Definition of a Signal

Definition: A signal is a function.

*Recall that a function $x(t)$ represents the variation of a quantity x, called the **dependent variable**, with respect to one or more **independent variables**, t.*

Recall that a function is defined as $\boxed{f : A \rightarrow B}$*, where:*

- *A represents the **domain** of the function f, which is the set from which the independent variable t takes its values.*
  - *The domain usually represents **time** and sometimes **space**.*
- *B represents the **codomain** of the function f, which is the set from which the dependent variable x takes its values.*
  - *The codomain may represent, e.g., voltage, current, etc.*

Remarks:

*The domain A can be either a **discrete** or **continuous** set.*

- *$\Rightarrow$ A signal can be classified as either a discrete-time signal or a continuous-time signal.*

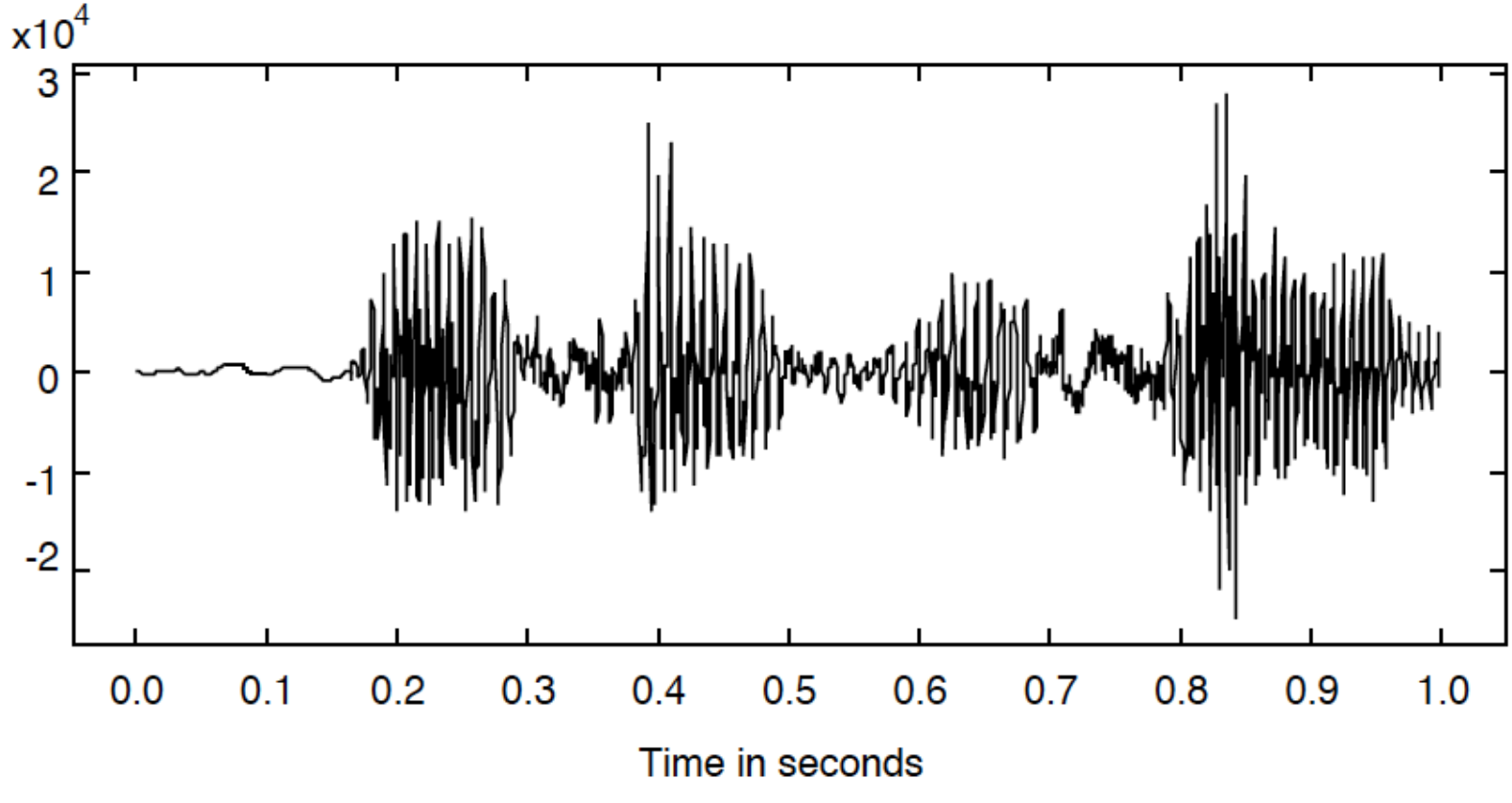
The codomain B can be either a discrete or continuous set.

- *$\Rightarrow$ A signal can be classified as either a discrete-valued signal or a continuous-valued signal.*

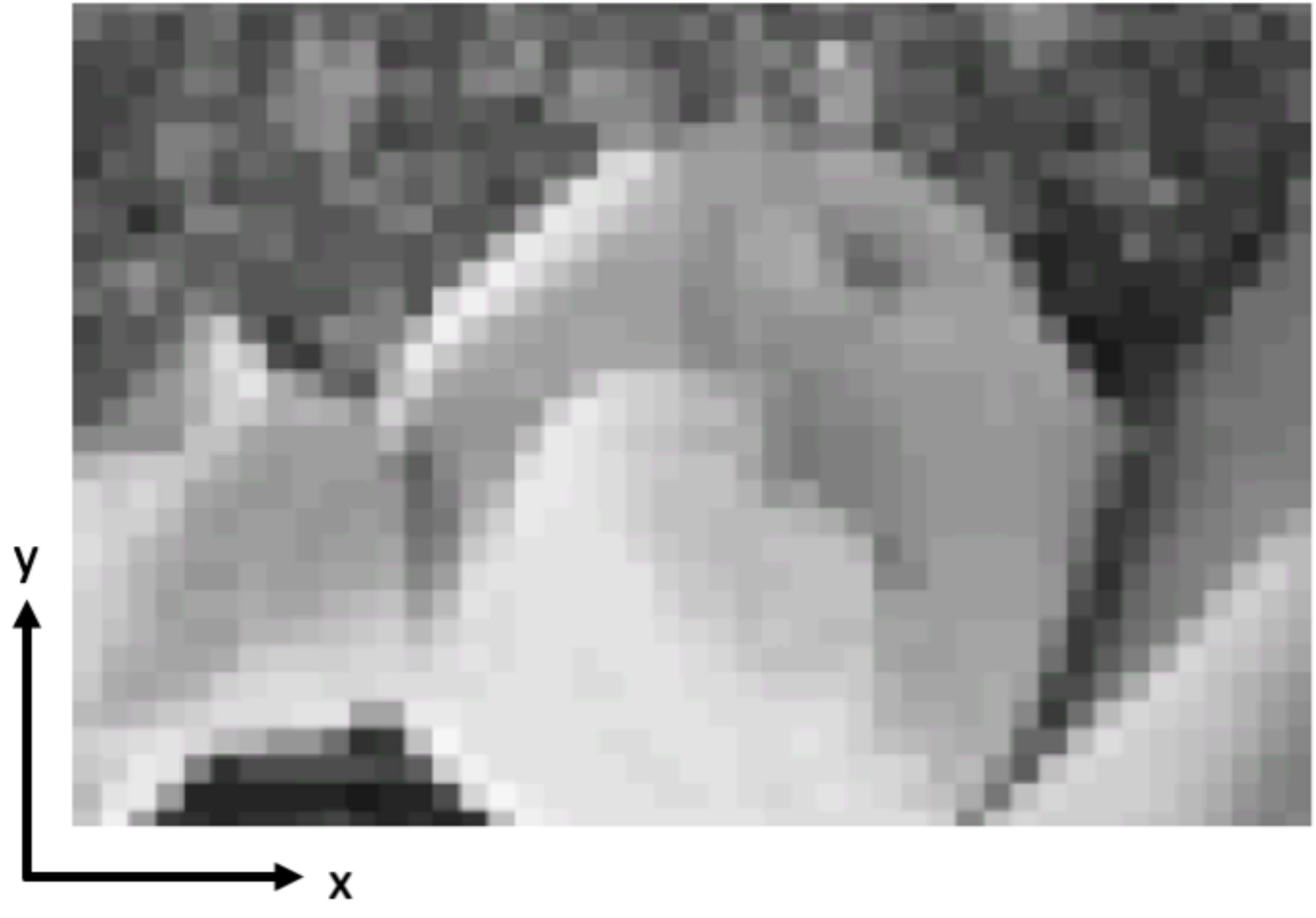
*The domain A or codomain B can be either a **one-dimensional** or a **multi-dimensional** set.*

Examples of Signals

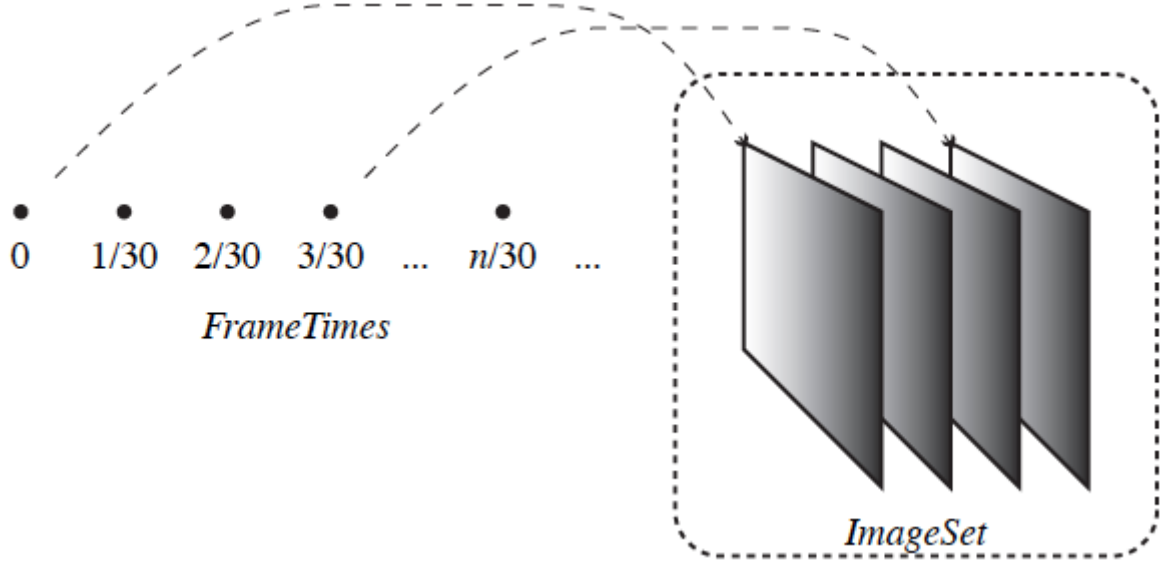
Audio Signals: e.g., speech and music signals have the form $\boxed{x = f(t)}$.



Images: e.g., (gray-scale) images are of the form $\boxed{z = g(x, y)}$.

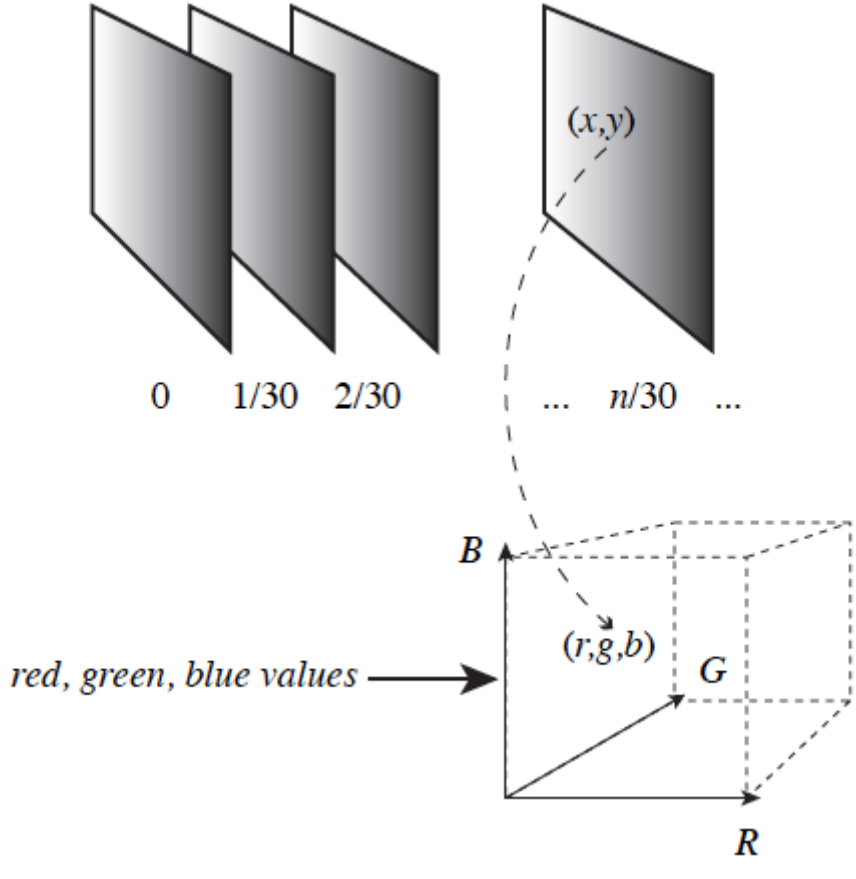


Video Signals: e.g., a black-and-white video signal can be thought of to be a function of both space and time, i.e., $\boxed{v = f(x, y, t)}$.



Video Signals: e.g., a color video signal can be thought of to be a vector of functions of space and time, i.e.,

$$(r, g, b) = \mathbf{f}(x, y, t) = [f_1(x, y, t), f_2(x, y, t), f_3(x, y, t)].$$

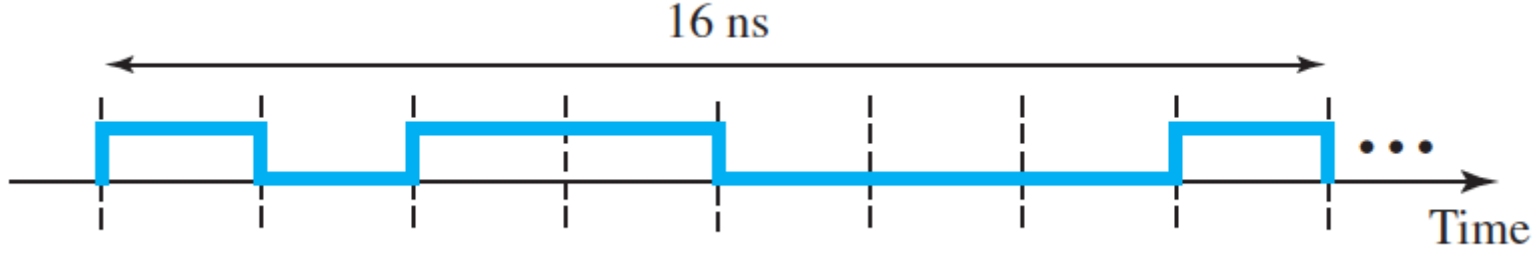


Weather Forecast: **e.g., temperature, humidity, and the speed and direction of the wind.**

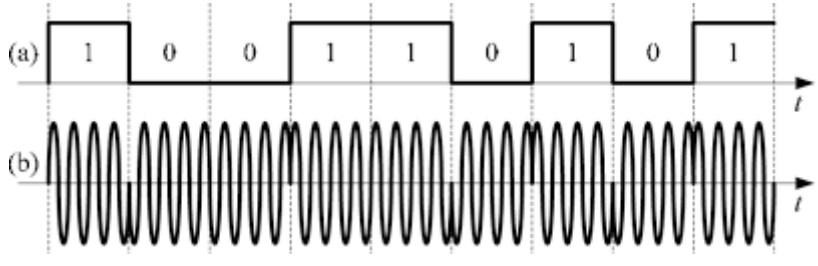
- These quantities are measured by using appropriate sensors.

Computer Data: **transmitted as a sequence of pulses.**

- For example, using binary pulses with 0V for '0' and +5V for '1'.

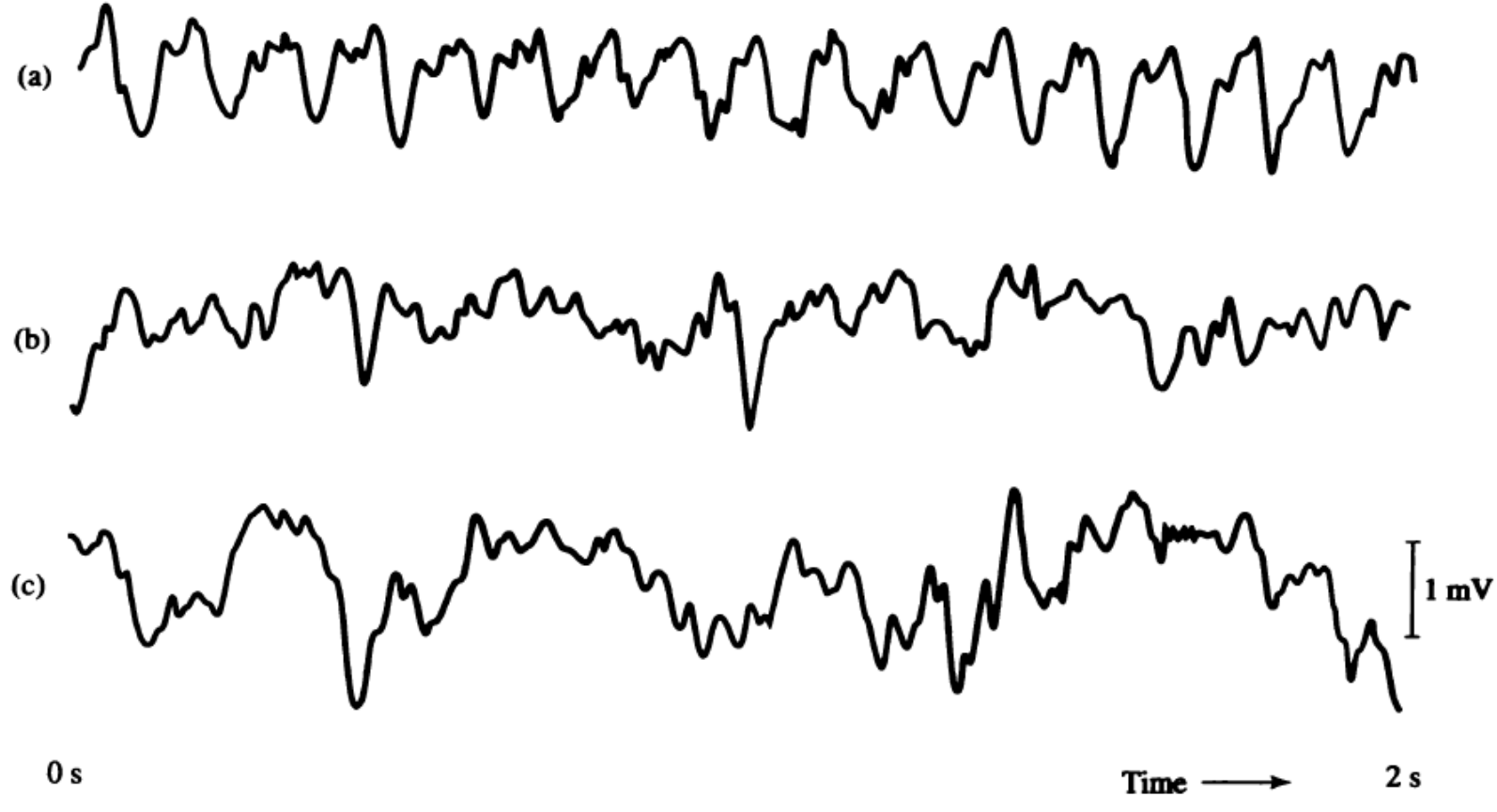


Communication: signals are modulated.



- Modulation makes a low-frequency signal suitable for transmission in a high frequency band, e.g., RF or optical.

Biomedical Signals: e.g., EEG/ECG Signals.



Financial: e.g., stock prices and exchange rates.

References:

[1] Simon Haykin and Barry Van Veen, Signals and Systems, Second Edition, John Wiley and Sons, 2003.

[2] Lecture Notes by Richard Baraniuk.
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