Eingebettete Systeme / Embedded Systems

(WS 2002/2003)

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Organization

- Montag, 14-16: Daniel Kästner
- Donnerstag, 9-11: Hans Rieder
- Vorlesungsbetreuung: Nicolas Fritz
- Sprechstunden:
  - Daniel Kästner: Montags, 10-11 Uhr, Room 430, Geb. 45.
- Folien auf Englisch, Vorlesung auf ...?
- Voraussetzung zur Scheinvergabe:
  - 50% der theoretischen Übungspunkte
  - Erfolgreiche Teilnahme am spraktischen Projekt
  - Bestandene Klausur
- Übungsbetrieb:
  - Theoretische Übungen + Programmieraufgaben
  - Praktische Übungen (Hans Rieder)

EZ-KIT Lite - DSP based system

The ADSP-2181-Kit Lite provides an evaluation suite of the VisualDSP++ development environment with the C-compiler, assembler, and linker.
Exercises:
- Signal processing
- communication
with the Viusual DSP Tools
[www.analog.com/products/info.asp?product=21xx-EZLITE]

DSP based system for audio, voice and general signal processing applications

Technical data:

- ADSP-2181 33 MIPS DSP
- AD1847 stereo codec
- RS-232 interface
- User push buttons
- Power supply
- Evaluation Suite of VisualDSP++

Applications:

- Audio
- Speech recognition
- Filter (FIR, IIR, Cepstrum,...)
- FFT, Wavelet, ...
- Simulation
- Automated systems (PID, ...)

Organization

- Website: http://www.cs.uni-sb.de/~kaestner/ES0203.html
- Mailing-Liste: es0203@cs.uni-sb.de
- Übungsgruppentermine?
  - Anzahl der Übungsgruppen?
  - Vorschläge: Do 11-13, Fr 9-11, Fr. 11-13
- Fragen?

Contents

- This week: What is an embedded system? Terminology and Importance.
- Mondays (Daniel Kästner):
  - Finite Automata, timed automata
  - Modelling: StateCharts and Statemate
  - Synchroneous Programming: Esterel
  - Transport protocols
  - Code generation for embedded processors
  - Safety analyses and verification

- Thursdays (Hans Rieder):
  - Networks
  - Industry applications
  - Bus systems and transport protocols
  - Digital signal processing

Definitions

- System: A system is a portion of the universe that has been chosen for studying the changes that take place within it in response to varying conditions [Encyclopedia Britannica].

- Model: Any real situation in the physical or biological worlds is subject to analysis by modelling if it can be described in terms of mathematical equations. As such, a model is a simplified representation of the real world including only those variables relevant to the problem at hand. A model may not include all relevant variables because a small percentage of these may account for most of the phenomenon to be explained [Encyclopedia Britannica].

Classifications of Systems

- System categories:
  - sequential vs parallel,
  - central vs distributed,
  - deterministic vs nondeterministic,
  - terminating vs nonterminating
- System types:
  - transformational
  - interactive
  - reactive (embedded, real-time)

System Types

- Transformational Systems:
  - Input/Output System: transforms sequence of inputs to sequence of outputs
  - Only initial and final states are of interest -> linear structure.
  - Computations terminate.

- Interactive Systems:
  - In continuous interaction with environment
  - Computations do not terminate
  - Computer controls the pace
  - Not necessarily deterministic.

System Types (c'ed)

- Reactive Systems:
  - In continuous interaction with an environment that cannot wait.
  - Computations do not terminate
  - Environment controls the pace
  - Generally intended to be deterministic
  - Typically embedded systems
  - Typically subject to critical reliability requirements
  - Inputs and outputs are related through their allowed combinations in time

Embedded Systems: Definition

- Embedded systems are embedded in a physical environment and interact with it for measuring or controlling purposes.
- Characteristics of embedded applications:
  - complex interaction with environment (non-deterministic, contineous behavior; signals arrive at enormeous rates; signal processing and information filtering become key issues)
  - high dependability requirements
  - often real-time processing required

Special Case: Real-Time Systems

- In a real-time system, the correctness not only depends on the logical results but also on the timing of the applications.

- Definition (Oxford Dictionary of Computing):
  Any system in which the time at which output is produced is significant.

  This is usually because the input corresponds to some movement in the physical world, and the output has to relate to that same movement. The lag from input time to output time must be sufficiently small for acceptable timeliness.

Special Case: Real-Time Systems

- Distinction:
  - Hard real-time system: It is vital that the system satisfies the timing condition. Failure results in catastrophic consequences, e.g. the loss of lifes. Examples: flight control software, airbag control.
  - Soft real-time system: It is desirable that the system satisfies the timing conditions; otherwise the functioning of the system is negatively affected. Example: MP3-Player, telephone software.

Embedded Systems: Trend

- Trend to replace conventional mechanics by digital embedded components.

- Reasons:
  - production cost,
  - functionality,
  - weight,
  - size.

Market for Embedded Processors

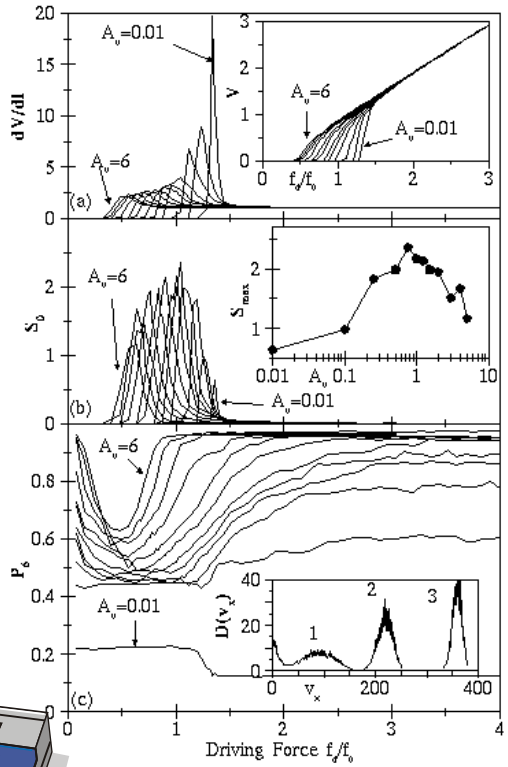
- Market for embedded processors estimated at almost $50 billion ($10^9$) in 1997; annual growth estimated at 35% per year (Micrologic Research).
- Worldwide semiconductor sales total $204 billion in 2000 (Semiconductor Industry Association).
- Embedded chips account for more than 90 % of all silicon processors sold [Leibson(Embedded Processor Forum), 2001]
- The global market for general-purpose DSPs grew 25.5% to $4.4 billion in 1999 [Tempe Research Company].

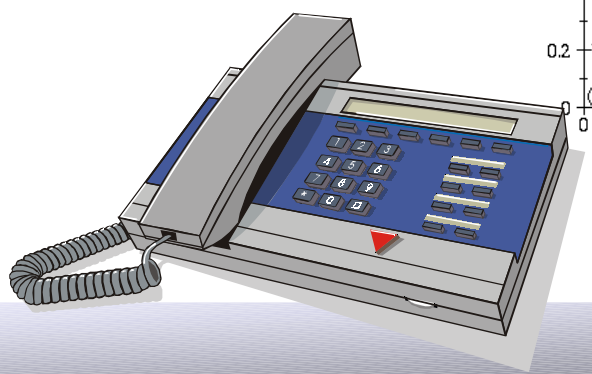
Examples: Consumer Electronics

- AV-R Receivers (e.g. Analog Devices SHARC)
- Smart Pen
- CD-player, DVD-player, MP3-player
- Organizer, PDAs
- Washing machines, microwave ovens, ...
- PC peripherals (hard disk control, graphic cards, ...)

Example: Telecommunication

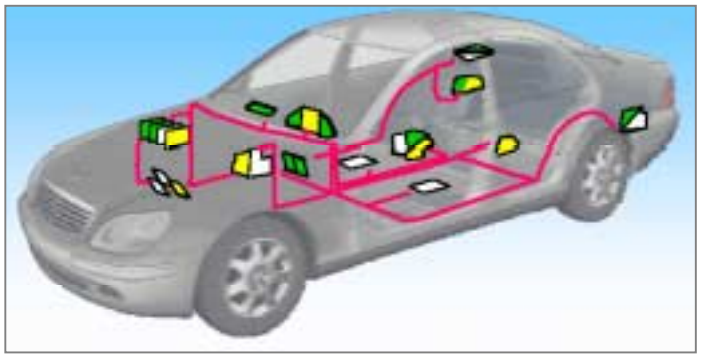
- Devices:
  - Cell phones
  - ISDN phones, fax
  - Answering machines, etc
- DSP-Applications:
  - voice and data compression
  - echo reduction
  - signal multiplexing
  - filtering





Examples: Automotive

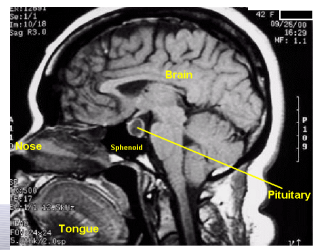
- An average passenger car has roughly the equivalent of six Pentium processors; currently there are up to 100 microprocessors per car.
  - Engine control
  - Active suspension
  - Air-conditioning
  - Airbag
  - Navigation systems (GPS)
  - Sound system, active noise cancellation
  - ...



Examples: Avionics and Healthcare Technology

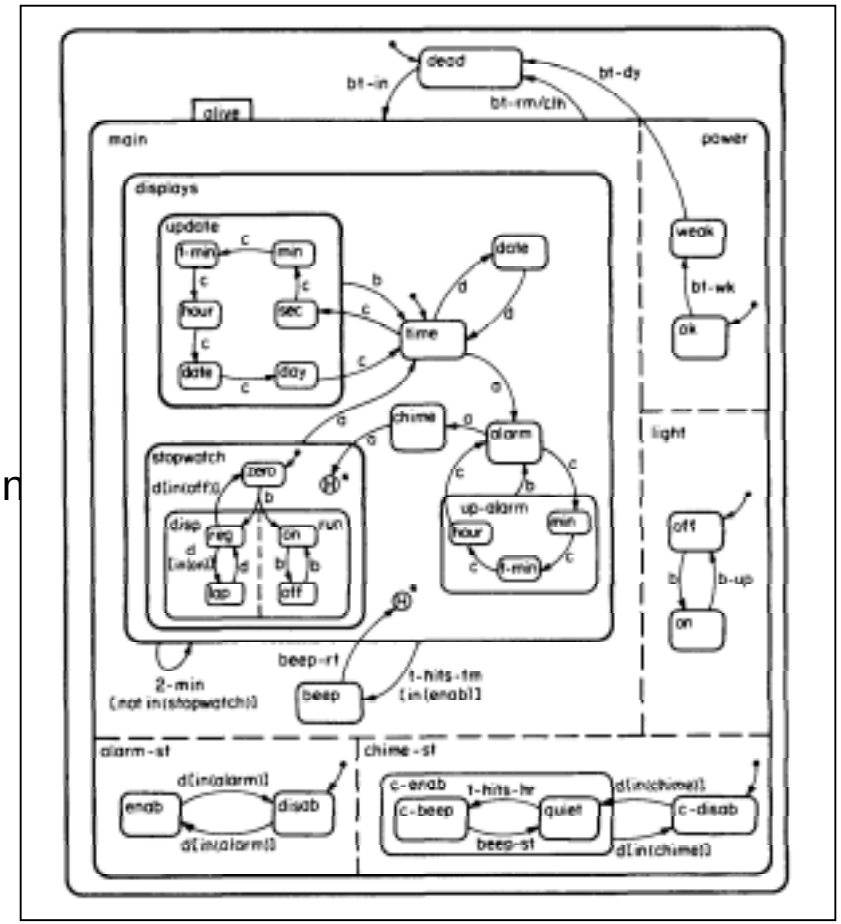
- Pilot information systems
- Fly-by-wire
- Security control

- Diagnostic imaging (Computed Tomography, Magnetic Resonance Imaging, ultrasound, etc)
- Electrocardiagram analysis
- Medical image storage/retrieval



System Modelling

- Goals of modelling:
  - Simulation
  - Animation
  - Validation
  - Formal verification
  - Static system analysis
  - Hardware/software codesign
  - Prototyping
  - Synthesis of test suites
  - Documentation



Why use formal methods?

- Informal formulations are liable to omissions and contradictions.
- Formal models enable verification by mathemetical methods.
- Formal models lead to (partly) automated analysis and test methods.
- Formal models lead to (partly) automated development methods and tools.
- Designs can be compared with each other.

Next Mondays

- Finite Automata
- Timed Automata
- StateCharts and Statemate
- Synchroneous languages:
  - ESTEREL
  - LUSTRE, SIGNAL