Wireless Networked Autonomous Mobile Robot with HAWK Animated Head System

Sputnik^3

Quick Start Guide

WARNINGS

Do NOT power on the robot before reading and fully understanding the operation procedures explained in this manual.

Never position your finger(s) in between the head's moving parts even when the power is off.

The robot head must be positioned to the rest position before turning on the robot.

Neither the robot, nor the program is bug free, accidence could happen; you have to make sure that the robot always maintains a safe distance from people during operation.

The robot should be turn off (i.e. the power switch should be on OFF position) when not in used. Battery should be fully charged before storage. Battery pack should be recharged every two weeks while in storage.

Failure to follow these warnings could cause serious injury or death and/or damage to the robot.

Copyright Statement

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Introduction

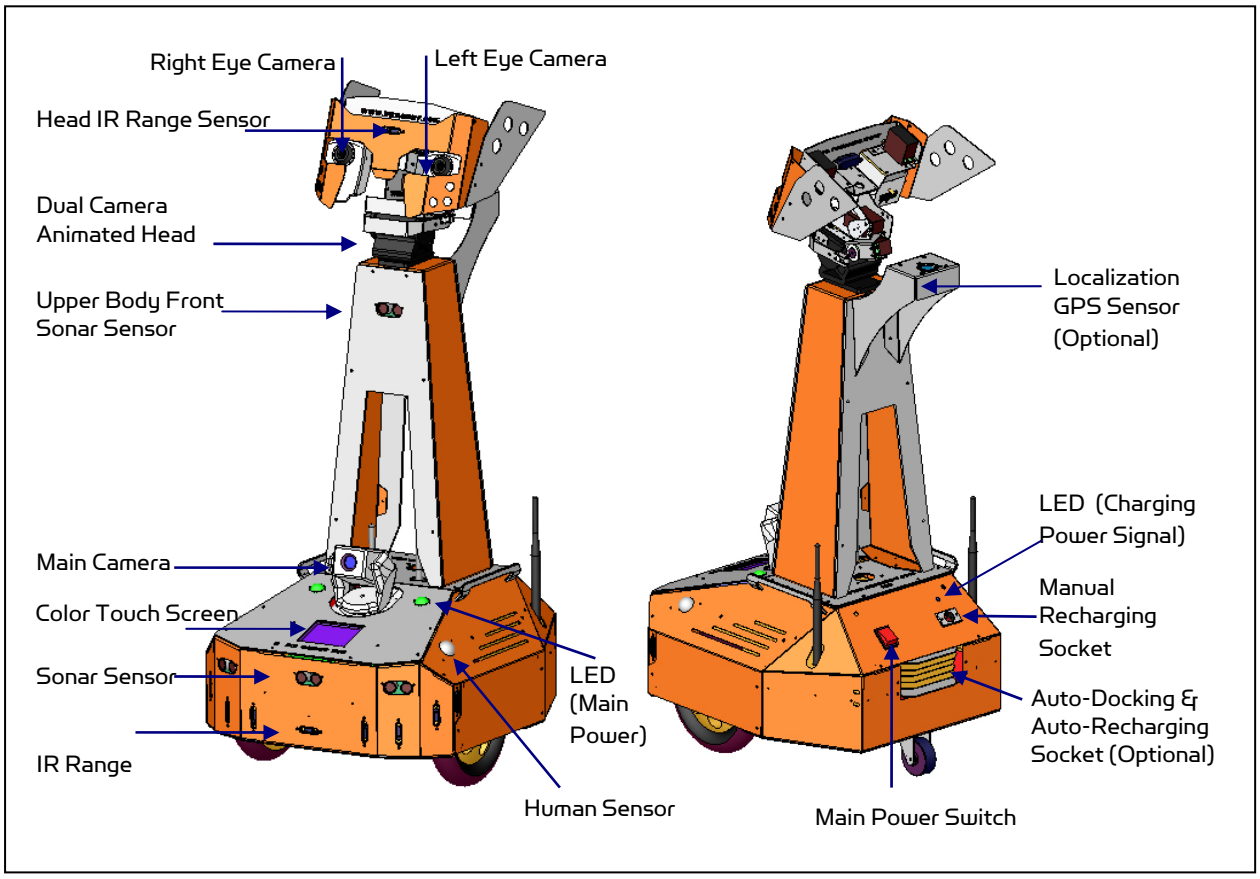
Sputnik[3] is designed and built on i90 robot base, featuring dual-camera animated head (HAWK head).

Key Features

- *6DOF animated head with dual 640x480 color cameras*
- *3.5 inch color display, playing video (.wmv), audio and displaying images*
- *Overall height of 90cm; Dimension 43cm (L) x 38cm(W) x 90cm (H)*
- *Fully wireless networked 802.11g*
- *OS independent application development tools*
- *Max speed of 75cm/sec*
- *Navigation sensors including 4 sonar and 10 IR range sensors*
- *Comprehensive circuit protection*
- *High resolution pan-tilt-zoom camera*
- *Max payload 10 kg (optional 40 kg) with robot weight of 8 kg*
- *Tele-operation and remote monitoring*
- *Extended operating time. 2 hours nominal operation time for each recharging.*
- *Upgrade options:*
    - *Navigation and localization providing collision-free point-to-point autonomous navigation*
    - *Vision-landmark base indoor localization (indoor GPS, position/orientation) sensor and the landmarks together provide precise position and direction information covering every inch of the floor.*
    - *Auto-docking and recharging station*
    - *Laser scanner; Power and battery systems for 4, 8 hours operation time are available.*

Sensors and External Components

The figure below illustrates the key functional components you will identify on the outside of Sputnik[3] robot.

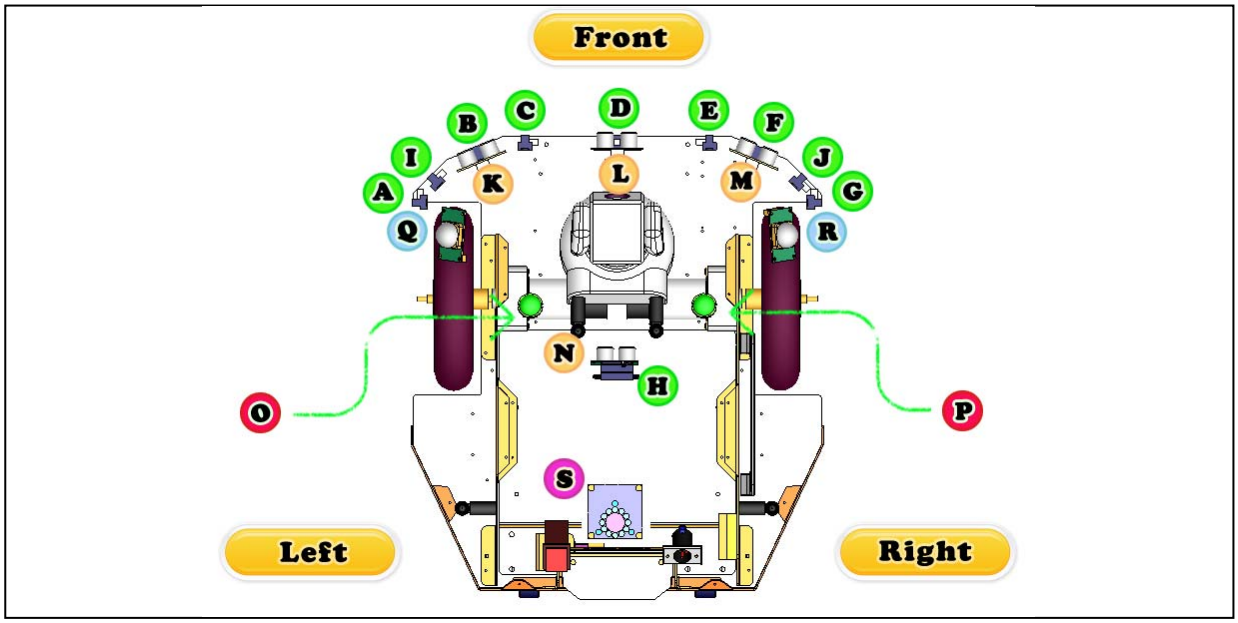


Sputnik[3] Overview

When the main power switch is on, the main power LED will be lit. When the robot detects input power from the recharging socket, the charging power signal LED will be lit.

The robot comes with 4 sonar and 10 IR range sensors. These range sensors are for environment detection and collision avoidance.

The optional localization GPS sensor on Sputnik[3] provides precise robot position and direction information for autonomous navigation docking task through working with the ceiling mounted landmarks.



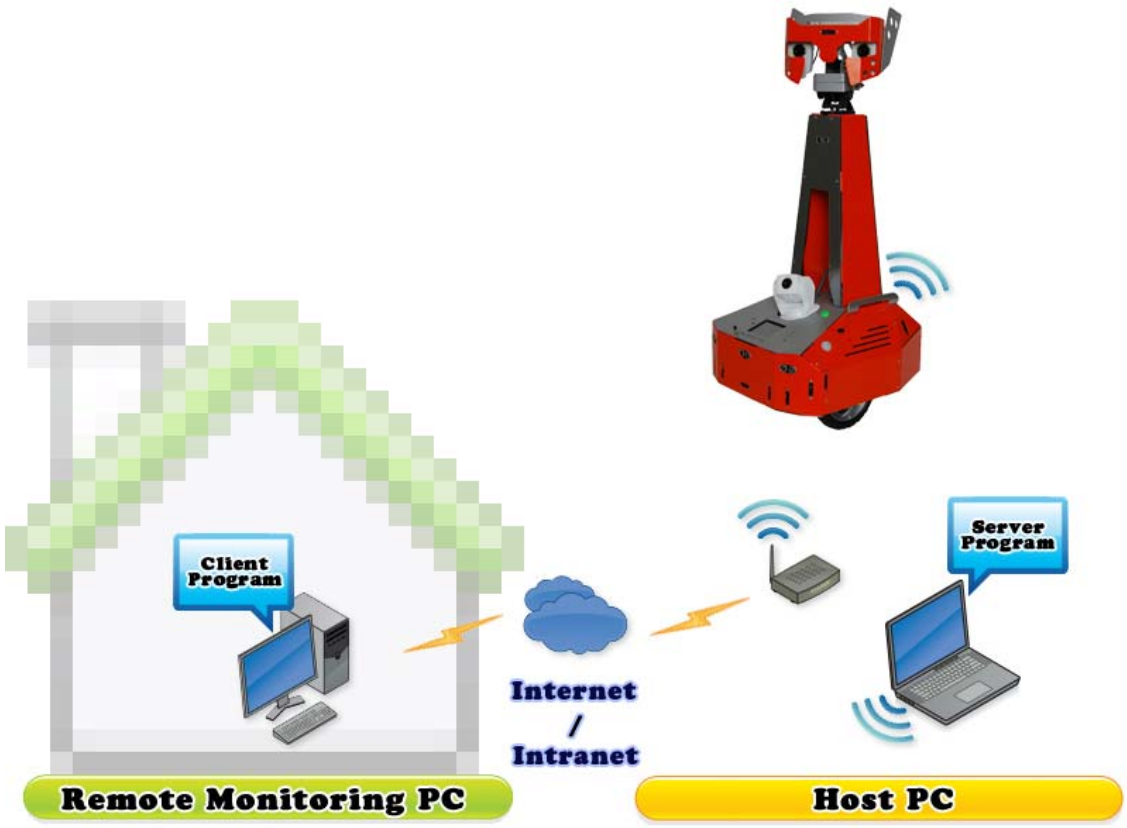
Sputnik[3] Sensor Module Location (Top View)

Sensor Module	Location
Ultrasonic #1	K - Left front
Ultrasonic #2	L - Middle front
Ultrasonic #3	M - Right front
Ultrasonic #4	N - Upper body front
Human Sensor #1	Q - Left front
Human Sensor #2	R - Right front
Infrared Range Sensor #1	A – Front left
Infrared Range Sensor #2	B – Front left
Infrared Range Sensor #3	C – Front middle
Infrared Range Sensor #4	D – Front middle
Infrared Range Sensor #5	E – Front middle
Infrared Range Sensor #6	F – Front right
Infrared Range Sensor #7	G – Front right
Infrared Range Sensor #8	H – Head front
Infrared Range Sensor #9	I – Front left
Infrared Range Sensor #10	J – Front right
DC Motor #1 with quadrature encoder	O - Left , use channel 1
DC Motor #2 with quadrature encoder	P - Right, use channel 2
Localization Sensor (optional)	S – Localization Sensor

Operation Scenario

Diagram below shows the typical operation scenario. The Sputnik[3] is a wireless networked robot. It connects to the wireless AP or router via IEEE 802.11b/g network. The host PC (or called server PC) running the Sputnik-III Control program could connect to this network via either:

- Network cable – Connect the host PC to one of the LAN ports on the back of the router (DO NOT connect to the WAN port), or
- Wireless – To connect the host PC to the wireless router, configure the host PC's wireless settings using the default wireless configuration settings found in the Network Connection session of this manual.



Typical Operation Scenario

Note: The host PC (or called server PC) could also be mounted on the robot instead off the robot if your application requires so.

User could be able to control the robot, see, talk and listen through the robot via the Dr Robot Remote Control program from anywhere around the world with Internet connection.

User could also play video, audio and displaying images on the Sputnik[3] color display.

Software Installation

Server PC

On the Server Computer, you should install the "Sputnik-III Control" program from the installation CD.

After program installation, you will find the following programs under the "Start-All Programs" list, and they are installed under the "Program Files" folder.

Dr Robot Inc – Sputnik-III Control – DrRobotDualCameraHeadControl
– DrRobotMotionPowerControl
– DrRobotLocalization-GPSSetup (optional)

Application data folder is set to "C:\DrRobotAppFile\"

You will find the following files in this folder:

DrRobotServiceConfig.xml	It contains the IP and port information about the service programs.
RobotConfig.xml	It contains the robot information, such as WiFi modules' IP, Cameras' IP, robot ID, camera user ID and password.
gatewayConfig.xml	Control Center program will save communication settings in this file. Gateway program will use it to setup communication with the robot.
WiRobotGateway.exe	This communication program will setup communication with robot.
DrRobotPortConfig.xml	
RobotHardWareConfig.xml	

Following sub-directories could be found under "C:\DrRobotAppFile\"

.\HeadMotionFile\	contains head motion script files.
.\PathFile\	contains path script files.
.\ServoConfig\	contains the head servo configure file "HeadServoConfig.xml" and arm servo configure file "ArmServoConfig.xml".
.\SensorConfig\	contains the IR Range sensor location information file "IrSensorConfig.xml" and the ultrasonic sensor location information file "UsSensorConfig.xml ".
.\Record\	contains all camera video recording files.

PDA (Color Touch Screen) on the Robot

Programs have been pre-installed on the PDA (color touch screen) on Sputnik[3].

DrRobotPDASensorClient	This program displays Sputnik[3] sensor information.

Remote Client Program on Client PC

On the client computer, you should install the "Sputnik-III Remote Control" program from the installation CD.

After program installation, you will find the following programs under the "Start -> All Programs" list, and they are installed under the "Program Files" folder.

Dr Robot Inc – DrRobotSputnikIIIRemoteControl

Application data folder is set to "C:\DrRobotAppFile\"

Following sub-directories could be found under "C:\DrRobotAppFile\"

DrRobotServiceConfig.xml It contains the IP and port information about the service programs.

RobotConfig.xml It contains the robot information, such as WiFi modules' IP, Cameras' IP, robot ID, camera user ID and password.

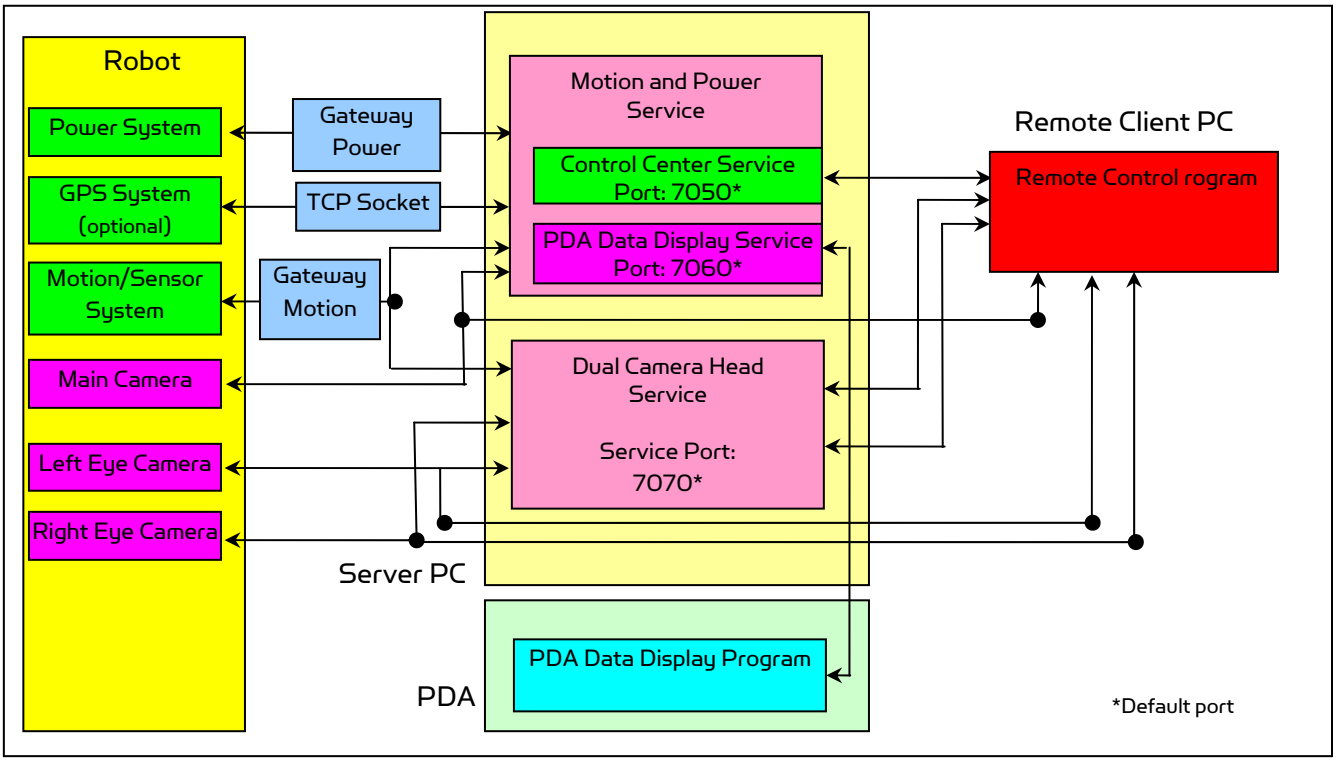
DrRobotPortConfig.xml

Following sub-directories could be found under "C:\DrRobotAppFile\"

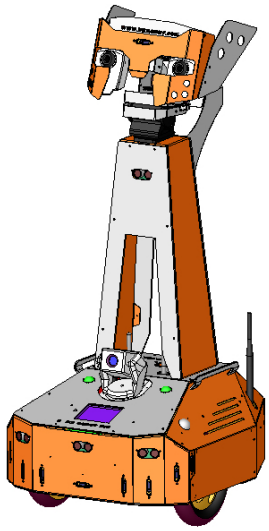
.\HeadMotionFile\ contains head motion script files.

.\ServoConfig\ contains the head servo configure file "HeadServoConfig.xml"..

.\Record\ contains all camera video recording files.



Robot Operations



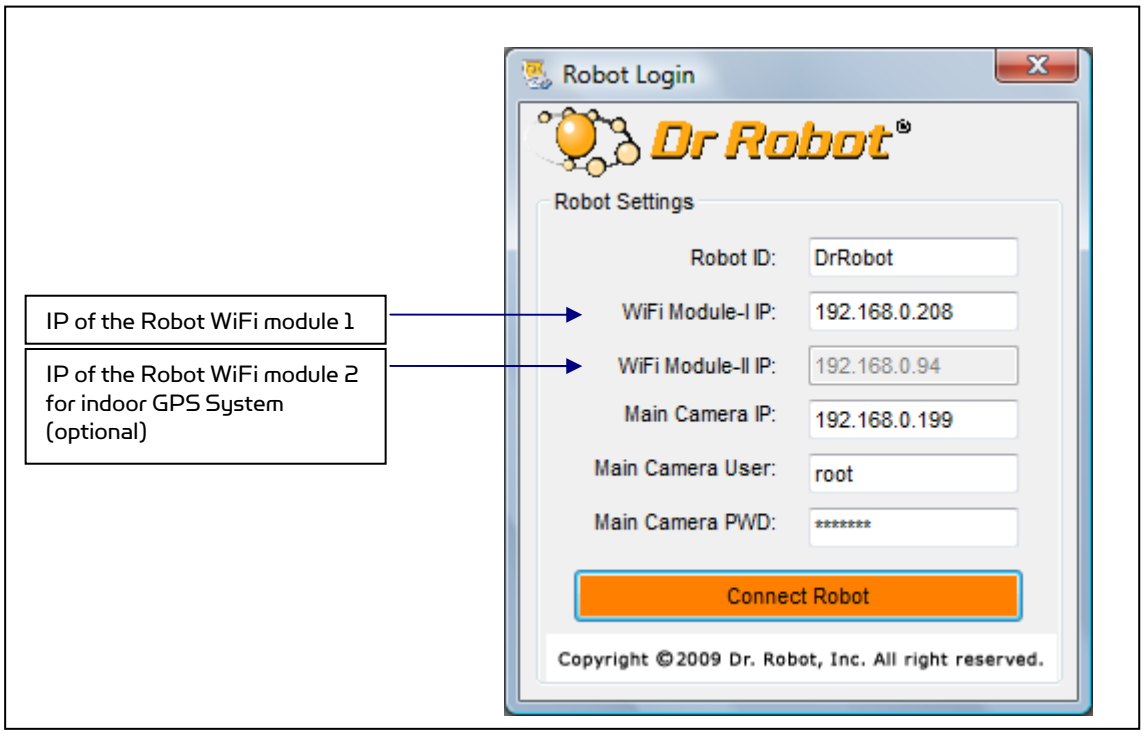
Step 1: If you have not installed the programs, insert the installation CD to CDROM and run the "Setup.exe" program which under "Sputnik-III Control Installation" folder to a PC (called server PC), set your PC IP to 192.168.0.104, Gateway: 192.168.0.200 and Subnet Mask 255.255.255.0.

Step 2: Connect the server PC to the wireless router (one of the LAN ports) (the router has IP 192.168.0.200) included in the package.

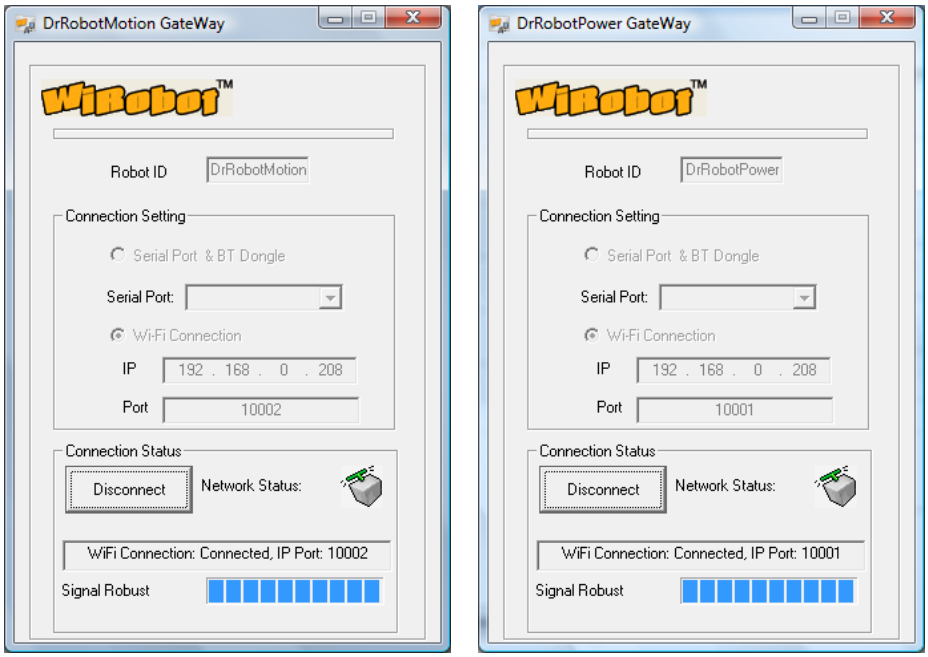
Step 3: Position the robot head to the rest position as shown on the right. This is VERY IMPORTANT for your and robot's safety.

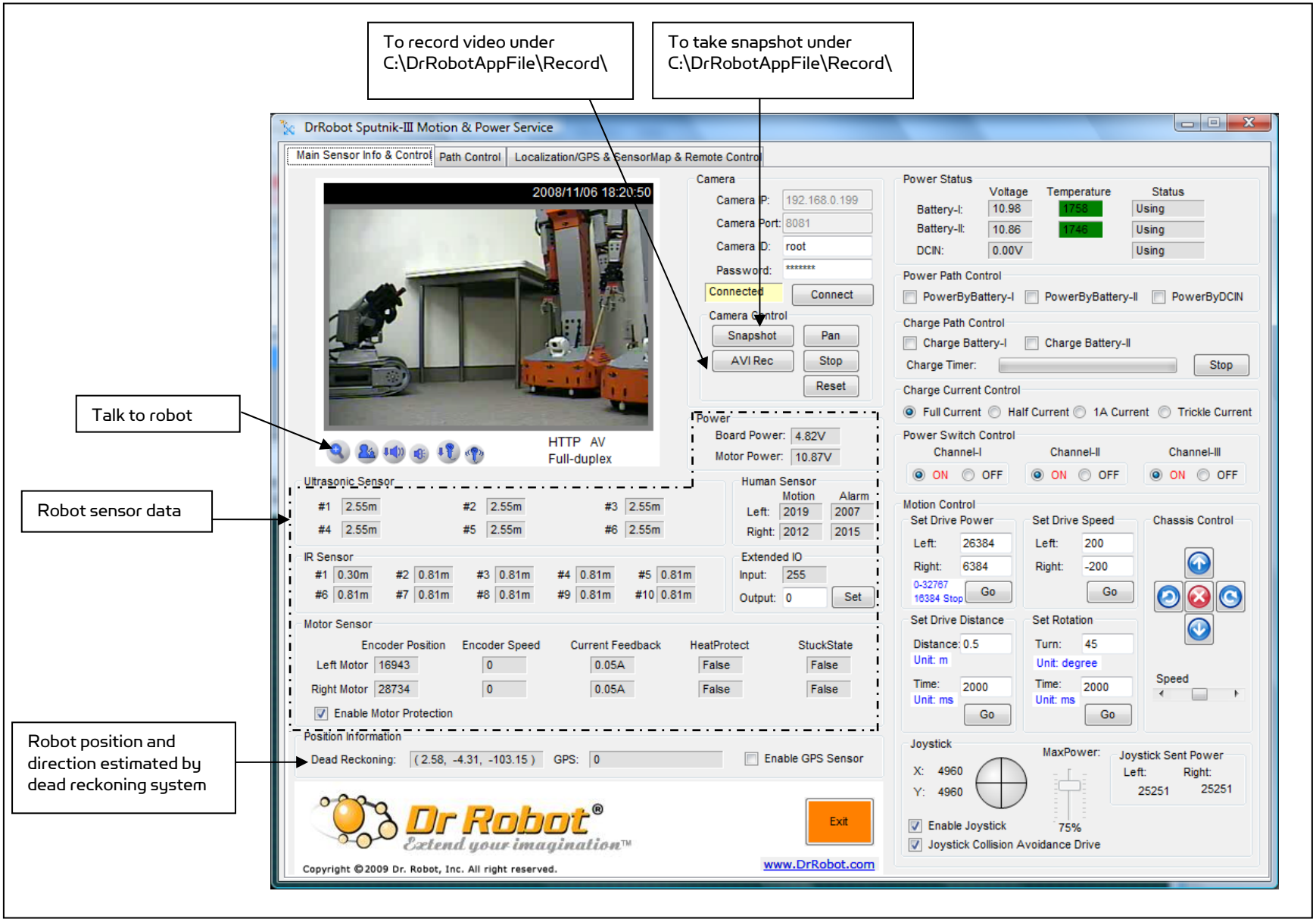
Step 4: Turn on the robot main power switch on the back. NOTE: Always keep a safe distance from the robot.

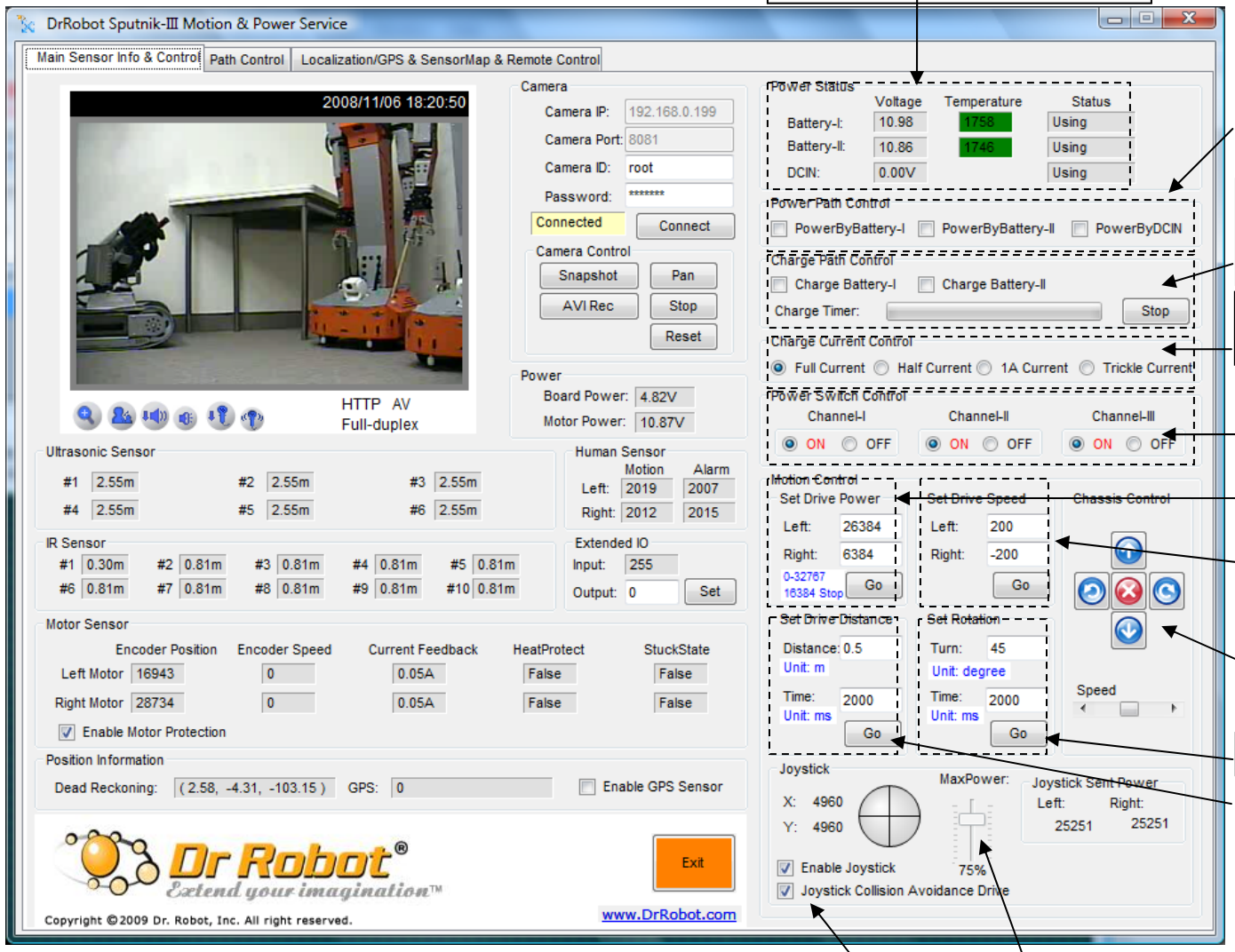
Step 5: Run the "DrRobotMotionPowerControl" from Start -> All Programs -> Dr Robot Inc -> Sputnik-III Control -> DrRobotMotionPowerControl. The "DrRobotMotionPowerControl" connect to robot via the DrRobotMotion gateway & DrRobotPower gateway programs. It requires robot information which can be found in "Networking Connection and Login Information" section. After entering or confirming the information, then click "Connect Robot".



Two gateway programs will be called up to establish communication connections with the electronic system on the robot.







Showing status of all power sources: Battery I, II and external DC input

From where the system will take power from: Battery I, II or external DC input

To control which battery or both to be charged and the max charging time

Charging speed/mode control

Power on/off the sub-systems (detail in Appendix III)

Motor PWM control

Motor speed control

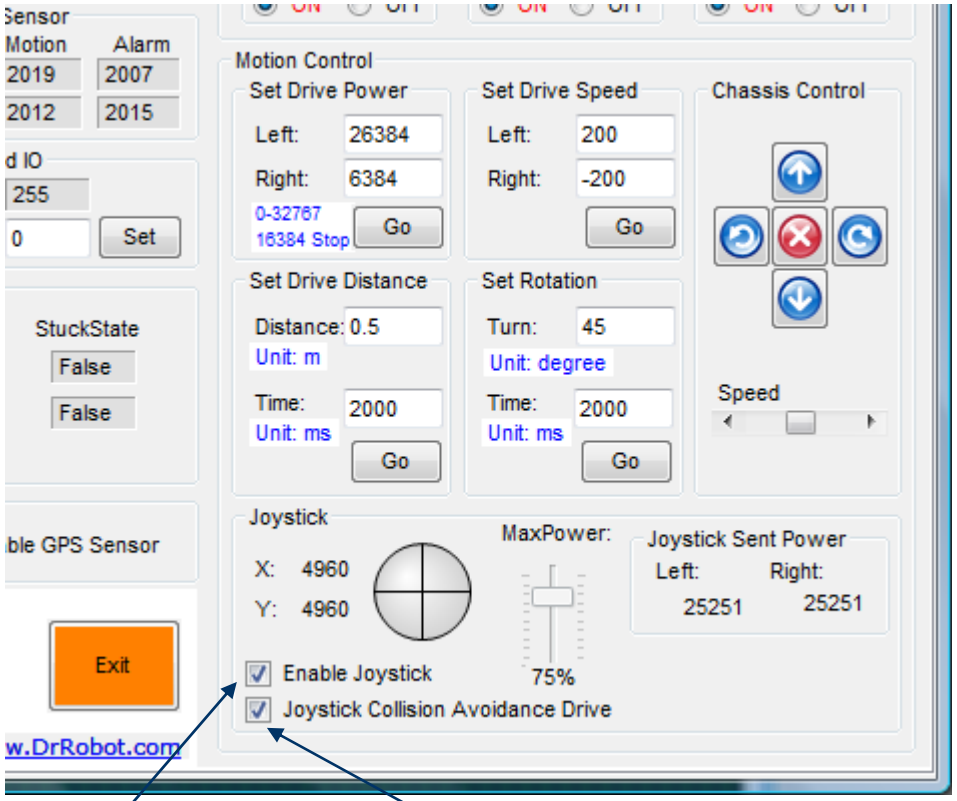
Simple motion control: drive forward, backward, left, right and stop

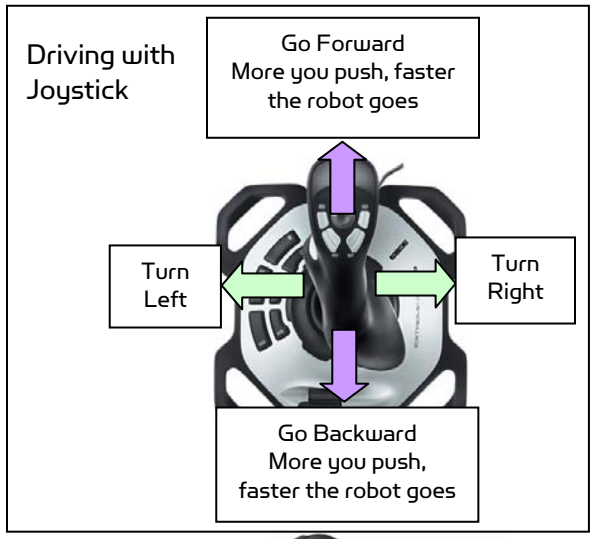
To turn within set time

Drive forward (set distance) within set time

When checked, autonomous collision avoidance feature will be activated during the joystick control

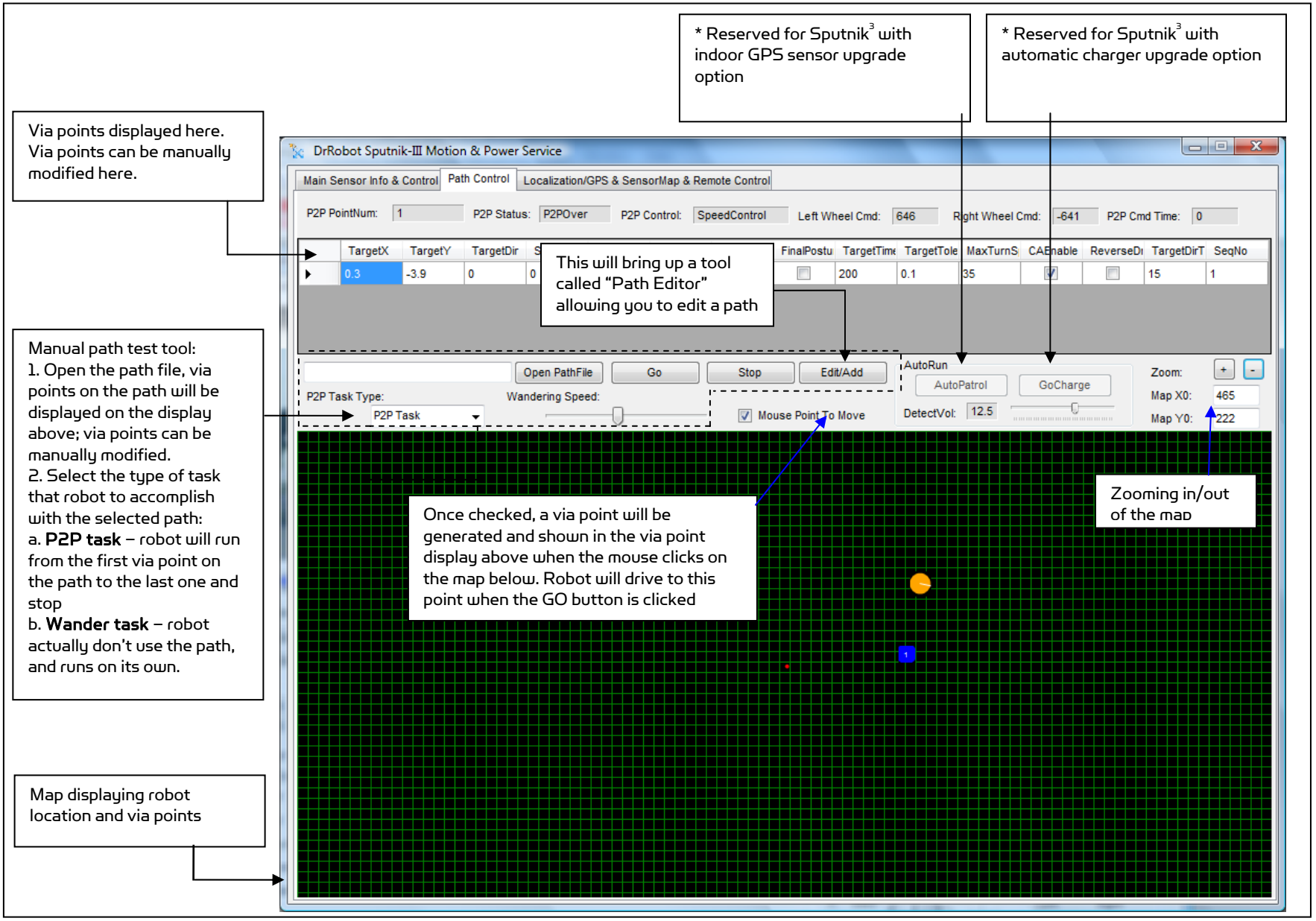
Max power output when joystick is fully pushed



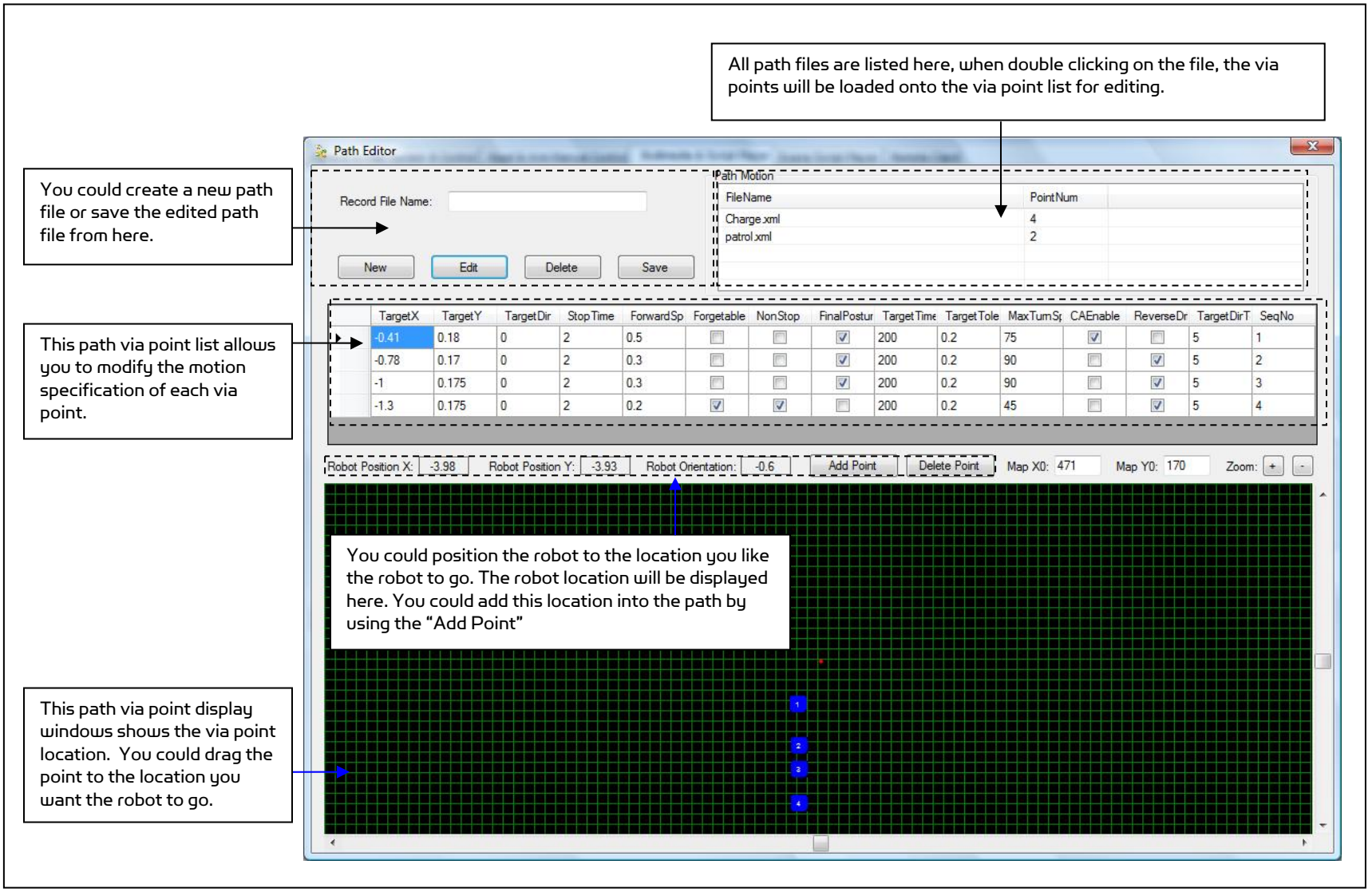


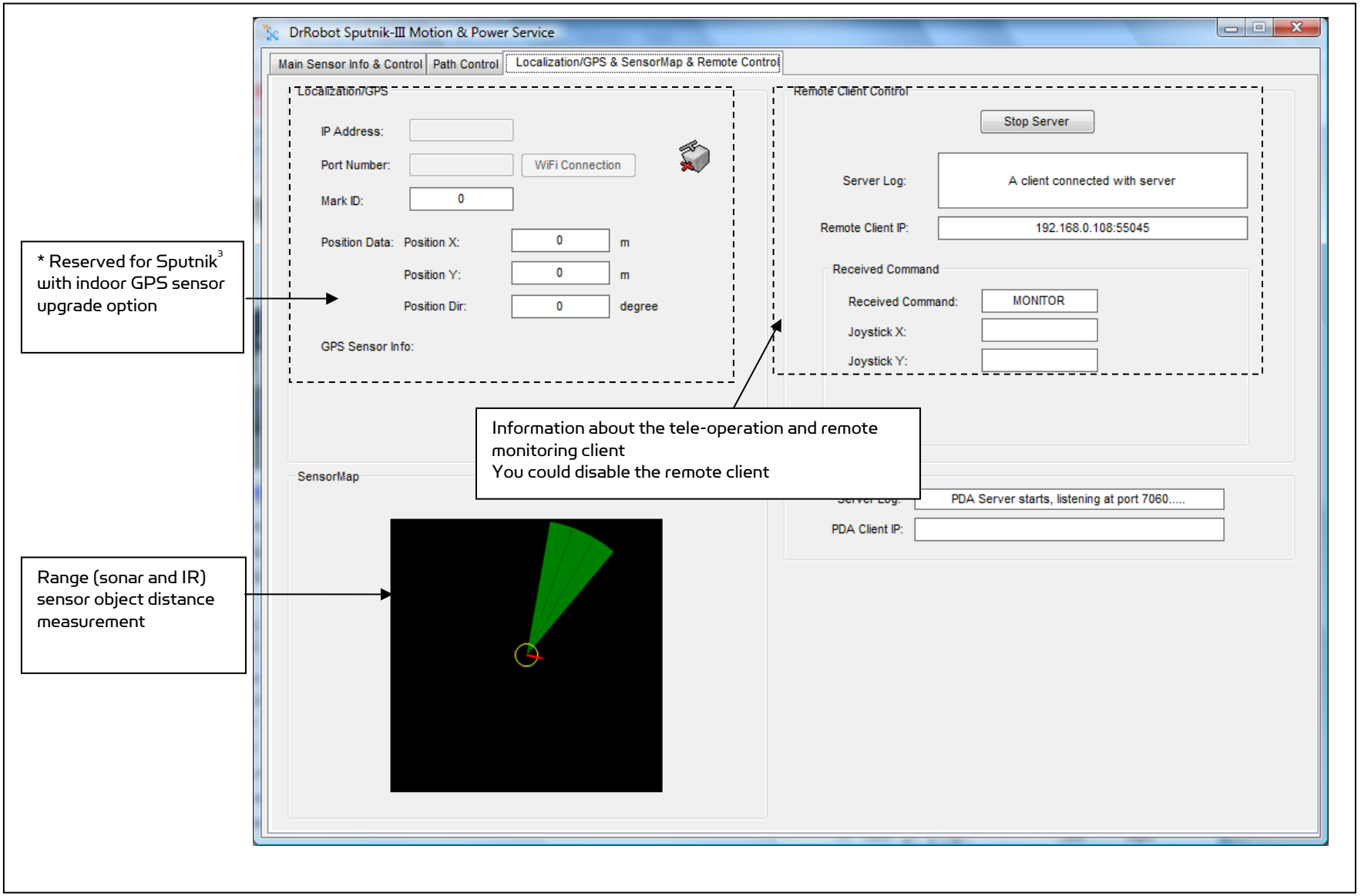
To Enable Joystick Control

Robot base collision avoidance feature is enabled by default. During joystick operation, you could temporally disable this feature by holding the side button (#2) on the joystick handle (as shown above)

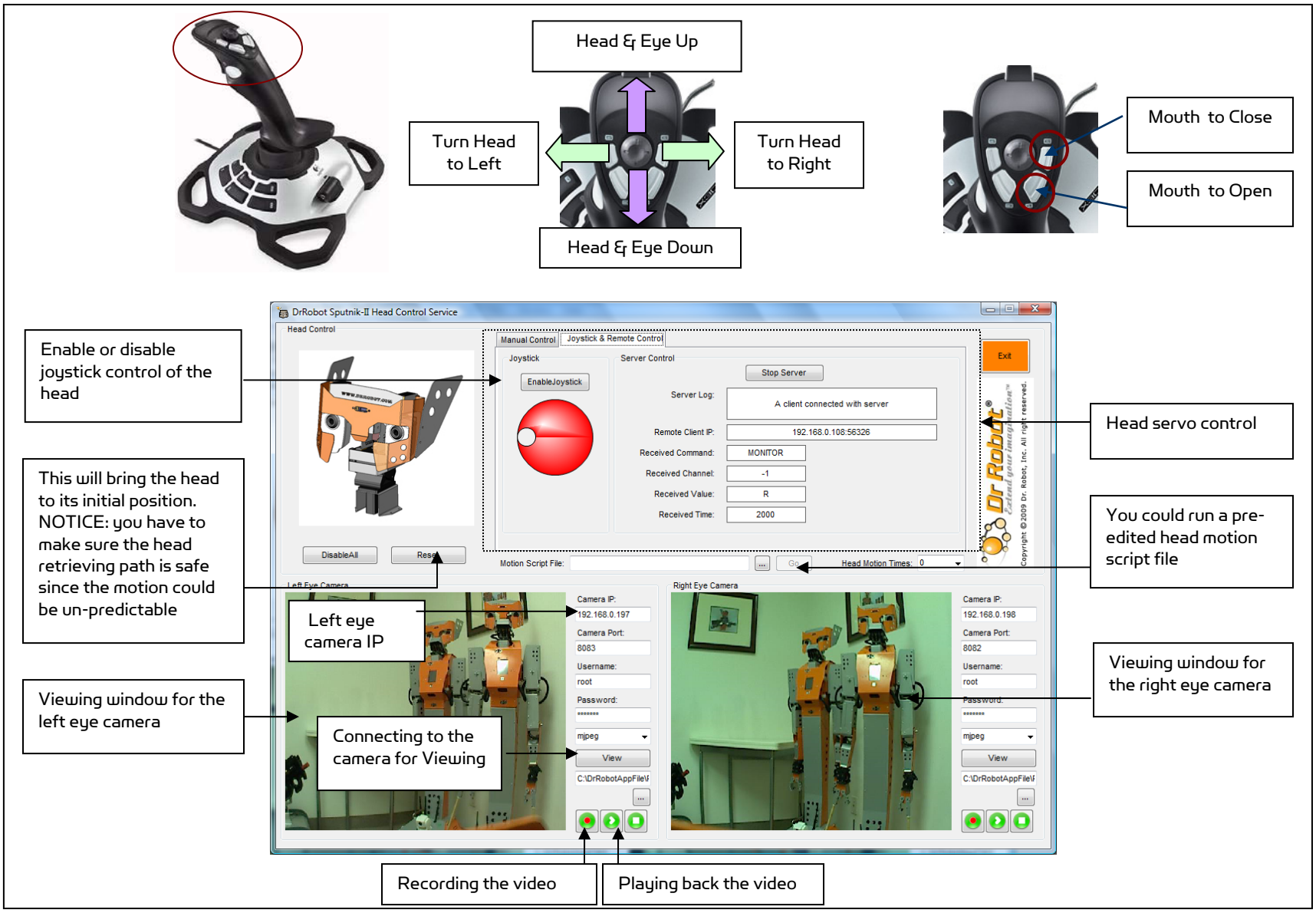


The Path Editor opened from the "Path Control" allows you to edit a path file such as the charging and patrol path

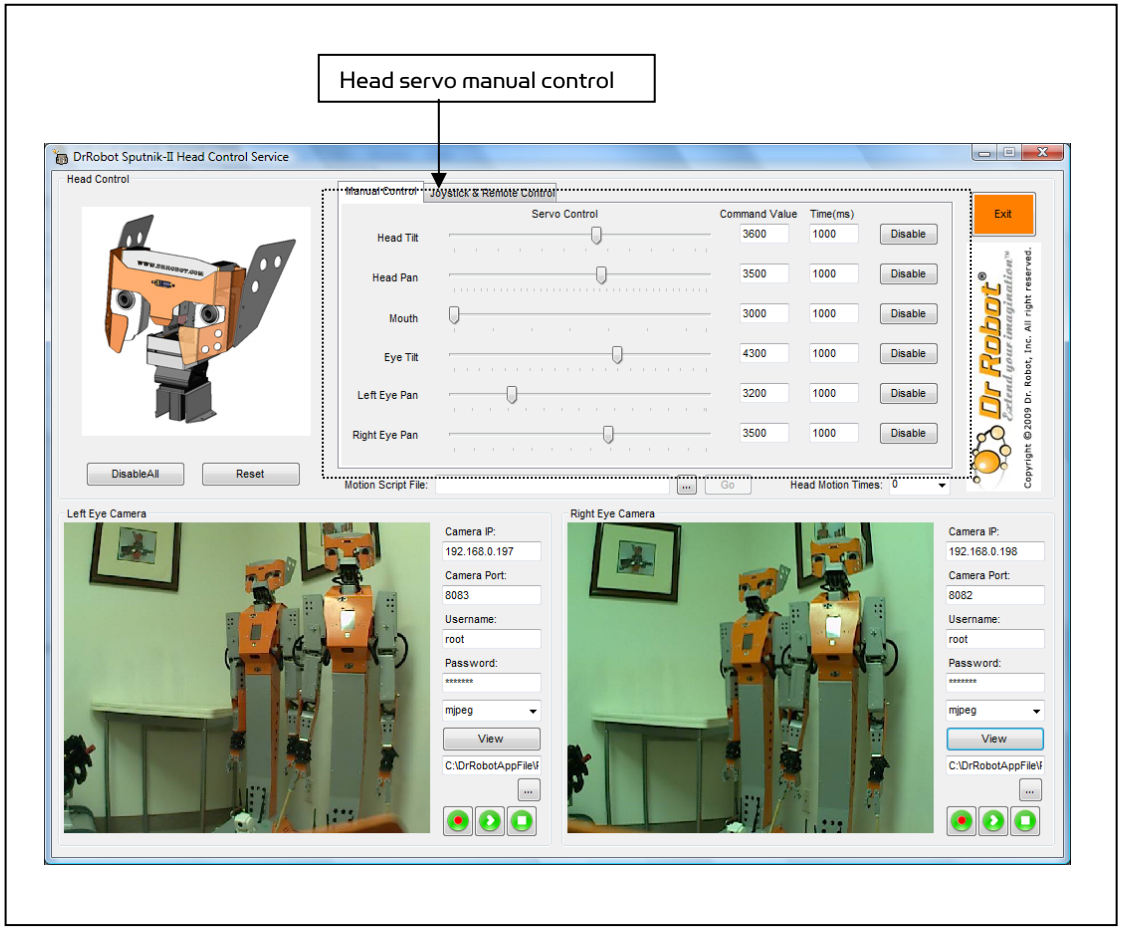




Step 6: Run DrRobotDualCameraHeadControl program. It provides motion control of the animated head and functions to the two eye cameras. You could run pre-edited head motion script files (.xml). The format and sample head motion script file can be found in Appendix II. You could control the head movement manually (through the "Manual Control" tag) or by the included joystick (NOTE: Do not forget to enable the joystick first).



You could also manually control the head motion joint by joint through the “Manual Control” tag.



Remote Monitoring and Tele-operation

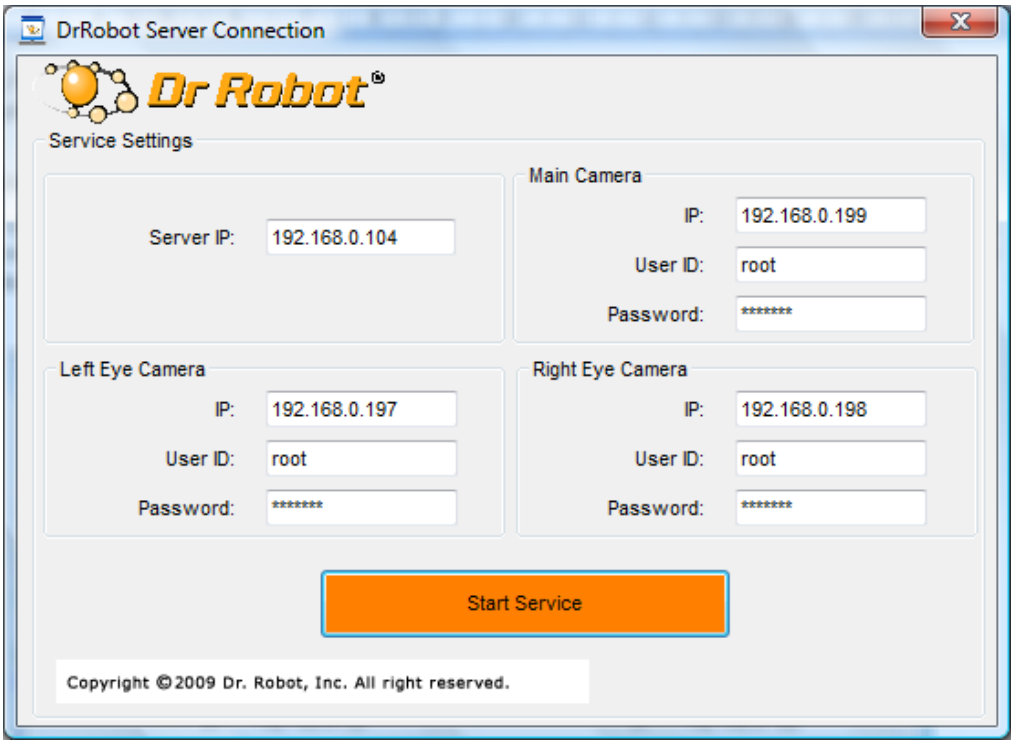
Step 1: If Internet remote monitoring/control is required, you need to connect the wireless router WAN port to your broadband Internet modem. You need to find out the public IP assigned by your ISP. (you should be able to find this information from the router status page) This IP will be used by the remote client to connect to the host PC and the devices on the robot.

If firewall is in-place in your network, you also need to make sure all the network ports used by the wireless devices (e.g. the 8081, 8082, 8083, 8084 for cameras), 7030 and 7040 on the server and remote client sides are not blocked for the Internet remote monitoring/control tasks to operate properly.

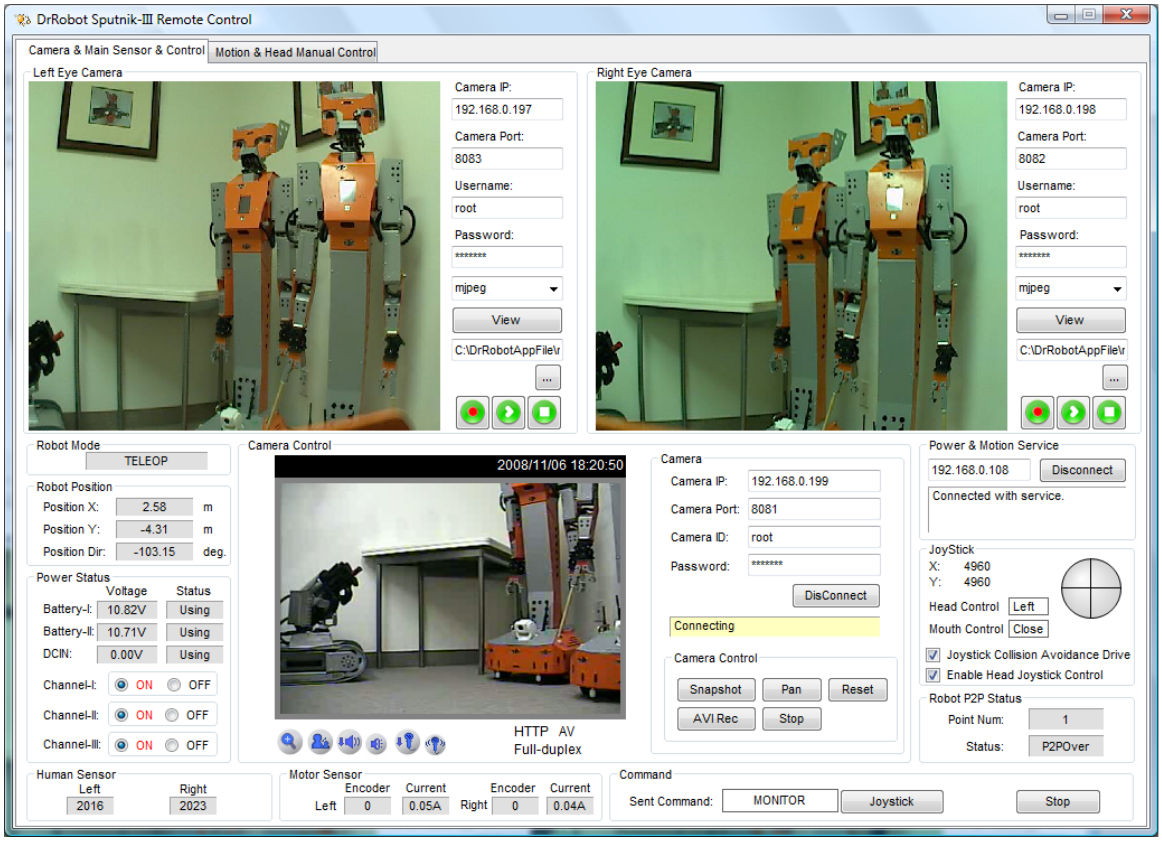
Step 2: Installing the Sputnik-III Remote Control program from the installation CD. "DrRobotSputnik-IIIRemoteControl" program allows you to remotely control the robot, obtain main robot sensor information, view, listen and talk through robot.

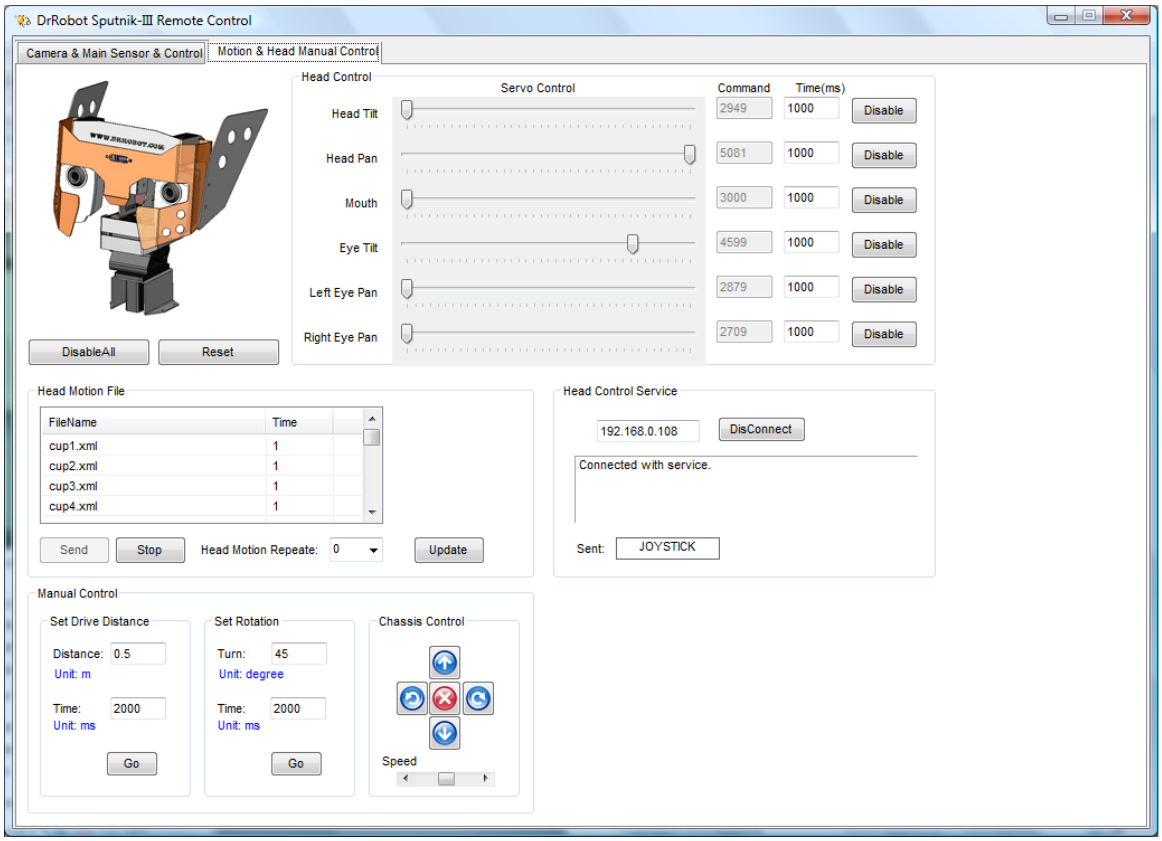
Step 3: Run the DrRobotSputnik-IIIRemoteControl program.

Step 4: Enter or confirm the remote server and other devices' IP. When you are connecting from public network, your server IP must be a public IP, and with the pre-configured router settings, all the devices on the robot will share the same public IP with the server IP. Then click the "Connect".



Step 5: After login, the DrRobotSputnik-IIIRemoteControl program will look as below.





Recharging

To keep the battery at ideal condition, we recommend recharging the robot at least once every two weeks during storage (e.g. robot is not in use).

Plug the charging plug from the portable charger onto the secondary recharging socket on the back of the robot, **and then turn on the robot.** The charging process will normally take about 2 hours if the battery power is totally exhausted. The charging process will automatically stop when completed.

Further Development & Programming

The Sputnik[3] Control program is written with C# program with Visual Studio 2008 express under .Net 3.5 framework. You could download the development tools (Visual Studio 2008 express under .Net 3.5 framework) free from Microsoft. Please refer to the "Dr Robot Application Development Notes on C# Programming for Robot Control" for further information.

The control program uses the supporting components and libraries that should have been installed when you install the control program from the installation CD:

1. **DRROBOTSentinelCONTROL.OCX:** Please refer to "WiRobot SDK API Reference Manual.pdf" for detail.
2. **WiRobotGatewayPlus.exe**
3. **DrRobotSensorMapBuilder.dll:** This dll file provides functions to build the environmental map for collision avoidance feature.
4. **DrRobotP2PSpeedDrive.dll:** This dll file provides functions to drive a robot form one specific point to another.
5. **DrRobotConstellation.dll**: Sputnik[3] robot uses the sonar based Constellation indoor GPS localization system. This dll file provides the functions to locate the robot position with the Constellation system.
6. **DrRobotGPS.dll** Sputnik[3] use the vision-landmark based indoor GPS localization system. This dll file provides the functions to locate the robot position with vision based GPS system.
7. **VitaminControl.dll** This is the camera control component for the Pan-Tilt-Zoom camera (P/N: AV-PTZ-VH) used for i90 robots such as Sentinel –II, Sentinel-III, and Sputnik[3]. Please refer to "PTZ Camera ActiveX Control Reference Manual.pdf" for detail.
8. **AXIS Media Control Library Set** These are the camera control component for the AXIS Mini Camera (P/N: AXCAM) used for the Dual-camera Head and Scout arm. Please refer to "AXIS Media Control SDK Help" for detail.

For support on development using Microsoft Robotics Studio, operation system other than MS Windows, or raw communication protocol, please contact support@DrRobot.com.

Network Connection and Login Information

Network Settings

As default, your PC running the Sputnik-III Control program should have IP settings as below:

Name	**Server PC**	**IP (Port)**	192.168.0.104
Gateway	192.168.0.200(Router IP)	**Subnet Mask**	255.255.255.0

The included pre-configured wireless 802.11 b/g router has the following pre-set settings:

SSID	dri	**Router LAN**	192.168.0.200
WEP	128bits	**Login ID**	admin
KEY	11223344556677889 9AABBCCDD	**Password**	drrobot
Key Type	Open Key		

with virtual server settings as followings:

Virtual Server	Port	Protocol	Server IP
Sputnik-III Remote Control program	7050,7070	TCP/IP	192.168.0.104
Main PTZ Camera	8081	TCP/IP	192.168.0.199
Left Eye Camera	8083	TCP/IP	192.168.0.197
Right Eye Camera	8082	TCP/IP	192.168.0.198

WiFi module connects to two serial devices through channel I and II (TCP/IP port 10001 and 10002 respectively). They are pre-configured as below:

Name	**Robot WiFi Module 1**	**IP**	192.168.0.208
Channel-I (10001)	115200, 8,N,1, no flow control, UDP, Datagram 01, remote IP:0.0.0.0	**Channel-II (10002)**	115200, 8,N,1, flow control, UDP, Datagram 01, remote IP:0.0.0.0

Other wireless devices settings are listed below:

Name	IP (Port)	Login	Password
Main PTZ Camera	192.168.0.199 (8081)	root	drrobot
Left Eye Camera	192.168.0.197 (8083)	root	drrobot
Right Eye Camera	192.168.0.198 (8082)	root	drrobot

Advanced Network Settings

It's possible to use different network settings (e.g. IP) for the server PC, but the "Virtual Server" settings on the router must also be changed accordingly in order for the Internet remote monitoring feature to work properly.

You could also change the router settings such as IP and SSID etc. If you need to do so, you are required to change the network settings on the WiFi modules on the robot by following the guidelines as illustrated on the WiFi Module manual.

Appendix I Power Switching Control

Three power sub-systems as defined below could be turn on or off individually through the "DrRobotMotionPowerControl" or "DrRobotSputnik-IIIRemoteControl" Program.

Channel-I	DC-DC board –I	Main Camera (12V)
Channel-II	DC-DC board –I	1. PMS5005 Main power (5V)
		2. PDA, LED 5V
Channel-III		Left Eye Camera, Right Eye Camera power 5.1V
		Head Servo Power 6V

Appendix II Servo Control for Sputnik^3 Animated Head

Sputnik^3 animated head uses RC servo motors. RC Servo motor position is defined by the pulse width from the control signal line. The pulse width value in milliseconds for specific position (e.g. 0°, 90° and 180°) is servo manufacturer and model depending.

The conversion between the servo command used in the Sputnik^3 Control programs and the pulse width is:

The servo command = 2250 * Pulse Width in millisecond.

The max, min and initial servo position (in servo command) are defined in HeadServoConfig.xml for the Sputnik^3 animated head respectively. Servo motion (e.g. joint motion) range will be limited therefore by the max and min value specified in these files.

Appendix III Head Motion Script File

Here is the sample head motion script file extracted from "yes.xml" that can be found under C:\DrRobotAppFile\HeadMotionFile\

Note, the servo command values are NOT the absolute servo command value, they are the difference relative to the servo initial value (initial servo position in servo command are defined in HeadServoConfig.xml).

```
<HeadServoMotionTable
xmlns="http://tempuri.org/headServoMotionTable.xsd">
    <ServoMotionStep>
    <Servo1>0</Servo1>
    <Servo2>0</Servo2>
    <Servo3>0</Servo3>
    <Servo4>0</Servo4>
    <Servo5>0</Servo5>
    <Servo6>0</Servo6>
    <Time>1000</Time>
    </ServoMotionStep>

    <ServoMotionStep>
    <Servo1>300</Servo1>
    <Servo2>0</Servo2>
    <Servo3>0</Servo3>
    <Servo4>0</Servo4>
    <Servo5>0</Servo5>
    <Servo6>0</Servo6>
    <Time>1000</Time>
    </ServoMotionStep>
```

(continued…)

```
        <ServoMotionStep>
        <Servo1>-600</Servo1>
        <Servo2>0</Servo2>
        <Servo3>0</Servo3>
        <Servo4>0</Servo4>
        <Servo5>0</Servo5>
        <Servo6>0</Servo6>
        <Time>2000</Time>
        </ServoMotionStep>

        <ServoMotionStep>
        <Servo1>600</Servo1>
        <Servo2>0</Servo2>
        <Servo3>200</Servo3>
        <Servo4>0</Servo4>
        <Servo5>0</Servo5>
        <Servo6>0</Servo6>
        <Time>2000</Time>
        </ServoMotionStep>
    …
```