

gRAPI: An indoor four-wheeled robot API for a gumstix connex

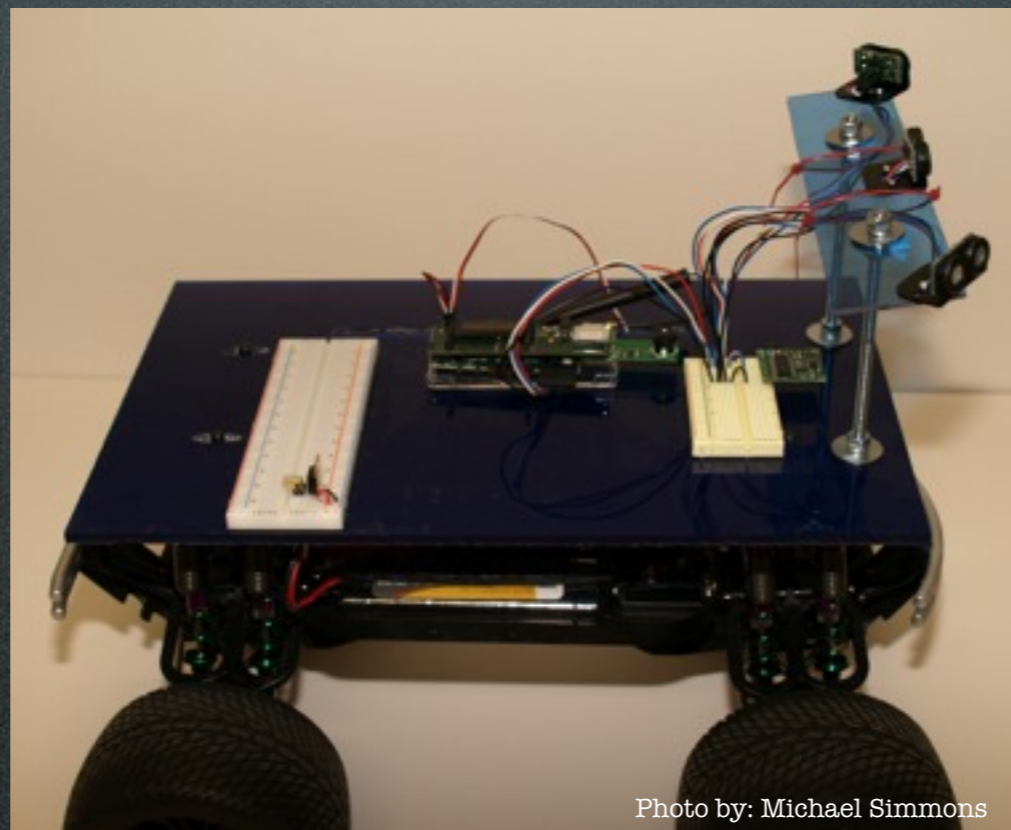


Photo by: Michael Simmons

by
Michael Simmons

Outline

- Preliminary setup
 - Work with ISL
 - Hardware Selection
 - Computer Setup
 - Hardware Setup
- Software Development
 - Development of gRAPI
 - Testing of gRAPI
- Demo/Videos of test programs

Preliminary Setup

ISL Hallway Hummer



ISL Minimoto Electric ATV



Hardware Selection

Hardware	
	Traxxas E-Maxx Monster Truck
	4 x 6 cell 7.2 V battery for powering the robot
	2 x battery chargers for the 6 cell batteries
Sensors	
	3 x Devantech Ultrasonic Range Finder sensors
	Devantech electronic compass sensor
Controller	
	gummstix connex motherboard
	tweener
	robostix
	wifistix
	serial cable
	power cable
Lab Equipment	
	DC power supply
	multimeter
	oscilloscope
	10" x 15" sheet of plexiglass
	2 x 6" bolt and nut and lock washer
	22 AWG wire for connecting hardware
	wire cutter and stripper
Development Tools	
	Desktop computer running Ubuntu Linux
	Laptop computer running Ubuntu Linux
	wireless router

Platform selection criteria for robot platform

Platform Selection Criteria			Selected
Environment	Indoor	Outdoor	Indoor
Power Source	Battery	Fuel	Battery
Ground Clearance	High	Low	High

Robot Platform



Traxxas E-Maxx RC electric
monster truck

Controller



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gumstix connex
motherboard

robostix
expansion board

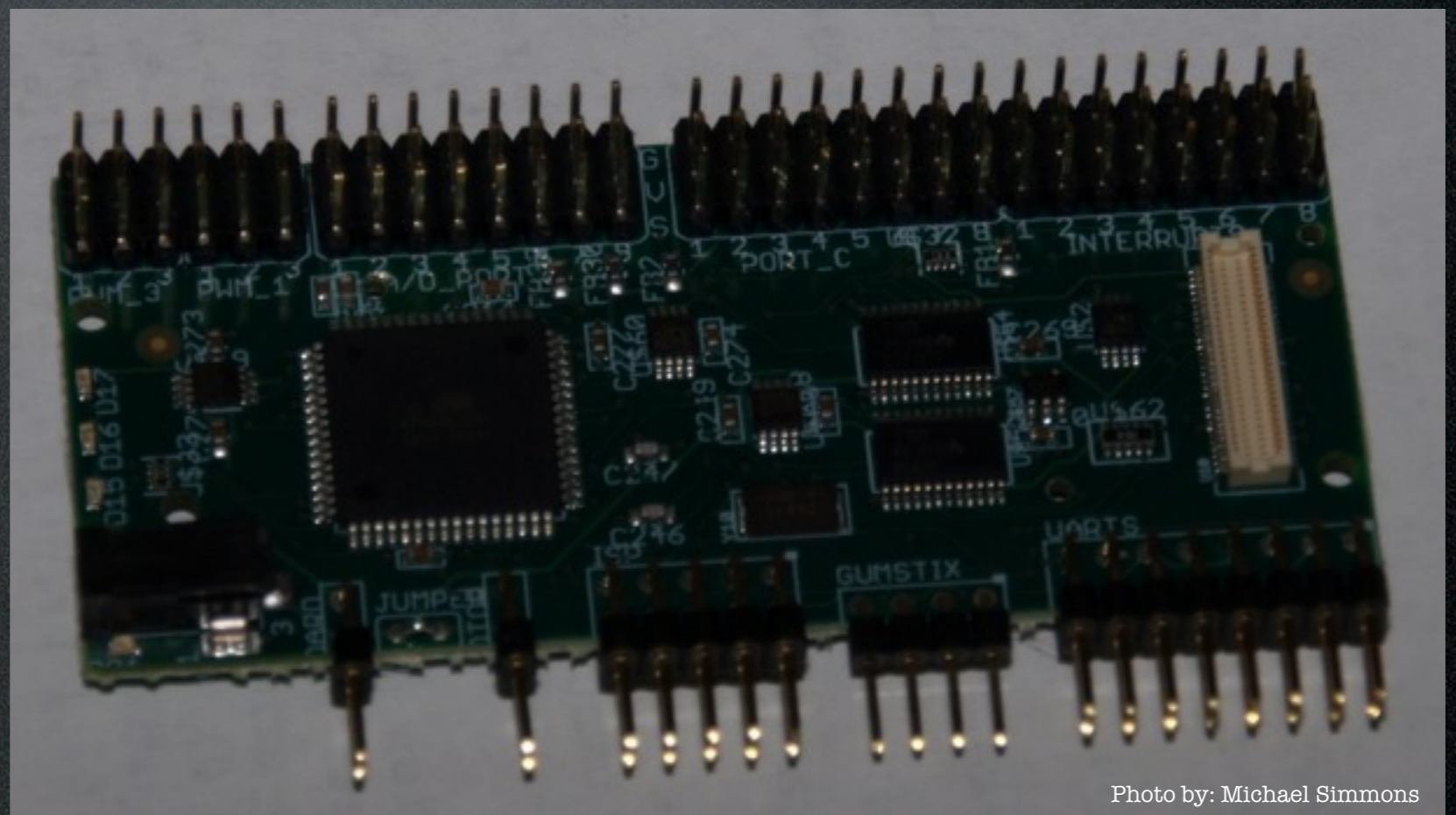
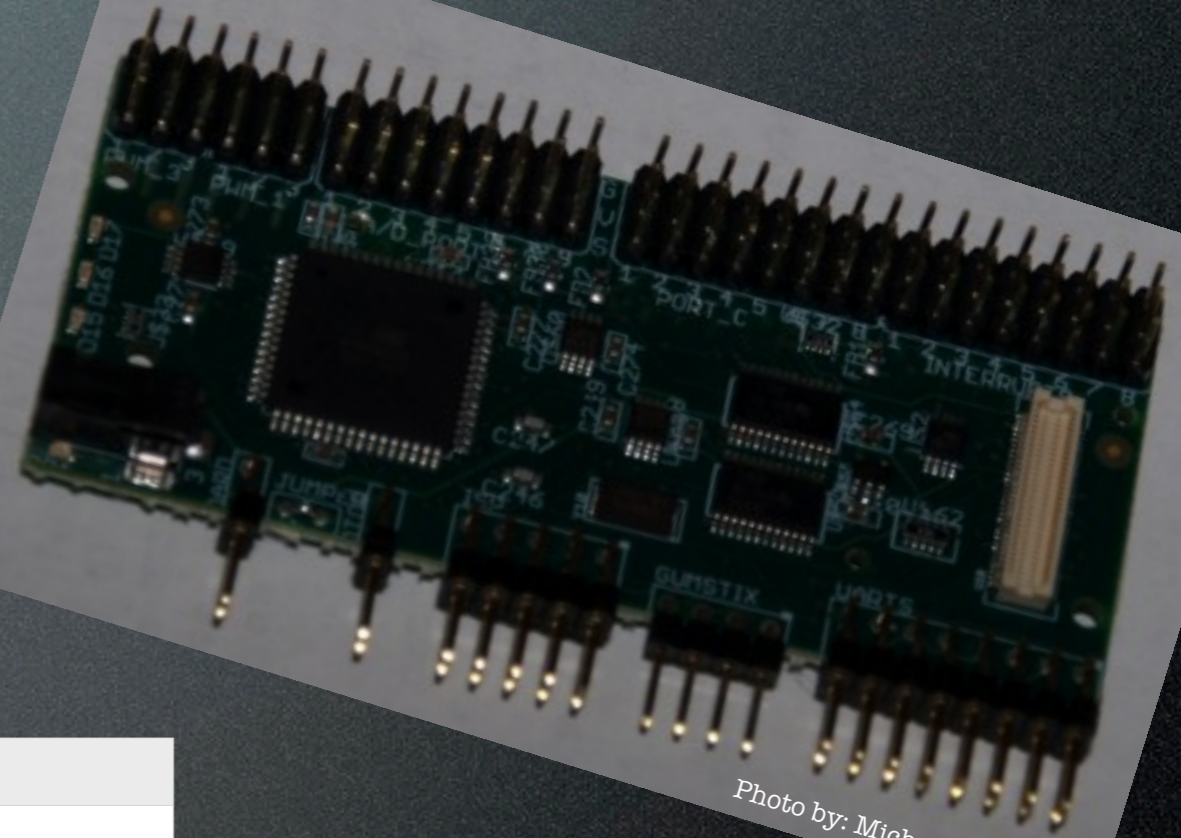
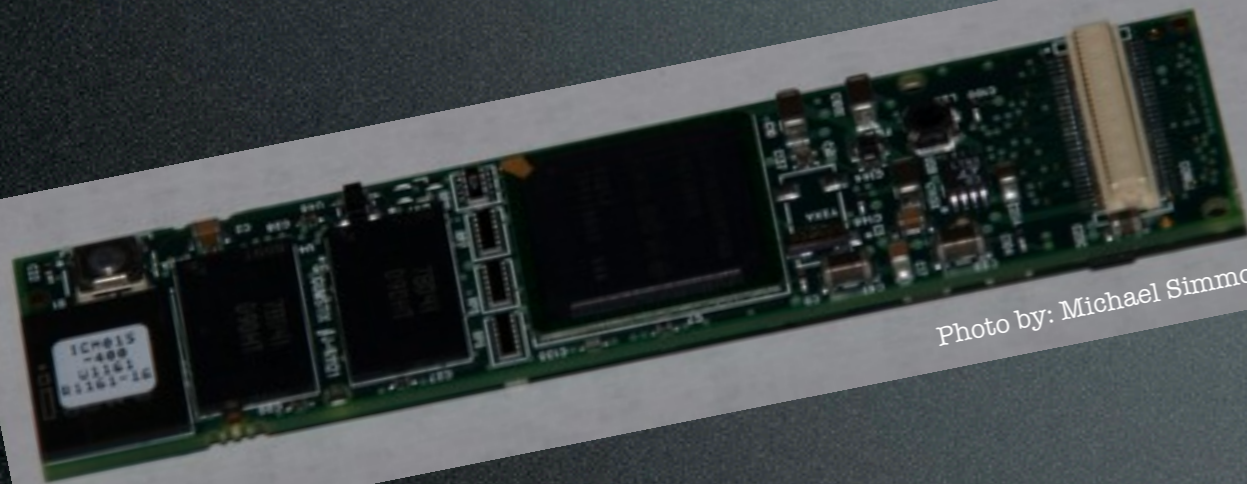


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Robot Controller



Robot Controller		
gumstix		
	Processor Type	Intel® XScale® PXA255
	Processor Speed	400 MHz
	Memory	16MB
robostix		
	Processor Type	ATmega128
	Processor Speed	16 MHz
	Memory	128 Kbyte

Sensors

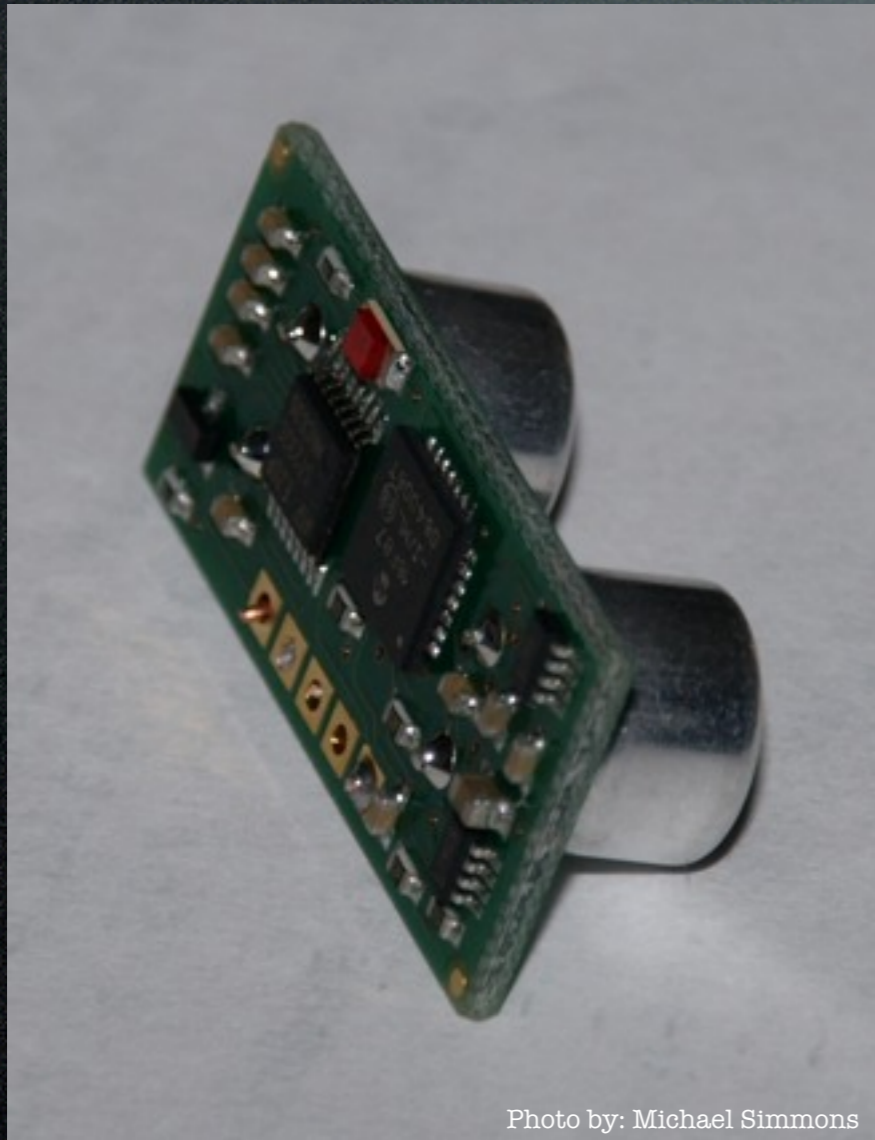


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Devantech SRF10
Ultrasonic range
finder sensor

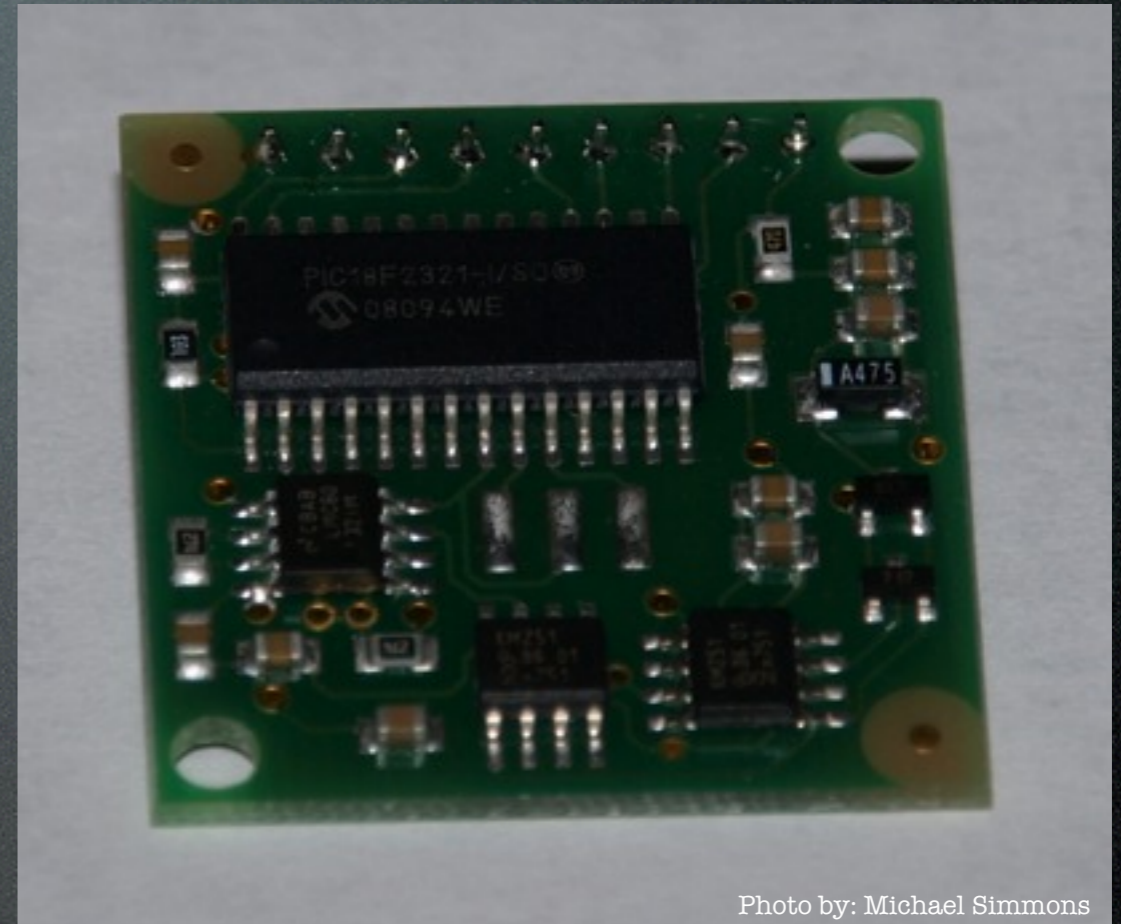
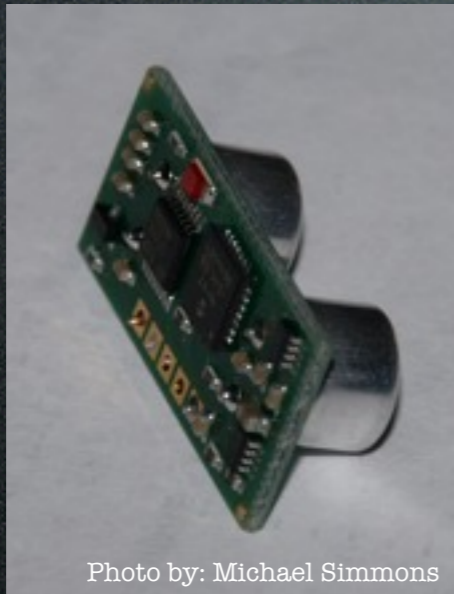


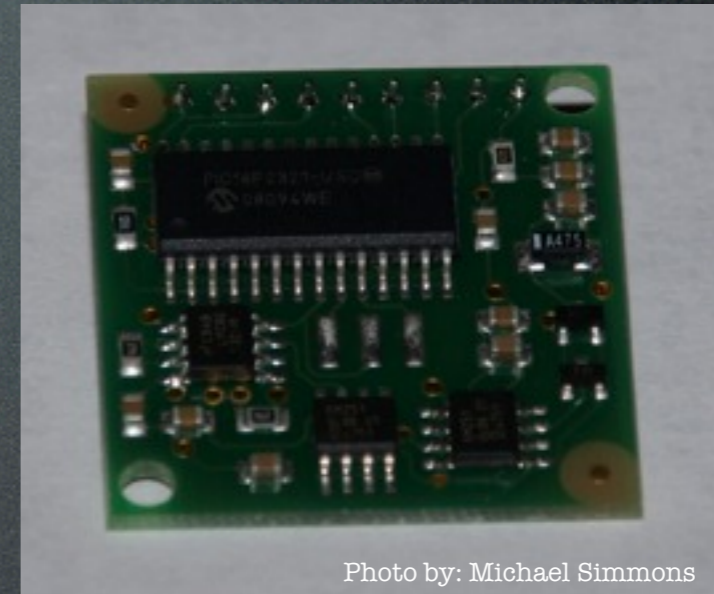
Photo by: Michael Simmons

Devantech electric
compass

Sensors



Range Sensor



Navigational Sensor

	Statistics
Range Sensor	3cm - 6m range
	I2C interface
	Ultrasonic
Navigational Sensor	0.0 - 359.9 degrees
	I2C interface

Computers used for Development

Computer Specifications	Desktop	Laptop
Processor	AMD Athon™ XP 2800	Intel Centrino
Processor Speed	2250 MHz	1700 MHz
Memory	1 Gig	512 MB
Operating System	Ubuntu Linux	Ubuntu Linux

Code Development Process

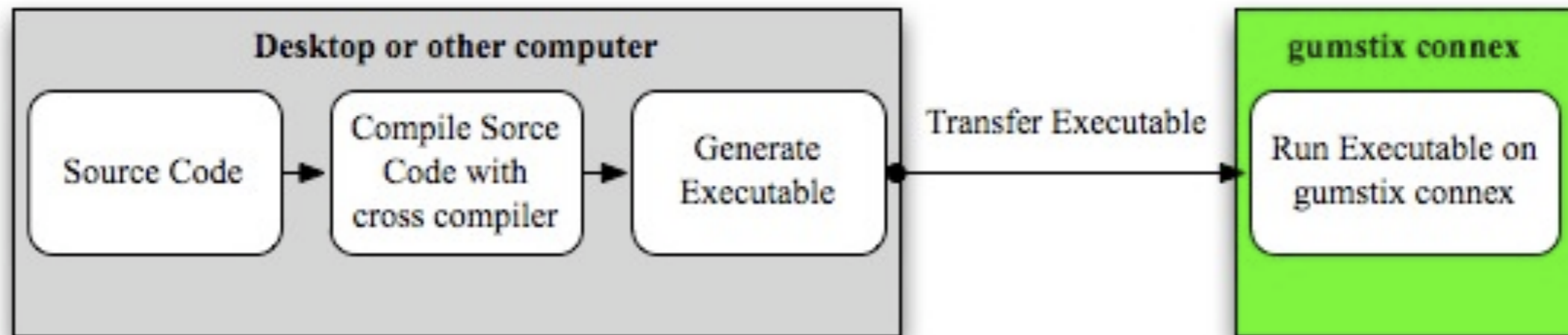
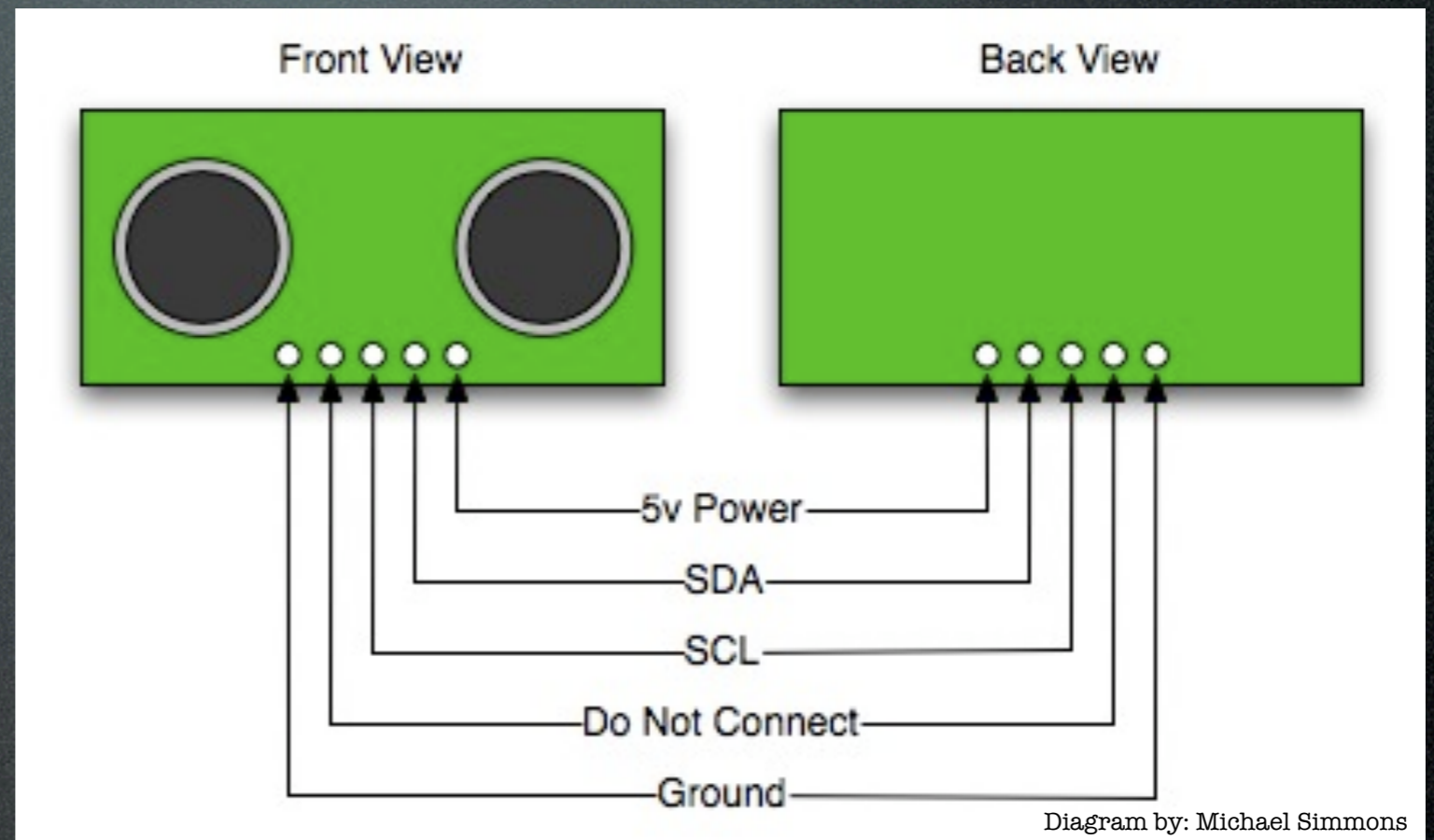
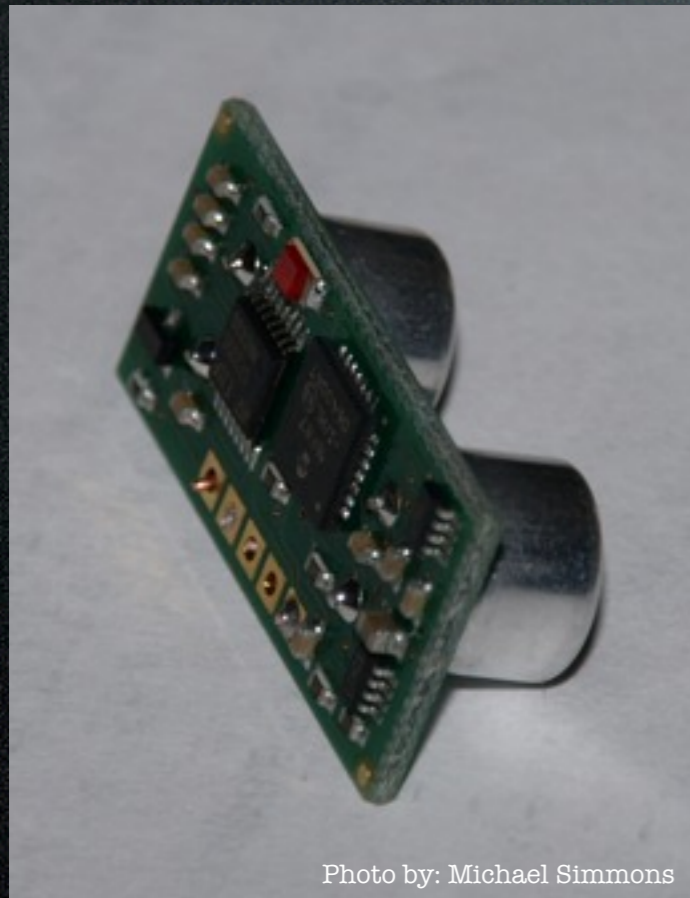


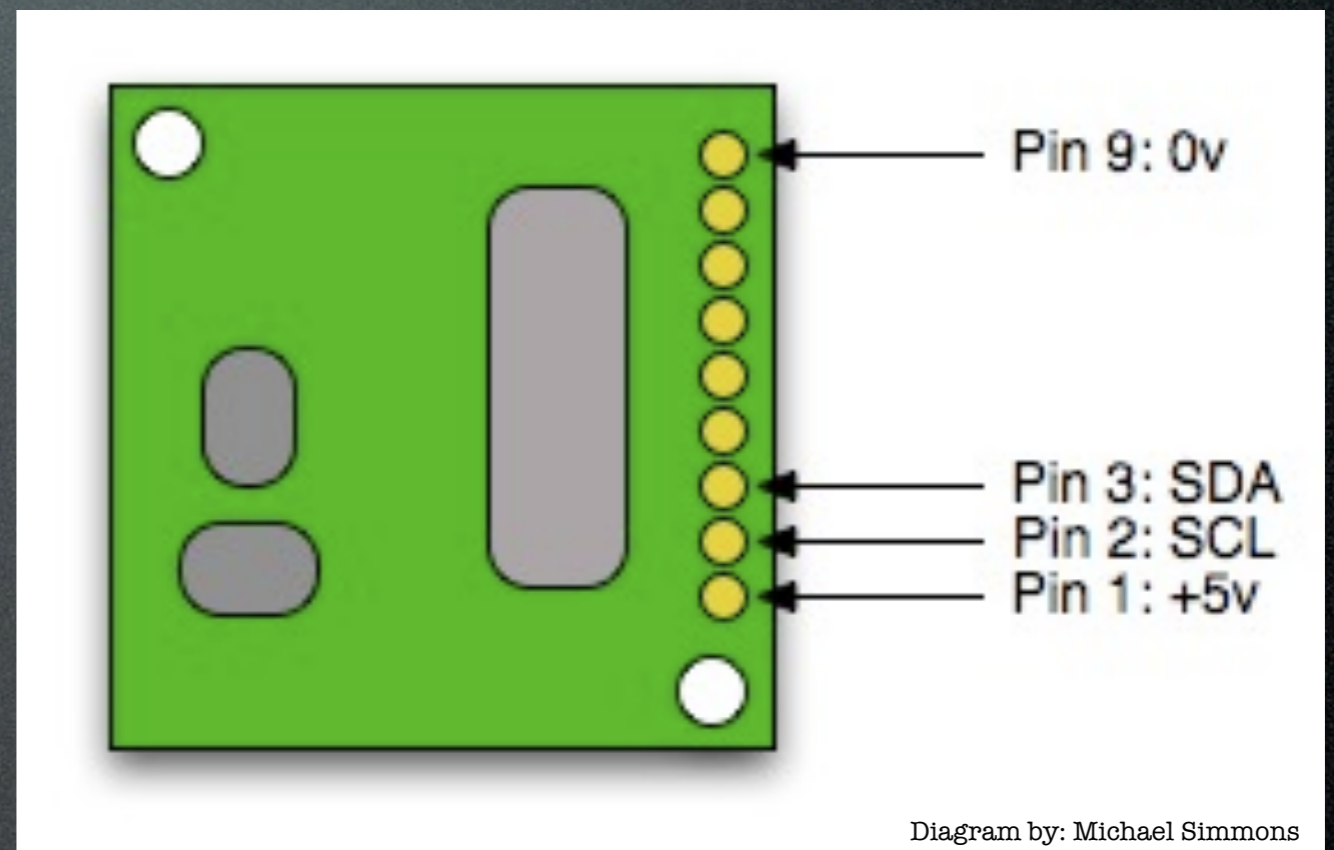
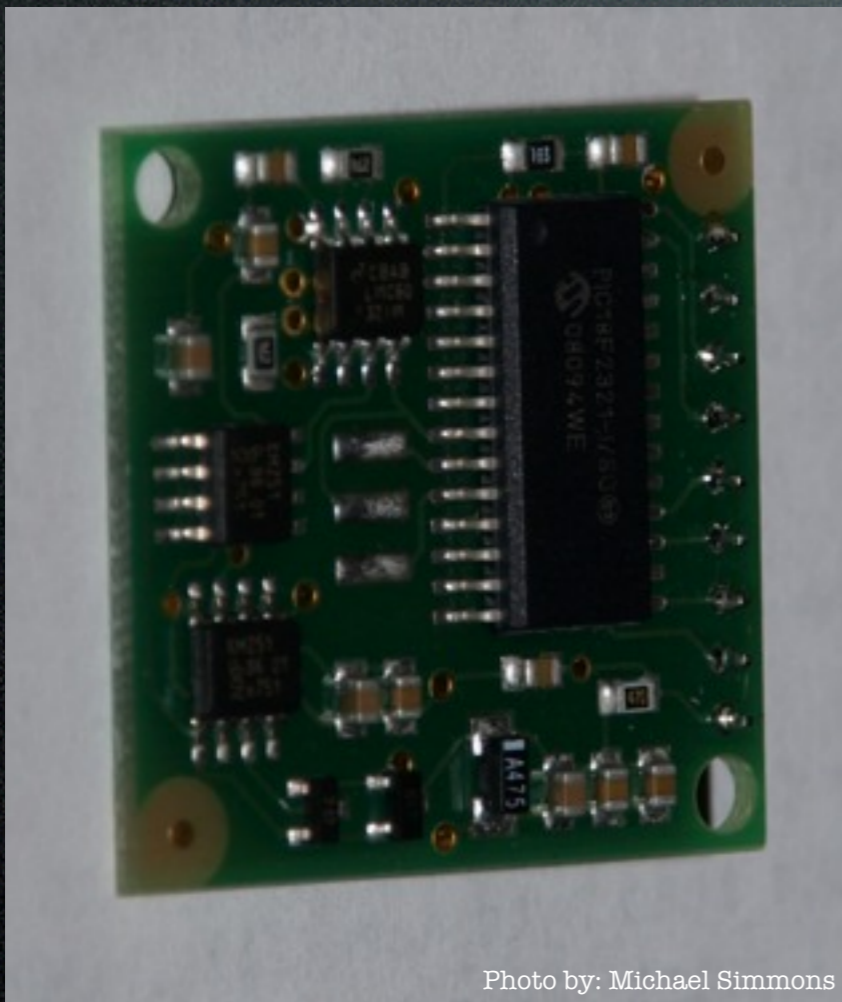
Diagram by: Michael Simmons

Hardware Setup



SDA - data line
SCL - clock line

Hardware Setup



Hardware Analysis



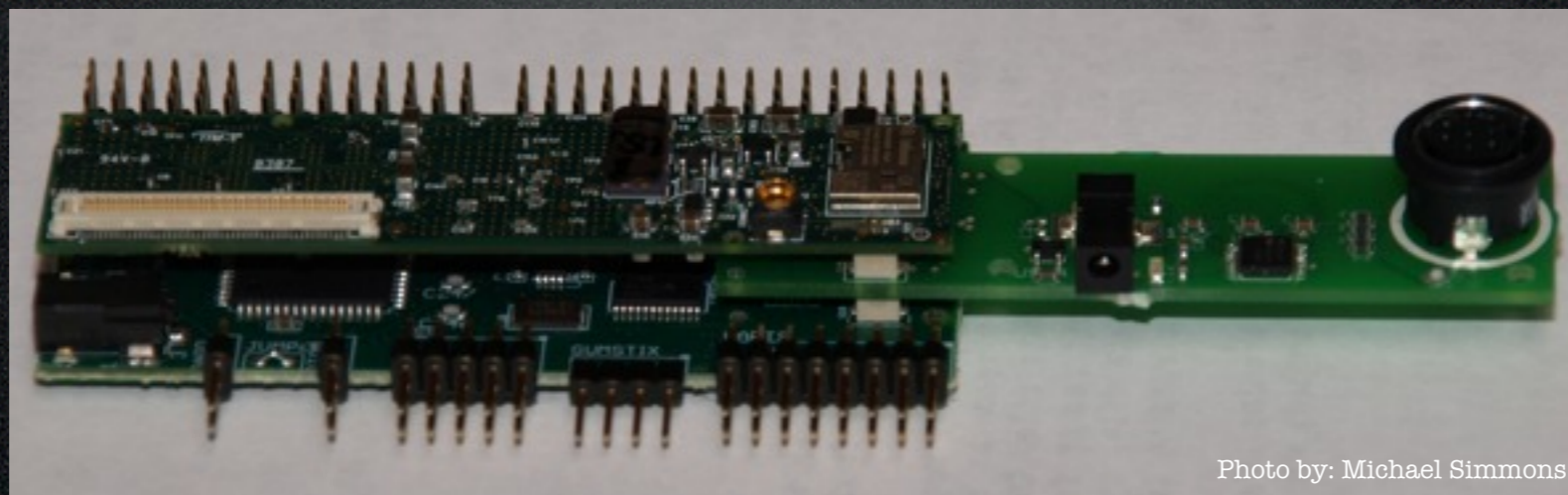
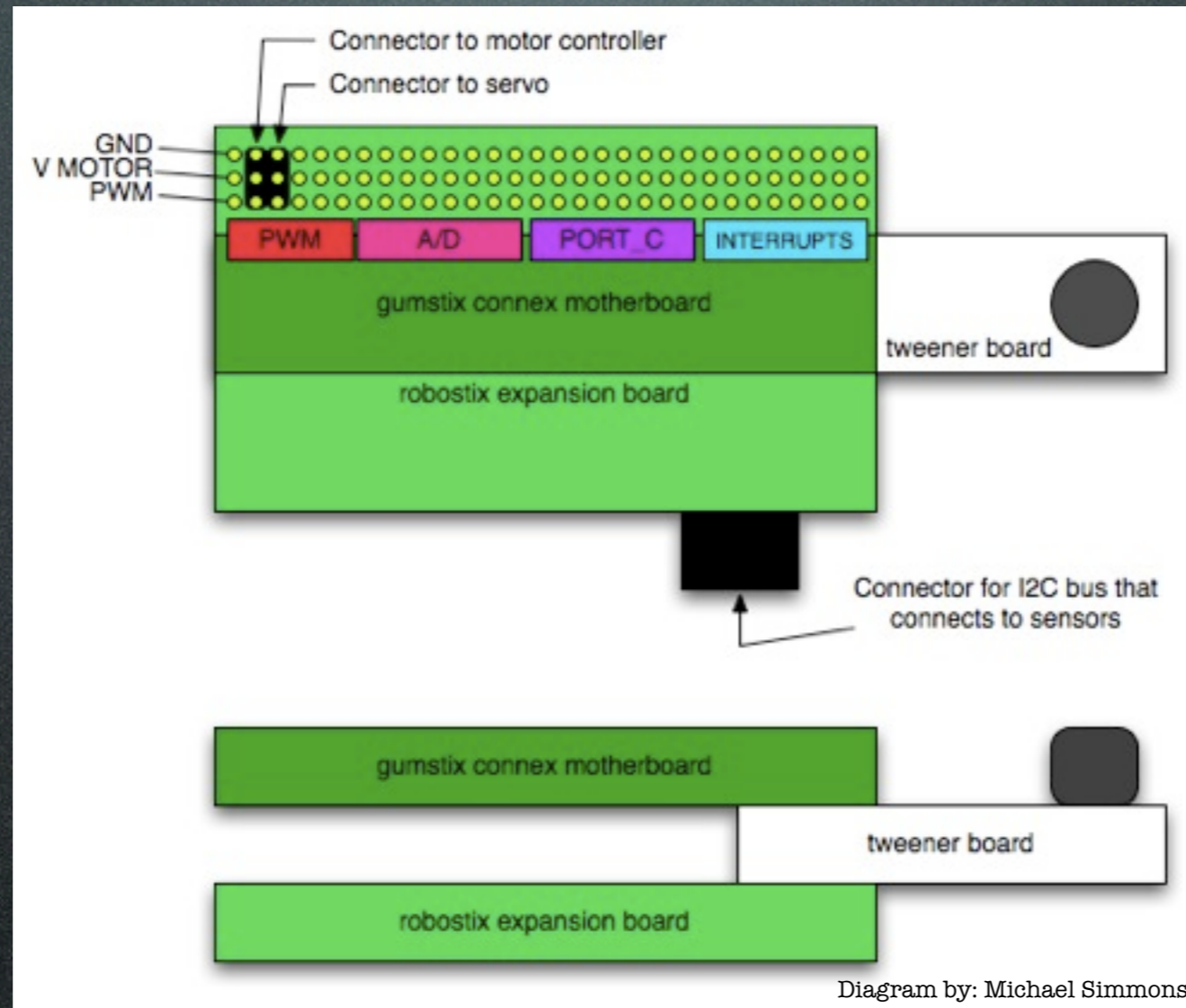
Photo by: Michael Simmons



Photo by: Michael Simmons

Servo	Oscilloscope Reading
Maximum Left Turn	1 ms pulse width
Maximum Right Turn	2 ms pulse width
Center	1.5 ms pulse width
Motor Controller	
Maximum Speed Forward	2 ms pulse width
Maximum Speed Reverse	1 ms pulse width
Stop	1.5 ms pulse width

Hardware Setup



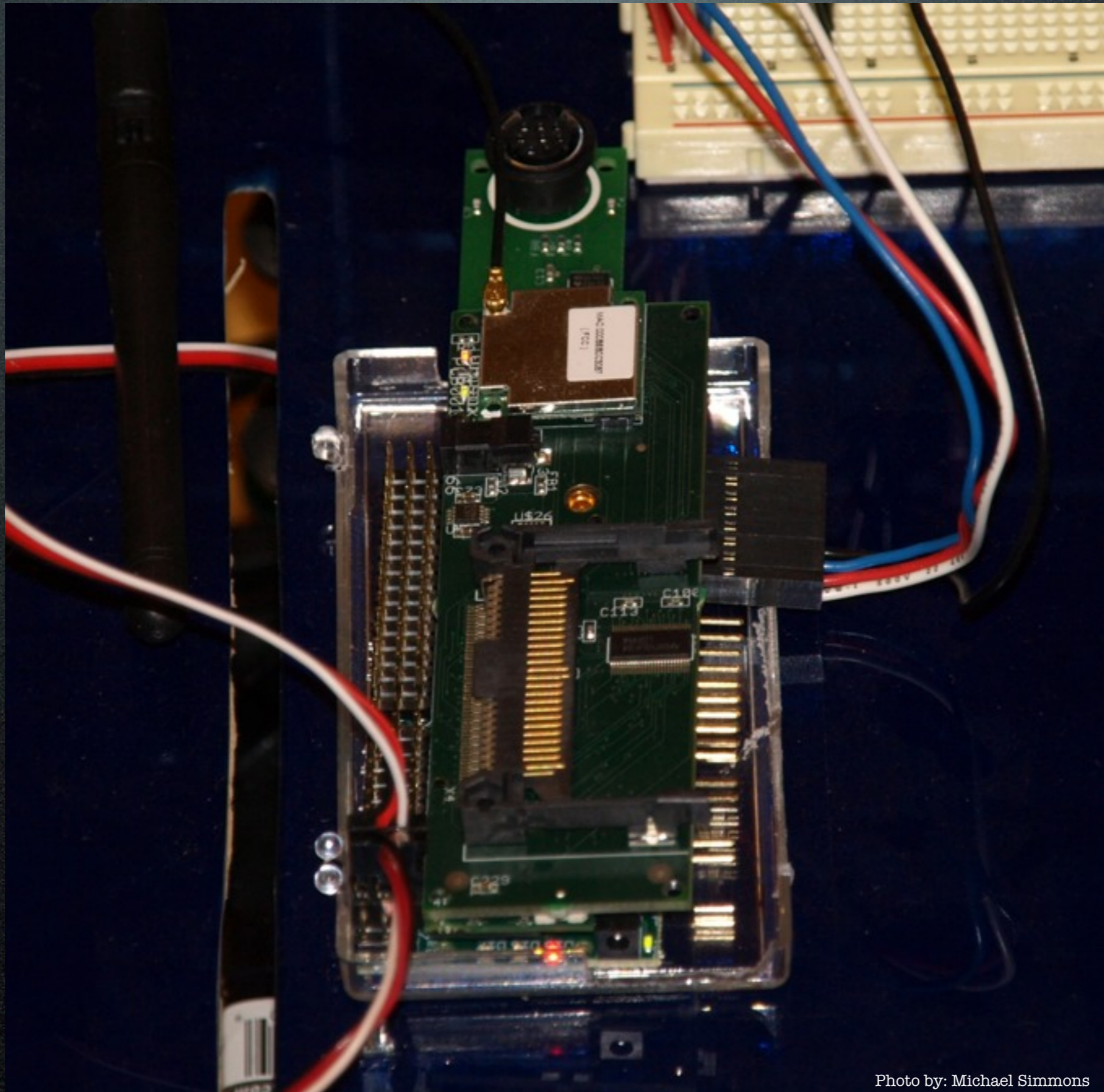


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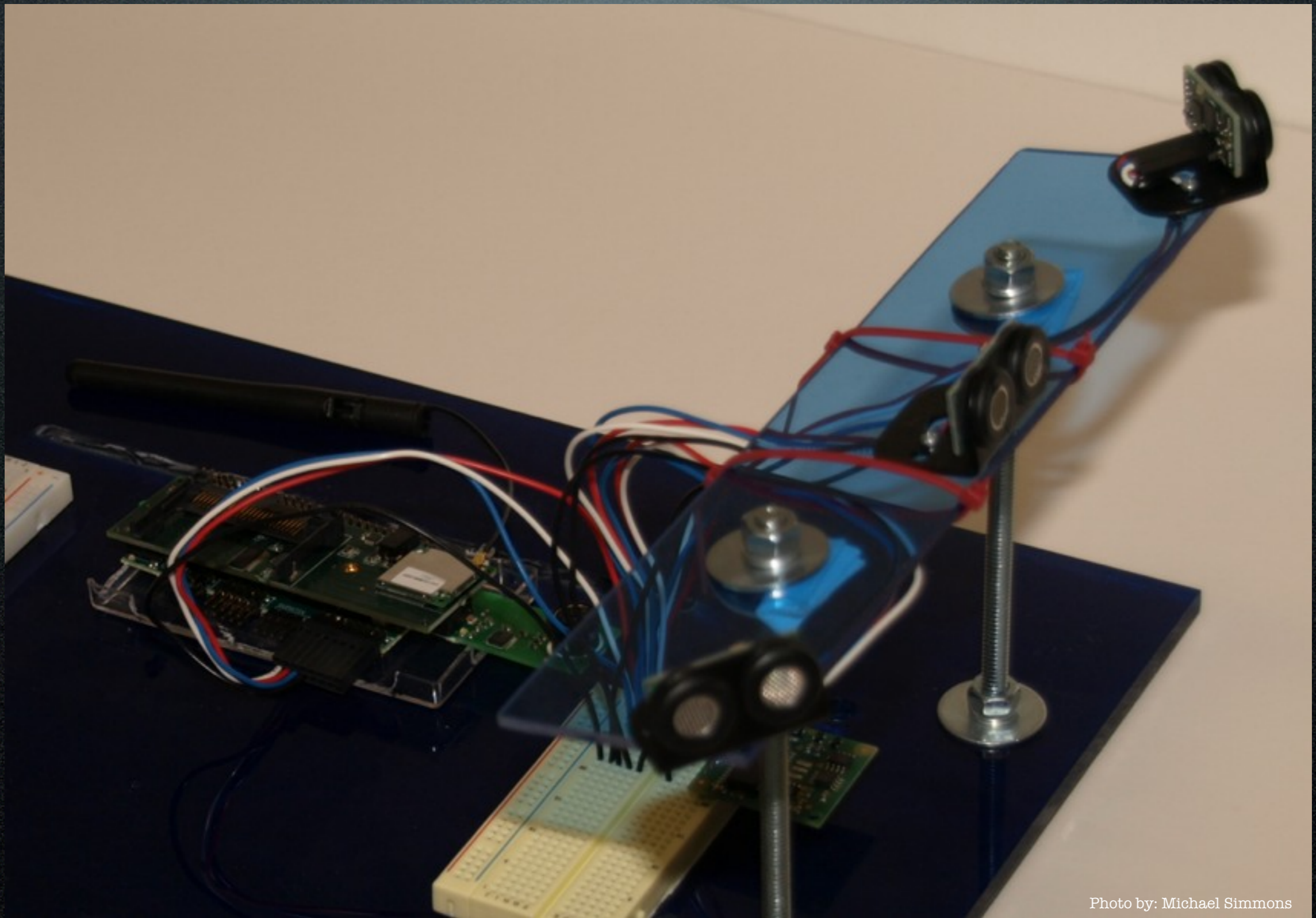


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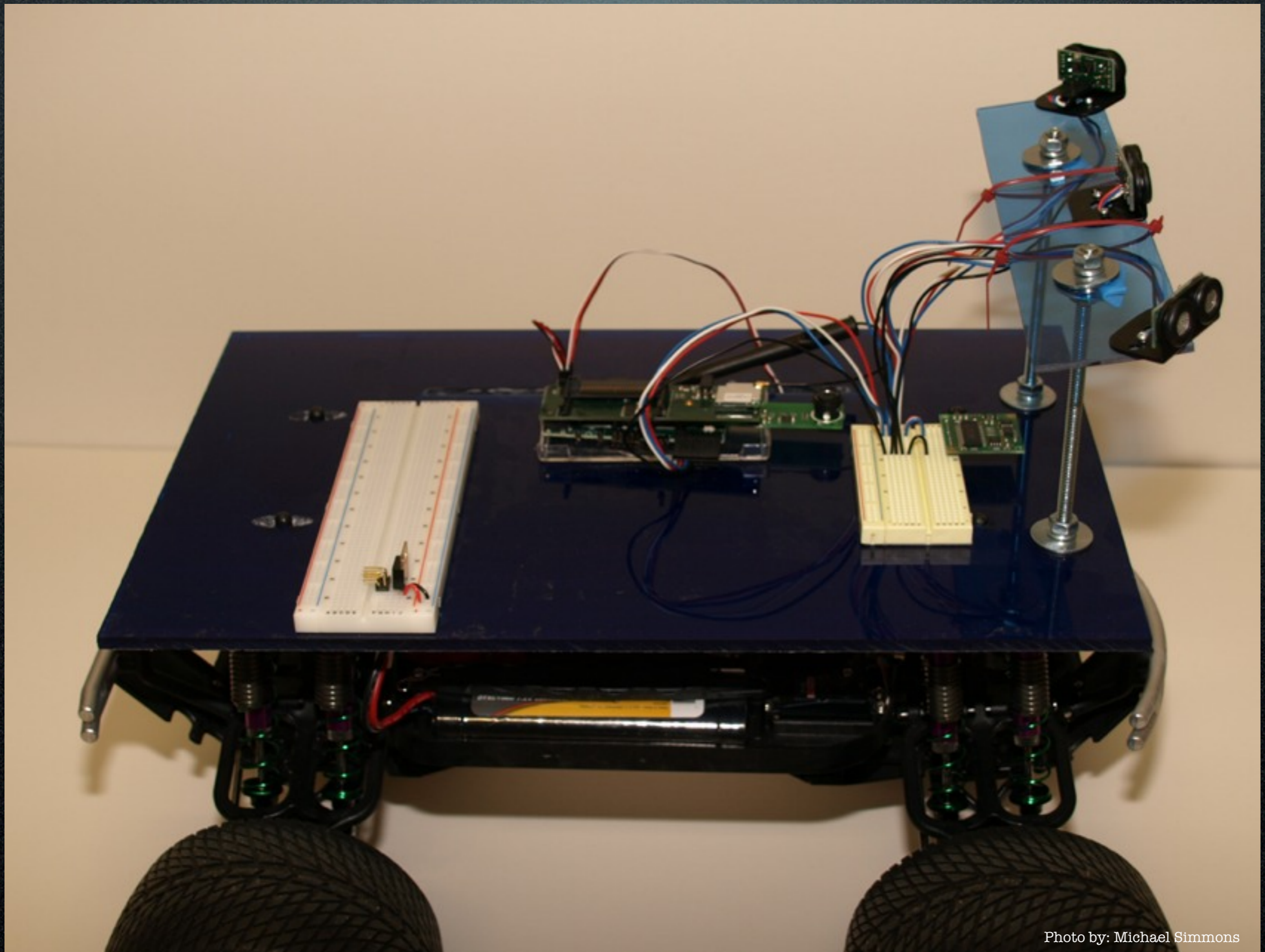


Photo by: Michael Simmons

Software Development

Development of gRAPI



Photo by: Michael Simmons

	Parameters	Description
Servo(int handle, int low, int high, int pwm)	handle	returned value from open
	low	set the servos minimum value for operation
	high	set the servos maximum value for operation
	pwm	pin location on the robostix's PWM pins
void center ()		centers the wheels
void right (int percent)	percent	the percentage to the maximum value to the right
void left (int percent)	percent	the percentage to the maximum value to the left
int increase(int percent)	percent	amount percent is increased: percent += increase
int decrease(int percent)	percent	amount percent is decreased: percent -= decrease

Development of gRAPI

Servo	PWM Value	Percent Value
Maximum Left	1000	100
50% to the Left	1250	50
Center	1500	NA
50% to the Right	1750	50
Maximum Right	2000	100

Development of gRAPI

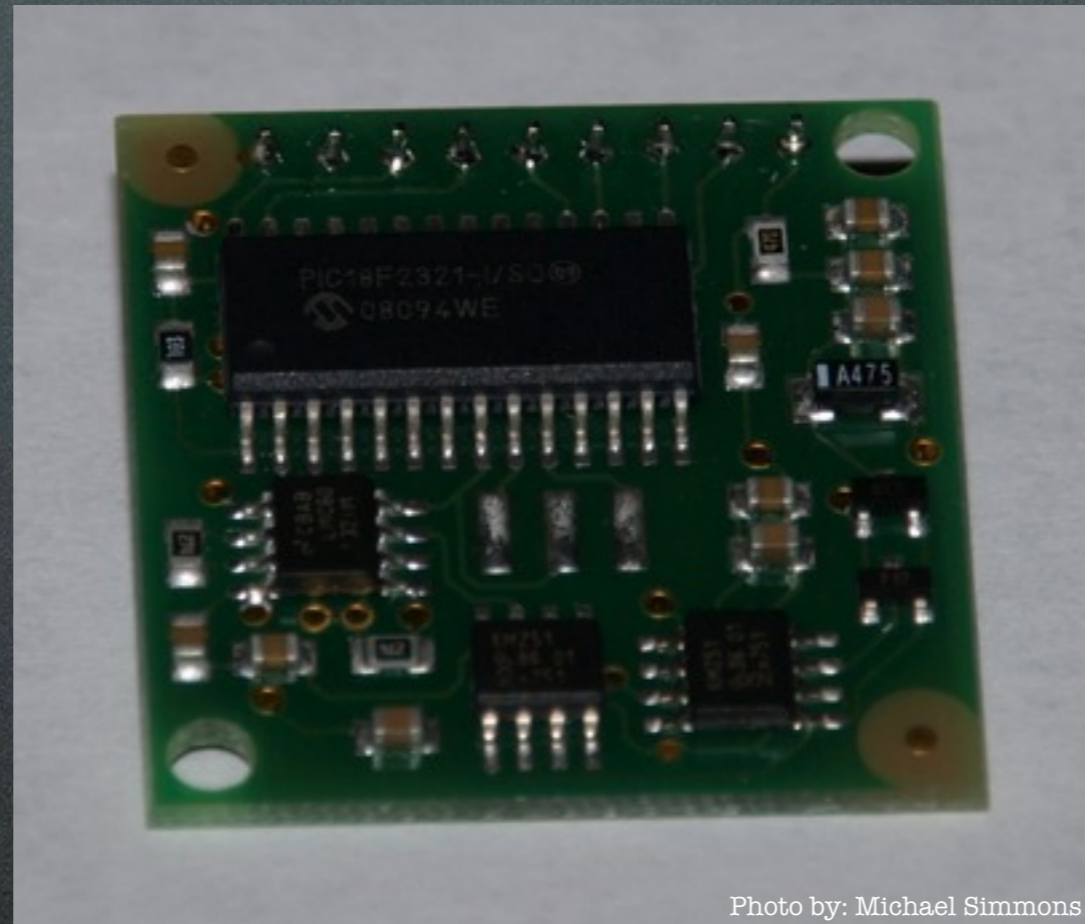


	Parameters	Description
Motor(int handle, int low, int high, int pwm, int delay)	handle	returned value from open
	low	set the motors minimum value for operation
	high	set the motors maximum value for operation
	pwm	pin location on the robostix's PWM pins
	delay	how often a pulse is sent to the motor
void stop()		stops the movement of the motor
void forward(int percent)	percent	the percentage to the maximum value for forward
void reverse(int percent)	percent	the percentage to the maximum value for reverse
int increase(int percent)	percent	amount percent is increased: percent += increase
int decrease(int percent)	percent	amount percent is decreased: percent -= decrease

Development of gRAPI

Motor	PWM Value	Percent Value
Maximum Reverse	1000	100
50% Reverse	1250	50
Stop	1500	NA
50% Forward	1750	50
Maximum Forward	2000	100

Development of gRAPI



	Parameters	Description
Cmps03(int handle)	handle	returned value from open
double readC()		gets the value from the buffer
int calibrate()		calibrates the sensor

Development of gRAPI



	Parameters	Description
Srf10(int handle, int addr, char resultType)	handle	returned value from open
	addr	device address used on the I2C bus
	resultType	stored buffer value type: c = centimeter, i = inches, s = microseconds
void ping()		starts the ranging and clears the buffer
int readS()		gets the value from the buffer
void setGain(int gainValue)	gainValue	new gain value for sensor: from 0 - 16; 0 = gain of 40, 16 = gain of 700
void setRange(int rangeValue)	rangeValue	new range value for sensor: ((Range Register x 43mm) + 43mm)
void setResultType (char resultType)	resultType	stored buffer value type: c = centimeter, i = inches, s = microseconds
void changeAddress(int newAddress)	newAddress	new address to be assigned to sensor: Hex; E0, E2, E4, ..., FE

Testing: Two Phases

Testing gRAPI: Phase One

	Program Name	Description	Results
Servo			
	testServo	moved servo through complete range	Passed
Motor			
	testMotor	moved motor forwards and backwards	Passed
Srf10			
	testSensor	pinged sensor and read result from buffer	Passed
Cmps03			
	testCompass	read result from buffer	Passed

Demo

Phase One

- testServoRL
- testSpeedFwRv

Testing gRAPI: Phase Two

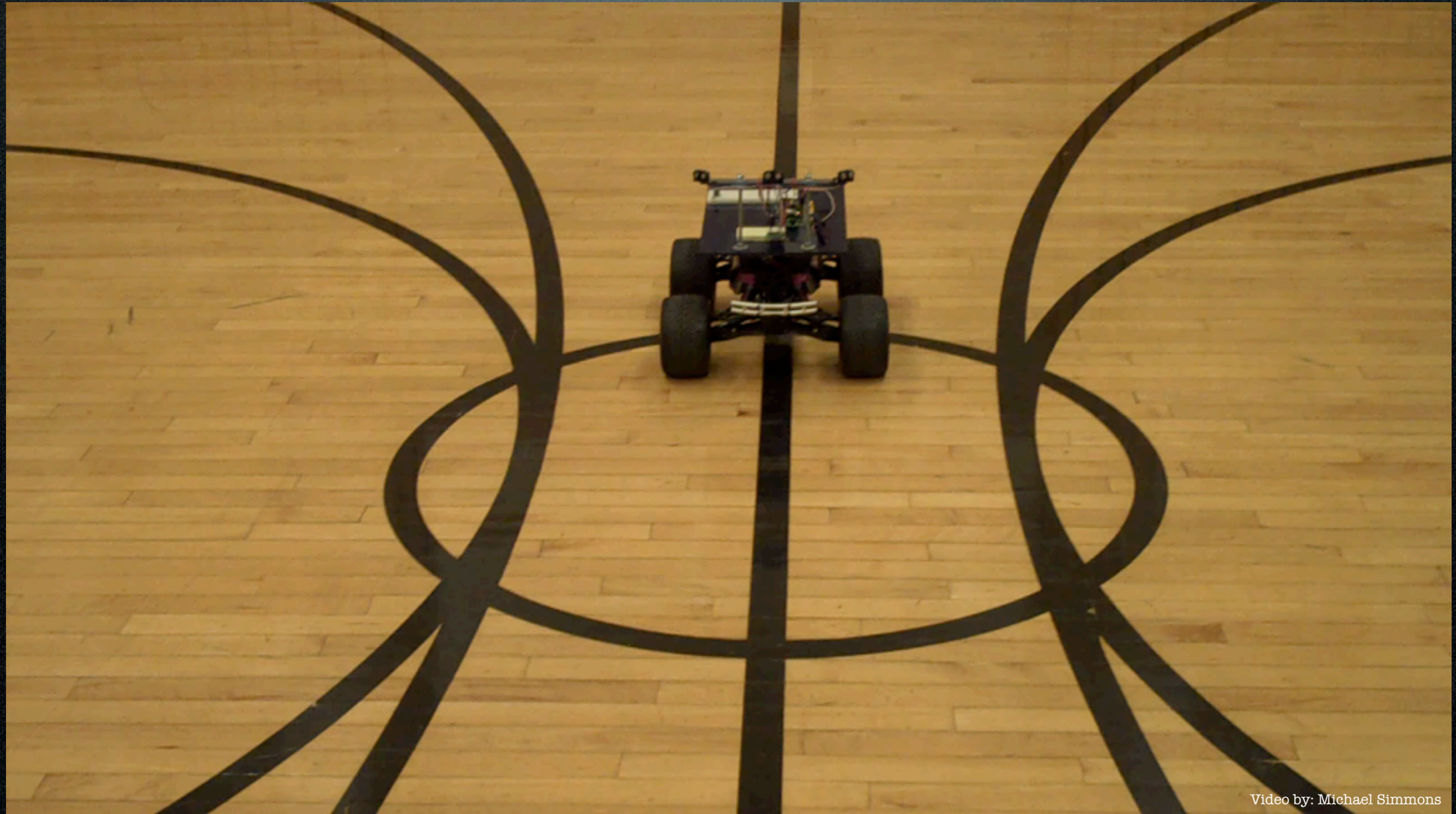
	Program Name	Description	Results
Motor, Servo, Compass			
	pointNorth	moves robot so it is heading north	Passed
	figure8	moves robot in a figure a pattern	Passed
Motor, Servo, SRF10			
	wallHugger	follows the wall using the left sensor	Passed

Demo

Phase Two

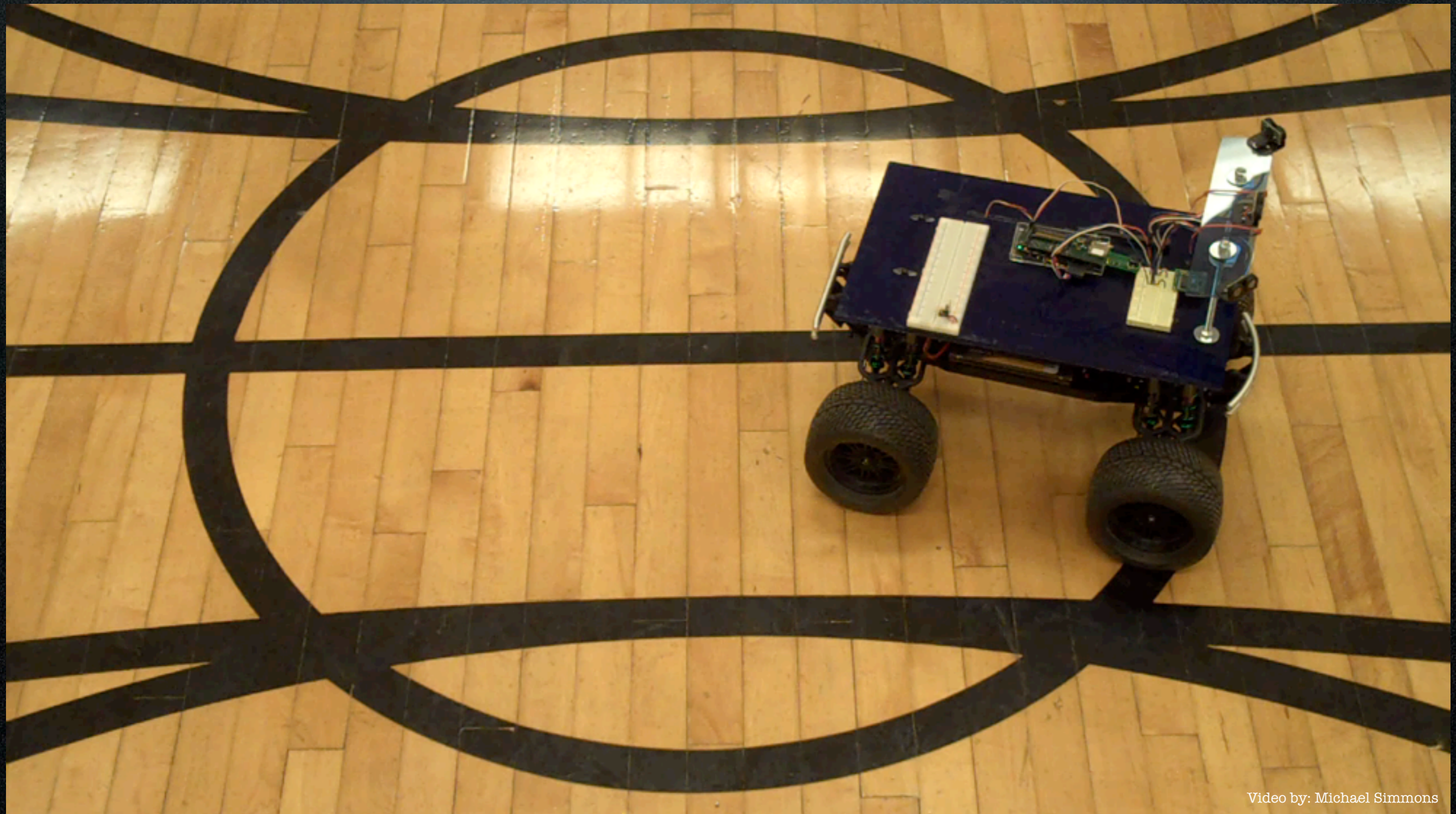
- testSensorServoMotor

Videos of Phase Two Testing: Figure 8



Video by: Michael Simmons

Videos of Phase Two Testing: Point North



Video by: Michael Simmons

Issues during development

Problems seen	Did not go forward
	Did not go reverse
	Error messages for code

Conclusion

- The goal of this project was to develop gRAPI, an application programming interface (API) for a gumstix connex motherboard in order to control an indoor four-wheeled robot.
 - Hardware was selected: robot platform, sensors, and controller
 - software was developed and tested to control hardware
- The ISL Hallway Hummer project will be able to use gRAPI to pursue other research goals for the use of autonomous robots in search and rescue.

Any Questions?

Thank You

- Everyone for coming
- Dr. J & Dr. Renner
- ISL

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