CSE Program in
Embedded Systems
Training Talent for the Emerging
Cyber-Physical Systems

Changing Society, Transforming Lives

Rajesh Gupta, Ryan Kastner, Tajana Rosing
Things we care about...

- How computing is changing?
- How (computer) engineering education is changing?
- What are we doing about it?
Microelectronic Materials, Devices & Systems

- Pretty much anything we need to build a complete system can be done on a chip
  - Digital, analog, baseband, RF, memory, non-volatile memory,…
  - And in sufficient quantity to make reasonable SOCs

From cost efficient mixed-signal µcontrollers …

Cypress PSOC

…to multi-processor systems

Pad-limited die in 65nm
Engineering and Engineering Education Trends

- From components to emergent systems of systems
- Proliferation of computing in curricula
- Society and infrastructure applications
  - Fundamental reexamination of work, energy in over two hundred years
  - Fundamental understanding of biological systems as an engineer would.
Migration to sensorial computing

Tremendous innovations in form and function

(a) Top
47 × 68 × 7 mm (1.85 × 2.78 × 0.28”)

1. Accelerometer for x, y-axis
2. Magnetic field sensor
3. Pressure sensor
4. Humidity sensor
5. Ultrasound tranceiver
6. Microphone
7. Light sensor
8. Connector (SW download)
9. DSP
10. RFM radio (for localization)
11. PCB antenna for RFM radio
12. Blue tooth antenna
13. Blue tooth module
14. Loudspeaker
15. ADC magnetic field sensor
16. Accelerometer for x-axis
17. Codec chip
18. Microcontroller
19. Switches (Power, Reset)
20. Battery connector
21. Power supply
22. Battery monitors
23. Switches to functional units

(b) Dimension of enclosure:
70 × 55 × 18 mm
Weight: 65 grams
Battery lifetime: 4h 35 min.
Shape of computers to come...small

Courtesy: Mani Srivastava, UCLA
...and mobile

**Sensor:**
- Application specific.

**Microcontroller:**
- OS, networking.
- Signal processing.
- Power management.

**Transceiver**
- ISM Band (433/900 MHz, 2.4 GHz)

**Energy Storage:**
- Battery
- Fuel cell

**Autonomous Power Supply:**
- Solar power.
- Temperature differences.
- Vibration.
- ...

Source: Estrin, MOBICOM’03

Intelligent, mobile, perceptive embedded systems
Changing Face of Computing: Computing + Space + Time

- A whole new ballgame in computing
  - New observables, new knowledge, new control points.

- Three broad classes:

  - **Stationary Devices**
  - **Mobile Devices**
  - **Sensor Devices**
Computer Engineering: A Changing Discipline

Share of CE Students in CSE Department

60 CE majors randomly chosen
14 students responded in CSE Dept.
18 students responded in ECE Dept.
9 questions asked

Main reason for choosing CE:
20: both hardware + programming

Top needs for courses:
- Embedded Systems, Hardware
- Parallel Programming
- High Performance Computing

Our Explorations
“Initiation” Exercises

**Basic I/O**
- P1: PushButton & LED/LCD
- P2: Potentiometer & LED/LCD

**Bus Control**
- P3: “Hello Chip!” (I2C Bus)
- P4: Event Capture & Count/Measure

**Touch**
- P5: Capsensing & Display & Count
- P6: Music Synthesis & Bar graph

**USB**
- P7: Joystick Mouse!
- P8: Logic Design
- P9: Process Controller

**Wireless and Motion**
- P10: Transceivers
- P11: Motion Control

Choon B. Kim
“Play Music”: 6 concepts in 62 lines

```
#include <m8c.h>
#include "PSoCAPI.h"

#define CLOCK 32000
#define C4_NOTE 261.63
#define D4_NOTE 293.66
#define E4_NOTE 329.63
#define F4_NOTE 349.23
#define G4_NOTE 392
#define A4_NOTE 440
#define B4_NOTE 493.88
#define C5_NOTE 523.25

void main()
{
    LCD_1_Start();
    CSD_1_Start();
    CSD_1_SetDefaultFingerThre();

    while (1) {
        CSD_1_ScanAllSensors();
        ...
        if (bIsSensorActive())
            freq = _NOTE;
            PWM8_1_WritePeriod(freq);
    }
}
```

API, Touch/Sample, Display, Reactivity, Frequency, Calibration
CSE Lab: Courses & Faculty

- Courses
  - Embedded systems
    - CSE 30, CSE 237A, CSE 237B, CSE 237C, CSE 237D
  - Logic, RTL design
    - CSE 140, CSE 140L, CSE 143
  - Architecture
    - CSE 141, CSE 141L, CSE 148

- Faculty
  - CK Cheng, Yoav Freund, Rajesh Gupta, Ryan Kastner, Steve Swanson, Michael Taylor, Dean Tullsen, ...
  - Andrew Kahng, Charles Elkan
  - Choon Kim

Platforms
- Cypress PSOC
- Intel DBPX272
- Digilent/Xilinx
- Altera
Thank You!

- Intel Corporation
- Cypress Corporation
- Northrop-Grumman
- QUALCOMM
- Xilinx
- Convey Computers