
EVERYTHING ELSE IS CHILD'S PLAY.
The Power Glove.™ You plug it in like any joystick. But the similarity stops there.
Because now you don't just guide the action. You are the action.

GESTUR

Sensing & Feedback Glove for interfacing with Virtual Reality

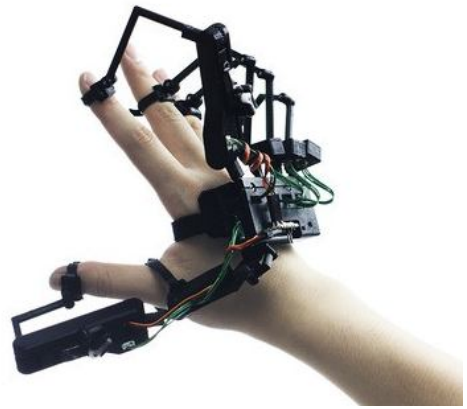
Initial Design Review

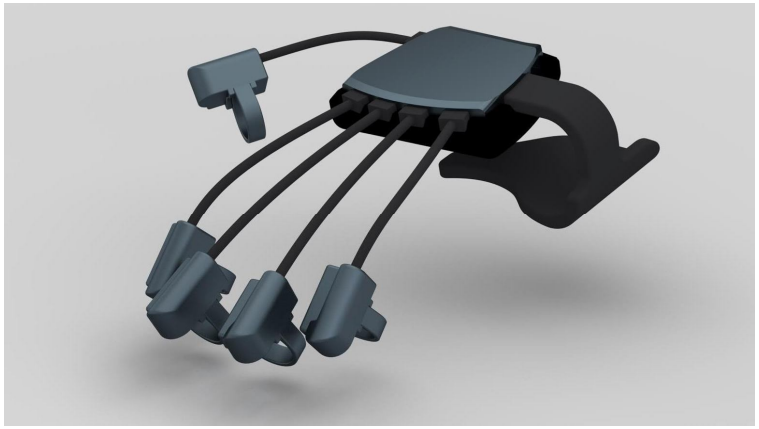
ECE 189A, Fall 2016

University of California, Santa Barbara

History & Introduction

- Oculus and Vive are great but…
- Haptic feedback gloves exist but…
- Started in ECE 92, now in ECE 189...





Development Team

Kyle Carson: Embedded/API Software Design, Networking, Unity

Ryan Kaveh: CPLD, Hardware Interfacing, Haptic Feedback Network

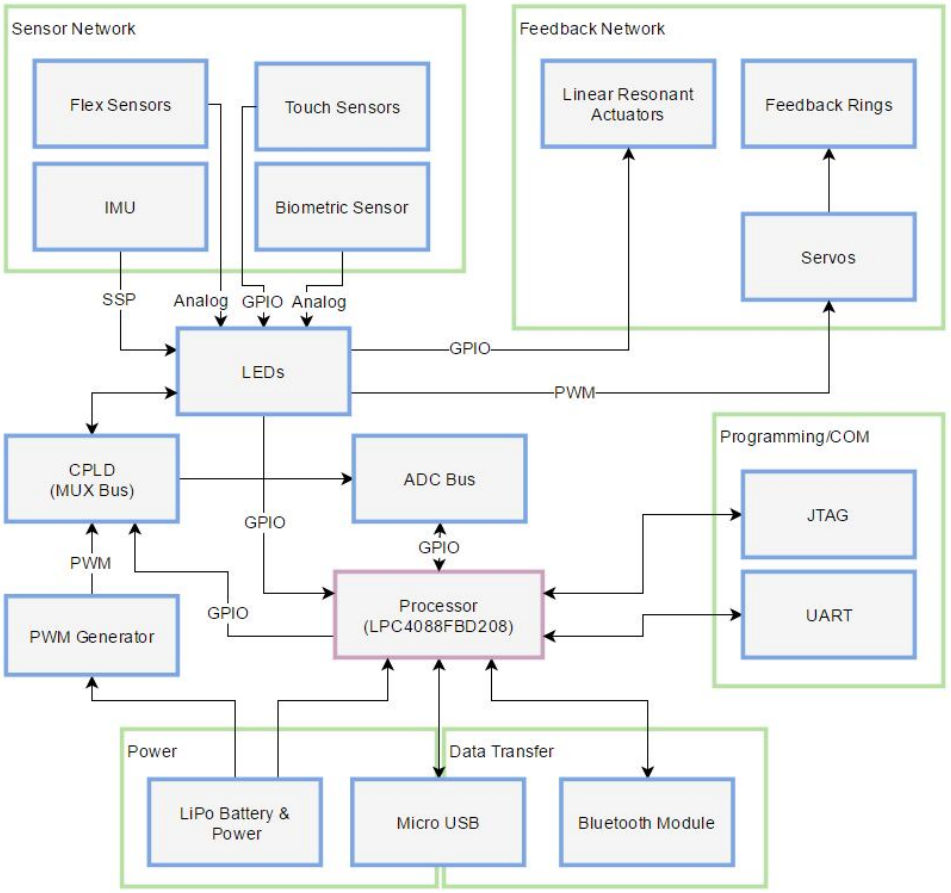
Jon Young: Hardware & Board Design

3rd Year ME student: Glove Assembly

Initial Specification

- Real-time sensing of hand position in 3D space
  - IMU will provide hand location
  - Flex sensors will provide joint locations relative to hand
  - Software API for cross-referencing the raw data to model the hand
- Haptic feedback interface between user and virtual environment
  - Rings & cables will provide normal force
  - Vibration elements will help stimulate palm
- Unity Playroom
  - Construct a virtual environment to test the gloves functionality

High Level Block Diagram



Development Plan

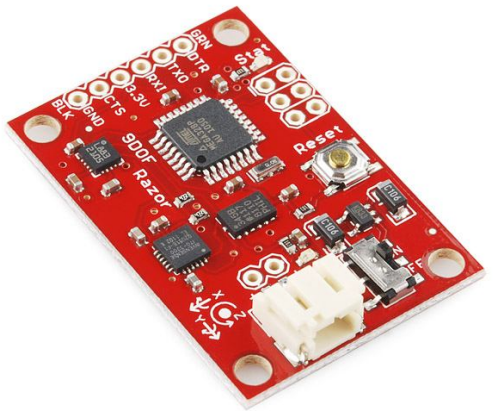
- Fall Quarter
  - Completed board design
  - Full Glove concepts/mockups/prototype (with haptic feedback system in place)
  - Modeling software & initial API
- Winter Quarter
  - Develop subsystems and integrate into main design
  - Refine physical design to make multiple
  - Unity playroom
- Spring Quarter
  - Final integration and debugging
  - Construct final pair of gloves
  - HW/SW integration with VR headset

Parts - Microcontroller

- NXP LPC 4088
  - 165 GPIO
  - 5 UART & 3 I²C (we only need 2 and 1 respectively)
  - Can handle preprocessing & transfer of finger sensor data
- Integrates well with LPCOpen
- Cost:
  - $12.92

Parts - IMU

- Includes 9 Degrees of Freedom (DOF) for accurate modeling of position and rotation in 3D space
  - Includes an accelerometer (ADXL345), gyroscope (ITG-3200), and magnetometer (HMC5883L)
  - Onboard ATmega328 handles data processing for both YPR and AHRS data, sent over serial protocol
- Cost:
  - $74.95



Parts - Flex Sensors

- Flex Sensors will keep track of finger, wrist, and palm movements
  - Communicate with processor through an array of ADCs
- Currently working with two flex sensors
  - Velostat (piezoresistive material)
  - Custom fit Spectra symbol flex sensor
    - >1 million use life cycle
    - Makes attachment straightforward
- Cost:
  - ~$8 per (2.2”)spectra symbol sensor
    - ~$8 x 24 = $180
  - $4 per sheet of Velostat (11” x 11”)

Parts - Touch Sensors

- Simple conductive cloth that will provide digital 0 (like a short) whenever it comes in contact with other ‘buttons’ on the glove
- Will only sense contact with ‘buttons’ on glove
  - Managing complexity while maintaining low profile
- Cost:
  - $8.95 (per linear foot)
  - We have leftovers

Parts - Biometric Sensors

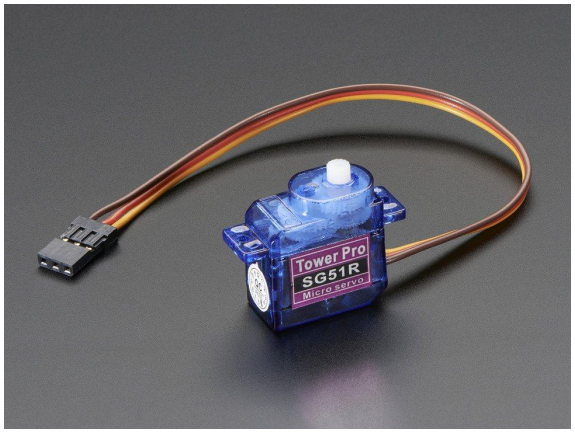
- Will watch heart rate and send data to Unity Playroom
- Help us build fun simulations and monitor user
- Easily integrates into our MUX bank
- Cost:
  - $24.95

Parts - Haptic Feedback System

- 3D printed rings will stretch skin along neurally dense portions of your skin to simulate normal force
  - Based off of research performed by Professor William Provancher from the ME department at the University of Utah
    - Focus on Bulbous corpuscle (raffini corpuscle) stimulation (type of mechanoreceptor in in skin)
      - Almost completely responsible for our sense of grip and control of finger position on objects
      - Slow to adapt & Super high concentration around finger tip
- Rings are actuated along finger by servos (servos controlled by PWM signals)
- Cost:
  - Free thanks to Professor Visell

Parts - DC Servos

- Low profile servos used to actuate 3D printed rings
- Connect to rings with bicycle cable
  - Also looking into low friction, high strength wire
- Originally wanted pancake stepper motors but that would require H-bridge and we were worried about taxing our processor too much
- Cost:
  - $5.95 (9 per board)

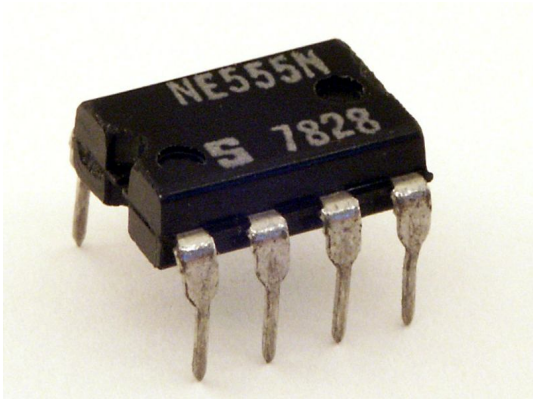


Parts - CPLD

- The CPLD will provide muxes and an optional bus expansion in order to reduce our use of the 4088's GPIO ports
- Will use as a 'shield' on top of our own board
- Cost:
  - $30.29

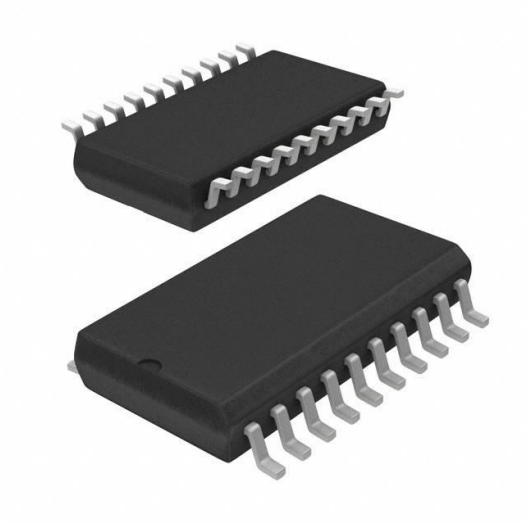
Parts - 555 Timers

- PWM generation
- Simple to configure (no wires from processor - all done in hardware)
- Plan to put POTs on their triggers so we can personally calibrate
- Cost:
  - $0.47 (8 per board)
  - Might get more if there's signal degradation due to high fan out



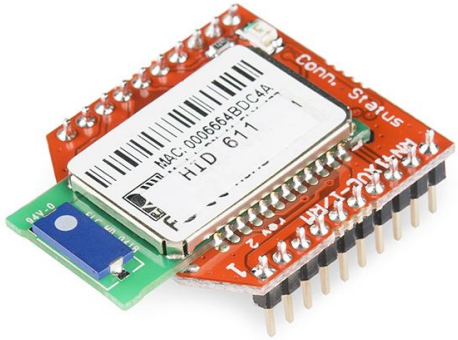
Parts - External ADCs

- Will convert analog sensor data to digital words for processing
- 0-5 V, 8-bit provides more granularity in range of motion
- Easy to configure
- Cost:
  - $2.95 (4 per board)



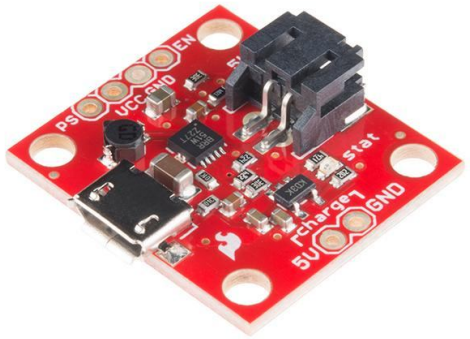
Parts - Bluetooth Controller

- RN41-XV bluetooth module
- Will handle all data transfer from glove to computer
  - Last project sent data at 115.2 Kbps
  - This one can hit more than 240 Kbps (should be more than perfect)
- Easily integrated and sample code exists
- Cost:
  - $29.95



Parts - LiPo Battery System

- Allow for wireless usage, as well as passing a wired power source through to the board
- Cost:
  - $19.95



Critical Elements

- Haptic Feedback Rings are the heart of the haptic feedback system - while we could replace them with vibration elements, the glove would not bring anything terribly new to the table
- IMU is integral to the glove’s sensing ability -> fortunately we already have experience
- Glove Assembly is a difficult problem because light wear could cause it to break connections
- With the old glove, we have a proof of concept and sample C code (high level)

Technology/IP Reuse

- LPCopen sample code
- We’ve found good githubs to work from (no need to reinvent wheel)
- The old glove provides proof of concept and spring board for all sensors and major interfaces

Bill Of Materials

- Total to make 2 gloves: ~$1,030

1	Part/Description	Manufacturer	Manufacturer Part #	Vendor	Vendor Part #	Package	Units/Board	Total Units	Unit Cost	Total Cost
2	**Board Mounted Components**									
3	Processor	NXP Semiconductors	LPC4088FBD208	Digi-Key	568-9835-ND	208-LQFP	1	2	$12.92	$25.84
4	Bluetooth Module	Roving Networks	RN41XV	Sparkfun	WRL-11600	XBee Breakout	1	2	$29.95	$59.90
5	LiPo Power Module	Microchip, Texas Instrur	MCP73831T, TPS61200	Sparkfun	PRT-11231	Breakout	1	2	$19.95	$39.90
6	CPLD	Lattice Semiconductor	LC4256ZE-B-EVN	Digi-Key	220-1146-ND	Breakout	1	2	$30.29	$60.58
7	ADC	Texas Instruments	ADC0804LCWMX/NOPB	Digi-Key	ADC0804LCWMX/N	SOIC	4	8	$2.95	$23.60
8	555 Timer	Texas Instruments	NA555DR	Digi-Key	296-21752-1-ND	SOIC	8	16	$0.47	$7.52
9	Main Crystal	Abracon LLC	ABLS-12.000MHZ-B4-T	Digi-Key	535-10218-1-ND	SMD	1	2	$0.27	$0.54
10	LiPo Battery	Union Battery	585460	Sparkfun	PRT-08483	n/a	1	2	$12.95	$25.90
11	**Non-Board Mounted Components**									
12	IMU	InvenSense, Analog De	ITG-3200, ADXL345, HMC	Sparkfun	SEN-10736	Breakout	1	2	$74.95	$149.90
13	Flex Sensor	Spectra Symbol	FSL0020103ST	Spectra Symbol	FSL0020103ST	n/a	24	48	***$7.95***	$381.60
14	Touch Sensor	LessEMF	A1220	LessEMF	A1220	n/a	5	10	***$8.95***	$89.50
15	Biometric Sensor	World Famous Electron	pulse-sensor-amped	Sparkfun	SEN-11574	n/a	1	2	$24.95	$49.90
16	Linear Resonant Actuator	Adafruit	1201	Digi-Key	1528-1177-ND	n/a	2	4	$1.95	$7.80
17	Servos	Adafruit	2201	Digi-Key	1528-1110-ND	n/a	9	18	$5.95	$107.10

Conclusion

- Right now we are iterating on our feedback system design
  - Building sample Unity playroom
  - Recruiting ME (3 students interested already)
  - Purchasing flex sensors and characterizing them ourselves
    - Also contacting manufacturers to get customized ones
  - Finalizing assembly details (which cables to use, how to route, etc.)
  - Building our board!
- Questions?