RoboSim User's Guide

Version 0.5.0

Contents

1 Introduction

`RoboSim` is a robot simulation environment, developed by the UC Davis Center for Integrated Computing and STEM Education (C-STEM) **(http://c-stem.ucdavis.edu)**, for programming Barobo Mobot and Linkbot. The same Ch program can control hardware robots or virtual robots in RoboSim without any modification.

2 RoboSim GUI

RoboSim can be conveniently launched by double clicking its icon on the desktop. The RoboSim graphical user interface (GUI), shown in Figure 1, allows the user to change between hardware and virtual robots when a Ch robot program is executed. There is no save button within the GUI, all changes made are automatically saved.

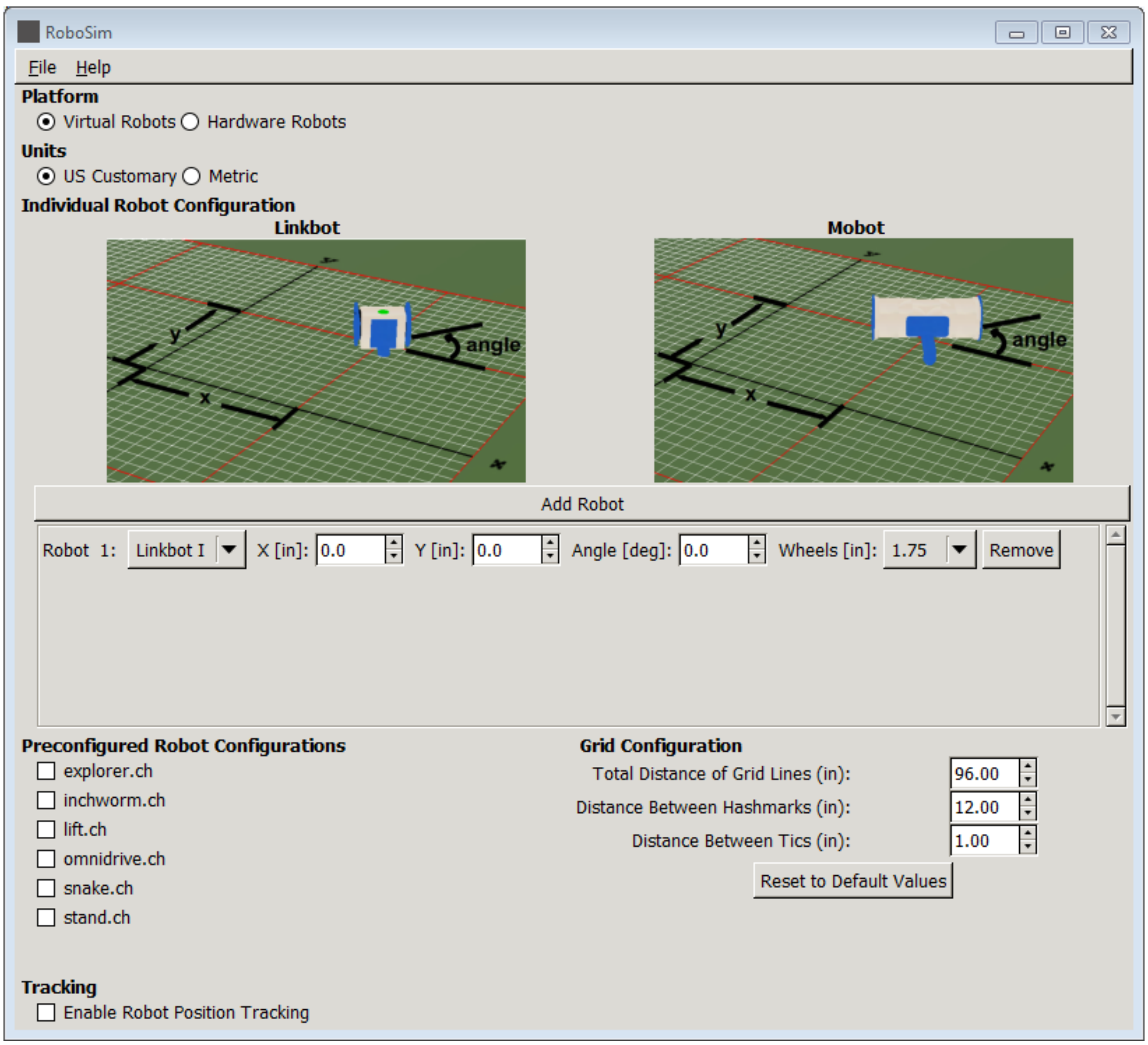

Figure 1: The RoboSim GUI.

2.1 Platform

The **Platform** entry as shown in Figure 2, allows the user to decide whether a Ch program controls the hardware or virtual robots. Each time a new Ch program is started, it will check the setup based on this entry. For a Ch robot program to control a virtual robot, check the box for **Simulated Robots**. If the box for **Hardware Robots** is checked, a Ch program will control the physical hardware robots.

Figure 2: Initial robot configuration dialog.

2.2 Units

Simulations within RoboSim can be run either in **US Customary** units consisting of inches, degrees, and seconds or **Metric** units with centimeters, degrees, and seconds. Changing units will effect the grid spacing drawn beneath the robots and the spacing between robots. Changing between these two options will change the labels within the GUI to indicate the units being used.

2.3 Individual Robot Configuration

Initial robot configurations can either be done through the **Individual Robot Configuration** or **Pre-configured Robot Configuration** section. The **Individual Robot Configuration** section, as shown in Figure 3, has options to allow robots to be positioned within the RoboSim scene either with or without wheels but not attached to each other.

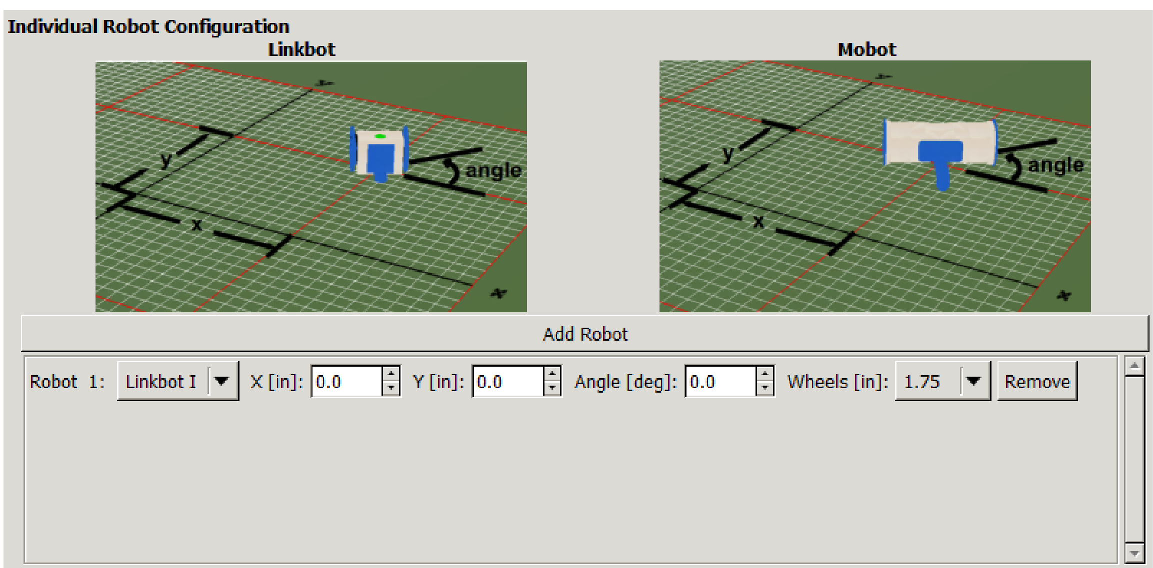

Figure 3: Individual robot configuration dialog.

The user can specify the X and Y coordinates as well as the orientation angle of a virtual robot. Images for the Linkbot and Mobot showing the meaning of each of the options are displayed above the configuration box. They are screenshots of the virtual robots positioned at one foot in both the X and Y coordinates with the orientation angle of 30 degrees from the X-axis.

Initially, the individual robot list contains one Linkbot-I at (0, 0) with 1.75 inch wheels. More robots can be added by the 'Add Robot' button below the configuration images. Clicking this button will add a robot into RoboSim, each offset from the previous one in the x-direction by 6 inches or 15 centimeters depending upon the units selected. The order within the robot list will be the order in which the robots will be read into the simulation program.

2.3.1 Robot Type

There are three options for robot type available. Linkbot-I, Linkbot-L, and Mobot. The options are presented in a drop down menu.

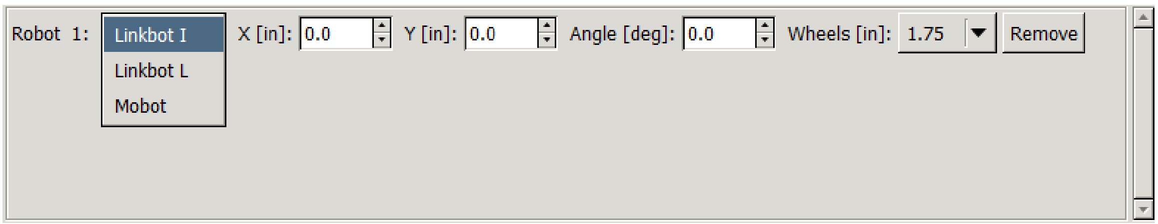

Figure 4: Picking a robot type.

2.3.2 Robot Position

Both X and Y positions can be chosen independently for each robot.

2.3.3 Robot Angle

The rotation angle from the x-axis can be used for changing the orientation of the two robots respective to each other.

2.3.4 Wheels

Since so many times the robots are run with wheels and a caster connected, a drop down menu is provided to select different wheel sizes. The options listed are the radii of the wheels provided with Linkbots when purchased from Barobo. Each wheel is drawn with a series of dots along the one radius to easily show the rotation of the wheel. The correlation between wheel radius and number of dots is given in Table 1.

Number of Dots	Wheel Radius
3	1.625 inch
4	1.75 inch
5	2.00 inch

Table 1: Wheel sizes and number of dots.

2.3.5 Remove

A robot can be removed from the RoboSim by clicking the 'Remove' button.

2.4 Preconfigured Robot Configurations

In addition to positioning robots independently within the RoboSim, some **Preconfigured Robot Configurations**, as shown in Figure 5, which represent commonly used Linkbot configurations are available to the user. Selecting one of these options will display a picture of the configuration built with the hardware Linkbots and corresponding to a Ch robot program presented in Chapter 13 in the book *Learning Robot Programming with Linkbot for the Absolute Beginner*. When one of these options is selected, the specific configuration for this setup is passed into Ch and robots specified in the individual robot configuration are ignored. To switch back to the individual configuration, just unselect the selected preconfigured robot configuration.

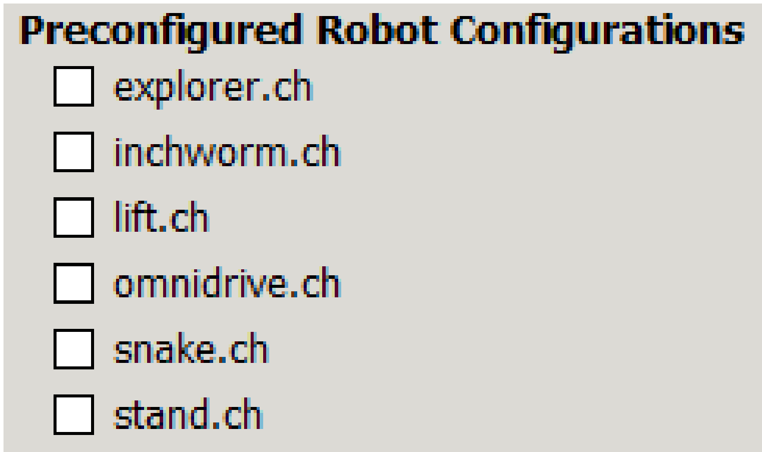

Figure 5: Preconfigured Linkbots.

2.5 Grid Configuration

To be able to see how far robots have moved, a grid is enabled under the robots. There are three options to alter the layout of the grid lines under the **Grid Configuration**. Total distance is the entire distance between -x and x for which grid lines will be displayed. Hashmarks are the red lines drawn within the configuration images. By default, the distance between two hashmarks is 12 inches in US Customary units and 50 centimeters in Metric units. Tics are the most frequent lines drawn in a light gray. By default, the distance between two tics is 1 inch in US Customary units and 5 centimeters in Metric units.

Switching between US Customary and Metric units will change these default values to logical starting points for the metric system. The 'Reset to Defaults' button will allow the default values for both US Customary and Metric to be reinstated after they have been changed. Depending upon which units are currently selected from Section 2.2, either the US Customary defaults, shown in Figure 6, or the Metric defaults, as shown in Figure 7, will be set.

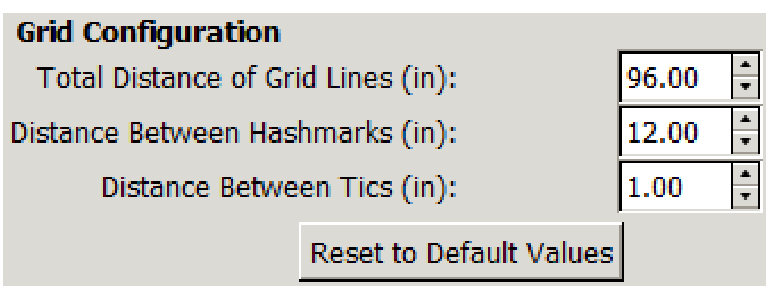

Figure 6: Default US Customary Grid Spacing.

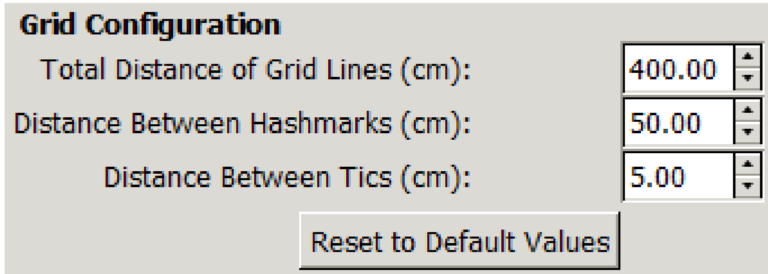

Figure 7: Default Metric Grid Spacing.

2.6 Tracking

Tracking where robots have been can be enabled by selecting the check box 'Enable Robot Position Tracking', as shown in Figure 1. When the tracking is enabled, green lines for robot trajectories will be drawn for each robot.

3 Running a Ch Program with RoboSim

Once the simulation environment has been configured with the RoboSim GUI in Section 2, the user can run Ch programs in ChIDE to control the virtual robots. The RoboSim GUI should remain open while simulating robots. Once it is closed, the system will revert to hardware mode. The RoboSim scene with virtual robots for each simulation are created upon running a Ch program. For example, when the Ch program `moveforward3.ch` below

```
/* File: moveforward3.ch
   Move forward for Linkbot-I as a two-wheel vehicle */
#include <linkbot.h>
CLinkbotI robot;

/* connect to the paired robot and move to the zero position */
robot.connect();
robot.resetToZero();

/* move forward by rolling two wheels for 360 degrees */
robot.moveForward(360);
```

is executed in ChIDE, a RoboSim scene shown in Figure 8 will be displayed.

```
Paused: Press any key to start
```

is displayed in the RoboSim scene to reminder the user that the virtual robot will not move until the user presses any key on the keyboard. This gives the user an opportunity to examine the RoboSim scene before the motion begins.

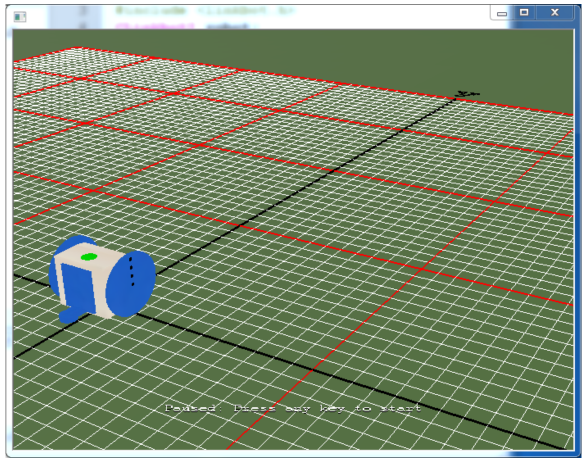

Figure 8: A RoboSim scene with a virtual robot at its starting position.

While a robot is moving in the RoboSim scene, the user can press any key to pause the motion of the robot. When the motion is paused, the message

```
Paused: Press any key to restart
```

will be displayed in the RoboSim scene. The user can press any key to restart the motion.

When the user presses the 't' key, the robot trajectory is tracked in a green line in the RoboSim scene as shown in Figure 9.

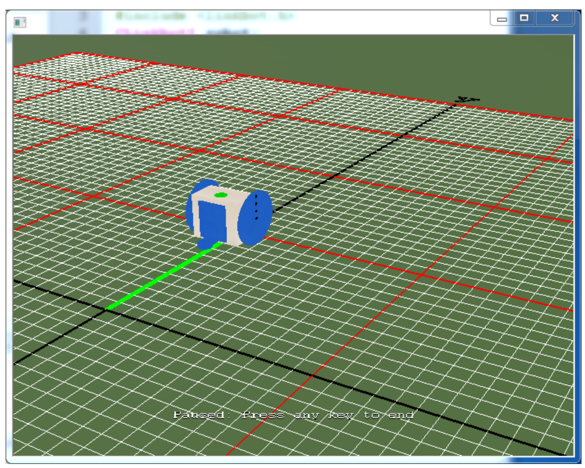

Figure 9: A RoboSim scene with a virtual robot and its trajectory tracked.

When the program is finished, the message

```
Paused: Press any key to end
```

will be displayed in the RoboSim scene. Pressing any key, the RoboSim scene will disappear.

4 Interacting with a RoboSim Scene

The user can interact with a RoboSim scene through the keyboard and mouse.

The ground plane is for reference only. It is designed to disappear when viewing the robots from below to be able to inspect the movement from all angles.

4.1 Keyboard Input

The RoboSim scene responds to keyboad input as outlined in Table 2. As described in the previous sections, the 't' key will toggle the tracking of robot trajectories.

key	**action**
r	toggle robot visibility and enable tracking
t	toggle robot tracking
any other key	Pause and unpause simulation

Table 2: Keyboard input for RoboSim

The 'r' key will toggle the display of virtual robots or robot trajectories. This feature is useful when the user would like to view a trajectory traced by a robot without the virtual root blocking the trajectory. Figure 10 shows a RoboSim scene with a tracked robot trajectory only.

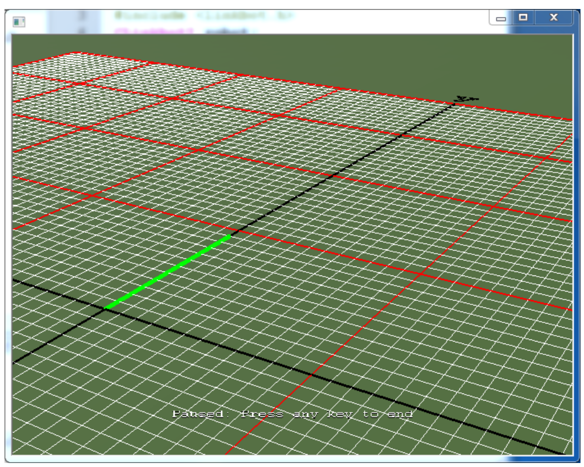

Figure 10: A RoboSim scene with a tracked robot trajectory only.

As described in the previous section, the motion of robots in the RoboSim scene can be paused and restarted by pressing any other key on the keyboard.

4.2 Mouse Input

Clicking on a robot in a RoboSim scene will enable a pop up which displays the robot number and the current position of the robot, as shown in Figure 11 with the position (0, 10.9817) inches for the X and Y coordinates for the Robot 1. Clicking again the displayed position for the robot will disappear.

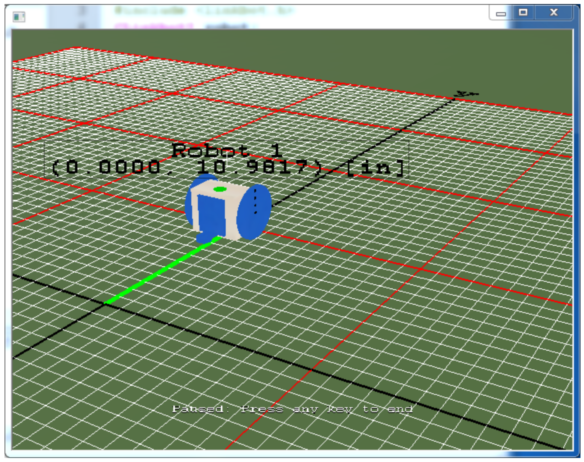

Figure 11: A RoboSim scene with a virtual robot and its position displayed.

The user can execute a Ch robot program in debug mode in ChIDE, line by line, with the command `Next`. At the end of each motion statement, the user can click the robot in the RoboSim scene to obtain the X and Y coordinates of the robot. The ability to obtain the X and Y coordinates of a robot during its motion along a trajectory can be very useful for learning many math concepts.

The mouse can be used to move the camera around the scene. Holding the left mouse button and dragging the mouse pans the camera as outlined in Table 3. Holding the right mouse button and dragging the mouse enables scaling of the view by zooming in and out. Holding both left and right mouse buttons and dragging changes the location of the camera within the scene.

The ground plane is for reference only. The ground plane will disappear when viewing the robots from below so that the user can inspect the movement from all angles.

button	**action**
Hold left mouse button and drag	rotate camera
Hold right mouse button and drag	zoom in and out
Hold both left and right buttons, and drag	pan around scene
Click on a robot	display the robot position

Table 3: Mouse input for the RoboSim scene.

A Manual Configuration File Generation

A.1 Robot Attributes

Each robot element is required to have one attribute titled **id** which is an unique identifier for the simulation to reference. A second optional attribute is **orientation** which orients the face of a second robot when it is being attached to a first robot.

`<linkboti id="0"/>`	one linkbot I with id = 0
`<linkboti id="0" orientation="3"/>`	Linkbot I is 'upside-down'

Table 4: Examples

attribute	**values**	**description**
id	unique integer	a unique integer to identify each robot
orientation	1	robot face number is at 12 o'clock
	2	robot face number is at 3 o'clock
	3	robot face number is at 6 o'clock
	4	robot face number is at 9 o'clock

Table 5: Robot Attributes