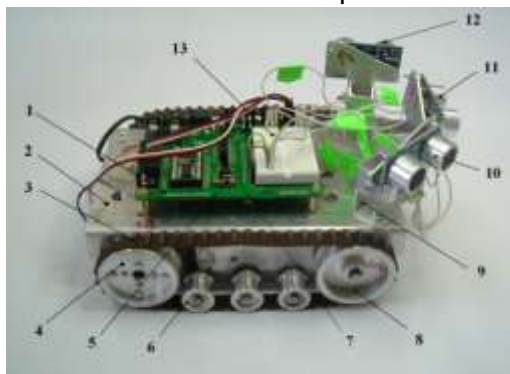


Figure1

- 1-Parallax development board
- 2-Mechanical structure
- 3-Caterpillar
- 4-Active roll
- 5-On/Off button
- 6-Roll for the expansion of the caterpillar
- 7-Reset button
- 8-Pasive roll
- 9-Ultrasonic sensor support
- 10-Ultrasonic sensor right
- 11-Ultrasonic sensor center
- 12-Ultrasonic sensor left
- 13-I/O connections



Figure2

- 1-Battery support
- 2-Batteryes
- 3-Servomotor left
- 4-Servomotor right



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As it can be seen in the pictures above the movement is controlled by a Parallax development board, sensor module are represented by 3 ultrasonic sensors and the engines are two Futaba servomotors

The movement control of the robot presumes the planning of the moving trajectory step in which we make a compromise between time and placement accuracy the movement of a virtual robot in a virtual space was researched with the intention to adapt to specific conditions without human interference. To reach this goal in the case of a real robot there can be used series of strategies like space mapping, the strategy of surface scanning, and iterative methods. In the case of iterative methods the moving planning algorithm builds the trajectory based on a space position set and intelligent control system transposes this trajectory in spatial positions filled by the robot.

With iterative methods the performance of the robot can be adjusted to a level which can allow the robot to adapt to new layouts. The object avoidance technique is a real time control technique. The term 'object detection' is a set of software techniques which allow mobile systems, such as mobile robots and manipulator robots to adjust the trajectory based on the environment. The software support used for measurement until the obstacle and the control solutions of the actuators offer mobile systems reflexes for intelligent avoidance of the obstacle even so the obstacle is in move.

Because of the high complexity of this process, obstacle avoidance algorithm uses close loop control in which the robot plans continuous positions around the obstacle. If an obstacle stays in the way of the robot reaching the target, the obstacle will be avoided until he will find the position in which he can move to the existing target.

Potential fields technique

In this case are used vectors to represent behavior and the operation of vector sum for mixing the adequate vectors, different behavior to achieve the emergent behavior.

A potential field represents a field of vectors characterized by amplitude and direction (a,d). In general vectors are used to represent certain forces. They are drawn like an arrow in which the length of the arrow represents the strength of the force and the angle represents the direction of the force.

There are five types of primary potential fields which can be mixed to generate more complex fields

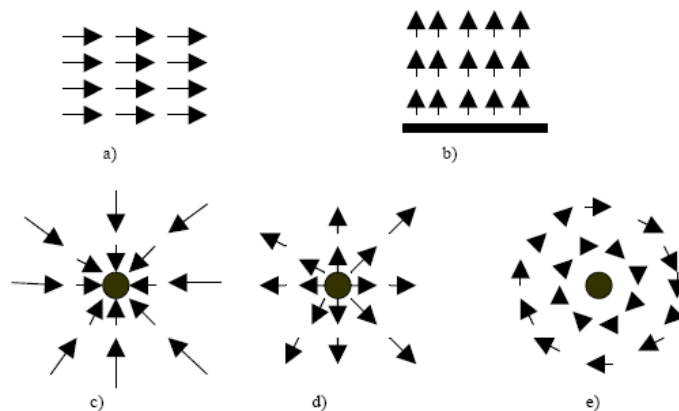


Figure 3

primary potential fields : a) uniform b) perpendicular c) attraction d) reject e) tangential

As it can be seen in the figure ,the length of the arrow varies regardless with the distance until the center witch produces the potential field .For example in the attraction field the length of the arrows is smaller near the proximity of the object . The method in witch the arrows of the vectors change is called amplitude profile Potential fields can be represented mathematically with polar coordinates. This can be visualized with a graphic and the profile , for example the rejection potential field profile tell us that the robot run away from the center with constant speed indifferent how close it is as long ass it is in the generated field .In the moment the robot leaves the field he's speed drops to zero and stops .The field is binary ,the robot executes just two types of movement , either it moves away or it's stop .In reality the use of a constant amplitude causes problems on the border of the field leading to uncontrolled moves .To avoid this types of problems they are uses differently amplitude profile in witch the answer is proportional with the stimulation ,it's the case of linear drop off profile and exponential drop off profile .In the case of linear drop off profile the amplitude of the vectors decreases linear ,an independently observer can see that the robot ,initially far away object is moving with maximum speed thought the object ,then it slows down to avoid a collision .Mathematically speaking the decreases of the amplitude vectors it's represented through a line $Y=MX+B$,where X is the distance through the obstacle , Y is the amplitude , B is a bias of the line and M is the slope .If is not specify otherwise the slope is $m=1$ (up) or $m=-1$ (down)

In the case of exponential drop off profile ,the decreases is proportional with the square of the distance through the project

An simple example for implementing the potential field vectors it can be made for a robot with one proximity sensor attached to the back of the robot. It will be implemented an rejection field for obstacle avoidance .

$$V \text{ direction} = -180$$

$$V \text{ amplitude} = (D-d)/D \text{ for } d \leq D$$

$$= 0 \text{ for } d > D$$

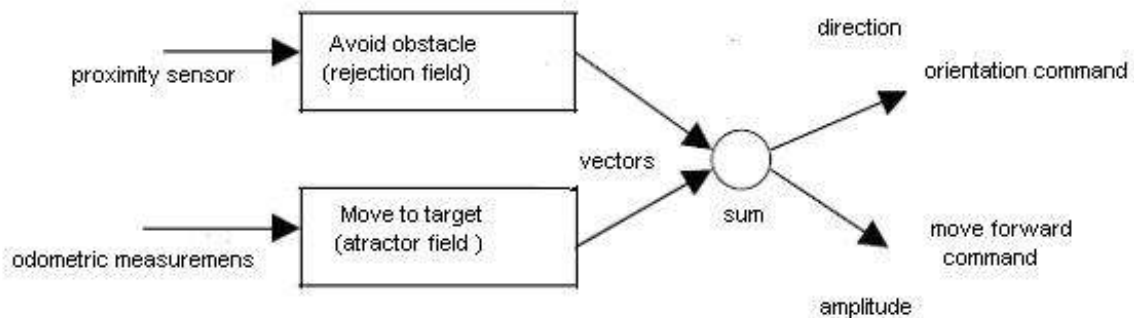


Figure 4

There are also some disadvantages to the vector fields algorithms ,one of this is the local minim issue , this is when the sum all of all vectors is zero , and the robot is stopping. To resolve this problem we can use navigation templates or motor layouts to generate little random amplitude vectors to move the robots when it stops.

Bug algorithms

The bug algorithm use the simples way to move to the target if there are not objects considered as obstacle ,if there are obstacles there are bypassed on there contour until the movement to the target is possible again .In this kind of algorithm there are used only the latest sensor values

Considering that the robot is one point in the map moving from s to t and having a detection sensor in bug1 algorithm ,immediate when the obstacle is detected the robot make's a complete turn on the obstacle contour until he reaches again in the minimum distance through the target

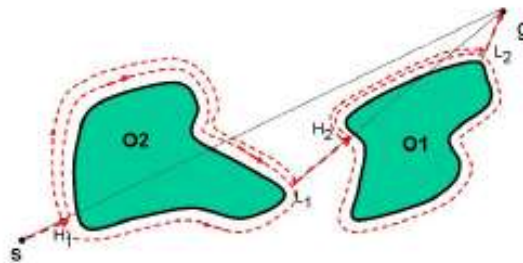


Figure 5

s-start point

H₁-the meeting point with the object O2

L₁-minimum distance point in witch the object leaves the contour of the object O2

H₂- the meeting point with the object O1

L₂-minimum distance point in witch the object leaves the contour of the object O1

g-target

In Bug2 algorithm the robot has a little distance to travel and is more efficient . Therewith are some layouts in witch the algorithm is not recommended like in a maze structure

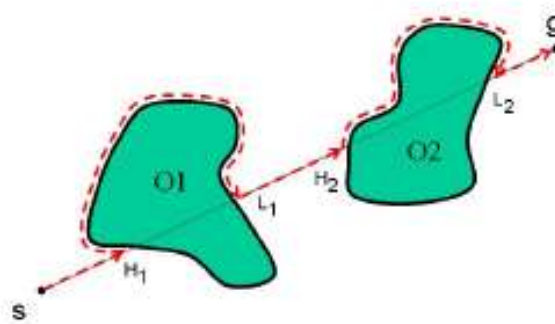


Figure 6

s-start point

H₁-the meeting point with the object O2

L₁-minimum distance point in witch the object leaves the contour of the object O2

H₂- the meeting point with the object O1

L₂-minimum distance point in witch the object leaves the contour of the object O1

g-target



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The simplicity of this algorithm has some inconvenience. None of these methods consider the robots kinematics because the only data used are the recent ones and the noise of the sensors has a massive impact over the performance

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