EXERCISE 1

Multimedia Databases (Exercises)

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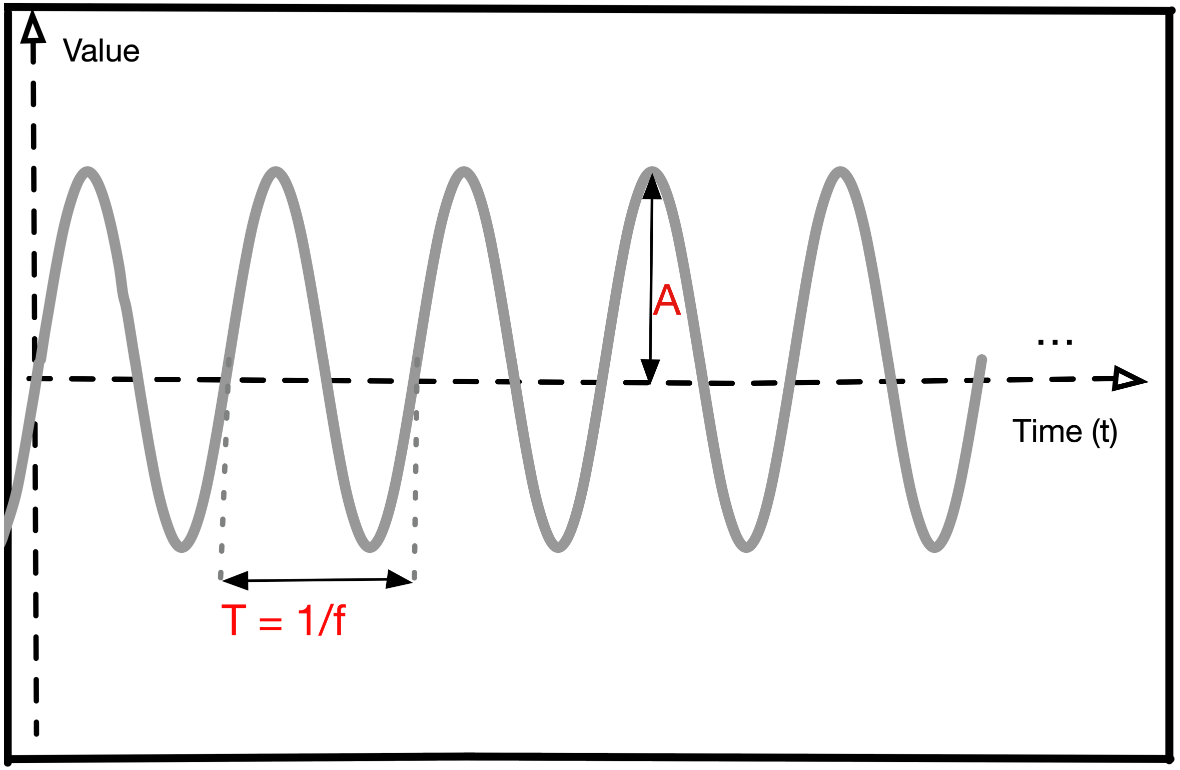
1: Representing an Analog Signal



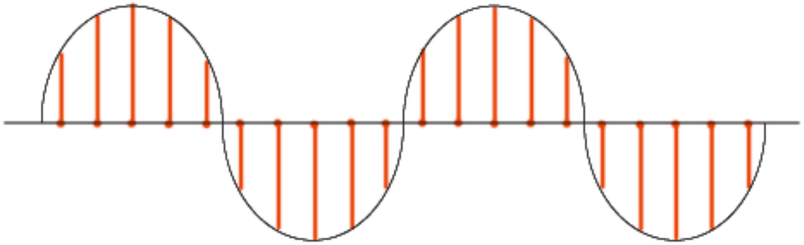
A is the amplitude of the sine curve (the peak deviation of the function from zero.)

T is the period of the sine curve (length of one cycle of the curve).

f is the frequency (number of cycles per second)

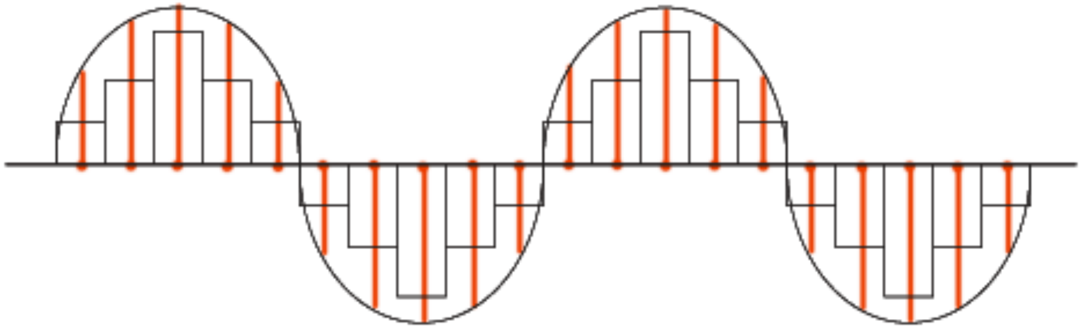
1: PCM Sampling

- With sampling, a fixed grid of measuring points of equal distance Δt is defined on the axis over which the analog signal changes. The current value(s) of the signal at the measuring points of this grid is called a sample.
  - The density of the measured values is called sampling rate.
  - The fixed grid can be points in time (example audio signal) or spatial dimensions (example pixels).
  - The sampling rate specifies how accurately the original signal can be reconstructed.



1: PCM Quantization

- The quantization corresponds to the conversion of the measured values obtained during discretization to a discrete, countable value range (usually in the binary system).
  - Resolution: bits per sample (bit resolution)
  - The accuracy depends on the number of bits per measured value



Quantization Error

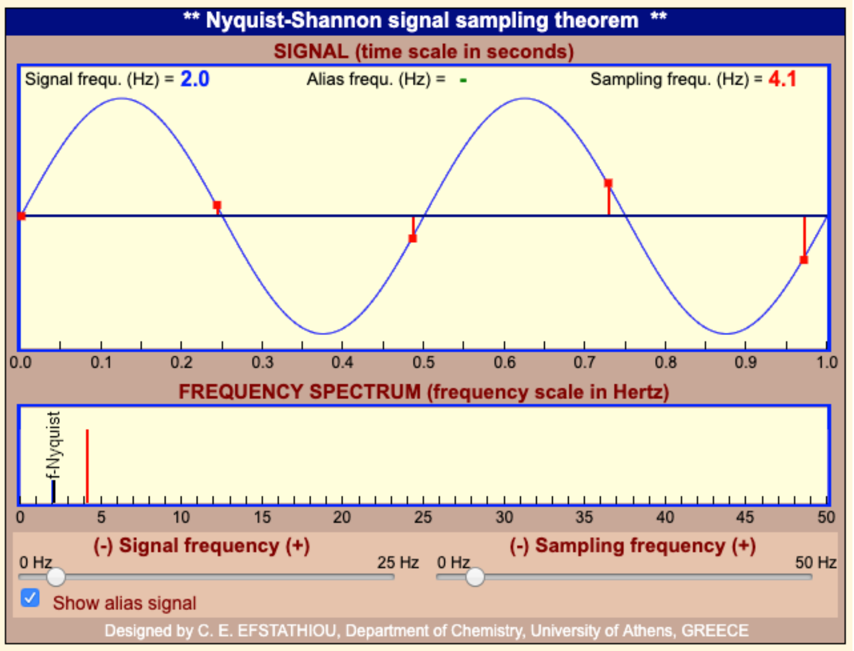
- Maximum Quantization Error $Q = \frac{\Delta x}{2^{N+1}}$
  Δx is the range of the signal, N is the number of bits
- The range of our signal Δx = 10 - (-10) V = 20 V

Therefore,

$$Q = 20/2^{5+1} = 20/64 = 0.3125 \text{ V}$$

1: Nyquist-Shannon Sampling Theorem.

If a function (signal) with the highest occurring frequency f_g is sampled at a sampling rate f_S, so that $f_S > 2 * f_g$, then this function can be reconstructed from the sampled values without losing the underlying information.
Developed by Harry Nyquist (1928) and proved by Claude Shannon.



Applet: http://195.134.76.37/applets/AppletNyquist/Appl_Nyquist2.html

1: Nyquist-Shannon Sampling Theorem.

- Given,

$$f(x) = \sin(0.7\pi x) + \sin(\pi x) + \sin(3\pi x)$$

- We must first determine the individual frequency components

$$f(x) = \sin(2\pi f_1 x) + \sin(2\pi f_2 x) + \sin(2\pi f_3 x)$$

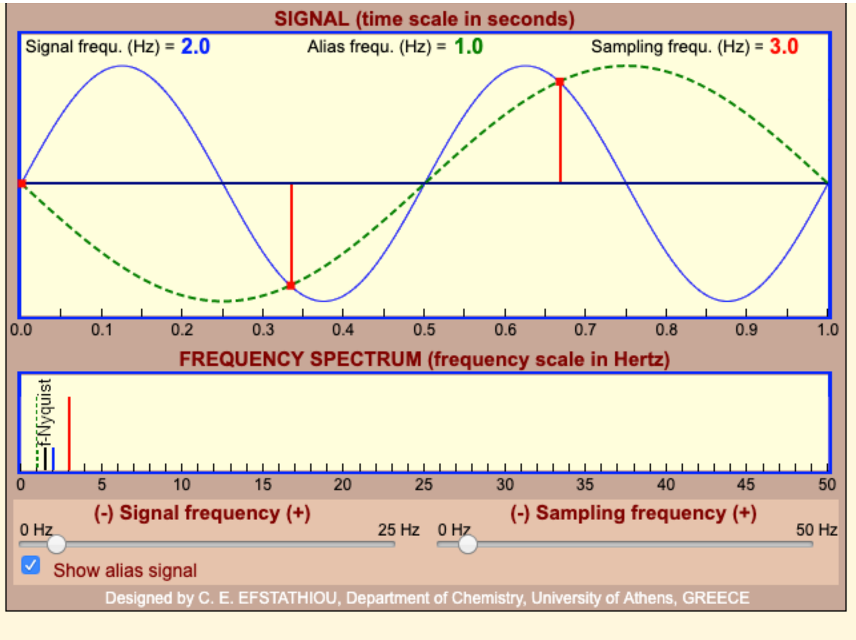
- Therefore,

$f_1 = 0.35$ Hz, $f_2 = 0.5$ Hz, $f_3 = 1.5$ Hz (f_3 is the highest frequency component)

- Thus, the minimum sample rate $f_s > 2 \cdot f_3$ => $f_s > 3$ Hz

1: Aliasing

Aliasing arises when a signal is discretely sampled at a rate that is insufficient to capture the changes in the signal.



Aliasing due to a low sampling rate (less than twice the highest frequency component)

2: Structured and Unstructured Data

Structured	Unstructured	Semi-Structured
• Predefined schema • Referred to as quantitative data.	• It has no pre-defined model. • Collecting, processing, and analyzing unstructured data represents a significant challenge.	• Does not obey the formal structure of data models associated with relational databases or other forms of data tables. • Contain tags or other markers to separate semantic elements and enforce hierarchies of records and fields within the data.
Data that fits within fixed fields and columns in relational databases. Names, addresses, location etc.	Text, video, audio	XML, JSON

2: Structured and Unstructured Data

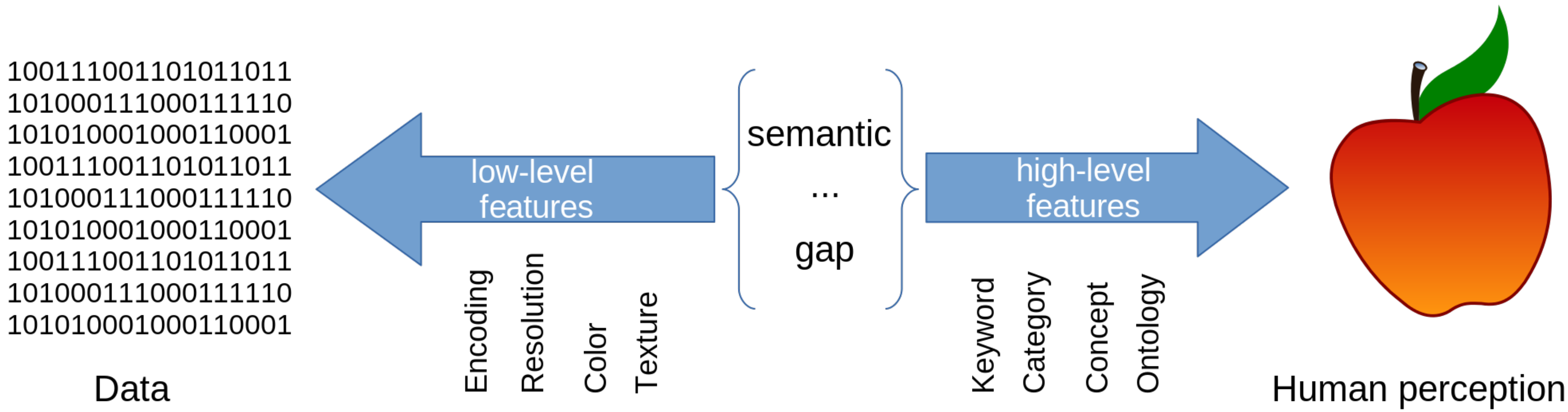
Structured	Unstructured	Semi-Structured
Can be implemented/stored in a relational DB	• Can't reside in a traditional row-column DB	• Can't reside in a traditional row-column DB
• Standard SQL querying • Hits exact matching	Metadata is needed. Structured? • Y ⇒ exact matching (e.g. videos by an author) • N ⇒ Information Retrieval methods • Fuzzy matching e.g. Similarity-based comparison	Typically requires either a structured query such as XPath, or a keyword query that does not take structure into account.

3: Semantic gap

3: Low-level and High-Level Features

- Low-level features:
  - Examples: Color histogram, pixel intensity, pixel gradient etc.
  - Easy to extract, directly from data
  - No semantics
- High-level features:
  - Examples: Winter sports, Person Skiing, snow, mountain
  - More semantics
  - More difficult to extract

3: Bridging Semantic Gap



4: MMDB vs Classical Databases

Based on: https://link.springer.com/content/pdf/10.1007/978-0-387-35561-0_13.pdf

- Data model: Contains unstructured data, no fixed model. Must manage both unstructured and structured metadata.
- Data Volume: MM databases often have huge volumes of data.
- Indexing:
  - Metadata can be multi-dimensional (e.g. color histogram) → classical indexing can not be adopted
  - Keywords(metadata) are by far the predominant method used for indexing multimedia data
  - Automated indexing uses features such as color, shape, texture, spatial information for images. Note, tone, duration for music data.

4: MMBD vs Classical Databases

- Querying and information retrieval:
  - Retrieval algorithms must support content and context-based retrieval
  - Should offer support for spatial and temporal queries
  - Querying by examples
  - Flexible querying using fuzzy predicates.