Vision Document

For Environment Model Building Tool (EMBT)

Version 1.2

Submitted in partial fulfillment of the requirements of the degree of MSE

Esteban Guillen
CIS 895 – MSE Project
Kansas State University
# Table of Contents

1. Introduction ............................................................................................................. 4  
   1.1. Motivation ........................................................................................................ 4  
1.2. Cooperative Robotics Simulator ........................................................................... 4  
   1.2.1. Environment Simulator .................................................................................. 4  
   1.2.2. Simulator Control Panel ................................................................................ 4  
   1.2.3. 3D Environment Display ............................................................................ 4  
   1.2.4. Environment Model Building Tool ............................................................... 4  
   1.2.5. Robot Simulator ........................................................................................... 4  
2. Project Overview ...................................................................................................... 5  
   2.1. Introduction ....................................................................................................... 5  
   2.2. Goal .................................................................................................................. 5  
   2.3. Purpose ............................................................................................................ 5  
3. Requirements Specification ....................................................................................... 6  
   3.1. Critical Use Cases .............................................................................................. 6  
      3.1.1. Use Case: Build Environment Models ......................................................... 7  
         3.1.1.1. SR1 [Critical Requirement] ................................................................. 7  
         3.1.1.2. SR2 [Critical Requirement] ................................................................. 7  
         3.1.1.3. SR3 ................................................................................................. 7  
         3.1.1.4. SR4 ................................................................................................. 7  
         3.1.1.5. SR5 ................................................................................................. 7  
         3.1.1.6. SR5.1 ............................................................................................... 7  
         3.1.1.7. SR5.2 ............................................................................................... 8  
         3.1.1.8. SR5.3 ............................................................................................... 8  
         3.1.1.9. SR5.4 ............................................................................................... 8  
         3.1.1.10. SR5.5 [Future Requirement] ............................................................. 8  
         3.1.1.11. SR5.6 [Future Requirement] ............................................................. 8  
         3.1.1.12. SR5.7 [Future Requirement] ............................................................. 8  
   3.1.2. Use Case: Build Environment Terrains ......................................................... 8  
      3.1.2.1. SR6 [Critical Requirement] ................................................................. 8  
      3.1.2.2. SR7 ................................................................................................. 8  
      3.1.2.3. SR8 [Critical Requirement] ................................................................. 8  
      3.1.2.4. SR9 ................................................................................................. 9  
      3.1.2.5. SR10 ............................................................................................... 9  
      3.1.2.6. SR11 ............................................................................................... 9  
   3.1.3. Use Case: Build Environment Objects .......................................................... 9  
      3.1.3.1. SR12 [Critical Requirement] ............................................................... 9  
      3.1.3.2. SR13 [Critical Requirement] ............................................................... 9  
      3.1.3.3. SR13.1 .............................................................................................. 9  
      3.1.3.4. SR14 [Critical Requirement] ............................................................... 9  
      3.1.3.5. SR15 ............................................................................................... 9  
      3.1.3.6. SR16 .............................................................................................. 10  
      3.1.3.7. SR17 .............................................................................................. 10  
      3.1.3.8. SR18 .............................................................................................. 10  
      3.1.3.9. SR18.1 [Future Requirement] ........................................................... 10
3.1.3.10. SR19 ........................................................................................................ 10
3.1.4. Use Case: View in 3D ................................................................. 10
  3.1.4.1. SR20 ......................................................................................... 10
  3.1.4.2. SR21 ......................................................................................... 10
  3.1.4.3. SR22 ......................................................................................... 10
  3.1.4.4. SR23 ......................................................................................... 10
3.1.5. Use Case: Save Model To XML .................................................. 10
  3.1.5.1. SR24 [Critical Requirement] ......................................................... 11
  3.1.5.2. SR25 [Critical Requirement] ......................................................... 11
3.1.6. Use Case: Load Saved Model ..................................................... 11
  3.1.6.1. SR26 [Critical Requirements] ....................................................... 11
3.1.7. Use Case: Import Object(s) ......................................................... 11
3.1.8. Use Case: Import Terrain(s) ....................................................... 11
3.2. Assumptions .................................................................................... 11
3.3. Constrains ...................................................................................... 12
3.4. Environment .................................................................................... 12
1. Introduction

1.1. Motivation
The concept for the Environment Model Building Tool (EMBT) was driven from the need to
dynamically build 3D graphical environment models for the Cooperative Robotics Simulator
(CRS). The original CRS hard coded the environment model and had no way to store and reuse
the environment models. The EMBT will be an independent tool that allows the user to
interactively create and save graphical 3D environment models for the CRS to use.

1.2. Cooperative Robotics Simulator
The CRS is a new research group at Kansas State University and is headed by Dr. DeLoach. The
purpose for creating the group was to build a cooperative robotics simulator that could simulate a
large number of autonomous robots working in a virtual environment. The CRS group is
currently broken up into five components: Environment Simulator, Simulator Control Panel, 3D
Environment Display, Environment model Building Tool, and Robot Simulator.

1.2.1. Environment Simulator
The Environment Simulator is the central component of the entire system. It is
responsible for keeping track of the state of the virtual environment, including each robot.
The Environment Simulator is also the main interface of the EMBT.

1.2.2. Simulator Control Panel
The Simulator Control Panel will connect to the Environment Simulator to monitor and
control the current simulation.

1.2.3. 3D Environment Display
The 3D Environment Display will be used to display the virtual environment in 3D. The
3D Environment Display will get all its viewing information from the Environment
Simulator.

1.2.4. Environment Model Building Tool
The Environment Model Building Tool will be used to create 3D environment models for
the Environment Simulator. The models will be in the form of a XML file.

1.2.5. Robot Simulator
The Robot Simulator will simulate the actions of various kinds of robots. It will
communicate with the Environment Simulator to update sensor readings and location
changes.
2. Project Overview

Figure 1. EMBT Project Overview

2.1. Introduction
Figure 1 shows, at a high level, how the EMBT will interface with and effect other components of the CRS. The EMBT will provide an XML file to the Environment Simulator. The XML file will describe the objects and the terrain which represents the environment model. The objects will be described as a collection of primitive shapes (boxes, spheres, cones, and cylinders). The terrain will be described as a collection of polygons connected in a mesh. The objects and terrain will have attributes that add details to their physical make up.

The XML file describes the initial state of the environment in the CRS. The Environment Simulator will parse the XML file and send the 3D Environment Display (3DED) messages which describe the initial state. After the 3DED has received the initial state from the Environment Simulator the XML file is no longer used in the current simulation run.

The EMBT will provide a 2D perspective to build objects and terrains. The tool will also provide a 3D perspective to view objects, terrains and environment models. From the 3D perspective the user will be able to navigate through the scene by mouse movements. The final perspective will be able to view the XML code for the objects and terrains.

2.2. Goal
To provide a tool that can allow a user to build and reuse 3D environment models.

2.3. Purpose
To improve on the current method of building, reusing, and describing environment models.
3. Requirements Specification

The requirements specification will describe all the features that the EMBT will have. The features will be identified by a specific requirement (SR). SR’s can be tagged as “Critical” or “Future”. Critical SR’s are one that are considered most important and will be the focus during implementation. Future SR’s are one that are not vital for the system to run and will be implemented if time permits, otherwise a future developer will implement them.

3.1. Critical Use Cases
3.1.1. **Use Case: Build Environment Models**

**Description:** This use case describes constructing the environment model from a 2D perspective.

**Includes:** Import Object(s), Import Terrain(s)

**Pre-Conditions:** There must be environment objects and environment terrains saved to disk. The user is in the environment model building mode.

**Details:** The user will build environment models from environment objects and environment terrains. The user will have a window to place environment objects and environment terrains, for building the environment model. The user will select either an object or terrain from a preview window and place it on the window surface. There will be a preview window for both objects and terrains. The object preview window will list all available objects in a hierarchical structure and allow the user to select an object to preview. A selected object will be displayed in 3D on the preview window. The selected object can then be placed in the model building window. The terrain preview window will function in the same way as the object preview window. Once the object or terrain has been placed on the window surface it can be resized, moved, and rotated with the use of the mouse. Each object and terrain will also have its own properties window that the user can pull up to modify attributes values for the object or terrain. The user will also be able to zoom in and out of the window. Objects and terrains that are modified from the properties window can be saved as new objects and terrains. A group of objects can also be selected and saved as a new object (for example a group of houses could be saved as a city block).

**Post-Conditions:** An environment model is constructed and is ready to be saved.

**Specific Requirements:**

3.1.1.1. **SR1 [Critical Requirement]**

The system shall provide a 2D graphical user interface to build environment models.

3.1.1.2. **SR2 [Critical Requirement]**

The system will allow the user to build environment models from environment objects and environment terrains.

3.1.1.3. **SR3**

The system will allow the user to specify camera locations in the environment model. There will be a default camera with a top down view pointing a location (0,0,0).

3.1.1.4. **SR4**

The system will allow the user to specify light source locations in the environment model. There will be a default light source to represent the sun.

3.1.1.5. **SR5**

The system will provide a zoom-in and zoom-out feature for the environment model building graphical user interface.

3.1.1.6. **SR5.1**

The system will provide an object preview window for listing and viewing available objects from the object database.
3.1.1.7. SR5.2
The system will provide a terrain preview window for listing and viewing available terrains from the object database.

3.1.1.8. SR5.3
The object preview window will allow the user to select an object from a list and view it in 3D.

3.1.1.9. SR5.4
The terrain preview window will allow the user to select a terrain from a list and view it in 3D.

3.1.1.10. SR5.5 [Future Requirement]
The system will allow the user to select objects from the window surface and save the group as a new object. The object will be saved to the object database.

3.1.1.11. SR5.6 [Future Requirement]
The system will allow the user to save objects, which have been modified from the properties window, as new objects to the object database.

3.1.1.12. SR5.7 [Future Requirement]
The system will allow the user to save terrains, which have been modified from the properties window, as new terrain objects to the terrain database.

3.1.2. Use Case : Build Environment Terrains
Description: This use case describes building environment terrains from a 2D perspective.
Includes: Modify Elevation, Set Terrain Properties, Save to Terrain Database
Pre-Conditions: The user is in the environment terrain building mode.
Details: The user will be provided with a window to create the terrain. The window will initially have a flat surface. The user will be able to select regions of the surface and modify the elevation for the selected regions. Modifying the elevation will be controlled by mouse actions. A color coding will be used to provide visual feedback about the elevation changes. Black will represent the lowest elevations and white will represent the highest elevations. The user will be able to specify different terrain properties, from a properties window, for a selected region. The properties will include things such as grassy surfaces, rocky surfaces, water surfaces, sand surfaces, forest surfaces, and dirt surfaces. The user will also be able to zoom in and out of the window. The user will be able to save the terrain to the terrain database.
Post-Conditions: When the user is done creating the terrain it saved to the terrain database.
Specific Requirements:

3.1.2.1. SR6 [Critical Requirement]
The system shall provide a 2D graphical user interface to build environment terrains

3.1.2.2. SR7
The system will allow the user to build environment terrains by selecting regions of an initially flat surface and then modifying the elevation.

3.1.2.3. SR8 [Critical Requirement]
The system will allow the user to save environment terrains to the terrain database.
3.1.2.4. SR9
The system shall provide a property window for each section of an environment terrain. The property window will allow the user to modify the physical attributes of the environment terrain.

3.1.2.5. SR10
Physical attributes for environment terrains will include color, dimensions, reflection properties, location, friction, temperature and the type of surface. The type of surface will include grassy surfaces, rocky surfaces, water surfaces, sand surfaces, forest surfaces, and dirt surfaces.

3.1.2.6. SR11
The system will provide a zoom-in and zoom-out feature for the environment terrain building graphical user interface.

3.1.3. Use Case: Build Environment Objects
Description: This use case describes building environment objects in a 2D perspective.
Includes: Draw Primitive(s), Use Saved Object(s), Resize, Move, Rotate, Set Object Properties, Save To Object Database.
Pre-Conditions: The user is in the object building mode.
Details: The user will be provided with a window to create the object. Environment objects will be constructed from cube, cone, cylinder, and sphere primitive shapes as well as existing objects. The user will draw primitive shapes on the window. The user will also be able to use an existing object from the database of objects and place it in the window. An existing object will have all its primitive shapes placed in the window when selected. Once the shapes are drawn on the window the user can resize, move, and rotate them with the mouse. Each primitive shape will have a properties window that the user can use to modify attribute values of the shape. The user will also be able to zoom in and out of the window.
Post-Conditions: When the user is done creating the new object it can be saved to disk.
Specific Requirements:

3.1.3.1. SR12 [Critical Requirement]
The system shall provide a 2D graphical user interface to build environment objects.

3.1.3.2. SR13 [Critical Requirement]
The system will allow the user to build environment objects from the following Java 3D primitive shapes; Cones, Spheres, Cylinders, and Boxes.

3.1.3.3. SR13.1
The system will allow the user to build environment objects from existing objects in the object database. When an existing object is selected its primitive shapes will be placed in the window.

3.1.3.4. SR14 [Critical Requirement]
The system will allow the user to save environment objects the object database.

3.1.3.5. SR15
The system shall provide a property window for each environment object. The property windows will allow the user to modify the physical attributes of the environment object.
3.1.3.6. SR16
Physical attributes for environment objects will include weight, color, dimensions, reflection properties, temperature, location, friction, and rotations.

3.1.3.7. SR17
The system will allow the user to resize environment objects with the mouse.

3.1.3.8. SR18
The system will allow the user to move the location of environment objects with the mouse.

3.1.3.9. SR18.1 [Future Requirement]
The system will allow the user to rotate an object with the mouse.

3.1.3.10. SR19
The system will provide a zoom-in and zoom-out feature for the environment object building graphical user interface.

3.1.4. Use Case: View in 3D
Description: This use case describes viewing a model, object or terrain in 3D.
Pre-Conditions: There user must be in model building, object building or terrain building mode.
Details: The user will be provided with a window for viewing in 3D. The window will provide a 3D representation of the 2D building perspective. The user will be able to rotate the scene about the x, y, and z axis with mouse movements. The user will also be able to zoom in and out with mouse and keyboard actions.
Post-Conditions: None
Specific Requirements:

3.1.4.1. SR20
The system will allow the user to view environment objects from a 3D perspective.

3.1.4.2. SR21
The system will allow the user to view environment terrains from a 3D perspective.

3.1.4.3. SR22
The system will allow the user to view environment models from a 3D perspective.

3.1.4.4. SR23
The system will allow the user to navigate through 3D perspectives with mouse movements.

3.1.5. Use Case: Save Model To XML
Description: This use case describes exporting XML representations of the environment model.
Pre-Conditions: There must be an environment model to export.
Details: There will be a menu item to either export or import the environment model. Both imported and exported files will be in XML format and will describe the objects and terrains included in the environment. When exporting an environment model the user will be provided with a window to name the XML file. When importing an environment model the user will be provided with a window to select a XML file.
Post-Conditions: There will be a new file saved to disk.
Specific Requirements:
3.1.5.1. SR24 [Critical Requirement]
The system will allow the user to save the environment model to an XML format.

3.1.5.2. SR25 [Critical Requirement]
The system will be required to comply with a DTD for the XML file produced when
saving the environment model. The Environment Simulator will determine the DTD
specification. The DTD file will continually be evolving as the project progresses. A
sample of the current DTD will be provided in the DTD Description Document.

3.1.6. Use Case: Load Saved Model
Description: This use case describes loading environment models.
Pre-Conditions: There must be an environment model to load.
Details: There will be a menu item to import the environment model. Imported files will
be in XML format and will describe the objects and terrains included in the environment.
When importing an environment model the user will be provided with a window to select a
XML file.
Post-Conditions: The user will be in the environment building mode as described in Use
Case 1.
Specific Requirements:

3.1.6.1. SR26 [Critical Requirements]
The system will allow the user to open and edit saved environment models.

3.1.7. Use Case: Import Object(s)
Description: This use case describes loading environment objects into the environment
model.
Includes: Search Object Database.
Pre-Conditions: There must be environment objects saved to disk. At a minimum the
Java 3D primitive shapes (cone, box, sphere, and cylinder) will be provide. The user
must be in environment building mode.
Details: The user will select environment objects from a menu. The user can then draw
the environment object on the window provided by Use Case 1.
Post-Conditions: The object will be added to the environment model.
Specific Requirements: SR7 from use case 1.

3.1.8. Use Case: Import Terrain(s)
Description: This use case describes loading environment terrains into the environment
model.
Includes: Search Terrain Database.
Pre-Conditions: There must be environment terrains saved to disk. At a minimum a flat
surface will be provided. The user must be in environment building mode.
Details: The user will select environment objects from a menu. The user can then draw
the environment terrain on the window provided by Use Case 1.
Post-Conditions: The object will be added to the environment model.
Specific Requirements: SR7 from use case 1

3.2. Assumptions
- The user has a JVM 1.3.1 or later and Java 3D 1.3.1 or later installed.
- The user should have a graphics card that supports OpenGL.
- The user will need a 1.6GHz processor or better.
• The user will need 512MB of system memory.

3.3. Constrains

• The DTD file provided by the Environment Simulator will determine the structure of the XML file produced when saving the environment model.

• Java is not the most efficient language for 3D and 2D graphics, so speed will be a constant issue.

• Building 3D objects in a 2D view has limited capabilities.

3.4. Environment

• The EMBT will be written in Java and compiled with the JDK 1.4.2 and Java 3D 1.3.1.

• Eclipse will be the development environment.

• The EMBT will be tested under Windows XP, Linux, and Solaris.

• Version control will be handled by CVS.