UNDERGRADUATE REPORT

REU Report: An Implementation of the MDLe Platform

by Jacqueline Cockrell
Advisor: P.S. Krishnaprasad

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Jacqueline Cockrell
Advisor: Dr. Krishnaprasad

Introduction to MDLe

Motion description language (MDLe) is a language that enables people to develop systematic solutions to tasks of robot motion planning. The ideas of am MDLe system have suggested the possibility of the “implementation of a framework that will integrate a set of tools to provide a platform with an interface of standard language acting as a protocol between the user and the implementational details of a specific robot.”

Such a platform could possibly be used to test different algorithms for motion planning, or to create a virtual internet laboratory, making it possible for people to control robots remotely.

The purpose of this project is to create a possible implementation of this MDLe platform.

The Mathematical Model

The robot's motion is restricted by a non-holonomic constraint (like an automobile), and thus cannot move in a sideways motion. Modeled as a drift-less three wheeled cart, the robot's steering and translation are achieved by differentially driving the two front wheels, with the rear wheel serving as a supporting castor.

The kinematic model is:

$$\dot{g} = g(A1v1 + A2v2)$$

where g, A1, A2 are given by**:**

$$g = \begin{bmatrix} \cos\theta & -\sin\theta & x \\ \sin\theta & \cos\theta & y \\ 0 & 0 & 1 \end{bmatrix}$$

$$A1 = \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$A2 = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

and the angular velocity, v1, and transnational velocity, v2, are given by:

$$v1 = \frac{(ul - ur)}{W} \qquad v2 = \frac{(ul + ur)}{2}$$

where ul and ur are the velocities of the left and right wheels, respectively.

W is the distance between the two front wheels.

Plans, Behaviors and Atoms

The simplest unit of the MDLe motion language is the **atom**. Examples of common atoms are: move forward, turn right, turn left, turn parallel to something, and turn perpendicular to something. In MDLe, a finite set of atoms define a number of simple motions. There is an interrupt (any condition requiring the robot to discontinue execution of the atom) associated with each atom.

A group of atoms can be strung together to create a **behavior**. As with atoms, there is an interrupt associated with each behavior. An example of a behavior is exiting a room.

Finally, a sequence of behaviors can be assembled to create a **plan.** A plan is a specific task, such as navigating through the hallways to find a specific room. As can be expected, there is also an interrupt associated with each plan.

“The Mailman”

The purpose of my project was to create a plan that would enable the robot to deliver mail to Dr. Krishnaprasad's office, starting off in the ISL laboratory. The plan was written in the C++ programming language. Following are the atoms and behaviors that make up this plan.

Note: The robot has 16 sonars, spaced evenly and circling around the upper side of the robot.

Behavior #1: Exit Lab: (A1, A2, A3)*
Behavior interrupt: any of the back 5 sonars detects something

Atom #1: go forward
Atom interrupt: any of these 5 conditions are met:

1. Sonar #1 finds something <= L1 (distance away)
2. Sonar #2 finds something <= L2
3. Sonar #3 finds something with $d\cos 2\theta \le R$ (radius of robot)
4. Sonar #16 finds something <=L1
5. Sonar #14 finds something with $d\cos 2\theta \le R$

Atom #2: turn slightly to the left
Atom interrupt: condition #3 from above is no longer true

Atom #3: turn slightly to the right
Atom interrupt: condition #5 from above is no longer true

Behavior #2: Prepare to Head Down Hall: (A4, A5)
Behavior interrupt: sonar #12 and #14 get same reading

Atom #4: go forward until wall is reached
Atom interrupt: 2 of these sonars detect something: 1,2,3,15 and 16

Atom #5: turn left until parallel to wall
Atom interrupt: same as behavior interrupt

Behavior #3: Proceed down hallway:
(A1,A12,A1(A6,A8,A10)(A7,A9,A11)*
Behavior interrupt: intersection is reached (judgment made by comparing line angles to determine whether a wall is in front - if there is, intersection has been reached)

Atom #1: mentioned under behavior #1
Atom interrupt: same as in behavior #1

Atom #6: turn left
Atom interrupt: robot is perpendicular to side wall (sonar #8 gets same reading as sonar #10)

Atom #7: turn right
Atom interrupt: robot is perpendicular to side wall (sonar #8 gets same reading as sonar #10)

Atom #8: go forward
Atom interrupt: left side is clear (no conditions of interrupt for atom #1 are true)

Atom #9: go forward
Atom interrupt: right side is clear (no conditions of interrupt for atom #1 are true)

Atom #10: turn right
Atom interrupt: robot is parallel to side wall (sonar #12 gets same reading as sonar #14)

Atom #11: turn left
Atom interrupt: robot is parallel to side wall (sonar #12 gets same reading as sonar #14)

Atom #12: stop and wait (to see if object in the way moves)
Atom interrupt: 5 seconds have passed

Behavior #4: Proceed to Dr. Krishnaprasad's Office: (A5,A1)
Behavior interrupt: robot has reached Dr. Krishnaprasad's office (sonars on right side have lost something)

Atom #5: turn left until parallel to wall
Atom interrupt: sonar #12 and #14 get same reading

Atom #1: go forward
Atom interrupt: any of these 5 conditions are met:

1. Sonar #1 finds something <= L1 (distance away)
2. Sonar #2 finds something <= L2
3. Sonar #3 finds something with $d\cos 2\theta$ <= R (radius of robot)
4. Sonar #16 finds something <=L1
5. Sonar #14 finds something with $d\cos 2\theta$ <= R

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References

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