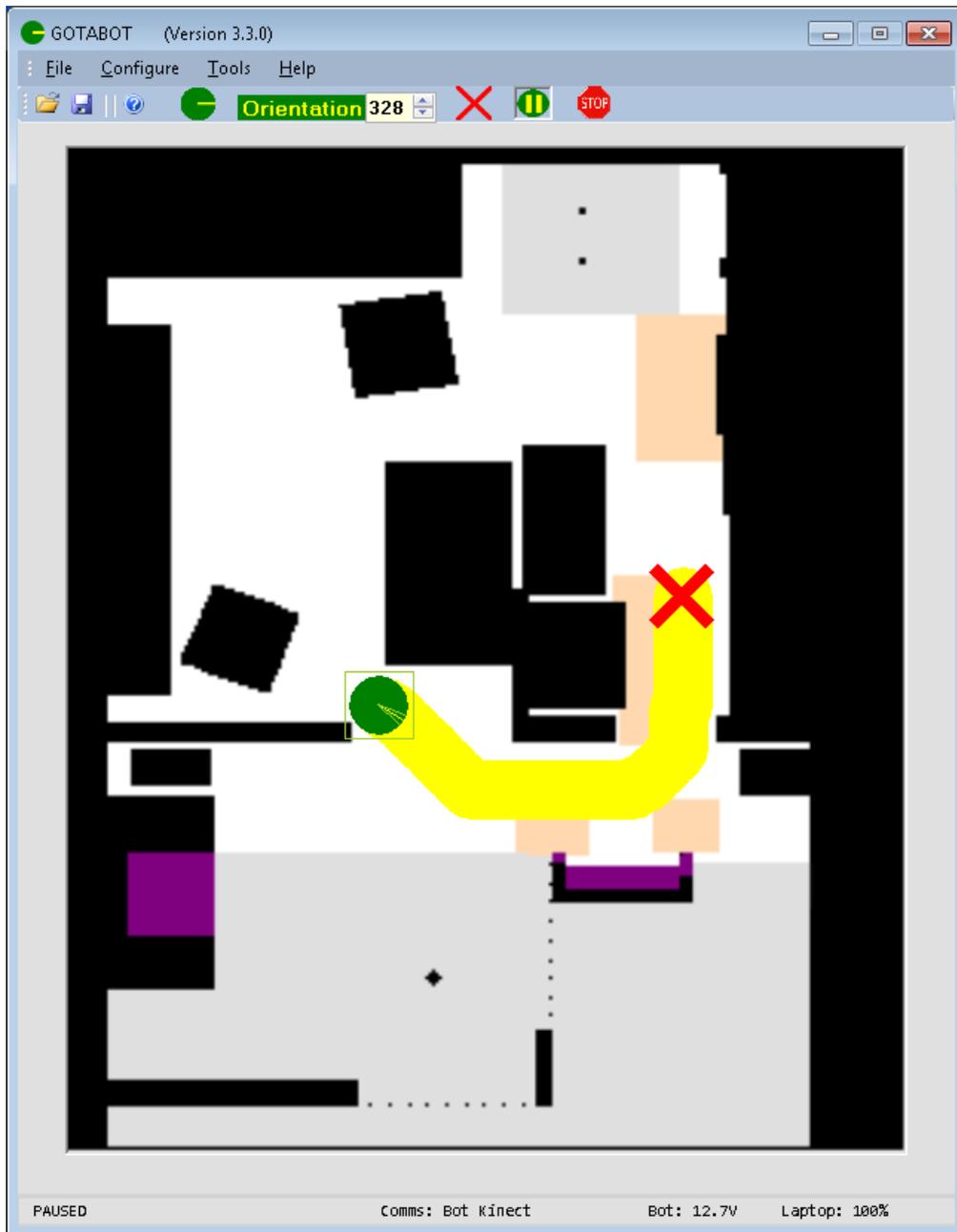


GotABot

User Guide version 3.6.0



GotABot User Guide

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1. Introduction

So you've got a robot and need some software to make it do stuff. Perhaps GotABot can help with that. Using a map, it can plan a route and direct your robot to a desired destination. With odometry and a camera, Kinect or laser scanner, GotABot will track the robot and correct its position and trajectory so as to stay on course.

GotABot also supports optional enhancements such as [bumper switches](#), [compass](#), [Kinect or URG04LX Laser Range Finder](#) or simple IR [Range Finders](#).

Additional information and the latest version of the software may be found on the website: <http://gotabot.weebly.com/>.

Important Safety Information

Although great effort has been taken to debug GotABot, it is a "Use at your own risk" type program. Please use common sense and follow all safety instructions provided by the robot manufacturer.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE

GotABot User Guide

2. Getting Started

Place the robot on the map by:
1) Click this icon
2) Then click the map at the desired location

Make the robot go to a destination by:
1) Click this icon
2) Then click the map at the desired location

Pause the robot's movement. Re-click to resume movement.

Stop the robot's movement.

This is the robot. The bright yellow line indicates the direction, or orientation, it is facing.

Yellow-Green lines indicate the uncertainty region of the robot's pose.

Salmon colored (Red=255, Green=216, Blue=176) areas indicate magnetic disturbances (due to nearby metal or whatever). Compass readings are treated as less accurate.

Robot's battery status.

Communications established with these devices.

Black (Red=0, Green=0, Blue=0) indicates solid objects and areas where the robot can't go.

White (Red=255, Green=255, Blue=255) indicates areas where the robot is free to move.

Grey (Red=223, Green=223, Blue=223) indicates areas where the robot can try to go if necessary, but probably shouldn't.

Purple (Red=128, Green=1, Blue=128) indicates areas which Range Finders or Kinect sensors indicate as empty but which are in fact solid objects or areas where the robot should not go.

Figure 1 Overview

QuickStart

If Using Evolution Robotics ER1

- 1) [Configure GotaBot and the ER1](#)
- 2) [Choose the localization method and configure](#)

If Using a Heathkit Hero-1

- 1) [Use the Heathkit Hero-1 setup guide](#)
- 2) [Create a map](#)
- 3) [Operate](#)

If Using a Kinect or URG04LX Laser Range Scanner

- 1) [Create a map](#)
- 2) [Configure the Scanner.](#)
- 3) [Configure various variables](#)
- 4) [Operate](#)

If Using a Webcam and LandMarks

- 1) [Create a map](#)
- 2) [Setup some Landmarks](#)
- 3) [Configure various variables](#)
- 4) [Operate](#)

Then What?

Once basic operation is achieved the user may explore this manual for additional capabilities and options.

TIP: Easy Localization

Localization using the Kinect is easier, faster and more accurate than localization using a camera and landmarks.

System Configuration and Installation of GotABot

System Configuration

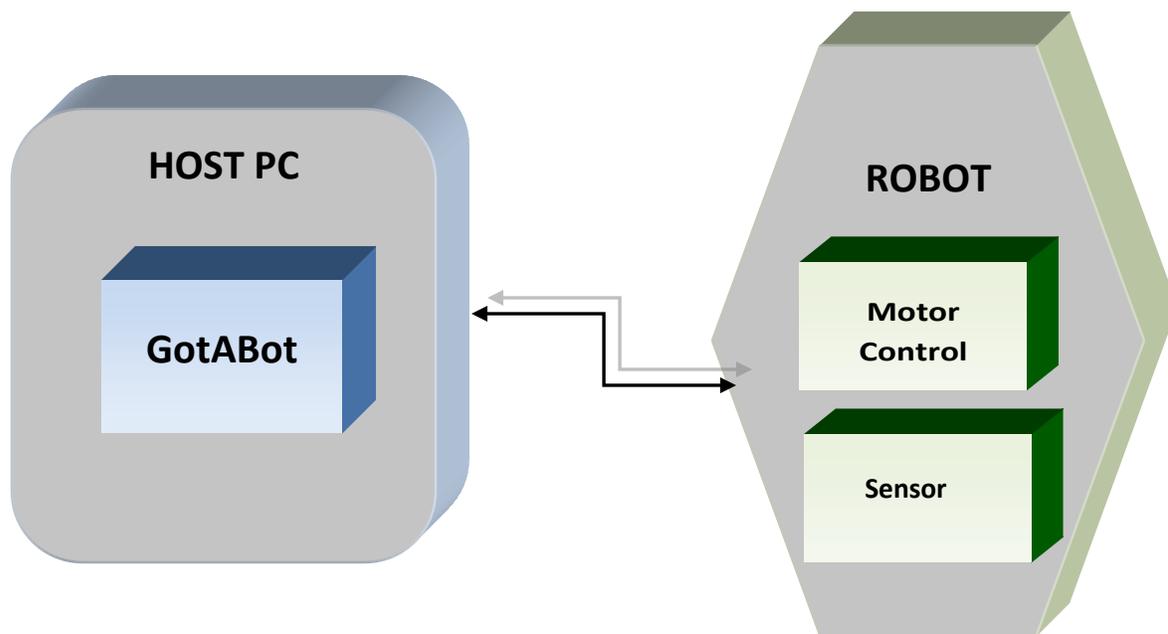
Before installing GotABot, one should first decide how to configure one's robotic system. There are a number of factors to consider such as:

- 1) The robot which is to be controlled
- 2) Will GotABot act as a standalone controller or will it be controlled by a higher level program.
- 3) Will the robot use a Kinect or laser scanner or a webcam to determine its position.

These and other considerations will be discussed in subsequent chapters.

Simple System Configuration

The simplest system configuration is as shown below. The Host PC may be separate from the robot and communicate to it via a wireless link or it might be on or part of the robot itself. This is the easiest configuration and should, be used first if for no other reason than to familiarize oneself with GotABot operation.



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Other System Configurations

Although the previous 'Simple System Configuration' works well, there are other configurations which may be more optimal for some applications:

- 1) If you wish to add additional behaviors, customize GotABot's operation, or allow a separate program to use all or portions of GotABot's functionality then see the chapter "[API](#)".
- 2) If your robot is not an ER1 or Hero then it might be controllable through the RoboRealm interface. More details are contained in a later chapter, "[GotABot Control of a RoboRealm Robot](#)". Alternatively, [GotATranslator](#) may be customized for you robot.
- 3) If your robot does not have image processing capabilities or you wish to have faster Image Recognition capabilities or perhaps you need to reduce power consumption, then see the chapter "[Local Image Recognition](#)".
- 4) A Kinect or URG04 Scanner is easier to setup and can provide better performance than image recognition of Landmarks. For even more reliable results, both Scanner and Landmark recognition may be used simultaneously.

Installation

For most applications, GotABot is installed on a host computer which can communicate with your robot.

The recommended minimum requirements of the computer are:

- Pentium® III class, Intel® Celeron®, or AMD processor, or better - 1000 MHz or faster
- Windows XP or better (Windows XP must be updated with Net Framework)
- 256 MB RAM
- 50 MB of free Hard Disk Space

GotABot is a portable application and it may be unzipped or copied to any convenient directory.

3. Creating a Map

Maps are BMP files representing the environment the robot will operate in. They can be created by most graphics programs including Microsoft Paint.

- **Black** (Red=0, Green=0, Blue=0) areas represent walls, furniture and “out of bound” areas.
- **Grey** (Red=223, Green=223, Blue=223) represents areas which may be occupied or areas where the robot should not travel through unless it can find no other route.
- **White** (Red=255, Green=255, Blue=255) represents open space through which the robot is free to move.
- **Purple** (Red=128, Green=1, Blue=128) indicates areas which Range Finders or Kinect sensors indicate as empty but which are solid objects or areas where the Robot should not go.
- **Salmon** (Red=255, Green=216, Blue=176) indicates areas with magnetic disturbances. Compass readings are treated as less accurate

Scale

The map's scale is set by using GotABot's Tool Bar's Map menu (*Click Configure->Map->Grid Size and Configure->Map->Grid Units*)

Creating Maps With Microsoft Paint

- 1) *Measure the actual area you want mapped – be accurate.*
- 2) *Decide on a scale. The scale can be in units of inches or cm and each pixel may represent multiple inches or cm. With the tight spaces my robot would navigate in, I decided on a scale of 1 grid square = 1 inch.*
- 3) *Start Paint (Start -> Run..->'mspaint')*
- 4) *Set the Map Size (Press Ctrl+E then set the map width and height)*
- 5) *Enlarge the map (Press Ctrl+PgUp)*
- 6) *Show a grid (Press CTRL+G)*
- 7) *Using the grid and the mouse position indicator in the bottom-right, draw the map.*
- 8) *Save the map in the GotABot directory with the filename "GotABot_Map.bmp".*

TIP: Map Scale

Due to a lack of rigorous testing, it is strongly recommended that the user choose a Scale of 1 Grid Size = 1 inch.

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As an example, this is a map that I use:

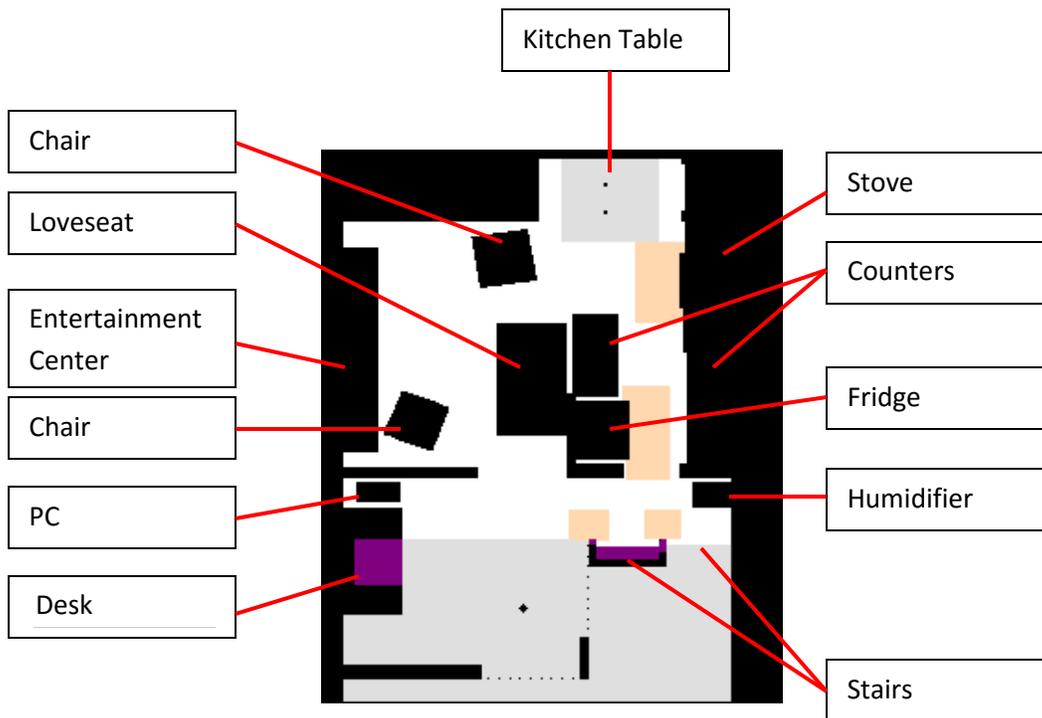


Figure 2 Example Map

...but shouldn't the robot make the map?

Well. It can (see the chapter on SLAM), but unfortunately, making a high accuracy map is a decidedly non trivial problem. Robot generated maps are especially problematic when the only measuring instruments are a cheap webcam, dodgy odometry and low cost range sensors. All in all, the best maps are drawn by old fashioned humans.

4. Scanner Configuration

GotABot provides interfaces to a Microsoft Kinect (first generation) or to a URG04 Laser Range Finder. Either will provide for excellent localization and collision prevention. Localization using one of these Scanners is in many ways superior to using visual Land Mark as it is easier to configure, more accurate and localizes faster.

Additionally, the Kinect has a microphone array for enhanced speech recognition. Highly recommended.

Configuration

Configure operation by opening the Scanner Configuration window (click *Configure->Scanner*).

The Offset fields represent the Scanner's position on the robot relative to the robot's center (typically centered on the drive wheels). Click the 'Continuous Scan' box and adjust the Calibration sliders to correct any errors in the range measurements.

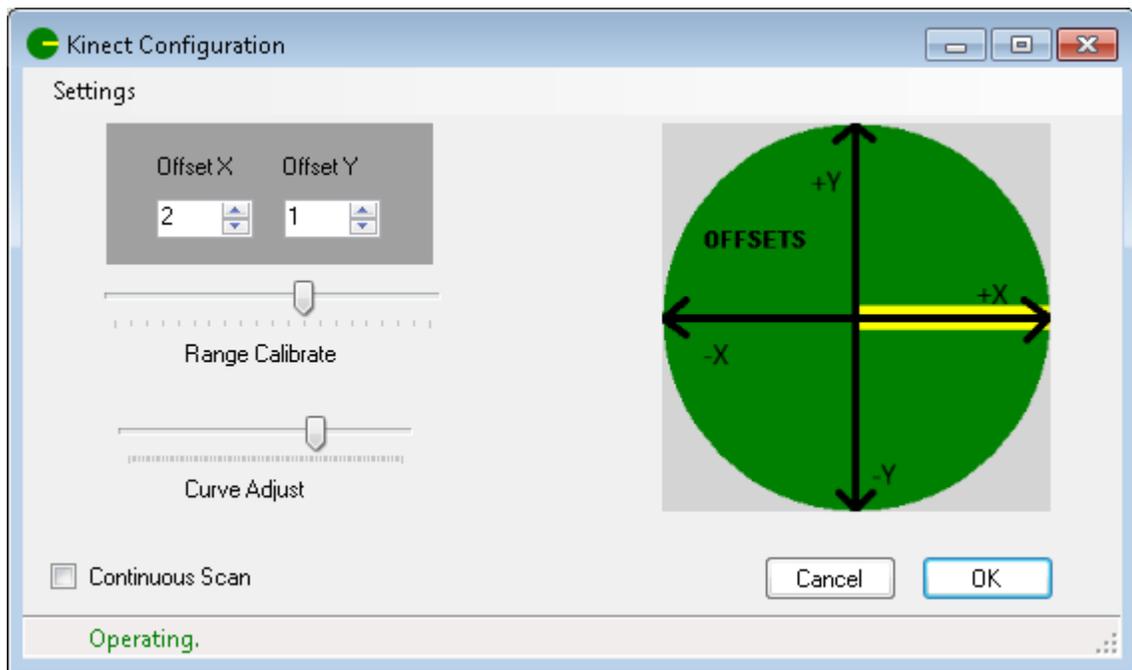
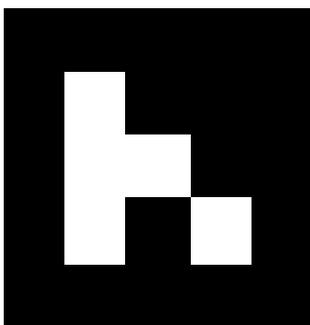


Figure 3 Scanner Configuration Window

If using a URG04, select its COM port by clicking *Settings->Select URG Port*.

5. Landmark Configuration

In addition to the Kinect interface, Landmark recognition may be used for determining the robot's position. Landmarks are user selected images that the robot can recognize and measure range and direction to. Knowing the Land Mark's location and the estimated robot's position and orientation, GotABot uses simple geometry to determine where the robot is located.



4 Example of Glyph or Fiducial

For detection of Land Marks, GotABot provides interfaces to four image recognition programs. Any or all may be selected (Click *Configure->Visual Localization->Recognizer* to select):

1) GotAGlyph

[GotAGlyph](#) is a Glyph recognition program provided with the GotABot package. Glyphs are a grid pattern of white squares on a black background. The high contrast between the white and black coupled with the square shapes and 2D planar nature yield an easy to identify image. This is the easiest, most convenient recognition program to start with. Unfortunately, it requires significant processing resources.

2) RoboRealm

[RoboRealm](#) is a commercial program which, among its many capabilities, can perform Fiducial recognition. These fiducials are highly similar to Glyphs.

3) RCC

The **recommended** image processor. This application is provided with the [Evolution Robotics](#) ER1 robot. Included in this application is a powerful image recognition utility suitable for identifying many types of images.

4) AVM

[AVM](#) is an optional plug-in for RoboRealm which can be used for image recognition. Difficult to configure the distance determination but somewhat useful for recognizing non 2D objects.



Figure 5 Example of a Highly Recognizable Land Mark

Establishing a Land Mark is realized by:

- 1) [Select](#) the Landmark
- 2) Capture an image of it
- 3) [Enter it](#) in the GotABot database

Selection of Land Mark Images

Without a doubt, the selection of good Land Marks is the most crucial component to ensuring adequate localization. A few well chosen Land Marks will be the equal of dozens of randomly chosen images of a typical home environment.

A good Land Mark will be:

- 1) Unique
- 2) Easily recognizable by the robot's image processing algorithm
- 3) Useable over a wide range of distance and angles

In practice, 2D Land Marks such as Fiducials, Glyphs, pictures, posters and playing cards are excellent choices. When first setting up, it would be well advised to temporarily attach a few of these to strategically located spots. Later, they can be replaced or augmented by a series of normal room images.

Tips For Good Land Marks

- 1) A good Land Mark should contain a number of high contrast features which the robot's algorithm can easily discern. Silhouette, or black and white, images are highly recommended!
- 2) Land Marks are most robust when they are in a single plane such as a picture, poster or playing card. Using such a Land Mark, the distance from robot to Land Mark can be estimated accurately over a wide range of distances and angles.
- 3) If Landmark images containing various features at various distances must be used, the valid region over which distance can be accurately measured will be relatively shallow. In such situations, it is best to make multiple Land Mark images, each at a slightly different distance.
- 4) Land Marks will yield more accurate range information when the orientation of the robot to Land Mark is close to that of the original image. If the Land Mark will be seen over a wide range of angles then create multiple Land Marks by capturing images at different angles.
- 5) Images which primarily consist of repeating features such as sets of drawers, slatted doors, patterned wallpaper or furniture, railings, etc, do not make good Land Marks.
- 6) Land Mark images which contain unwanted objects may be edited in Paint. Usually, the desired details may be easily isolated by overwriting everything else with grey rectangles.
- 7) Good locations for Land Marks include ends of corridors, doorways and any place where careful maneuvering is required to pass through tight spaces.
- 8) Ideally, the Land Mark should be at the same height as the camera.
- 9) Landmarks may not be recognized if they are placed against a 'busy' background. In such cases, a blank border around the land mark will improve recognition (i.e. if your landmark is, say, a picture attached to a patterned background then insert a slightly larger blank sheet of paper between the picture and the background)

The Trouble With Land Marks

As a rule of thumb, there should be at least one Land Mark visible at any location the robot is likely to stop. With one Land Mark, the robot's pose (i.e. – its position and orientation) can usually be calculated accurately, but sometimes, especially when the robot's pose is not accurately known, errors will occur and the pose will be *shifted*. Usually, these errors will be corrected with time and further localizations, but sometimes the snowball accelerate downhill, the reported pose drifts ever further from reality and the robot runs into a wall.

The treatment for this error condition is simple – add more Land Marks. Make sure that wherever the robot is likely to look, there is a good Land Mark. If there are two Land Marks visible everywhere then so much the better. Errors introduced by one Land Mark will be corrected by the others.

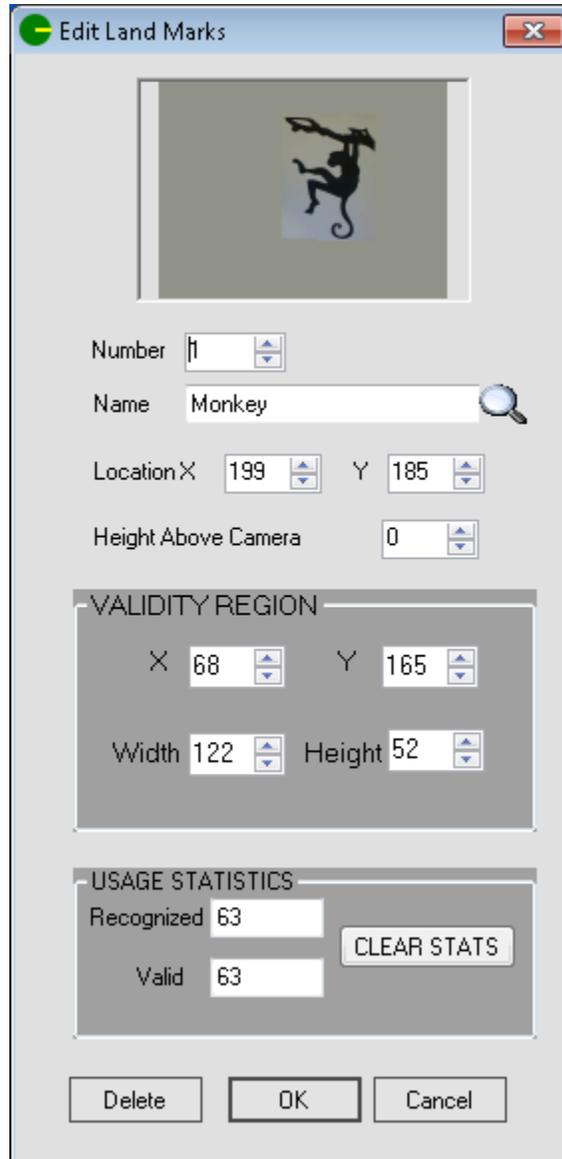
Accuracy Counts!

When establishing a Land Mark, make sure that the center of recognition is accurately transcribed in the Land Mark Edit form. It is probably necessary and certainly advisable to check where the image recognition software thinks the center is.

Having established where the actual center is, make sure that the range to this point is also correct.

The Edit Land Mark Window

Land Marks are entered through the Edit Land Mark window (*Click Configure->Visual Localization->Landmarks*). Remember to [save your settings](#) after making changes (*Click File->Save Settings*).



The screenshot shows the 'Edit Land Marks' dialog box. At the top, there is a preview window displaying a silhouette of a monkey. Below the preview, the following fields are visible:

- Number: 1
- Name: Monkey
- Location X: 199, Y: 185
- Height Above Camera: 0
- VALIDITY REGION:
 - X: 68, Y: 165
 - Width: 122, Height: 52
- USAGE STATISTICS:
 - Recognized: 63
 - Valid: 63
 - CLEAR STATS button

At the bottom of the dialog, there are three buttons: Delete, OK, and Cancel.

Figure 6 Edit Land Mark Form

Land Mark Number

Each Land Mark has a unique number. As the number field is changed, the corresponding Land Mark and its [Validity Region](#) are plotted on the map.

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Land Mark Name

The Land Mark Name field must contain the exact name reported by the robot.

Search Land Mark Name

Pressing the Magnifying Glass icon beside the Name field allows a search of the Land Mark database by name.

Land Mark Location

This is the location of the center of the Land Mark. It may be entered by:

- 1) Click on either of the Location X or Y up / down entry box.
- 2) Click on the map at the location of the Land Mark.

Height Above Camera

This is an optional field, but it can help to calculate a more accurate range to a LandMark when the LandMark is not at camera level. This is typically useful when the camera is near ground level and the LandMark is, say, a picture hung at a much higher eye level.

Land Mark Validity Region

To lessen the chance of harm due to false Land Mark recognitions, a validity region is required for each Land Mark. This region restricts the area and robot orientation within which the recognition will be judged to be valid.

The validity area is a rectangle and is entered by:

- 1) Click on either of the Validity Region X or Y up / down entry box.
- 2) On the map, position the mouse at one of the Validity Region's corners, press the left button and draw a rectangle. Release the button.

Land Mark Usage Stats

These values are generated by the GotABot program and provide information on the usefulness of each Land Mark. Low Recognition or Validity numbers may be an indication that the Land Mark information is incorrect or that a better Land Mark is required.

6. Additional GotABot Configuration

A number of other parameters may also be set.

Robot Selection

Selection of a robot to control is achieved through this option (*Click Configure->Bot->Robot Select ->* and select your robot. Alternatively, see [GotABot Control of a RoboRealm Robot](#) or [GotATranslator](#) for additional robot control options.

IP Address and Port

The robot's IP address and port may be set with this option (*Click Configure->Bot->Robot IP Address and Configure->Bot->Port*)

Password

If a password is required to establish communications with the robot, it may be set with this option (*Click Configure->Bot->Password*).

Pose

The robot's pose may be set with this option (*Click Configure-> Pose*). A robot's pose is a series of parameters which describes the robot's position on a map, the direction it is facing, and the uncertainties in each of these parameters.

Settings

GotABot's configuration setting may be saved or reloaded by selecting the "File" menu Settings options.

Robot Diameter

The robot's diameter may be set with this option (*Click Configure->Bot->Robot Diameter*). The Robot Diameter not only determines the smallest openings the Robot can move through, but it also sets the distance the Robot will try to stay away from walls and other obstructions. Setting the diameter too large will restrict the Robot from certain openings and/or may cause the Robot to perform many small "stop, turn and go" corrections while navigating narrow spaces. Setting the diameter too small will result in the Robot colliding with the walls. It's a tradeoff.

Camera Resolution

This setting will define the camera's resolution (*Click Configure->Visual Localization->Camera->Camera Resolution*). Resolution is entered in the form 800, 600.

Camera FOV

This setting will define the camera's horizontal FOV or Field Of View (*Click Configure->Visual Localization->Camera->Camera FOV*).

Camera Offset

This setting will define how far the camera is from the *turning* center of the robot (a positive value indicates that the camera is closer to the front of the robot than the turning center) (*Click Configure->Visual Localization->Camera->Camera Offset*). Note – the turning center is usually centered between the two drive wheels.

TIP: Camera Selection / Configuration

Get the very best camera you can afford.

- a) Choose a camera with a wide Field Of View. A minimum 60 degree FOV is recommended. More is better.
- b) Choose a camera with good low light capability.
- c) Choose the highest resolution the camera, wifi link and PC speed will support. 1280 x 1024 works well. Even higher resolutions are better.

Range Finders

Range Finders are optional and are used to perform small pose corrections when near walls. Rangefinders are also used to provide a limited obstacle detection capability.

Velocity

The robot's linear velocity may be set with this option (*Click Configure->Bot->Velocity*)

Robot Acceleration

The robot's linear acceleration may be set with this option (*Click Configure->Bot->Acceleration*)

Robot Angular Velocity

The robot's angular velocity may be set with this option (*Click Configure->Bot-> Angular Velocity*)

Robot Angular Acceleration

The robot's angular acceleration may be set with this option (*Click Configure->Bot-> Angular Acceleration*)

Max Travel

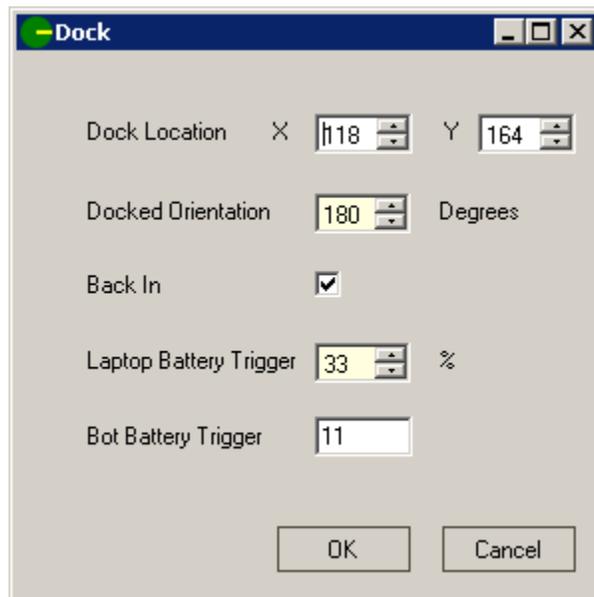
GotABot normally uses an old fashioned 'Sense / Plan / Act' algorithm and thus only checks corrects its position when stopped. Therefore we want the robot to stop frequently and acquire any visible land marks so GotABot can update its location and correct its path. The maximum distance the robot moves before stopping to re-localize may be set by selecting this option (*Click Configure->Bot->Max Travel*).

Docking Configuration

Docking is the process which allows the Robot to (automatically) recharge its batteries.

To configure automatic docking click *Configure->Dock*:

- 1) **Dock Location** is the **Robot** location when docked.
- 2) **Docked Orientation** is the Robot's orientation when docked.
- 3) **Back In** should be checked if the Robot must back into the Dock.
- 4) The **Laptop Battery** and **Robot Battery** Trigger fields will trigger an automatic docking operation when either of the respective battery levels falls below the trigger level



The screenshot shows a dialog box titled "Dock" with a blue title bar and standard window controls. It contains the following settings:

- Dock Location**: X coordinate is 118, Y coordinate is 164.
- Docked Orientation**: 180 Degrees.
- Back In**: Checked (checkbox).
- Laptop Battery Trigger**: 33 %.
- Bot Battery Trigger**: 11.

At the bottom right, there are "OK" and "Cancel" buttons.

7 Docking Configuration Form

Localization Time

This setting may be used to control the length of time that GotABot will search for landmarks. Longer times will increase the number of times landmarks will be recognized (up to a maximum of 25 valid recognitions) thereby improving the localization accuracy. This setting may need to be increased if the image processing software is running on a slow PC or if other programs such as video servers are consuming the PC's time. (Click *Configure->Visual Localization->Visual Localization Time*)

Mute

This setting prevents GotABot from speaking. (Click *Configure->Options->Mute*)

Enable Robot RCC

This setting allows GotABot to identify Land Marks using a robot based RCC recognizer. (Click *Configure->Visual Localization->Recognizer->Enable Robot RCC*).

Enable Local RCC

This setting allows GotABot to identify Land Marks using a host based RCC recognizer. (Click *Configure->Visual Localization->Recognizer->Enable Local RCC*). See the chapter titled "[Local Image Recognition](#)" for a more complete description.

Enable Local RoboRealm

This setting allows GotABot to identify Land Marks using a host based RoboRealm application as a [Fiducial](#) recognizer. (*Click Configure->Visual Localization->Recognizer->Enable Local RoboRealm*). See the chapter titled “ [RoboRealm Interface](#)” for a more complete description.

Enable GotAGlyph

This setting allows GotABot to identify Land Marks using the GotAGlyph recognizer included with GotABot. (*Click Configure->Visual Localization->Recognizer->Enable GotAGlyph*).

7. Operation

Software

By default, GotABot assumes that it is controlling an Evolution Robotics ER1 robot or a [Heathkit Hero 1](#). Other robots may be controlled with [GotATranslator](#) or [RoboRealm](#).

Operation Controls

Destination

The robot may be commanded to go to a destination by:

- 1) Click on the Tool Bar's Destination Icon ()
- 2) Click on the map at the desired position

A yellow path (follow the yellow brick road) will be drawn on the map leading from the robot to the destination and the robot will be commanded to follow it to the destination.

Robot Position

The robot's position on the map may be changed by:

- 1) Click on the Tool Bar's Robot Icon ()
- 2) Click on the map at the desired position
- 3) Click on the Tool Bar's Robot Orientation up/down controls ()
- 4) Adjust to the desired orientation

OR – Click *Configure-> Pose* and adjust as required.

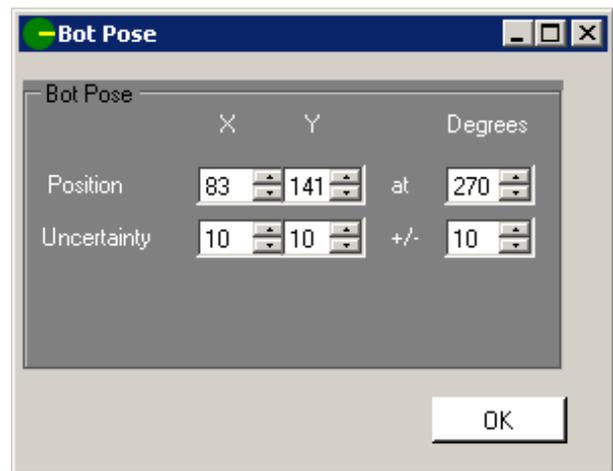


Figure 8 Robot Pose Form

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Dock

Docking is the process which allows the Robot to (automatically) recharge its batteries.

Docking Configuration is described in [Docking Configuration](#). To manually initiate a docking operation click *Tools->Dock*.

Localize

Selecting this option (*Click Tools->Localize*) will force GotABot to use [Land Marks](#) and / or [Kinect](#) or other scanner to determine its position and orientation

Simulated Movement

Selecting this option (*Click Configure->Options->Simulated Movement*) will prevent GotABot from communicating with the robot. Instead, robot movement is simulated on the map.

Stop

Double clicking on this Tool Bar icon () will force the robot to stop.

Debugging

Two mechanisms are provided for debugging, a log file and a debug window. The log file, *GotABot_Log.txt*, may be consulted to review movement and Land Mark recognition events while the debug window (*click ViewTools-> Debug Info*) provides real time information.

Manual Controls

The robot may be controlled manually by using the keyboard's Arrow keys (Forward, Back, Turn Left, and Turn Right). **WARNING:** Use caution with these controls. Rapid changes in direction could conceivably cause stress to the robot's motor control electronics. Some robots are under engineered in this area.

TIP – Close the Debug Window

When not in use, the Debug Window should be closed. This will speed processing considerably.

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8. Voice Commands

Voice commands are enabled by clicking *Configure->Options->Voice Command Enable*. Make sure that the Window's voice recognition service is running. Note that there are also some optional settings for selectable destinations as well as weather and news URLs.

Examples of voice commands include:

COMMAND	RESULT
"GotABot stop"	Stop all motion
"GotABot pausemode"	Pause driving to destination NOTE: Say 'pausemode' as one word
"GotABot status"	Report status
"GotABot localize"	Perform a localization operation
"GotABot recharge"	Go to dock and recharge
"GotABot destination alpha"*	Go to destination alpha
"GotABot forwards"	Move forward twelve inches
"GotABot backwards"	Move backwards six inches
"GotABot clockwise"	Turn 45 degrees right
"GotABot anticlockwise"	Turn 45 degrees left
"GotABot batchfile bravo"*	Execute the user defined batch file "kbatch_bravo.bat NOTE: Say 'batchfile' as one word
"GotABot elevate"	Rotate the Kinect sensor up 5 degrees
"GotABot depress"	Rotate the Kinect sensor down 5 degrees
"GotABot funny"	Tell a joke
"GotABot newscast "	Start news feed
"GotABot fox newscast "	Start FOX news feed
"GotABot bbc newscast"	Start BBC news feed
"GotABot npr newscast "	Start NPR news feed
"GotABot forecast"	Get weather forecast
"GotABot telltime"	Tell the time (say 'telltime' as one word)
"GotABot thankyou"	Even a robot appreciates acknowledgement
"GotABot Hello"	More pleasantries
"GotABot good bye"	Even more pleasantries

* GotABot recognizes Alpha, Bravo, Charlie, Delta and Foxtrot

9. Compass

One of the most useful sensors for a robot is a magnetic compass. GotABot provides an interface for an optional [Phidget Spatial 1044](#) sensor. Download and install the PhidgetSpatial [drivers](#) and [calibration](#) program before using this interface.

Configuration of the compass is accessed by using its Configuration Window (click *Configuration->Compass*). The only parameter which needs to be set is the 'Orientation Offset' which shifts the compass orientation so as to agree with GotABot's orientation (click *Settings->Orientation Offset*).

NOTE: The compass orientation is assumed to have an uncertainty of +/- 16 degrees. The robot's orientation will only use the compass orientation when the robot's pose has an orientation uncertainty of 16 degrees or greater.

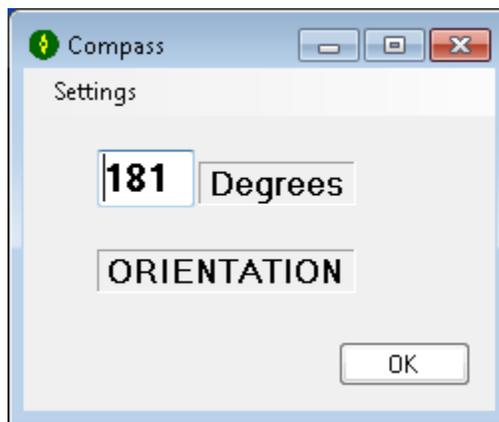


Figure 9 Compass Configuration Window

10. Local Video

There are a number of ways to remotely view the robot's video. If the robot has an onboard laptop or tablet, I recommend using RealVNC (<https://www.realvnc.com/>). This not only allows viewing, but also allows easy remote control of the laptop. Much easier than trying to type on a doom seeking rapidly moving robot of destruction.

Alternatively, video from the Robot may be remotely viewed using GotAGlyph (*click Configure->Visual Localization->Recognizer->Enable GotAGlyph*). GotAGlyph can access the video either directly through a MJPEG video stream or through a [Virtual Camera](#) utility which allows the video stream to appear as a local webcam.

Optionally, If not inherently provided by the robot, there are also numerous video streaming programs which may be used. I have used [WebCam XP 5](#) (free edition) – it works well and the price is right, but there are many other alternatives as well. [Yawcam](#), Skype, Microsoft Messenger are all free and suitable for streaming video

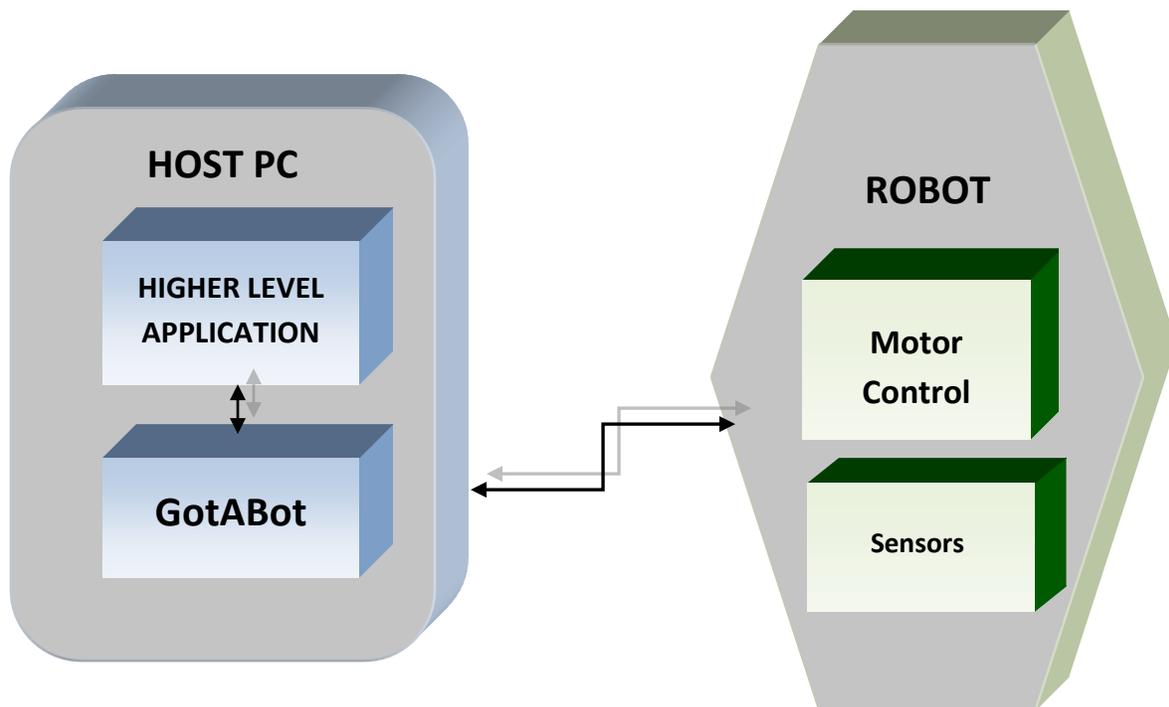
See the chapter [Local Object Recognition](#) for additional details on setting up remote viewing.

Note: When streaming video with a Robot based image recognizer, the [localization time](#) may have to be increased to account for the increased processing load on the robot's processor.

11. API

Up to this point, we have discussed how GotABot may be controlled through the GUI (Graphical User Interface). This chapter will explore an alternate control method, the API (Application Program Interface). The API is accessed by opening a TCP/IP socket to GotABot and using simple text commands to control GotABot and / or any robots connected to GotABot. This method of providing control is common and widely used by many robot control programs.

An API is especially useful when we have a higher level program or script which provides additional functions or behaviors for the robot. Theoretically, one could create a stack of API enabled programs, each relying and building on lower level functions to achieve new heights of robot behavior.



GotABot contains two identical APIs, either of which can be used by other programs or the user to pass commands or data to GotABot.

Accessing the API through Telnet

Accessing the API can be as simple as using a Telnet session. Although manual telnet control may have limited practical applications, it is very useful for debugging the commands and their sequences before implementing them in a script or program.

There are many different telnet programs but, as an example, here is how one could telnet to GotABot using the telnet program provided with Windows XP:

- 1) On the PC which will run the telnet program, click the **Start** button (lower left corner of your screen).
- 2) Click **Run** and type: `"telnet <ip address> <port>"`

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Where the <ip address> is the [ip address](#) of the PC running GotABot
and <port> is the [port number of the robot](#) + 100 (API #1)
or [port number of the robot](#) + 400 (API #2)

An example could be *"telnet 192.168.1.150 9100"*

- 3) If the robot has a [password](#), then the first step will be to login:

Type: *"login <password>"* followed by pressing *"Enter"*

Where <password> will be the same password used by the robot
GotABot will respond with either "LOGIN ACCEPTED

OK >"

or "ERROR: INCORRECT PASSWORD >"

- 4) Once logged in, any of the API [commands](#) may be used.

TIP – Install Telnet Client for Windows 7 or 8

As explained in [http://technet.microsoft.com/en-us/library/cc771275\(v=ws.10\).aspx](http://technet.microsoft.com/en-us/library/cc771275(v=ws.10).aspx), the telnet client is not installed by default for Windows 7 or 8.

TO INSTALL:

1. Open a command prompt window. Click **Start**, type **cmd** in the **Start Search** box, and then press **ENTER**.
2. Type the following command:

```
pkgmgr /iu:"TelnetClient"
```

3. If the **User Account Control** dialog box appears, confirm that the action it displays is what you want, and then click **Continue**.
4. When the command prompt appears again, the installation is complete

API Commands

GotABot supports the following API commands:

```
set destination xxx xxx
set pose xxx xxx xx xx xxx xx
set ranger xx xxx xx
set orientation xx xx
dock
localize
stop
bumper xxx
get pose
get rangers
get status
get path xxx xxx
login xxx
load settings xxx
save settings
load map xxx
transmit xxxxxxxx
receive
help
```

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Set Destination Command

This command is equivalent to the GUI's [Destination](#) command.

Example

COMMAND: *"set destination 50 135"*

RESPONSE: *"OK > "*

ACTION: Instructs GotABot to plan a path from the Robot to map position 50 135, and then to issue driving directions to the Robot.

Set Pose Command

This command allows the calling program to set the robot's location, orientation and uncertainties. The command format is:

```
set pose <location x> <location y> <uncertainty x> <uncertainty y> <orientation> <orientation uncertainty>
```

Example

COMMAND: *"set pose 150 202 8 9 90 10"*

RESPONSE: *"OK > "*

ACTION: This instructs GotABot that the robot is located at location 150, 202 with an 8 unit uncertainty in the X axis, 9 unit uncertainty in the Y axis, and with an orientation of 90 +/- 10 degrees.

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Set Ranger Command

This command allows the calling program to inform GotABot of a short range Sensor (typically IR or ultrasonic) reading. The command format is:

set ranger <ranger number (15-64)> <relative orientation> <distance in cm> <Ranger's maximum range in cm (optional – default = 80 cm)>

Example

COMMAND: *"set ranger 15 90 32"*

RESPONSE: "OK > "

ACTION: This instructs GotABot that the robot's Range Sensor #15 is orientated at 90 degrees relative to the ranger location and has detected an object at a distance of 32 cm from the ranger.

Set Orientation Command

This command allows the calling program to set the robot's orientation and uncertainty. The command format is:

set orientation <orientation> <orientation uncertainty>

NOTE: This command will only update the orientation when the robot is stopped and the orientation uncertainty is less than the existing uncertainty.

Example

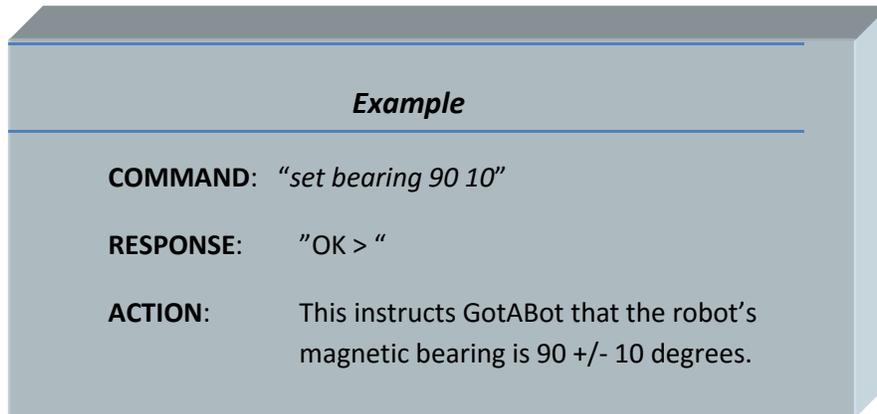
COMMAND: *"set orientation 90 10"*

RESPONSE: "OK > "

ACTION: This instructs GotABot that the robot's orientation is 90 +/- 10 degrees.

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Set Bearing Command



Example

COMMAND: *"set bearing 90 10"*

RESPONSE: *"OK > "*

ACTION: This instructs GotABot that the robot's magnetic bearing is 90 +/- 10 degrees.

This command allows the calling program to set the robot's orientation and uncertainty. The command format is:

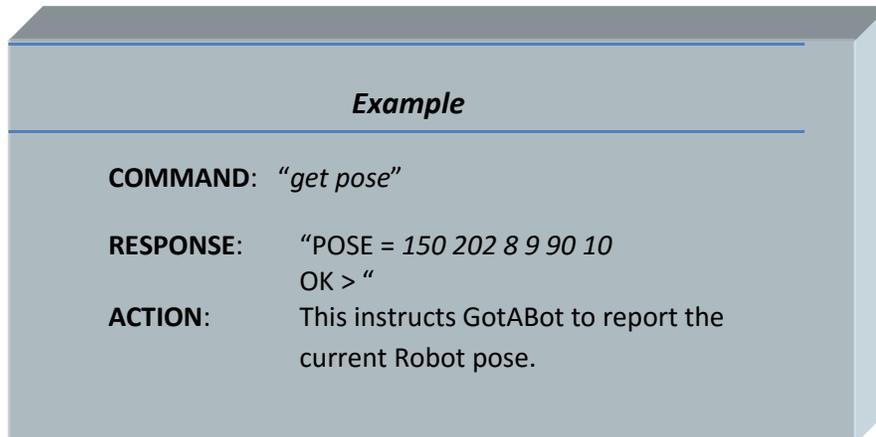
set bearing <bearing> <orientation uncertainty>

NOTE: This command differs from 'set orientation' in that it conforms to the conventional magnetic bearing standards - i.e the angles increase in a clock wise direction.

Get Pose Command

This command will instruct GotABot to respond with the robot's current pose in the format:

<location x> <location y> <uncertainty x> <uncertainty y> <orientation> <orientation uncertainty>



Example

COMMAND: *"get pose"*

RESPONSE: *"POSE = 150 202 8 9 90 10
OK > "*

ACTION: This instructs GotABot to report the current Robot pose.

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Get Rangers Command

This command will instruct GotABot to respond with the [Ranger data](#) in the format:

```
<ranger number> <range> <relative orientation> <X offset from robot center><Y offset from robot center>  
<ranger number> <range> <relative orientation> <X offset from robot center><Y offset from robot center>
```

...

```
<ranger number> <range> <relative orientation> <X offset from robot center><Y offset from robot center>
```

Example

COMMAND: *"get rangers"*

RESPONSE: "1 25 60 4 8
2 15 -60 -4 8
6 9 0 8
11 6 180 0 -8
OK > "

ACTION: This reports that Ranger #1 has detected an object at 25 units, at an orientation of 60 degrees, and that the ranger is located at an XY offset of 4, 8 from the center of the robot. Similarly, all other enabled rangers (in this example 2, 6 and 11) are also reported

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Get Status Command

This command will instruct GotABot to respond with the robot's current driving status ("docked" or "moving" or "stopped")

Example

COMMAND: *"get status"*

RESPONSE: "stopped
 OK > "

ACTION: This instructs GotABot to report the
 Driving status.

Dock Command

This command is equivalent to the GUI's [Dock](#) command.

Example

COMMAND: *"dock"*

RESPONSE: OK > "

ACTION: This instructs GotABot to Dock with its
 charging station

Get Path Command

This command will instruct GotABot to plan a path from the robot to a destination, and then to respond with a series of locations indicating the steps required to reach that destination. The command format is: `get path <location x> <location y>` (where location x and location y are the desired destination)

Example

COMMAND: *"get path 150 55"*

RESPONSE: *" Path =
171 188
178 181
178 177
180 175
180 160
181 159
181 157
182 156
182 125
176 119
176 77
154 55
150 55
OK >> "*

ACTION: Plan a path to location 150, 55 and then report the steps to reach that destination.

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Localize Command

This command is equivalent to the GUI's [Localize](#) command.

Example

COMMAND: *"localize"*

RESPONSE: " POSE = 150 202 8 9 90 10
 OK > "

ACTION: This instructs GotABot to perform a
 localize operation (look for Land Marks ,
 deduce the Robot's position and
 orientation) and then to report the
 Robot's pose.

Stop Command

This command is equivalent to the GUI's [Stop](#) command. All active GotABot and robot activities should stop on receipt of this command.

Example

COMMAND: *"stop"*

RESPONSE: " OK > "

ACTION: Stop all movement and localization.

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Bumper Command

This command allows the client program to report that a bumper switch has detected a collision. Four separate types of collisions may be reported:

bumper left
bumper right
bumper front
bumper rear

Upon receipt, GotABot will initiate a Collision Recovery sequence

COMMAND	RECOVERY SEQUENCE
<i>bumper left</i>	<i>stop, move backward, rotate right, move forward</i>
<i>bumper right</i>	<i>stop, move backward, rotate left, move forward</i>
<i>bumper front</i>	<i>stop, move backward</i>
<i>bumper rear</i>	<i>stop, move forward</i>

After completing the Recovery Sequence, GotABot will resume travel to its destination.

Example

COMMAND: *"bumper left"*

RESPONSE: *" OK > "*

ACTION: Stop all movement, then move backward, rotate right and finally move forward.
Resume travel to destination.

TIP: Get Some Bumper Switches

Bumper Switches are such simple devices that their utility is frequently under appreciated. I would argue that given the inherent contrariness of a typical robot, bumper switches are well nigh indispensable.

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Login Command

This command is required when GotABot's [password](#) is set.

Example

COMMAND: *"login alpha1"*

RESPONSE: " LOGIN ACCEPTED
 OK > " or
 "ERROR: INCORRECT PASSWORD > "

ACTION: Login to both GotABot and the Robot.

Load Map Command

This command is equivalent to the GUI's Load Map (*Click map->Open Map*) command.

Example

COMMAND: *"load map home.bmp"*

RESPONSE: " OK > "

ACTION: Instructs GotABot to load the map file
 'home.bmp'.

Load Settings Command

This command is equivalent to the GUI's [Load Settings](#) command.

Example

COMMAND: *"load settings settings.xml"*

RESPONSE: *" OK > "*

ACTION: Instructs GotABot to load the settings file 'settings.xml'.

Save Settings Command

This command is equivalent to the GUI's [Save Settings](#) command.

Example

COMMAND: *"save settings"*

RESPONSE: *" OK > "*

ACTION: Instructs GotABot to save the settings file.

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Transmit Command

This command allows the calling program to transmit a command directly to the robot.

Example: *"transmit gripper close"* (instructs)

Example

COMMAND: *"transmit gripper close"*

RESPONSE: " OK > "

ACTION: Instructs the Robot to close its gripper, assuming the robot has a gripper and understands the command 'gripper close'.

Receive Command

This command allows the calling program to receive data directly from the robot. This command must be reissued each time new data is required.

Example

COMMAND: *"receive"*

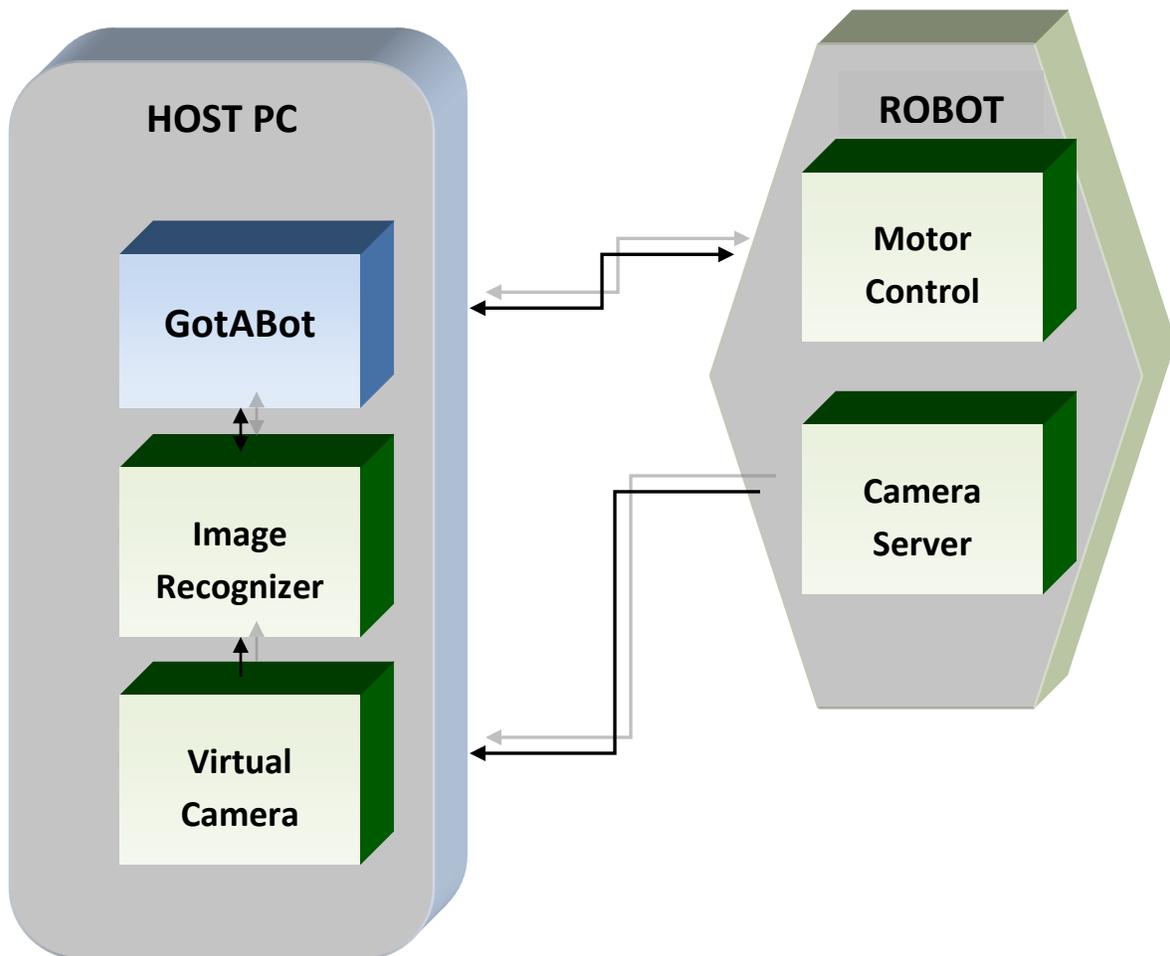
RESPONSE: " OK > "

ACTION: Instructs GotABot to relay data received from the Robot.

12. Local Image Recognition

[GotABot's simple system configuration](#) uses a robot based Image Recognition service. In other words, the robot is not only capable of moving on command but also of performing image recognition. An example of such a robot is the Evolution ER1, where the software (Evolution RCC) performs both motor control and image recognition.

An alternative approach moves the image recognition function from the robot to the host PC. This has a



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number of advantages including:

- i) The host PC is usually more powerful than the robot, hence able to process images faster.
- ii) The robot will enjoy a longer battery life if it does not have to process images.
- iii) Capturing images is more convenient on the host PC.
- iv) Many robots do not have image recognition capabilities.
- v) This configuration provides a method for viewing the Robot's video feed.

The principle disadvantage of this approach is the increased complexity of configuring and operating multiple programs.

Configuration

GotABot

GotABot may be configured to use a local image recognizer through its Configure Menu (Example: *Click Configure-> Enable Recognizer-> Enable Local RCC*). Note – all of the other software programs, motor control, camera server, virtual camera and image recognizers, should be loaded and started *before* starting GotABot.

Motor Control

Presently, GotABot directly interfaces with the Heathkit Hero 1 or the Evolution ER1 robot. Other Robots may be controlled via [RoboRealm](#) or through [GotATranslator](#).

Virtual Camera

This software will convert the video stream provided by the Robot's Camera Server and make it appear as a normal web cam. This allows programs such as Evolutions RCC or RoboRealm to easily access the Robot's video.

There are a number of virtual camera applications available but I have had good luck with webcamXP5 free edition and [webcamXP5 pro](#) (60 day free trial then...pricey, but works well) for this function. Each will install a virtual camera driver which is listed as "IP Camera (JPEG/MJPEG)" and can be connected to as a regular webcam.

[RoboRealm](#) may also be used as the Virtual Camera driver. Be sure to follow the setup instructions at http://www.roborealm.com/help/Virtual_Camera_Driver.php. The following screen shots show how RoboRealm is configured for my needs:

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1) Press *Options*->*Video* and select IP Camera



Figure 10 RoboRealm Camera Select

NOTE: For this example, we have selected the webcamXP5 IP camera interface.

2) Select 'Video Capture'

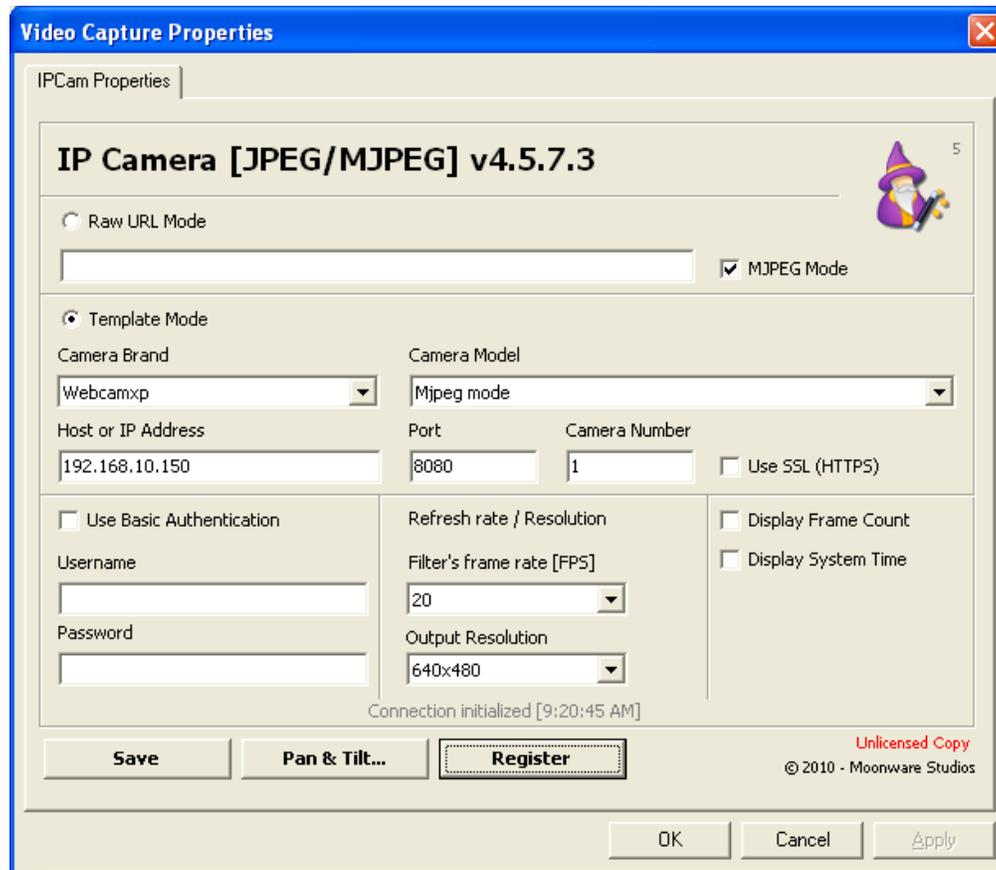


Figure 11 RoboRealm Video Capture

HINT: Remember to press 'Save' when done

HINT: It may be necessary to restart RoboRealm (several times) before the video operates properly.

3) Press *Options*->*Other* and Check 'Virtual Camera'. Choose 'Source' in the 'Use Image' drop box.

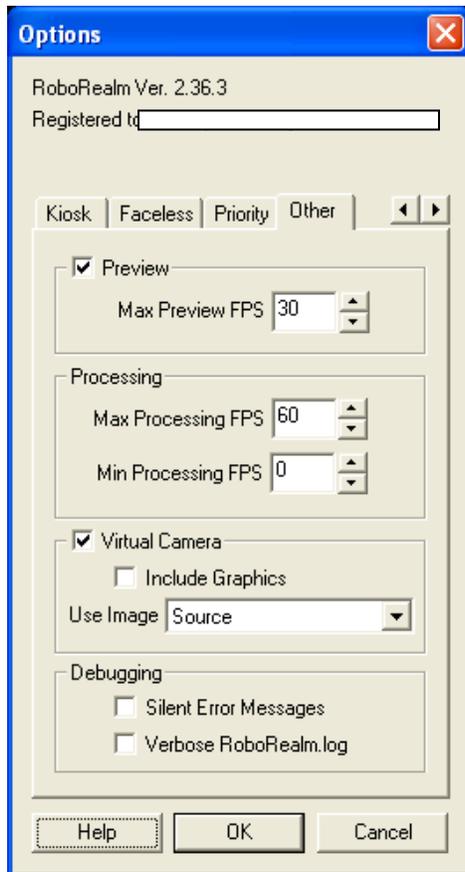


Figure 12 RoboRealm Virtual Camera

HINT: It may be necessary to save the configuration and restart RoboRealm before the Virtual Camera operates properly.

Image Recognizer Configuration

Local RCC Configuration

- i) Use the Settings -> Camera tabs to select the virtual camera.
- ii) Use the Setting -> Remote Control tab to select "Allow API control of this instance".
- iii) Use the Setting -> Remote Control tab to set the LRCC Port to the Robot's port +200 (ie if the Robot is on port 9000 then set the local RCC port to 9200).
- iv) Use the Setting -> Remote Control tab to set the Password so that it is identical to the Robot's.

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RoboRealm Configuration

(see [Using RoboRealm to Recognize Fiducials](#))

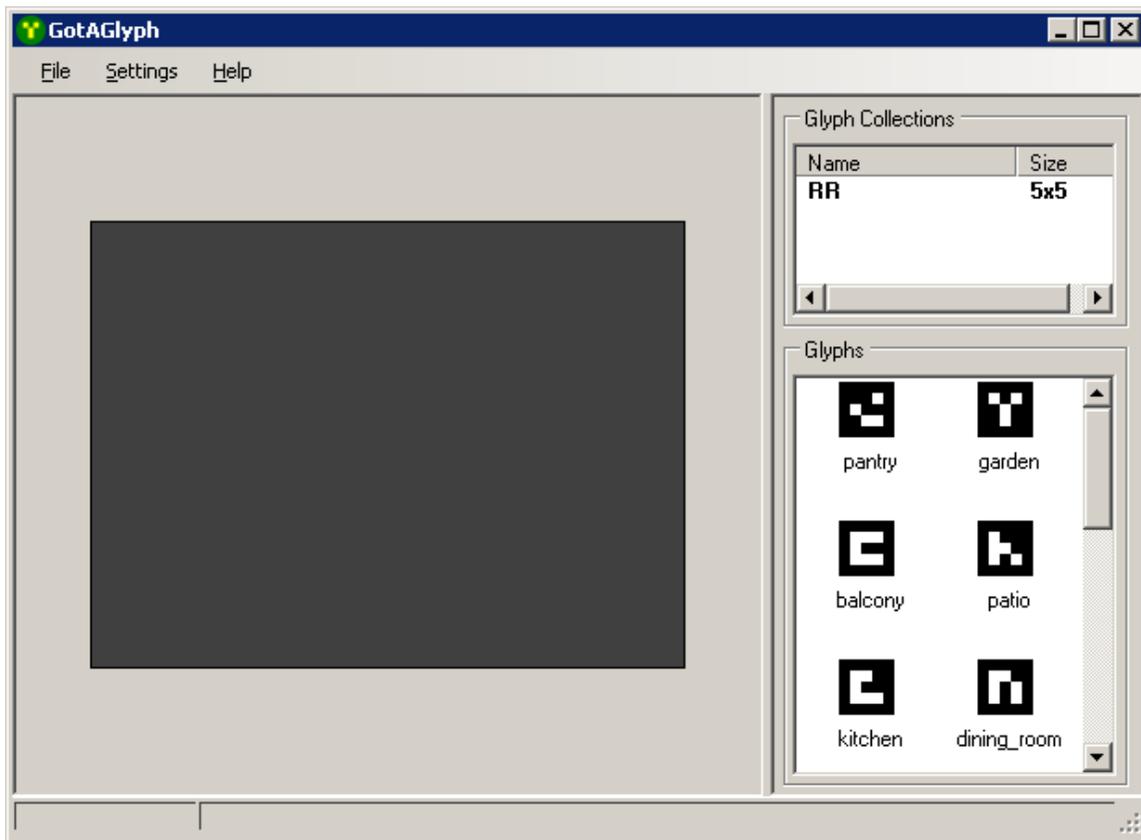
GotAGlyph Configuration

(see [GotAGlyph](#))

Camera Server

I used [WebCam XP 5](#) (free edition) – it works well and the price is right.

13. GotAGlyph



13 GotAGlyph Main Window

GotAGlyph is a Glyph recognition application provided with GotABot which can be used in a [Local Image Recognition Configuration](#). This program is an adaptation of [GRAFT](#) (Glyph Recognition and Tracking Framework) with the principle difference being an added API for communication. Operational instructions and documentation is provided on the GRAFT homepage (<http://www.aforgenet.com/projects/gratf/>).



14Glyph Example

Glyphs are highly recognizable Land Marks and are a subset of the [Fiducials](#) which may be recognized by RoboRealm. Glyph Size and usage is the same as Fiducial usage as explained in the chapter "[Using RoboRealm to Recognize Fiducials](#)". (NOTE – Y Rotation is not yet implemented for GotAGlyph)

GotAGlyph is started by selecting *Configure->Visual Localization->Recognizer->Enable GotAGlyph*. The camera's horizontal FOV (Field Of View) must be entered (*Click Settings->Options*).

14. RoboRealm Interface

[RoboRealm](#) is an application for use in computer vision, image analysis, and robotic vision systems. By combining RoboRealm with GotABot we can form the nucleus of a powerful Robot navigation system. This chapter explains some of the ways they can work together and how to integrate them via [RoboRealm's API](#) (In RoboRealm: Press *Options*->*API Server* and check the '*Activate RoboRealm API Server*'; Enter 6060 in the '*Port*' box).

NOTE: An example of a RoboRealm robo file, suitable for operation with GotABot, is included with GotABot's installation package.

Allow RoboRealm to Control ER1

Although RoboRealm contains interfaces to a number of robots, the Evolution ER1 robot is not one natively supported. Using GotABot however, RoboRealm can now command ER1 motor functions. (Click *Configure*->*Options*->*Allow RoboRealm to Control Robot*)

RoboRealm can control the ER1 via the variable '*move*'.

Variable '*move*'

0	Stop
1	Drive Forward
2	Drive Back
5	Turn Left
6	Turn Right

GotABot polls this variable and directs the ER1 to respond as commanded. Additionally, GotABot writes the ER1's battery voltage to the RoboRealm variable '*battery*' and the ER1's raw position reading to the RoboRealm variable '*position*'.

GotABot Control of a RoboRealm Robot

GotABot can control several types of robots by accessing RoboRealm's interfaces to these robots. GotABot sets two RoboRealm variables, '[move](#)' and '[command](#)', either of which can be used by RoboRealm to control a robot.

Configuring GotABot for this is accomplished by pressing *Robot*->*Robot Select* ->*RoboRealm Robot*

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NOTE: It is critical to [set the Robot attributes](#), acceleration, velocity, move accuracy, etc to match the robot's characteristics.

Variable 'move' Control Method

This control mechanism works best (which is to say it will only work) if the robot has a relatively slow angular velocity— perhaps 45 degrees per second. The move control method has the advantage of being easy for RoboRealm to work with.

Variable 'move'

0	= Stop
1	= Drive Forward
2	= Drive Back
5	= Turn Left
6	= Turn Right

RoboRealm must poll this variable and respond as directed. Additionally, GotABot reads the RoboRealm variable 'battery' and displays it as a voltage in its GUI Status bar.

Variable 'command' Control Method

In this method, GotABot controls the type and magnitude of the move by writing two variables to RoboRealm, 'command' and 'intDistance'. This control mechanism is potentially more accurate than the move method but requires a script to be added within RoboRealm to translate the command to actions.

Examples of 'command' and intDistance:

Variable	'command'	'intDistance'	
	move	10	= Drive forward 10 inches
	move	-10	= Drive backwards 10 inches
	turn	33	= Turn left 33 degrees
	turn	-125	= Turn right 125 degrees
	stop		= STOP

RoboRealm must poll this variable and respond as directed. When RoboRealm has completed the command, it must write '0' (zero) to the variable 'command'.

Additionally, GotABot reads the RoboRealm variable 'battery' and displays it as a voltage in its GUI Status bar.

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Using RoboRealm to Recognize Fiducials

RoboRealm provides [Fiducial Recognition](#), a powerful means of determining location based on known Fiducial locations. Enabling this capability is accomplished by loading the Fiducial module in RoboRealm and (in GotABot) by pressing *Configure->Visual Localization->Recognizer->Enable Local RoboRealm*. Fiducial names, locations and validity regions are [entered](#) into GotABot's Land Mark data base in the same manner as are Land Marks.

Fiducial Size

Fiducial are normally a fixed size of 4.25" square:

|----- 4.25"-----|

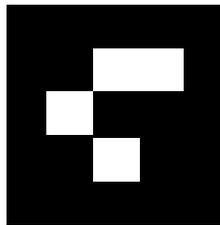


Figure 15 Fiducial Size

Naturally, one size does not fit all, and sometimes we need to use bigger or smaller Fiducials. For this, the Fiducial name must be modified so that GotABot can interpret the range information correctly. As an example, say that a Fiducial named "Cat" was not 4.25" square but double sized at 8.5" square. This requires that the Fiducial name "Cat" be changed to "Cat_!#\$4". Other sizes are similarly used by adding similar suffixes to the Fiducial name:

Fiducial Size	Suffix
0.53"	_!#\$0
1.06"	_!#\$1
2.13"	_!#\$2
4.25"	
8.5"	_!#\$4
17"	_!#\$5
34"	_!#\$6
68"	_!#\$7
136"	_!#\$8
272"	_!#\$9

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Fiducial Y Rotation

RoboRealm provides a variable which reports the Y rotation angle of the Fiducial relative to the robot - very useful for localization (*Click Configure->Visual Localization->Recognizer->Enable Local RoboRealm->Enable Y Rotation* to enable usage). Enable this option only if you achieve consistently accurate results after setting RoboRealm's '[depth of field](#)' (see http://www.roborealm.com/forum/index.php?thread_id=4087# for one solution to Y Rotation inaccuracies).

15. AVM Interface

[AVM](#) is an optional plug-in for RoboRealm which can be used for image recognition. Compared to the other image recognition applications, range and bearing information is less precise, recognition is slower and setup more difficult. However, AVM can provide superior recognition of some types of objects.

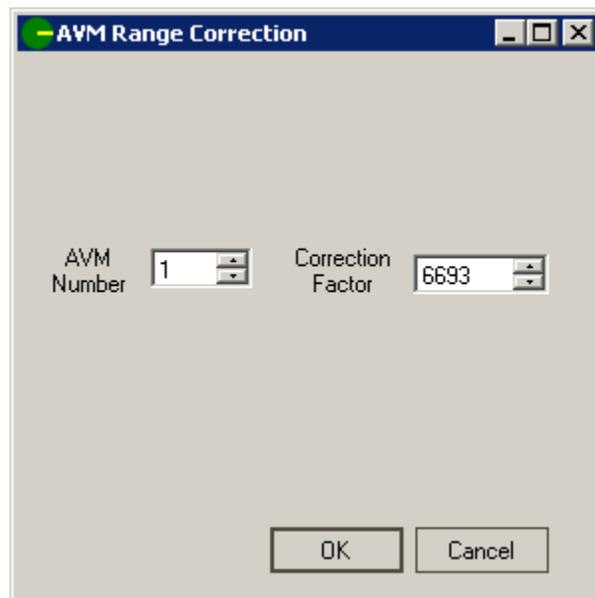
AVM recognition is enabled by clicking *Configure->Visual Localization->Recognizer->Enable AVM*.

AVM LandMark [entry](#) requires the following additional steps:

- i) The LandMark name is of the form *AVM_1* where, in this case, the number '1' signifies that this LandMark is the first image (or *object* in AVM parlance) which the AVM application was trained to recognize.
- ii) Range is calculated from the size of the rectangle drawn by AVM around the LandMark. This requires that each LandMark be individually calibrated (click *Configure->Visual Localization->Recognizer->Enable AVM->Range Calibration*). The *Correction Factor* may be calculated by:
 - a. start the [Debug Window](#) (click *View->Debug Info*)
 - b. perform a localization (click *Tools->Localize*)
 - c. In the Debug Window's Debug Log, look for an entry of the form:

```
"#####"  
"Localizing: 0: object ""AVM_1"" 10 30 910.5 100 344.5773"
```

In this example, the reported range is 344.5773 cm. Adjust the *Correction Factor* and repeat until the correct range is reported.



16 AVM Range Correction Form

16. SLAM

SLAM, or Simultaneous Localization And Mapping, has long been one of the holy grails of the robot navigation world. After all, making a map by hand can be a fussy and aggravating exercise of measurement and transcription. Far better to let our clever robots handle these mundane details.

Over the years, many schemes utilizing various sophisticated algorithms and differing sensors have

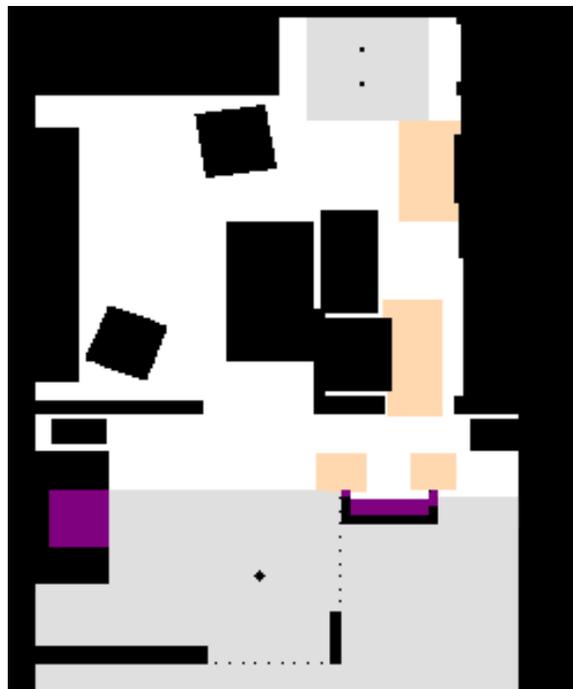


17 Kinect Derived SLAM Map

been developed and offered. Indeed, many academic careers have been built on this research.

At times, SLAM has been declared a 'solved problem' but new information on inadequacies of existing methods and new methods of addressing these inadequacies continue to be developed.

GotABot uses a variation of "Particle Filtering" for SLAM operations.



18 Hand Drawn Map



19 URG04 Derived SLAM Map

SLAM operation is started by clicking *Tools->SLAM*.

The Trouble With SLAM

In a word, the trouble with SLAM can be summed up as 'accuracy'. Unless the Robot's odometry or localization technique is exceptional and the ranging devices measure flawlessly, the resulting map will be less accurate, likely considerably less accurate, than a map generated by the user. For example, compare the user generated map with its equivalent Kinect derived SLAM map. Not as good, eh? Fortunately, even given the lower accuracy, the SLAM map is still adequate for most navigational purposes.

Kinect vs URG04 Map

As expected, the URG04 with its much wider FOV produces a map far superior to the Kinect's. Wall edges are more true with less noise and generally closer to their actual locations. More important than this is the ease of use in creating the map. The time required to map with the Kinect was several times longer and required judicious application of pirouettes, pruning, modifying and careful movements to keep the Particles from diverging and failing. By contrast, mapping with the URG04 was relatively easy, requiring only directing the Bot around the area to be mapped.

SLAM Requirements

The most obvious requirement for SLAM operation is, of course, to have some method of determining empty from occupied space. GotABot may employ a [Kinect](#), [URG04](#) or [Ranger API commands](#) to achieve this..

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SLAM Operation

To initiate and control the map making process, follow these steps:

STEP 1) Open the SLAM form by clicking *Tools->SLAM*.

STEP 2) Select a SLAM map when prompted. An unexplored SLAM map is a uniform grey (Red=223, Green=223, Blue=223). An example map is included in the installation package.

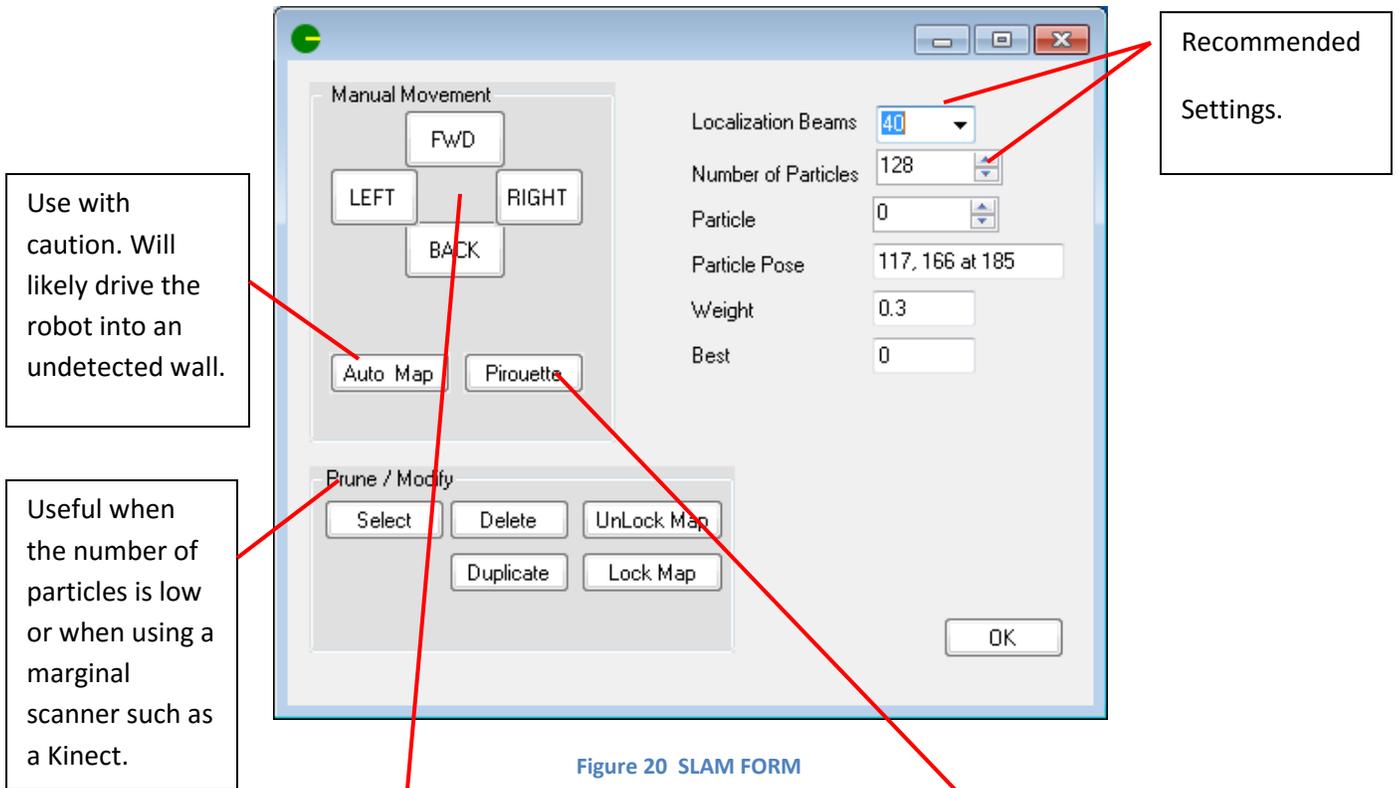


Figure 20 SLAM FORM

STEP 3) Use the [Robot Pose form](#) to set the map pose to match the actual robot's pose.

STEP 4) Perform a localization (click *Tools->Localize*), followed. optionally, by a *Pirouette*.

STEP 5) Use the *Manual Movement* controls or the Destination Icon  to move and map.

STEP 6) Repeat step 5 until the map is adequately explored or the battery is drained.

STEP 7) Save the map. (Click *Configure->Map->Save Map*).

STEP 8) (Optional) The map may be enhanced or corrected by editing in a graphics editor such as MSPaint.

NOTE: The SLAM map is locked to a scale of 1 Grid Square = 1 inch

APPENDIX A: Evolution Robotics ER1

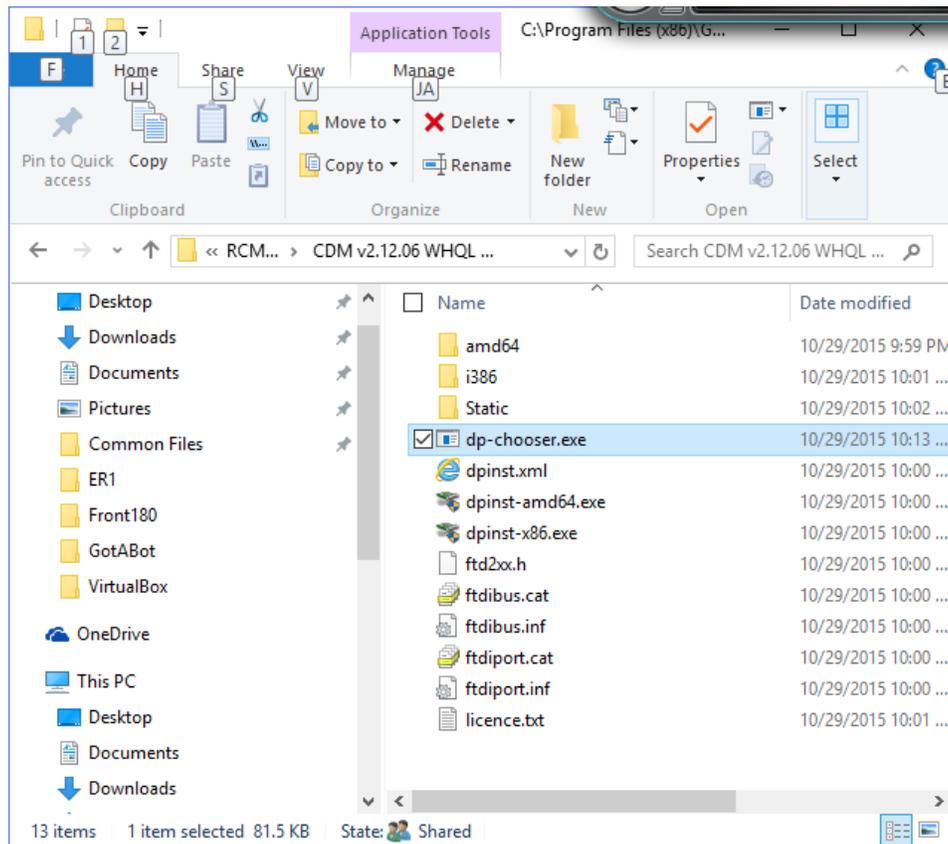
ER1 Driver Installation For Modern Windows Systems

The ER1's RCC software can be used to perform image recognition under any recent Windows operating system. However, controlling the robot itself requires the hardware drivers which have a different installation method than that described in the ER1 manual.

Preferred Driver Installation Method

This driver installation method is slightly finicky. Follow these steps carefully. They have been tested successfully on Windows 7, 8 and 10 but have often needed to be uninstalled / reinstalled several times before working.

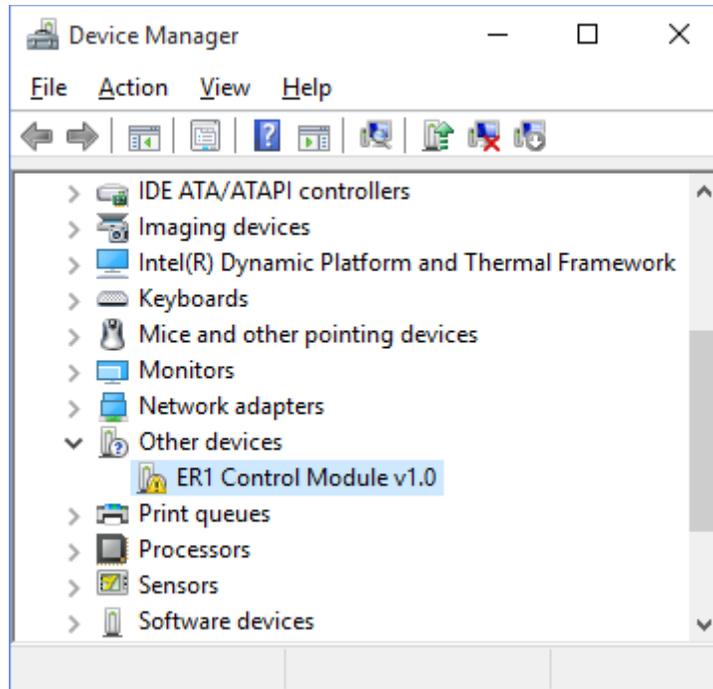
- 1) Within the "RCM Drivers" directory under the GotABot directory are RCM drivers for the RCM's FT232 chip (file name = CDM v2.12.06 WHQL Certified.zip). Unzip this file.
- 2) In the unzipped directory, right click on dp-chooser.exe and click on 'Run as Administrator'



- 3) Click 'Yes' and then follow the instructions to install.
- 4) Open Device Manager.
- 5) Connect the ER1 to your laptop or Tablet.

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6) The Device Manager should show a new device 'ER1 Control Module 1.0' probably under the 'Other devices' category. Double click on it.

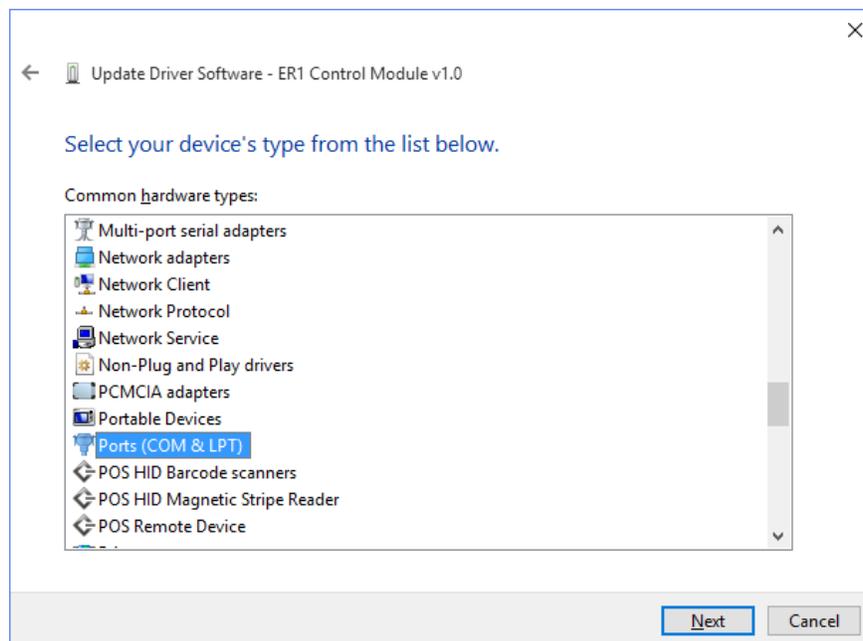


7) Click 'Update Driver...'

8) Click 'Browse my computer for driver software'

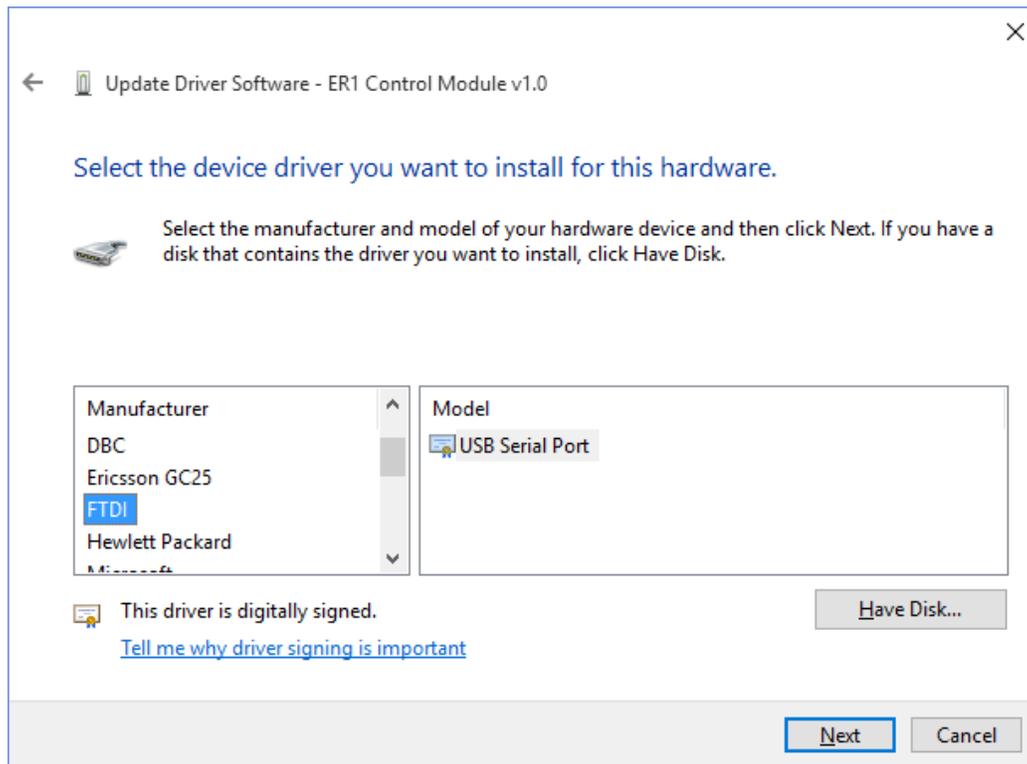
9) Click 'Let me pick from a list of device drivers on my computer'

10) Click 'Ports(COM & LPT)'



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11) Select 'FTDI' and click 'USB Serial Port' (but see Note below first).



Note: If there are multiple choices under 'Model', choose the entry containing the text ' v2.12.06'.

12) Click 'Yes' and wait for driver installation to complete.

13) The device manager should show a new Com Port. Double click it and check that the drivers were installed correctly. If not, or if the RCM is listed in some other category than 'Ports(COM & LPT)', or if GotABot keeps announcing 'No power' then try reinstalling (told you it could be finicky).

Alternative Installation # 1 ER1 Operation Using Win 7 XP Mode

To setup:

1. Start a Windows XP Virtual Machine
2. Configure the XP machine's network
 - a. Select your computers network adapter (on the toolbar, press Configure->Options->Networking)
 - b. Use the Control Panel to set the IP address (press Start->Control Panel->Network and Internet-> (etc))
3. Connect the ER1
4. Install the ER1 software and start it
5. Attach the RCM's USB port (on the toolbar, press USB->ER1 Control Module v 1.0)

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6. Install drivers

Alternative Installation # 2 ER1 Operation Using VirtualBox

To setup:

1. install [VirtualBox](#)
2. install Extensions and Guest Services
3. Setup a virtual machine using whatever compatible Windows version is available
4. under the Settings menu set the Network adapter to Bridged
5. start the virtual machine
6. configure the virtual machine's network
7. Connect the ER1
8. install the ER1 software and start it
9. Attach the RCM's USB port (click Devices->USB and select the ER1 entry)
10. Install drivers

GotABot Operation With Alternative Installations

Generally, it is best to install GotABot under the more modern operating system, not under the legacy system running the ER!'s RCC application. Connect to the RCC using the legacy's IP address and the [RCC's port](#).

If GotABot is installed under the legacy system then make sure that the system has been updated with Net Framework.

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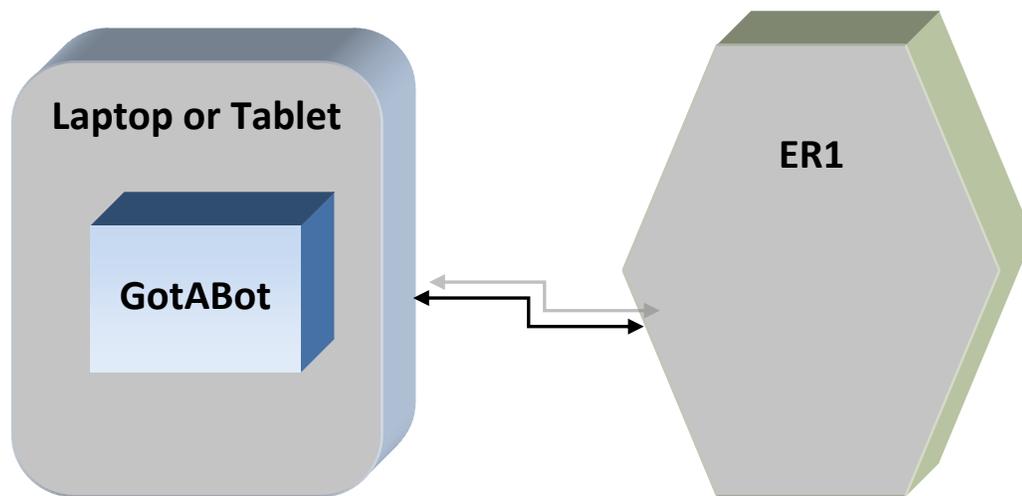
ER1 Communications

There are two ways to communicate with the ER1, Direct Control and RCC Control. The Direct method is preferred.

Direct Control

This communication method is preferred for its speed, versatility and ease of use as it does not require the RCC program to be run.

1. Start 'Device Manager' .
2. Connect the ER1 to your laptop.
3. In 'Device Manager', note the Com Port number of the new port associated with the ER1.
4. Start GotABot
5. Configure the 'Bot Com Port (click *Configure->Bot Com Port* and select the correct Port).
6. Select [ER1 \(Direct Control\)](#).



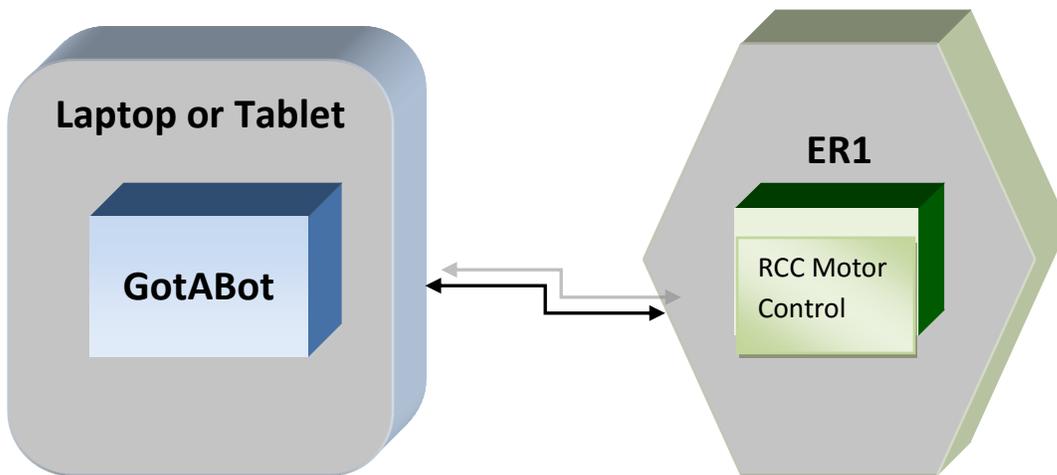
RCC Control

This communications mode requires that the ER1 application (RCC) is operating and connected to the ER1. It is slightly slower and less versatile than the Direct Communications mode.

1. Start the ER1 application (RCC) and connect the ER1 to your laptop. Verify that this program communicates with the ER1.

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2. The RCC software must be configured to accept API control (*click Settings->Remote Control -> Allow API control of this instance*). See the ER1 User Guide - Accessing the API - for more complete instructions.
3. Start GotABot
4. Configure [GotABot's IP Address, Port](#) and [Password](#).
5. Select [ER1 \(RCC Control\)](#).



Optional ER1 Hardware

The ER1 has the capability of accessing both digital and analog ports through its Robot Control Module (RCM). GotABot exploits this capability by employing them to access various sensors and devices which extend and enhance its basic operation.

Use of these capabilities is optional and not required for basic operation. Robot's other than the ER1 may enjoy similar capabilities through use of the appropriate [API](#) command.

ER1 Bumper Switches

Gotabot supports three Bumper switches; left, right and rear. Behavior due to a Bumper Switch activation is the same as per the [Bumper Switch API command](#).

Bumper Switch Wiring

RIGHT SWITCH

<i>Switch Contact</i>	<i>Signal Name</i>	<i>RCM J5-</i>
N.C.	+5V	1
N.O.	GND	25
Center	DIO	21

LEFT SWITCH

<i>Switch Contact</i>	<i>Signal Name</i>	<i>RCM J5-</i>
N.C.	+5V	1
N.O.	GND	25
Center	DI1	21

REAR SWITCH

<i>Switch Contact</i>	<i>Signal Name</i>	<i>RCM J5-</i>
N.C.	+5V	1
N.O.	GND	25
Center	DI2	22

NOTE: Bumper switches are highly recommended - almost mandatory.

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ER1 IR RangeFinders

Gotabot supports up to fourteen GP2Y0A21 Sharp IR Range Sensors (10-80cm detection distance). Behavior due to a Range Switch readings is the same as per the [Ranger API command](#).

Ranger Wiring

J6 Connector

Pin	Signal	Ranger
1	+5V	Ranger VCC
2	+5V	Ranger VCC
3	A0	Ranger 0
4	A2	Ranger 2
5	A4	Ranger 4
6	A6	Ranger 6
7	A8	Ranger 8
8	A10	Ranger 10
9	A12	Ranger 12
10	A14	Ranger 14
11	GND	Ranger GND
12	GND	Ranger GND
13	GND	Ranger GND
14	+5V	Ranger VCC
15	+5V	Ranger VCC
16	A1	Ranger 1
17	A3	Ranger 3
18	A5	Ranger 5
19	A7	Ranger 7
20	A9	Ranger 9
21	A11	Ranger 11
22	A13	Ranger 13
23	GND	Ranger GND
24	GND	Ranger GND
25	GND	Ranger GND

NOTE: Add a bulk decoupling capacitor (100 uF is good) between +5V and GND.

NOTE: In practice, IR Range Finders are far less useful than one might expect. For the same cost as a few IRs, a used Kinect sensor provides much greater utility.

Evolution IR Sensor Pack

GotABot also supports the Evolution IR Sensor Pack. These sensors are of an older technology, not nearly as advanced as the [Sharp](#) sensors. They do not provide a consistent range reading and are sensitive to the color of any detected objects. Nevertheless, they do provide some utility and GotABot can utilize them for collision detection, obstacle detection, or localization.

For bump detection, the sensors should be positioned such that:

- Sensor 1 = left bumper
- Sensor 2 = center bumper
- Sensor 3 = right bumper

Config.txt

- 1) It is possible that the RCM software will think that the computer is always being charged. In this case, add a file named *config.txt* to the ER1 directory. The contents of this file are:

```
[hardware]
disregard_charging_laptop=1
stop_when_charging=0
```

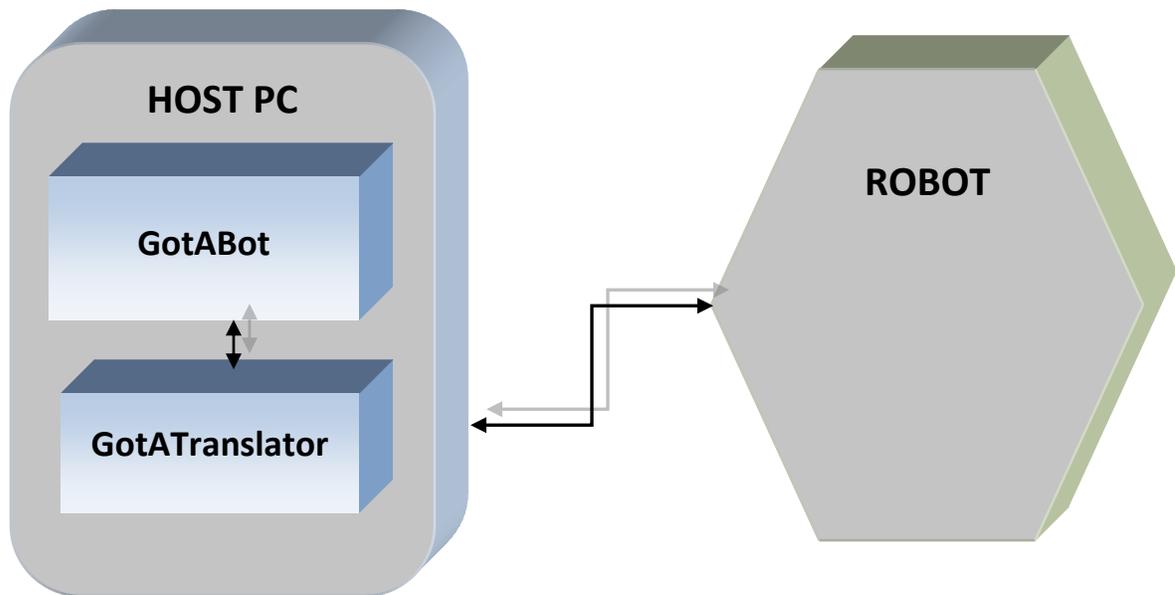
APPENDIX B: Random Hints And Tips

Accessing a laptop while it is tethered to a robot is inconvenient. I use RealVNC (<https://www.realvnc.com/>) to login from my desktop. Much easier.

If GotABot is installed in a Windows XP system then make sure that the system has been updated with Net Framework.

APPENDIX C: GotATranslator (or How To Interface With New Bots)

So, you've got a robot which is neither supported by GotABot nor by RoboRealm. Perhaps we can help with that. GotATranslator is a Visual Basic project which can translate GotABot output into a format your robot can understand (some assembly required).



STEP 1: Download GotATranslator from <http://gotabot.weebly.com/>

STEP 2: Download Visual Basic Express (its free) from <http://www.microsoft.com/visualstudio/en-us/products/2010-editions/visual-basic-express>

STEP 3: In Visual Basic Express, open the GotATranslator project

STEP 4: Configure GotATranslator's interface with the robot:

- i) In Visual Basic Express, open the module *modPublicDeclarations*
- ii) Set the variable *boolPassThroughUnTranslated* to 'false'
- iii) If your robot's interface is USB or RS232 then set *strComPort* to the name of the port your PC or laptop will use to communicate with the robot. Set the variable *boolComPort* to 'true'. Open the module *modBotIF* and modify the port settings in the function *ftnOpenComPort*.
- iv) If your robot's interface is Socket Based then modify *Robot_IPAddress* and *Robot_Port* to be compatible with the Robot's interface.

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STEP 5: Tell GotATranslator how to translate GotABot commands to your robot's format:

- i) In Visual Basic Express, open the Module *modGotABotTranslate*
- ii) In the Function *ftnOneLineTranslate* there is a CASE statement. Modify its code as directed by the embedded comments
- iii) Minimally, only the "move" code needs to be modified

STEP 6: Run GotATranslator . Check the "Show Robot Communication" box

STEP 7: Start the Robot

STEP 8: Start GotABot. *Click Robot->Robot Select->ER1*. Make sure the IP address and port numbers are correct

STEP 9: Click on GotABot's Battery Status field (on GotABot's Status Bar – bottom of window – should say "—" before connecting). This will cause GotABot to try to connect with the Robot.

-Check GotABot and GotATranslator Comms status (on Status Bar – bottom of windows) to see if they are communicating.

-Check GotATranslator's Communications log to diagnose problems

STEP 10: Test / Debug / Repeat

APPENDIX D: Heathkit Hero-1

The Heathkit Hero-1 is one of the all time great hobbyist robots. First produced in 1982, it has all the features required by GotABot; mobility, odometry, range sensing and an interface. Unfortunately, its early technology results in limited sensor range and discrimination, poor steering accuracy, and glacially slow processing. Still, extending this iconic platform's capabilities with a modern laptop or tablet is educational and a hoot to boot.



Figure 21 Heathkit Hero-1

Hero-1 / GotABot Configuration

Follow these steps:

- 1) The Hero must have a Serial or USB interface as well as a the requisite 1.U or 1.3 ROM with 4 MHz crystal. Configure the interface for 9600 baud.
- 2) Create a [map](#).
- 3) Connect the laptop or tablet to the Hero. (See [example](#)).
- 4) Turn on the laptop and Hero.
- 5) Start GotABot.
- 6) Click *Configure->Bot->Bot Com Port* and select the port connected to the Hero.
- 7) Click *Configure->Bot->Bot Select* and select *Heathkit Hero*.
- 8) Click *File->Save Settings* and then restart GotABot.
- 9) Follow the onscreen instructions to download an assembly program to the Hero.
- 10) Test your setup by [Localizing](#) and [Manual movement control](#).
- 11) Job Done!

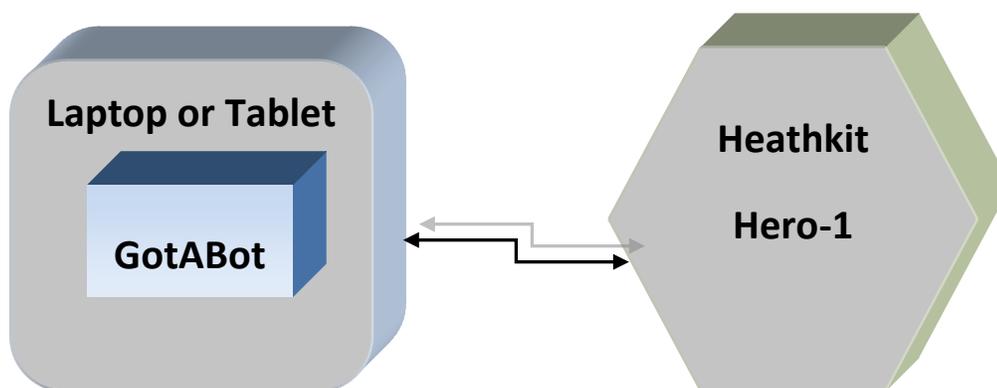


Figure 22 Hero-1 / GotABot Configuration

Hero To Tablet Connection Example

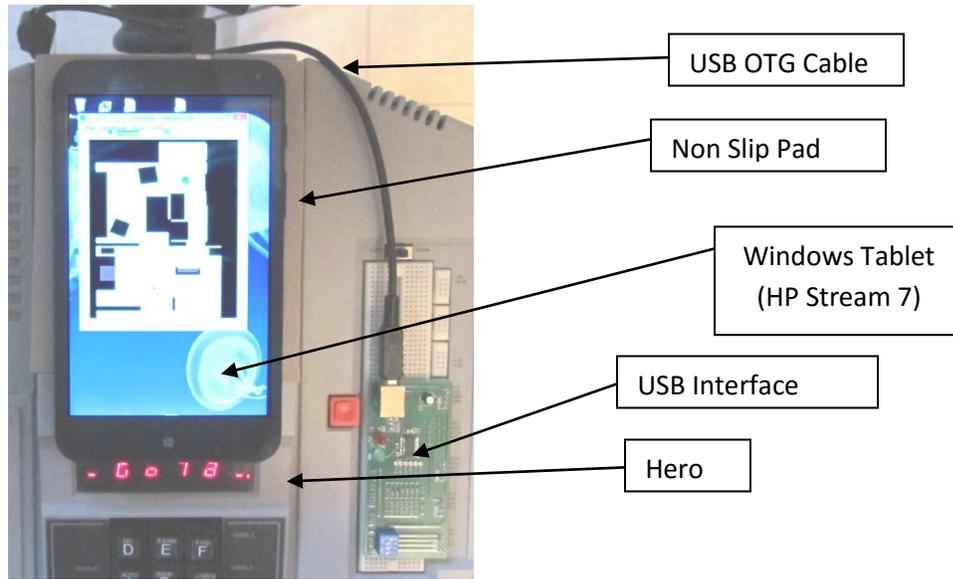


Figure 23 Hero To GotABot USB Connection

Laptop Remote

Operating the laptop while it is being carried hither and yon is challenging and inconvenient. I use [VNC](#) to log into the laptop from my desktop.

Hero-1 Hardware Compensation

If your Hero's hardware is not perfectly aligned then there are some settings which might compensate.

Hero-1 Steering Compensation

If your Hero veers left or right instead of going dead ahead, then click *Configure->Bot->Steering Bias Correction* and enter an adjustment.

Hero-1 Head Offset Compensation

If your Hero's head does not point straight ahead then click *Configure->Scanner* and adjust the *Scanner Offset in Degrees* field to compensate.

Hero-1 Distance Compensation

If your Hero does not accurately travel distances commanded then click *Configure->Bot->Distance Compensation* and enter the polynomial coefficients which describe its actual response.

TIP: Keep it simple

As discussed, the Hero-1 has limited sensing and movement accuracy. Successful operation will likely require an environment with extra wide pathways and uncluttered walls which return good echoes for the ultrasonic ranger.

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GLOSSARY

API	Application Program Interface.
AVM	Optional RoboRealm plug-in for image recognition and other functions.
Bot	Short for Robot.
ER1	Robot manufactured by Evolution Robotics.
Fiducial	In the context of GotABot, a Fiducial image is a high contrast picture designed to be easily recognizable by a computer vision program.
FOV	Field Of View. The horizontal angle, in degrees, captured by the camera.
Glyph	In the context of GotABot, a Glyph is a high contrast image designed to be easily recognizable by a computer vision program. It is composed of a rectangular grid of white squares on a square black background, which in turn is on a larger white background.
Land Mark	User selected images that the robot can recognize and measure range and direction to.
Localization	Determination of a Robot's pose through the use of Land Mark recognition or other sensory input.
Pose	The robot's position in space, quantified in the x, y and theta dimensions.
RCC	Robot Control Center. Software for controlling the ER1 and image recognition.
RCM	Robot Control Module. Hardware component of the ER1.
Recognizer	A program which uses the robot's camera and performs object recognition on the image. This program must be able to determine the range to the object and relative angle. The Recognizer is integral to the Landmark recognition process.
RoboRealm	An application for use in computer vision, image analysis, and robotic vision systems.
RR	Short for RoboRealm
SLAM	Simultaneous Localization And Mapping
USB OTG	On The Go. Enables devices such as some Tablets to act as USB hosts.
VGA	The VGA or Video Graphics Array standard specifies a resolution of 640 by 480 pixels.
YMMV	Your Mileage Might Vary.