Behavior Coordination Methods on Autonomous Navigation of Physical Robot

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Abstract

Behavior based architecture gives robot fast and reliable action. If there are many behaviors in robot, behavior coordination is needed. Subsumption architecture and motor schema is example of behavior coordination methods. In order to study those methods characteristics, computer simulation is not enough, experiments in physical robot are needed to be done.
It can be concluded from experiment result that the first method gives quick, robust but non smooth response. Meanwhile the latter gives smooth but slower response, and it is tend to reach target faster than the first one. Some limitation of physical robot experiment also presented here.

Keywords: behavior based robotics, subsumption architecture, motor schema, physical robot.

1. Introduction

Behavior based architecture is a key concept in creating fast and reliable robotic architecture. It replaces deliberative architecture that used in Shakey robot [7]. Behavior based robot doesn't need world model (that needs long time) to finish its task. The real environment is the only model which needed by robot. Another advantage is all behaviors run in parallel, simultaneous, and asynchronous way [9].

In behavior based architecture, robot must have behavior coordinator (sometimes called arbiter) to coordinate many robot's behavior. First approach that is suggested by Brooks [9] is Subsumption Architecture that can be classified as competitive method. In this method, there is only one behavior (that can be applied in robot) at one time. It is very simple method and it gives the fast performance result, but it has disavantage of non-smooth response and inaccuracy in robot movement.

To overcome competitive method weakness, Arkin [10],[11] suggest Motor Schema that can be classified as cooperative method. In this method, at one time, there can be more than one behavior that applied in robot, so every behavior has contribution in robot's action. This method results in a smoother response and more accurate robot movement, but it is more complicated than competitive one. The complete list of behavior coordination methods can be found in [8].

In order to study characteristics of behavior coordination methods above, some researcher has done those simulations by using robotic simulator software [4], [5]. However, experiments with physical robot are still needed to be done, because there are big differences between ideal environment (in computer simulation) and real world. This paper will describe about behavior coordination methods implementation on physical robot that can navigate itself autonomously.

2. Behavior Coordination methods

In behavior based robotics approach, methods of behavior coordination are significant. The designer needs to know how robot coordinate its behaviors and take the action in the real world. There are two approaches : competitive and cooperative. In competitive method, at one time, there is only one behavior that applied in robot.

The first suggestion on this type is Subsumption Architecture that suggested by Brooks [9]. This method divides behaviors to many levels, where the higher level behavior have higher priorities too. So it can subsume the lower level ones. The layered control system figure is given below.

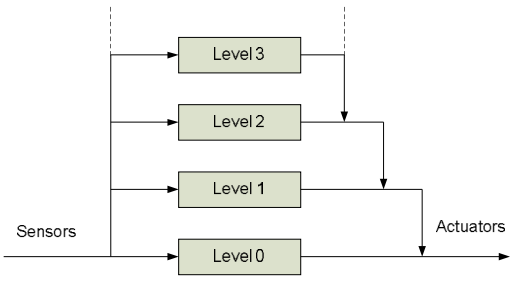

Figure 1. Layered control system [9]

In order to finish autonomous navigation task, robot should have these behaviors :

- Obstacle avoidance
- Search target
- Wandering
- Stop

Subsumption architecture for robot which can navigate autonomously shown in Figure 2.

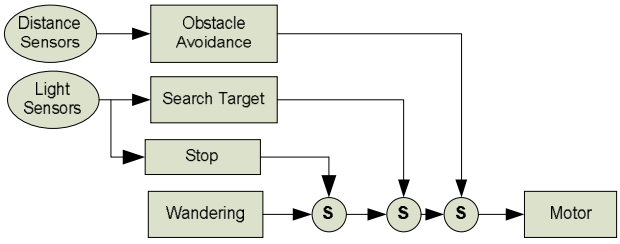

Figure 2. Robot's subsumption architecture for autonomous navigation

Form figure above, it can be seen that robot use distance sensors (i.e. ultrasonic sensor) to detect the obstacle and light sensors to find the target (light source, i.e. candles). Obstacle avoidance become the most important behavior, and wandering become the least important one. On this architecture, there is only one behavior that can be used by robot at one time.

The cooperative method have different approaches. In this method, at one time, there can be more than one behavior that applied in robot, so every behavior has contribution in robot's action. Arkin [10] suggest the motor schema method, which every object will be described as vector that has magnitude and direction. The result behavior is mixing between each behavior. The motor scheme for this method appears in the figure below.

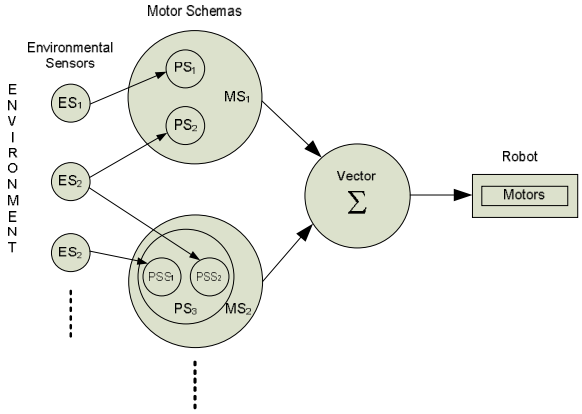

Figure 3. Motor schema method [10]

Motor schema for robot's autonomous navigation can be shown in Figure 4. The behavior structure is similar with Subsumption Architecture, except the way to mix all robot's behaviors.

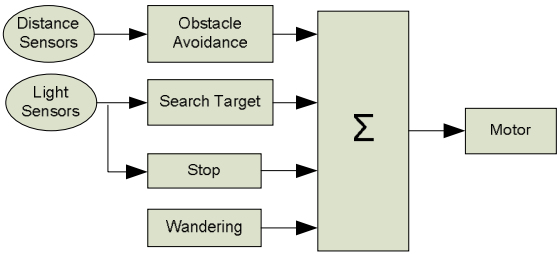

Figure 4. Robot's motor schema for autonomous navigation

3. Physical Robot Implementation

Simulation becomes an important aspect of robotic research. In comparison with real robot experiments, simulations are easier to set up, less expensive, faster, more convenient to use, and allow the user to perform experiments without the risk of damaging the robot [6].

However physical robot experiment is still urgently needed. There still many unpredictable aspects of robot that can not be perfectly modeled by robotics simulation software. The example is ultrasonic sensor that may not recognized obstacle near it because the sound wave generated by transmitter may reflected by obstacle surface to other direction that far away from the receiver. So physical robot implementation is needed to give robot's designer real and unique insight.

In order to realize physical robot, there are many robotics platform nowadays. Students or researchers don't have to build robot from the beginning, but they can use robotic kit that avalilable on the market today. LEGO NXT Robot is famous robotic kit for people of all ages. It consists of NXT Brick as controller, many kind of sensors (ultrasonic sensor, light sensor, touch sensor and sound sensor), and servo motors as actuator. LEGO NXT components can be seen on Figure 5.

Figure 5. The Lego Mindstorms NXT [3]