The Pioneer Robots

CSci 5551: Intro. To Robotics

Organizational Matters

- Undergraduate Robotics Lab:
  - EE/CSci 2-140B
- Swipe U-Card to enter
- Robots are in cages, with color coded padlocks.
  - Re-charge the robots after use
- You will be assigned based on project proposals.

Hardware

Pioneer 1

Pioneer 3

- Laptop w/ Ubuntu
- Internal Computer with Redhat

Access locally or on ad-hoc network “AIBONET”
Login: csci5551
Password: csci5551

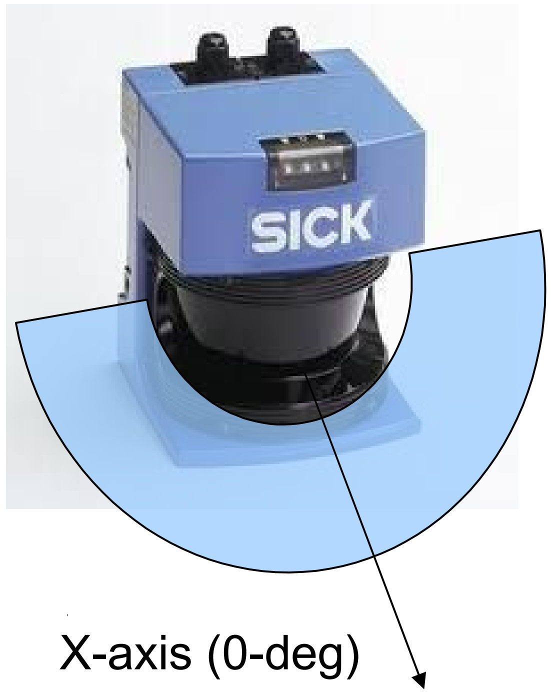
The Pioneer Robot

- Serial Connection
  - Send commands to microcontroller
- Differential Drive
  - Control wheel velocities independently
- Maximum Speeds
  - 0.6 m/s linear velocity
  - 150 deg/s rotational velocity
- Wheel Encoders
  - Resolution: 100 ticks/rev
  - Give velocity measurements
- SICK Laser Scanner
  - Details follow

- Additional Sensors:
- Sonar: 5 in front, 1 on each side
- Camera

SICK Laser Scanner

- Measures distance, e.g., to wall
- Connected via Serial (USB to Serial)
- Angular Resolution: 0.5 deg or 1 deg
- Distance Accuracy : +/-15 mm
  - between 1 m to 8 m
- Unreliable:
  - below 20 cm
  - Near edges (+/- 90 deg)
  - Power-Up Cycle: Scanner is ready when greenLED is on
- Connect using “Blocking Connect”



Battery Power

- Power-on Cycle
  - Main power switch controls sensors and robot
  - Red/White Buttons for Motor Control
  - Powering off the hardware at any point is ok
  - Pioneer 3 w/ internal computer: sudo /sbin/shutdown –h now
- Battery Usage
  - Monitor battery charge from Green/Yellow LED or LCD panel
  - Do not let charge drop below 11 V (can monitor w/ software)
  - Do not forget to turn off robot when finished
- Charging the Battery
  - Full charge requires 24 hours
  - Leave robots connected to charges while in cage

How to Break Your Hardware

- Pioneers with SICKs are Very Top-heavy
  - Unstable, they can turn upside down :D
  - Do not stop robot suddenly
  - Do not operate the robot on an incline
  - Monitor robot at all times during operation
- Wireless Antenna is Fragile
  - Do not disconnect antenna from PCMCIA card
  - Be extremely careful when removing the laptop from the robot

Robot Programming

- Aria
  - Provided by the manufacturer of Pioneers
  - Based on Player/Stage
- Player/Stage
  - General purpose robot programming
- ROS (Robot Operating System)
  - Developed by Willow Garage

Robot Programming w/ Aria

- Installing Aria and MobileSim
- Running programs in MobileSim
- Aria API
- Setup laser scanner & robot
- Some example code
- Demo video

Installing Aria & MobileSim

- Download ARIA and MobileSim from
  - http://robots.mobilerobots.com
- To install on Debian use:
  - dpkg –i libaria_2.7.2_i386.deb
  - dpkg –i mobilesim_0.5.0_i386.deb
- Default directory
  - /usr/local/Aria
  - /usr/local/MobileSim

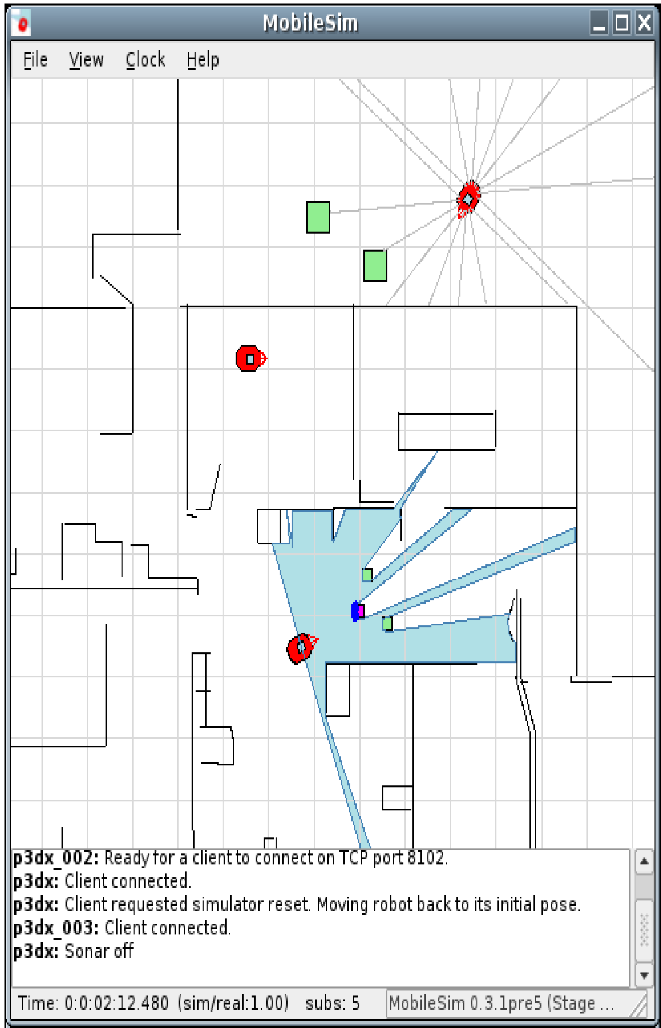
Running MobileSim

- MobileSim –m <mapfile> -r <robot>

  %MobileSim –m AMRoffice.map

- Run your own program

  %./sickWander



```
p3dx_002: Ready for a client to connect on TCP port 8102.
p3dx: Client connected.
p3dx: Client requested simulator reset. Moving robot back to its initial pose.
p3dx_003: Client connected.
p3dx: Sonar off
```

```
Time: 0:0:02:12.480 (sim/real:1.00)  subs: 5  MobileSim 0.3.1pre5 (Stage ...
```

ARIA:Software Interface to the Pioneers

- ARIA
  - ActiveMedia Robotics Interface for Application
  - Multi-threaded client/server API written in C++
- ARIA Directories
  - Main: /usr/local/Aria
  - Example: /usr/local/Aria/examples
  - Documentation: /usr/local/Aria/docs/index.html
- Environment Variables
  - LD_LIBRARY_PATH should include /usr/local/Aria/lib
    - Or “sudo ldconfig /usr/local/Aria/lib/”
  - ARIA should be set to /usr/local/Aria

```
%export ARIA=/usr/local/Aria
```

ARIA Class Overview

- Aria
- ArRobot
- ArDeviceConnection
  - ArTCPConnection
  - ArSerialConnection
- ArRangeDevice
  - ArSick
  - ArSonar
- ArAction
  - ArArctionStallRecover
  - ArActionBumpers
  - ArActionAvoidFront
  - ArActionAvoidSide
  - …
- ArKeyHandler

Some Aria Methods

- void Aria::init()
  - Performs OS-specific initializations.
  - MUST be called before any other Aria functions.
- void Aria::shutdown()
  - Shutdown all Aria/Process threads
- void Aria::setKeyHandler(ArKeyHandler *)
  - Sets a key handler function

Some Aria Methods

- void ArRobot::addRangeDevice(ArRangeDevice *)
  - Add a range device object to the current robot
  - Sonars and Lasers must be added in this fashion
- void ArRobot::setDeviceConnection(ArDeviceConnection*)
  - Sets the robot connection (sim or hardware)
- bool ArRobot::blockingConnect()
  - Block until successful robot connection
- void ArRobot::addAction(ArAction *,int)
  - Add an ArAction and set its priority
- void ArRobot::run()
  - Start the robot running in this thread

Some Aria Methods

- void ArRobot::runAsync(bool)
  - Start the robot running in its own thread
- void ArRobot::waitForRunExit()
  - Blocks until the robot finishes running
- int ArRobot::lock()
  - Lock the robot object (for thread-safe operation)
- int ArRobot::unlock()
  - Unlock the robot object
- bool ArRobot::comInt(char, int)
  - Poke the hardware (activate/deactivate sound/sonars, etc…)
- void ArRobot::attachKeyHandler(ArKeyHandler *)
  - Attach a key handler to a robot object

Control the Robot

- void ArRobot::setVel(double)
  - Sets the linear velocity of the robot
- void ArRobot::setRotVel(double)
  - Sets the rotational velocity of the robot
- void ArRobot::move(double)
  - Moves the robot straight
- void ArRobot::setHeading(double)
  - Sets “absolute” heading of the robot
- void ArRobot::setDeltaHeading(double)
  - Sets “relative” heading of the robot
- bool ArRobot::isMoveDone(double)
  - Is the last specified move done?
- void ArRobot::stop()
  - Stops the robot
- All of these must be wrapped in lock() and unlock()

Setting up SICK

```
ArSick sick;
ArSerialConnection laserConn;
sick.configureShort(usingSim, ArSick::BAUD38400,
ArSick::DEGREES180, ArSick::INCREMENT_HALF);
sick.setDeviceConnection(&laserConn);
laserConn.open("/dev/ttyUSB1");
sick.runAsync();
sick.blockingConnect();
```

- Resolution
  - **ArSick::INCREMENT_HALF** is 0.5 deg – 361 readings
  - **ArSick::INCREMENT_ONE** is 1 deg – 181 readings
- usingSim is a boolean telling whether the simulator is being used.
- Other parameters should not change.

Reading data from SICK

```
std::list<ArSensorReading *> *readings;
std::list<ArSensorReading *>::iterator it;
mySick->lockDevice();
readings = mySick->getRawReadings();
if (NULL!= readings) {
    if ((readings->end() != readings->begin())) {
        for (it = readings->begin(); it != readings->end(); it++) {
            std::cout << (*it)->getRange() << " ";
        }
        std::cout << std::endl;
    } else {
        std::cout << "(readings->end() == readings->begin())" << std::endl;
    }
} else {
    std::cout << "NULL == readings" << std::endl;
}
mySick->unlockDevice();
```

Example: Wander

- Uses actions to cause the robot to wander around and not hit obstacles
- Serial ports must be changed to use USB instead of default serial on Pioneers.
  - Robot = /dev/ttyUSB0
  - SICK = /dev/ttyUSB1

Example: Wander

```
// the serial connection (robot)   Do not use Arsimpleconnector
ArSerialConnection serConn;
// tcp connection (sim)
ArTcpConnection tcpConn;
// see if we can get to the simulator (true is success)
if (tcpConn.openSimple()) {
    // set the robots device connection to the sim
    printf("Connecting to simulator through tcp.\n");
    robot.setDeviceConnection(&tcpConn);
} else {
    // we couldn't get to the sim, so set the port on the serial
    // connection and then set the serial connection as the robots
    // device
    serConn.setPort("/dev/ttyUSB0");
    printf("Connecting to robot through serial.\n");
    robot.setDeviceConnection(&serConn);
}
robot.blockingConnect()
```

Building Examples In Linux

- Make a directory in your account

```
% mkdir aria-examples
```

- Copy all examples in it

```
% cp $ARIA/examples/*.cpp aria-examples
% cp $ARIA/tests/*.cpp aria-examples
% cp $ARIA/advanced/*.cpp aria-examples
```

- Replace makefile and build them

```
% make
```

- Modify and experiment!

A Makefile for Aria

Show the makefile

Some Suggestions

- If an Aria program freezes or refuses to exit properly:
  - CTRL-Z, then ‘killall –9 <progname>’
- For more elegant robot control, look at the
- ArAction class
  - Multiple actions run in their own threads
  - Can handle contingencies gracefully
  - See the actionExample.cpp file
- Pioneer 1 motors must be enabled manually
  - robot::comInt(ArCommands::ENABLE,1) does nothing
- Start project early
- Debug software issues with simulator
- Fine tune performance with hardware

Reference

- $firefox /usr/local/Aria/docs/index.html
- ActiveMedia
  - http://robots.mobilerobots.com
- Standard template library
  - http://www.sgi.com/tech/stl/