HARDWARE AND SOFTWARE CHALLENGES IN SENSOR INTEGRATION

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WHAT DO WE DO

- Complex hardware and software design
  - Small footprint
  - Embedded processor and DSP-based
  - RF, Wireless, Mixed signal and High-speed digital
  - Audio and Video
- OS Expertise
  - Embedded Linux, Android
  - Windows Embedded
  - Integrity, Velocity, MicroITRON
- Embedded Application Development
- Integrating third party solutions
- Verification and Validation
- Value-Added Services
  - Design for Manufacturability
  - Product prototyping and production co-ordination
  - Product Lifecycle Support
  - Low volume production
THE KOPIN GOLDEN-I

www.mygolden.com
CyberDisplay® SVGA microdisplay from Kopin Corporation
Texas Instruments' (TI) OMAP dual processor - 600 MHz ARM Cortex 8, 400MHz DSP
Micron Technologies high-performance memories packaged in advanced stackable Package on Package (POP) packaging for TI OMAP devices
Windows Embedded CE 6.0 operating system
Nuance Communication's VoCon3200 speech recognition software
Hillcrest Labs 6-axis, solid state real-time position tracker
Cambridge Silicon Radios (CSR) Bluetooth 2.1 EDR
Marvel Wi-Fi operating 802.11b and 802.11g at low-power
Mini-USB port for wired desktop and peripheral connectivity
Removable Micro SD card capable of 32GB on non-volatile storage
Single 1200 mA/hr Li-ion battery
A Typical Device

- Processor, Memory, Storage
- Input/Output
  - Display, mouse, keypad
  - Audio (mic/speaker), camera
- Operating System
  - Android, Windows CE, Linux, RTOS
- Connectivity
  - WLAN, BT, Ethernet
- Other devices...
  - GPS, nDoF Sensors, Other input/output
- Smart phone
- Tablet computer
- Gaming/Media device
- Head mounted computing
- Wrist mounted devices
- Heads up display
- Industrial front panel
- Medical device
- Heart rate sensor
- Pedometer
What are the use cases for the device?
What is the environment it will be used in?
What are the design constraints?
You want it HOW THIN/SMALL?
What operating system?
How long do you want it to last on battery?
What are the regulatory constraints?
What are the supply chain issues?
How much money do you want to spend?
When do you want it?
TYPES OF SENSORS

- Accelerometer – 1 axis/2 axis/3 axis
  - MMA8450QR1 (Freescale), ADXL345BCCZ (Analog devices)
- Gyroscope
  - L3GD20TR (STMicroelectronics)
- Magnetometer
- Temperature sensor
  - SA56004ADP (NXP semiconductors)
- Ambient Light Sensor
  - ISL29011IROZ-T7 (INTERSIL), MAX44009EDT (Maxim)
- Accelerometer + Magnetometer
  - LSM303DLHCTR (STMicroelectronics)
- Accelerometer, Magnetometer, Gyro
  - MPU-9150 (InvenSense)
- Proximity Sensor
  - GP2Y0D810Z0F (Sharp)
- Tilt Sensor
  - LMC7221AIM5 (National Semiconductor)
- Stow Sensor
  - SN74LVC1G123DCUR (Texas Instruments)
HARDWARE INTEGRATION - SENSOR SELECTION

- Integrated Sensor, OR
- Discrete Sensors

Photograph source iPhone 4s teardown at ifixit.com
Physical location (electrical, mechanical, industrial)

Board layout constraints
- Supplier constraints, SMT Guidelines, trace routing, keepouts, ground guard, PCB Mounting
- Reflow specification

Operating constraints
- Temperature, Performance

Interference from other devices
- Inside the product/external interference
Device integration
- Time Synchronization between sensor devices
- Latency of input to reporting it to the fusion layer
- Other devices that depend on sensor input like camera’s
- Power management – wake up on sensor input

Sensor integration
- Independent Microcontroller
  - Building an independent device
  - Using a Microcontroller for sensor fusion and reporting to a host controller
- System Microprocessor

Storage of sensor calibration data

Sensor reliability
- What is the usable life of your product?
SOFTWARE INTEGRATION - OPERATING SYSTEM

- Operating system selection
  - Windows CE, Windows 8, Android
  - Embedded Linux
  - RTOS
  - No-OS/Scheduler

- Interface drivers
  - I2C/SPI/USB
  - Time Sync
SOFTWARE INTEGRATION

- **OS HAL Layer**
  - Input sub system/Sensor layer of OS
  - Calibration at Device Startup

- **Time Synchronization**
  - All sensors working with a common time source

- **Middleware Integration**
  - Calibration Libraries
    - Consistency of output between devices
  - Usage libraries
    - Sensor fusion
SENSOR NETWORKS

Source of pictures wahoo fitness website, cnn website
PUTTING IT ALL TOGETHER

- Point Zero – Starting reference
- Calibration and Accuracy
- Damping of input
- Third party middleware
- Time Reference
- Sensor integration increases the use cases of the product
- Sensor fusion...in the cloud.
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