Winter 2014 Project

ECE 579

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Intelligent Robotics II

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Contents

PeopleBot Localization

I. Introduction

The robot localization problem is a key problem in making truly autonomous robots. It can be difficult to determine what to do next. In order to localize itself, a robot has access to relative and absolute measurements giving the robot feedback about its driving actions and the situation of the environment around the robot. Given this information, the robot has to determine its location as accurately as possible. What makes this difficult is the existence of uncertainty in both the driving and the sensing of the robot.

Imagine yourself walking down a street. The street is filled with obstacles, like houses, trees, and other people. You want to go to the supermarket. With your eyes closed. You will most probably find it rather difficult to find your way to the supermarket. Even if you know exactly which route to walk and even if there are no other people blocking the route. Fortunately, most of us have eyes that help us in finding our way. At every movement we make, our eyes tell us where that movement brought us in the world. They constantly correct the imperfections of our movements. You do not realize how inaccurate the movements that you make are, until you try to walk a straight line with eyes closed. Even though you think that the steps you make are steps on a straight line, it will probably quickly feel like you are moving away from the line. You will probably even start to lose your balance trying to stay on the line. Walking down a virtual line with your eyes open in general does not cause many problems. From the information that you get from your eyes, and other senses, you constantly obtain an idea of where you are in the world. You use this idea to decide what to do next, for example to move towards the line if you are moving away from it. Robots that move freely in the world have the same problems as humans when walking through the world. If they only move around not looking at where their actions take them, they will get lost because of imperfections in their moving mechanisms and the environment. Like humans, using eyes or other sensors, robots can detect these imperfections and get a better idea of where they are.

Figure1: PeopleBot Robot

II. Navigation and Localization

Robot navigation is the task of an autonomous robot to move safely from one location to another. The general problem of navigation can be formulated in three questions:

i. Where am I? The robot has to know where it is in order to make useful decisions. Finding out the whereabouts of the robot is called robotic localization.
ii. Where am I going? In order to fulfill some task the robot has to know where it is going. It has to identify a goal and this problem is therefore known as goal recognition.
iii. How do I get there? Once the robot knows where it is and where it has to go it has to decide on how to get there. Finding a way to get to the goal is known as path planning.

III. Obstacle Avoidance

At all costs robots should avoid colliding with the obstacles in their environments. In dynamic environments, that is, where there are multiple moving obstacles, obstacle avoidance is a difficult problem. Although the dynamics of moving obstacles can sometimes be predicted, like when trains run on a track, sometimes the dynamics may be more uncertain, like playing children running around. A robot uses path planning techniques to plan a collision free path from one location to another location. If the obstacles in the environment are dynamic, the path planning problem is NP-hard.

IV. Robot Specification and Controls

ActivMedia’s robots may be smaller than most, but they pack an impressive array of intelligent mobile robot capabilities that rival bigger and much more expensive machines. At the same time, the powerful P2OS server with ActivMedia Robotics client software, is fully capable of mapping its environment, finding its way home, and performing other sophisticated path planning tasks.

1. Physical Characteristics

Weighing only 9 kg (20 pounds with one battery), the basic Pioneer 2 Mobile Robot is lightweight, but its strong aluminum body materials and solid construction make it virtually indestructible.

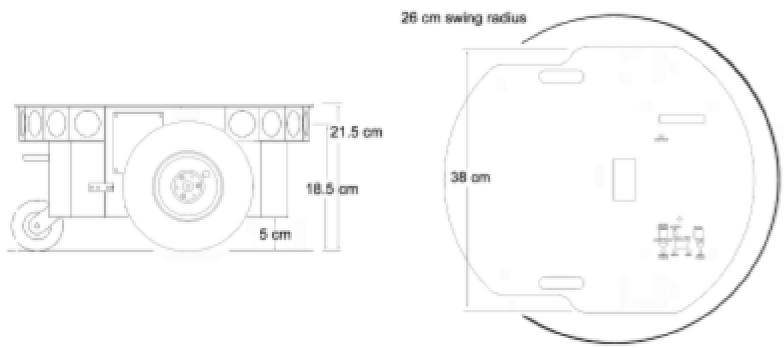


Figure 2: The Pioneer 2 physical dimensions and swing radius

2. Main Components

*Activ*Media robots are composed of several main parts:

a. Deck(s) and Console
b. Body, Nose, and Accessory Panels
c. Sonar Array(s)
d. Motors and encoders
e. Batteries and Power

a) Deck(s) and Console

The original Pioneer 2 are one piece, the top plate of the robot. The new DXe and AT models now have hinged top-plates which let you much more easily access the internal components of the robot.

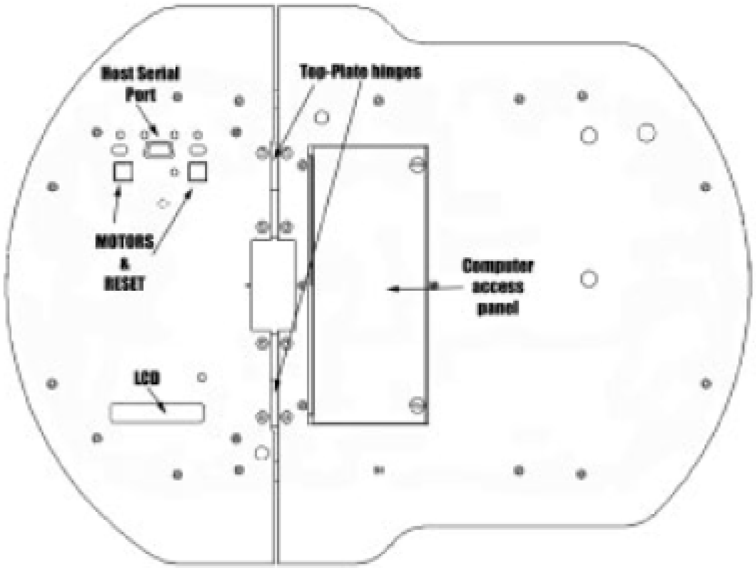


Figure 3: Pioneer 2 Console and hinged Deck

The robot's Deck is simply the flat surface for mounting projects and accessories, such as the PTZ Robotic Camera or a laser range finder. The PeopleBot's have lower and upper Decks. Feed-through slots on each side of the Deck let you conveniently route cables to the accessory panels on each side of the robot. A removable plug in the middle of the Deck on all models5 gives you convenient access to the interior of the robot.

In general, you should try to center the robot's payload over the drive wheels. If you must add a heavy accessory to the edge of the Deck, counterbalance the weight with a heavy object on the opposite end. A full complement of batteries helps balance the robot, too.

The Pioneer 2's or PeopleBot's Console consists of a liquid-crystal display (LCD), MOTORS, and RESET control buttons and indicators, and an RS232-compatible serial port with a 9-pin DSUB connector. The Pioneer 2 and PeopleBot

V1 Consoles sit at the front of the Deck. The Performance PeopleBot's Console is in the left column. Attached directly underneath the Console is the robot's microcontroller.

b) Body, Nose, and Accessory Panels

The ActivMedia robot is sturdy, but lightweight aluminum Body houses the batteries, drive motors, electronics, and other common components, including the front and rear sonar arrays. The Body also has sufficient room, with power and signal connectors, to support a variety of robotics accessories inside, including an A/V wireless surveillance system, radio modems or radio Ethernet, onboard computer, and more. a hinged rear door gives you easy access to the batteries, which you may quickly hot-swap to refresh any of up to three batteries.

The PeopleBot V1 has a removable pedestal mounted to its base Deck. A removable back panel gives you access to internal wiring and components, including stereo speakers, A/V and Ethernet radios, and microphone preamplifier. On top of the pedestal is the upper Deck where you may add components like the PTZ Robotic Camera that normally mounts to the Deck of a Pioneer 2. PeopleBot's also have an additional front sonar array. PeopleBot include front and rear bump rings for stability as well as sensitive collision detection. The PeopleBots have a Nose that is secured by a single screw beneath the front sonar array and one on the bottom of the robot.

Once the mounting screws are removed, simply pull the Nose away from the Body. This provides a quick and easy way to get to the accessory boards and disk drive of the onboard PC, as well as to the sonar gain adjustment for the front sonar array. The Nose also is an ideal place for you to attach your own custom accessories and sensors.

The robot come with removable panels on each side through which you may install accessory connectors and controls. A special side panel comes with the onboard PC option, for example, which gives users monitor, keyboard, mouse, and 10Base-T Ethernet access, as well as the means to reset and switch power for the onboard computer.

c) Sonar Arrays with Gain Adjustment

Natively, ActivMedia robots support both front and rear sonar arrays, each with eight transducers that provide object detection and range information for features recognition, as well as navigation around obstacles. With sonar expansion electronics, you may add up to 16 more sonar in two additional arrays of eight sonar each. PeopleBots, for instance, have an additional array at the front of the upper Deck.

The sonar positions in all arrays are fixed: one on each side, and six facing outward at 20-degree intervals. Together, fore and aft sonar arrays provide 360 degrees of nearly seamless sensing for the platform.

Each sonar array comes with its own driver electronics for independent control. Each arrays' sonar are multiplexed; the sonar acquisition rate is 25 Hz (40 milliseconds per sonar per array. Sensitivity ranges from ten centimeters (six inches) to nearly five meters (16 feet). You may control the sonar's firing pattern through software; the default is left-to-right in sequence 0 to 7 for each array.

The driver electronics for each array is calibrated at the factory. However, you may adjust the array's sensitivity and range to accommodate differing operating environments. The sonar gain control is on the underside of the sonar driver board, which is attached to the floor of each sonar module.

Sonar sensitivity adjustment controls are accessible directly, although you may need to remove the Gripper to access the front sonar, if you have that accessory attached. For the front sonar, for instance, locate a hole near the front underside of the array through which you can see the cap of the sonar-gain adjustment potentiometer. Using a small flat-blade screwdriver, turn the gain control counterclockwise to make the sonar less sensitive to external noise and false echoes.

Low sonar-gain settings reduce the robot's ability to see small objects. Under some circumstances, that is desirable. For instance, attenuate the sonar if you are operating in a noisy environment or on uneven or highly reflective floor, a heavy shag carpet, for example. If the sonar are too sensitive, they will "see" the carpet immediately ahead of the robot as an obstacle.

Increase the sensitivity of the sonar by turning the gain-adjustment screw clockwise, making them more likely to see small objects or objects at a greater distance. For instance, increase the gain if you are operating in a relatively quiet and open environment with a smooth floor surface.

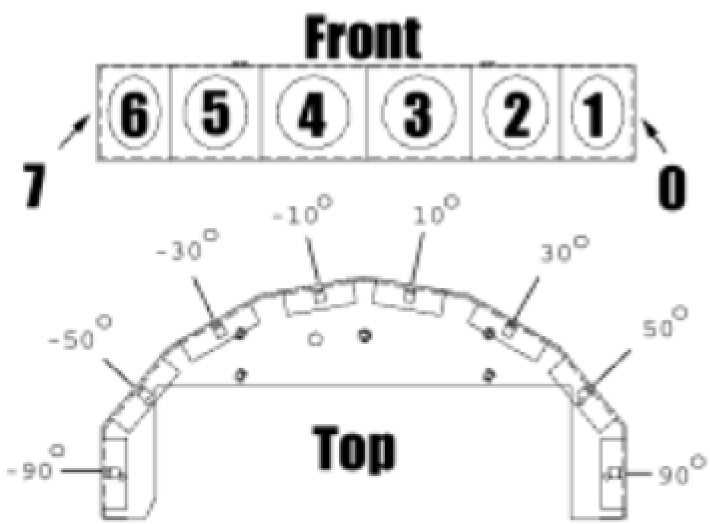


Figure 4: ActivMedia robot sonar array

d) Motors and Position Encoders

PeopleBot drive systems is high-speed, high-torque, reversible-DC motors, each equipped with a high-resolution optical quadrature shaft encoder for precise position and speed sensing and advanced dead-reckoning. Motor gearhead ratios and encoder ticks per revolution vary by robot model.

e) Batteries and Power

PeopleBot robots may contain up to three, hot-swappable, seven ampere-hour, 12 volts direct-current (VDC) sealed lead/acid batteries (total of 252 watt-hours), accessible through a hinged and latched back door. We provide a suction cup tool to help grab and slide each battery out of its bay. Spring contacts on the robot's battery power board alleviate the need for manually attaching and detaching power cables or connectors.

Battery life, of course, depends on the configuration of accessories and motor activity. PeopleBot charge life typically ranges from two to three hours. If you don't use the motors, your robot's microcontroller will run for several days on a single battery charge.

IMPORTANT: Batteries have a significant impact on the balance and operation of your robot. Under most conditions, we recommend operating with three batteries. Otherwise, a single battery should be mounted in the center, or two batteries inserted on each side of the battery container. Typical recharge time using the recommended accessory (800 mA) charger varies according to the discharge state; it is roughly equal to three hours per volt per battery. The Power Cube accessory allows simultaneous recharge of three swappable batteries outside the robot.

With the optional high-speed (4A maximum current) charger, recharge time is greatly reduced. It also supplies sufficient current to continuously operate the robot and onboard accessories, such as the onboard PC and radios. But with the higher-current charger, care must be taken to charge at least two batteries at once. A single battery may overcharge and thereby damage both itself and the robot.

3. Electronics

PeopleBot standard electronics reside on two main boards: a microcontroller and a motor-power distribution board. Each sonar array also has a controller board mounted in its base. A special I/O expansion board found inside the left column strut of the Performance PeopleBot distributes User I/O for use by the robot's joystick port as well as it's tabletop and break beam IR sensors.

A Main Power switch at the back of the robot controls power for the entire system. Processor control switches and indicators fit through the Console.

a) Motor-Power Board

Inside the robot, mounted to the battery box, is the Motor-Power board. It supplies both the 12 and five volts direct-current (VDC) power requirements of your robot's systems. The standard Motor-Power board has a 12-pin User-Power connector that supports four sets of five- and 12-VDC power ports (total 1.5 ampere) for custom accessories.

An optional computer-power section to the board supplies power for the onboard PC. It includes a special low-power and power-down circuit that lets you gently shut down the onboard PC without direct connection through a keyboard or monitor.

b) Microcontroller

The Pioneer 2/PeopleBot microcontroller has a 20 MHz Siemens 88C166 microprocessor with integrated 32K FLASH-ROM. It also has 32K of dynamic

RAM, two RS232-compatible serial ports, several digital and analog-to-digital, and PSU I/O user-accessible ports, and an eight-bit expansion bus. All of the I/O ports, except those used for the motors, encoders, and sonar, are available to the user for accessory hardware. The embedded operating software (P2OS) lets you support and manage each of these I/O ports.

c) Sonar Boards

Associated with each sonar array forward and rear is a sonar multiplexer/firing board. Wire leads to the individual sonar plug into a 16-pin connector on the board. A 10-conductor power/signal cable connects the sonar board with the microcontroller.

4. Controls, Ports, and Indicators

a) Main Power, Fuse, and Indicator

A single slide-switch on the rear left panel of Pioneer 2 and PeopleBot robots controls power to the entire robot and all its integrated accessories. Up is ON; down is OFF. A red LED on the Console indicates Main Power.

Inside, on the top right side of the battery box (accessible through the hinged back door) is the Main Power Fuse. It is an automotive-type (spade terminals) 15A fuse designed for tool-less replacement. To the left of the fuse, on the same battery connection board, is the main power relay, which isolates the high-ampere draw of the robot system from the Main Power Switch.

b) Recharge/Power Port

Below the Main Power Switch is the battery recharger port. It provides 12 VDC power to the robot's electronics, motors, and accessories, even without batteries. Use the recommended accessory power charger or equivalent.

The robot’s batteries should be maintained in a charged state above 11 VDC, as indicated on the Console LCD. We recommend recharging the battery when it falls below 11 VDC, even though the robot may continue to operate below 10 VDC. The microcontroller will sound a warning when the battery voltage falls below that level, and the optional computer power circuitry will automatically shut down the onboard PC. Discharging the batteries below 10 VDC may permanently damage them.

You may continue to operate the robot while charging its batteries, although that will lengthen the recharge time. Because the onboard PC draws much current, even the high-speed 4A charger will not be able to fully recharge the batteries unless you power down the PC.8

If you have only one battery onboard, plug your robot into the charger before “hot-swapping” the exhausted battery for a fresh one. To hot-swap two or three batteries, replace each battery one-at-a-time, leaving at least one battery in place to supply power to the robot. The Power Cube accessory is a convenient way to externally recharge one to three of the hot-swapped batteries.

c) Liquid-Crystal Display & Contrast Adjustment

Information about your robot's state and connections appears on a 32-character (two lines) liquid-crystal display (LCD) on the Console. When under control of the P2OS servers, for example, the display shows the state of communication with the client computer, along with the battery voltage and a blinking "heartbeat" asterisk (*) in the second line of text.

A small, contrast-adjustment potentiometer for the LCD is inset next to the display. Make sure the Main Power switch is ON and the battery is well charged. Then, using a small, flat-blade screwdriver, turn the adjustment screw to darken or lighten the screen so that the characters are clearly visible under your lighting conditions.

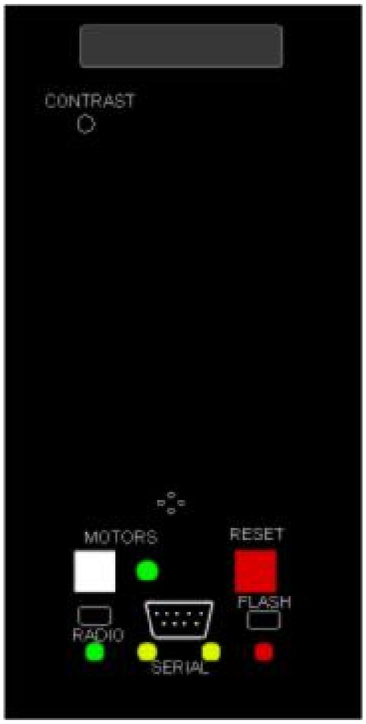


Figure 5: The Console

d) RESET and MOTORS

The RESET (red) and MOTORS (white) push-button switches on the Console affect the microcontroller's logic and motor-driver systems.

When pressed alone, RESET puts the microcontroller into its start-up state, disrupting any running program or client connection. It also disables the drive motors—just as if you cycle Main Power. But, unlike a cold-power restart, RESET preserves the contents of the microcontroller's RAM, so any user programs downloaded in standalone mode get restarted.

The MOTORS button and its associated green LED are under software control. Normally, your ActivMedia robot's motors are disabled when not connected with a client, such as Navigator or Saphira. When first connected with a client,9 the motors remain disabled (LED flashes) until you press and release the MOTORS button. Pressing and releasing the white MOTORS button then enables/disables the motors as long as the robot remains connected with a client.10 The green LED should light continuously when the motors are enabled and blink ON and OFF when disengaged.

When not connected with a client, pressing and releasing the MOTORS button puts your robot into joystick-drive mode. A subsequent press and release of the MOTORS button puts the robot into Self-Test Mode that exercises the robot's drive, controller, and I/O systems. Press and hold the MOTORS button in combination with the RESET button to put the microcontroller into a special system-download mode for reprogramming the onboard FLASH ROM.

e) SERIAL

ActivMedia robot's microcontroller has two serial ports and three connectors. One connector, labeled SERIAL, is a standard 9-pin D-SUB receptacle located on the Console and is for direct RS232-compatible serial data communication between the microcontroller and a client computer. This “Host” serial port shares its three-line transmit, receive, and ground connections with one of the two serial connectors that is inside the robot.

Amber LEDs on each side of the Host serial port light during data-exchange activity transmitted from or received by the microcontroller. I used Serial port for communicating with the Robot.

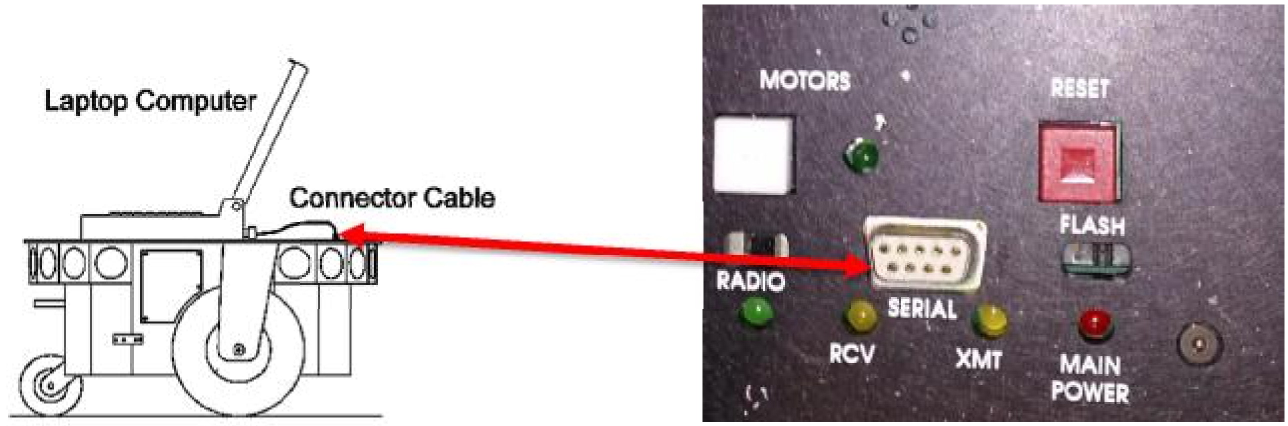


Figure 6: Serial Communication

f) RADIO

The RADIO slide switch on your robot’s Console controls power to the optional radio modem or Ethernet radio. It does not affect the SERIAL port functions directly, but you must switch the radio modem’s power OFF if you use the Console SERIAL port to connect a piggyback laptop or another external computer to the robot.

The radio modem gets power as well as signals through the internal, shared Host serial port and can interfere with Console SERIAL communications. In some cases, you may have to physically remove the radio serial connection from the microcontroller to eliminate that interference.

g) FLASH

A slide switch labeled FLASH is recessed into the Console. It write-protects the FLASH ROM-stored P2OS software and your robot's operating parameters. When switched forward, FLASH is enabled for writing. ActivMedia’s P2OS maintenance utilities warn you if FLASH is disabled.

5. PeopleBot Sensors and Emergency STOP

Performance PeopleBot’s tabletop sensors are very reliable diffuse IR detectors mounted to the front of the robot and which detect obstacles, particularly tabletops or rope barriers, that otherwise aren’t detected by the sonars. The tabletop IR detectors respond to any surface except glass or other mirrored surfaces, and can detect objects as thin as a human finger. They are oriented to trigger when an object is 28 cm (11.5 inches) or nearer to the front of the robot and 3.75 cm (1.5 inches) at the height of the lower deck.

Two “breakbeam” IR sensors, one on each side 3.75 cm (1.5 inches) forward of the left and right column struts and between the top and lower Decks of the Performance PeopleBot, sense objects which intrude into the robot’s profile, but which may not be otherwise detected by the sonars or tabletop IR sensors.

Since the tabletop and breakbeam IR sensors are connected to User I/O digital ports, their states are communicated from the P2OS server to a connected client, such as Saphira, in the standard Server Information Packet.

6. Safety Watchdogs and Configuration

Pioneer 2’s and PeopleBot’s standard onboard software, P2OS, contains a communications watchdog that will halt motion if communications between a client computer and the server are disrupted for a set time interval, nominally two seconds (watchdog parameter). The robot will automatically resume activity, including motion, as soon as communications are restored.

P2OS also contains a stall monitor. If the drive exerts a PWM pulse that equals or exceeds a configurable level and the wheels fail to turn (stallval), motor power is cut off for a configurable amount of time (stallwait). The server software also notifies the client which motor is stalled. When the stallwait time elapses, motor power automatically switches back ON and motion continues under server control.

All these “failsafe” mechanisms help ensure that your robot will not cause damage or be damaged during operation. You may reconfigure the communications, drive current, and stallwait values to suit your application.

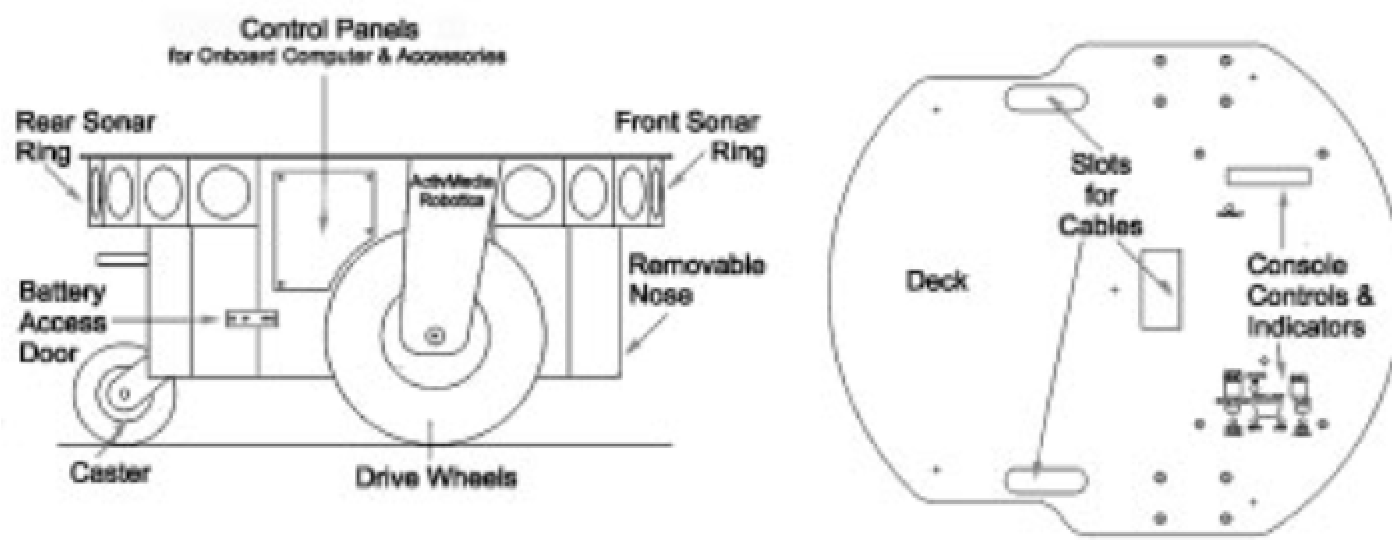


Figure 7: Components and some accessories of the PeopleBot

V. Software

As we see before, - PeopleBot Mobile Robots are intelligent mobile robots, ActivMedia's robots are truly intelligent, off-the-shelf mobile platforms, containing all of the basic components for sensing and navigation in a real-world environment, including battery power, drive motors and wheels, position-speed encoders, integrated sensors, and accessories. They are all managed by an onboard microcontroller and mobile-robot server software. ActivMedia robot also has a variety of expansion power and I/O ports for attachment and close integration of additional sensors and other accessories. Expansion includes an addressable I/O bus for up to 16 devices, two RS-232 serial ports, eight digital I/O ports, five A/D ports, PSU controllers and all accessible through a common application interface to the robot server software, P2OS.

The software packages can be downloaded from:

http://robots.mobilerobots.com/wiki/All_Software

Portland State University's login and password were requested directly from MobileRobots and are shown in the table below for future reference, the robot's serial number is necessary for any requests of support from MobileRobots.

Robot's Serial Number	PBBDBB1270
Login	Portland
Password	nT7>qEhy

If have a problem and can't find the answer, send an email to support@mobilerobots.com with the robot's Serial Number (PBBDBB1270).

There are three main software packages we need to use for localization and navigation: SonARNL, MobileEyes, and Mapper3basic. In addition to that these, there is another software which is just for simulation, which is good for testing purposes called MobileSim.

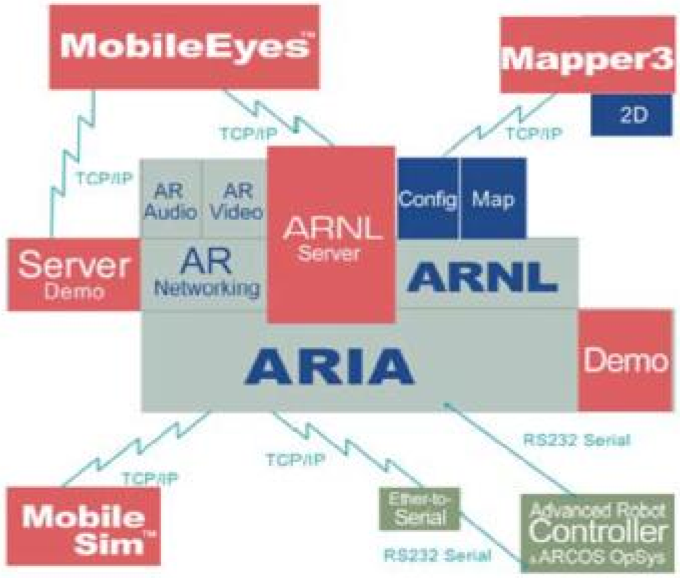


Figure 8: The complete localization and path planning solution

For now we are using Sonar-based Advanced Robotics Navigation and Localization (SonARNL) software on your sonar-enabled robot with the MobileEyes GUI client and Mapper3Basic map-building applications. In fact, SonARNL works with any and all sonar-enabled MOBILEROBOTS platform—new or old. And there is a higher performance navigation, mapping, and control features of MOBILEROBOTS' Advanced Robotics Navigation and Localization (ARNL) software that uses a laser range-finder accessory and onboard PC which we don't use now because of the high expense of the laser range finder.

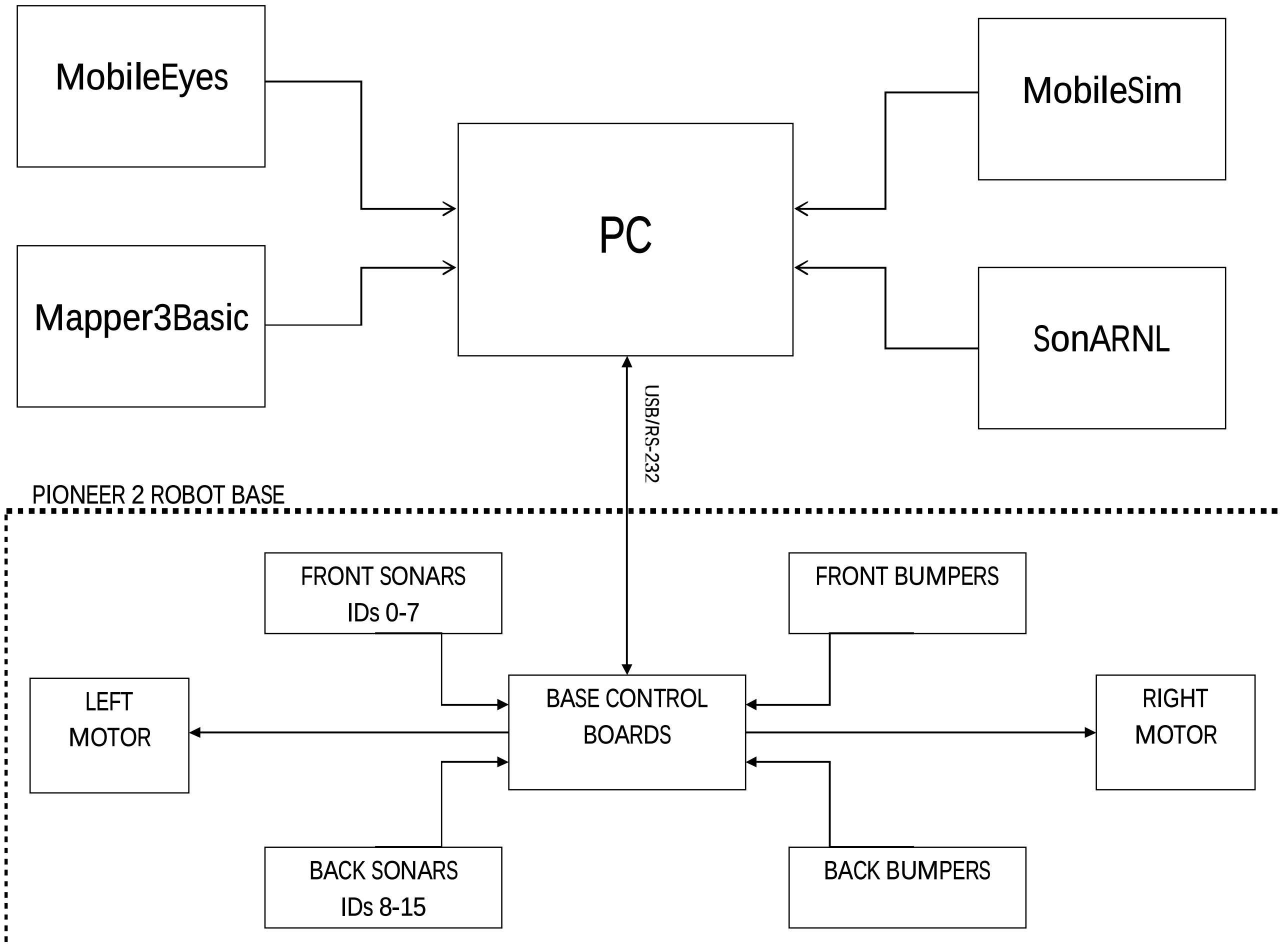


Figure 9: Robot Hardware and software components used for localization

After downloading and installing the software mentioned before we are ready to navigate the robot. Now we have two choices to demonstrate how to localize our PeopleBot robot, Simulation and real robot.

a) Simulation

The simulated SonARNL robot has three parts: MobileSim robot simulator, SonARNL's sonarnlServer, and the MobileEyes client. Start them up in order on your computers.

Step 1. Run MobileSim

Load a simulated world and the simulated robot into MobileSim from its start-up dialog or by explicit declaration as arguments on the start-up command line. The default Robot model is a Pioneer 3-DX, change it to PeopleBot simulated robot. Then after that load the map you want to localize your robot in. Note that you can use a map called Columbia which comes with the software package.

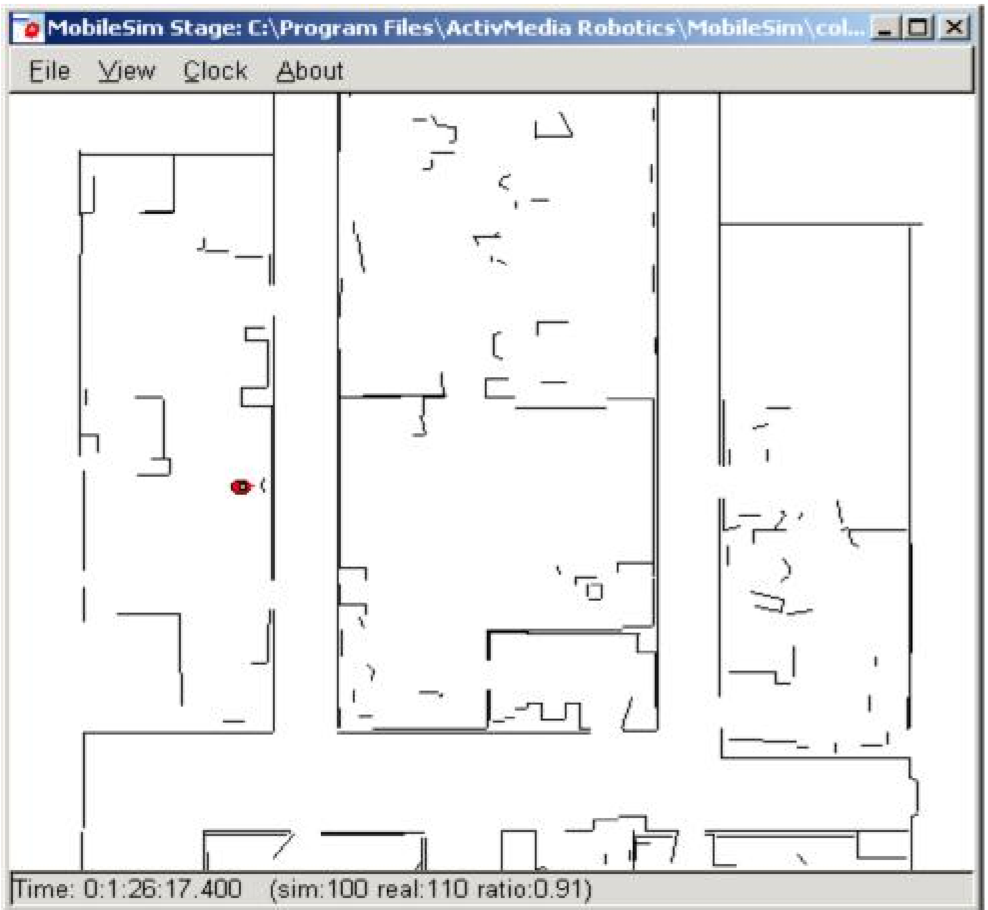


Figure 10: The MobileSim-simulated Pioneer PeopleBot at its dock in the map

Step 2. Run SonArnlServer.exe

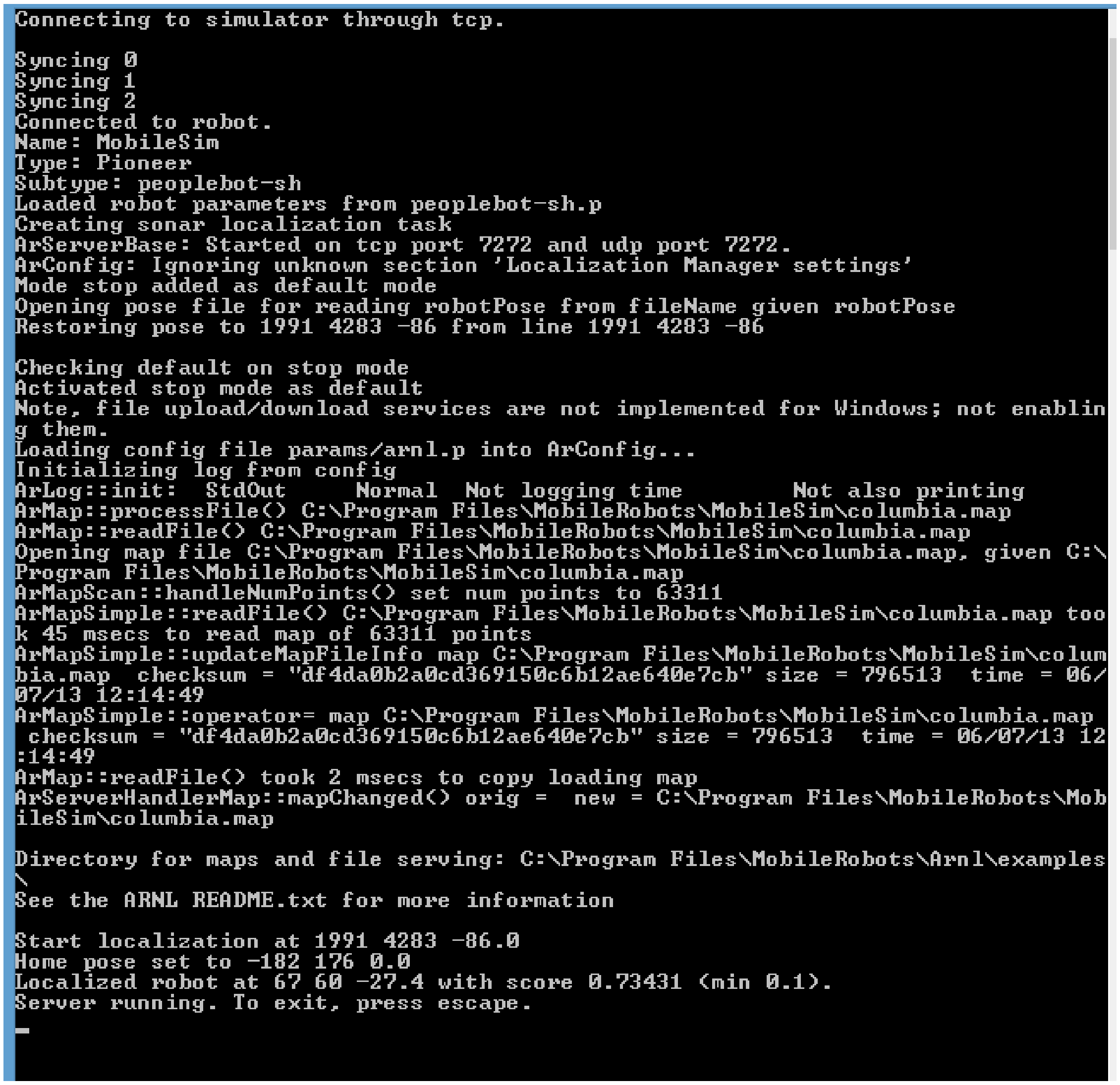
All MobileRobots platforms operate in a client-server environment. ARNL comes with a demonstration server called sonarnlServer. It is through server applications like sonarnlServer that clients like MobileEyes get control access to the robot and its accessories, such as the pan-tilt robotic camera, as well as to all the many features and functions of MobileRobots software, including ARIA, SonARNL, ARNetworking and so on.

Like any ARIA-based application, sonarnlServer takes several arguments that direct its connection with the robot. Once running, clients like MobileEyes also may send commands to sonarnlServer that change these and other operating parameters.

Finally, sonarnlServer needs a map. A SonARNL map defines not only the robot’s operating space for localization and navigation, but also defines goals like Dock for auto-charging and other predetermined destinations. See subsequent chapters for Mapper3Basic details.

In the Arnl/examples directory, a demonstration map is included that matches the simulated world map loaded into MobileSim above. For the purposes of this Quick Start demonstration, let’s just use sonarnlServer’s defaults with the sample Columbia map.

SonARNL’s sonarnlServer, through ARIA, prints out a lot of useful connection details on the console, including robot type and networking information.



```
Connecting to simulator through tcp.

Syncing 0
Syncing 1
Syncing 2
Connected to robot.
Name: MobileSim
Type: Pioneer
Subtype: peoplebot-sh
Loaded robot parameters from peoplebot-sh.p
Creating sonar localization task
ArServerBase: Started on tcp port 7272 and udp port 7272.
ArConfig: Ignoring unknown section 'Localization Manager settings'
Mode stop added as default mode
Opening pose file for reading robotPose from fileName given robotPose
Restoring pose to 1991 4283 -86 from line 1991 4283 -86

Checking default on stop mode
Activated stop mode as default
Note, file upload/download services are not implemented for Windows; not enablin
g them.
Loading config file params/arnl.p into ArConfig...
Initializing log from config
ArLog::init:  StdOut     Normal  Not logging time        Not also printing
ArMap::processFile() C:\Program Files\MobileRobots\MobileSim\columbia.map
ArMap::readFile() C:\Program Files\MobileRobots\MobileSim\columbia.map
Opening map file C:\Program Files\MobileRobots\MobileSim\columbia.map, given C:\
Program Files\MobileRobots\MobileSim\columbia.map
ArMapScan::handleNumPoints() set num points to 63311
ArMapSimple::readFile() C:\Program Files\MobileRobots\MobileSim\columbia.map too
k 45 msecs to read map of 63311 points
ArMapSimple::updateMapFileInfo map C:\Program Files\MobileRobots\MobileSim\colum
bia.map  checksum = "df4da0b2a0cd369150c6b12ae640e7cb" size = 796513  time = 06/
07/13 12:14:49
ArMapSimple::operator= map C:\Program Files\MobileRobots\MobileSim\columbia.map
 checksum = "df4da0b2a0cd369150c6b12ae640e7cb" size = 796513  time = 06/07/13 12
:14:49
ArMap::readFile() took 2 msecs to copy loading map
ArServerHandlerMap::mapChanged() orig =  new = C:\Program Files\MobileRobots\Mob
ileSim\columbia.map

Directory for maps and file serving: C:\Program Files\MobileRobots\Arnl\examples
\
See the ARNL README.txt for more information

Start localization at 1991 4283 -86.0
Home pose set to -182 176 0.0
Localized robot at 67 60 -27.4 with score 0.73431 (min 0.1).
Server running. To exit, press escape.
_
```

Figure 11: sonarnlServer connection

Step 3. Run MobileEyes

Simply launch MobileEyes and, from its startup dialog, specify the IP address or hostname of the computer that is running sonarnlServer. The hostname localhost or IP address 127.0.0.1 usually works if sonarnlServer is running on the same PC as you launch MobileEyes.

Figure 12: MobileEyes connection

After connecting you will see your robot in the map, now with this graphical user interface you can easily localize your robot.

Going to a Goal

Using Mapper3Basic, you may embed destinations with final headings (goals) into the map. Thereafter, they need only be referenced by name in order to have the robot automatically drive to that position and turn to the prescribed heading once it gets there. MobileEyes parses those goal names and displays them in its Goals: window as well as distinctive markers in the map.

The demonstration columbia.map has several goals. Double-click, for example, the Hallway 1 goal in the map, or choose it from the Goals: window, to have ARNL plan a path and drive your simulated robot to it. MobileEyes displays ARNL's planned path to the goal in light blue and refines that displayed path if and when the robot encounters an unexpected obstacle along the way.

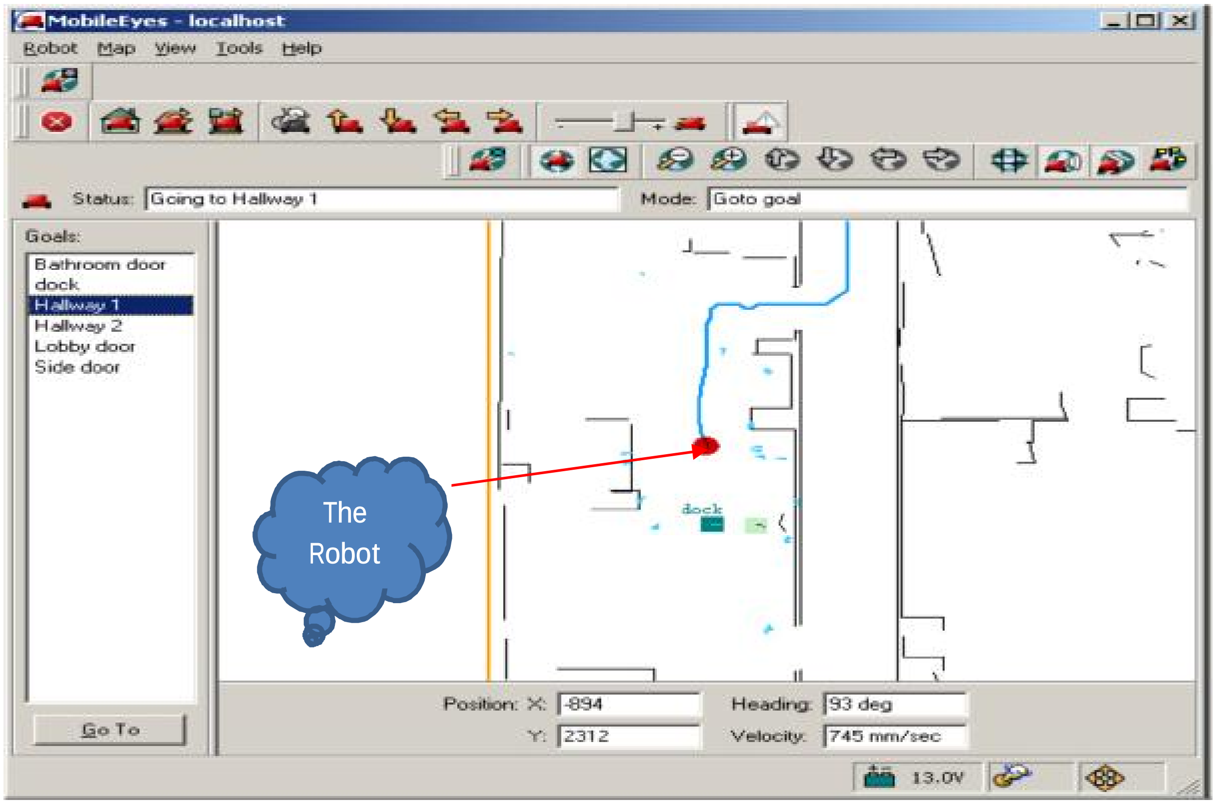


Figure 13: MobileEyes Graphical User Interface

b) Working with the Real Robot

SonARNL works with any sonar-enabled MOBILEROBOTS platform including PeopleBot. The trick is where to run the various components and connections. And you'll need to make a map of the robot's real operating space.

Step 1. Connect to the Robot

The simplest way to connect SonARNL with your robot is via a serial from the COM1 serial port on your host PC, laptop PC, or the onboard PC to the HOST serial port on the robot. Then, simply start up the sonarnlServer and MobileEyes software as described above.

In the absence of MobileSim, sonarnlServer defaults to making a connection with the robot through that default serial port.

Step 2. Run SonArnlServer.exe

Step 3. Run MobileEyes

You can notice that step two and three is exactly the same as explained before with simulation.

Mapper3Basic

Use the Mapper3Basic program to create maps, as well as add and edit forbidden spaces and goals. Mapper3Basic, in collaboration with sonarnlServer and comparable servers, also lets you manage your robot’s map files remotely over the network for deployment and use on your robots.

First, a quick word about the various map types and elements. If you have an ARNL-enabled MOBILEROBOTS platform, use it to make maps for all your robots. SonARNL and ARNL maps are interchangeable.

Also, Mapper3 and Mapper3Basic are the same application with identical features except the former also converts “2d” scan files created with an ARNL-enabled robot and containing raw laser and odometry readings into a map. Mapper3Basic cannot.

Maps created through Mapper3 and ARNL consist of occupancy grid-points and derived lines. Maps made with Mapper3Basic consist only of lines; no points.

Figure 14: Maps consist of occupancy-grid points (left) and extracted lines (right).

For localization, SonARNL can only use lines like those you may have drawn yourself with Mapper3Basic or add with Mapper3. For path-planning, SonARNL uses both points and lines. MobileSim uses both points and lines, too, as its view of the world. ARNL uses both lines and points for both localization and path-planning. Both a map's points and lines normally get displayed by Mapper3Basic or Mapper3.

VI. Summary

In this work we were able to connect and control the robot for navigation and localization with no additional hardware that could cost us, in the next step we should work to create a map and since we can't use mapper software, we should create our map using Mapper3Basic.

Mapper3Basic provides a wide range of tools to create and edit your maps into the best representations of your robot's real operating environments. The important thing to note, however, is that the map is only as good as your measurements, and your robot's ability to navigate the map is directly related to the fidelity of the map. Measure twice and once more again.