DESIGN PROJECT: AUTONOMOUS DIFFERENTIAL ROBOT SySML™

This project focuses on the development of SySML™ for an autonomous differential drive robot (DDR) to visually map its path through a forest environment with vertical cliffs on each side. For the SySML™ as shown in Figure 1, all diagrams need to be developed except Sequence and Use Case.

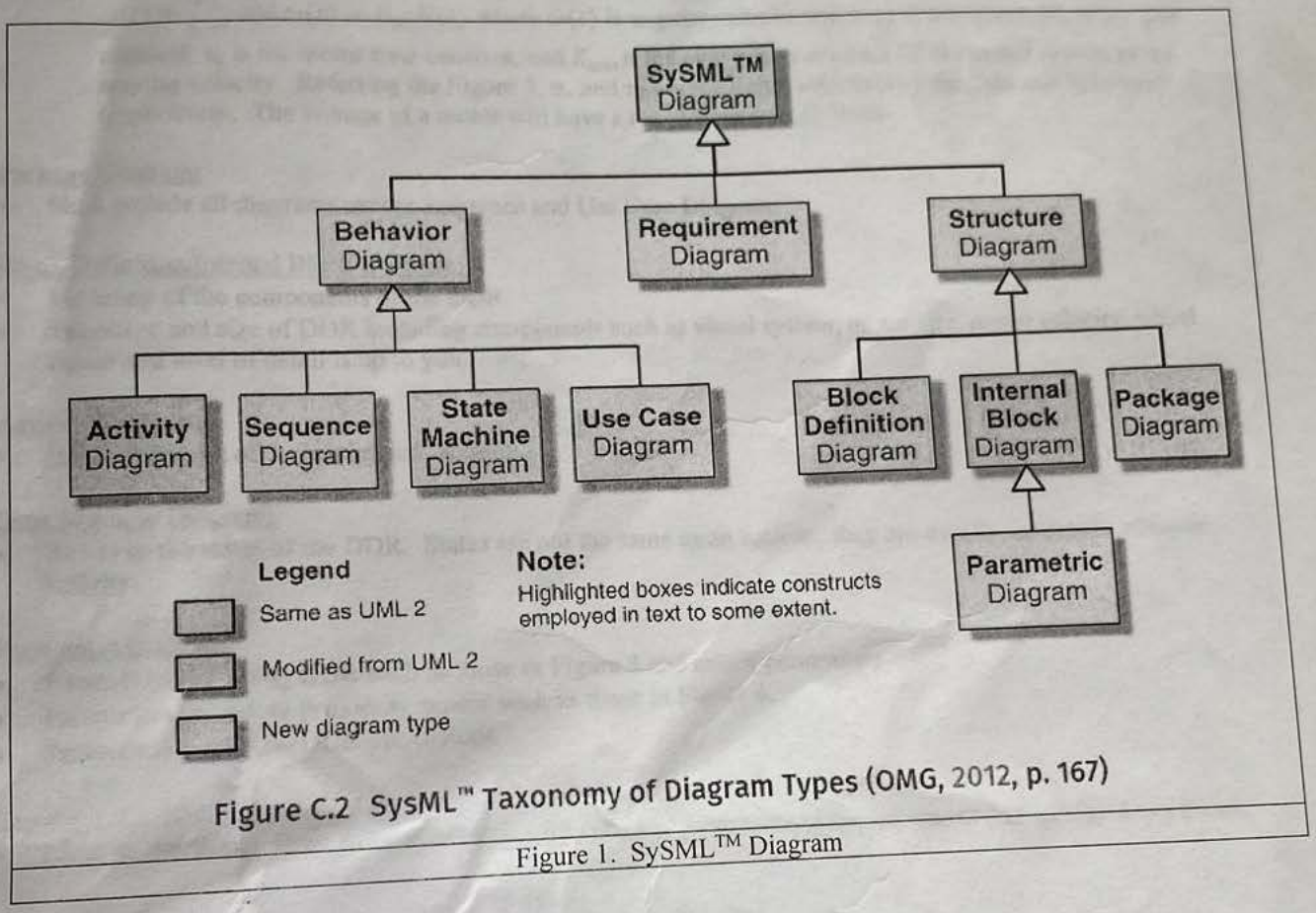


Figure 1. SySML™ Diagram

Forest Environment Characteristics:

The environment is shown in Figure 1.

- The circumference base of the biggest tree is 3 feet and the smallest 1 feet. Each tree will have a minimum radius (rt) of 15 feet to the closest trees, as shown in Figure 1.
- Each tree will have a minimum radius (rw) of 10 feet to the cliff wall, as shown in Figure 1.
- The start to finish linear distance of the environment is 15 miles.
- All trees have no branches lower that 20 feet above the ground

Operational Specifications:

- The system shall have a maximum velocity of 15 miles per hour.
- Visual maps of the area 360 degrees around the system shall be taken every one minute

- While the visual mapping is occurring, the location of the system must not change.
- The navigation of the environment shall be less than 2 hours.
- The proximity sensor shall have a linear range not less than 5 feet.

Differential Drive Robot (DDR):

- A DDR velocity and heading diagram is shown in Figure 3.
- Navigation shall be controlled by proximity sensors (refer to Figure 4.) only for obstacle avoidance and control strategy to maintain a heading of due east. Research in this area by the student will be required.
  - Senor configuration must account for operational specifications and the environment
- Must include a visual system.
  - Visual system must account for operational specifications and the environment
- Robot configuration such as shape, size, weight, components must be derived by the student in the SySML™
  - Modeling of DDR motors can be kept at a minimum, suggested to be modeled as a first order system, i.e. $\omega(t) = \frac{K_m}{\tau_s+1}$ and $\omega(t) = K_{\omega v}V(t)$ where $\omega(t)$ is angular velocity (rad/sec) of the motor, K_m is the gain constant, τ_s is the motor time constant, and $K_{\omega m}$ is the conversion constant for the motor voltage to the angular velocity. Referring the Figure 3, v_r and v_l are the linear velocities of the right and left wheel respectively. The voltage of a motor will have a range from 0 to 12 Volts.

Package Diagram:

- Shall include all diagrams except Sequence and Use Case Diagrams.

Block Definition/Internal Block Diagram:

- Modeling of the components of the DDR.
- The shape and size of DDR including components such as visual system, motor size, motor velocity, wheel radius and level of detail is up to you.

Activity Diagram:

- Implementation of the navigation strategy.

State Machine Diagram:

- Refers to the states of the DDR. States are not the same as an activity, they are usually the results of some activity.

Parametric Diagram:

- Parameters regarding DDR such as those in Figure 3 and motor parameters
- Parameters regarding proximity sensor such as those in Figure 4.
- Parameters regarding DDR dimensions

Requirement Diagram:

- Must be developed from environment characteristics and operational specifications and allocated to a Block.

Grading Criteria

- Report Criteria
  - SySML™ Professionalism – The project should use software, i.e. Magic Draw, Word Drawing Canvas, etc. in the development of the block diagrams.
  - Report Format – The project should be presented in a report format (Title page, Table of Contents, Table of Figures, References), describing the SySML™ in an organized sectional format
- SySML™ Criteria
  - Level of complexity – relates to number of model components
  - Level of completeness – relates to the development of the model to complete the operational specifications.
  - Level of accuracy – relates to numerical formulations, block interactions etc.

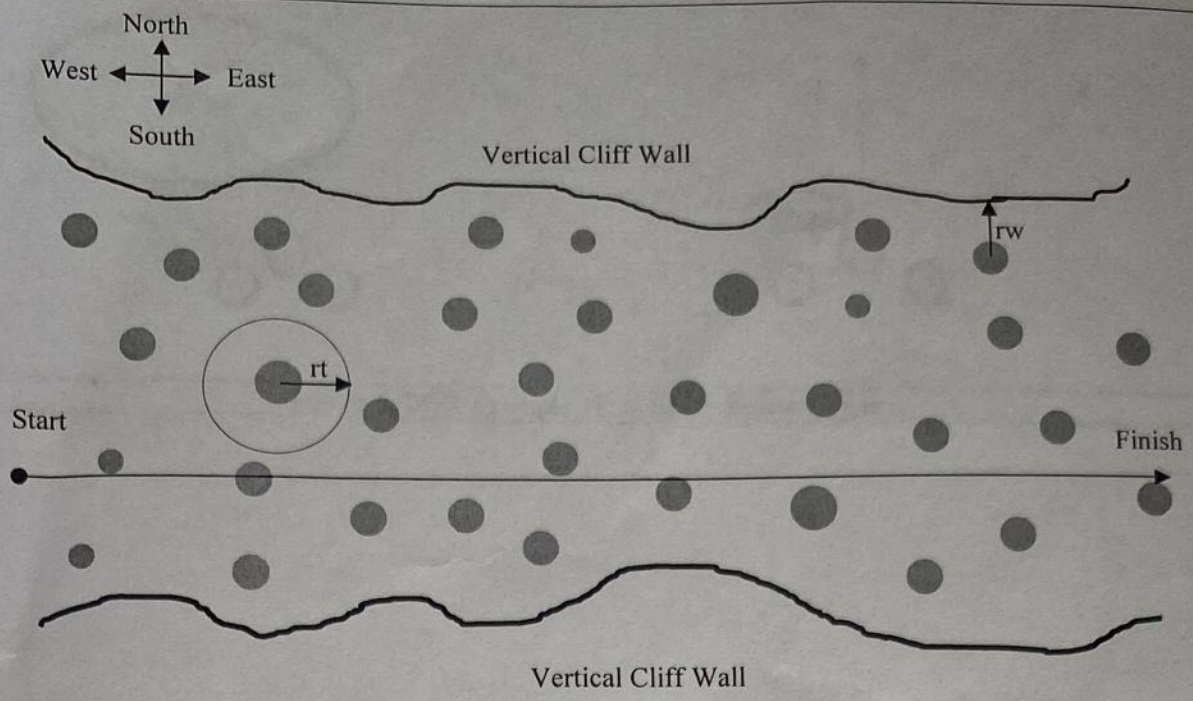
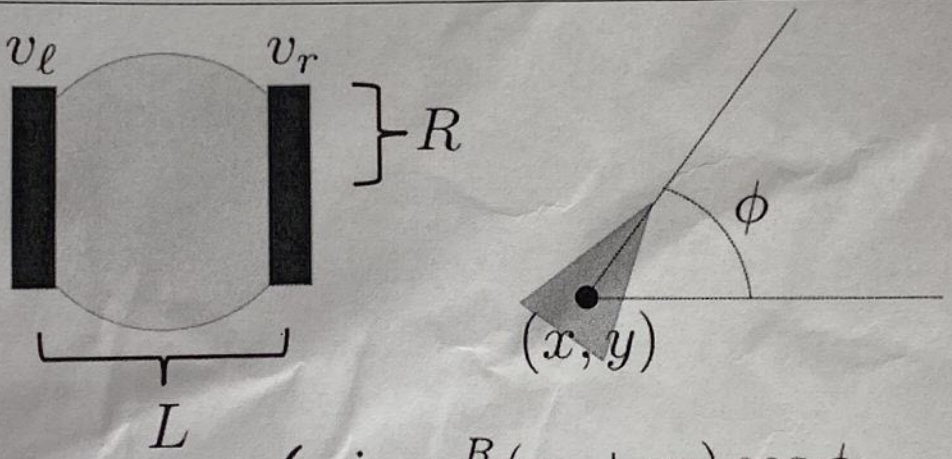


Figure 2. Environment Diagram



$$\begin{cases} \dot{x} = \frac{R}{2}(v_r + v_\ell)\cos\phi \\ \dot{y} = \frac{R}{2}(v_r + v_\ell)\sin\phi \\ \dot{\phi} = \frac{R}{L}(v_r - v_\ell) \end{cases}$$

Figure 3. DDR Velocity and Heading Diagram

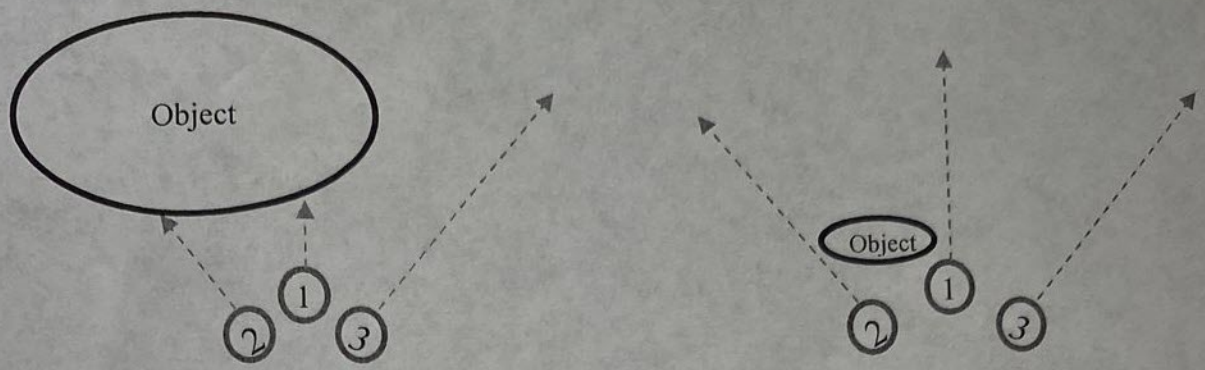


Figure 4. DDR Example Three Sonar Sensor Diagram