CS245 – Lecture 3

Embedded Design Domains

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Hybrid Embedded Systems

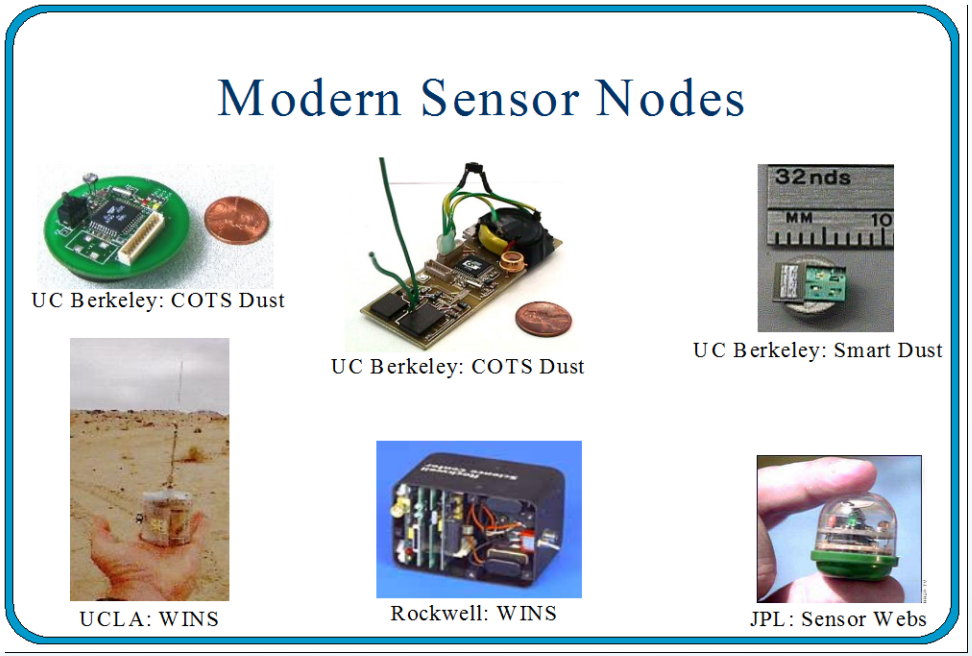
- Computation systems whose behavior is tightly integrated with the physical world
  - Eg., the behavior of an unmanned aerial vehicle (UAV) can be modeled by a combination of differential equations (the aerodynamics and low level feedback controllers) and a finite state automata (high level flight path decisions, such as to ascend or descend).
- Behavior is governed by both continuous-state dynamics from the physical world and discrete-state dynamics from the computation
- Passage of time during computation affects the state of the physical world

Hybrid Embedded Systems

- Aerospace
  - Flight control
  - Positioning & navigation
  - Instrumentation
  - Radar
- Automobiles
  - Engine management
  - Emission control
  - Safety & stability
  - Entertainment & comfort
- Robotics
  - Mission oriented

Sensor Networks

- Many sensor nodes
  - Sensing
  - Computation/storage
  - Communication
- Examples
  - Structure safety
  - Search and rescue
  - Military use
- Properties
  - Self organization
  - Energy Efficient
  - Distributed



Multimedia

- Compute systems centered around:
  - Signals, analog to digital conversion, quantization, sampling, processing, and digital to analogue conversion
  - Information theory, entropy, Huffman codes, compression, lossless compression
  - Images, audio, video
- Examples
  - Setup boxes
  - Blue ray players
  - Virtual reality
- Properties
  - Quality of service
  - Lots of data (formats and standards too)!

Consumer Electronics

- Home appliances
  - Yesterday's appliances: add computation
  - Tomorrow's appliances: add networking (Internet)
- Office electronics
  - Integration
  - Electronic paper (filing, printing, sending, and receiving)
- Home/office automation
  - Common fantasy about the automated home or office of the future with lights and appliances that operate by themselves or with minimal effort

Networking Equipment

- Stitching LANs
  - Bridge: same identity
  - Router: different identity
- Ports
  - Switch: recipient only
  - Hub: transmit to all
- Properties
  - Handle large volume of highly structured data
  - Little transformation

Medical Instruments

- Perform diagnosis (screening/evaluation)
  - Data collection & display
  - Appraisal (plan of action) of data
  - Observation & monitoring
  - Sensing & actuation
    - Accuracy and precision
- Examples
  - Radiation therapy
  - Artificial hearts
- Properties
  - Reliability

Distributed & Grid Computing

- Coordinated resource sharing and problem solving
- The grid is static, reliable, and has infinite resource (for practical purposes)
- Users (the mobile device e.g., PDA) has limited resources
- Middleware mitigates the resource sharing and coordination efforts

MEMS

- Small mechanical devices and systems
  - Few microns to a few millimeters
- These devices are called:
  - Micro Electro Mechanical Systems (MEMS)
  - Micro System Technology (MST)
  - Micromechanics
  - Micro Machines
  - Micro
  - Nanotechnology by some (usually refers to devices ranging in size from a nanometer to a micron)
- Encompasses all aspects of science and technology

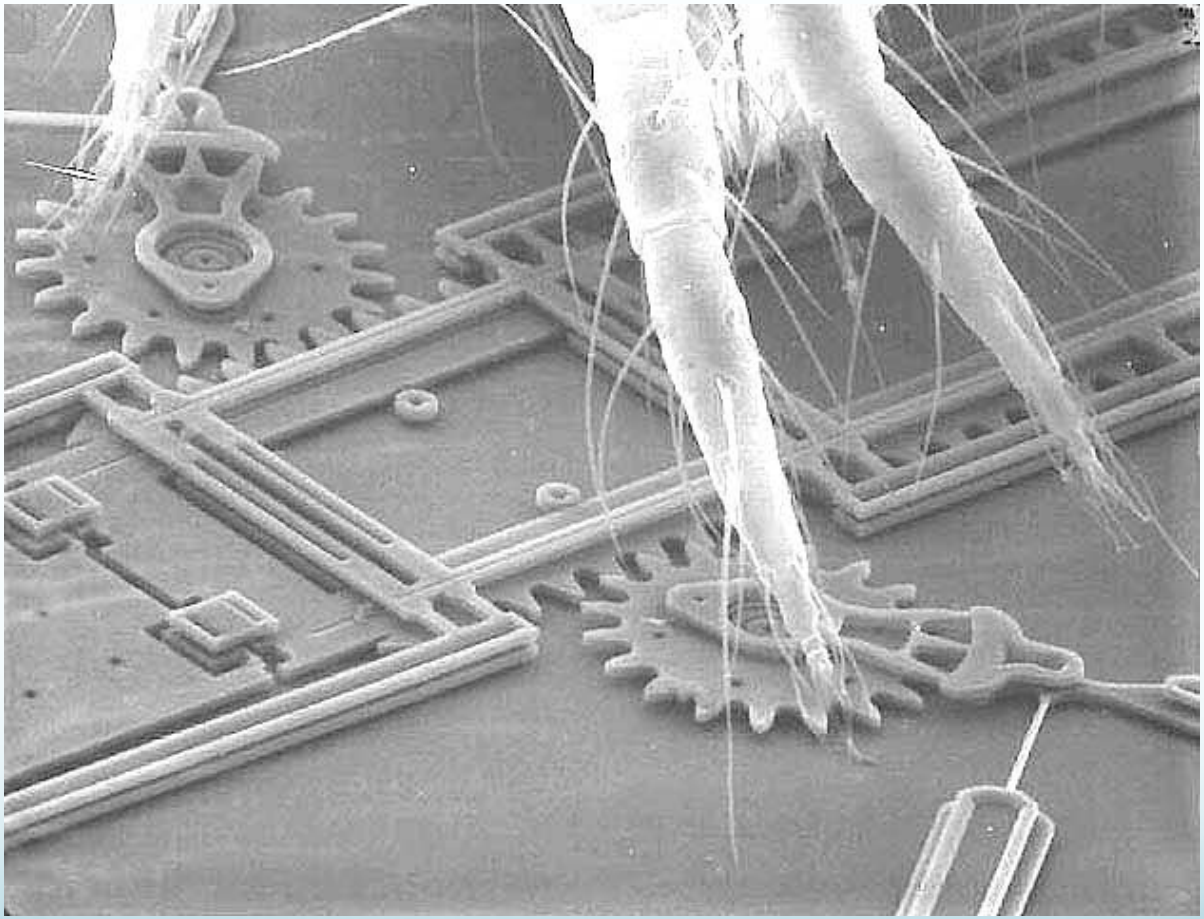
MEMS Design Concerns

- Forces related to volume (e.g., weight and inertia) decrease in significance
- Forces related to surface area (e.g., friction, surface tension, and electrostatics) increase in significance
- Examples from nature:
  - An ant carrying many times its weight
  - A water bug walking on the surface of a pond
- A need for thinking “outside” the box and adopting a new intuition of mechanical devices

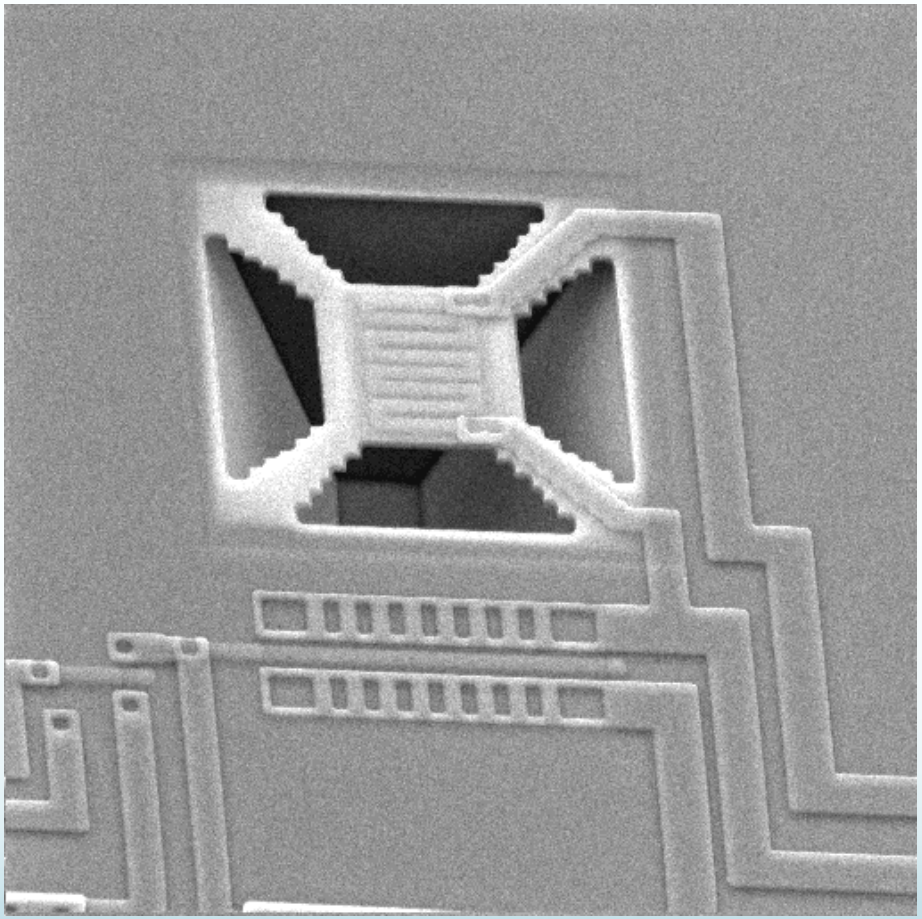
Inside MEMS Devises

- Motors, gears, pivots, linkages, and other mechanical devices
  - Made using silicon surface micromachining
- Transistors, resistors, capacitors, inductors, and other electronic devices
- MEMS internals tend to be rugged, respond rapidly, use little power, occupy a small volume, and are often much less expensive than conventional macro parts

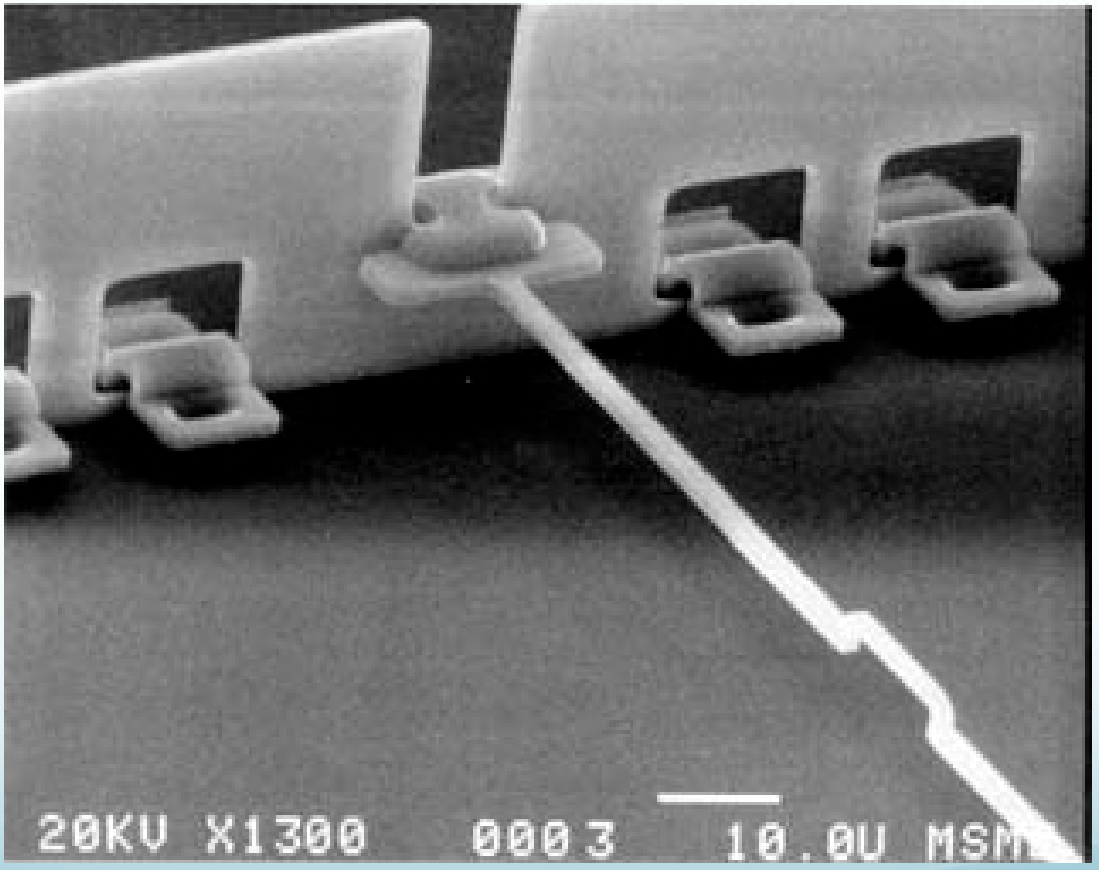
MEMS – Spider & Machine



MEMS – Tiny Heater



MEMS – Mirror



Nanotechnology

- A continuation of the MEMS slides …
- Molecular scale manipulation of systems
  - Due to the importance of quantum physics at the nanometer scale the mechanic, dynamic, and electro-magnetic properties act unusual
    - Atomic copper wires are bad conductors
    - Atomic magnetic bits lose their memory too quickly
- Is ohm's law correct at the molecule/atom level?

Nanotechnology

- Much of what you hear is *nanofiction*
- All *nanotechnology* today is passive
  - Silicon based
  - Synthetic material
- Most *nanoscience* concerned with controlling material properties (e.g., melting temperature, magnetic properties, charge capacity, mechanical properties, and color) without changing the materials' chemical composition
- Future nanoscience will attempt to create active components