Programming the MoBot

November 16, 2011

Contents

1 The CMobot MoBot Remote Control Library

The CMobot library is a collection of functions geared towards controlling the motors and reading sensor values of a MoBot module via the Bluetooth wireless protocol. The functions are designed to be intuitive and easy to use. Various functions are provided to control or obtain the speed, direction, and position of the motors. The API includes C-style functions as well as a C++ class called CMobot to facilitate C++ style api function calls.

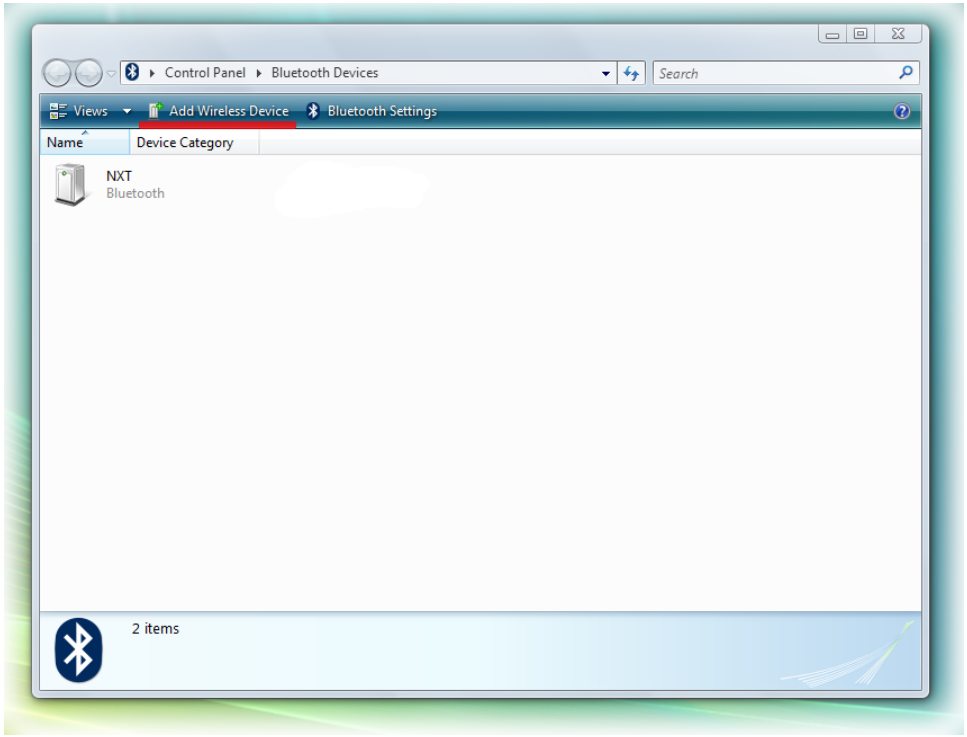
This documentation introduces the basic computer setup required for controlling the MoBot, as well as several demo programs and a complete reference for all API function provided with the CMobot library.

2 Bluetooth Pairing with the MoBot

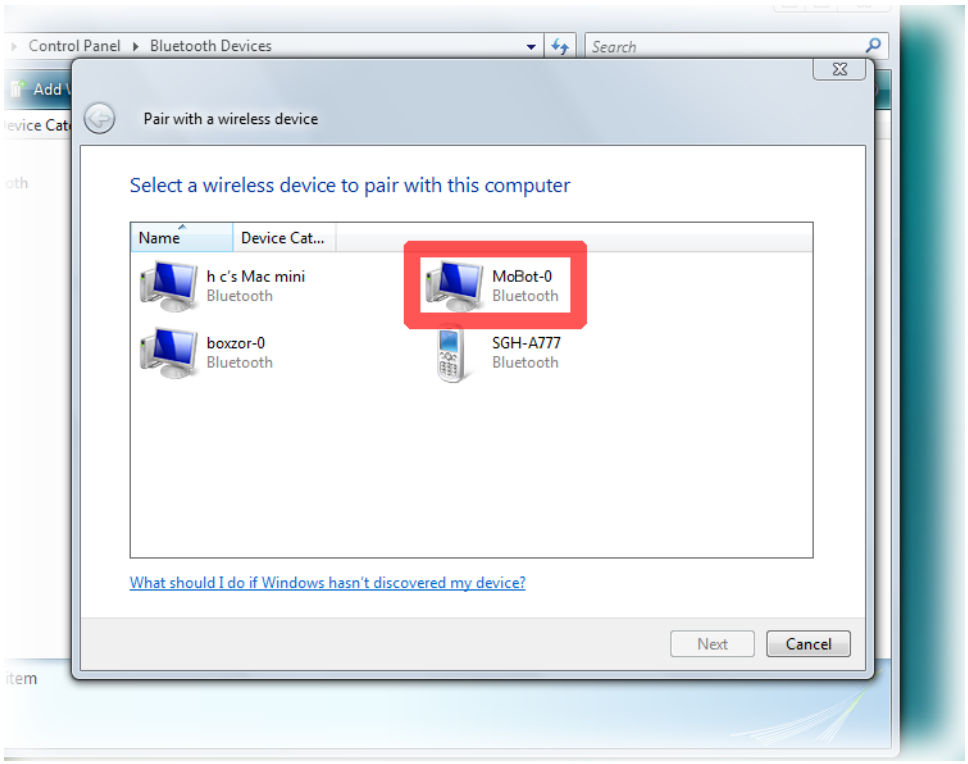
To control the MoBot with the Bluetooth wireless protocol, the controlling computer must be equipped with Bluetooth. If the computer does not have Bluetooth built-in, an external USB Bluetooth dongle may be used. The following instructions are for a Windows 7 computer with built-in Bluetooth. The basic process is the same for Windows XP and Vista, although the screenshots may appear different.

The first step is to open the Bluetooth applet by double-clicking the Bluetooth icon in the applet tray normally found at the bottom right of the screen, as shown highlighted in red in the following figure.

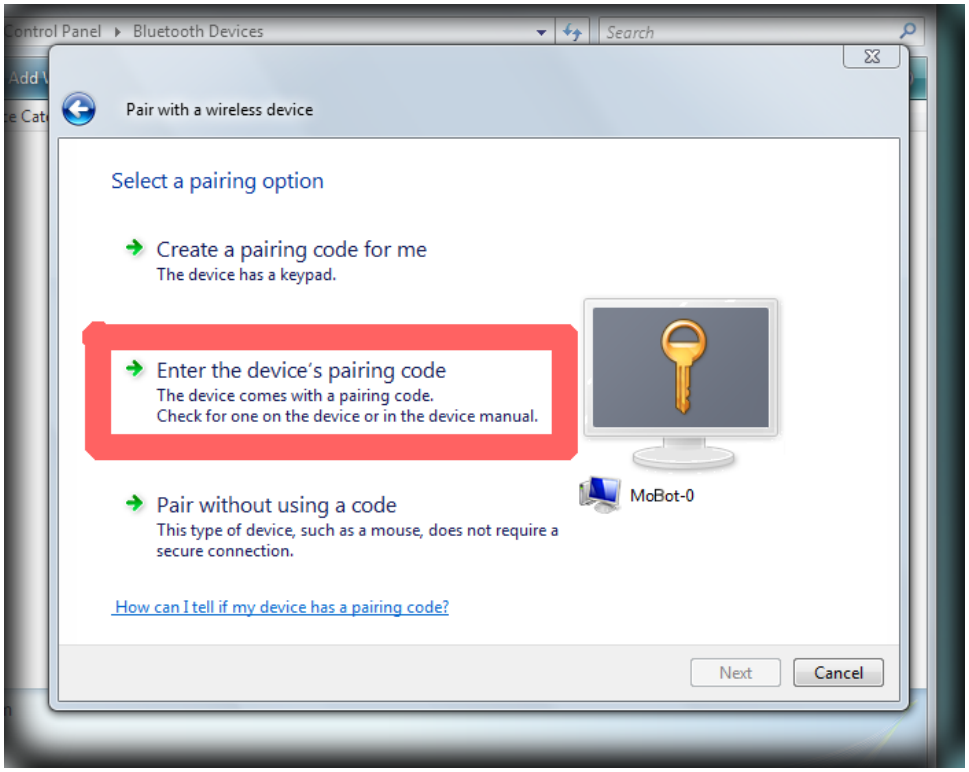
After double-clicking the icon, a new window will appear similar to the following.



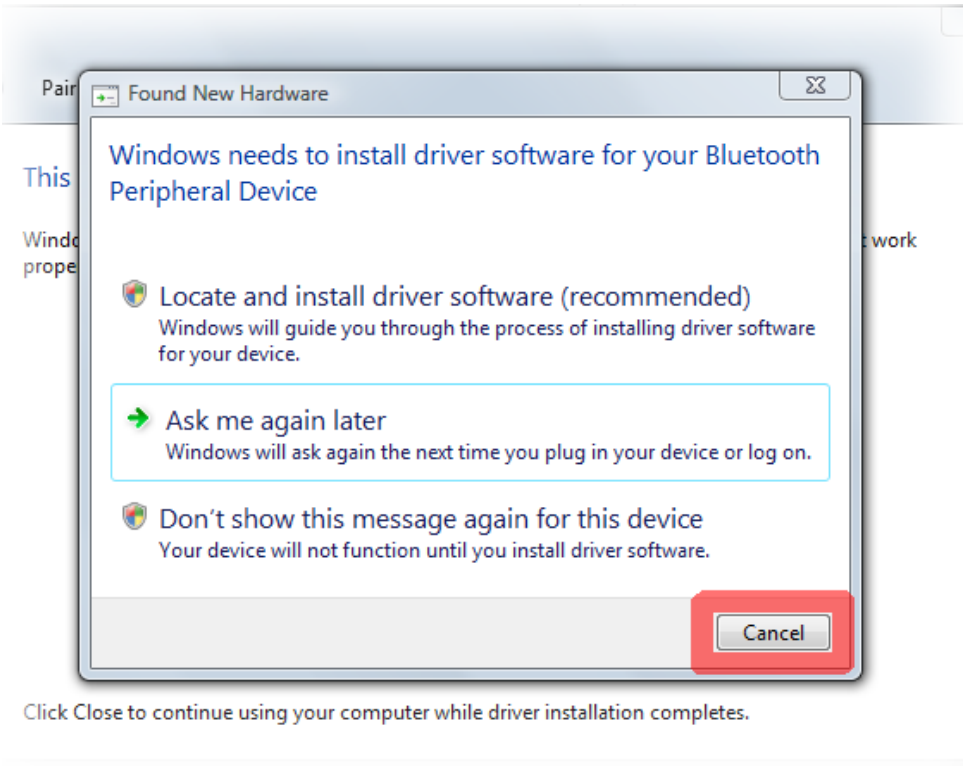
Next, click on the button labeled "Add Wireless Device" towards the top of the window. This will bring up the following dialog.



This dialog shows a list of all Bluetooth wireless devices that are in range. Among them should be the MoBot you wish to connect to. If the MoBot does not appear on this list, please ensure that the MoBot is within 10 meters of the connecting computer and that the MoBot is powered on. Double click on the icon representing the MoBot to proceed. Once you have double-clicked the icon, the following dialog box should appear.

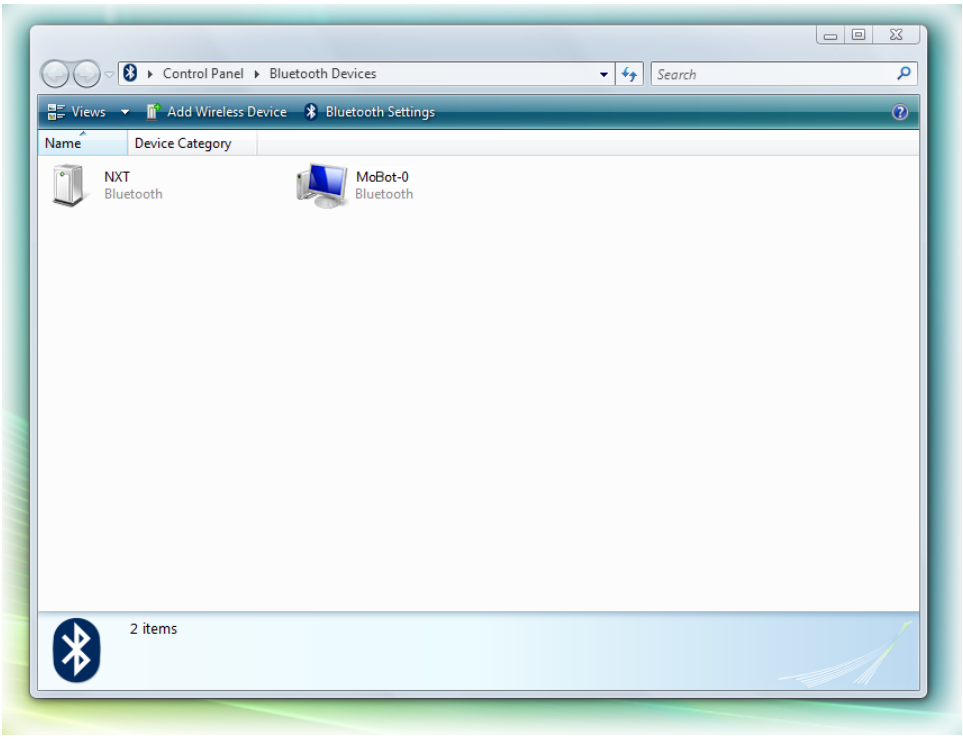


Select the second option, labeled "Enter the device's pairing code". MoBot modules come hard-coded with a default pairing code. When prompted for the pairing code, enter "1234". Once the computer is paired with the MoBot, the following dialog box may pop up asking to install drivers.

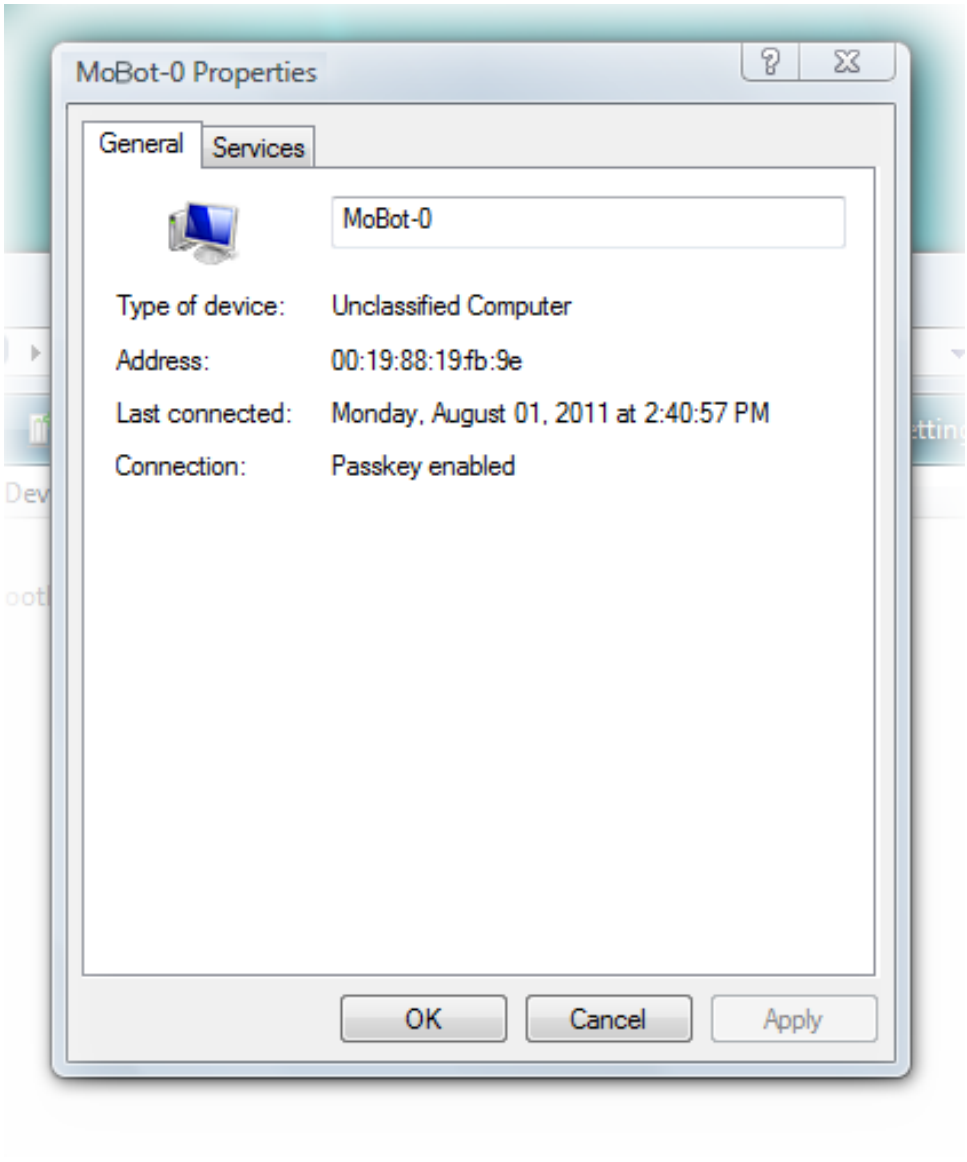


If the previously illustrated dialog box appears, just click the "cancel" button at the bottom right. No extra drivers are necessary for controlling the MoBot module.

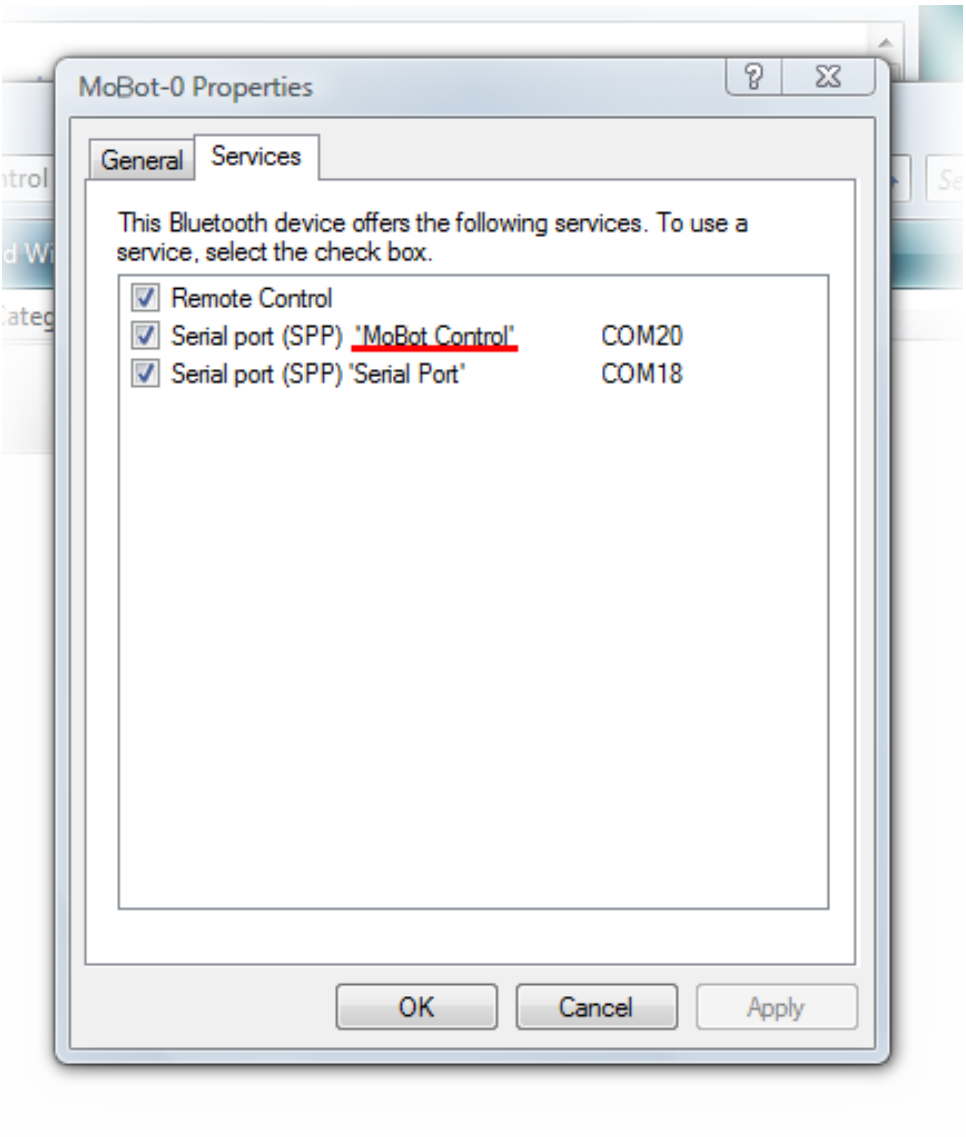
At this point, the following dialog should be shown.



The next step is to enable the MoBot control service. Double-click on the icon denoting the MoBot module to bring up the following dialog:

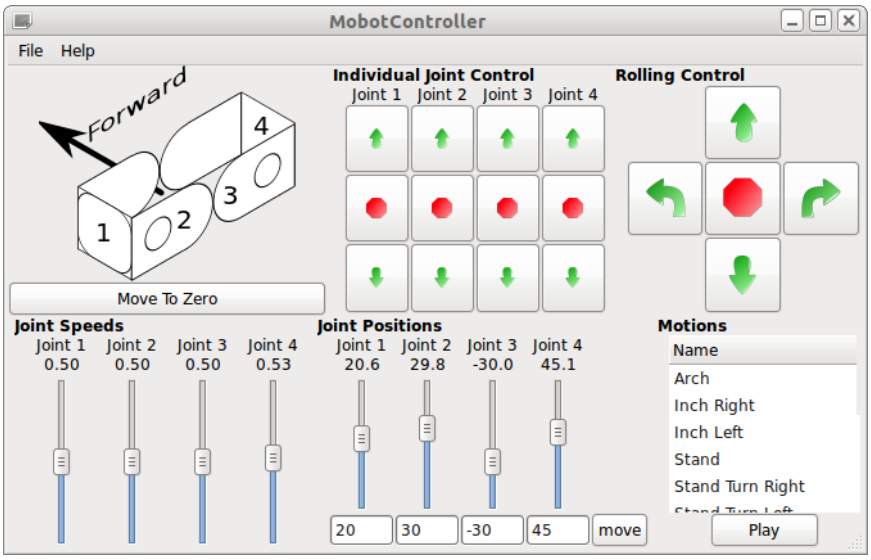


Click on the tab labeled “Services”



Ensure that the service titled “MoBot Control” is enabled. If it is not enabled, click on the check-box to enable it. Click on the “Ok” button to accept the changes and close the dialogs. The MoBot is now ready to be controlled with the MoBotComms library.

3 The MoBot Remote Control Program



The preceding figure shows the MoBot remote control program. The program displays a graphical interface which may be used to display information about the MoBot's joint positions, and also control the speeds and positions of the MoBot's joints. The interface is divided up into six sections; three on the top half of the interface, and three on the bottom half.

3.1 The MoBot Diagram and "Move To Zero" Button

The first section of the GUI located on the top left of the interface displays a schematic diagram of the MoBot, displaying motor positions. Underneath the diagram, there is a large button with the text "Move To Zero". When clicked, this button will command the connected MoBot to rotate all of its joints to a flat "Zero" position.

3.2 Individual Joint Control

The second section, located at the top-middle section of the interface, is the "Individual Joint Control" section. These buttons command the MoBot to move individual joints. When the up or down arrows are clicked, the MoBot begins to move the corresponding joint in either the positive, or negative direction. The joint will continue to move until the stop button, located between the up and down arrows, is clicked.

3.3 Rolling Control

This section contains buttons for controlling the MoBot as a two wheeled mobile robot. The up and down buttons cause the MoBot to roll forward or backward. The left and right buttons cause the MoBot to rotate towards the left, or towards the right. The stop button in the middle causes the MoBot to stop where it is.

3.4 Joint Speeds

The "Joint Speeds" section, located at the bottom left of the interface, displays and controls the current joint speeds of the MoBot. Joint speeds are a value between 0 and 1, with 1 meaning maximum joint power, and 0 meaning zero joint power. The speed may be set by sliding the vertical sliders to the desired positions.

3.5 Joint Positions

This section, located in the bottom-middle of the interface, is used to display and control the positions of each of the four joints of a MoBot. The joint positions are displayed in the numerical text located above each vertical slider. The displayed joint positions are in units of degrees. There are two methods to control the joints using this interface.

The first method of controlling the joints is by using the vertical sliders. Each vertical slider's position represents a joint's angle. The sliders for the two end joints vary from -180 degrees to 180 degrees, representing one complete rotation. The angles for the two body joints vary from -90 to 90 degrees. When the position of the slider is moved, the MoBot will move its joints to match the sliders.

The second method for moving the joints is by entering the exact angles for the joints. Below each of the four sliders lies a text entry box. Values in degrees may be typed into each of the four entry boxes. When the button on the lower right of the section labeled "Move" is clicked, the MoBot will move its joints to match the values typed into the boxes. If no value is typed into a box, that joint will not move.

3.6 Motions

This section, located on the bottom right of the interface, contains a set of preprogrammed motions for the MoBot. To execute a preprogrammed motion, simply click on the name of the motion you wish to execute, and then click the button labeled "Play".

4 Sample Ch MoBot Programs

To help the user become acquainted with the MoBot control programs, sample programs will be presented to illustrate the basics and minimum requirements of a MoBot control program.

4.1 Basics of a Ch MoBot Program

The first demo presents a minimal program which connects to a MoBot and moves some joints.

4.1.1 `gettingStarted.ch` Source Code

4.1.2 Demo Code for `gettingStarted.ch` Explained

The beginning of every MoBot control program will include header files. Each header file imports functions used for a number of tasks, such as printing data onto the screen or controlling the MoBot.

```
#include <mobot.h> // Required for MoBot control functions
```

Next, we must initialize the C++ class used to control the MoBot. This line initializes a new variable named `robot` which represents the remote MoBot module which we wish to control. This special variable is actually an instance of the `CMobot` class, which contains its own set of functions called "methods" or "member functions".

```
CMobot robot;
```

Next, we initialize two `double` type variables called "angle1" and "angle4", which we will use to store some joint angles.

```
double angle1, angle4;
```

The next line will connect our new variable, `robot`, to a MoBot that has been previously paired with the computer.

```
robot.connect();
```

Note that there are two common methods to connect to a remote MoBot. The most common method, demonstrated in the previous line of code, is used to connect to a MoBot that is already paired to the computer. It is also possible to connect to MoBots which are not paired with the computer. This method is necessary for connecting to multiple MoBots simultaneously, as only a single MoBot may be paired with the computer at a time. The second method uses the function `connectWithAddress()`, and its default usage is as such:

```
robot.connectWithAddress("11:22:33:44:55:66", 20);
```

The string `"11:22:33:44:55:66"` represents the Bluetooth address of the MoBot, which must be known in advance. The number `20` represents the Bluetooth channel to connect to. Channel `20` is the default channel MoBots listen on for incoming connections, but may be set to other values.

The next line will use the `moveToZero` member function. The `moveToZero` function causes the MoBot to move all of its motors to the zero position.

```
robot.moveToZero();
```

The next lines of code command joints 1 and 4 to rotate 90 degrees. Joints 1 and 4 are the faceplates of the MoBot which are sometimes used to act as "wheels".

```
angle1 = 90;
angle4 = 90;
robot.move(angle1, 0, 0, angle4);
```

4.2 Inchworm Gait Demo

The next demo will demonstrate a simple gait known as the "Inchworm" gait.

4.2.1 `inchworm.ch` Source Code

```
/* File: inchworm.ch
 * Perform the "inchworm" gait four times */

#include <mobot.h>

CMobot robot;

/* Connect to the paired MoBot */
robot.connect();

/* Set robot motors to speed of 0.50 */
robot.setJointSpeed(MOBOT_JOINT2, 0.50);
robot.setJointSpeed(MOBOT_JOINT3, 0.50);

/* Set the robot to "home" position, where all joint angles are 0 degrees. */
robot.moveToZero();

/* Do the inchworm gait four times */
int i;
for(i = 0; i < 4; i++) {
  robot.moveJointTo(MOBOT_JOINT2, -45);
  robot.moveJointTo(MOBOT_JOINT3, 45);
```

```
  robot.moveJointTo(MOBOT_JOINT2, 0);
  robot.moveJointTo(MOBOT_JOINT3, 0);
}
```

4.2.2 Demo Code for `inchworm.ch` Explained

The first portion of the code is identical to the previous demo, and performs the same function of declaring a MoBot variable and connecting to a paired MoBot.

```
#include <mobot.h>

CMobot robot;

/* Connect to the paired MoBot */
robot.connect();
```

The next lines of code set the joint speeds for the two body joints, joints two and three, to 50% speed. They are set to fify percent speed in order to slow the gait down in order to minimize slippage.

```
/* Set robot motors to speed of 0.50 */
robot.setJointSpeed(MOBOT_JOINT2, 0.50);
robot.setJointSpeed(MOBOT_JOINT3, 0.50);
```

Next, we move the robot into a flat "zero" position.

```
/* Set the robot to "home" position, where all joint angles are 0 degrees. */
robot.moveToZero();
```

Finally, we perform the actual inchworm gait. The inchworm gait is a gait defined by a sequence of motions performed by the body joints. The motions are as such:

1. The first body joint, referred to as joint A, rotates towards the ground. This drags the MoBot towards the direction of joint A.
2. The other body joint, joint B, rotates towards the ground. Since the center of gravity is currently positioned over joint A, this causes the trailing body joint to slide toward joint A.
3. Joint A moves back to a flat position.
4. Joint B moves back to a flat position.
5. Repeat, if desired.

The direction of travel depends on the selection of the initial body joint. In the following code example, joint 2 is chosen as the initial body joint to move. In this case, the MoBot will traverse towards joint 2. The entire gait is encapsulated in a "for" loop which executes the entire gait four times.

```
/* Do the inchworm gait four times */
int i;
for(i = 0; i < 4; i++) {
  robot.moveJointTo(MOBOT_JOINT2, -45);
  robot.moveJointTo(MOBOT_JOINT3, 45);
  robot.moveJointTo(MOBOT_JOINT2, 0);
  robot.moveJointTo(MOBOT_JOINT3, 0);
}
```

4.3 Standing Demo

4.3.1 `stand.ch` Source Code

```
/* Filename: stand.ch
 * Make a MoBot stand up on a faceplate */

#include <mobot.h>

CMobot robot;

/* Connect to the paired MoBot */
robot.connect();

/* Set robot motors to speed of 0.50 */
int i;
for(i = MOBOT_JOINT1; i <= MOBOT_JOINT4; i++) {
  robot.setJointSpeed(i, 0.50);
}
/* Set the robot to "home" position, where all joint angles are 0 degrees. */
robot.moveToZero();

/* Move the robot into a fetal position */
robot.moveJointTo(MOBOT_JOINT2, -85);
robot.moveJointTo(MOBOT_JOINT3, 80);

/* Rotate the bottom faceplate by 45 degrees */
robot.moveJointTo(MOBOT_JOINT1, 45);

/* Lift the body up */
robot.moveJointTo(MOBOT_JOINT2, 20);

/* Pan the robot around for 3 seconds */
robot.setJointSpeed(MOBOT_JOINT1, 0.30);
robot.moveContinuousTime(
    MOBOT_FORWARD,
    MOBOT_NEUTRAL,
    MOBOT_NEUTRAL,
    MOBOT_NEUTRAL,
    3000);
```

4.3.2 `stand.ch` Explained

The first portion of the program performs the necessary setup and connecting, similar to the previous demos. Similar to the previous inchworm demo, the motor speeds are set to 50% speed, and the function `moveToZero()` is called to put the robot into a flat position. Next, the following lines are executed:

```
robot.moveJointTo(MOBOT_JOINT2, -85);
robot.moveJointTo(MOBOT_JOINT3, 80);
```

These movement commands cause the MoBot to curl up into a fetal position with both of its endplates facing toward the ground. Next, the MoBot rotates one of the endplates by 45 degrees.

```
robot.moveJointTo(MOBOT_JOINT1, 45);
```

This endplate will eventually become the "foot" of the standing MoBot. Next, the MoBot lifts itself into a standing position, balancing on its endplate.

```
robot.moveJointTo(MOBOT_JOINT2, 20);
```

Note that the previous joint angle for Joint 2, a body joint, was -85 degrees. This motion causes joint 2 to rotate all the way to a 20 degree position, which lift up the body of the MoBot such that the MoBot is balancing on faceplate joint 1.

Finally, we rotate joint 1, the foot joint, for three seconds which causes the entire MoBot to rotate in place. The speed is first set to 30% speed to make the rotation a slow rotation. Next, the `moveContinuousTime` member function is used to continuously rotate a joint for a desired amount of time.

```
robot.setJointSpeed(MOBOT_JOINT1, 0.30);
robot.moveContinuousTime(
    MOBOT_FORWARD,
    MOBOT_NEUTRAL,
    MOBOT_NEUTRAL,
    MOBOT_NEUTRAL,
    3000);
```

5 Preprogrammed Motions

The MoBot API contains functions for executing preprogrammed motions. The preprogrammed motions are motions which are commonly used for MoBot locomotion. Following is a list of available functions and a brief description about their effect on the MoBot.

- `motionInchwormLeft()`: This function causes the MoBot to perform the inchworm gait once, moving the MoBot towards its left.
- `motionInchwormRight()`: This function causes the MoBot to perform the inchworm gait once, moving the MoBot towards its right.
- `motionRollBackward()`: This function causes the MoBot to rotate its faceplates, using them as wheels to roll backward.
- `motionRollForward()`: This function causes the MoBot to rotate its faceplates, using them as wheels to roll forward.
- `motionStand()`: This function causes the MoBot to stand up onto a faceplate, assuming the camera platform position.
- `motionTurnLeft()`: Uses the MoBot's faceplates as wheels, turning them in opposite directions in order to rotate the MoBot towards its left.
- `motionTurnRight()`: Uses the MoBot's faceplates as wheels, turning them in opposite directions in order to rotate the MoBot towards its right.

Note that all of the functions listed above are "blocking" functions, meaning they will not return until the motion has completed. These functions also have non-blocking equivalents which are discussed in Section 6.

5.1 inchworm2.ch: A Demo using the motionInchwormLeft() Preprogrammed Motion

This demo performs the same motion as the previous `inchworm.ch` demo, except it uses a built-in preprogrammed motion.

5.1.1 inchworm2.ch Source Code

```
/* File: inchworm.ch
 * Perform the "inchworm" gait four times */

#include <mobot.h>

CMobot robot;

/* Connect to the paired MoBot */
robot.connect();

/* Set robot motors to speed of 0.50 */
robot.setJointSpeed(MOBOT_JOINT2, 0.50);
robot.setJointSpeed(MOBOT_JOINT3, 0.50);

/* Set the robot to "home" position, where all joint angles are 0 degrees. */
robot.moveToZero();

/* Do the inchworm gait four times */
int i;
for(i = 0; i < 4; i++) {
  robot.motionInchwormLeft();
}
```

5.1.2 inchworm2.ch Explained

This program is identical to the previously discussed `inchworm.ch` demo, except for the final lines of the program, which appear as such:

```
int i;
for(i = 0; i < 4; i++) {
  robot.motionInchwormLeft();
}
```

Note that instead of controlling each joint in sequence explicitly, the function `motionInchwormLeft()` is used instead. The `motionInchwormLeft()` function automatically executes the inchworm gait on the MoBot module, and the encapsulating `for` loop executes the motion four times.

5.2 stand2.ch: A Demo Using the motionStand() Preprogrammed Motion

This demo is a simple demonstration of the `motionStand()` member function.

5.2.1 stand2.ch Source Code

```
/* Filename: stand2.ch
```

```
 * Make a MoBot stand up on a faceplate */
#include <mobot.h>

CMobot robot;
/* Connect to the paired MoBot */
robot.connect();
/* Run the built-in motionStand function */
robot.motionStand();
```

5.2.2 `stand2.ch` Explained

The source code for this demo is straightforward. After the initialization and connection as seen in previous demos, it executes the following line of code:

```
robot.motionStand();
```

This line of code causes the MoBot to perform a sequence of motions causing it to stand up on a faceplate. The function is a blocking function and will wait until the entire motion sequence is completed before continuing. There are also non-blocking versions of the motion functions, documented in Section 6.

6 Blocking and Non-Blocking Functions

All of the MoBot movement functions may be designated as either "blocking" functions or "non-blocking" functions. A blocking function is a function which does not return while operations are being performed. For instance, the `moveWait()` function is a blocking function. When called, the function will hang, or "block", until all the joints have stopped moving. After all joints have stopped moving, the `moveWait()` function will return, and the rest of the program will execute.

Furthermore, some functions have both a blocking version and a non-blocking version. For these functions, the suffix `NB` denotes that the function is non-blocking. For instance, the function `motionStand()` is blocking, meaning the function will not return until the motion is completed, whereas the function `motionStandNB()` is non-blocking, meaning the function returns immediately and the robot performs the "standing" motion asynchronously.

The function `move()` is an example of a non-blocking function. When the `move()` function is called, the function immediately returns as the joints begin moving. Any lines of code following the call to `move()` will be executed even if the current motion is still in progress.

Demos for the non-blocking functions are located in the next section of this document.

6.1 List of Blocking Movement Functions

- `move()`
- `moveContinuousTime()`
- `moveJointTo()`
- `moveTo()`
- `moveToZero()`
- `moveJointWait()`
- `moveWait()`

- `motionInchwormLeft()`
- `motionInchwormRight()`
- `motionRollBackward()`
- `motionRollForward()`
- `motionStand()`
- `motionTurnLeft()`
- `motionTurnRight()`

6.2 List of Non-Blocking Movement Functions

- `moveNB()`
- `moveContinuousNB()`
- `moveJointToNB()`
- `moveToNB()`
- `moveToZeroNB()`
- `motionInchwormLeftNB()`
- `motionInchwormRightNB()`
- `motionRollBackwardNB()`
- `motionRollForwardNB()`
- `motionStandNB()`
- `motionTurnLeftNB()`
- `motionTurnRightNB()`

7 Controlling Multiple Modules

The MoBot control software is designed to be able to control multiple modules simultaneously. There are a couple important differences in the program which enable the control of multiple modules. A small demo program which controls two modules simultaneously will first be presented, followed by a detailed explanation of the program elements.

7.1 `multipleModules.ch` Source Code

7.2 Demo Explanation

The first two lines of interest appear as such:

```
CMobot robot1;
CMobot robot2;
```

These two lines declare two separate variables which will represent the two separate MoBot modules. Next, we need to connect each variable to a physically separate MoBot. This is done with the following lines.

```
robot1.connectWithAddress("11:11:11:11:11:11", 20);
robot2.connectWithAddress("22:22:22:22:22:22", 20);
```

These lines connect the first variable, `robot1`, to the MoBot with address `11:11:11:11:11:11`. When running this demo, this demo address will need to be replaced with the actual address of the MoBot. The second argument, `20`, is the channel to connect to. By default, the MoBot will listen on channel 20 for incoming connections.

A similar process is done with `robot2`, causing it to connect to a second MoBot with address `22:22:22:22:22:22`.

```
robot1.moveToZeroNB();
robot2.moveToZeroNB();
```

These two lines command the two robots to move to their zero positions. Note that these functions are non-blocking. This means that the `moveToZeroNB()` function will return immediately, and will not wait for the first robot to finish completing the motion before commanding the second robot to begin. In a normal program, this effectively causes both robots to move to their zero positions simultaneously.

```
robot1.moveWait();
robot2.moveWait();
```

Since the `moveToZeroNB()` functions are non-blocking, we would like the program to wait until the motions are complete before continuing. By calling `moveWait()` on both of the robots, we can be assured that the robots have finished moving before the program continues.

```
robot1.motionStandNB();
robot2.motionStandNB();
robot1.moveWait();
robot2.moveWait();
```

Similar to the calls to `moveToZeroNB()`, this block of code instructs the two MoBots to stand. Note that we call the non-blocking versions of the stand function, called `motionStandNB()`. Since these functions are non-blocking, both robots will effectively stand simultaneously. Again, we call the `moveWait()` function on both robots to ensure that the robots have finished standing before the code continues.

A Data Types

There are data types which are used by the MoBot library to represent certain values, such as joint id's and motor directions.

Data Type	Description
`mobotJointId_t`	An enumerated value that indicates a MoBot joint.
`mobotJointState_t`	The current state of a MoBot joint.
`mobotJointDirection_t`	The current motion direction of a MoBot joint.

A.1 `mobotJointId_t`

This datatype is an enumerated type used to identify a joint on the MoBot. Valid values for this type are:

```
typedef enum mobot_joints_e {
  MOBOT_JOINT1 = 1,
  MOBOT_JOINT2 = 2,
  MOBOT_JOINT3 = 3,
  MOBOT_JOINT4 = 4
} mobotJointId_t;
```

The joints are enumerated in order from one side of the MoBot to the other. Joints 1 and 4 are faceplate joints, and joints 2 and 3 are body joints.

A.2 `mobotJointState_t`

This datatype is an enumerated type used to designate the current movement state of a joint. Valid values are:

- `MOBOT_JOINT_IDLE`: This value indicates that the joint is not moving.
- `MOBOT_JOINT_MOVING`: This value indicates that the joint is currently moving.
- `MOBOT_JOINT_GOALSEEK`: This value indicates that the joint is currently moving towards a predefined goal.

A.3 `mobotJointDirection_t`

This datatype designates a MoBot joint's commanded direction of travel. Valid values are

- `MOBOT_NEUTRAL`: There is no predesignated direction for the joint. If the joint is commanded to move to a specific location, the MoBot will decide the best direction to move the joint in order to achieve the goal with the smallest motion.
- `MOBOT_FORWARD`: Move the joint in the direction which increases its angular position.
- `MOBOT_BACKWARD`: Move the joint in the direction which decreases its angular position.

B Macros

B.1 `MoBot_joints_t`

The data type `MoBot_joints_t` contains the following macro datatypes.

Value	Description
IMOBOT_JOINT1	Joint number 1 on the MoBot, which is a face-plate joint.
IMOBOT_JOINT2	Joint number 2 on the MoBot, which is a body joint.
IMOBOT_JOINT3	Joint number 3 on the MoBot, which is a body joint.
IMOBOT_JOINT3	Joint number 4 on the MoBot, which is a face-plate joint.

B.2 MoBot_joint_direction_t

The data type MoBot_joint_direction_t indicates the commanded direction of a joint on the MoBot.

Value	Description
IMOBOT_NEUTRAL	This value indicates automatic direction control for a joint. The MoBot will choose the best direction to attain the commanded joint position.
IMOBOT_FORWARD	Move the joint in the forward direction.
IMOBOT_BACKWARD	Move the joint in the backward direction.

C MoBotComms API

The header file **mobot.h** defines all the data types, macros and function prototypes for the MoBot API library. The header file declares a class called CMobot which contains member functions which may be used to control the robot.

Table 1: CMobot Member Functions.

Function	Description
`CMobot()`	The CMobot constructor function. This function is called automatically and should not be called explicitly. This constructor will automatically try to connect with a paired MoBot using the `connect()` member function. To specify an address to connect to, please use the `CMobot(const char address[], int channel);` constructor.
`CMobot(const char address[], int channel);`	An alternate constructor which may be used to explicitly specify the address of a MoBot to connect to.
`~CMobot()`	The CMobot destructor function. This function is called automatically and should not be called explicitly.
`connect()`	Connect to a remote MoBot module. This function connects to an already-paired MoBot module in Microsoft Windows. This function does not currently work for non-Windows operating systems, such as Mac or Linux. For those operating systems, please use the `connectWithAddress()` function instead.
`connectWithAddress()`	Connect to a MoBot module by specifying its Bluetooth address.
`disconnect()`	Disconnect from a MoBot module.
`getJointAngle()`	Gets a joint's angle.
`getJointSpeed()`	Gets a motor's speed.
`getJointState()`	Gets a motor's current status.
`isConnected()`	This function is used to check the connection to a MoBot.
`move()`	Move all four joints of the MoBot by specified angles.
`moveNB()`	Identical to `move()` but non-blocking.

Table 1: CMobot Member Functions (Continued).

Function	Description
`moveContinuousNB()`	Move joints continuously. Joints will move untill stopped.
`moveContinuousTime()`	Move joints continuously for a certain amount of time.
`moveTo()`	Move all four joints of the MoBot to specified absolute angles.
`moveToNB()`	Identical to `moveTo()` but non-blocking.
`moveJointTo()`	Set the desired motor position.
`moveJointToNB()`	Identical to `moveJointTo()` but non-blocking.
`moveJointWait()`	Wait until the specified motor has stopped moving.
`moveWait()`	Wait until all motors have stopped moving.
`moveToZero()`	Instructs all motors to go to their zero positions.
`moveToZeroNB()`	Identical to `moveToZero()` but non-blocking.
to "0" for automatic direction, "1" for forward, and "2" for reverse.	
`setJointSpeed()`	Sets a motor's speed.
`stop()`	Stop all currently executing motions of the MoBot.

Table 2: CMobot Member Functions for Compound Motions.

Compound Motions	These are convenience functions of commonly used compound motions.
`motionInchwormLeft()`	Inchworm gait towards the left.
`motionInchwormLeftNB()`	Identical to `motionInchwormLeft` but non-blocking.
`motionInchwormRight()`	Inchworm gait towards the right.
`motionInchwormRightNB()`	Identical to `motionInchwormRight` but non-blocking.
`motionRollBackward()`	Roll on the faceplates toward the backward direction.
`motionRollBackwardNB()`	Identical to `motionRollBackward()` but non-blocking.
`motionRollForward()` .	Roll on the faceplates forwards.
`motionRollForwardNB()`	Identical to `motionRollForward()` but non-blocking.
`motionStand()`	Stand the MoBot up on its end.
`motionStandNB()`	Identical to `motionStandNB()` but non-blocking.
`motionTurnLeft()`	Rotate the MoBot counterclockwise.
`motionTurnLeftNB()` ..	Identical to `motionTurnLeft()` but non-blocking.
`motionTurnRight()` ...	Rotate the MoBot clockwise.
`motionTurnRightNB()` .	Identical to `motionTurnRight()` but non-blocking.

CMobot::connect()

Synopsis

```
#include <mobot.h>
int CMobot::connect();
```

Purpose
Connect to a remote MoBot via Bluetooth.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters
None.

Description
This function is used to connect to a MoBot. The MoBot must first be paired with the computer. This function currently only works in Microsoft Windows operating systems. For other operating systems, please use the `connectWithAddress()` function.

Example
Please see the example in Section 4.1.2 on page 11.

See Also
`connectWithAddress()`

CMobot::connectWithAddress()

Synopsis

```
#include <mobot.h>
int CMobot::connectWithAddress(const char* address, int channel);
```

Purpose
Connect to a remote MoBot via Bluetooth by specifying the specific Bluetooth address of the device.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters
`address` The Bluetooth address of the MoBot.
`channel` The Bluetooth channel that the listening program is listening on. The default channel is channel 20.

Description
This function is used to connect to a MoBot.

Example

See Also
`connect()`

CMobot::disconnect()

Synopsis

```
#include <mobot.h>
int CMobot::disconnect();
```

Purpose
Disconnect from a remote MoBot.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters
None.

Description
This function is used from disconnect to a MoBot. A call to this function is not necessary before the termination of a program. It is only necessary if another connection will be established within the same program at a later time.

Example

See Also

CMobot::getJointAngle()

Synopsis

```
#include <mobot.h>
int CMobot::getJointAngle(mobotJointId_t id, double &position);
```

Purpose
Connect to a remote MoBot via Bluetooth.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters

`id`	The joint number to wait for. This is an enumerated type discussed in Section A.1 on page 20.
`position`	A variable to store the current position of the MoBot motor. The contents of this variable will be overwritten with a value that represents the motor's angle in degrees.

Description
This function gets the current motor position of a MoBot's motor. The position returned is in units of

degrees and is accurate to roughly ±0.1 degrees.

Example

See Also
`connectWithAddress()`

CMobot::getJointSpeed()

Synopsis

```
#include <mobot.h>
int CMobot::getJointSpeed(mobotJointId_t id, double &speed);
```

Purpose
Get the speed of a joint on the MoBot.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters

`id`	The joint number to pose. This is an enumerated type discussed in Section A.1 on page 20.
`speed`	A variable of type `double`. The value of this variable will be overwritten with the current speed setting of the joint, which is a value between 0 and 1.

Description
This function is used to find the speed of a joint. This is the speed at which the joint will move when given motion commands. The values should be between 0 and 1.

Example

See Also

CMobot::getJointState()

Synopsis

```
#include <mobot.h>
int CMobot::getJointState(mobotJointId_t id, mobotJointState_t &state);
```

Purpose
Determine whether a motor is moving or not.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters

`id`	The joint number to pose. This is an enumerated type discussed in Section A.1 on page 20.
`state`	An integer variable which will be overwritten with the current state of the motor. This is an enumerated type discussed in Section A.2 on page 20.

Description
This function is used to determine the current state of a motor. Valid states are:

- `IMOBOT_JOINT_IDLE` : 0: The motor is idle.
- `IMOBOT_JOINT_MOVING` : 1: The motor is moving.
- `IMOBOT_JOINT_GOALSEEK` : 2: The motor is heading towards a specified position.

Example

See Also

CMobot::isConnected()

Synopsis

```
#include <mobot.h>
int CMobot::isConnected();
```

Purpose
Check to see if currently connected to a remote MoBot via Bluetooth.

Return Value
The function returns zero if it is not currently connected to a MoBot, or non-zero otherwise.

Parameters
None.

Description
This function is used to check if the software is currently connected to a MoBot.

Example

See Also

CMobot::motionInchwormLeft()
CMobot::motionInchwormLeftNB()

Synopsis

```
#include <mobot.h>
int CMobot::motionInchwormLeft();
int CMobot::motionInchwormLeftNB();
```

Purpose
Perform the inch-worm gait to the left.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters
None.

Description
This function causes the MoBot to perform a single cycle of the inchworm gait to the left. This function comes in two flavors; a blocking and a non blocking version. The function `motionInchwormLeft()` is blocking, and the function will hang until the motion has finished. The alternative function, `motionInchwormLeftNB()` will return immediately, and the motion will execute asynchronously.

See Also
`motionInchwormRight()`

CMobot::motionInchwormRight()
CMobot::motionInchwormRightNB()

Synopsis

```
#include <mobot.h>
int CMobot::motionInchwormRight();
int CMobot::motionInchwormRightNB();
```

Purpose
Perform the inch-worm gait to the right.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters
None.

Description
This function causes the MoBot to perform a single cycle of the inchworm gait to the right.

This function has both a blocking and non-blocking version. The blocking version, `motionInchwormRight()`, will block until the MoBot motion has completed. The non-blocking version, `motionInchwormRightNB()`, will return immediately, and the motion will be performed asynchronously.

See Also
`motionInchwormLeft()`

CMobot::motionRollBackward()
CMobot::motionRollBackwardNB()

Synopsis

```
#include <mobot.h>
int CMobot::motionRollBackward();
```

```
int CMobot::motionRollBackwardNB();
```

Purpose
Use the faceplates as wheels to roll backward.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters
None.

Description
This function causes each of the faceplates to rotate 90 degrees to roll the robot backward.

This function has both a blocking and non-blocking version. The blocking version, `motionRollBackward()`, will block until the MoBot motion has completed. The non-blocking version, `motionRollBackwardNB()`, will return immediately, and the motion will be performed asynchronously.

See Also
`motionRollForward()`

CMobot::motionRollForward()
CMobot::motionRollForwardNB()

Synopsis

```
#include <mobot.h>
int CMobot::motionRollForward();
int CMobot::motionRollForwardNB();
```

Purpose
Use the faceplates as wheels to roll forward.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters
None.

Description
This function causes each of the faceplates to rotate 90 degrees to roll the robot forward.

This function has both a blocking and non-blocking version. The blocking version, `motionRollForward()`, will block until the MoBot motion has completed. The non-blocking version, `motionRollForwardNB()`, will return immediately, and the motion will be performed asynchronously.

See Also
`motionRollBackward()`

CMobot::motionStand()

CMobot::motionStandNB()

Synopsis

```
#include <mobot.h>
int CMobot::motionStand();
int CMobot::motionStandNB();
```

Purpose
Stand the robot up on a faceplate.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters
None.

Description
This function causes the robot to motionStand up into the camera platform.

This function has both a blocking and non-blocking version. The blocking version, `motionStand()`, will block until the MoBot motion has completed. The non-blocking version, `motionStandNB()`, will return immediately, and the motion will be performed asynchronously.

See Also

CMobot::motionTurnLeft()
CMobot::motionTurnLeftNB()

Synopsis

```
#include <mobot.h>
int CMobot::motionTurnLeft();
int CMobot::motionTurnLeftNB();
```

Purpose
Rotate the MoBot using the faceplates as wheels.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters
None.

Description
This function causes the MoBot to rotate the faceplates in opposite directions to cause the robot to rotate counter-clockwise.

This function has both a blocking and non-blocking version. The blocking version, `motionTurnLeft()`, will block until the MoBot motion has completed. The non-blocking version, `motionTurnLeftNB()`, will

return immediately, and the motion will be performed asynchronously.

See Also
`motionTurnRight()`

CMobot::motionTurnRight()
CMobot::motionTurnRightNB()

Synopsis

```
#include <mobot.h>
int CMobot::motionTurnRight();
int CMobot::motionTurnRightNB();
```

Purpose
Rotate the MoBot using the faceplates as wheels.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters
None.

Description
This function causes the MoBot to rotate the faceplates in opposite directions to cause the robot to rotate clockwise.

This function has both a blocking and non-blocking version. The blocking version, `motionTurnRight()`, will block until the MoBot motion has completed. The non-blocking version, `motionTurnRightNB()`, will return immediately, and the motion will be performed asynchronously.

See Also
`motionTurnLeft()`

CMobot::move()
CMobot::moveNB()

Synopsis

```
#include <mobot.h>
int CMobot::move(double angle1, double angle2, double angle3, double angle4);
int CMobot::moveNB(double angle1, double angle2, double angle3, double angle4);
```

Purpose
Move all of the joints of a MoBot by specified angles.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters
None.

Description
This function moves all of the joints of a MoBot by the specified number of degrees from their current positions.

The function `move()` is a blocking function, which means that the function will not return until the commanded motion is completed. The function `moveNB()` is the non-blocking version of the `move()` function, which means that the function will return immediately and the physical robot motion will occur asynchronously. For more information on blocking and non-blocking functions, please refer to Section 6 on page 17.

Example
Please see the demo at Section 4.1.2 on page 11.

See Also

CMobot::moveContinuousNB()

Synopsis

```
#include <mobot.h>
int CMobot::moveContinuousNB(
  mobotJointDirection_t dir1,
  mobotJointDirection_t dir2,
  mobotJointDirection_t dir3,
  mobotJointDirection_t dir4);
```

Purpose
Move the joints of a MoBot continuously in the specified directions.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters
Each integer parameter specifies the direction the joint should move. The types are enumerated in `mobot.h` and have the following values:

- `MOBOT_NEUTRAL` : The joint should not move.
- `MOBOT_FORWARD` : The joint will begin moving in the positive direction.
- `MOBOT_BACKWARD`: The joint will begin moving in the negative direction.

More documentation about these types may be found at Section A.3 on page 20.
Description
This function causes joints of a MoBot to begin moving at the previously set speed. The joints will continue moving until the joint hits a joint limit, or the joint is stopped by setting the speed to zero. This function is a non-blocking function.

Example

See Also

CMobot::moveContinuousTime()

Synopsis

```
#include <mobot.h>
int CMobot::moveContinuousTime(int dir1, int dir2, int dir3, int dir4, int msecs);
```

Purpose
Move the joints of a MoBot continuously in the specified directions.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters
Each integer direction parameter specifies the direction the joint should move. The types are enumerated in `mobot.h` and have the following values:

- `MOBOT_NEUTRAL` : The joint should not move.
- `MOBOT_FORWARD` : The joint will begin moving in the positive direction.
- `MOBOT_BACKWARD`: The joint will begin moving in the negative direction.

The `msecs` parameter is the time to perform the movement, in milliseconds.

Description
This function causes joints of a MoBot to begin moving. The joints will continue moving until the joint hits a joint limit, or the time specified in the `msecs` parameter is reached. This function will block until the motion is completed.

Example

See Also

CMobot::moveTo()
CMobot::moveToNB()

Synopsis

```
#include <mobot.h>
int CMobot::moveTo(double angle1, double angle2, double angle3, double angle4);
int CMobot::moveToNB(double angle1, double angle2, double angle3, double angle4);
```

Purpose
Move all of the joints of a MoBot to the specified positions.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters
None.

Description
This function moves all of the joints of a MoBot to the specified absolute positions.

The function `moveTo()` is a blocking function, which means that the function will not return until the commanded motion is completed. The function `moveToNB()` is the non-blocking version of the `moveTo()` function, which means that the function will return immediately and the physical robot motion will occur asynchronously. For more details on blocking and non-blocking functions, please refer to Section 6 on page 17.

Example
Please see the demo at Section 4.1.2 on page 11.

See Also

CMobot::moveJointTo()
CMobot::moveJointToNB()

Synopsis

```
#include <mobot.h>
int CMobot::moveJointTo(int id, double position);
int CMobot::moveJointToNB(int id, double position);
```

Purpose
Move a joint on the MoBot to an absolute position.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters

`id`	The joint number to wait for.
`position`	The absolute angle to move the motor to.

Description
This function commands the motor to move to a position specified in degrees at the current motor's speed. The current motor speed may be set with the `setJointSpeed()` member function. Please note that if the motor speed is set to zero, the motor will not move after calling the `moveJointTo()` function.

The function `moveJointTo()` is a blocking function, which means that the function will not return until the commanded motion is completed. The function `moveJointToNB()` is the non-blocking version of the `moveJointTo()` function, which means that the function will return immediately and the physical robot motion will occur asynchronously. For more details on blocking and non-blocking functions, please refer to Section 6 on page 17.

Example
Please see the example in Section 4.1.2 on page 11.

See Also
`connectWithAddress()`

CMobot::moveJointWait()

Synopsis

```
#include <mobot.h>
int CMobot::moveJointWait(int id);
```

Purpose
Wait for a joint to stop moving.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters

`id`	The joint number to wait for.

Description
This function is used to wait for a joint motion to finish. Functions such as `poseJoint()` and `moveJoint()` do not wait for a joint to finish moving before continuing to allow multiple joints to move at the same time. The `moveJointWait()` or `moveJointWait()` functions are used to wait for robotic motions to complete.

Please note that if this function is called after a motor has been commanded to turn indefinitely, this function may never return and your program may hang.

Example
Please see the example in Section 4.1.2 on page 11.

See Also
`moveWait()`

CMobot::moveWait()

Synopsis

```
#include <mobot.h>
int CMobot::moveWait();
```

Purpose
Wait for all joints to stop moving.

Return Value
The function returns 0 on success and non-zero otherwise.

Description
This function is used to wait for all joint motions to finish. Functions such as `poseJoint()` and `moveJoint()` do not wait for a joint to finish moving before continuing to allow multiple joints to move at the same time. The `moveWait()` or `moveJointWait()` functions are used to wait for robotic motions to complete.

Please note that if this function is called after a motor has been commanded to turn indefinitely, this function may never return and your program may hang.

Example
See the sample program in Section 4.1.2 on page 11.
See Also
`moveWait(), moveJointWait()`

CMobot::moveToZero()
CMobot::moveToZeroNB()

Synopsis

```
#include <mobot.h>
int CMobot::moveToZero();
int CMobot::moveToZeroNB();
```

Purpose
Move all of the joints of a MoBot to their zero position.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters
None.

Description
This function moves all of the joints of a MoBot to their zero position. Please note that this function is non-blocking and will return immediately. Use this function in conjunction with the `moveWait()` function to block until the movement completes.

The function `moveToZero()` is a blocking function, which means that the function will not return until the commanded motion is completed. The function `moveToZeroNB()` is the non-blocking version of the `moveToZero()` function, which means that the function will return immediately and the physical robot motion will occur asynchronously. For more details on blocking and non-blocking functions, please refer to Section 6 on page 17.

Example
Please see the demo at Section 4.1.2 on page 11.

See Also

CMobot::setJointSpeed()

Synopsis

```
#include <mobot.h>
int CMobot::setJointSpeed(int id, double speed);
```

Purpose
Get the speed of a joint on the MoBot.

Return Value
The function returns 0 on success and non-zero otherwise.

Parameters

`id`	The joint number to pose.
`speed`	An variable of type `double` indicating the requested speed.

Description
This function is used to set the speed of a joint of a MoBot. Valid speed values range from 0 to 1.
Example

See Also

CMobot::stop()

Synopsis

```
#include <mobot.h>
int CMobot::stop();
```

Purpose
Stop all current motions on the MoBot.

Return Value
The function returns 0 on success and non-zero otherwise.

Description
This function stops all currently occuring movements on the MoBot. Internally, this function simply sets all motor speeds to zero. If it is only required to stop a single motor, use the `setJointSpeed()` function to set the motor's speed to zero.

Example

See Also
`setJointSpeed()`

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