All-Terrain Autonomous Navigation Robot with GPS-IMU

Jaguar 4x4 Wheel

With Manipulator Arm

User Guide

Install Fuse; Charge the battery pack before use

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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I. Specifications

Jaguar 4x4 Wheel with Arm Mobile Platform is designed for indoor and outdoor operation requiring higher ground clearance and faster maneuverability. It comes with a rugged 3+1DOF robotic arm (Jaguar Arm), Jaguar Arm is light on weight, low on power consumption and compact on size. It has 3 DOF + 1 DOF gripper, with maximum reach of over 710mm (28 in), max payload capacity of 4Kg at max reach, while weights under 10Kg. Wrist mounted color video camera provides high resolution (640x480) close-up view. Jaguar Arm is ideal or object inspection and handling. It could also work as an articulated sensor platform. Integrated software features independent joint space control as well as gripper Cartesian space control. While it only has 3 rotation joints (excluding gripper), when working together with the Jaguar 4x4 Wheel mobile robot, Jaguar Arm could achieve full 6DOF, and reach virtually any position and at any orientation within its allowed working space.

Jaguar 4x4 Wheel with Arm Mobile Platform is driven by four powerful (105W) motors, one for each wheel. This platform is rugged, light weight (< 33Kg), fast (max 7km/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 with Arm Platform is fully wirelessly 802.11N connected. It integrates outdoor GPS and 9 DOF IMU (Gyro/Accelerometer/Compass) for autonomous navigation. 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 faster maneuverability (max 7Km/hr)
- Indoor and outdoor operation requiring higher ground clearance and on tough terrains
- Weather and water resistant enclosure
- Climbing up > 45° slope or stairs (max 110mm or 4.5")
- Light weight (< 33Kg) 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)
- Integrated high resolution video camera with audio
- All 802.11N wirelessly connected
- Rugged robotic arm (3DOF + 1DOF gripper)
- Compact, lightweight and durable with aluminum main construction Manipulator Arm
- 710mm (28 in) reach with max 4Kg payload (Manipulator Arm)
- Low energy consumption
- Wide gripper opening (150mm/ 6 in)
- Integrated joint-space and gripper Cartesian space arm control
- Wrist mounted camera providing high resolution (720x480) close-up view
- Additional on arm option includes Infrared LED, white LED for night and day time illumination, dust blower, laser scanner and various sensing devices
- Head mounted display (optional) and Gamepad controller providing outdoor operation with large and clear view even under direct sunlight
- Integrated laser scanner (Optional)
- 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®

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 – 7Km/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 +40°
Shock resistant chassis

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
Color Camera (640x480) at Manipulator Arm

Communication

WiFi802.11G (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 20AH
LiPo battery charger
Nominal operation time: 3 hours

Motor

Wheel Motors (24V): 4 units
Max output (after gear down) (x4): Max 80W, 65Kg.cm/wheel
Rated current: 2.75A, Max current: 16A

Dimensions

Height: 432mm (17")
Width: 573mm (22.5")
Length: 615mm (24")
Weight: 32.8Kg (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®, Java®

Jaguar Core Components

JAGUAR4x4W-ME	Jaguar 4x4 Wheel Chassis (including motors and encoders)	1
JAGUAR-ARM	Jaguar Manipulator Arm	1
PMS5006	Motion and Sensing Controller	1
WFS802	Serial to network Module	2
DMD1202	10A (peak 20A) Dual-channel DC Motor Driver Module	4
PMCHR12	DC-DC Power Board	1
AXCAM-A	640x480 Networked Color Camera (max. 30fps) with Two-Way Audio	1
OGPS501	Outdoor GPS Receiver with 5Hz Update Rate and WAAS	1
IMU9002	9 DOF IMU (Gyro/Accelerometer/Compass)	1
WRT802G	802.11N wireless AP/router	1
BPN-LP-10	22.2 V 20 AH LiPo Battery Pack	1
LPBC5000	2A LiPo Battery Charger	2
GPC0010	Gamepad Controller	1

Main Upgrade Options

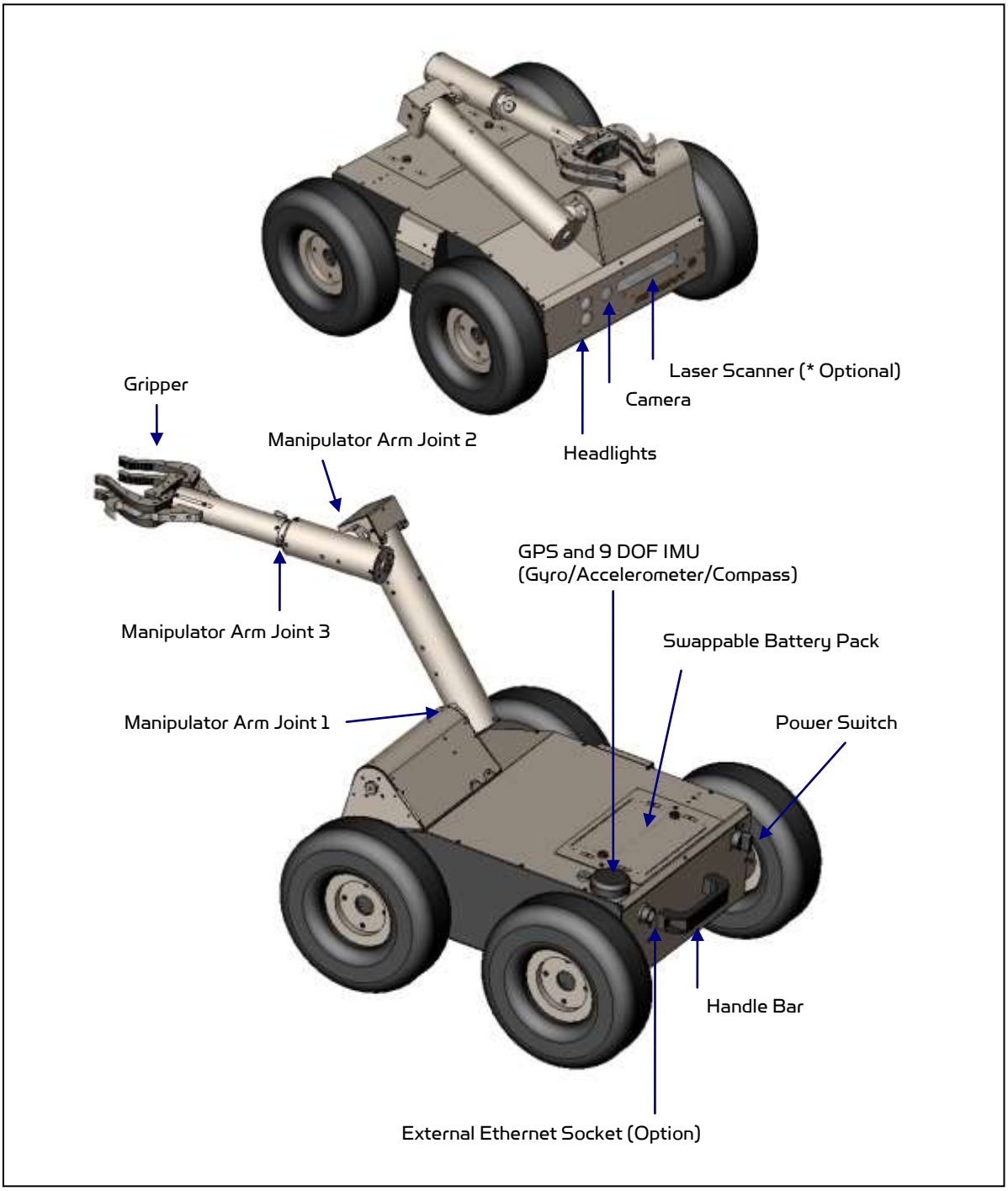
Laser Scanner (Range 5.6m) for Indoor Application	LAS05M
Laser Scanner (Range 4m) for Indoor Application	LAS04M
Laser Scanner (Range 30m) for Outdoor Application	LAS30M
22.2V 20 AH Li-Polymer Battery Pack	BPN-LP-20
Head Mounted Display (800x600)	HMD8H6H
802.11N Wireless AP/Router	WRT802N
Host Controller PC	HCPC1008

Please contact support@drrobot.com for custom design and integration inquiry.

II. Knowing Your Robot

Overlook

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



Jaguar 4x4 Wheel Platform with Manipulator Arm

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.
- Axis camera SDK – installed from CD

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.

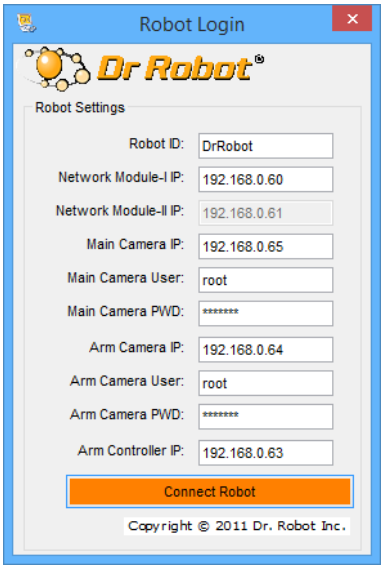
Using Dr Robot Jaguar Control Program

After turn on the robot, please make sure your PC could find the WiFi network with SSID "DriJaguar", and connect with this network with key "drrobotdrrobot". After successful connection, please fix your PC IP address as "192.168.0.104" at this wireless interface. You could try to ping the main control module by command "ping 192.168.0.60" to make sure the connection work well.

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"



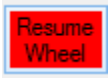
Google Earth is then loaded (this may take a while).

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.

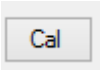
"FlyToSetPoint" button will bring you to the location (latitude/longitude) specified in "outdoorrobotconfig.xml". This is the location you would like the map to center and show around. You should modify this location according to your location. This could be done by inputting the value in this xml file 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.

It will display the 2 motor driver board state. If all of them in ESTOP(emergency stop) state, you could click the button 

to release the Estop.

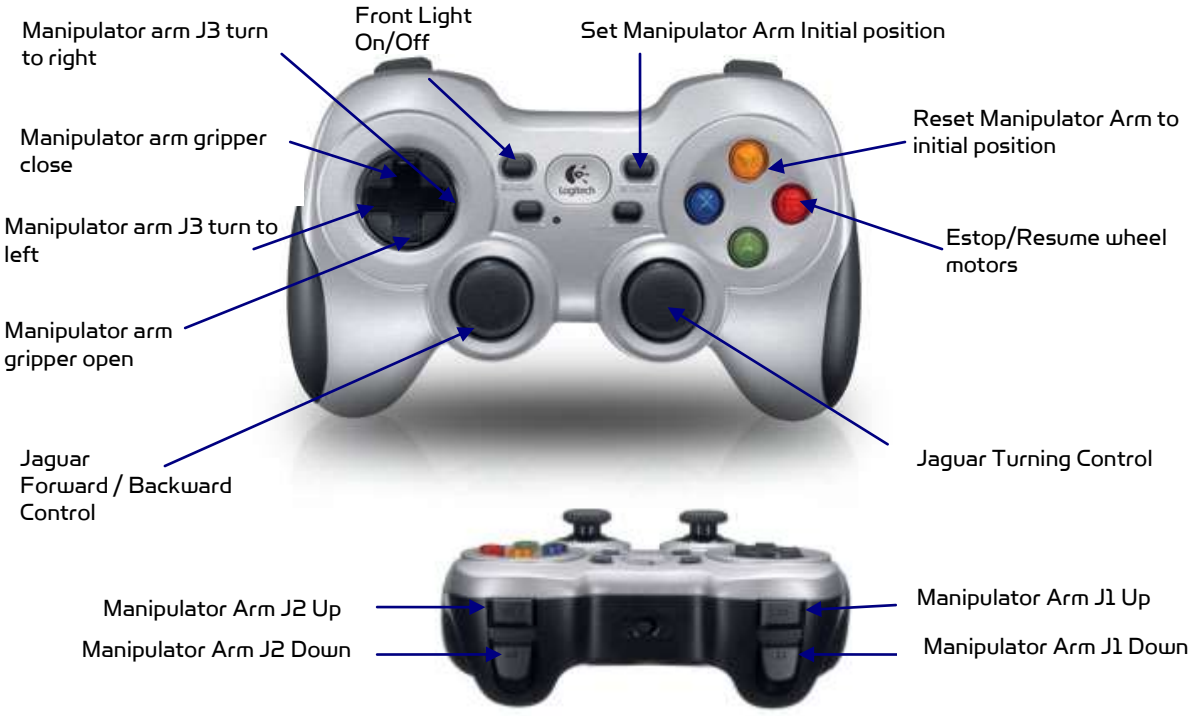
When the GPS-IMU module is presented, this program will connect and display the GPS information on Google Earth and IMU raw data on the text boxes.

The Gyro reading should be around "0" if the robot sit still without any motion. If you find any value of gyro axis reading bigger than "10", you could click button 

to make the controller calculate the gyro offset again.

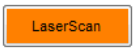
When camera is presented, the video and AV control buttons will be shown in the video window.

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.



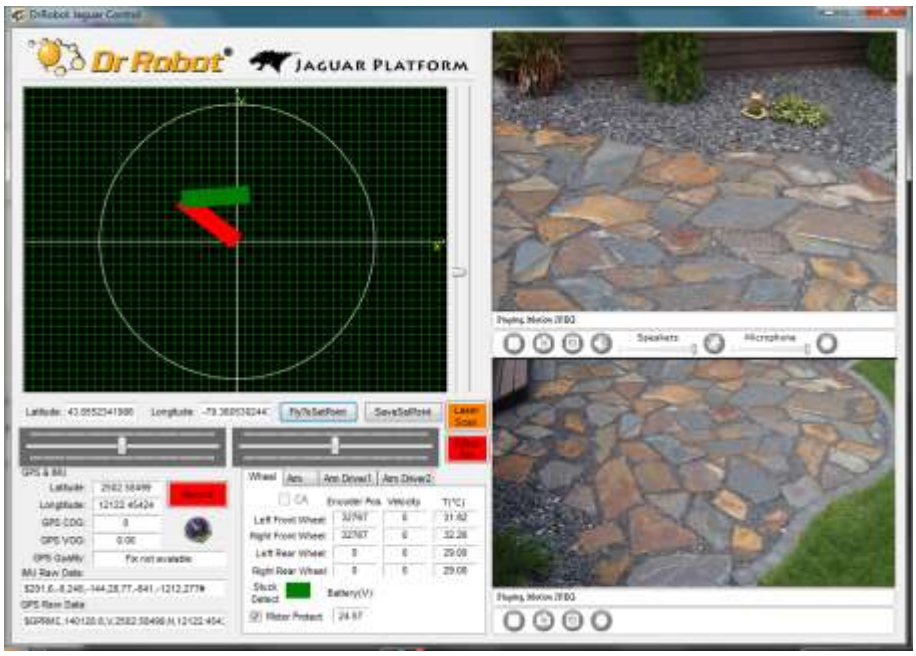
Gamepad Controller

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

When 

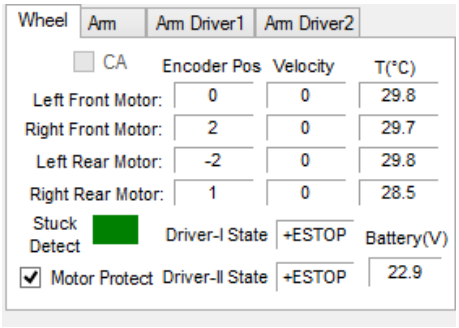
is clicked (with optional laser range scanner), it will display laser scanner data in polar view as shown below.

Click "Turn on" and then "Scan" button. You could use trackbar to adjust the data cut-off distance (i.e. any obstacle with distance larger than this value will be ignored). By checking , you will enable the collision avoidance function.

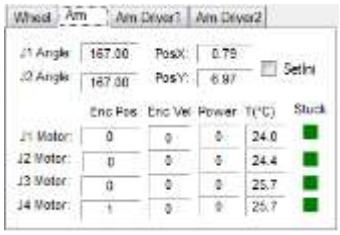


When switching to manipulator arm control, the GUI will display the manipulator arm position if you set the arm initial position.

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.



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



Shows Joints Angle Information and Control Value
* Arm J4 is Gripper

If you press the "Start" button on gamepad to set manipulator initial position, it will "check" 

.
After that, you could press "B" button on gamepad to reset manipulator arm to initial position.

When you operate the manipulator arm, please pay attention to the temperature sensor readings to avoid overheating the motors

"Arm Driver1" tab will display motor driver controller 1 states (for Joint 1 and 2). If you did not get the sensor reading back, you could click "QueryCmd" button to send query command. Please make sure the channel 1 and 2 are working in position control mode (Mode:3).

will display channel1, 2 motor's current.

"Arm Driver2" tab will display motor driver 2 states (for Joint3 and Gripper). If you did not get the sensor reading back, you could click "QueryCmd" button to send query command. Please make sure the channel 1 is working in position control mode (Mode:3) and channel 2 is working in open loop mode.

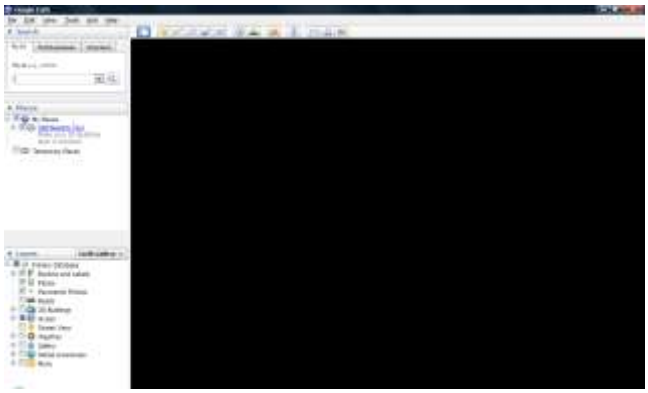
will display channel 1 and 2 motor's current.

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 by using "Windows Task Manager"; otherwise, you may not be able to display Google Earth when you start Jaguar control program again.

is Emergency Stop for manipulator arm (disable) action.

You could click the 

button to resume the manipulator arm controller.

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 locking screws of the 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 shown.

* 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 connects 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 Operation 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	drrobot
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 10001 to base controller board	TCP 115200. 8, N, 1, flow control
Port 2	Port 10002 to Laser Scanner(option)	TCP 19200/115200. 8, N, 1, no flow control

Ethernet Module 3	192.168.0.63	
Port 1	Port 10001 to manipulator motor controller 1	TCP 115200. 8, N, 1, no flow control
Port 2	Port 10002 to manipulator motor controller 2	TCP 115200. 8, N, 1, no flow control

Camera	192.168.0.65 Port 8081
User ID	root
Password	drrobot

Manipulator Arm Camera	192.168.0.64 Port 8082
User ID	root
Password	drrobot

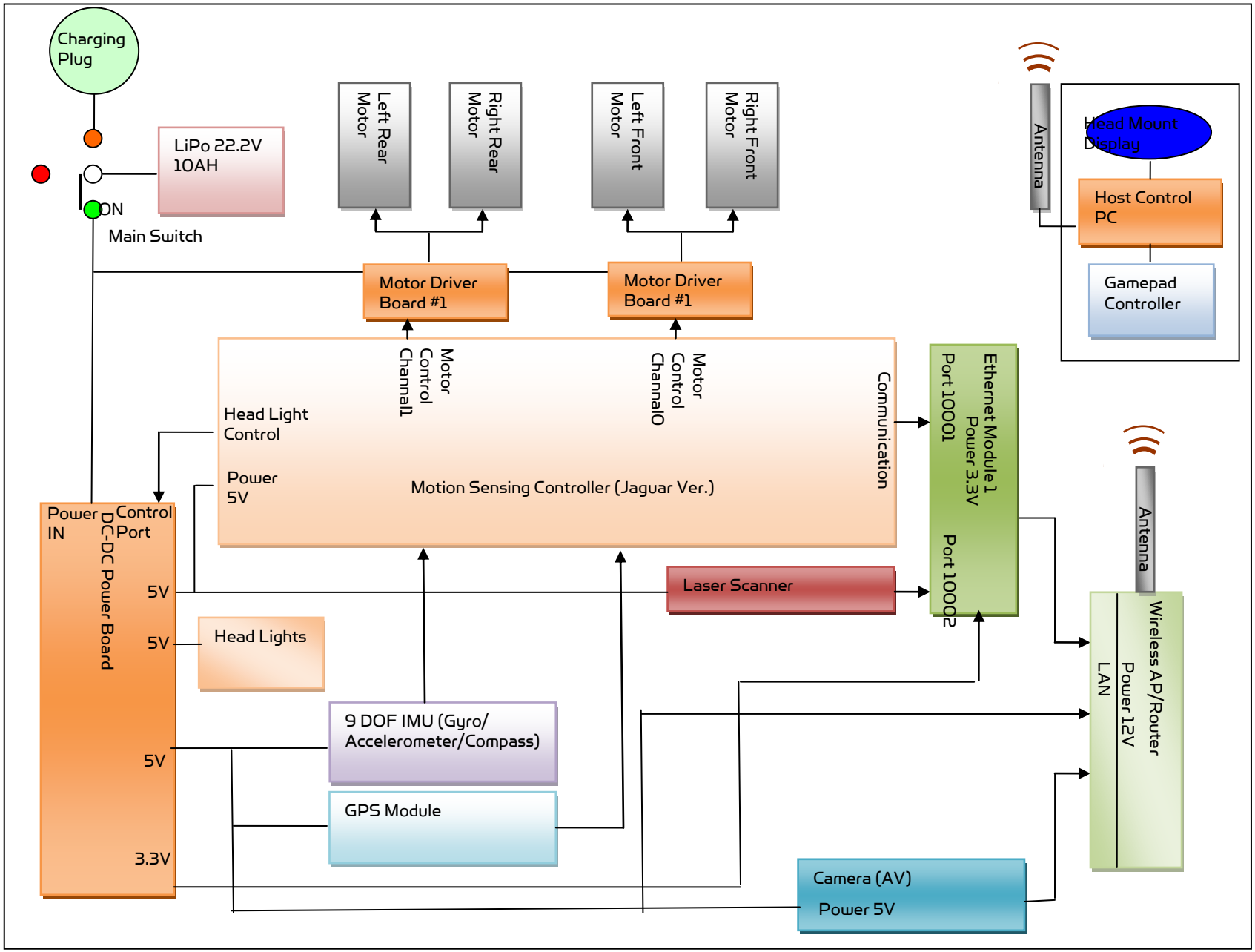
Advanced Network Settings

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).



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Jaguar 4x4 Wheel Base System

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 10A continuous power per channel, peak up to 20A per channel for a few seconds
Input voltage	6~24V, 30V absolute max

Motion and Sensing Controller

PMS5006 board is based on ARM Cortex-M4 controller. It will work as a main control center. Receive remote PC control command and send back all the sensor data, including IMU sensor, GPS module data and all the motor sensors, such as motor encoder, motor temperature, and motor driver board state.

Input power	5V
Motor Control Channel	Channel 0 will control front motors and channel 1 will control rear motors.
Motor control mode	Open Loop control; Velocity control; Position control

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	ITG3205 Triple-Axis digital output gyro sensor
Accelerometers	3 Axis ADXL345 13bit resolution Max +/-16G
Magnetic Compass	3 Axis HMC5883L magnetometer
Output Frequency	50Hz(Gyro an Acceerometers) 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	240°

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	270°

Batteries

Battery type	Li-Po
Rated Voltage	22.2V (12 cells, 3.7V/cell)
Capacity	20Ah
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

Jaguar Manipulator Arm System

Motor Driver Board

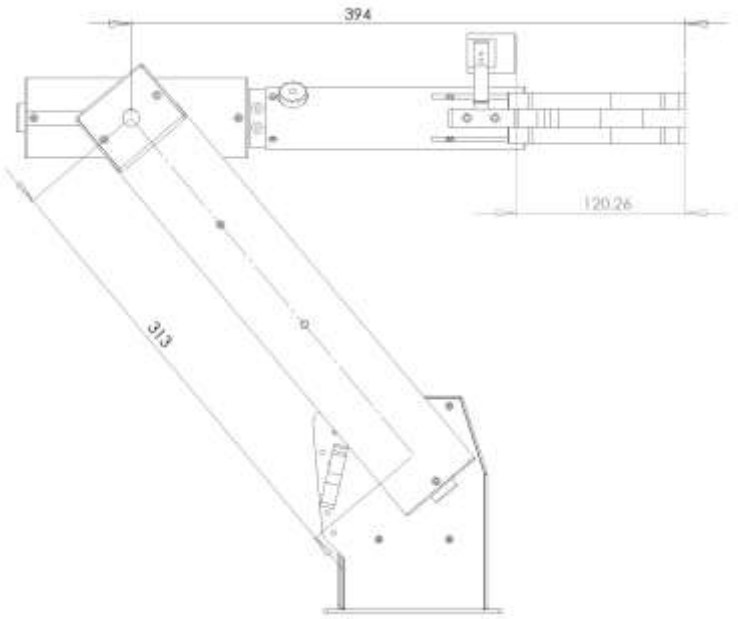
Two motor driver boards are used,

Input power	H-Bridge 2 channels
Max current	up to 10A continuous power per channel, peak up to 20A per channel for a minute
Input voltage	7~30V

Camera

Input power	48V
Resolutions	720x480 to 176x120
Horizontal Field of View	51°
Frame rate	H.264: 30 fps in all resolutions Motion JPEG: 30 fps in all resolution
Video compression	H.264 (MPEG-4 Part 10/AVC), Motion JPEG

Dimension



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V. Further Development & Programming

The Jaguar Control program

The Jaguar Control program is written with Visual Studio 2010 (in C#) under .Net 3.5 framework.

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

> 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

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, Matlab, and ROS. You should also contact Dr Robot with any questions regarding protocol.

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

Control program will connect to this board at 192.168.0.60, port 10001 by TCP socket.

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 for Hokuyo URG-04LX.

For URG-04LX-UG01(5.6m) or UTM-30LX(30m) setting is: 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)

IMU sensor message will be ended with "CRLF"(\r\n").

Format:

"$seq,Yaw,0.3,Gyro,gyroX,gyroY,gyroZ,Accel,accelX,accelY,accelZ,Comp, magX,MagY,magZ,(reserved text)"

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

After "Yaw", the value will be the estimate robot heading angle. You could use it or estimate the heading by raw gyro, accelerometer, compass and GPS sensor data. The unit is radian.

After "Gyro", the data will be 3-axis raw gyro sensor data.

After "Accel", the data will be 3-axis raw accelerometer sensor data.

After "Comp", the data will be 3-axis raw compass sensor data.

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.

Manipulator Arm

The manipulator arm is controlled by 2 RoboteQ SDC2130 control boards.

The program will communicate with it via 192.168.0.63, port 10001/10002 using TCP protocol.

You could find the manual from RoboteQ web site. You need to make sure that none of the motors gets stuck when driving the arm, since this may over-heat and burn the motors and/or motor driver board.

The emergency stop command is "!EX\r" and resume command is "!MG\r".

Joint Number	
Joint1 (Motor Driver board 1 channel 1)	Encoder : One circle count is 5700 Angle Resolution: 5700/ (2*PI) This joint is working in position control mode(mode 3): For example: Command: "!PR 1 -200\r" It will drive this joint up. Command: "!PR 1 200\r" It will drive this joint down. Command: "!P 1 -250\r" It will drive this motor to encoder position -250.(make sure you know where it is and not in stuck state) On control board, we set current limitation for this joint. It will enter emergency stop state when current is over 12A or current over 7A for over 1000ms. You could read temperature sensor via analog channel 3(AI 3). The temperature sensor is B57164K103J, you could find how to convert the readings to temperature from the sample codes.
Joint2(Motor Driver board 1 channel 2)	Encoder : One circle count is 5700 Angle Resolution: 5700/ (2*PI) This joint is working in position control mode(mode 3): For example: Command: "!PR 2 -200\r" It will drive this joint up. Command: "!PR 2 200\r" It will drive this joint down. Command: "!P 2 -250\r" It will drive this motor to encoder position -250.(make sure you know where it is and not in stuck state) On control board, we set current limitation for this joint. It will enter emergency stop state when current is over 8A or current over 6A for over 1000ms. You could read temperature sensor via analog channel 4(AI 4). The temperature sensor is B57164K103J, you could find how to convert the readings to temperature from the sample codes.

Joint3(Motor Driver board 2 channel 1)	Encoder : One circle count is 3724 Angle Resolution: 3724/ (2*PI) This joint is working in position control mode(mode 3): For example: Command: "!PR 1 -200\r" It will drive this joint to right. Command: "!PR 1 200\r" It will drive this joint left. Command: "!P 1 -250\r" It will drive this motor to encoder position -250.(make sure you know where it is and not in stuck state) On control board, we set current limitation for this joint. It will enter emergency stop state when current is over 8A or current over 5A for over 1000ms. You could read temperature sensor via analog channel 3(AI 3). The temperature sensor is B57164K103J, you could find how to convert the readings to temperature from the sample codes.
Gripper(Motor Driver board 2 channel 2)	Encoder : One circle count is 756 Angle Resolution: 756/ (2*PI) This joint is working in open loop control mode(mode 0): For example: Command: "!G 2 -200\r" It will drive Gripper close. Command: "!G 2 200\r" It will drive Gripper open. Command: "!G 2 0\r" It will stop this motor.(make sure you send this command to stop the Gripper before it reaches mechanical limitation) On control board, we set current limitation for this joint. It will enter emergency stop state when current is over 2A or current over 1A for over 1000ms. You could read temperature sensor via analog channel 4(AI 4). The temperature sensor is B57164K103J, you could find how to convert the readings to temperature from the sample codes.

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.