LAB 1 RECITATION

Getting to Know Your Robot:

Locomotion and Odometry

Demo, Code and Memo Due

Thursday, 3/12/10

PURPOSE

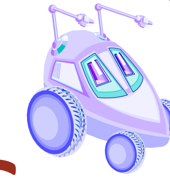
- Introduce locomotion and odometry concepts
- Install all necessary software and connect to the Traxster II
- Introduction to Visual C# programming and IDE
- Use the demo code to confirm that all of the actuators, sensors and peripherals on your robot are working
- Create your first program to get the robot moving
- Examine problems with raw odometry for pose estimation

LOCOMOTION

- ***Locomotion*** refers to the way that a robot moves from place to place
- In ***locomotion***, the environment is fixed and the robot moves by impart force on the environment
- Wheels are more energy efficient than legs and simpler to control and the effector of choice in robotics
- Wheel may not necessarily be holonomic
- ***Holonomic*** means that the robot can control all of its available degrees of freedom

STEERING

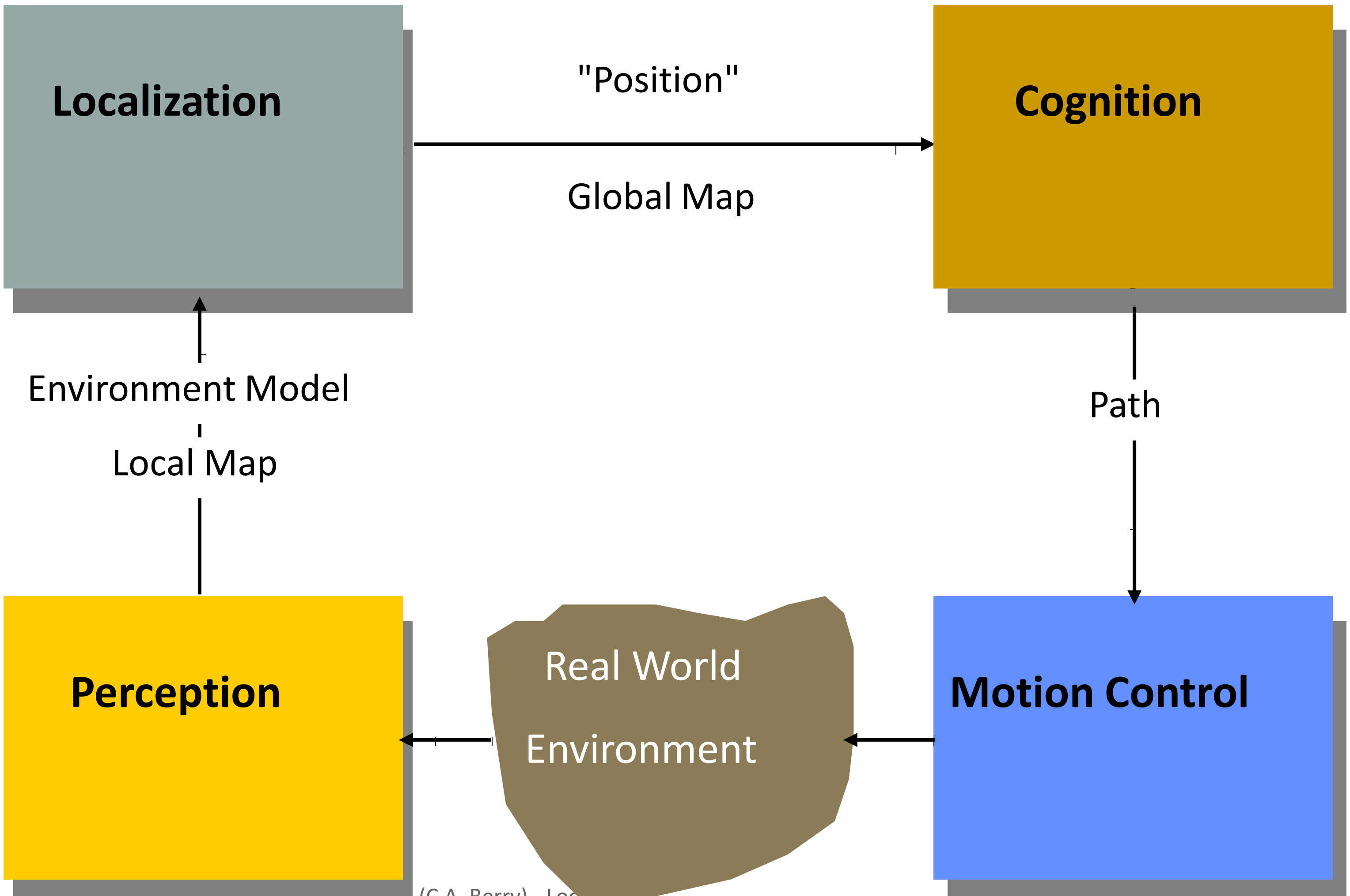
- The ability to drive wheels separately and independently through separate motors is **differential drive**
- The ability to steer wheels independently is **differential steering**
- If both wheels are driven at the same speed the robot moves forward or backward
- If the wheels have the same speed but opposite direction, the robot spins
- If one wheel is driven faster than the other, the robot moves in a circle or turns



TRAJECTORY AND MOTION PLANNING

- Two concerns in locomotion
  - Getting the robot to a particular location (goal)
  - Having the robot follow a trajectory
- ***Navigation*** is concerned with getting to a goal
- ***Trajectory planning (motion/path planning)*** is more difficult than moving the robot to a particular location. This is related to forward and inverse kinematics.
- **Optimal trajectory** deals with finding the safest, shorts, or most efficient path

LOCOMOTION CONCEPTS: PATH PLANNING



MOBILE ROBOT KINEMATICS

- ***Mobile robot kinematics*** is the dynamic model of how a mobile robot behaves
- Kinematics is a description of mechanical behavior of the robot for design and control
- Mobile Robot Kinematics is used for:
  - Position estimation
  - Motion estimation
- Mobile robots move unbounded with respect to their environment
  - There is no direct way to measure robot position
  - Position must be integrated over time
  - The integration leads to inaccuracies in position and motion estimation

ODOMETRY

- Odometry is a means of implementing **Dead Reckoning**
- A way of determining a robot’s position based upon previous known position information given a specific course heading and velocity
- Periodically requires error measurement to be ‘fixed’ or reset
- Meant for short distance measurements

RELATIVE POSITIONING: ODOMETRY AND KINEMATICS

- Given wheel velocities at any given time, compute position/orientation for any future time
- Advantages
  - Self-contained
  - Can get positions anywhere along curved paths
  - Always provides an “estimate” of position
- Disadvantages
  - Requires accurate measurement of wheel velocities over time, including measuring acceleration and deceleration
  - Position error grows over time

ODOMETRY ERRORS

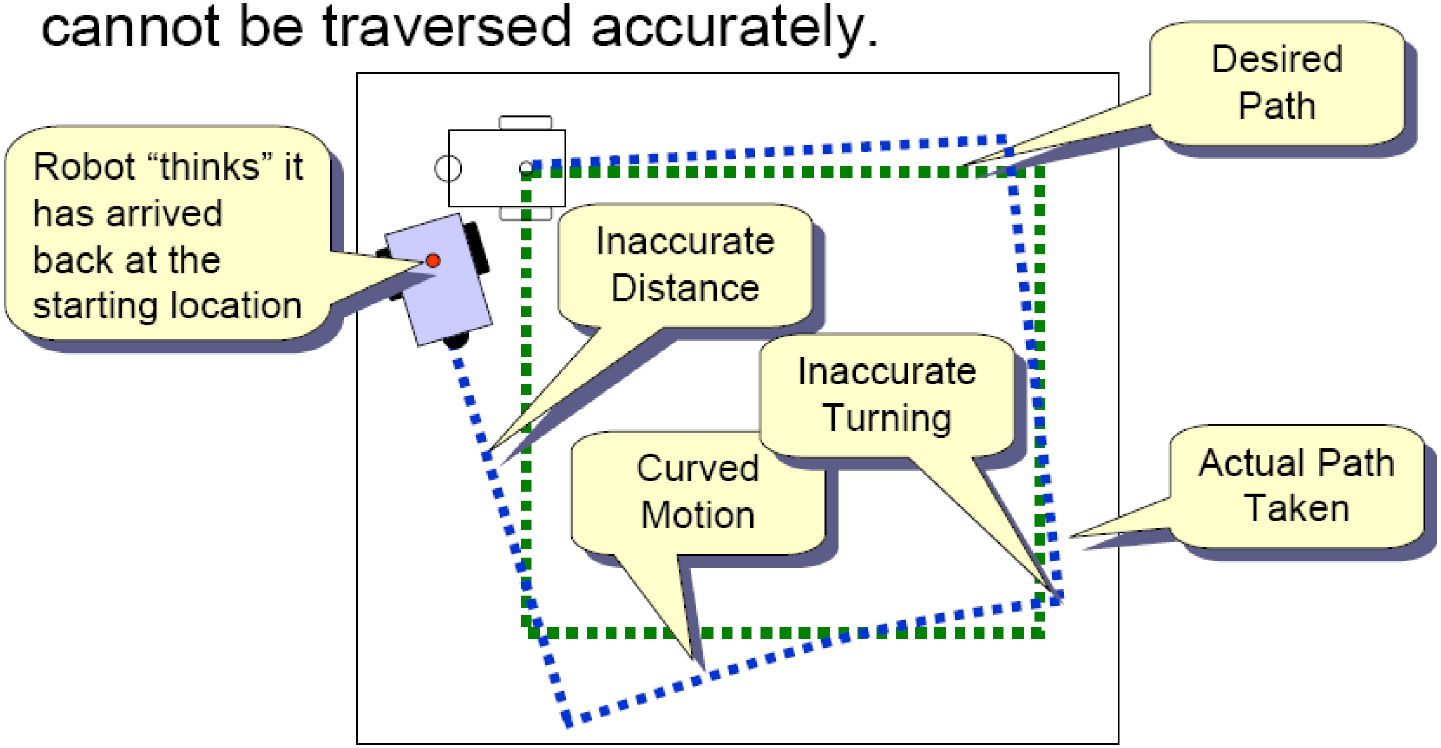
- Systematic
  - Unequal wheel diameters
  - Misalignment of wheels
  - Finite encoder resolution
  - Finite encoder sampling rate
- Non-systematic
  - Travel over uneven floors
  - Unexpected objects in the floor
  - Wheel slippage due to
    - Over acceleration
    - Slippery floor
    - skidding

ODOMETRY ERRORS

- Imprecise measurements
  - Discrepancy with actual speed and turn angles
- Inaccurate control model
  - Tracks/Wheels/Motors are not perfectly aligned or do not make contact at a single point
- Immeasurable physical characteristics
  - Friction
  - Wobbling wheels
  - Surface is not perfectly smooth and hard
  - Sliding

DEAD RECKONING

- As a result of these error factors, a simple path cannot be traversed accurately.



OPEN LOOP CONTROL

- **Open Loop Control** does not use sensory feedback, and the robot state is not fed back into the system
- **Feed-forward control**
  - The command signal is a function of some parameters measured in advance
- Feed-forward systems **are effective** only if
  - They are well calibrated
  - The environment is predictable and does not change

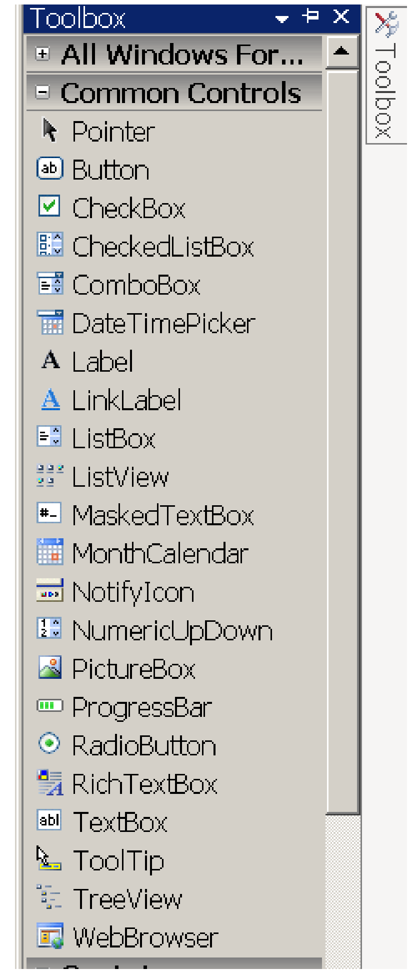
PROGRAMMING

- This is not a **programming** class but **programming** is an integral part of this course
- The best way to learn to program in any language is to practice, practice, practice
- The best reference for Visual C# is the online MSDN library, programming books and websites

VISUAL C

- Object-oriented language with a class library of pre-built components
- Event-driven visual programming language created using an IDE
- Program responds to timer expirations and user events such as mouse clicks and keystrokes

- The toolbox can be used to drag and drop objects such as labels, textboxes and buttons onto the windows application



PRELIMINARY STUFF

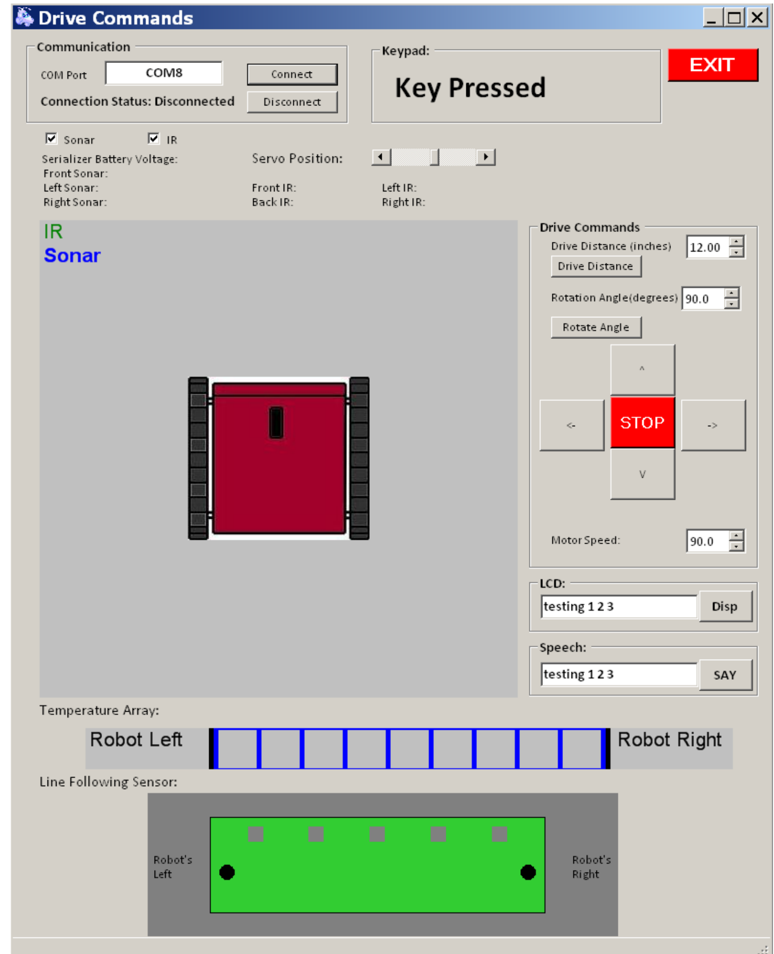
- All course materials are on the course Angel folder
- Does your laptop have?
  - Microsoft Visual Studio with C#
  - Bluetooth radio
- Create a course lab folder on your computer
- Download
  - Demo_App.zip
  - Unzip all files to the Lab 1 folder

VISUAL C# IDE

- Start Page
  - Displays IDE and web-based resources
  - Links to recent projects and getting started
- View
  - Solution Explorer
  - Toolbox
  - Properties
- Open the project
  Demo_App\IRSonar_App\Demo_App.sln
- Select tab DemoForm.cs
  - View Code
  - View Designer
  - Build the solution (F7)
  - Run the solution (F5)

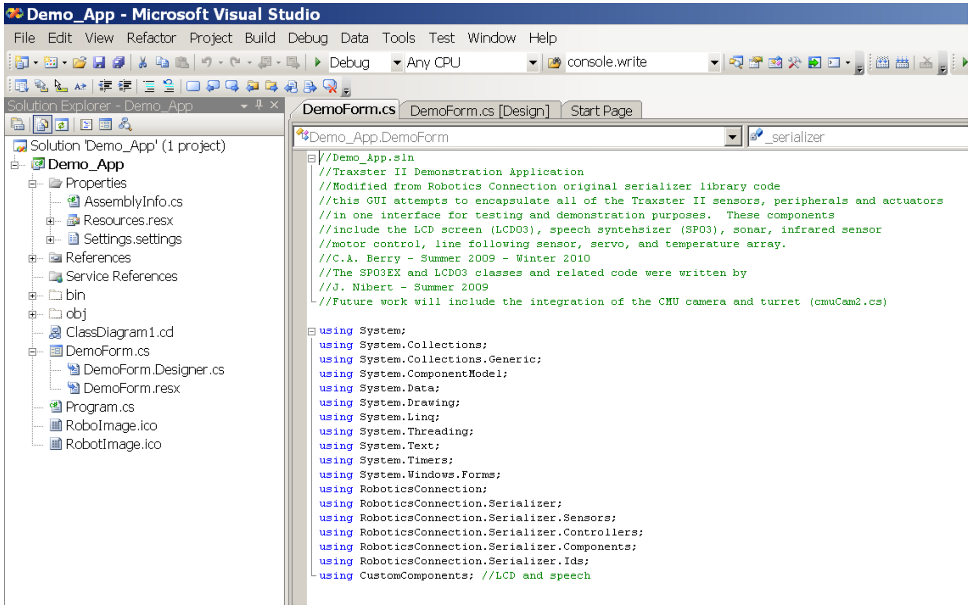
DEMO APP GUI

- Use this application to test all of the robot's actuators, sensors and peripherals
- Controls or displays
  - Communication
  - Servo
  - IR
  - Sonar
  - Drive Commands
  - LCD
  - Speech
  - Keypad
  - Temperature Array
  - Line Following Sensor



DEMO APP CODE (HEADING)

- All code must have a heading with the name of the solution, a description of the functionality, the names of the authors and dates of last revision. Use single-line comments (//) or delimited comments (/*)
- The ***using*** directive tells the compiler where to look for a class in a ***namespace*** which includes a collection of related classes



DEMO APP CODE (BODY)

- Visual Studio generates some code automatically that creates and initializes the GUI
- You will insert your variables in the public partial class
- You will insert your code in the form() function
- Define the required sensor objects
- Define the timer for the controller events (100 ms)
- Timer also used for keyPad presses
- Define the event handlers for the objects
- Feel free to modify this code and eliminate unnecessary code or GUI objects or create your own GUI from scratch

DEMO APP (DRIVE COMMAND)

- There are two drive commands
  - dmc-differential motor control
  - pmc – PID motor control
- The PID motor control provides feedback from the encoders and should be more accurate
- For driving a distance use
  - *TravelAtSpeed* with sleep or
  - *Distance* and *TravelDistance()*
- For turning an angle
  - *TravelAtSpeed* with sleep or
  - *RotationAngle* and *Rotate()*