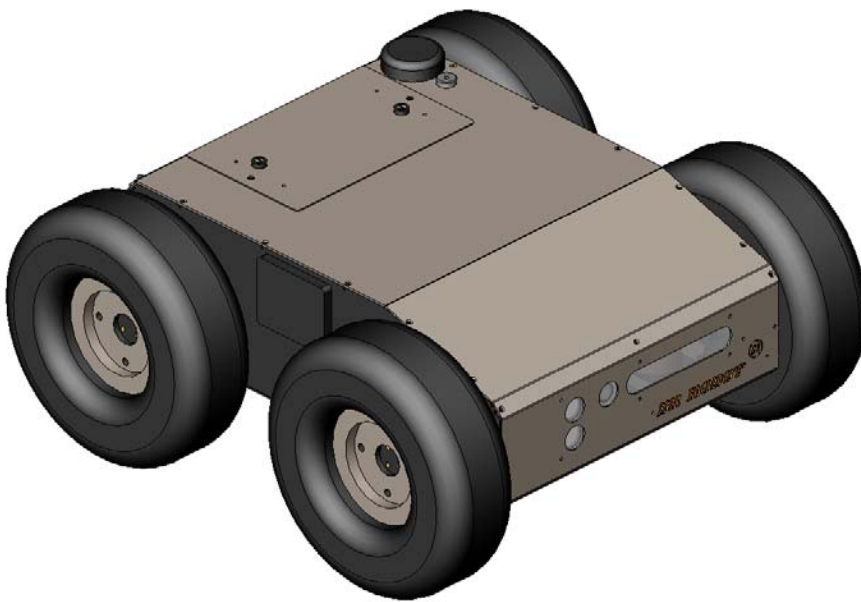




All-Terrain Autonomous Navigation Robot with GPS-IMU

# Jaguar 4x4 Wheel

## User Guide



## WARNINGS

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

Always **charge** the battery when battery is running low or before storage.

Always **turn your robot off** when not in use. Over-draining the battery (such as keeping the robot on without charging) will damage the battery.

Never position your finger(s) in between the track and/or arm's moving parts even when the power is off.

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

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

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

## Copyright Statement

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[www.DrRobot.com](http://www.DrRobot.com)

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# I. Specifications

Jaguar-4x4-wheel Mobile Robotic Platform is designed for indoor and outdoor operation requiring higher ground clearance and faster maneuverability. Jaguar-4x4-wheel platform is a wheeled version of the Jaguar-Lite platform. Jaguar-4x4-wheel is driven by four powerful (80W) motors, one for each wheel. Jaguar-4x4-wheel platform is rugged, light weight (< 20Kg), fast (max 11km/hr), with high ground clearance (88mm), compact, weather and water resistant. It is designed for tough terrains and capable of running over vertical step up to 155mm and climbing up low rise stairs (up to 110mm step). Jaguar-4x4-wheel is fully wirelessly (802.11G) connected. It integrates outdoor GPS and 9 DOF IMU (Gyro/Accelerometer/Compass) for autonomous navigation. The integrated high resolution video/audio and laser scanner (optional) provide remote operator detail information of the surrounding. Besides the ready to use control and navigation software, a full development kit including SDK, data protocol and sample codes, is also available.

## Key Features

- Rugged and reliable mobile platform for indoor and outdoor applications with faster maneuverability (max 11Km/hr) and high ground clearance
- Indoor and outdoor operation requiring higher ground clearance and on tough terrains
- Weather and water resistant enclosure
- Climbing up > 45° slope and stairs (max 110mm or 4.5")
- Light weight (< 20Kg) and compact design with large payload capacity
- Autonomous navigation with outdoor GPS and 9 DOF IMU (Gyro/Accelerometer/Compass)
- Managing max 155mm (6") vertical step (obstacle)
- Surviving max 1200mm (4ft) drop to concrete
- Integrated Laser scanner (Optional)
- Integrated high resolution video camera with audio
- All 802.11G (optional 802.11N) wirelessly connected
- Head mounted display (optional) and Gamepad controller providing outdoor operation with large and clear view even under direct sunlight
- Ready to use control and navigation software
- Full development kit including SDK, data protocol and sample codes, supporting Microsoft® Robotics Studio, Microsoft® Visual Studio, NI LabVIEW®, MATLAB®, Java®

### Mobility

Terrain: Sand, rock, concrete, gravel, grass, soil and others wet and dry

Slope: > 45°

Maximum vertical step: 155mm (6")

Stair climbing: Max stair step height 110mm (4.5")

Traverse: > 200mm (8")

Speed: 0 – 11Km/hr

Turning radius: 0, min 750mm (29.5") diameter of turning space

Ground clearance: 88mm (3.5")

Operator remote control

Autonomous navigation with GPS and 9 DOF IMU (Gyro/Accelerometer/Compass)

Indoor vision landmark GPS (Optional)

### Survivability

Sealed weather resistant enclosure

Temperature: -30° to +50°

Shock resistant chassis  
Drop to concrete: Max: 1200mm (4ft) Rated: 900mm (3ft)

#### Electronics

Motion and sensing controller (PWM, Position and Speed Control)  
5Hz GPS and 9 DOF IMU (Gyro/Accelerometer/Compass)  
Laser scanner (4m or 30m) (Optional)  
Temperature sensing & Voltage monitoring  
Headlights

#### Video / Audio

Color Camera (640x480, 30fps) with audio

#### Communication

WiFi 802.11G (Optional WiFi 802.11N)  
Ethernet (Optional)

#### External Auxiliary Ports

Ethernet (Optional)  
General purpose communication and power port (Optional)

#### Operator Control Unit

Gamepad controller  
Head mounted display (dual 640 x 480), equivalent to 60" display viewed in 2.7m (9 feet) (Optional)  
Portable computer (Optional)

#### Power

Rechargeable battery: LiPo 22.2V 10AH  
LiPo battery charger  
Nominal operation time: 2 hours (Optional 4 hours)

#### Motor

Wheel Motors (24V): 4 units  
Max output (after gear down) (x4): Max 80W, 100Kg.cm/wheel  
Rated current: 2.75A, Max current: 16A

#### Dimensions

Height: 265mm (10.5")  
Width: 573mm (22.5")  
Length: 615mm (24")  
Weight: 20Kg (Standard Configuration)

#### Payload

Carrying Payload (on flat surface): max 30Kg  
Dragging Payload (on flat surface): max 50Kg

#### Application Development

Full development kit including SDK, data protocol and sample codes, supporting Microsoft® Robotics Studio, Microsoft® Visual Studio, ROS, NI LabVIEW®, MATLAB® and Java®

Microsoft **ROBOTICS STUDIO**



Visual Studio



LabVIEW

MATLAB



ROS



## Jaguar Core Components

JAGUAR4x4W-ME	Jaguar 4x4 Wheel Chassis (including motors and encoders)	1
PM55005-J4W	Motion and Sensing Controller (Jaguar 4x4 Wheel Version)	1
WF5802G	WiFi 802.11b/g Wireless Module	1
DMD1200	12A (peak 25A) Dual-channel DC Motor Driver Module	2
PMCHR12	DC-DC Power Board	1
AXCAM-A	640x480 Networked Color Camera (max. 30fps) with Two-Way Audio	1
OGP501	Outdoor GPS Receiver with 5Hz Update Rate and WAAS	1
IMU9000	9 DOF IMU (Gyro/Accelerometer/Compass)	1
WRT802G	802.11b/g wireless AP/router	1
BPN-LP-10	22.2 V 10 AH LiPo Battery Pack	1
LPBC5000	2A LiPo Battery Charger	1
GPC0010	Gamepad Controller	1

## Main Upgrade Options

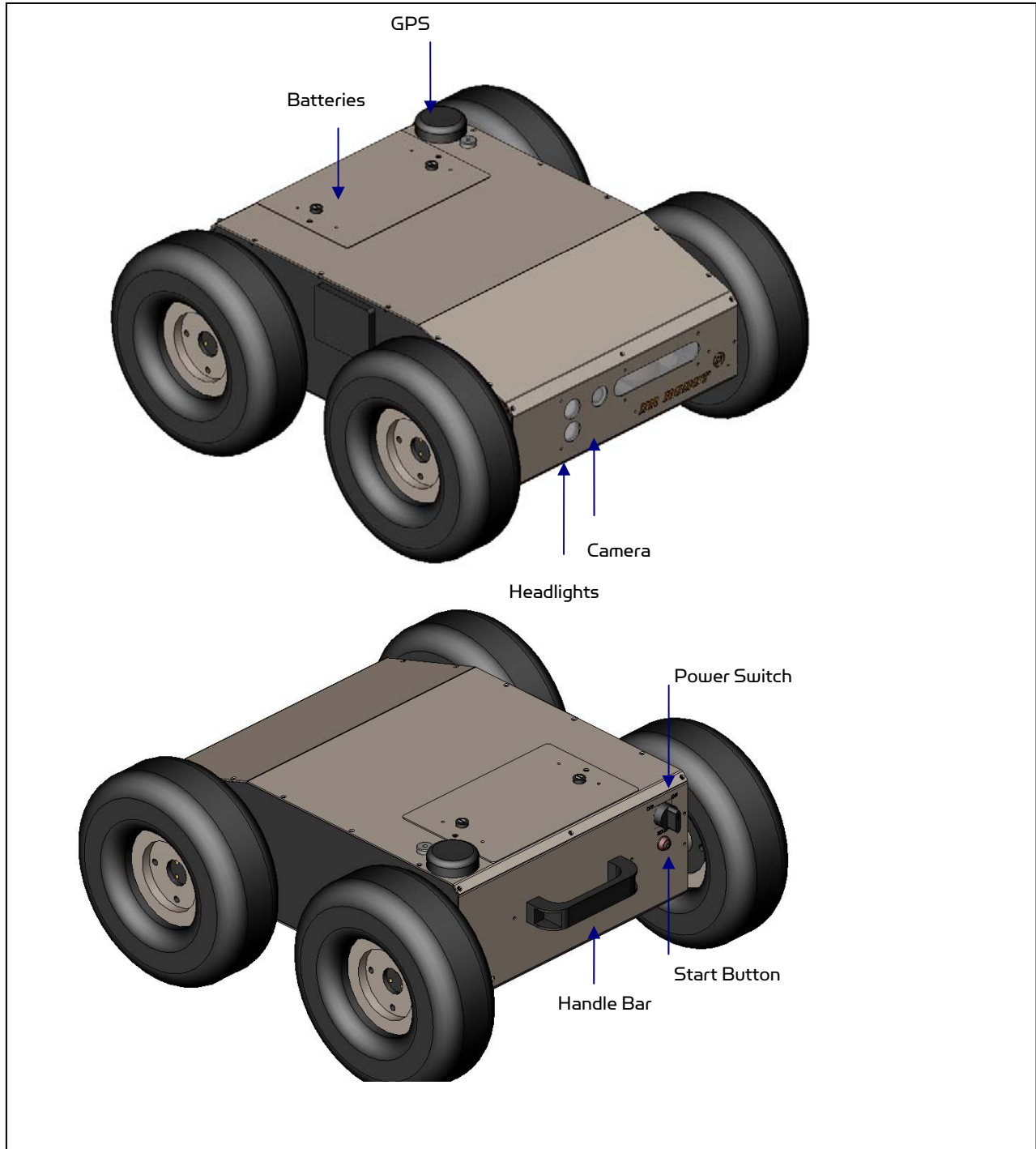
Laser Scanner (Range 4m) for Indoor Application	LAS04M
Laser Scanner (Range 5.6m) for Indoor Application	LAS04M
Laser Scanner (Range 30m) for Outdoor Application	LAS30M
22.2V 20 AH Li-Polymer Battery Pack Upgrade	BPN-LP-20
Head Mounted Display (800x600)	HMD8H6H
802.11N Wireless AP/Router	WRT802N
Host Controller PC	HCPC1008

Please contact [support@drrobot.com](mailto:support@drrobot.com) for custom design and integration inquiry.

## II. Knowing Your Robot

### Overview

The figure below illustrates the key components that you will identify on the Jaguar-4x4-Wheel robot.



**Jaguar-4x4-Wheel Platform**

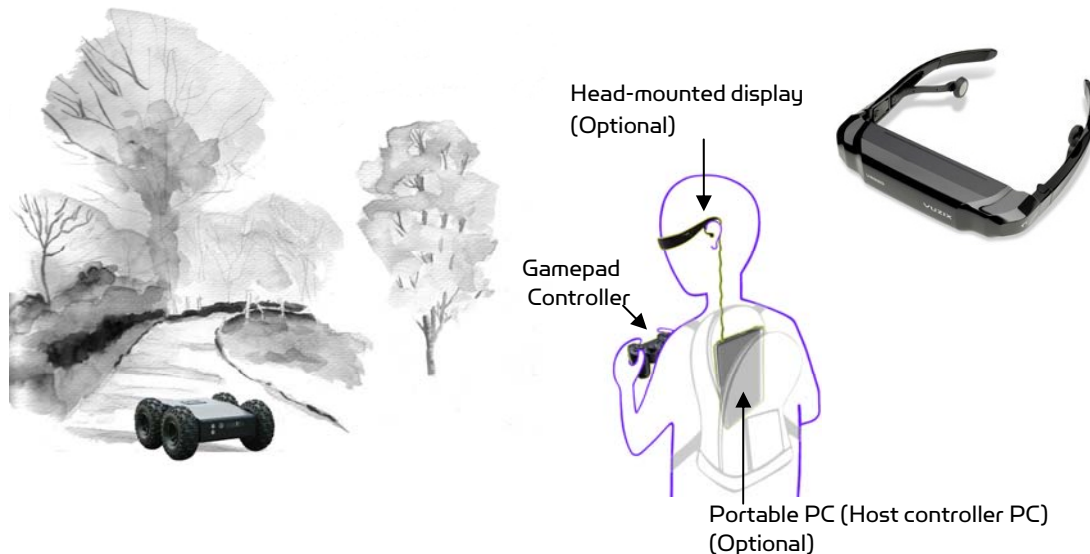


## Operation Scenario

Diagram below illustrates the typical operation scenario. The Jaguar-4x4-wheel is a wireless networked outdoor mobile robot. It comes with a wireless 802.11 AP/router. The remote host controller PC running the “Jaguar Control” program connects to the Jaguar-4x4-wheel robot via:

- Network cable – Connect the robot on-board AP/router. (DO NOT connect to the WAN port), or
- Wireless – To connect the host controller PC to the on-robot wireless AP/router, configure the host PC’s wireless settings using the default wireless configuration settings found in the Network Connection session of this manual.

Human operator carrying the host controller PC could use the head-mounted display (accessory option) and the included game-pad controller in outdoor environment to monitor and control the operator under any outdoor lighting environment, even under direct sunshine. The included “Jaguar Control” program will therefore be projected on the head-mounted display, where you could see all the sensor information from the robot, and the video streamed from the camera on robot (Please refer to “Jaguar Control program” session for detail).



Typical Operation Scenario

Note: The host controller PC running the “Jaguar Control” program could be mounted on the robot instead off the robot if your application requires so.

## Software Installation

Jaguar Control programs, application development library and supporting documents could be found from the Jaguar software CD.

On the host controller computer, you should install the following programs from the installation CD:

- **“Jaguar Control” program** - installed by the Setup.exe from CD
- **Google Earth program** - could be downloaded from <http://earth.google.com/download-earth.html>. Please follow its installation instruction.

### III. Operation of Jaguar Robot

End user could develop his own Jaguar control program using the supplied development API and tools. Here, we will show you how to control the robot using the included "Jaguar Control Program" (You need to install Google Earth program first).

#### Turn on/off the Platform

Please follow the below steps to turn on the robot.

1. Turn the main switch to "ON" position.
2. Press the start button for a while (around 1 second) then release.

If you see the green LED on the start button is on, the system is powered up.

If not, please check the battery to make sure it is fully charged.

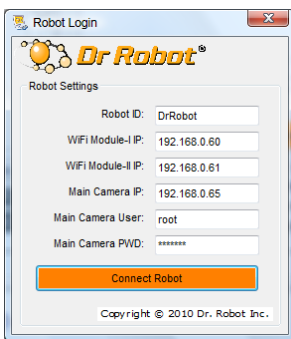


Turn the main switch to "OFF" position, the system will shut down.

#### Using Dr Robot Jaguar Control Program

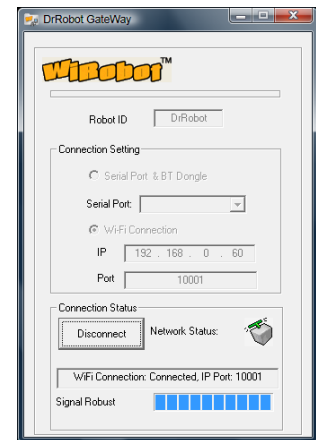
This program will demonstrate how to control and navigate the Jaguar-4x4-wheel, and how to interpret, process, display and log multi-sensor information. This program is provided with source code (c#).

- updates motor encoder reading, motor temperature, board voltage and battery voltage measured at 10Hz;
- reads and displays IMU and Laser Range sensor data;
- displays GPS readings on the Google Earth;
- displays and controls Axis camera.

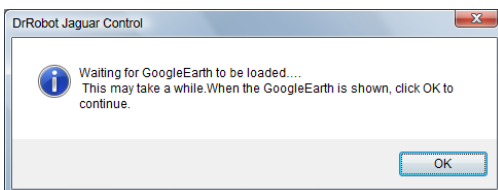


Once you start this program, you will see a "Login Window"

It will read all the configuration information from "outdoorrobotconfig.xml" under c:\DrRobotAppFile\.



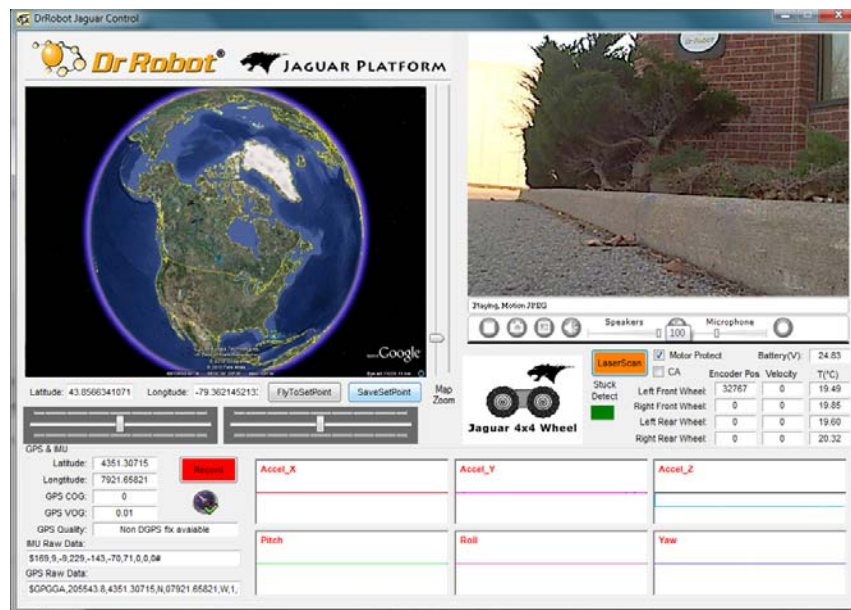
When "Connect Robot" is clicked, it will start the WiRobotGateway program (also under c:\DrRobotAppFile\) and will try connecting to the Robot.



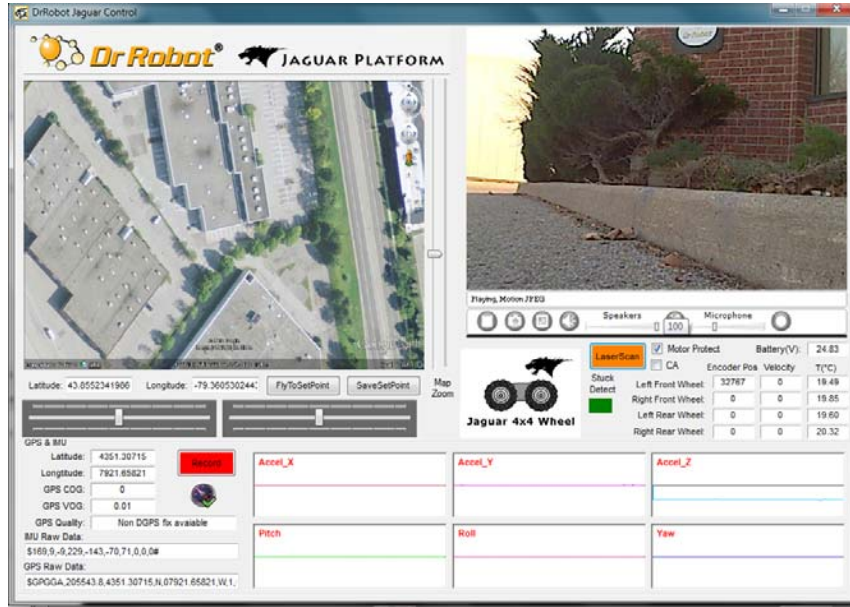
Google Earth is then loaded (this may take a while).

Google Earth supports offline use (without Internet), but you have to obtain the map online ahead of use.

When Internet is not presented, this loading process will take a longer time when trying to connect with Google Earth website. You will not get the correct Latitude and Longitude position by clicking on map before the map loading is finished. When loaded, click "OK" button.



"FlyToSetPoint" button will bring you to the location (latitude/longitude) specified in "outdoorrobotconfig.xml". This is the location you would like the map to center and show around. You should modify this location according to your location. This could be done by inputting the value in this xml file or navigating on Google Earth map to your interested point, then clicking "SaveSetPoint" button. The location value of the map center will then be saved to the "outdoorrobotconfig.xml" when program is closed.

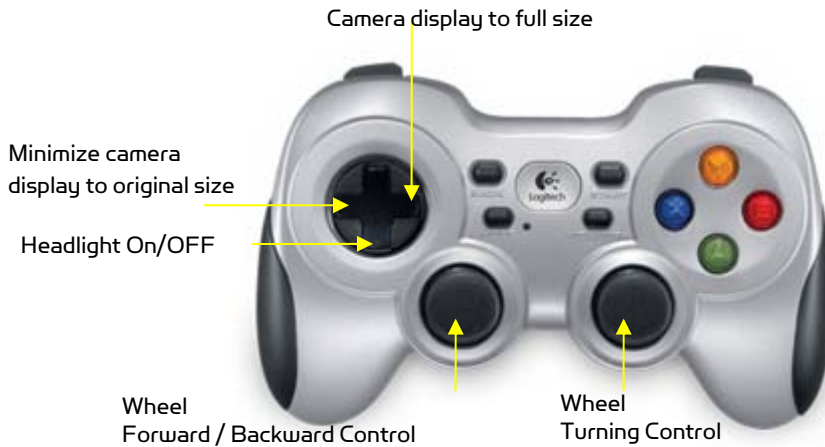


You could use the vertical track bar to zoom in or out.

When the GPS-IMU module is presented, this program will connect and display the GPS information on Google Earth and IMU raw data on the 6 chart boxes.

When camera is presented, the video and AV control buttons will be shown in the video window.

You could use the included Gamepad controller to navigate the robot. When used outdoors, especially under direct sun lights, head-mounted display (optional accessory) will provide clear and large display with excellent outdoor experience.



### Gamepad Control

Note: when using Gamepad control, you need to make sure the program window is in "focus".

When **LaserScan** is clicked, it will display laser scanner data in polar view as shown below.

Yellow: Driving Direction (Modified by sensor map)

Blue: Gamepad Driving Direction

Polar Sensor Map

Enable Collision Avoidance  
\* When the "CA" checkbox is checked, the program will limit the maximum output PWM to 65% full power.

Encoder Pos	Velocity	T(°C)
Left Front Wheel: 32631	0	17.84
Right Front Wheel: 125	0	18.56
Left Rear Wheel: 32606	0	18.22
Right Rear Wheel: 167	0	18.66

Encoder Pos	Velocity	T(°C)
Left Front Wheel: 32631	0	17.84
Right Front Wheel: 125	0	18.56
Left Rear Wheel: 32606	0	18.22
Right Rear Wheel: 167	0	18.66

Battery information and motor information is displayed here. If the robot uses the included Li-Po battery, you need to stop the robot when voltage is below marked voltage (22.2V) in order to prevent battery damage. Motor temperatures are also displayed here. "Encoder Pos" boxes show the encoder position values received in motor driver board from motion control board.

**Motor Protect** When selected, the motors will be disabled when measured motor temperature is higher than the safety threshold (we recommend this feature is enabled for normal operation); When de-selected, this motor over-heat protection feature is disabled.

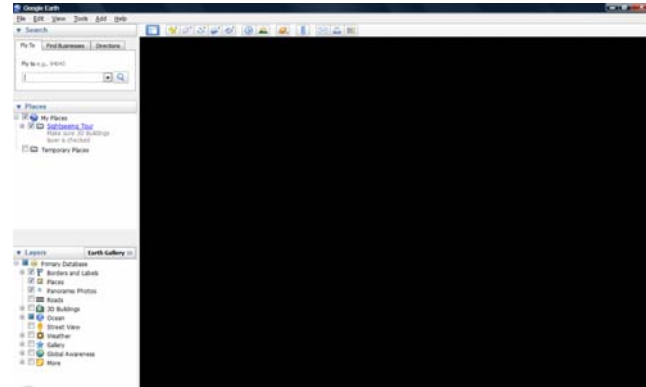
The two horizontal track bars show the Gamepad controller's left and right stick control value.



You could record raw GPS-IMU/Encoder sensor data using **Record** button. The raw sensor data file will be saved to "c:\DrRoboAppFile" folder with file name GPSIMURec\*.txt.

All traces are displayed on Google Earth by KML data. Since the current version of Google Earth does not provide programming method to clear these KML data, there is risk of memory leak. You could manually clear these KML

data by right-clicking on "Temporary Places", then choosing "Delete Contents". (That is why we did not hide Google Earth program)





On normal program exit, Google Earth will be closed. However, you should double check using "Windows Task Manager"; otherwise, you may not be able to display Google Earth when you start Jaguar control program again.

## Recharging





Jaguar robot uses high performance LiPo batteries. Extreme caution is needed when dealing with this type of battery, explosion and damage could occur. Please read the Charge Station manual first and follow all the safety rules before proceeding further.

- 1) Turn off the robot
- 2) Loose the screws of Battery Box, disconnect the 2-Pin Tamiya connector and take the Battery Box out.

3) Power on the Charge Station. Use  to make sure "LiPo BALANCE" is displayed on the LCD screen. If not, use "Type/Stop" button to change battery type to "LiPo Battery" and press


 to set charging mode to "LiPo BALANCE".



4) You can use  +  /  +  buttons to change the charge current, DO NOT exceed the 2A charging current and do not modify the battery voltage. It should be "22.2V (6S)" for Jaguar robot.


5) Connect the charging 7-Pin, 3-Pin & 2-Pin connectors to charger as below images.



6) Press  button for few seconds, the charge station will check the battery and display what the reading is. It should be same as your settings above.

7) If everything is right, you can press  button again to start charging.



8) Press  to switch the display to show the battery status. The display should show each battery reading as below image.



**\* Note:** If any battery reading is missing, please turn off the charging station and turn the Power switch to “OFF”, and check the 7-pin connector, make sure it is connect well.

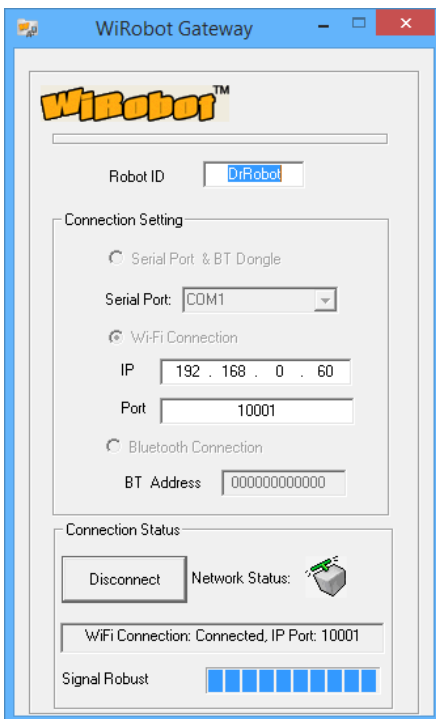
9) **Keep the charger away from children and pet at all time! Never leave the charger unsupervised when it is connected to its power supply.** For more detail about charger station operation, warning and error message, maintenance and safety message, please refer to “Intelligent Digital Balance Charger Operating Manual”.

## Using DrRobot Jaguar4X4 Motor Control Demo Program

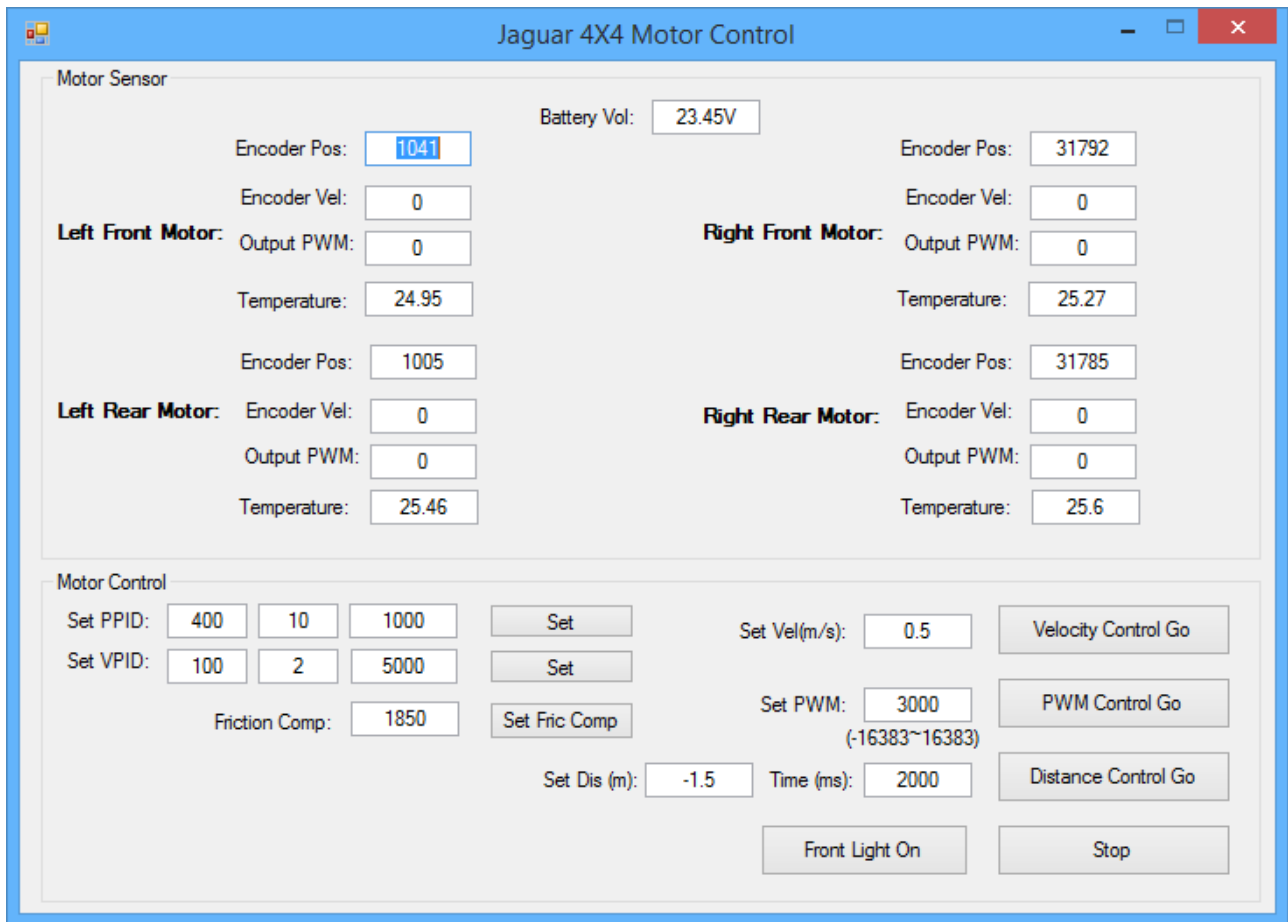
You could install the Jaguar4X4 Motor Control demo program from the CD. After installation, you could run the WiRobotGateway program from Desktop.

Please input the Robot ID as “DrRobot”. Make sure the IP address is your robot IP (default is “192.168.0.60”) and the port number is “10001”.

Click the “Connect” button.



Then run the DrRobot Jaguar4X4 Motor Control Demo program.



In this program, you could use open loop PWM control (by clicking "PWM Control Go" button), velocity control (by clicking "Velocity Control Go" button) and position control (by clicking "Distance Control Go" button).

You also could adjust the default velocity control PID and position control PID parameters. All default values are displayed on the program GUI.

## IV. Hardware and Electronics

### Network Settings

#### Wireless Router Setting

The included pre-configured wireless 802.11 B/G router has the following pre-set settings:

<b>SSID</b>	DriJaguar	<b>Router LAN</b>	192.168.0.245
<b>WEP</b>	128bits	<b>Login ID</b>	admin
<b>KEY</b>	drrobotdrrobot	<b>Password</b>	drrobot
<b>Key Type</b>	Open Key		



## Device Default Network Settings

Note: The Ethernet modules are configured to serial-to-Ethernet mode in Jaguar platform.

<b>Ethernet Module 1</b>	192.168.0.60
<b>Port 1</b>	Port Number 10001, UDP 115200. 8, N, 1, no flow control
<b>Port 2</b>	Port Number 10002, TCP 19200. 8, N, 1, no flow control

<b>Ethernet Module 2</b>	192.168.0.61
<b>Port 1</b>	Port Number 10001, TCP 57600. 8, N, 1, no flow control
<b>Port 2</b>	Port Number 10002, TCP 115200. 8, N, 1, no flow control

<b>Camera</b>	192.168.0.65    Port 8081
<b>User ID</b>	Root
<b>Password</b>	drrobot

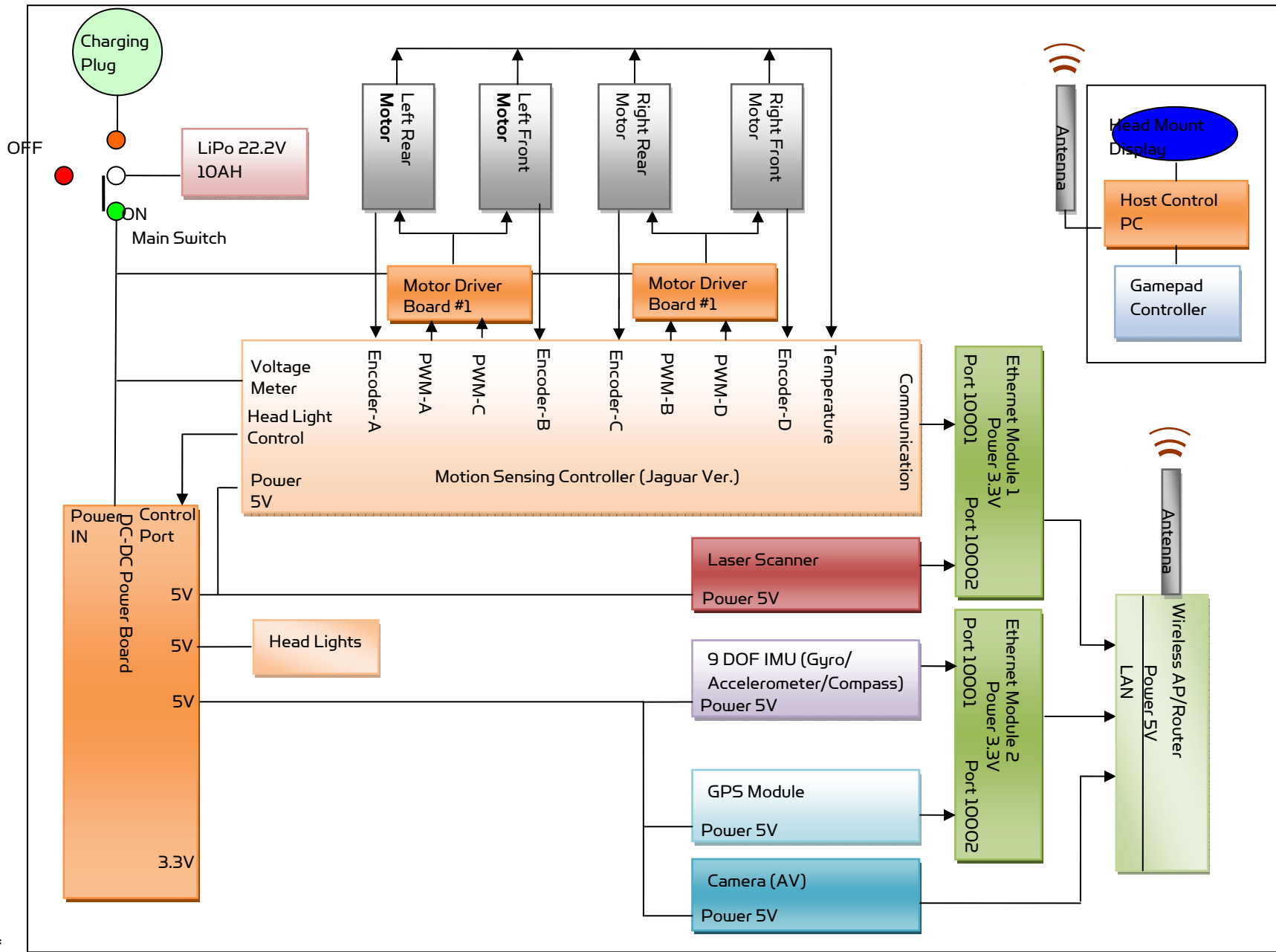
## Advanced Network Settings

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

Please contact [support@DrRobot.com](mailto:support@DrRobot.com) if you need further support.

## Hardware Architecture

The diagram below illustrates the inter-connection between the core electronic circuits and modules (some are optional accessories).



## Motor Driver Board

The left front and left rear motors are connected to the 1st channel on the motor driver board while the right front and right rear motors are connected to the 2nd channel.

<b>Input power</b>	H-Bridge 2 channels
<b>Max current</b>	up to 25A continuous power per channel, peak up to 50A per channel for a few seconds
<b>Input voltage</b>	6~24V, 30V absolute max

## Motion and Sensing Controller

This is a special version of PMS5005 board.

<b>Input power</b>	5V
<b>6 PWM output</b>	Channel 3, 4 for left and right wheels
<b>Motor control mode</b>	PWM control; Velocity control; Position control
<b>Sensor sampling</b>	Encoders: Channel 1,2 for left and right rear wheel Channel 3,4 for left and right front wheel
	Board voltage measuring
	Battery voltage measuring
	Motor temperature measuring (4 units)
	Other extended A/D channels (please contact Dr Robot).

## Camera

<b>Input power</b>	5V
<b>Lens</b>	4.4mm: 47° horizontal view, F2.0, fixed iris, fixed focus
<b>Light sensitivity</b>	1-10000 lux, F2.0 0 lux with headlights LED on
<b>Resolutions</b>	640x480 to 160x120
<b>Frame rate</b>	H.264: 30 fps in all resolutions Motion JPEG: 30 fps in all resolutions MPEG-4 Part 2: 30 fps in all resolutions
<b>Video compression</b>	H.264 (MPEG-4 Part 10/AVC), Motion JPEG MPEG-4 Part 2 (ISO/IEC 14496-2)
<b>Audio streaming</b>	Two-way
<b>Other features</b>	PIR motion sensor with configurable sensitivity. Max range: 6 m

## GPS

<b>Input power</b>	5V
<b>Update rate</b>	5Hz
<b>Sensitivity</b>	-185dBW minimum
<b>Accuracy</b>	Standard GPS service: Position: <= 15m 95% typical Velocity: 0.1knot RMS steady state WAAS service: Position: <= 3m 95% typical
<b>Output Interface</b>	NMEA 0183, default GPRMC/GPGGA/GPGSA/GPVTG Binary Output

## 9DOF IMU (Gyro, Accelerometer & Digital Compass)

<b>Input power</b>	5V
--------------------	----

<b>Gyro Sensors</b>	ITG3200 Triple-Axis digital output gyro sensor
<b>Accelerometers</b>	3 Axis ADXL345 13bit resolution Max +/-16G
<b>Magnetic Compass</b>	3 Axis HMC5883L magnetometer
<b>Output Frequency</b>	50Hz Output all sensors raw AD data, magnetic sensor will be measured every 220ms

## Laser Scanner

Two laser scanner options are available, one with measurement range of 0.02-4m, and other one is 0.1-30m.

<b>Input power</b>	5V
<b>Detectable range</b>	0.02-4m
<b>Accuracy</b>	0.02 to 1m: +/- 10mm 1 to 4m: 1%
<b>Measurement Resolution</b>	1mm
<b>Angular Resolution</b>	approx 0.36° (360°/1024 partition)
<b>Scanning angle</b>	240°

<b>Input power</b>	12 V
<b>Detectable range</b>	0.1-30m
<b>Accuracy</b>	0.1 to 10m: +/- 30mm
<b>Measurement Resolution</b>	1mm
<b>Angular Resolution</b>	approx 0.25° (360°/1440 steps)
<b>Scanning angle</b>	270°

## Batteries

<b>Battery type</b>	Li-Po
<b>Rated Voltage</b>	22.2V (6 cells, 3.7V/cell)
<b>Capacity</b>	10Ah
<b>Discharge rate</b>	Max 50A continuous, Max 100A peak
<b>Max charge rate</b>	10A
<b>Cycle life</b>	500-1000 times

## Charger

<b>Charger type</b>	LiPo Charger
<b>Maximum charge current</b>	2A
<b>Maximum discharge current</b>	2A
<b>Power Input</b>	100-240V

## Powertrain (motor, speed-reducer and encoder)

The following specifications are defined at the output shaft after speed-reduction.

Drive wheel shafts

<b>Track-wheel motors (4 units)</b>	DC motors with steel gearbox
<b>Motor rated voltage</b>	24V
<b>Motor rated current</b>	2.75A
<b>Motor max current</b>	16A
<b>Shaft rated speed</b>	230RPM
<b>Shaft rated torque</b>	13.5 Kg.cm
<b>Shaft encoder resolution</b>	150 counts per revolution

# V. Further Development & Programming

## The Jaguar Control program

The Jaguar Control program is written with Visual Studio 2008 express (in C#) 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. **WiRobotGateway.exe**
3. **AXIS Media Control Library Set** These are the camera control component for the AXIS Mini Camera (P/N: AXCAM) used for Jaguar robot. Please refer to "AXIS Media Control SDK Help" for detail.

## Motion Control/Sensing System

Jaguar-4x4-Wheel comes with a special version of PMS5005 as its motion control and sensing board. It follows the Dr Robot WiRobotSDK protocol. User could control and access Jaguar by Dr Robot ActiveX control (DrRobotSentinelActiveXControl.ocx) and WiRobot gateway program.

Based on the protocol, you could develop your own program for any operation system. You could request protocol sample code from Dr Robot using C++/Java. You should also contact Dr Robot with any questions regarding SDK API and protocol.

The communication port is connected at Ethernet module-I port 1.

Gateway program will connect to this board at 192.168.0.60, port 10001.

Here is C# sample code to control Jaguar-4x4-Wheel System with ActiveX control,

myJaguar is DrRobotSentinelActiveXControl.

Wheel Motor control:

```
private void myJaguar_MotorSensorEvent(object sender, EventArgs e)
{
    leftRearWheelMotor.encoderDir = myJaguar.GetEncoderDir1();
    leftRearWheelMotor.encoderPos = myJaguar.GetEncoderPulse1();
    leftRearWheelMotor.encodeSpeed = myJaguar.GetEncoderSpeed1();

    rightRearWheelMotor.encoderDir = myJaguar.GetEncoderDir2();
    rightRearWheelMotor.encoderPos = myJaguar.GetEncoderPulse2();
    rightRearWheelMotor.encodeSpeed = myJaguar.GetEncoderSpeed2();

    WheelMotor.output    leftFrontWheelMotor.outputPWM =
myJaguar.GetMotorPWMValue4();
    rightFrontWheelMotor.outputPWM = myJaguar.GetMotorPWMvalue5();
    leftRearWheelMotor.outputPWM = myJaguar.GetMotorPWMValue1();
    rightRearWheelMotor.outputPWM = myJaguar.GetMotorPWMValue2();
}
```

You could read board voltage(5V) and battery voltage in standard sensor Event.

```
private void myJaguar_StandardSensorEvent(object sender, EventArgs e)
{
    boardVol = ((double) myJaguar.GetSensorBatteryAD1() / 4095 * 9);
    motVol = ((double) myJaguar.GetSensorBatteryAD2() / 4095 *
34.498);
}
```

You could read motor temperature sensor in custom sensor event, function Trans2Temperature() is based on the sensor specification to translate AD value to temperature (in celcius degree).

Also you could read left/right wheel motor encoder in this event.

```
private void myJaguar_CustomSensorEvent(object sender, EventArgs e)
{
    // front left track motor
    double tempM =
Trans2Temperature((double)myJaguar.GetCustomAD5());
    tempM = double.Parse(tempM.ToString("0.00"));
    lblTemp1.Text = tempM.ToString("0.00");
    // front right track motor
    tempM = Trans2Temperature((double)myJaguar.GetCustomAD6());
    tempM = double.Parse(tempM.ToString("0.00"));
    lblTemp2.Text = tempM.ToString("0.00");
    // rear left track motor
    tempM = Trans2Temperature((double)myJaguar.GetCustomAD7());
    tempM = double.Parse(tempM.ToString("0.00"));
    lblTemp3.Text = tempM.ToString("0.00");
    // rear right track motor
    tempM = Trans2Temperature((double)myJaguar.GetCustomAD8());
    tempM = double.Parse(tempM.ToString("0.00"));
    lblTemp4.Text = tempM.ToString("0.00");

    leftFrontWheelMotor.encoderPos = myJaguar.GetEncoderPulse4();
    leftFrontWheelMotor.encodeSpeed = myJaguar.GetEncoderSpeed4();
    leftFrontWheelMotor.encoderDir = myJaguar.GetEncoderDir4();

    rightFrontWheelMotor.encoderPos = myJaguar.GetEncoderPulse5();
    rightFrontWheelMotor.encodeSpeed = myJaguar.GetEncoderSpeed5();
    rightFrontWheelMotor.encoderDir = myJaguar.GetEncoderDir5();
}
```

To stop all motor, you could use:

```
myJaguar.DcMotorPwmNonTimeCtrAll(16384, 16384, 16384, 16384, 16384,
16384);
```

For track/wheel motor control, we use independ-drive mode. Under this mode, PWM channel 3 is driving Left front wheel motor, PWM channel 4 is driving right front motor, PWM channel 0 is driving left rear motor and PWM channel 1 is driving right front mtoor.

To move forward with full power

```
myJaguar.DcMotorPwmNonTimeCtrAll(32767,0,NOCONTROL,32767,0,NOCONTROL);
```

To move backward with full power

```
myJaguar.DcMotorPwmNonTimeCtrAll(0,32767,NOCONTROL,0,32767,NOCONTROL);
```

To turn left with full power

```
myJaguar.DcMotorPwmNonTimeCtrAll(0,0,NOCONTROL,0,0,NOCONTROL);
```

To turn right with full power

```
myJaguar.DcMotorPwmNonTimeCtrAll(32767,32767,NOCONTROL,32767,32767,NOCONTROL);
```

For encoder speed/position control of each motor, you could refer to "DrRobot Jaguar4X4 Motor Control Demo" program and you could find the source code in the installation folder.

To control head lights, using expanded IO port bit7.

```
Turn off light: myJaguar.SetCustomDOUT(expandedIO & 0x7f);
```

```
Turn on light: myJaguar.SetCustomDOUT(expandedIO | 0x80);
```

Software watchdog: The system will automatically stop all the motors if it does not receive any data package in 5 seconds.

## Laser Scanner

Laser Ranger sensor (4m version, URG-04LX) is connected to Ethernet module-1 port 2 after voltage level conversion. You could access the sensor data via TCP socket at port 10002 with IP 192.168.0.60.

Default settings for the serial port are: 115200, 8, N, 1, no flow control, TCP, port number 10002

Date and communication protocol could be found in "URG-04LX commspec\_eg.pdf".

## GPS

GPS sensor output interface is RS232 serial port, and connected to Ethernet module-2 port 2 after voltage level conversion. You could access the sensor data via TCP socket at port 10002 with IP 192.168.0.61.

Default settings for the serial port are: 115200, 8, N, 1, no flow control, TCP, port number 10002

NMEA 0183 sentence is described in file "GPS18x\_TechnicalSpecifications.pdf". GPS configuration tool is SNSRXCFG\_200.exe

## 9 DOF IMU (Gyro/Accelerometer/Compass)

The output interface for this IMU sensor module is serial port. It is connected to Ethernet module-2 port 1. You could read from this sensor via TCP port 10001 at IP 192.168.0.61. Serial Port Settings: 57600, 8, N, 1, no flow control, TCP, port number 10001. The sensor output rate is 50Hz (20ms) with output format of ASCII.

It's easier to read with a terminal program since the sensors' measurements are reported in ASCII. All measurements are delimited with "," characters as well as a carriage return and line feed at the end of the data frame.

### Format:

```
"$seq,accelX,accelY,accelZ,,gyroX,gyroY,gyroZ,magnetomX, magnetomY, magnetomZ#"
```

"seq" is data package sequence number, value is in range: 0 ~255.

After "seq", the data are raw AD value for each sensor.

### Sample data string:

```
"$2,9,1,255,20,40,3,235,4000,20#"
```

Please note the magnetic sensor will be measured every 220ms, so if the output value is 0, means no new magnetic sensor data in this data package.

## Camera with Two Way Audio

You need to install the camera ActiveX control on your system by running the "AXISMediaControlSDK.exe". You could find some sample codes (C++, C#, VB) in C:\Program Files\Axis Communications\AXIS Media Control SDK\samples and the corresponding SDK documents in C:\Program Files\Axis Communications\AXIS Media Control SDK\doc.

By using the Microsoft's "Windows Media Encoder 9" and Axis video capture driver, you could also access this camera in Intel's OpenCV as same as accessing a USB camera.

## Advanced Development

Please refer to document "GPS-IMU Sensor Module and Outdoor Autonomous Navigation Program" for detail on autonomous navigation programming using the Jaguar GPS and IMU system module.

Support and sample codes are available for using OpenCV, LabVIEW and MATLAB. Please contact [support@drrobot.com](mailto:support@drrobot.com) for further information.