Reducing Uncertainty through Cooperative Localisation and Mapping (CLAM)

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1 Abstract

Recently, many authors have considered the problem of simultaneous localisation and mapping (SLAM). My current research focussed on a somewhat different problem, that of *cooperative* localisation and mapping (CLAM). Basically, CLAM involves two or more robots cooperating to build maps of the environment. This cooperation can be used to increase the *speed* with which maps are constructed, and, more importantly, increase the *accuracy* of the resultant maps.

The aim of SLAM, as opposed to CLAM, is to build a map of an unknown environment and simultaneously localise the robot with respect to this map. The map might be relational, or it might be defined with respect to some coordinate system (the latter is more common). If the robot has access to some kind of global localisation sensor, such as satellite GPS, this task is not very difficult. The processes of localisation and mapping are effectively *de-coupled* – the robot can use the GPS sensor to determine its position, then use this knowledge, together with other sensor readings, to construct the map. Unfortunately, the robots used in many applications (such as service robots, mining robots, underwater vehicles, and so on) are not able to use this kind of sensor. They robots must instead rely on a mixture of odometry (or inertial navigation or dead-reckoning) and landmarks (i.e. estimating their position by comparing observed landmarks against those in the map). For these robots, processes of localisation and mapping are *strongly coupled* – to determine its position, the robot must have a map, but to build the map, the robot must first know its position. It is this strong coupling that makes SLAM so difficult.

When constructing a SLAM system, one must be aware of two key problems:

- Odometry is subject to cumulative drift.
- Landmarks can be ambiguous.

The concept of CLAM can be used to address both of these problems. Imagine a group of robots travelling through unknown environment. These robots can operate much like a team of surveyors mapping out an area, or a squad of soldiers moving through a hostile environment.

- The robots can reduce odometric drift by 'watching' each other. Consider, for example, a scenario involving two robots. At any given point in time, only one robot is allowed to move (the actor). The other robot (the observer) watches the actor and estimates its relative position. This estimate is combined with the actor's own estimate (based on odometry) to obtain an estimate that is more accurate than that which can be obtained using odometry alone. When the distance between the robots becomes large, or when a robot is about to become occluded, the robots swap roles.
- The robots can also resolve ambiguity in landmarks by acting as landmarks *themselves*. Consider the following scenario. The robots have detected a pair of landmarks, which may or may not be the same. To resolve this ambiguity, one robot stays and watches the first landmark, while the other sets out for the second. If the robots subsequently meet up, they know that there is in fact only one landmark. If they fail two meet, they know that there are indeed two distinct landmarks.

Note that, with CLAM, the localisation and map building processes are effectively de-coupled once again: during the map-building phase, the robots use *each other* for localisation. Once the map is built, however, the robots can go their separate ways and use the *map* for localisation.

My current research is aimed at exploring and validating the CLAM concept. I am particularly interested in the relationship between the uncertainty in each robot's location, the number of robots involved in the mapping process and the different exploration strategies they employ.

References

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