What is DSP?
Lecture Outline

1) **Why learn DSP?**
2) **Applications of DSP**
3) **DSP Hardware**
4) **DSP Programming**
5) **DSP Course Outline**

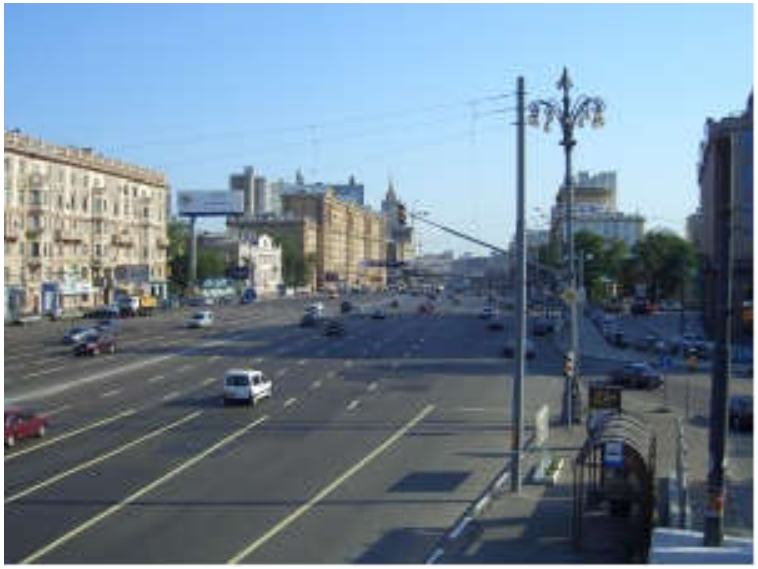
Why learn DSP?

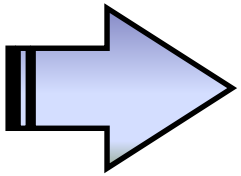
DSP – Digital Signal Processing

- ALL kinds of Sounds
- ALL kinds of Images
- ALL kinds of Videos
- Cardiograms
- X-Ray snapshots
- Seismic vibrations
- Financial trends
- Radar & Sonar signals
- Network traffic

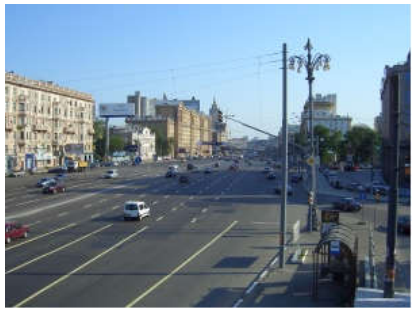
Why learn DSP?

Task example: resize the image (0.5x)





Simple decimation



Resizing with low-pass filtering

Applications of DSP

Military Applications

- ✓ Radar
- ✓ Sonar
- ✓ Secure communication

Medical Applications

- ✓ Diagnostic imaging
- ✓ Medical image storage

Space Applications

- ✓ Space photograph enhancement
- ✓ Data compression

Digital Signal Processing

Industrial Applications

- ✓ Oil and mineral prospecting
- ✓ Process monitoring and control

Scientific Applications

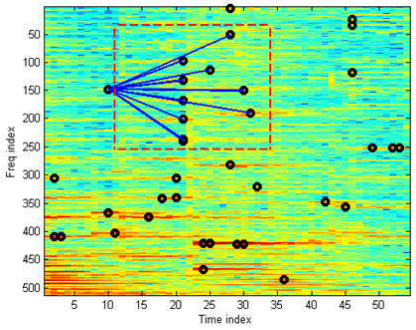
- ✓ Spectral analysis
- ✓ Simulation and modeling

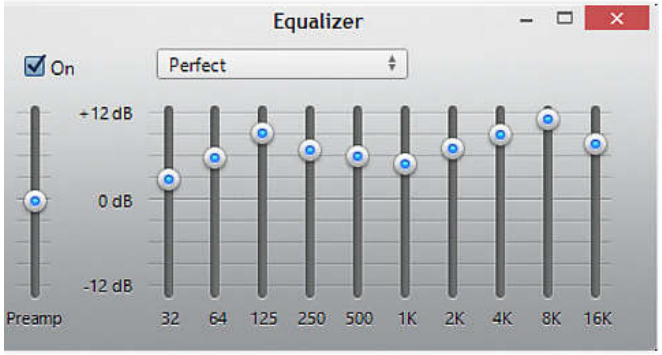
Commercial Applications

- ✓ Image and sound compression
- ✓ Movie effects
- ✓ Sound effects

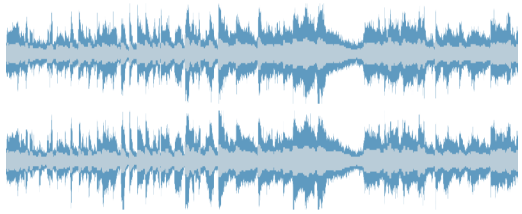
DSP in pictures

Digital fingerprints





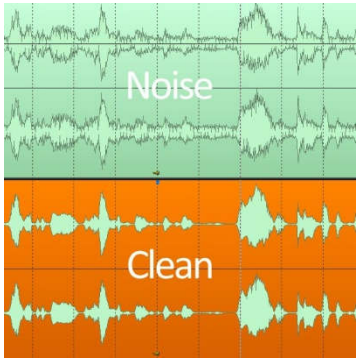
Signal



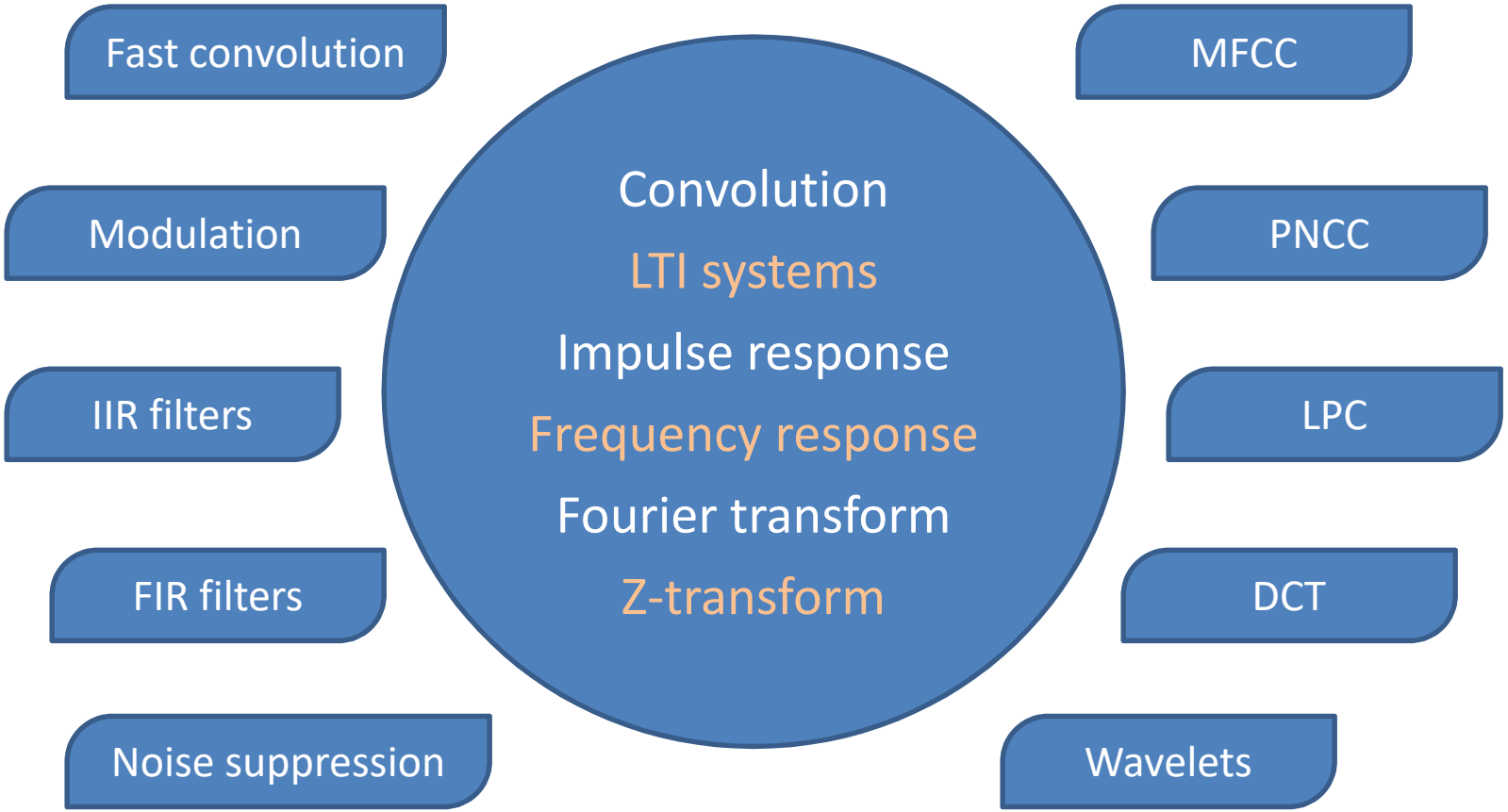
All kinds of filters

$$y[n] = 0.9x[n] + 0.2x[n-1] - x[n-3] - 0.5y[n-1] - 0.3y[n-3]$$

Digital compression



DSP in pictures



DSP Hardware

RISC DSP Microprocessors

- ❑ Fixed point vs. floating point
- ❑ lots of very fast cache memory contained within the chip;
- ❑ separate buses for the program and data, allowing the two to be accessed simultaneously (**Harvard Architecture**);
- ❑ fast hardware for math calculations contained directly in the microprocessor.

- ➢ Texas Instruments
- ➢ Freescale MSC81xx
- ➢ Analog Devices ADSP-21xx
- ➢ etc.

DSP Programming

Real-time DSP applications:

- C/C++/ SIMD (MMX/SSE) / CUDA
- DSP microprocessors

```
#define BUF_SIZE 40

const short sineTable[BUF_SIZE]= {
0x0000,0x01E0,0x03C0,0x05A0,0x0740,0x08C0,0x0A00,0x0B20,
0x0BE0,0x0C40,0x0C60,0x0C40,0x0BE0,0x0B20,0x0A00,0x08C0,
0x0740,0x05A0,0x03C0,0x01E0,0x0000,0xFE20,0xFC40,0xFA60,
0xF8C0,0xF740,0xF600,0xF4E0,0xF420,0xF3C0,0xF3A0,0xF3C0,
0xF420,0xF4E0,0xF600,0xF740,0xF8C0,0xFA60,0xFC40,0x0000};
short out16[BUF_SIZE]; /* 16 bits output sample buffer */
short out12[BUF_SIZE]; /* 12 bits output sample buffer */
short out8[BUF_SIZE]; /* 8 bits output sample buffer */
short out6[BUF_SIZE]; /* 6 bits output sample buffer */

void main()
{
    short i;
    for (i = 0; i < BUF_SIZE; i++)
    {
        out16[i] = sineTable[i];        /* 16-bit data */
        out12[i] = sineTable[i]&0xfff0; /* Mask off 4-bit */
        out8[i] = sineTable[i]&0xff00;  /* Mask off 8-bit */
        out6[i] = sineTable[i]&0xfc00;  /* Mask off 10-bit */
    }
}
```

Some optimization tips:

- ❑ Using Integers instead of Floating Point variables whenever possible.
- ❑ Replacing transcendental functions (sin, cos, log) with series of additions, subtractions and multiplications. For example, the McLaurin power series for sin(x):

$$\sin(x) = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \ldots$$

- ❑ Using Look-Up Tables (LUT) with pre-calculated values of functions (for instance, trigonometric tables).

DSP Tasks

Basically, all DSP techniques are designed to solve two key scientific and practical tasks:

1) **Signal Modification (processing one signal to obtain another signal).**
   This kind of problem occurs when there's a need to enhance a signal or to separate signals

2) **Signal Interpretation.**
   In this case the objective is to obtain the certain characterization of signal. For example, the objective of a speaker recognition system is to extract speaker-dependent features from speech signal and interpret them correctly

Artificial intelligence:

DSP + ML

Television, communication

Quite “hypey”
(real science, though)

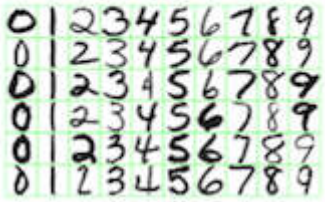
amazon

NETFLIX SOUNDCLOUD

Recommendation engines

Personal assistants: Google Now, Microsoft Cortana, Apple Siri, etc.

Optical character recognition



Filtering algorithms/ news feeds

DSP Course Outline

1) **Signals and Systems**
2) **Fourier Analysis**
3) **Basics of Filtering**
4) **Filter Design & Analysis**
5) **Sampling Rate Conversion**
6) **Speech Signal Processing**