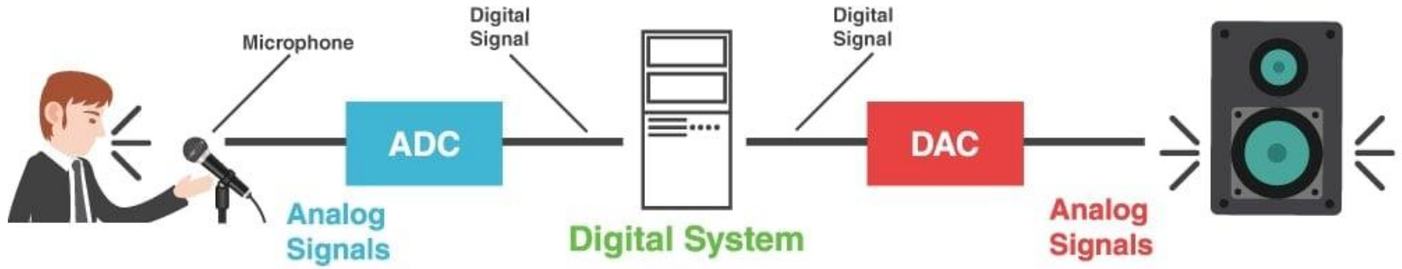
ĐẠI HỌC QUỐC GIA HÀ NỘI
TRƯỜNG QUỐC TẾ
VNU-INTERNATIONAL SCHOOL

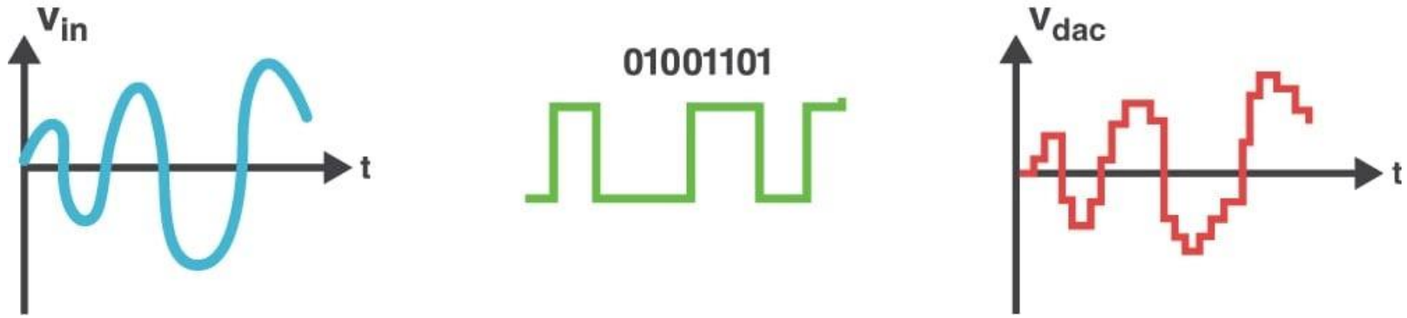
CHAPTER 5: ADVANCED DSP APPLICATION TOPICS

Dr. Dinh-Tan Pham

Audio signal processing

- Audio signal processing refers to the manipulation and analysis of sound signals using digital or analog methods.
- Applications: audio compression, enhancement, noise reduction, and sound synthesis.





Audio signal processing

Analog vs. Digital Processing

- ✓ Analog Processing: It's less flexible and more prone to noise and distortion than digital methods.
- ✓ Digital Processing: Converts audio signals into digital form (discrete-time, quantized samples), where they are processed using algorithms and mathematical operations. This method allows for greater precision, repeatability, and advanced techniques.

Audio signal processing

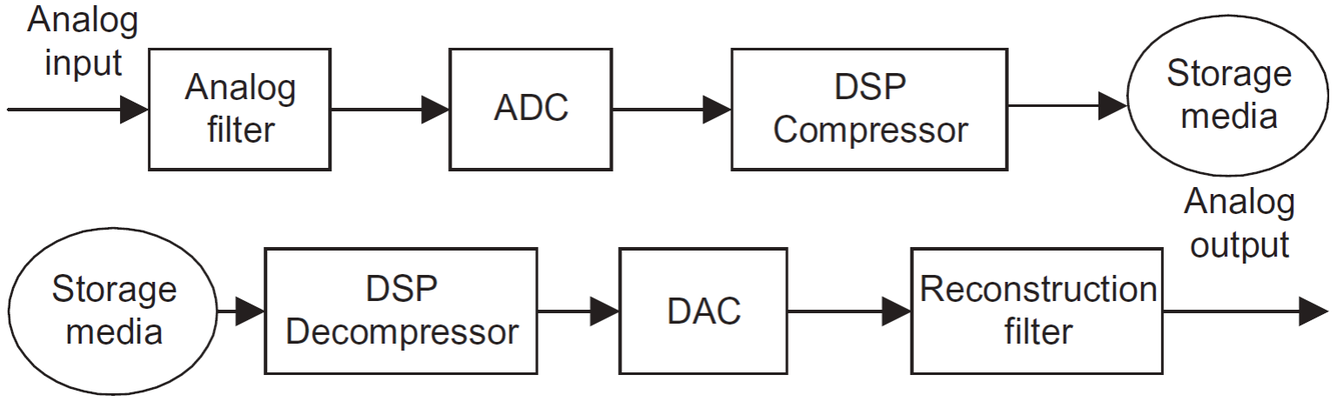
Sampling and Quantization

- ✓ Sampling: According to the Nyquist-Shannon sampling theorem, the sampling rate must be at least twice the highest frequency of the audio signal to avoid aliasing. Example: For human hearing (which ranges up to 20 kHz), the standard sampling rate is 44.1 kHz, used in CDs.
- ✓ Quantization: After sampling, each sample is quantized into a finite number of bits. Higher bit depths offer better dynamic range and less quantization noise.

Audio signal processing

Audio Compression

- ✓ Lossy Compression: Formats like MP3, AAC, and OGG reduce file size by discarding inaudible frequencies and other data, but they lose some fidelity.
- ✓ Lossless Compression: Formats like FLAC and ALAC preserve all audio information but provide smaller size reductions than lossy formats.



Audio signal processing

Speech Processing

- ✓ Speech Recognition: Converting spoken words into text (e.g., voice assistants).
- ✓ Speech Synthesis: Generating artificial speech from text (e.g., text-to-speech systems).
- ✓ Speech Coding: Reducing the bandwidth required for transmitting voice signals (e.g., in telecommunications and VoIP).

Audio signal processing

Noise Reduction

- ✓ Spectral Subtraction: Identifying and removing noise components from the frequency domain representation.
- ✓ Adaptive Filtering: Using an adaptive filter to subtract estimated noise from the signal.
- ✓ Noise Gates: Mute low-level background noise while allowing louder signals to pass.

Audio signal processing

Music Production

- ✓ Mixing: Combining multiple audio tracks to create a final stereo or surround sound mix.
- ✓ Mastering: The final step in music production, which involves adjusting the overall tonal balance, dynamics, and loudness for playback on various platforms.

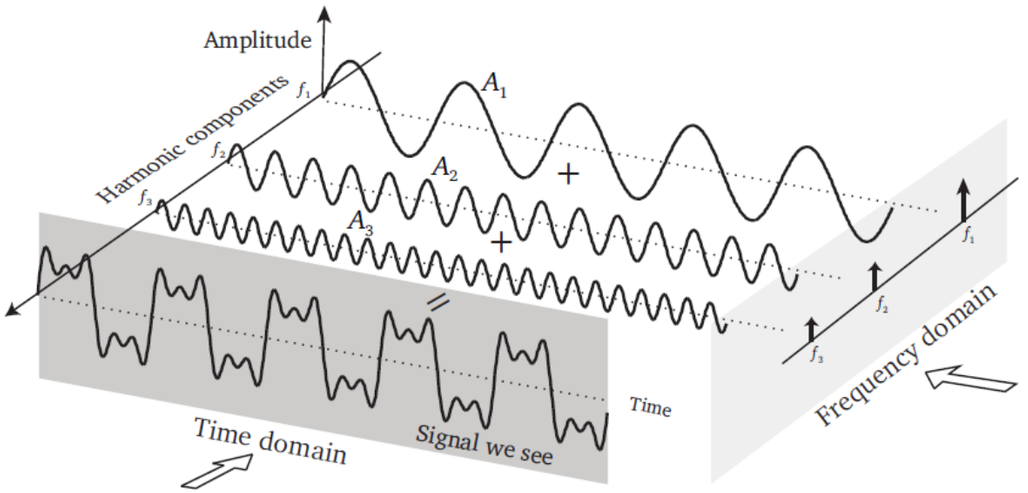
Audio signal processing

Hearing Aids

- ✓ Digital audio signal processing is used to enhance speech and reduce background noise for people with hearing impairments.
- ✓ Modern hearing aids employ techniques like adaptive filtering, compression, and frequency shifting to improve intelligibility.

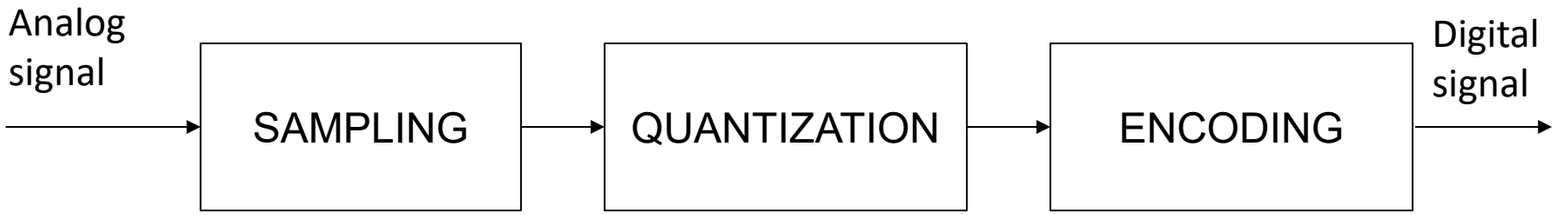
Audio signal processing

- Hearable range: from 20 Hz to 20 kHz
- Informative range: 300 Hz – 3,400 Hz
- Audio sampling rate for telephone line: 8,000 Hz



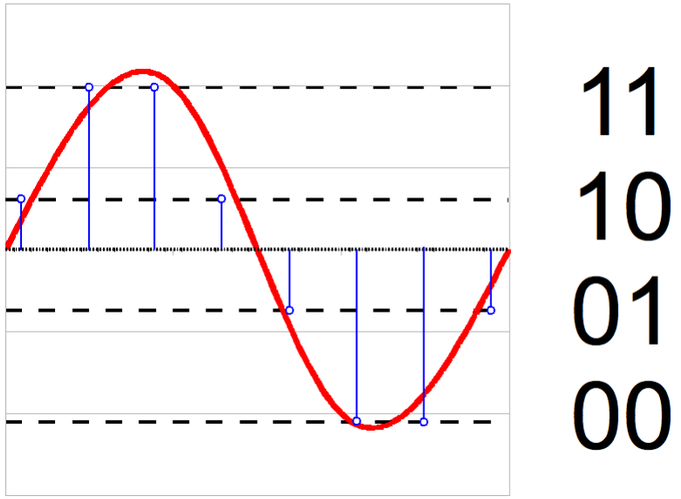
Audio signal processing

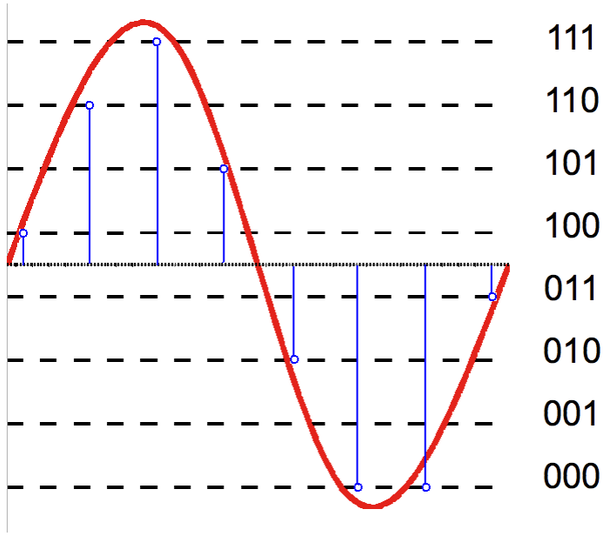
- ❖Pulse Code Modulation (PCM): 64 kbps
  - ✓Sampling: 8,000 Hz
  - ✓Quantization
  - ✓Encoding: 8 bits/sample
- ❖MP3: 128 kbps



Audio signal processing

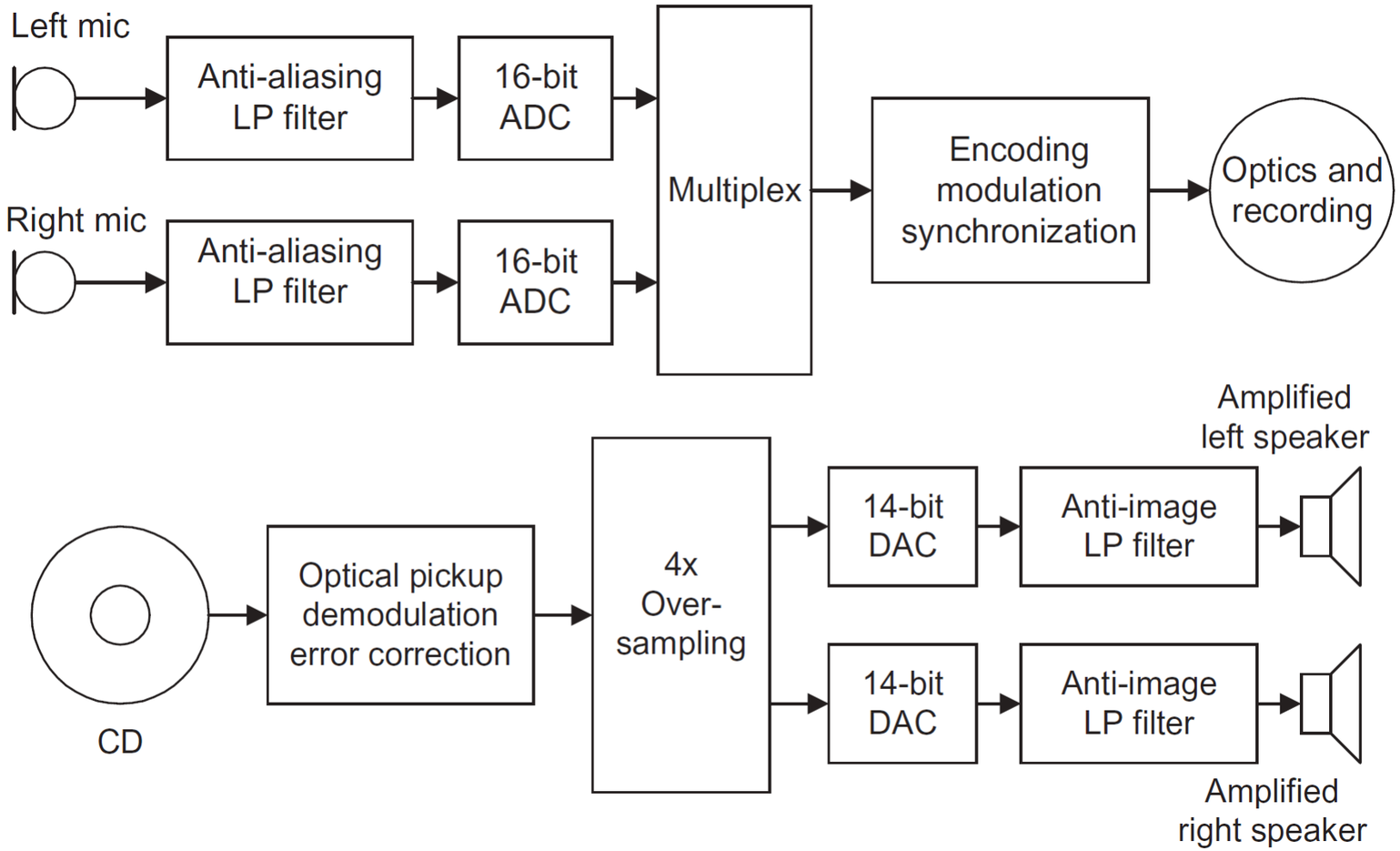
Quantization





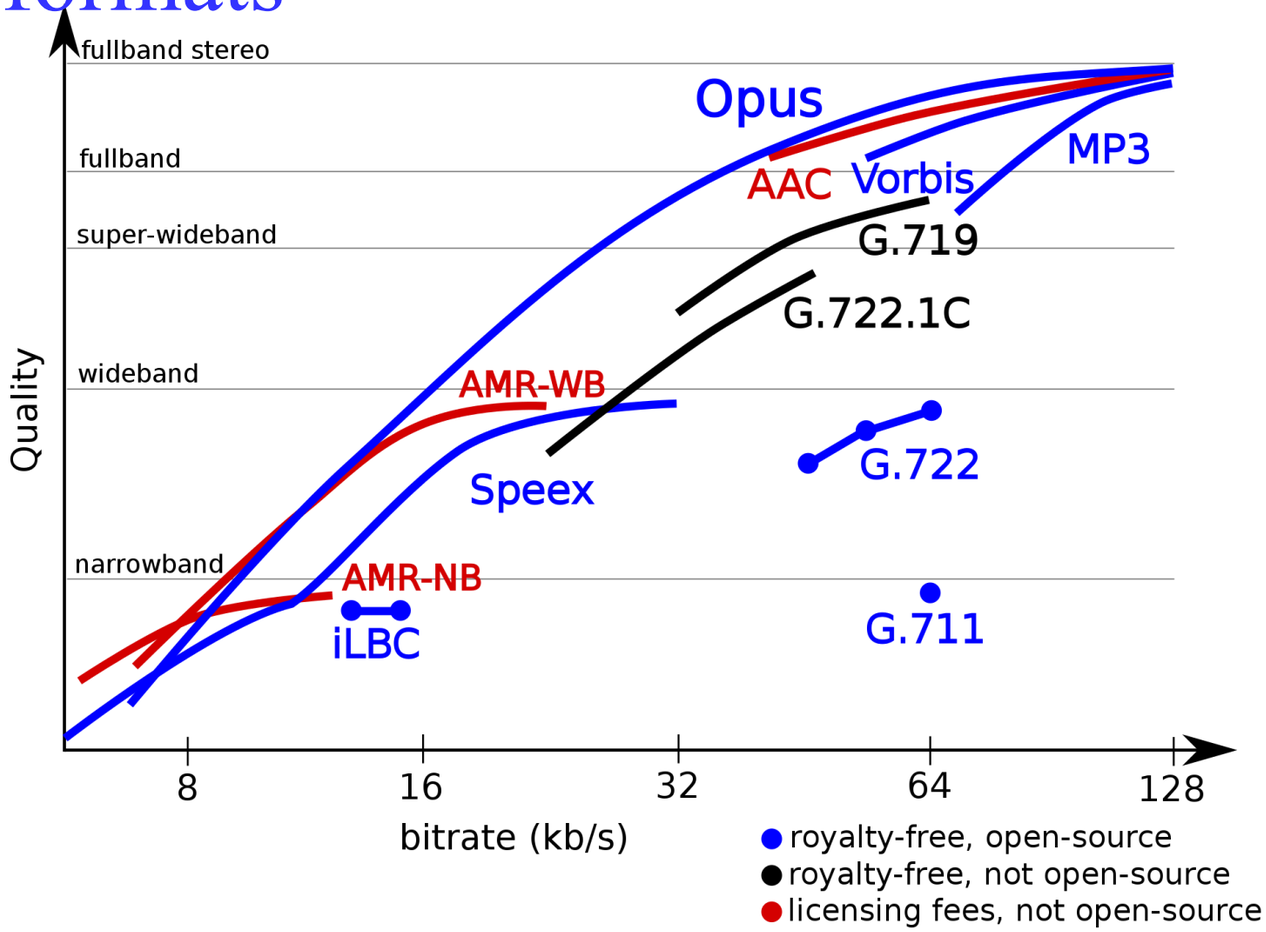
Audio signal processing

CD recording: 705.6 Kbps for mono, 1.411 Mbps for stereo



Audio signal processing

Audio coding formats



Biomedical signal processing

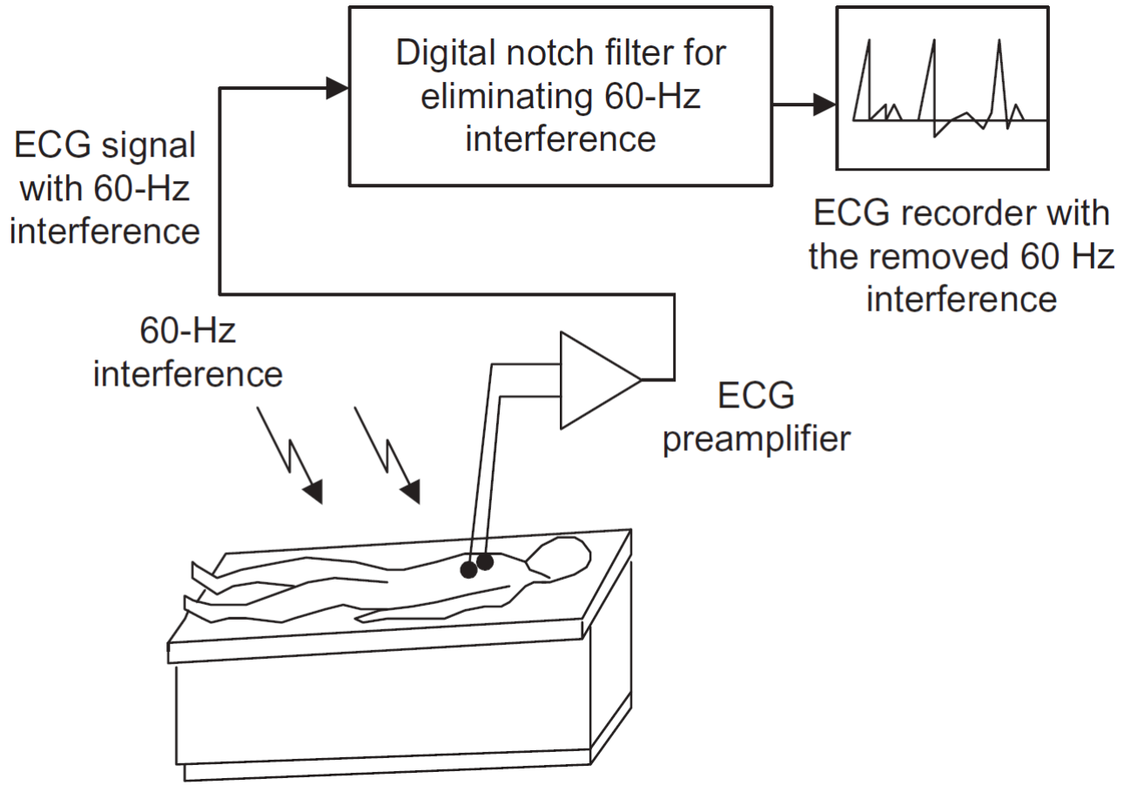
- Biomedical signal processing refers to the analysis of biological signals using computational techniques to extract meaningful information.
- These signals originate from various physiological processes in the body and are often used in medical diagnostics and therapeutic monitoring.

Biomedical signal processing

- Electrocardiogram (ECG): Measures the electrical activity of the heart.
- Electroencephalogram (EEG): Records brain activity.
- Electromyogram (EMG): Monitors muscle electrical activity.
- Electrooculogram (EOG): Tracks eye movements.
- Photoplethysmogram (PPG): Detects blood volume changes in tissues.

Biomedical signal processing

Noise reduction: Biomedical signals are often noisy due to interference from the environment or movement artifacts, so filtering techniques are used to isolate relevant information.



Biomedical signal processing

Feature extraction: Identifying specific patterns, such as heart rate from an ECG or seizure events from an EEG.

Classification: Machine learning and pattern recognition techniques are applied to classify signals into different categories (e.g., normal vs. abnormal heart rhythms).

Biomedical signal processing

Data compression: Large volumes of biomedical data are collected over time, necessitating techniques to compress the data for storage or transmission without losing vital information.

Automation of diagnosis: Development of automated systems to assist clinicians by analyzing signals and suggesting potential diagnoses.

Digital image processing

- Image Acquisition: Capturing or importing the image through cameras, scanners, or sensors.
- Preprocessing: Preparing the image for further analysis by reducing noise, adjusting brightness/contrast, and correcting any distortions (e.g., lens distortion).
- Segmentation: Dividing an image into regions or objects of interest (e.g., identifying tumors in medical images).

Digital image processing

- Feature Extraction: Identifying important features like edges, textures, or shapes for further analysis.
- Enhancement: Improving image quality by sharpening, denoising, or enhancing contrast to make features more prominent.
- Restoration: Recovering an image degraded by blurring or noise, often using techniques like deblurring or denoising algorithms.

Digital image processing

- Compression: Reducing the size of the image file while retaining important information, essential for storage or transmission, especially in high-resolution imaging.
- Object Recognition: Identifying objects or patterns in the image using machine learning or pattern recognition algorithms.

Digital image processing

- Filtering
- Histogram Equalization
- Edge Detection
- Morphological Operations
- Image Segmentation
- Transformations

Original image

Enhanced image

Digital image processing

- Medical Imaging
- Remote Sensing
- Robotics
- Facial Recognition
- Autonomous Vehicles
- Augmented Reality

Computer vision with OpenCV and MediaPipe

Youtube link:

✓ https://www.youtube.com/watch?v=pG4sUNDOZFg

Github link:

✓ https://github.com/nicknochnack/Full-Body-Estimation-using-Media-Pipe-Holistic

Remark:

✓ FACE_CONNECTIONS → FACEMESH_TESSELATION

✓ mp_drawing.draw_landmarks??→ mp_drawing.draw_landmarks