ELCE 705
DIGITAL SIGNAL PROCESSING

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Roots of DSP

- The roots of DSP are *in the 1960s and 1970s* when digital computers first became available.

- Computers were expensive during this era, and DSP was limited to only a few critical applications. as:
  - *radar & sonar*, where national security was at risk;
  - *oil exploration*, where large amounts of money could be made;
  - *space exploration*, where the data are irreplaceable;
  - *medical imaging*, where lives could be saved.

- The personal computer revolution of the *1980s and 1990s* caused DSP to explode with new applications. DSP was suddenly driven by the commercial marketplace.

- *21st Century -*Anyone who thought they could make money in the rapidly expanding field was suddenly a DSP vendor

Course Outline

- Discrete-time Signals and Systems

- DTFT, Z-transform, DFT, FFT

- Sampling Theorem and Reconstruction

- System Structures and Analyses

- Filter Design

- Introduction to the Digital Signal Processor.

- Practice includes problem solving & simulation

- Matlab Signal processing toolbox

Lecture notes and other materials are provided by UMMoodle

http://ummoodle.umac.mo/

Course Outline

- Assessment
  - Simulation Project Report   30%
  - Written Exam   35%

  (Examples, Tutorials & Simulation Assignments)
  - Final project   35%

  Hand in report via http://ummoodle.umac.mo/
  - Please hand in your report on time. Otherwise, 5 points per day will be deducted from your grade.

Weekly Office Hours

Individual students may come without appointments to discuss any aspect of their study

- Office Location: E11- 3050

  - Monday 10:30 -11:30am

  - Thursday 10:30-11:30am

Text & References

- Discrete-time Signal Processing, 3nd Edition,
    - A.V. Oppenheim, R.W. Schafer, earson/Prentice Hall, 2010
    - 影印本，电子工业出版社

- "Digital Signal Processing Using Matlab"
    - V.K. Ingle, J.G. Proakis,
    - PWS Publishing Company, 2000

Signal Processing Toolbox --Matlab

- Signal Processing Toolbox is a collection of industry-standard algorithms for analog and digital signal processing.

  - Graphical user interfaces for interactive design and analysis
  - Command-line functions for advanced algorithm development
    http://www.mathworks.com/products/signal/description1.html

  - Function Reference

    http://www.mathworks.com/access/helpdesk/help/toolbox/signal/index.html
    ?/access/helpdesk/help/toolbox/signal/f9-131178c.html
    &http://www.mathworks.com/products/signal/demos.html

DSP vs. DSP

- Digital Signal Processing
  - Mathematical manipulation of digital signals

- Digital Signal Processor
  - Microprocessors designed to perform Digital Signal Processing

Historical Perspective

- The digital signal processing theory has advanceD in uneven steps over a long period of time.

    - Since the invention of calculus in the 17th century, scientists and engineers have developed models in terms of functions of continuous variables and differential equations.

    - *Numerical techniques*
        - Solve equations when analytical solutions are not possible.
        - Special case of some of the discrete-time system we work on today.

    - Signals ---- being processed on digital computers
        - Increasing sophisticated signal processing algorithms.

Continues

- In 1965, the FFT was disclosed, which accelerate the evolution of digital signal processing
  - In 1967, calculation of a 8192-point DFT on the top-of-the line IBM 7094 took ….
    - ~30 minutes using conventional techniques
    - ~5 seconds using FFTs
- The DSP theory is keeping developing.

Data Dependencies in a 16-point FFT
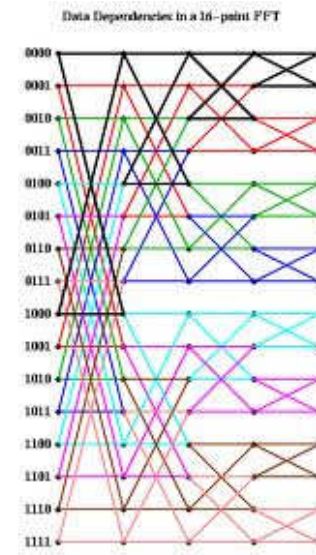
Digital Signal Processing

- *Digital Signal Processing* is distinguished from other areas in computer science by the unique type of data it uses: *signals*.

- In most cases, these signals originate as sensory data from the real world: seismic vibrations, visual images, sound waves, etc.

- DSP manipulates these signals after they have been converted into a *digital form*.

- Digital signal processing includes a wide variety of goals:
  - Enhancement of visual images
  - Recognition and generation of speech
  - Compression of data for storage and transmission
  - ……………

Classification of Signals

- A **continuous-time signal** is defined at every instant of time;

- A continuous-time signal with a continuous amplitude is usually called an **analog signal;**

- A **discrete-time signal** is defined at discrete instants of time, and hence, it is a sequence of numbers;

Classification of Signals

A continuous-time signal

A digital signal

A sampled - data signal

A quantized boxcar signal
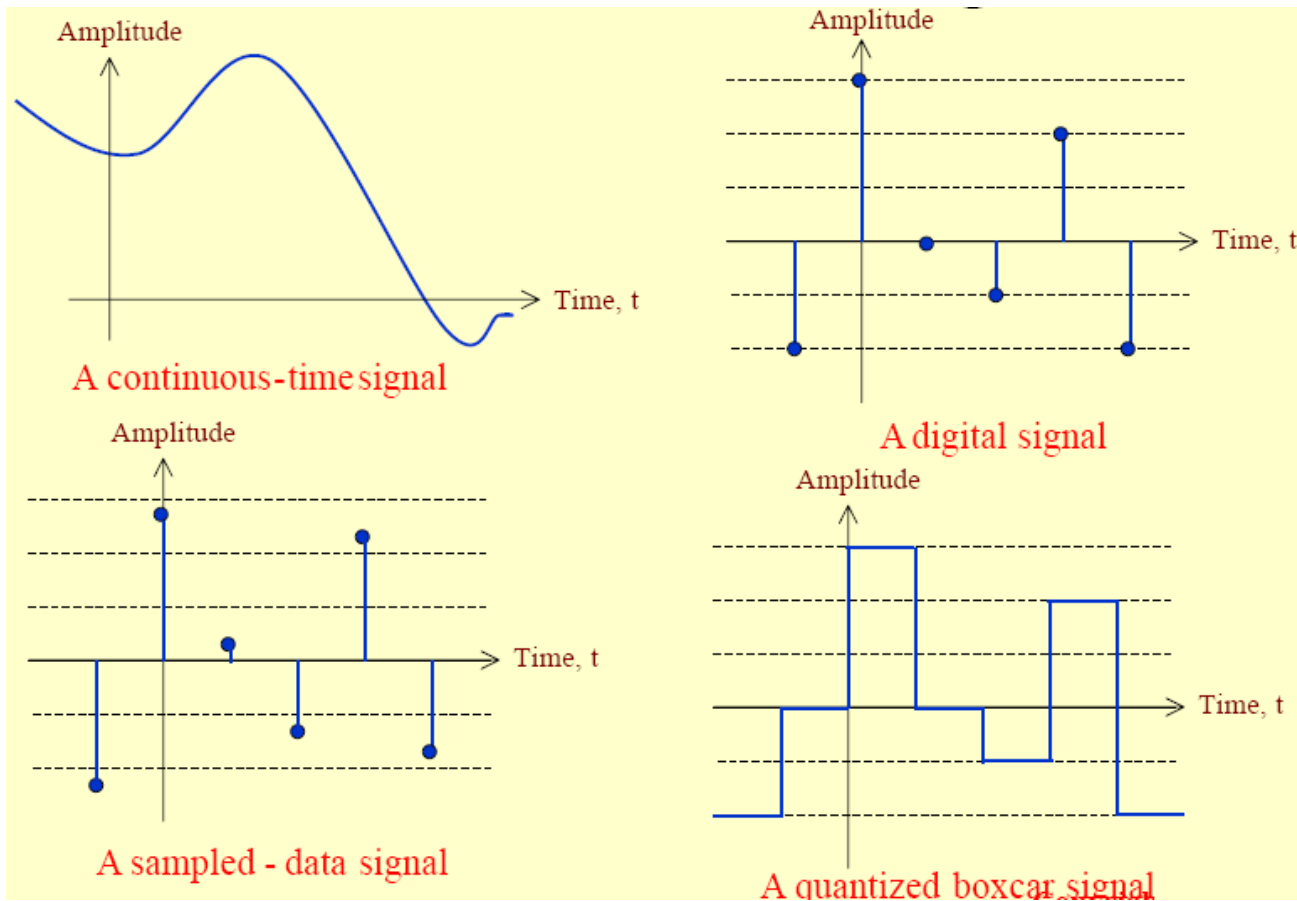
Classification of Signals

- A discrete-time signal with continuous-valued amplitudes is called a sampled-data signal

- A discrete-time signal with discrete-valued amplitudes represented by a finite number of digits is referred to as the digital signal

- A digital signal is thus a quantized sampled- data signal

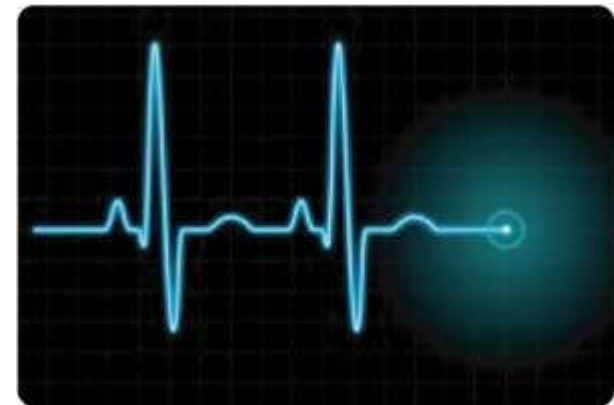- A continuous-time signal with discrete-value amplitudes is usually called a quantized boxcar signal

Examples of Typical Signals

- **Speech and music signals** – Represent air pressure as a function of time at a point in space

- Waveform of the speech signal "I like digital signal processing" is shown below
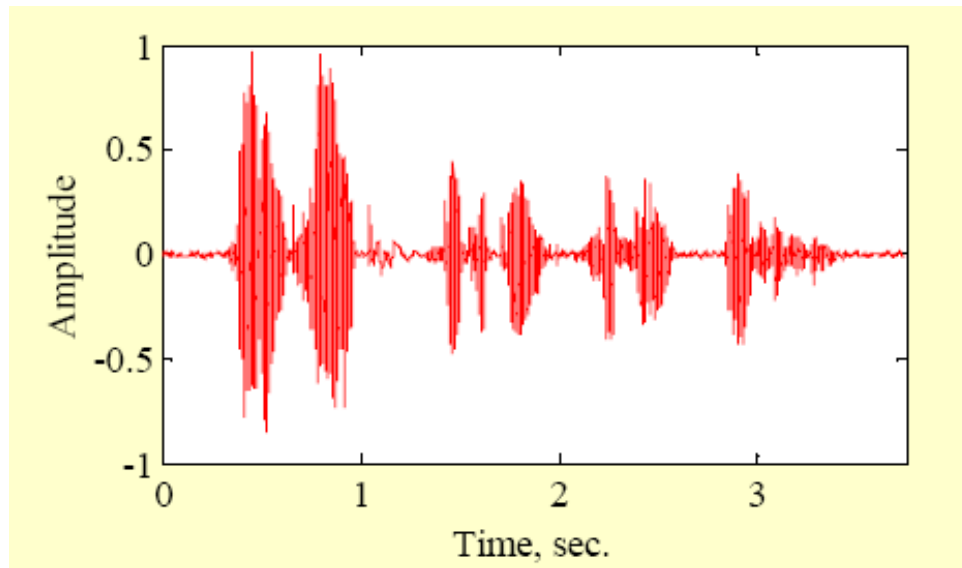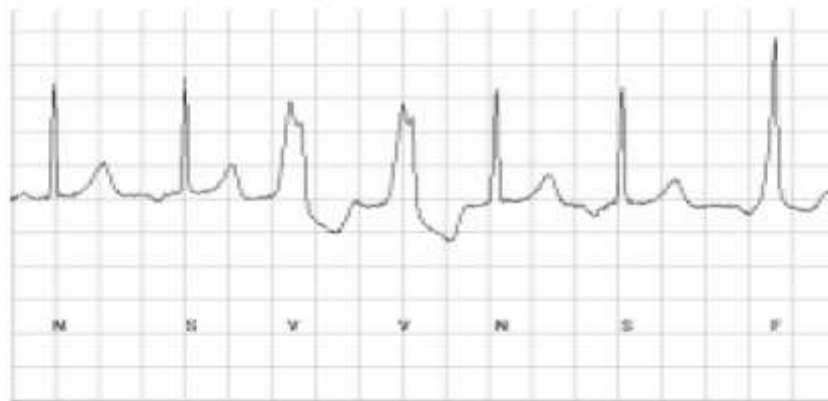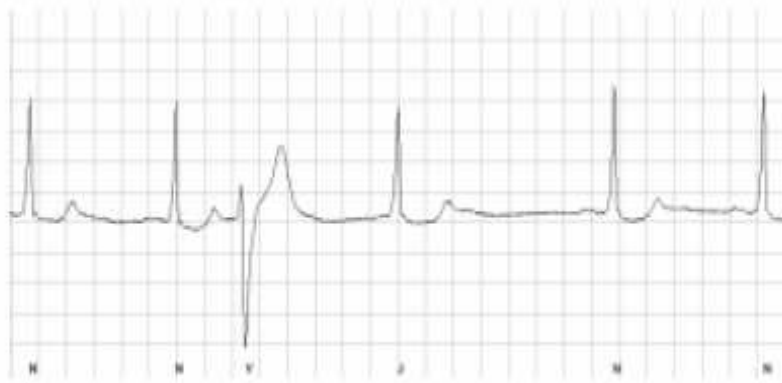
Examples of Typical Signals

- **Electrocardiogram Signal** – Represent the electrical activity of the heart

- One period of the waveform shown below represents one cycle of the blood transfer process from the heart to the arteries
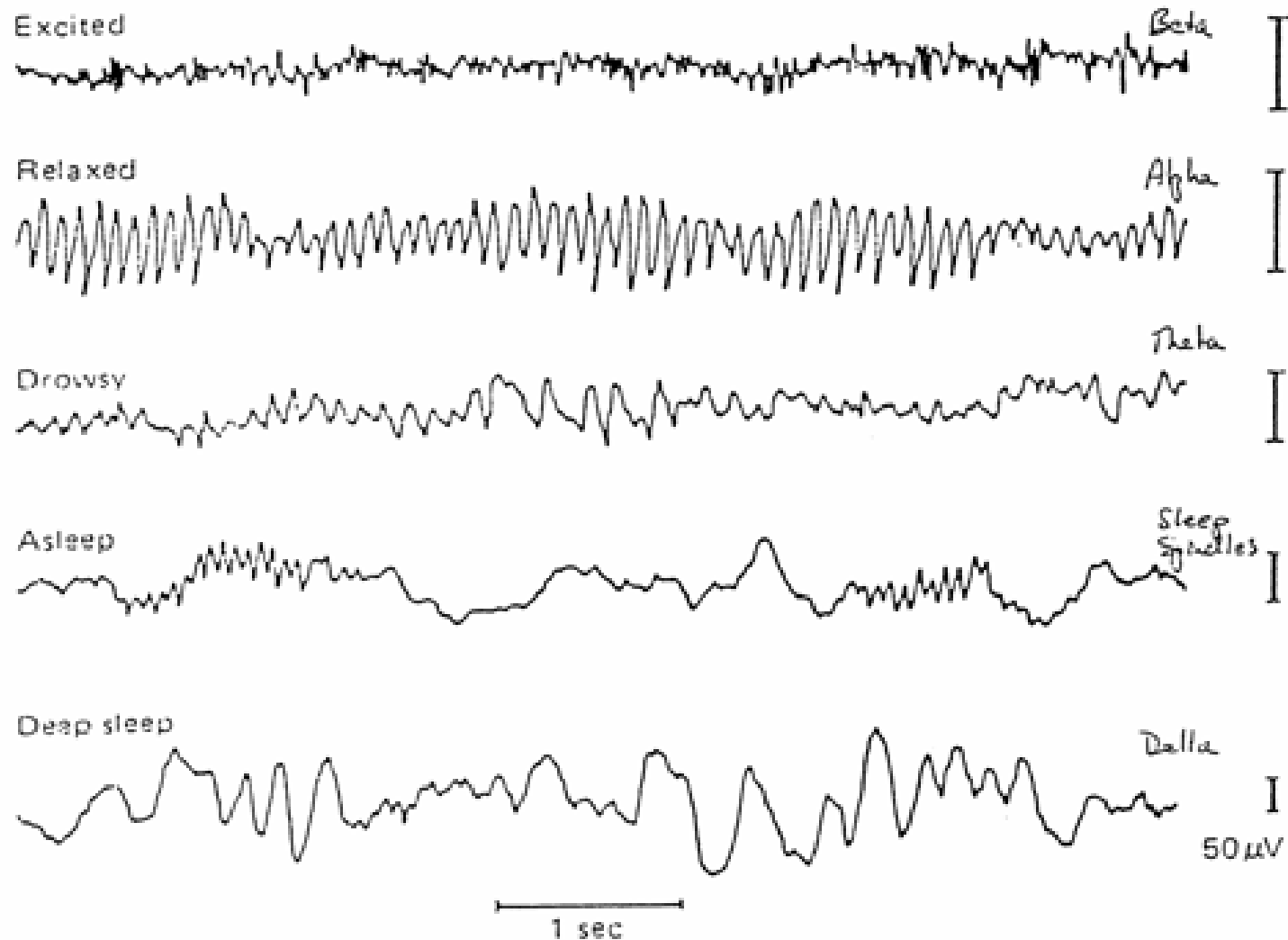
Cases of Abnormal Electrocardiogram

Electroencephalogram

Excited — Beta

Relaxed — Alpha

Drowsy — Theta

Asleep — Sleep Spindles

Deep sleep — Delta

50 μV

1 sec

http://neurodevelopmentcenter.com/index.php?id=39

脑电（EEG）的节律（即主要频率成分）：
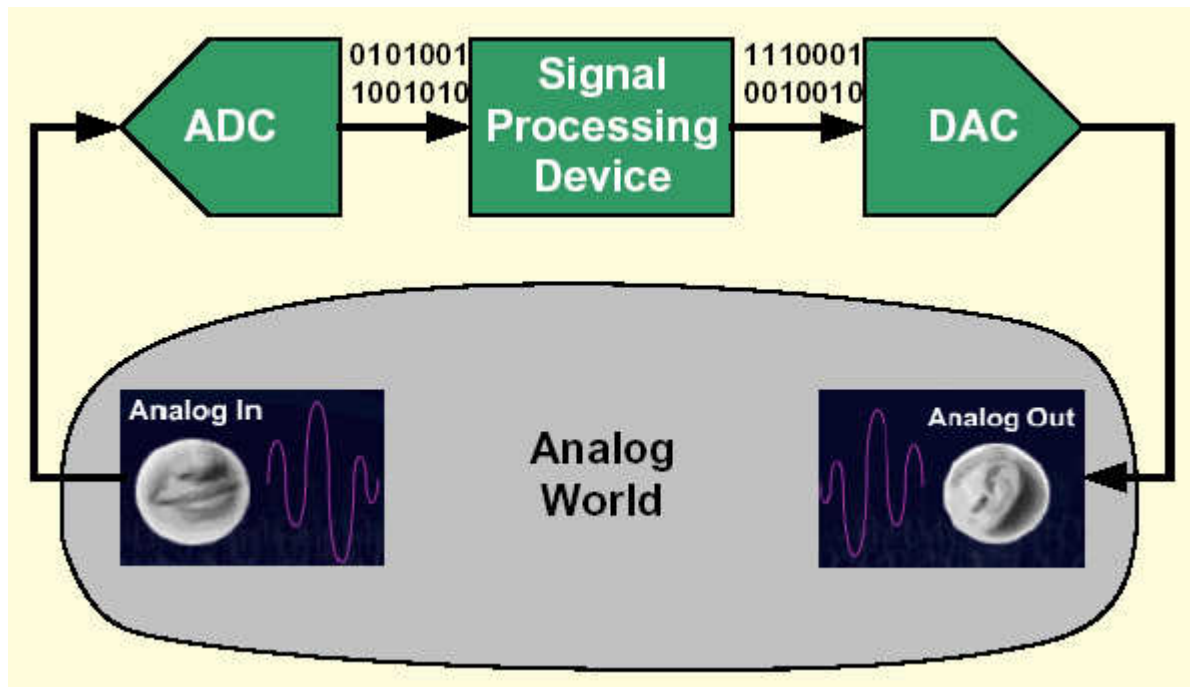
δ 节律：<4Hz 的成分； （深睡）
Deep Sleep

θ 节律：4Hz～8Hz 的成分； （浅睡）
Light Sleep

α 节律：8Hz～13Hz 的成分； （清醒）
Conscious

β 节律：>13Hz 的成分。（受刺激或思考
Thinking or Excited

General Digital Signal Processing System

Three stages of digital processing

- A/D conversion
  - The analog signal is digitized
  - It is *sampled* and each sample is quantized to a finite number of bits.
- The digitized samples are processed by a digital signal processor
- D/A conversion
  - The resulting output samples may be converted back into analog form by an analog reconstructor

Things that have DSPs

- Some typical and well-known items which contain one (or many) embedded DSPs:
  - the cell phones
  - fax machines
  - DVD players and other home audio equipment
  - your car (for example: the anti-lock braking system)
  - computer disk drives
  - satellites (they have a lot)
  - the "switch" at your local telephone company (more than a lot)
  - digital radios
  - high-resolution printers
  - digital cameras

THE END