Special Topics: Simple Robots and Microprocessors
ECE 292
Lecture Notes 1

Reading: syllabus, Chapter 1, 5, 6

Computer System: Layers of Abstraction

Application Program
Language
Operating System
Instruction Set Architecture (and I/O Interfaces)
Microarchitecture
Logic Gates
Circuits
Devices
Two Books

Course Outline

- Introduction to Embedded Computer Systems; Introduction to Stiquito
- Electronics, soldering skills, instrumentation, power supplies
- Basics of Computer control – Input/Output
- Controlling the Gait of Stiquito
- An examination of a small embedded Computer System
- Optimization of embedded system code
- Hardware/software co-design
- Testing Embedded Systems
- Building Stiquito/basic Stamp board
- Stiquito race/report due (Pizza Party??)
Class Activities

• 40% Laboratory demonstrations
• 10% Lab notebook
• 10% Quizzes
• 20% Final project/race results
• 20% Final report – Magazine Article

Class Materials

• Each person: Book - Stiquito for Beginners, hobby knife, needle-nose pliers (hemostat helpful)
• Parallel port kit (from me, at cost - $10)

• Other materials you may want:
  • Brass Screws
  • Your own Basic Stamp
Computers are everywhere

Q: Where are computers today?
• On your desktop (of course!)
• In your microwave oven
• Controlling automobiles
• In a Palm Pilot PDA
• In your pager
• In a cell phone
• In a Nintendo console
• In your Gameboy . . .
• Everywhere!

What is Embedded?
How Big is it?

Embedded is the largest and fastest-growing part of the worldwide microprocessor industry
Embedded is approximately 100% of worldwide unit volume in microprocessors
Average of 30-40 processors per home
  • (only 5 are within the home PC)
“Turley's Law”:
  • “The amount of processing power on your person will double every 12 months

Microprocessor Shipments
All types, all markets

Source: Information Architects
Home Entertainment Rules

Home entertainment and consumer electronics are the fastest-growing segment of the electronics industry

- $6.5 billion in U.S. games in 1998
  - Mario Kart made more money than Oscar winners

Falling cost of 32-bit processors has made this market the hot growth area for the next decade
Many home applications have a nearly infinite capacity to consume performance

Consumer Electronics
The Shifting RISC Lead

Market share over time for different RISC architectures from 1991 to 1998.

Source: Microprocessor Report, 1999

Memory

Memory is *INFORMATION DELAYED IN TIME*

Examples of memory devices:
- Flip-flops - Static memory
- Capacitors - Dynamic memory
  - They “forget” and must be periodically refreshed
- Metal oxides - Tapes, disks
  - Hold a magnetic field
- Transmission lines - Mercury delay lines
  - Used in early computers
- Optical patterns - CD, DVD, paper (barcodes)

Semiconductor memory has made large programs possible

Q: *How many megabytes of DRAM do you have in your computer?*
Peripherals

Input devices
- Mechanical - strain gauges, keyboards, mice
- Electrical - Field probes, network cables
- Magnetic - Tape heads, disk heads
- Optical - wands, cameras
- Sound - microphones

Output devices
- Mechanical - impact printers, card punches
- Electrical - Network cables
- Magnetic - Tape heads, disk heads
- Optical - CRT, projectors
- Sound - speakers

Input + output = Input/Output = I/O

Stiquito - What Is It?

- Invented by Jonathan Mills, CS Department, Indiana University, in 1992.
- Hexapod (six legs)
- Small - can sit on a credit card (75mm x 70mm x 25mm, 10g)
- Inexpensive ($5.00 in mass quantities), easy-to-build
- Can carry about 50g of weight
- Travels using a “Nitinol” muscle
Stiquito - How Does It Work?

- Nitinol wire actuator contracts
- Leg catches surface as it bends backward
- Other legs slide forward
- Robot moves forward

Nitinol - What Is It?

- Alloy of nickel and titanium
- Contracts when heated
- When cooled, must be “stretched” back to its original size
- Lasts millions of cycles

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Controlling Stiquito Manually

Simple operation, no components, two switches, requires tether

Controlling Stiquito - PC Parallel Port

- Attach Stiquito to a PC's Parallel port via a tether
- Provide a separate power source from the PC
- Program via C, BASIC, or Assembler
- Simple circuit, easier to change program
Controlling Stiquito - A Simple Analog Circuit

Comprised of:
- 4 resistors/Pots
- 8 “transistors”
- 2 capacitors
- 1 LED
- 555 timer

Battery and circuit sits on top - no tether

Controlling Stiquito - Complex Microcontroller

Uses a microcontroller
- PIC
- MC68HC11
- 80C32
- FPGA
- Basic Stamp

Programming & hardware design
Difficult & advanced
What Next?

- Monday’s Lab - yes, Memorial Day!!!
- Over the weekend, start work on Stiquito.
- Contemplate the variations of the robot:
  - Two degrees of freedom?
  - Screws?
  - Control of each leg separately?
  - Build one together with your lab partner?
  - Make a plug for your Stiquito instead of crimping it to the manual controller?
- These require you to think ahead to the end-of-semester project, and what will make Stiquito walk best.