All-Terrain Autonomous Navigation Robot with GPS-IMU

Jaguar V6 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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Table of Contents

I. Specifications

Jaguar V6 Mobile Robotic Platform with manipulator arm is designed for indoor and outdoor applications requiring robust maneuverability, terrain maneuverability and object manipulation. 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 V6 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.

The integrated rugged 3+1DOF robotic manipulator (Jaguar Arm) is designed for compact mobile robots. It is light on weight, low on power consumption and compact on size. It has 3 DOF + 1 DOF gripper, with maximum reach of over 707mm (28 in), max payload capacity of 4Kg at max reach, while weights under 10Kg. Wrist mounted color video camera provides high resolution (720 x 480) close-up view. Jaguar Arm is ideal for 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 mobile robot, Jaguar Arm could achieve full 6DOF, and reach virtually any position and at any orientation within its allowed working space.

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 (< 41Kg with manipulator arm) 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)
- 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
- Rugged robotic arm (3DOF + 1DOF gripper) for compact mobile robots
- 707mm (28 in) reach with max 4Kg payload
- 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
- 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: > 35°
Maximum vertical step: 300mm (12")
Stair climbing: Max stair step height 300mm (12")
Traverse: > 360mm (14")
Four articulated arms
Speed: 0 – 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

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 on base
Color Camera (720x480, 30fps) on manipulator

Communication

WiFi802.11N
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

Track Motors (24V): 4 units
Max output (after gear down) (x2): Max 80W, 200Kg.cm/track
Rated current: 2.85A, Max current: 18A

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

Dimensions

Height: 400mm (15.7") (manipulator at rest)
Width: 700mm (27.6")
Length: 980mm (38.5") (extended arms) / 640mm (25.2") (folded arms)
Weight: 41Kg (Standard Configuration)

Payload

Carrying Payload (on flat surface): max 10Kg
Dragging Payload (on flat surface): max 30Kg

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

JAGUARV6-ME	Jaguar V6 Chassis (including motors and encoders)	1
JAGUARARM	Jaguar Manipulator Arm	1
PMS5006-JV6	Motion and Sensing Controller (Jaguar V6 Version)	1
WFS801	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
WRT802N	802.11N wireless AP/router	1
BPN-LP-20	22.2 V 20 AH LiPo Battery Pack	1
LPBC5000	2A LiPo Battery Charger	2
GPC0010	Gamepad Controller	1

Main Upgrade Options

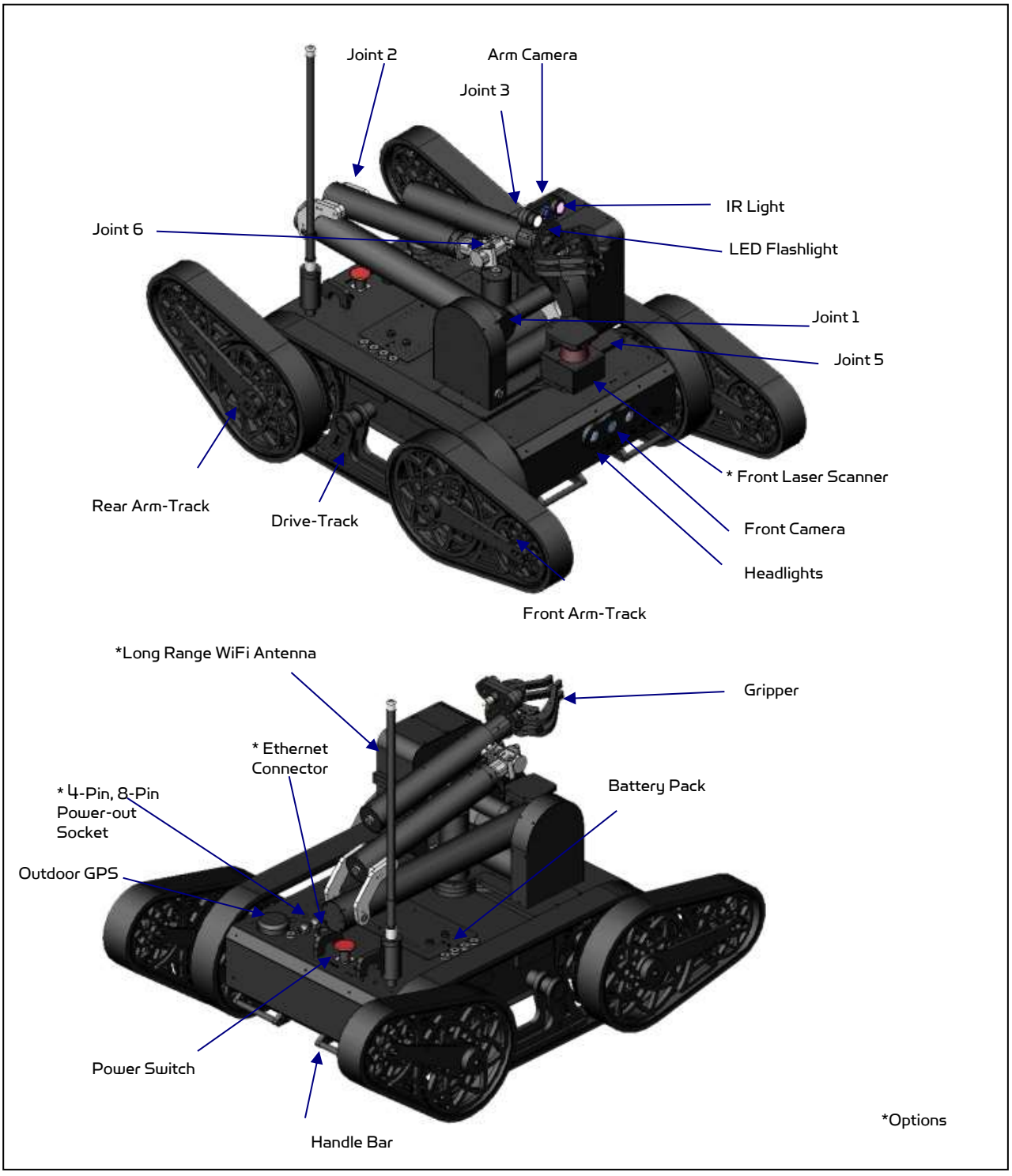
Laser Scanner (Range 4m) for Indoor Application	LAS04M
Laser Scanner(Range 5.6m) for Indoor Application	LAS56M
Laser Scanner (Range 30m) for Outdoor Application	LAS30M
22.2V 20 AH Li-Polymer Battery Pack	BPN-LP-20
Head Mounted Display (800x600)	HMD8H6H
802.11N Wireless AP/Router	WRT802N
Indoor GPS	SG-NAV
On-board Tablet PC	MSSURPRO
PTZ Camera	CAMA2156

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

II. Knowing Your Robot

Overlook

The figure below illustrates the key and optional components that you will identify on the Jaguar V6 robot.



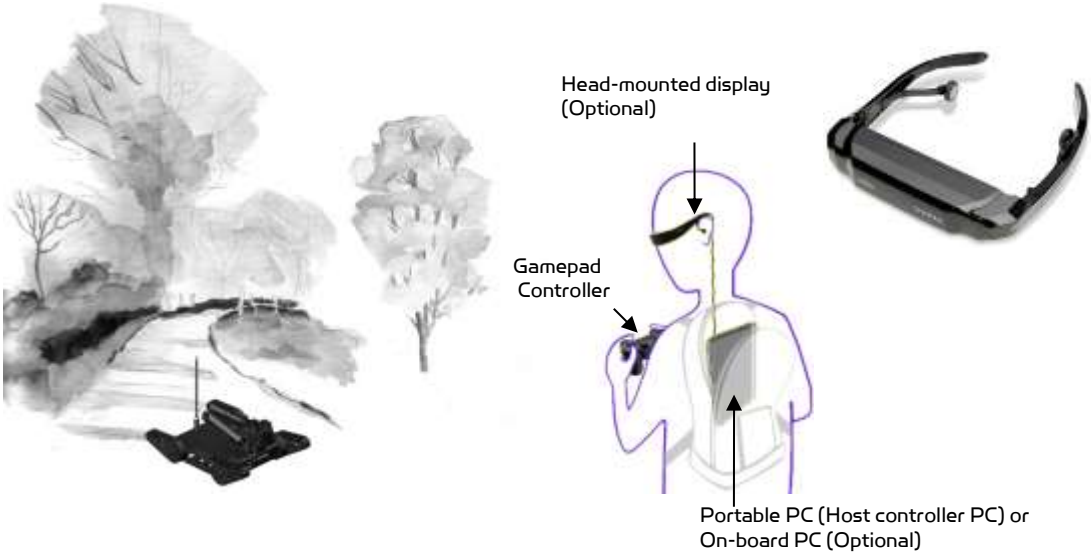
Jaguar V6 with Manipulator Arm Platform with Options

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 installed from CD.

Install all the supporting program from the "third party" folder in the 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" (Note: You need to install Google Earth program and other third party program first).

Turn on/off the Platform

Please follow the steps below to power up the robot.

1. Turn to release the red button.

2. Press and hold the start button for about 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.

* To power off the robot, push down the red button, the system will shut down.

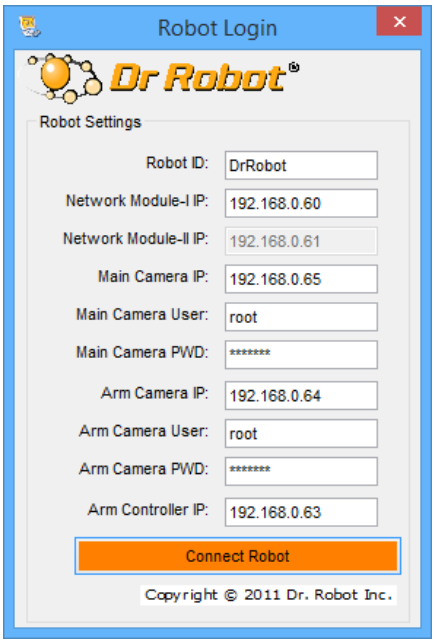
Using Dr Robot Jaguar Control Program

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 flipper arms 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 camera.

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



When "Connect Robot" is clicked, it will try to connect 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 GPS&IMUchart boxes.

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

After the program starts up, the motor driver board is in the "Estop" state due to the safety reason. You need use "EStopWheel" button to release the motor driver board from emergency stop state.

You also need switch to 'FlipArm" tag and click "ESTOP_F" button to make sure

is not in "+ESTOP" state.

Same as the rear flip arm, please make sure Rear Driver State is not in "+ESTOP" state. After that it should look like below:

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".

All the Flipper Arms on the robot are independently controlled.

Here we use keyboard to control each arm.

Key	Functions
"Q"	Left Front Flipper Arm Up
"A"	Left Front Flipper Arm down
"W"	Right Front Flipper Arm Up
"S"	Right Front Flipper Arm down
"O"	Left Rear Flipper Arm up
"K"	Left Rear Flipper Arm down
"P"	Right Rear Flipper Arm up
"L"	Right Rear Flipper Arm down
"Z"	Set Flipper Arm initialize position
"X"	Set front flipper arm to same position
"M"	Set Rear flipper arm to same position
"E"	Set Front flipper arms to up 30 degree
"D"	Set Front flipper arms to down 60 degree
"I"	Set rear flipper arms to up 30 degree

"J"	Set rear flipper arms to down 60 degree
"C"	Set front flipper arms to 0 degree(stretch to front) Set rear flipper arms to 0 degree(stretch to back)
"Y"	Set Front Light On/Off

Initializing or resetting arm-track (flipper arm) position:

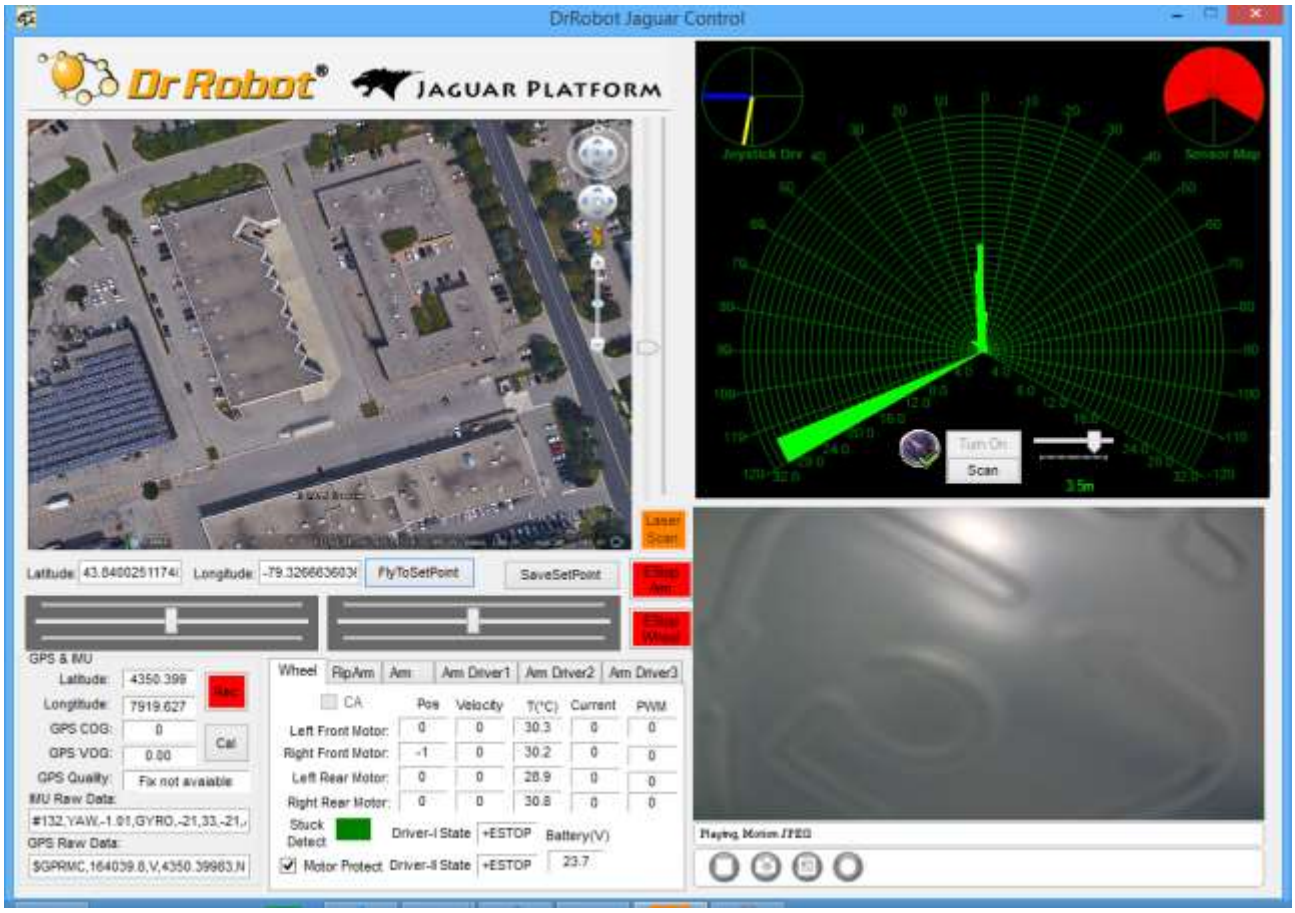
After powering up the robot, or when the actual arm position is different from the arm position window (shown on the right), you should reset the arm-track (flipper arm) position as following:

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

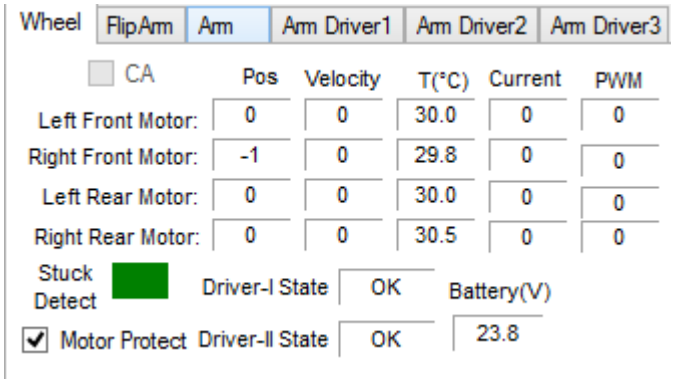
- then, click the "Z" button on keyboard to save this value and to set initial position.

When 

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



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



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. If the motor driver board state is in the “ESTOP”, you need click “Estop Wheel” button to release the board from emergency stop state.

Motor Protect 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.

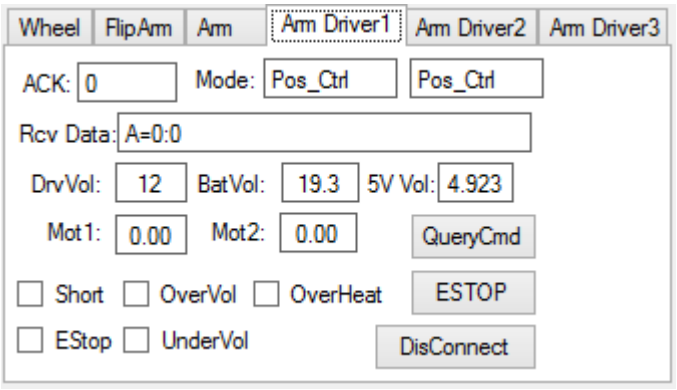
"FlipArm" tag will display all the information about the front/rear flip arm motors and the state of the flip arm motor driver board.

"Arm" tag shows Joints Angle Information and Control Value
* Arm J4 is Gripper

It would be better if you could make sure the manipulator arm is at "reset" position (shown in below picture) before you turn on the robot.

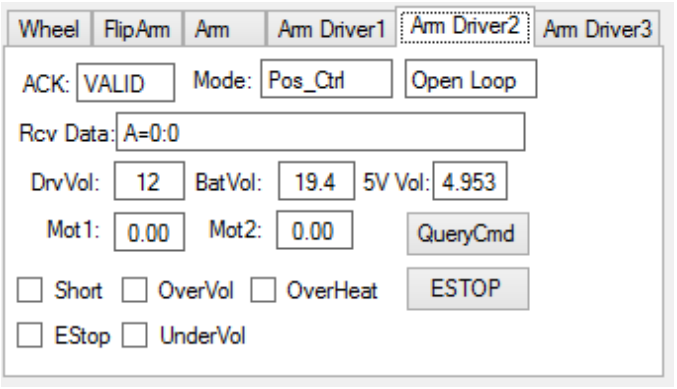
If the robot is already on, please drive each joint carefully to "reset" position and press the "Start" button on gamepad to set manipulator initial position, it will "check"  .
After that, you could press "B" button on gamepad to reset manipulator arm to initial position. This "reset" process also will provide the motor protection based on mechanical limitation, so it should be mandatory.

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



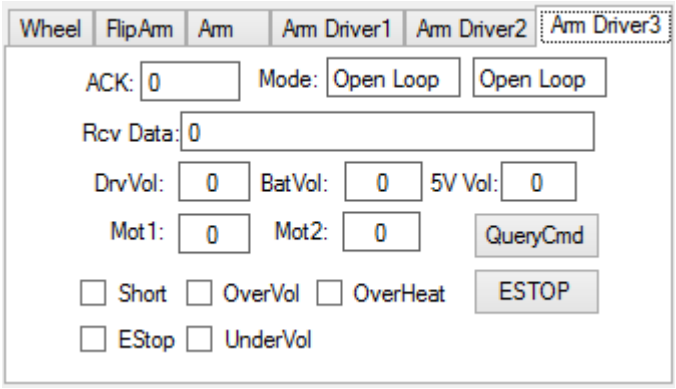
"Arm Driver1" tab will display motor driver controller 1 states (for Joint 1 and 2). If you did not get the sensor reading back, you could click "QueryCmd" button to send query command. Please make sure the channel 1 and 2 are working in position control mode (Mode:3).

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.



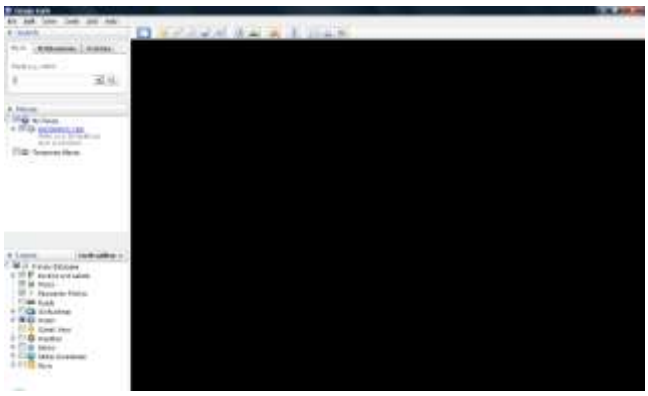
"Arm Driver3" tab will display motor driver 3 state(for optional pan unit).

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.

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. Here is the procedure for using standard charging station, please refer to the proper manual coming with the fast charger.

1) Push down the red button to turn off the robot

2) Loose the locking screws of the Battery Box, disconnect the 2-Pin battery 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 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 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 on-robot pre-configured wireless AP has the following pre-set settings:

PicoStation	SSID	KEY	IP	ID	Password
PicoStation-1: Local Wireless Network(option)	DriJaguar	drrobotdrrobot	192.168.0.245	drrobot	drrobot
PicoStation-2: Long Range Wireless Bridge (On Robot) (optional)	DriJaguarBridgeY	drrobotdrrobot	192.168.0.21	drrobot	drrobot
PicoStation- 3: Long Range Wireless Bridge (Off Robot) (optional)	DriJaguarBridgeY	drrobotdrrobot	192.168.0.20	drrobot	drrobot

Note:
* PicoStation 2, 3 work in peer to peer (bridge) mode, and must work together. No other device could connect with this wireless network (DriJaguarBridge).

* You could connect Picostation 3 to your network. In this way, your local network will wirelessly "bridge" to the robot.

* On-board PC could connect with wireless network "DriJaguar",(option)

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 Main Motion/Sensor Controller PMS5006	TCP 115200. 8, N, 1, no flow control
Port 2	Port 10002 to Laser Range Sensor	TCP 115200. 8, N, 1, no flow control

Ethernet Module 2	192.168.0.61(reserved)	
Port 1	Port 10001 to Pan/Tilt Unit	TCP 115200. 8, N, 1, no flow control
Port 2	Port 10002 to second Laser port	TCP 115200. 8, N, 1, no flow control

Ethernet Module 3	192.168.0.63	
Port 1	Port 10001, Manipulator Arm Joint 1/2 motor driver board	TCP 115200. 8, N, 1, no flow control
Port 2	Port 10002 Manipulator Arm Joint 3/4(rotate/gripper),motor driver board	TCP 115200. 8, N, 1, no flow control

Ethernet Module 4	192.168.0.62	
Port 1	Port 10001, Manipulator Arm Joint pan/Tilt motor driver board	TCP 115200. 8, N, 1, no flow control
Port 2	Port 10002 reserved	TCP 115200. 8, N, 1, no flow control

Camera	IP	Port	User ID	Password
Front camera	192.168.0.65	Port 8081	root	drrobot
Zoom camera(option)	192.168.0.64	Port 8082	root	drrobot

Optional embedded PC(Ubuntu with ROS)	192.168.0.68 user name:drrobot password: drrobot
Optional Hokuyo UTM-30LX-EW Laser Ranger Scanner	192.168.0.69 port: 10940

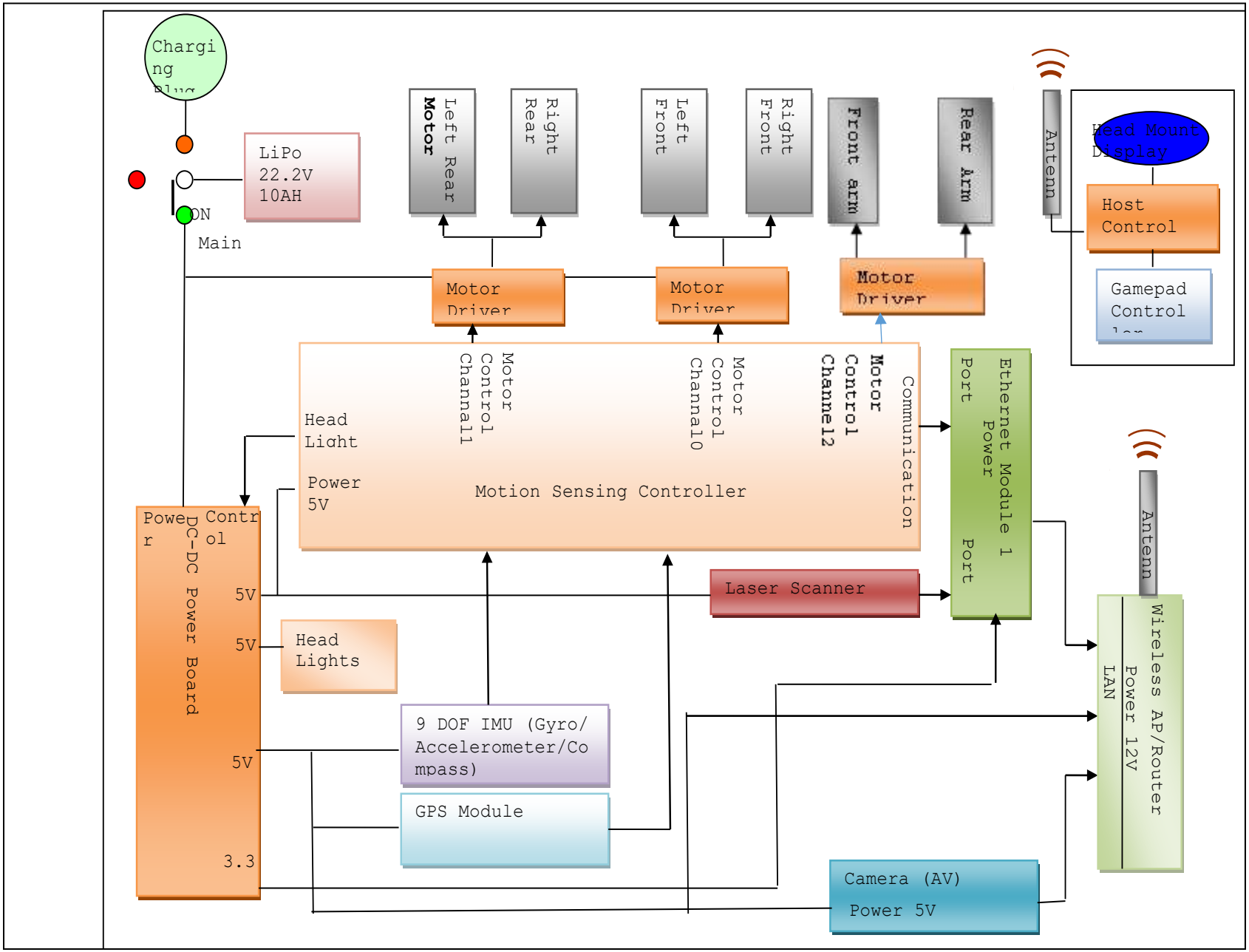
Advanced Network Settings

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).



Jaguar V6 Base System

Motor Driver Board

Three motor driver boards are used, two of them working in open loop mode for the left and right track/wheel motors while the other one working in encoder position control mode is for the flipper arm motors.

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	12~30V, 30V absolute max
Motor control mode	Open loop PWM control; Velocity control; Position control
Sensor sampling	Encoders, motor current, motor temperature

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 -0	Channel 0 will control front left motor and channel 1 will control front right motor.
Motor Control Channel -1	Channel 0 will control rear left motor and channel 1 will control rear right motor.
Motor Control Channel -2	Channel 0 will control front flipper arm motor and channel 1 will control rear flipper motor.
Motor Control Channel -3	reserved
IMU/GPS Reading	Read GPS and IMU readings

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

Three laser scanner options are available, with measurement range of 0.02-4m, 0.02-5.6m and 0.1-30m.

Input Power	5V	
Detectable Range	0.02-4m	
Accuracy	0.02 to 1m: +/- 10mm	1 to 4m: 1%
Angular Resolution	approx. 0.35° (360°/1024 partition)	
Scanning Angle	240°	

Input Power	5V	
Detectable Range	0.02-5.6m	
Accuracy	0.06 to 1m: +/- 30mm	1 to 5.6m: 3%
Angular Resolution	approx. 0.35° (360°/1024 partition)	
Scanning Angle	240°	

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

Batteries (2 Packs) – Specification per pack

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

Jaguar Manipulator Arm System

Motor Driver Board

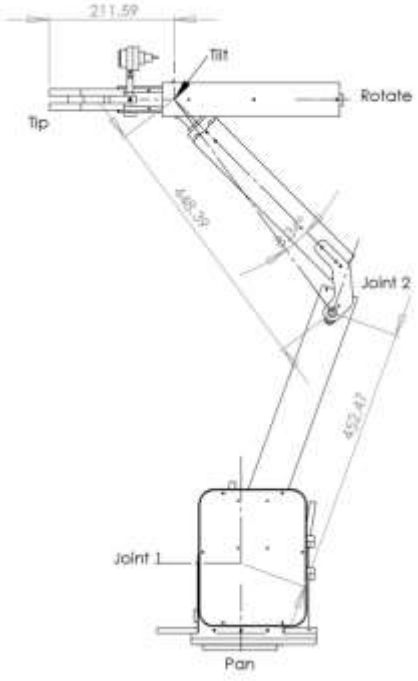
Two motor driver boards are used,

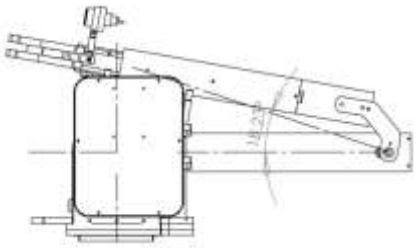
Input power	H-Bridge 2 channels
Max current	up to 10A continuous power per channel, peak up to 20A per channel for a minute
Input voltage	7~30V

Camera

Input power	12V
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





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.

Flipper 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	1140 counts per revolution

Drive track shaft

Track-wheel motors (2 units)	DC motors with steel gearbox
Motor rated voltage	24V
Motor rated current	2.85A
Motor max current	18A
Shaft rated speed	230RPM
Shaft rated torque	13.5Kg.cm
Shaft encoder resolution	counts per revolution

V. Further Development & Programming

The Jaguar Control program

The Jaguar Control program is written with Visual Studio 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:

> 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.

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. 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.

Manipulator Arm

The manipulator arm is controlled by 3 RoboteQ SDC2130 control boards.
The program will communicate with it via 192.168.0.63 and 192.168.0.62 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 19000 Angle Resolution: 19000/ (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 conver the readings to temperature from the sample codes.
Joint2(Motor Driver board 1 channel 2)	Encoder : One circle count is 53706 Angle Resolution: 53706/ (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 conver 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 conver 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 conver the readings to temperature from the sample codes.
Pan unit Gripper(Motor Driver board 3 channel 1)	Encoder : One circle count is around 14275.33(with external gear ratio 46:12) Angle Resolution: 14275.33/ (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 conver the readings to temperature from the sample codes. The rotation angle range is ~270 degree ~ + 270 degree
Arm tilt(Motor Driver board 3 channel 2)	Encoder : One circle count is around 7448 Angle Resolution: 7448/ (2*PI) This joint is working in position control mode(mode 3): For example: Command: "!PR 2 -200\r" It will drive this joint to right. Command: "!PR 2 200\r" It will drive this joint left. 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 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 conver the readings to temperature from the sample codes. The rotation angle range is -180 degree ~ + 180 degree

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 ROS, LabVIEW and MATLAB. Please contact support@drrobot.com for further information.