



All-Terrain Autonomous Navigation Robot with GPS-IMU

Jaguar V4

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.

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www.DrRobot.com

Contact

General: info@DrRobot.com

Technical Support: support@DrRobot.com

25 Valleywood Drive, Unit 20
Markham, Ontario, L3R 5L9, Canada
Tel: (905) 943-9572 Fax: (905) 943-9197

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I. Specifications

Jaguar V4 Mobile Robotic Platform is designed for indoor and outdoor applications requiring robust maneuverability and terrain maneuverability. It comes with four articulated arms and is fully wirelessly 802.11N connected. It integrates outdoor GPS and 9 DOF IMU (Gyro/Accelerometer/ Compass) for autonomous navigation. Jaguar V4 platform is rugged, light weight (< 30Kg), compact, weather and water resistant. It is designed for extreme terrains and capable of stair or vertical climbing up to 300mm with ease. The 4 articulated arms could convert the robot into various optimal navigation configurations to overcome different terrain challenges. The integrated high resolution video/audio and optional laser scanner 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 robust maneuverability
- With Four articulated arms that could convert the robot into various navigation configurations to overcome different terrain challenges
- Indoor and outdoor operation requiring higher ground clearance and on tough terrains
- Weather and water resistant enclosure
- Climbing up > 55° slope or stairs (max 300mm or 12")
- Light weight (< 30Kg) and compact design with large payload capacity
- Autonomous navigation with outdoor GPS and 9 DOF IMU (Gyro/Accelerometer/Compass)
- Managing max 300mm (12") vertical step (obstacle)
- Surviving max 600mm (2ft) drop to concrete
- Integrated Laser scanner (Optional)
- Integrated high resolution video camera with audio
- All 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, ROS, NI LabVIEW®, MATLAB®, Java®

Mobility

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

Slope: > 55°

Maximum vertical step: 300mm (12")

Stair climbing: Max stair step height 300mm (12")

Traverse: > 360mm (14")

Four articulated arms

Speed: 0 – 6.5Km/hr

Turning radius: 0, min 850mm (33.5") diameter of turning space

Ground clearance: 38mm (1.5"); Max 150mm (6") with Stand-Up Arms

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: 600mm (2ft) Rated: 300mm (1ft)

Electronics

Motion and sensing controller (PWM, Position and Speed Control)
5Hz GPS and 9 DOF IMU (Gyro/Accelerometer/Compass)
Laser scanner (5.6m, 4m or 30m) (Optional)
Temperature sensing & Voltage monitoring
Headlights

Video / Audio

Color Camera (640x480, 30fps) with audio

Communication

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: 1.5 hours (Optional 3 hours)

Motor

Track Motors (24V): 4 units
 Max output (after gear down) (x2): Max 80W, 100Kg.cm/track
 Rated current: 2.75A, Max current: 16A

Arm Motor (24V): 2 units
 Max output (after gear down): Max 80W, 450Kg.cm
 Rated current: 2.75A, Max current: 16A

Dimensions

Height: 176mm (7")
Width: 700mm (27.6")
Length: 980mm (38.5") (extended arms) / 640mm (25.2") (folded arms)
Weight: 30Kg (Standard Configuration)

Payload

Carrying Payload (on flat surface): max 15Kg
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

JAGUARV4-ME	Jaguar V4 Chassis (including motors and encoders)	1
PM55005-JV4	Motion and Sensing Controller (Jaguar V4 Version)	1
WF5802G	WiFi 802.11b/g Wireless Module	1
DMD2500	25A (peak 50A) 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
OGP5501	Outdoor GPS Receiver with 5Hz Update Rate and WAAS	1
IMU9000	9 DOF IMU (Gyro/Accelerometer/Compass)	1
WRT802N	802.11N 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

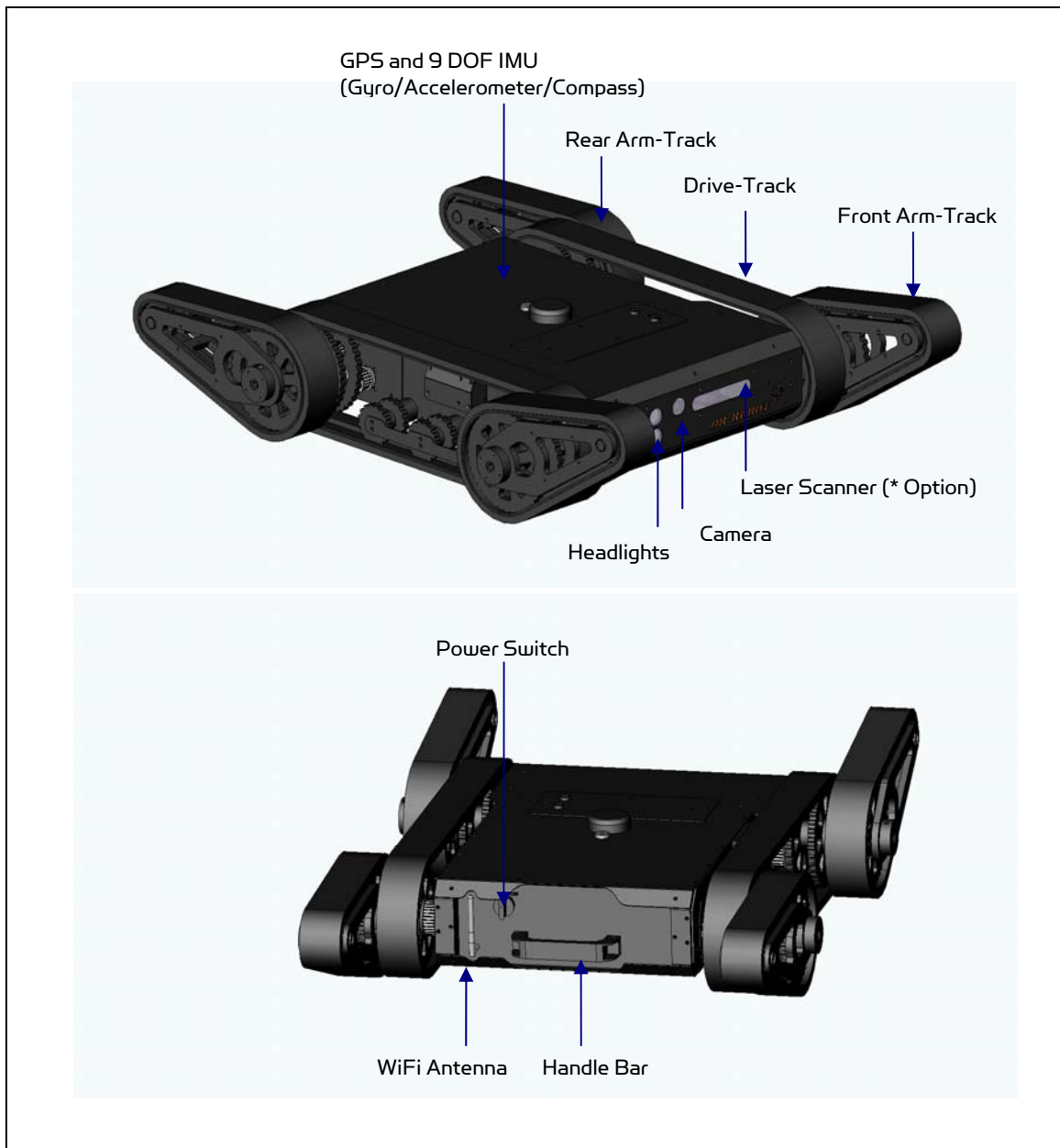
Laser Scanner (Range 4m) for Indoor Application	LAS04M
Laser Scanner (Range 5.6m) for Indoor Application	LAS56M
Laser Scanner (Range 30m) for Outdoor Application	LAS30M
Upgrade to 22.2V 20 AH Li-Polymer Battery Pack	BPN-LP-U20
Head Mounted Display (800x600)	HMD8H6H
802.11N Wireless AP/Router	WRT802N
Host Controller PC	HCPC1008

Please contact 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 robot.



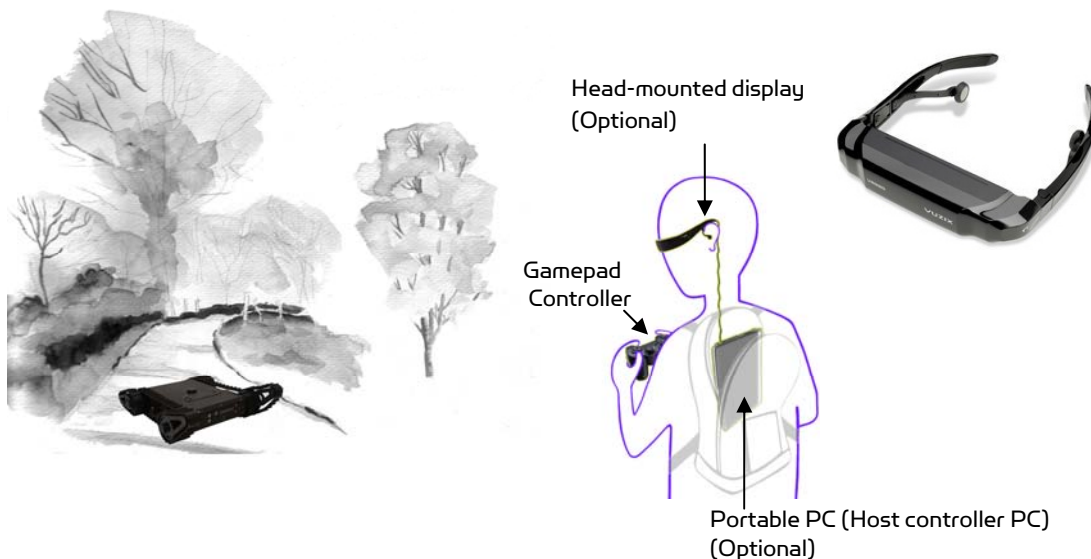
Jaguar Platform

Operation Scenario

Diagram below illustrates the typical operation scenario. The Jaguar 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 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.

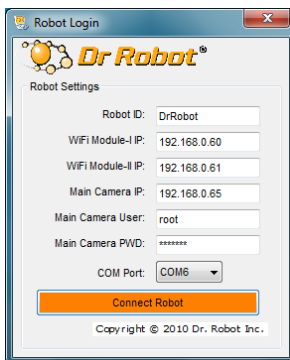
Turn the main switch to "OFF" position, the system will shut down.



Using Dr Robot Jaguar Control Program

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

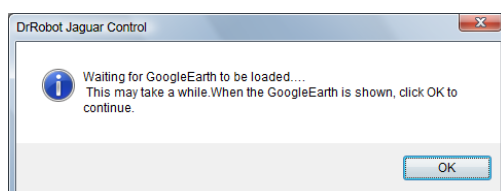
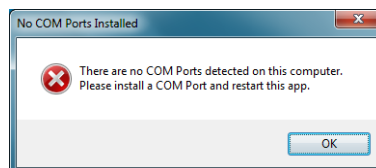
- updates motor encoder reading, motor temperature, board voltage and battery voltage measured at 10Hz;
- reads and displays IMU and Laser Range sensor data;
- displays GPS readings on the Google Earth;
- displays and controls Axis camera.



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

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

* If your computer has not a COM port, the warning window should popup. You need to install a USB-2-Serial adapter.



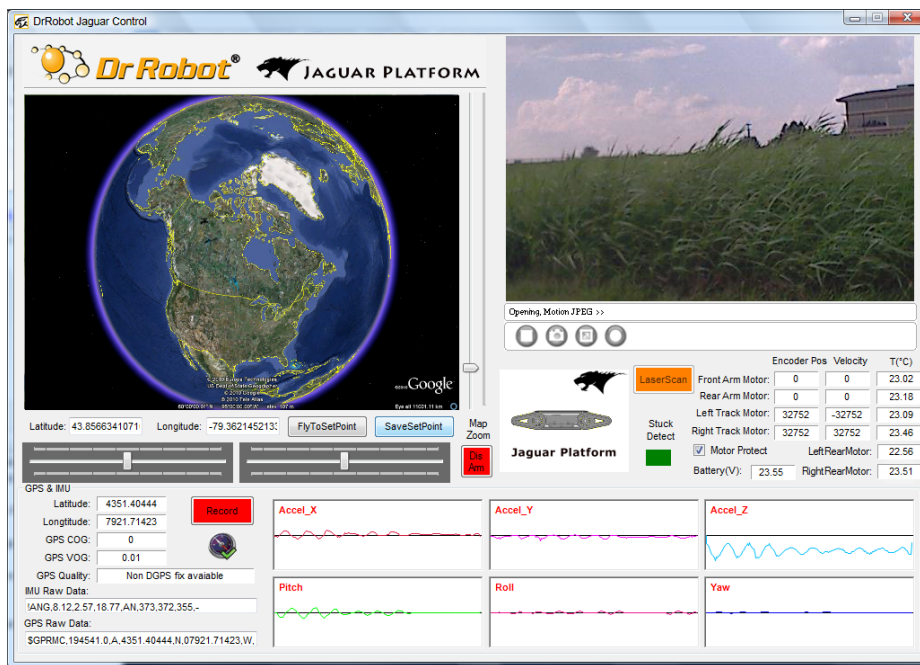
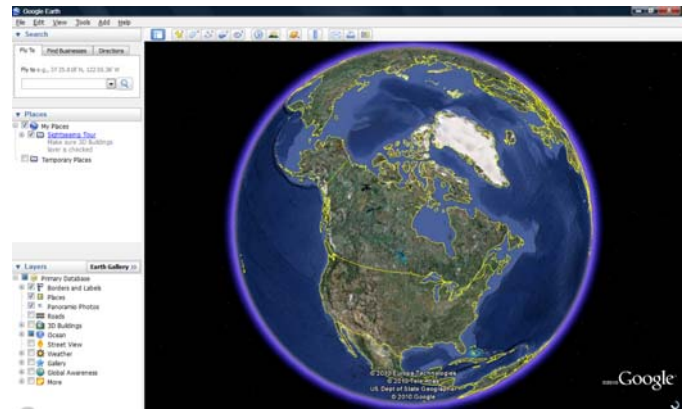
When "Connect Robot" is clicked, it will start the WiRobotGateway program (also under c:\DrRobotAppFile\) and will try connecting to the Robot.



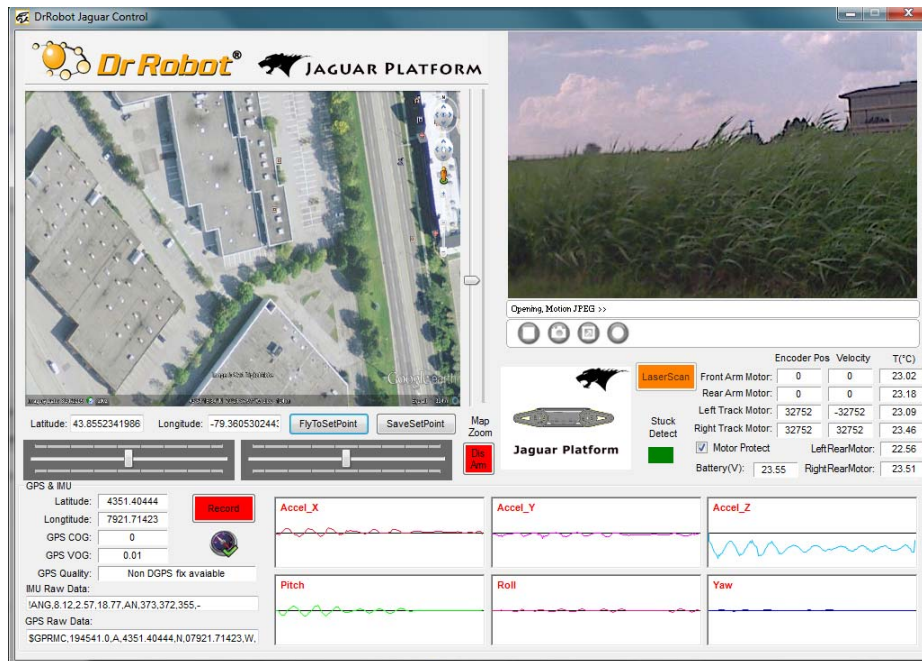
Google Earth is then loaded (this may take a while).

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 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 outdoor, especially under direct sun lights, head-mounted display (optional accessory) will provide clear and large display with excellent outdoor experience.



Gamepad Controller

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

Initializing or resetting arm-track position:

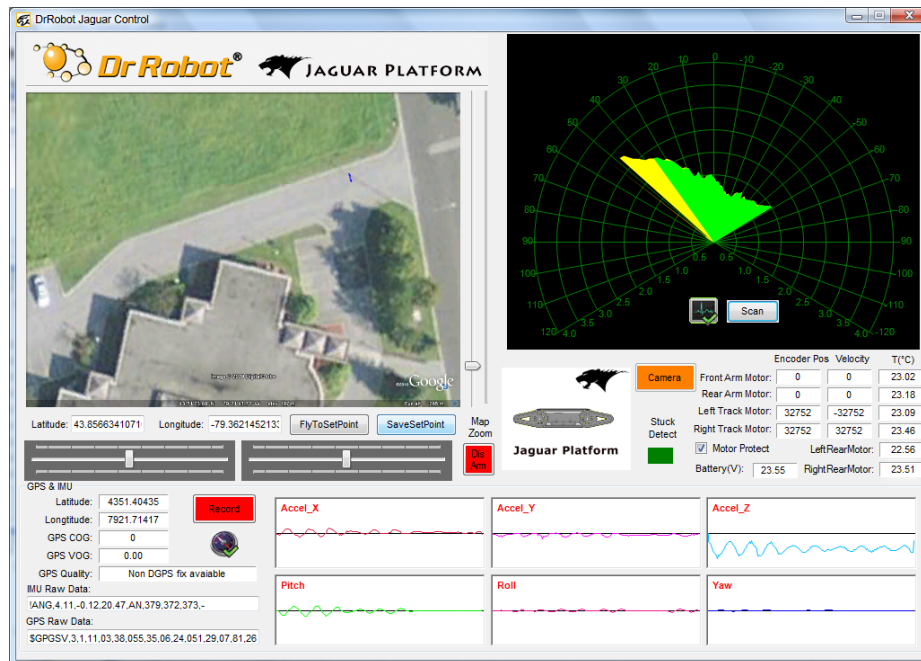
After powering up the robot, or when the actual arm position is different from the arm position window (shown on the right), you should reset the arm-track position as following:

- drive the arm forward and being flat on the ground (as shown below), we call this initial or "0" position (extend forward)



- then, click the "Set arm's initial position" button to save this value and reset arm position display.

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



	Encoder Pos	Velocity	T(°C)
Front Arm Motor:	0	0	23.02
Rear Arm Motor:	0	0	23.18
Left Track Motor:	32752	-32752	23.09
Right Track Motor:	32752	32752	23.46
<input checked="" type="checkbox"/> Motor Protect	LeftRearMotor:	22.56	
Battery(V):	23.55	RightRearMotor:	23.51


Battery information and motor information is displayed here. If the robot uses the included LiPo 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**

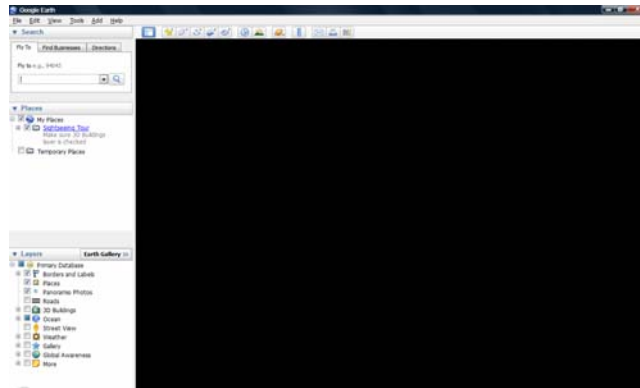
When selected, the motors will be disabled when measured motor temperature is higher than the safety threshold (we recommend this feature is enabled for normal operation); When de-selected, this motor over-heat protection feature is disabled.

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  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.




is to disable arm action.

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 & 4-pin connectors to charger

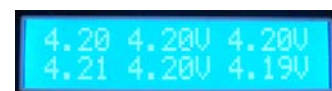


6) Press  button for few seconds, the charge station will check the battery and display what the reading is. It should be same as your settings above.

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".

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:

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

Device Default Network Settings

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

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

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

Camera	192.168.0.65 Port 8081
User ID	root
Password	drrobot

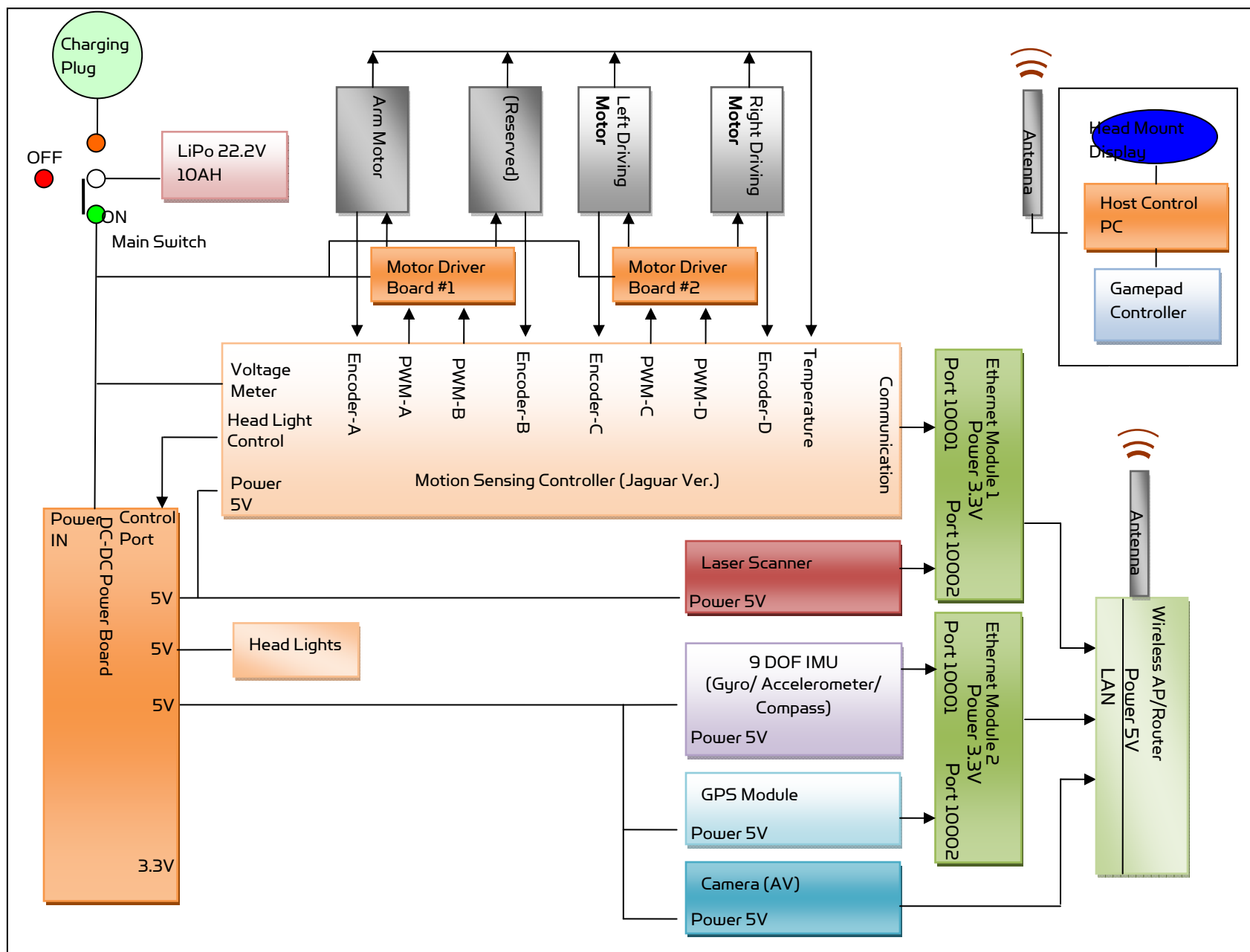
Advanced Network Settings

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 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

Two motor driver boards are used, one for the left and right track/wheel motors while the other one is for the arm motor.

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

Motion and Sensing Controller

This is a special version of PM55005 board.

Input power	5V
6 PWM output	Arm motor: Channel 0 Left and right track/wheel motors: Channel 3 – Drive Power; Channel 4 – Turn Power
Motor control mode	PWM control; Velocity control; Position control
Sensor sampling	Encoders: Channel 0, for left and right arm-track Channel 3, 4 for left and right track/wheel
	Board voltage measuring
	Battery voltage measuring
	Motor temperature measuring (3 units)
	Other extended A/D channels (please contact Dr Robot).

Camera

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

GPS

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

9 DOF IMU (Gyro, Accelerometer & Digital Compass)

Input power	5V
Gyro Sensors	LY530ALH - 300°/s single-axis gyro LPR530ALH - 300°/s dual-axis gyro
Accelerometers	3 Axis ADXL345 13bit resolution Max +/-16G
Magnetic Compass	3 Axis HMC5843 magnetometer
Output Frequency	50Hz Output all sensor raw data and processed data by on-board MCU through serial port

Laser Scanner

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

Input power	5V
Detectable range	0.02-4m
Accuracy	0.02 to 1m: +/- 10mm 1 to 4m: 1%
Measurement Resolution	1mm
Angular Resolution	approx 0.36° (360°/1024 partition)
Scanning angle	±40°

Input power	12V
Detectable range	0.1-30m
Accuracy	0.1 to 10m: +/- 30mm
Measurement Resolution	1mm
Angular Resolution	approx 0.25° (360°/1440 steps)
Scanning angle	±70°

Batteries

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

Charger

Charger type	LiPo Charger
Maximum charge current	2A
Maximum discharge current	2A
Power Input	100-240V

Powertrain (motor, speed-reducer and encoder)

The following specifications are defined at the output shaft after speed-reduction, including the gearbox and /or pulley system.

Arm shaft

Track-arm motor (1 unit)	DC motor with steel gearbox
Motor rated voltage	24V
Motor rated current	2.75A
Motor max current	16A
Shaft rated speed	19RPM
Shaft rated torque	92Kg.cm
Shaft encoder resolution	1083 counts per revolution

Drive track shaft

Track-wheel motors (2 units)	DC motors with steel gearbox
Motor rated voltage	24V
Motor rated current	2.75A
Motor max current	16A
Shaft rated speed	170RPM
Shaft rated torque	14.5Kg.cm
Shaft encoder resolution	1227.4 counts per revolution *

*Before pulley-belt speed reduction (34:20), the motor shaft encoder resolution is 722 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-A) used for Jaguar robot. Please refer to "AXIS Media Control SDK Help" for detail.

Motion Control/Sensing System

Jaguar 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 System with ActiveX control,

myJaguar is DrRobotSentinelActiveXControl.

Arm and drive motor control:

```
private void myJaguar_MotorSensorEvent(object sender, EventArgs e)
{
    //here is front arm ouput pwm value
    armMotor[0].pwmOutput = myJaguar.GetMotorPWMValue1();

    //here is front left arm encoder reading
    armMotor[0].encoderDir = myJaguar.GetEncoderDir1();
    armMotor[0].encoderPos = myJaguar.GetEncoderPulse1();
    armMotor[0].encodeSpeed = myJaguar.GetEncoderSpeed1();

    //here is front right arm encoder reading
    armMotor[1].encoderDir = myJaguar.GetEncoderDir2();
    armMotor[1].encoderPos = myJaguar.GetEncoderPulse2();
    armMotor[1].encodeSpeed = myJaguar.GetEncoderSpeed2();

    forwardPower = myJaguar.GetMotorPWMValue4();
    turnPower = myJaguar.GetMotorPWMValue5();
}
```

```
}
```

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 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 and right track/wheel motor encoder in this event.

```
private void myJaguar_CustomSensorEvent(object sender, EventArgs e)
{
    // front arm motor temperature
    double tempM =
    Trans2Temperature((double)myJaguar.GetCustomAD5());
    tempM = double.Parse(tempM.ToString("0.00"));
    lblTemp1.Text = tempM.ToString("0.00");

    // left track motor
    tempM = Trans2Temperature((double)myJaguar.GetCustomAD7());
    tempM = double.Parse(tempM.ToString("0.00"));
    lblTemp3.Text = tempM.ToString("0.00");

    // 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);
```

To control arm motor using PWM control with value 32767 (full PWM) you could use:

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

or

```
myJaguar.DcMotorPwmNonTimeCtr(0, 32767);
```

Using position control, move motor to encoder position 2000 in 2000 ms, you could use:

```
myJaguar.DcMotorPositionTimeCtrAll(2000, NOCONTROL, NOCONTROL, NOCONTROL, NOCONTROL, NOCONTROL, 2000);
```

or

```
myJaguar.DcMotorPositionTimeCtr(0, 2000, 2000);
```

Using velocity control, move motor at encoder speed 200, you could use:

```
myJaguar.DcMotorVelocityNonTimeCtrAll(200, NOCONTROL, NOCONTROL, NOCONTROL, NOCONTROL, NOCONTROL);
```

or

```
myJaguar.DcMotorVelocityNonTimeCtr(0, 200);
```

For track/wheel motor control, we use differential-drive mode. Under this mode, PWM channel 3 is forward power and PWM 4 is turning power.

To move forward with full power

```
myJaguar.DcMotorPwmNonTimeCtr(3, 0);
```

To move backward with full power

```
myJaguar.DcMotorPwmNonTimeCtr(3, 32767);
```

To turn left with full power

```
myJaguar.DcMotorPwmNonTimeCtr(4, 0);
```

To turn right with full power

```
myJaguar.DcMotorPwmNonTimeCtr(4, 32767);
```

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: 19200, 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. DCM estimation and 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,accleY,accelZ,gyroY,gyroZ,gyroX,magnetomX,magnetomY,magnetomZ#"

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

Sample data string:

"\$2,0,9,255,20,40,3,235,400,20#"

Please note the magnetic sensor will be measured every 220ms, so if the output value is 0, means no magnetic sensor 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 for further information.