18-549: Embedded Systems Design

Lecture 2: Project Overview

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Overview of Lecture

- ***Some* project ideas**
  - Internet-of-Things
  - Assistive Technology
  - Multimedia
  - Embedded Infrastructure
- **Typical Hardware Platforms**
- **Past Projects**

Administrivia

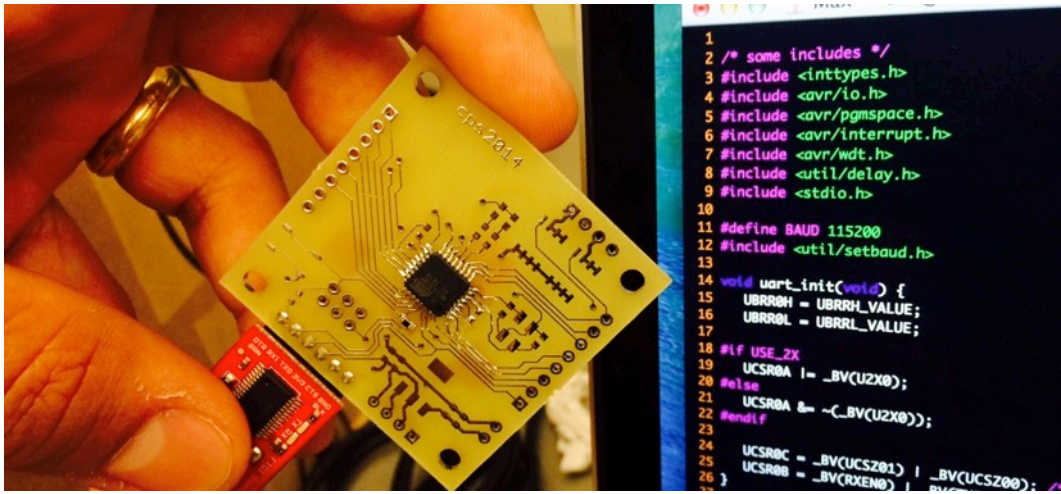
- **Lab 1 goes out today (due Monday 2/2)**
  - PCB Design and Layout
  - Monday's class will directly address this lab
  - Lab document will be posted on website and blackboard
  - First part is individual, but you need groups now…

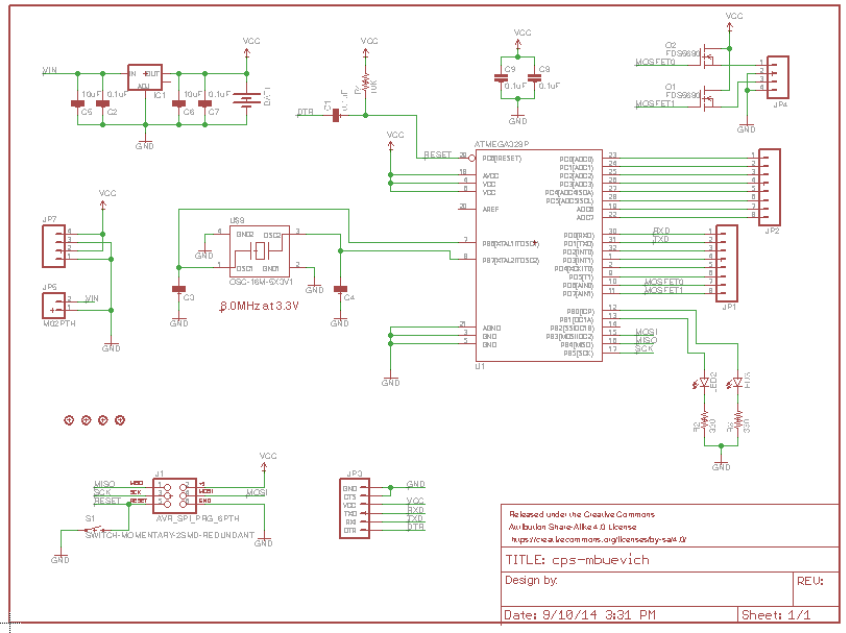
- **Project Design Proposal due (2/11) which is 3 weeks**
  - We will start scheduling group meetings now.
  - You really need groups now!

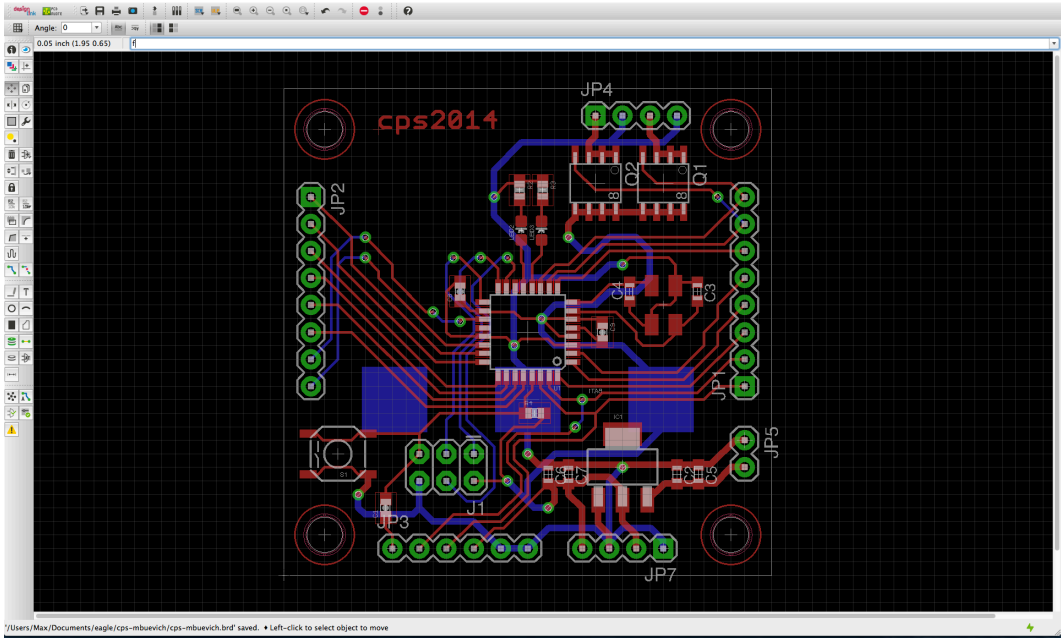
Lab 1

- Out: later today
- Due: Mon 02/02
- *Must be done individually*

- Design PCB with Multi-Bit Sensor and Actuator







Not So **Simple Example**

Kilobot (Harvard)

Project Components

- **Proposal Document**
- **Project Pitch Video**
  - Time Lapse Video (optional)
- **Website**
  - Concept, motivation, technical specifications, requirements, risks + mitigation strategies, presentations
- **Demo + Poster**

Design Proposal

- Prefatory information
- Project description
- Design requirements
- Design trade studies
- System description/depiction
- Architecture
- Project management
- Related Work (competition)
- References

See Proposal Guidelines on Blackboard for more info!

Design Proposal

Design Proposal Element	Pages	Weight (points out of 10)
1. Prefatory info	0	0.2
2. Project description	0.5	0.3
3. Design requirements	1	1
4. Architecture	1	1
5. Design trade studies	2.5	2
6. System description/depiction	3.5	2
7a. Project management: Schedule	1	0.5
7b. Project management: Team member responsibilities	0.5	0.3
7c. Project management: Budget	0.5	0.5
7d. Project management: Risk management	0.5	1
8. Related Work	0.5	1
9. References	0.5	0.2
Totals:	13	10

What to look for in a good project?

- **Sensors and Actuators**
  - Does it capture or interact with the physical world?
- **Processing**
  - Is there local compute?
  - Planning the next move?
  - Image or sound processing?
- **Communication**
  - Is it distributed?
  - Wireless or wired?
- **Human-Computer Interface**
  - Is there an intuitive (or fun) way to interact with the system?

Requirements

- **Custom Hardware**
  - Your project must consist of a custom designed PCB
- **No Arduino IDE**
- **Course Staff "Sniff Test"**
  - We want to see enough elements from the previous page with justification for who is doing what…

Internet of Things (IoT) Buzz…

SenseWeb

pachube

Feeds Apps Support Blog Community

What is it?

Use and bu
which upda
real-time.

- Send your d
- Leverage a
- Get applicat
- Use and ben data

cosm BETA

About How it works S

Connect to your world

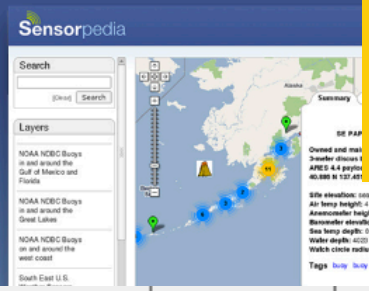
Where the Internet of Things is being built.

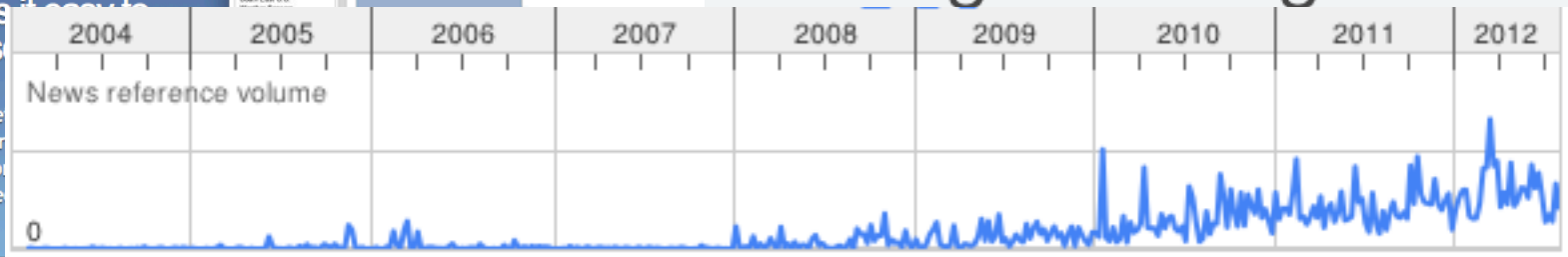
Sensorpedia

Explore.
Contribute.
Share.

Sensorpedia makes it easy to find and share sens

We're currently in a limited be
Follow the Senorpedia blog for
happenings or email us for mo
about how you can get involve





Twine: $556,541 KICKSTARTER Project

http://supermechanical.com/twine
John Kestner sign out
TWINE 1
Accelerometer
Temperature
SPOOL
New Rule
edit share
WHEN
Accelerometer
is knocked
options
WHILE
Calendar
Time of day
is after
7:00pm
options
+filter
THEN
Tweet
Someone's at the door. It's (time).
from @TwineOne
You can use these names to insert sensor values in your message:
(Twine 1 temperature)
(Twine 1 button)
(time)
(date)
+action
+

NEST:

$4 billion

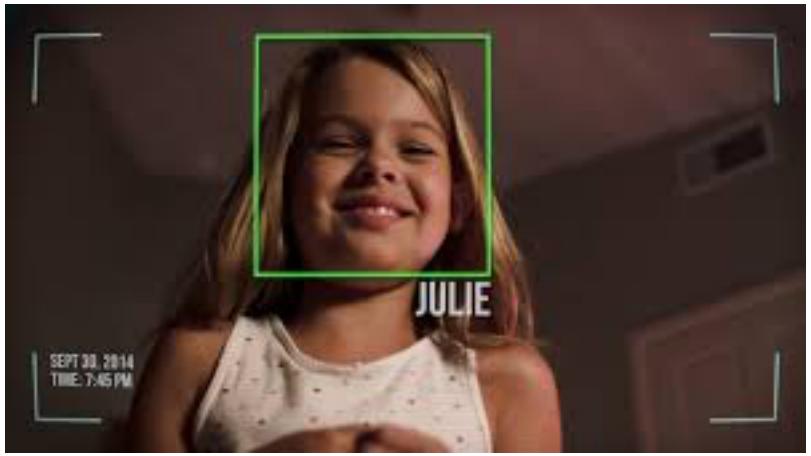
Pebble: $10,266,846

KICKSTARTER Project

Information Technology Transformation

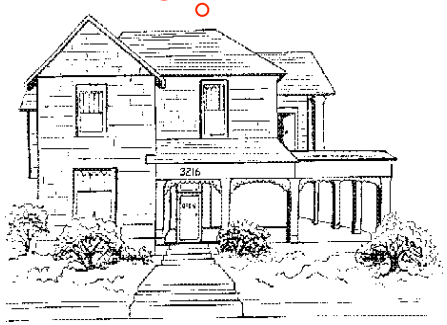
Distributed Amazon Echo

Personal Robot Assistant



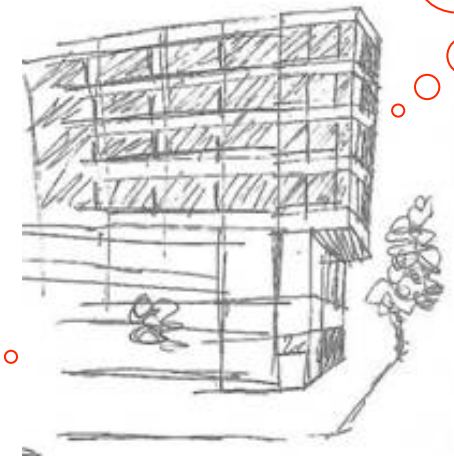
Smart Infrastructure (s)

When is my first meeting?



Ugh, the network is slow…

Why are they blasting the A/C??



This pipe is leaking!

Smart Buildings

- **Control Automation Framework**
  - Make programming physical spaces easy
  - How do we represent rule logic?
  - IFTTT ++
- **NEST++**
  - Automatically learn patterns and suggest schedules
  - Lighting, HVAC and Plug Loads

Embedded Systems for Assistive Technologies

Portable Medical Muscle Stimulator ARM

Companion Home Management Panel

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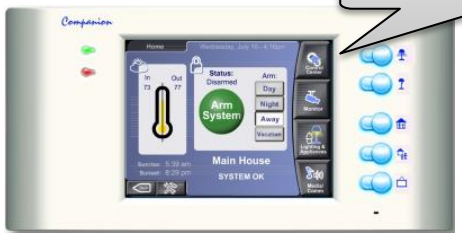
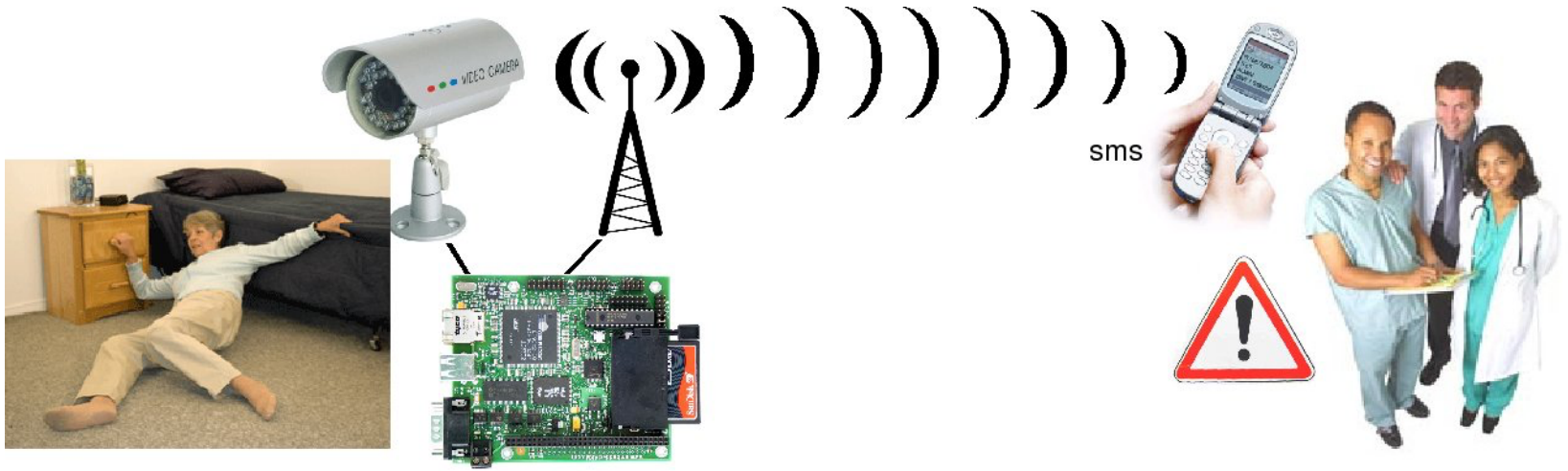


Fall Prevention Alarm System

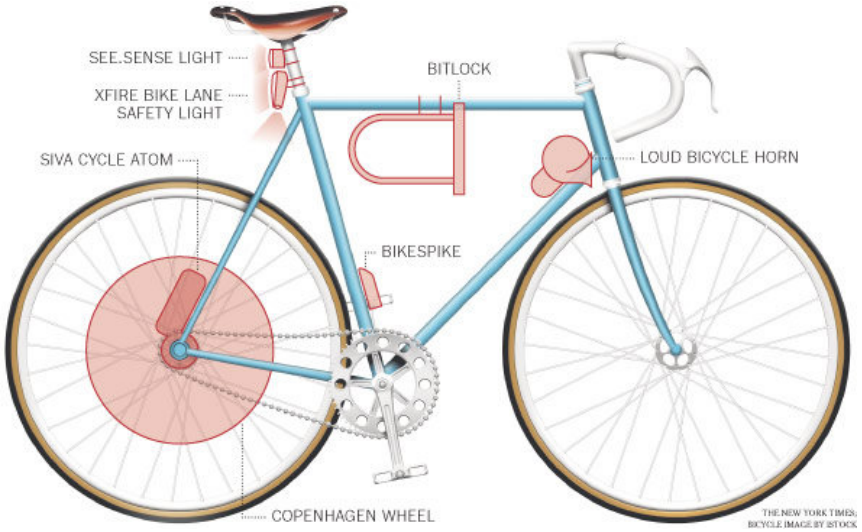
Pacemaker
16-bit custom proc

Safety Glove

Mio Pulse Sensor



Cyclist Safety



"Gadgets to Boost Bike Safety" - NYT

Hovding Airbag

SMART sensor helmet

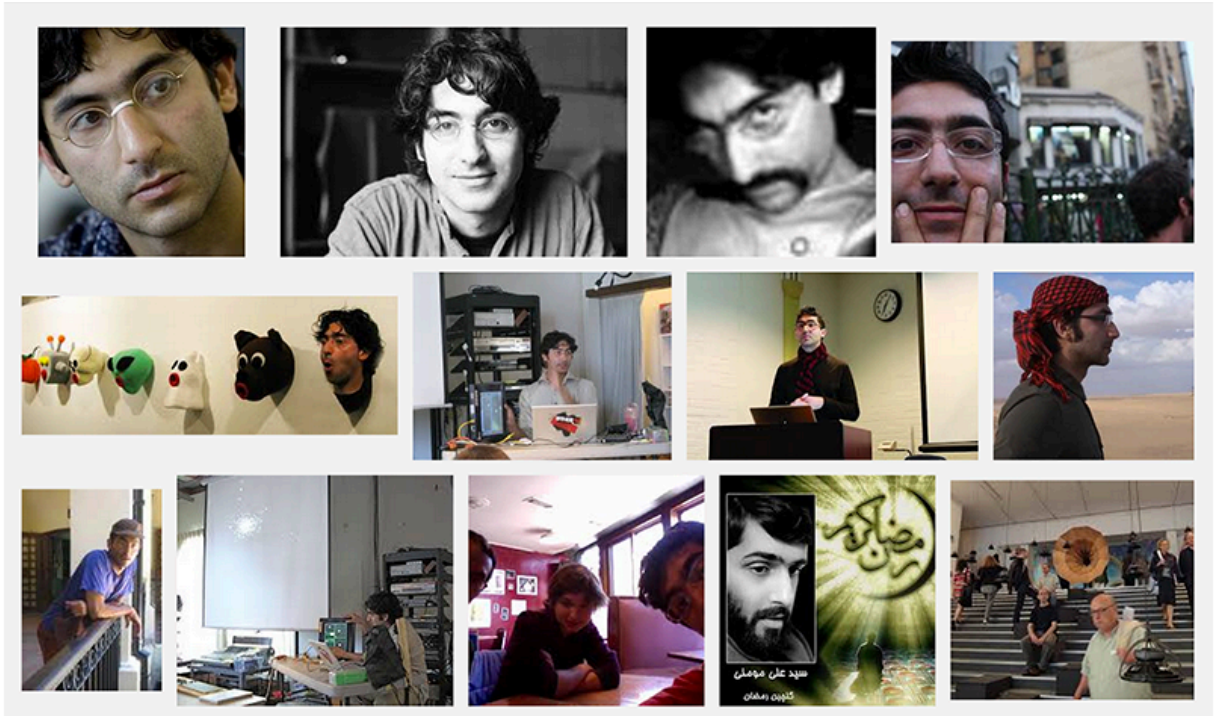
Helios Bars

BLAZE Headlight

Multimedia

Ali Momeni

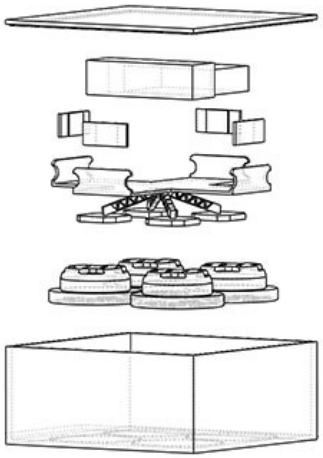
art + design + engineering + culture



[Projects in Collaboration with Ali (Google Slides Link)]

Hoverboard

We designed the Whitebox developer kit to be user-friendly. Open it up, take a look inside, and tinker with it.



Hendo Hoverboard

Camera Commander

BLE Drone

Smartphone + Camera

Charging Station

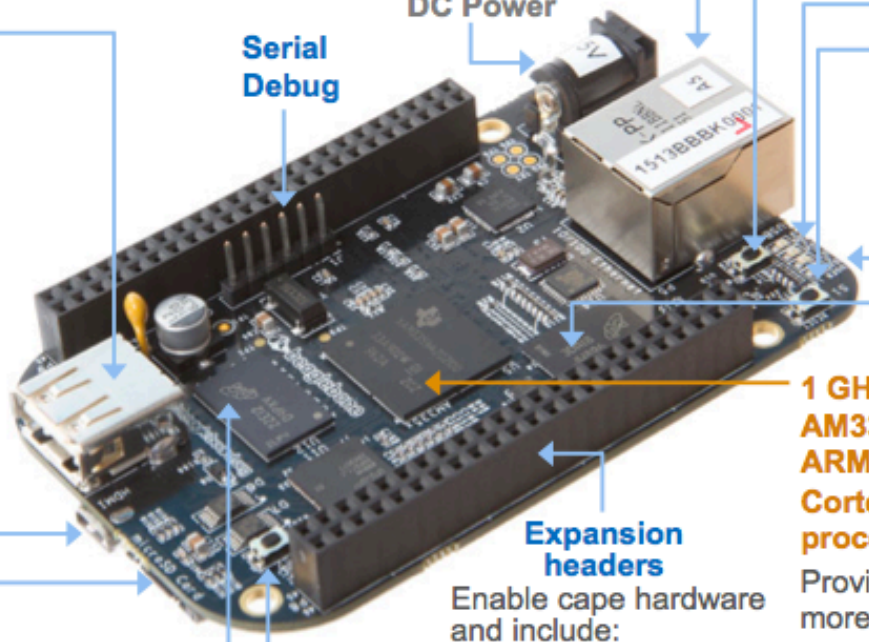
Infrastructural Embedded Systems

- Embedded systems can also exist to provide infrastructural support
  - Example: real-time operating systems, real-time scheduler, distributed debugger, interoperable bus interface, secure protocol stack
- Many different kinds of projects
- Common theme
  - Multiple embedded devices cooperating to provide a certain application
  - Key capability that might be transparent to the end-user, but badly needed for the (often distributed) application running on that platform
  - "… the most powerful things are those that are effectively invisible in use" [Mark Weiser]
- Often also characterized by a key quality-of-service property ("-ility")
  - Reliability, security, debuggability, scalability, real-time, etc.

Platforms

mbed

BeagleBone Black
1 GHz performance ready to use for $45



10/100 Ethernet

USB Host
Easily connects to almost any everyday device such as mouse or keyboard

microHDMI
Connect directly to monitors and TVs

microSD
Expansion slot for additional storage

512MB DDR3
Faster, lower power RAM for enhanced user-friendly experience

Serial Debug

DC Power

Boot Button

Power Button

LEDS

Reset Button

USB Client
Development interface and directly powers board from PC

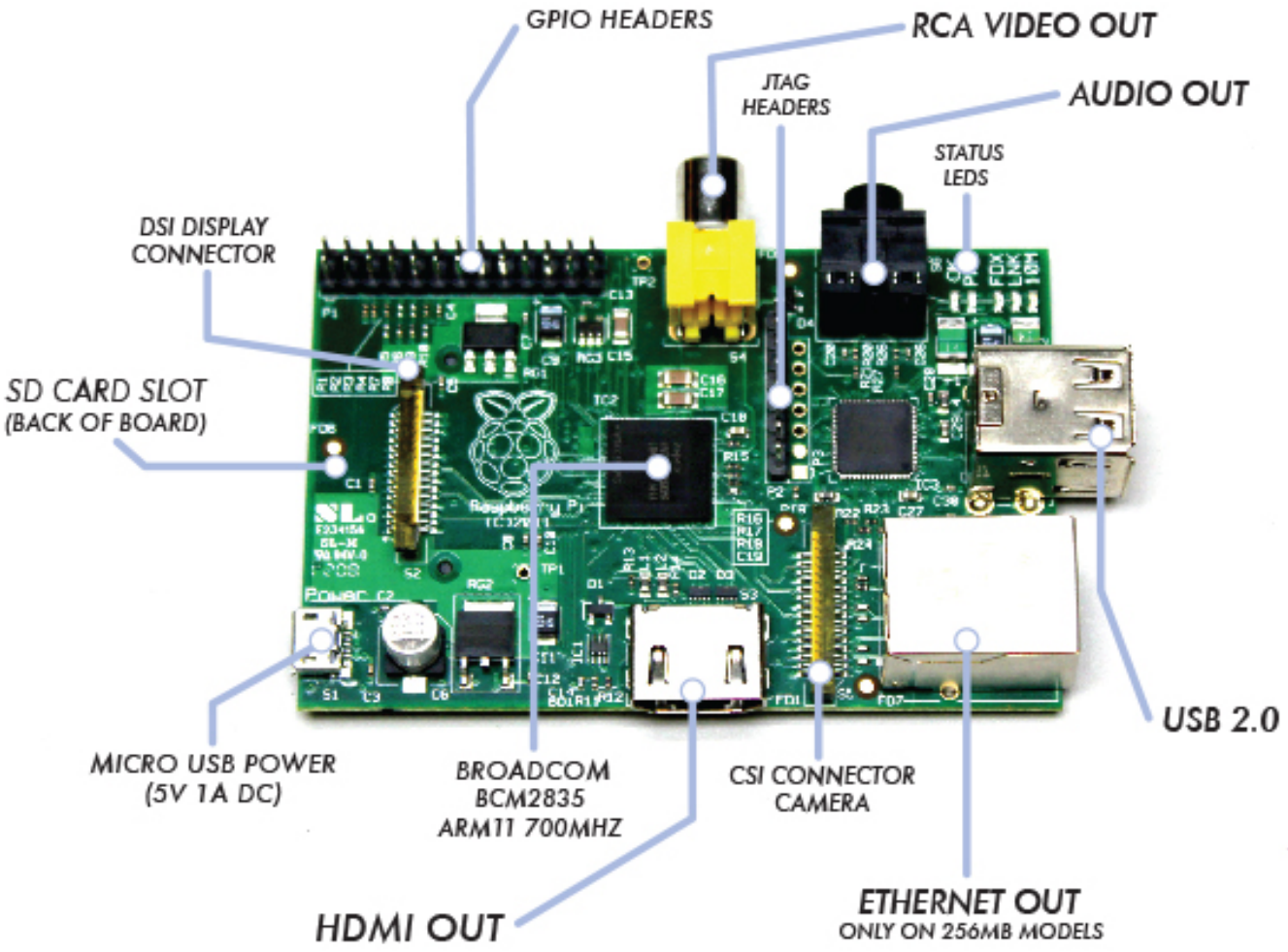
2GB on-board storage using eMMC
- Pre-loaded with Ångström Linux Distribution
- 8-bit bus accelerates performance
- Frees the microSD slot to be used for additional storage for a less expensive solution than SD cards

1 GHz Sitara AM335x ARM® Cortex™-A8 processor
Provides a more advanced user interface and up to 150% better performance than ARM11

Expansion headers
Enable cape hardware and include:
- 65 digital I/O
- 7 analog
- 4 serial
- 2 SPI
- 2 I2C
- 8 PWMs
- 4 timers
- And much much more!

Included in price:
- Power supply ~ $10
- USB network cable ~ $3
- 2GB on-board storage $5-$10
- PRU for real-time tasks typically on FPGA ~ $20

Raspberry Pi



U Doo

4xRaspberry Pi

+

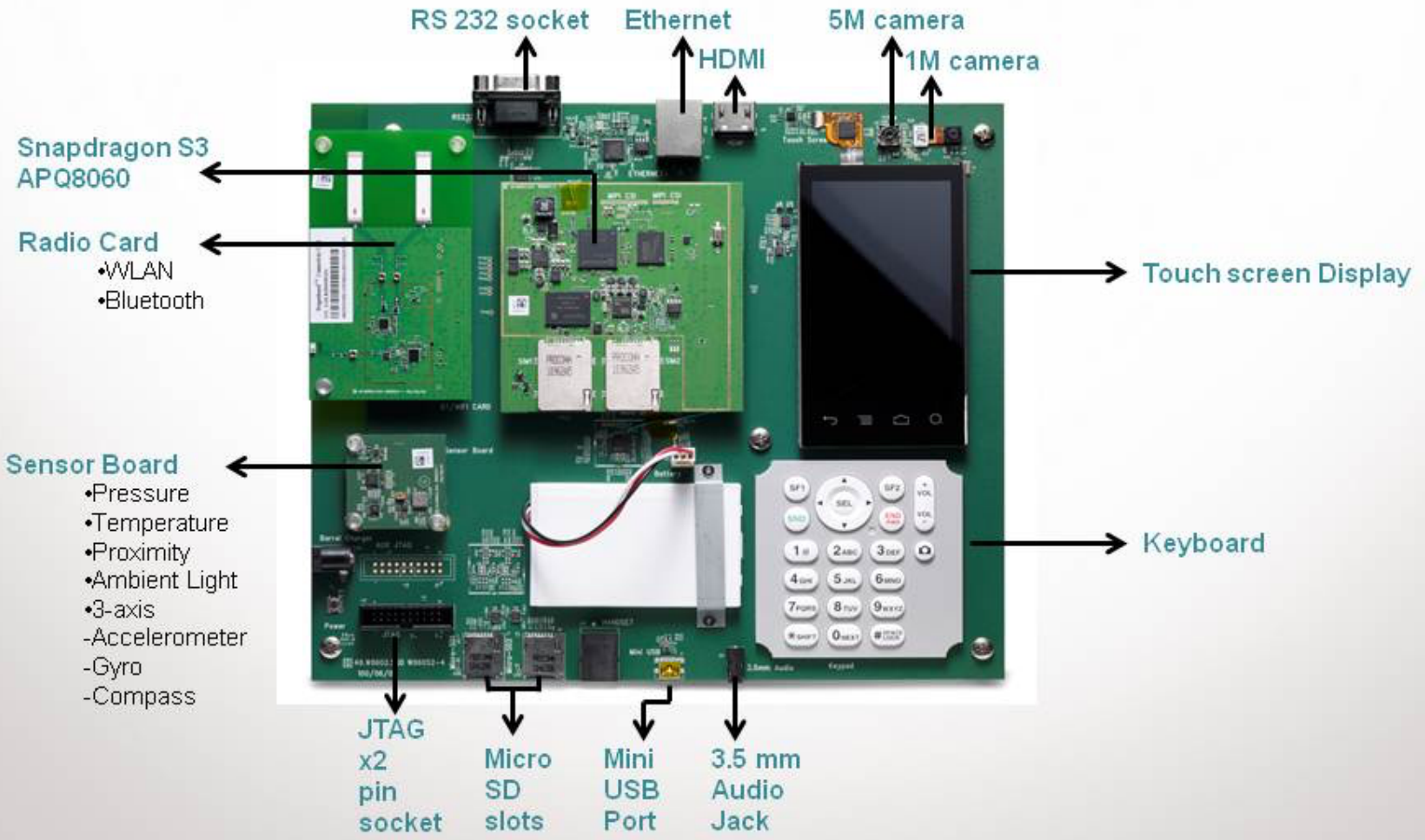
Arduino DUE

=

Kinect 2

Feature	Kinect for Windows 1	Kinect for Windows 2
Color Camera	640 x 480 @30 fps	1920 x 1080 @30 fps
Depth Camera	320 x 240	512 x 424
Max Depth Distance	~4.5 M	~4.5 M
Min Depth Distance	40 cm in near mode	50 cm
Horizontal Field of View	57 degrees	70 degrees
Vertical Field of View	43 degrees	60 degrees
Tilt Motor	yes	no
Skeleton Joints Defined	20 joints	26 joints
Full Skeletons Tracked	2	6
USB Standard	2.0	3.0
Supported OS	Win 7, Win 8	Win 8
Price	$299	TBD

DragonBoard based on Snapdragon Processor



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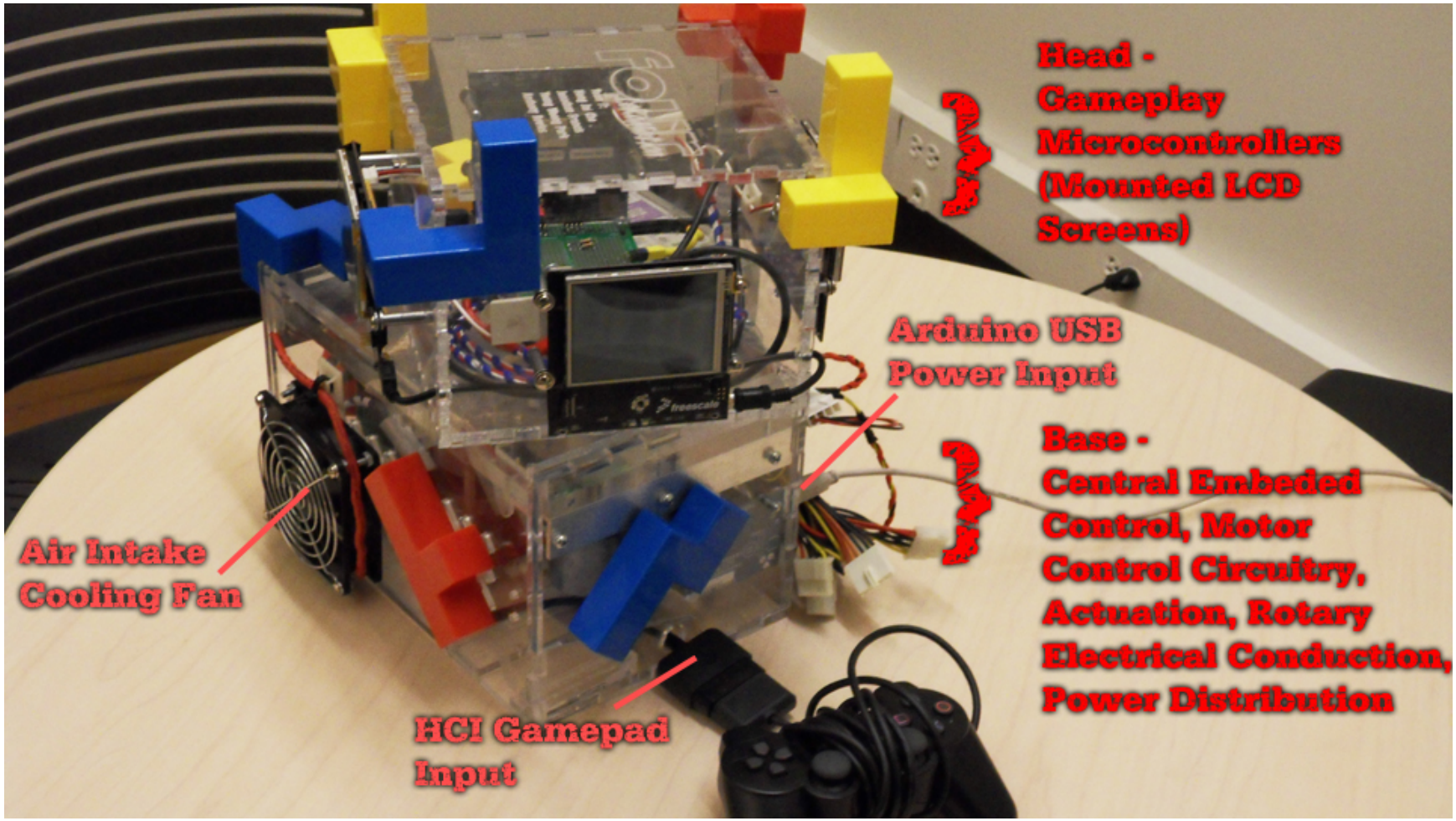
Previous Projects

Full Music Jacket

State-of-the-art design. Seamless integration. The next leap forward in jackets.

Four Loko-Motion

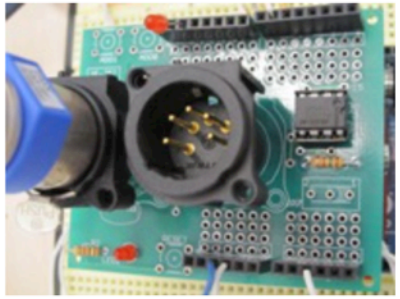


https://www.youtube.com/watch?v=gUjO8b0RTHk#t=60

Seeing Sound

- Spectrum Analyzer Shield:

- DMX Shield:



- LED Display:

More Past Projects

- RAPTR: http://www.ece.cmu.edu/~ece549/spring12/team1/index.php
- ScanDroid: http://www.cmuscandroid.com/index.html
- Katamari Controller: http://www.ece.cmu.edu/~ece549/spring12/team6/index.html
- WonkaBot - 3D Chocolate Printer: http://www.ece.cmu.edu/~ece549/spring12/team10/
- Humming Bird: http://www.ece.cmu.edu/~ece549/spring12/team28/index.html

Finalize Groups NOW…

- Finish forming groups now!
- Stay after class…