Separating Moving Objects from Landmarks

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Abstract

Navigation and localization are still one of the most fundamental tasks to be accomplished by mobile autonomous robots. One of the main purposes of the navigation and localization process is to build a precise, usually allocentric spatial static representation (e.g. [S. Thrun and Schulz, 2000]). Although robots are able to carry more and more powerful sensors, the question is, which informations are needed for localization and navigation. One way to do these tasks with only a minimal amount of resources is via landmarks. Furthermore it is an easy and failsafe way to do so. Localization can be done with only a single 180° degree camera, and a navigation by the change of the landmark ordering is very robust against misinterpretations and errors. This technique uses the fact that, seen from the agent, landmarks are switching locations only in a certain way ([Wagner, Visser, and Herzog, 2004]). With an additional timer the robustness of this technique can be further increased. But with timing and the use of angles between the landmarks, it is also possible to measure the distances between the landmarks and the agent. Furthermore this technique can be extended to detect moving objects and to compute the speed and direction of them.

Localization and navigation in times of GPS-receivers is no challenging task anymore. But in order to localize the agent must be outdoor and localization is done globally. To navigate relative to some local objects all these objects need to be properly located on a map. Furthermore it give only its own position and does not help localize other, potentially moving objects.

For this several authors such as Lewitt and Lawton, Schlieder and Wagner ([Lewitt and Lawton, 1990], [Schlieder, 1993], and [Wagner, Visser, and Herzog, 2004]) have considered navigation via landmarks. These approaches do not rely on a precise allocentric map. In contrast to Lewitt and Lawton, the approach of Wagner overcomes the problem of a incorrect localization via the so-called round-view. In addition it needs less information than the approach of Schlieder.

Here we first describe a way how an agent can localize itself with landmarks. These landmarks can be, for example visible objects or RFID chips. Accordingly the agent needs an appropriate receiver for this particular kind of landmark. This method is useful if only the agent is moving. It is described how a timer can help by detecting errors and increase the robustness of this approach.

Then it is discussed which informations are needed in order to localize and navigate; to detect moving objects and to compute an allocentric map. Therefore informations like time, position, direction, and speed of the agent are considered, as well as the angles between the other objects. The question is, which of these informations are needed to compute the position, direction, and speed of the other objects.

Localization with Landmarks

In figure 1 an agent and three landmarks are present and the agent sees the landmarks from left to right as \( PQR \). The plane can be divided into sections, as seen in figure 1 and only from the sequence of landmarks the agent can determine without using quantitative measures such as angles, that it is located in the down left section. This localization is always possible as long as the agent sees all landmarks in an angle of 180° degrees. This technique was introduced by [Wagner, Visser, and Herzog, 2004]. Furthermore they have shown that the sequences of landmarks can only change in
a certain way if the agent moves, and it is possible to derive the shape of the landmarks from these changes. Therefore
This approach is very robust against different kinds of errors, i.e. incorrectly recognized landmarks. But there is some information lost if only the changes are considered. From the timing of these changes not only a topological shape, but also some quantitative measures of the landmarks can be derived.

In figure 2 the agent moves in a circle around the set of landmarks. Whenever two landmarks change the position in the sequence of landmarks the agent knows that it has crossed the line that goes through these two landmarks. Without timing it can say that it has detected three landmarks, with timing it can compute the exact positions of the landmarks relative to the circle. This observation is true not only for three, but for any arbitrary number of landmarks.

With this information the agent is then able to better navigate in this area.

Moving Objects
Localization and navigation becomes even more involving when not only the agent but some of the visible “landmarks” are moving. The first task is to detect any moving objects, and then to find out how they do move. Without time the second task cannot be solved even for three objects, if only one of them is moving. This is shown in figure 3. Here object $B$ is moving and the gray dots mark its position on times $t_2$ to $t_5$.

Without timing the agent could go on for one and a half cycle before it detects something is wrong, while with timing the agent detects the moving object $B$ soon after time $t_5$. If the agent knows how long it needs to perform one cycle it detects the moving object after exactly one cycle. In this case after crossing the line $AC$ shortly after time $t_5$ it knows that only object $B$ is moving.

Thus with time as additional resource the agent can detect moving objects better, but it is not sufficient to recognize them fast and to get exact information of their movement and speed, if both the agent and some of the objects are moving. In order to calculate the position, direction, and speed of other object the agent can, in addition, use the angle in which it sees the other objects. If the agent passes by other unmoving objects, then it can compute the positions of these landmarks after only two measurements of angles in two different positions. To detect moving objects other techniques are needed. One way to do this is that the agent measures the change of the angles over time.

When an agent passes by, or encircles a number of unmoving landmarks then the angles between these landmarks change in a fixed way according to the arrangements of landmarks. Therefore it follows, that if some of the landmarks are moving, then the angles change differently, and therefore the agent is able to derive the direction and speed of the moving objects.

The goal of this work is to show under which conditions such a localization can be done, and how complicated it is. I.e. with a known starting position for all of the object and knowledge about moving and unmoving objects it is rather easy to do a complete localization. How this knowledge can be achieved is another part of this work.

References

