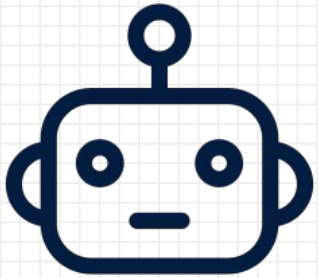
# BotSense



*Brains for Robots*

# Human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April 9, 2018

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RoboCup 2007

Many different hardware platforms – no sensors, or common way to program

## Problems:

- ✗ Don't want to build robots, just program.
- ✗ Want to work on high-level intelligent algorithms, eg. multi-agent cooperation.
- ✗ Need stable educational curricula for STEM.
- ✗ Robots are "stupid" - lacks sensors, computer.
- ✗ Robot manufacturers discontinue hardware.

## Approach:

- Reusable sensors.
- Reusable embedded controller.
- Common computing framework.
- Open-source!

## Solution:

- ✔ Give robots sensors:

IMU, camera, foot and hand haptics using standard I2C, USB.

- ✔ Standardize servo position feedback.
- ✔ Visual feedback, lots of LEDs
- ✔ Integrate with modular components:

sensor hub, small computer board.

## Solution cont'd:

- ✔ Develop translation interface to several hardware platforms (MCU).
- ✔ Develop open middleware or framework.
- ✔ Customers can re-use/share same software apps/curricula with many robots!
- ✔ Open-source OS (Linux!), C, C++, Python, XML.

## Business Side:
## How do we get $$ to make this happen?

- ✔ Present idea to community (IEEE, AAAI).
- ✔ Academic collaborations.
- ✔ Write a grant (or two).
- ✔ Small steps/while we wait.
- ✔ Small business grant Phase I from NSF!!!

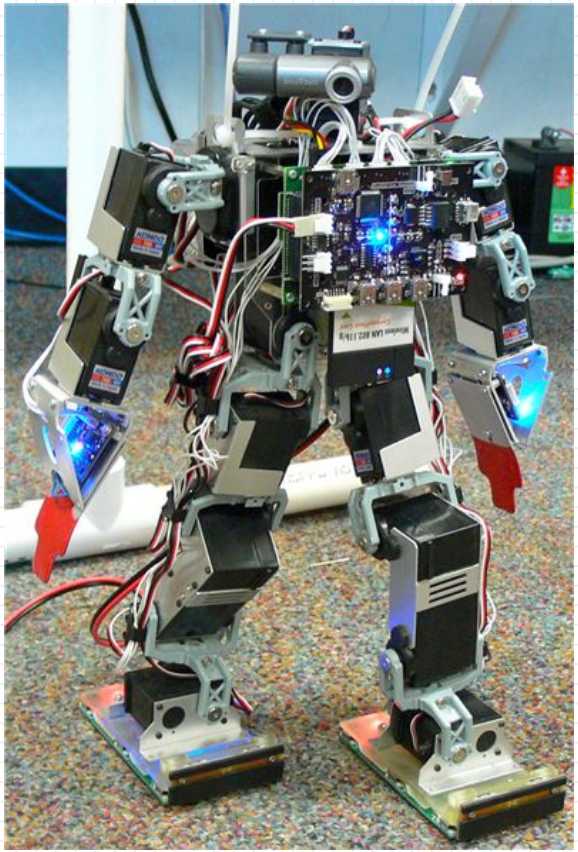
## Now What?

- Project management (SIUE, RN Collaboration)
- Hardware design (feet, hands, parts)
- Electronics & sensors design
- Firmware
- Software

USB Camera

* Sensor I/F Board

“Brain Pack” SBC



Off-the-shelf Robot:

*Servos, Joints, MCU, Battery*

*IMU

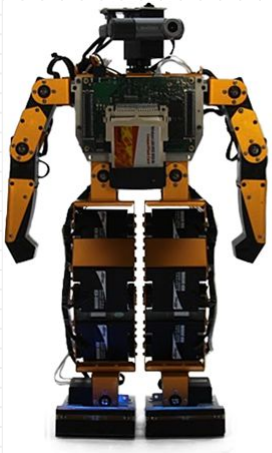
WiFi Compact Flash

*Hand Sensors

*Foot Sensors

*Designed by RoadNarrows

## Hardware System



## Kord

Status: Commercial Beta

The Kord is a general purpose IO board that is used to connect all of the other Brainpack components to the "brain," which is a KoreBot II Linux-based single board computer (shown below). The Kord is designed to work well with the Brainpack, however, it is also a very appealing add-on to existing KoreBot II users as well for a large range of applications, not just Brainpack. It's key features include:

- On-board power supply and power management
- Power distribution system
- 3-Port USB hub for cameras and other accessories
- 6x - I2C ports to connect hands, feet, and other sensors
- RS-232 serial console port
- 2x - RS-232 device ports
- IR remote receiver
- Tri-axis high-resolution accelerometer
- 12x - Configurable LEDs

## Brackets

Status: Commercial Beta

In order to the allow the Brainpack to work on a wide-variety of humanoid platforms we developed several different bracket sets. These are made from waterjet cut aluminum and act as mounts for the KoreBot II, camera, feet, and hands. If a humanoid platform is changed or a new platform is released we can simply design a new bracket set which allows us to quickly add Brainpack hardware support. Currently we have bracket sets for the Robotis Bioloid Series, Hitec RoboNova, Kondo KHR Series, and Kyosho Manoi.

## Bellum DM

Status: Prototyping

While we can interface with most off-the-self humanoid platforms, the interface between our controller and the motors can sometimes be slower than we want it. The Bellum is an optional high-speed servo motor controller replacement that eliminates this slow link. The Bellum DM is specifically designed to replace the standard controller on the Robotis Bioloid line of humanoids but other Bellum boards can be designed for other humanoid platforms to improve their performance as well.

## Hand

Status: Commercial Beta

The Brainpack Hand is a smart I2C device that contains a strain gauge sensor that allows a robot to "feel" objects. It is usually used for simple grasping but can also be used as a tactile sensor, much like how a blindfolded person would use their hands when they were wandering around a cluttered room. The hand also provides several LEDs to display status information.

## Foot

Status: Commercial Beta/Redesign

The Brainpack Foot is a smart I2C device that contains eight force sensors to allow a humanoid robot to balance and adapt to various terrain changes. Six of the force sensors are in the sole of the foot and two are in the toe to provide tactile feedback when an object is kicked. LEDs in the foot can display force data or a variety of patterns. Our second generation Foot which is currently in development will replace our current force sensors with strain gauges to give the Foot better reliability and accuracy. It will also be slightly smaller to meet RoboCup Soccer rule requirements opening up this new market to the Brainpack.

## Camera

Status: Off-the-Shelf Commercial Product

The USB camera is mounted on the head of a humanoid and can support vision algorithms such as object tracking or facial recognition.

## KoreBot II & Wi-Fi Card

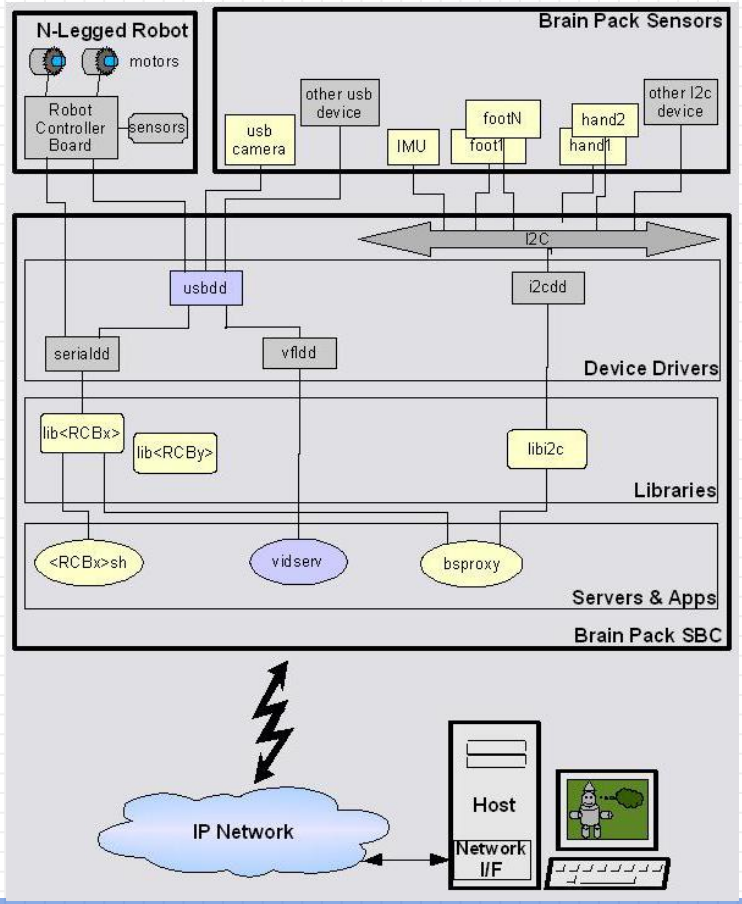
Status: Off-the-Shelf Commercial Product

The KoreBot II is a 600MHz Linux-based single board computer and is the "brain" of the Skewlzone Brainpack. The 802.11 b/g Wi-Fi card plugs into the KoreBot II and adds wireless capabilities to the system. This means that a robot could be controlled remotely or the vision system could be streamed to a remote user.

## Project Management Considerations

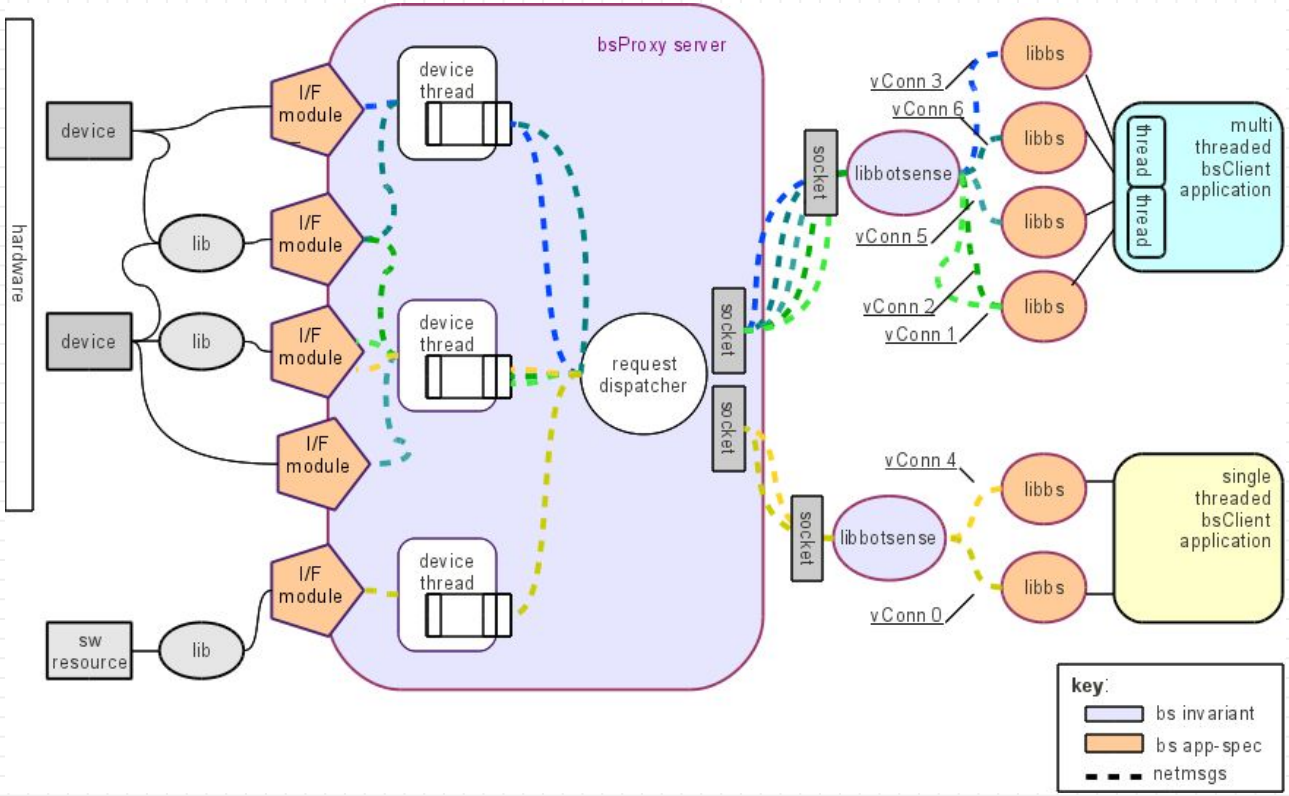
- Tracking tasks and milestones.
- Coordinating software/meetings with SIUE.
- Source Code Management (H/W, EE, S/W).
- Versioning, packaging, releases.
- Integration & Test.
- Defect and Issue Tracking.
- Product Documentation.
- Having fun & outreach.

- Motors/Camera/Raw Data
- Device Drivers/Firmware
- Libraries
- Servers & Apps
- Connect to/from Higher Level Apps

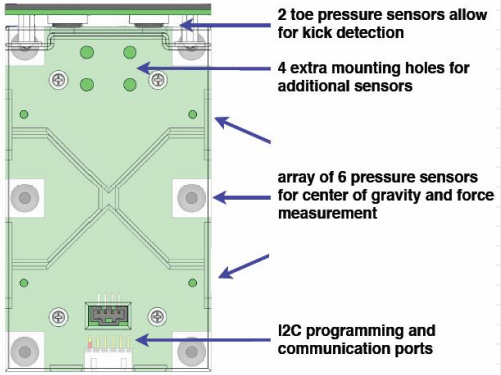


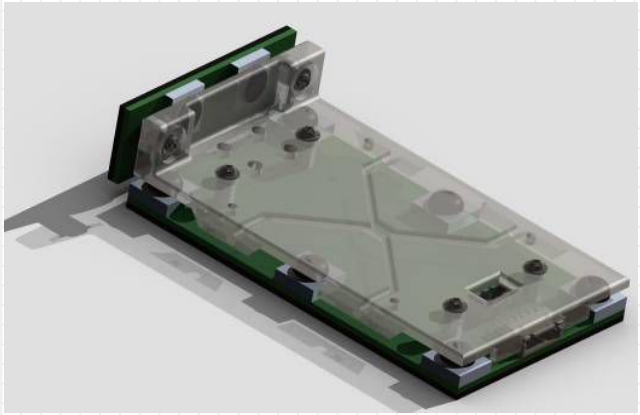

Software Reference Architecture

# BotSense Framework



# Sensor Data Example – The Foot sensor



- ✔ on-board firmware calibrated data.
- ✔ provided vector data via I2C netmsgs.
- ✔ msg format defined in xml.
- ✔ raw, calibrated or vector data available.

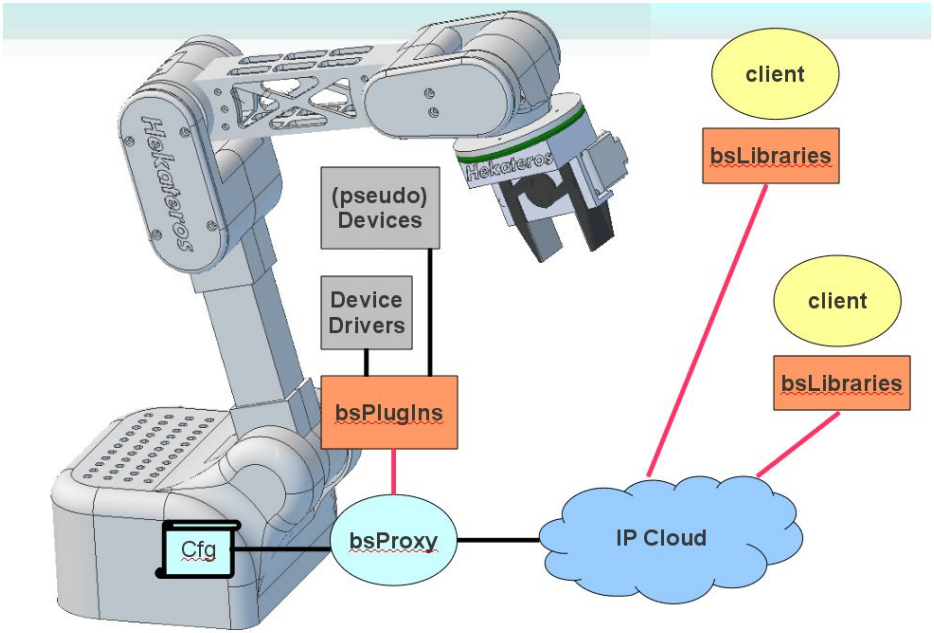
## Robot Configuration Definition Files

- .kin files defined kinematics/joints for various robot types. XML (Carnegie Mellon Tekkotsu.org)
- urdf - Unified Robot Description Format e.g. joints, links, mesh. XML (ROS.org)

## Legs versus Arms versus Wheeled

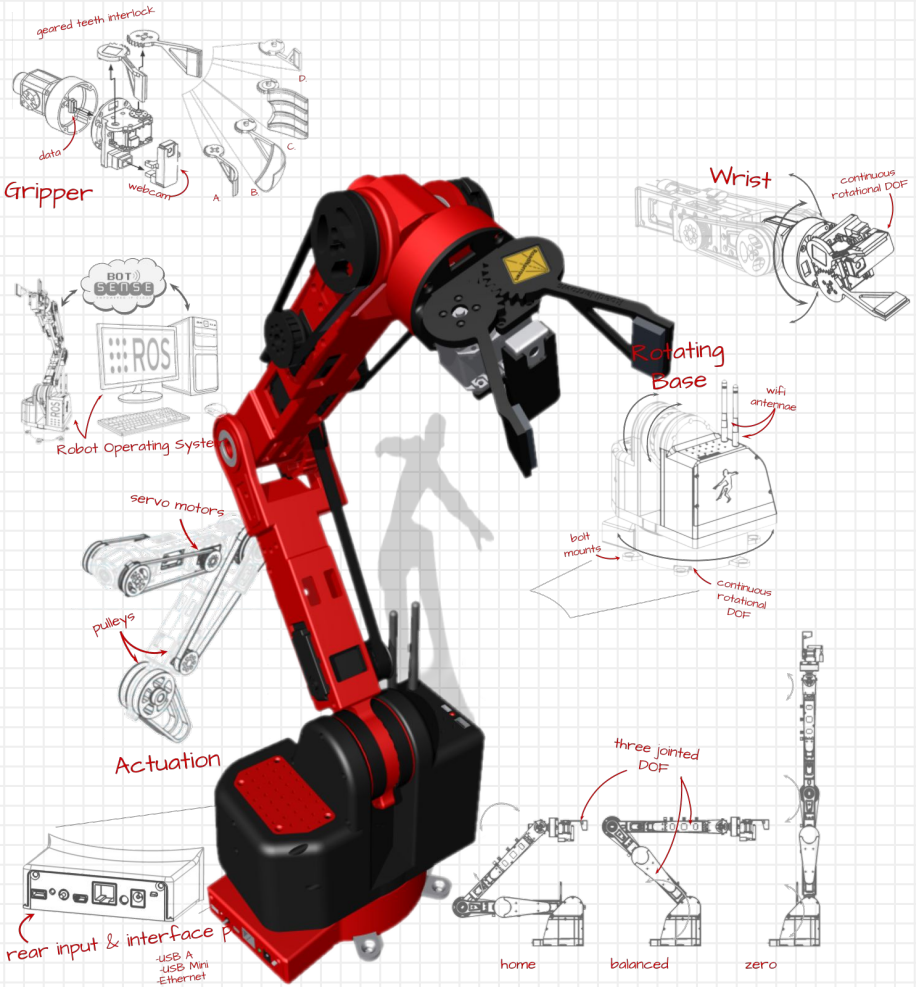
- Legged robots are hard.
- Limited academic market.
- Arms, though, can be pretty useful!
- Manipulators were > $50,000 (overkill) or < $1000 (useless), and no open software.
- RoadNarrows pivoted priority to arms and wheeled platforms.
- BotSense architecture didn't care, arms, legs, or wheels.

- Motors/Camera/Raw Data
- Device Drivers/Firmware
- Libraries
- Servers & Apps
- Connect to/from Higher Level Apps/Clients




BotSense Framework

## Software Reference Architecture


geared teeth interlock
data
webcam
A
B
C
D
Gripper
Wrist
continuous rotational DOF
BOT SENSE
ROS
Robot Operating System
Rotating Base
wifi antennae
bolt mounts
continuous rotational DOF
servo motors
pulleys
Actuation
three jointed DOF
rear input & interface p
-USB A
-USB Mini
-Ethernet
home
balanced
zero

# Control Panel

**Real-time dashboard**

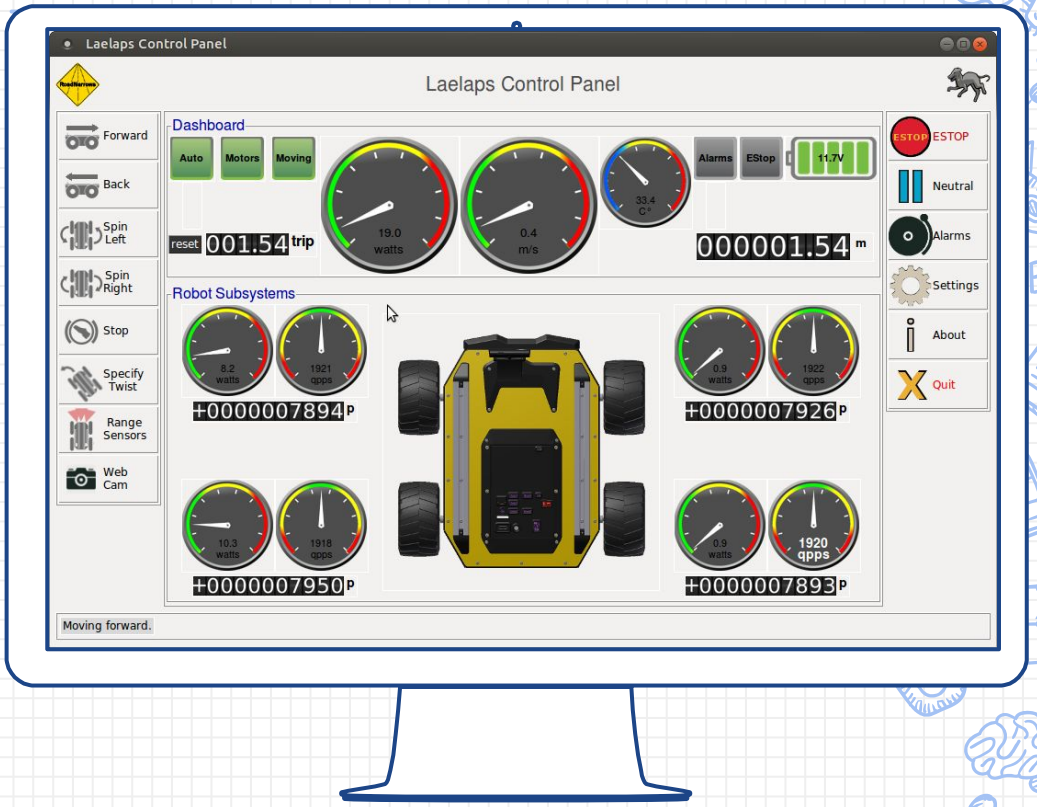
Remote control

Motor status

Alarm Menu

EStop

Web Cam Menu



# Control Panel and Monitor

**Real-time dashboard**

Alarm status

Control panel

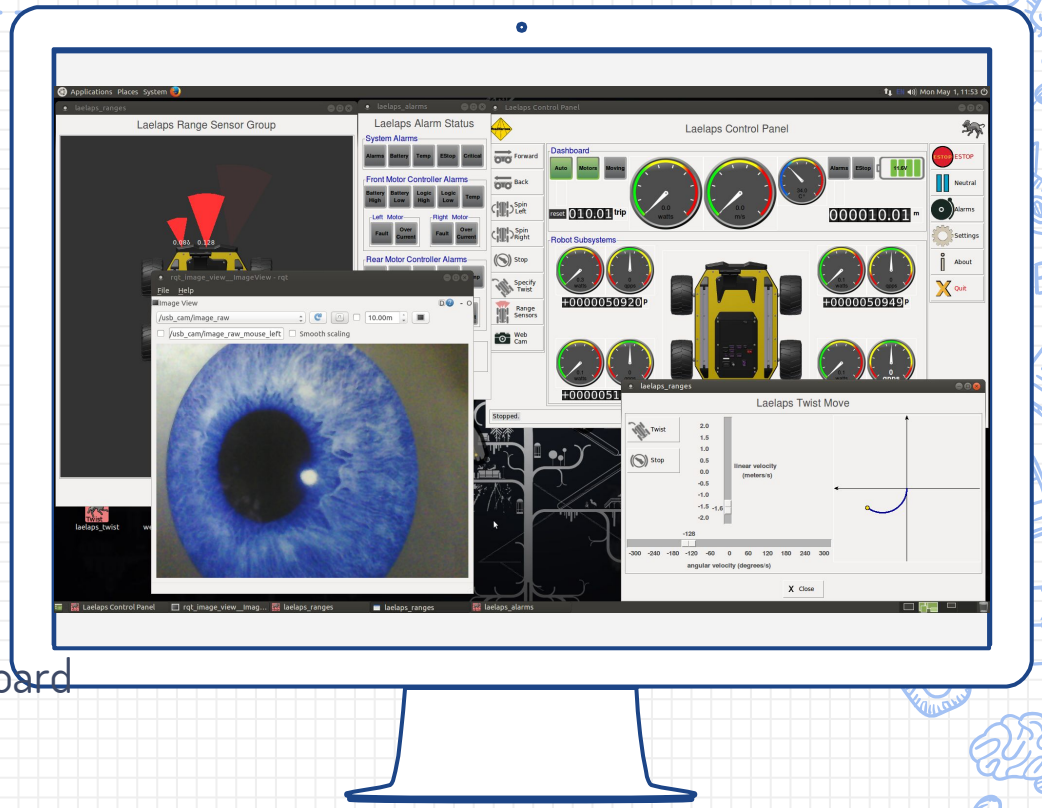
Motors

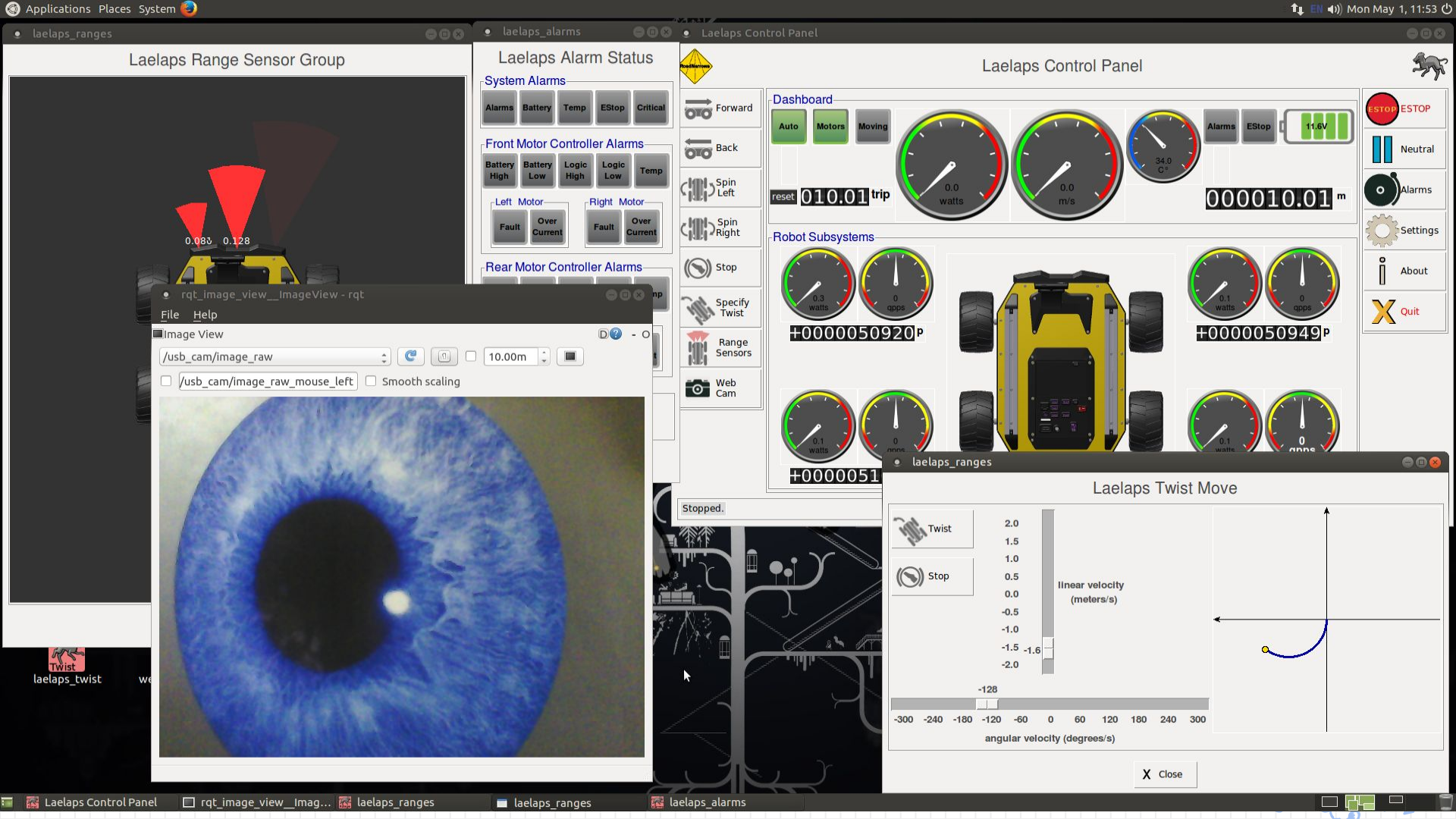
Motion, velocity

Camera streaming

IR distance sensing

C++ connects via wifi to on-board computer ROS Nodes.




Applications Places System
Mon May 1, 11:53
laelaps_ranges
Laelaps Range Sensor Group
0.088
0.128
laelaps_alarms
Laelaps Alarm Status
System Alarms
Alarms
Battery
Temp
EStop
Critical
Front Motor Controller Alarms
Battery High
Battery Low
Logic High
Logic Low
Temp
Left Motor
Fault
Over Current
Right Motor
Fault
Over Current
Rear Motor Controller Alarms
Laelaps Control Panel
Laelaps Control Panel
Forward
Back
Spin Left
Spin Right
Stop
Specify Twist
Range Sensors
Web Cam
Dashboard
Auto
Motors
Moving
0.0 watts
0.0 m/s
34.0 C°
Alarms
EStop
11.6V
reset
010.01 trip
000010.01 m
Robot Subsystems
0.3 watts
0 apps
+0000050920 p
0.1 watts
0 apps
+0000050949 p
+0000051
Stopped.
ESTOP
Neutral
Alarms
Settings
About
Quit
rqt_image_view__ImageView - rqt
File
Help
Image View
/usb_cam/image_raw
10.00m
/usb_cam/image_raw_mouse_left
Smooth scaling
laelaps_ranges
Laelaps Twist Move
Twist
Stop
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-1.6
linear velocity (meters/s)
-128
-300 -240 -180 -120 -60 0 60 120 180 240 300
angular velocity (degrees/s)
X Close
Twist
laelaps_twist
Laelaps Control Panel
rqt_image_view__Imag...
laelaps_ranges
laelaps_ranges
laelaps_alarms

## My hats

- ✔ Project lead. PI on NSF Grants.  Managed tasking, teams, communication, milestones.
- ✔ Oversight of system architecture, design.
- ✔ Hands-on embedded linux installs, drivers, versions.
- ✔ Robot .kin file descriptors.
- ✔ Software configuration management.

## More Information

### Fun:

Kuon and Hekateros Towing Demo

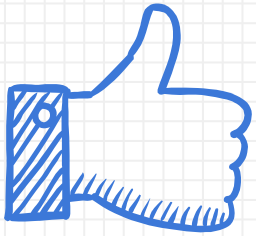
Hekateros Arm Promotion Video

### Further Reading:

https://github.com/roadnarrows-robotics/hekateros/wiki

Robot Operating System www.ros.org

Open Source Robotics Foundation www.osrfoundation.org



# THANKS!

## Any questions?

You can find me at

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