Contents

Chapter 1

INTRODUCTION

1.1 Introduction

Discrete-Time Signal Processing

Almost every signal is being digitized these days, for example: [1]

- digital TV
- LP $\longrightarrow$ CD $\longrightarrow$ DAT
- digital mobile phone(CDMA, GSM)
- video tape $\longrightarrow$ DVD

Signals: [2] Input, output, and internal functions that systems *process* or produce($\ni$: voltage, current etc.)

Example 1.1 *Usage of signals*

(a) Communications:

(i) Human to Human (voice, gesture, facial expression, hands ...)

(ii) Machine to Machine (audio, video, data ...)

(iii) Human to Machine (switch, remocon, OMR card[3], keyboard $\Longrightarrow$ desirably human language $\ni$: speech)

[1] LP(Long Playing), CD(Compact Disc), DAT(Digital Audio Tape), DVD(Digital Video Disc)

[2] **Systems:** Devices, processes, or algorithms which produce an output signal $y(t)$ given an input signal $x(t)$

[3] optical mark reader

(b) Control:

(i) remote control of consumer electronics (infrared)

(ii) factory/home/office automation (speech, image ...)

(iii) robot control (hand via joystick, speech)

(iv) car navigation (GPS via satellite)

(c) Scientific Probe:

(i) seismic signal processing (location of epicenter)

(ii) biomedical engineering (ECG, brainwave, medical images ∋: CT, MRI, PET...)

(iii) non-destructive inpection (microwave, ultrasonic wave...)

Signal Processing:
Representation, transformation, and manipulation of signal itself, or the information it contains.

OBJECTIVE:(two-fold)

1. Fast and accurate exchange of signals (or its informations) b/w systems. (e.g. communication)
2. Exact extraction of desired information from a signal. (e.g. speech recognition)

Example 1.2 *Information Extraction*

(a) ASCII code: 1000001(signal) $\longrightarrow$ A (alphabet: information)

(b) Speech recognition: electrical wave(signal) $\longrightarrow$ meaning (information)

Example 1.3 *Practical Applications*

(a) Military systems: Radar and sonar

(b) Broadcasting systems: AM/FM radio and TV stations, satellite

(c) (Data) communications: Internet(character, JPEG & MPEG images, audio), mobile phone

(d) Entertainment(consumer) electronics: Hi-Fi stereo, CD/DVD player, HDTV

(e) Toy industry: speaking doll(speech synthesis)

(f) Automobile electronics: EFI, navigation system via GPS

(g) Medical instruments: CT, MRI, ultrasonic

Evolution of Signal Processing:

Figure 1.1: How DPS has evolved.

Technological development: analog($\sim$ '60) $\longrightarrow$ digital('70$\sim$)

Hardware:

- microprocessor and digital computer (speed)
- micro-electronics technology $\ni$: IC, VLSI (size, cost)

Software:

- algorithms especially FFT by Cooley & Tucky:1965 (speed, efficiency)

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on-going day to day evolution

$\Downarrow$

Future???

("up to you bright engineering students!!!")

Typical DSP system:
Since most of the signals we deal with are continuous in nature, we have to convert them into discrete forms before we do any processing, e.g. digital TV, CD etc.

Figure 1.2: Block diagram of typical DPS system.

† $x(t), y(t)$: continuous-time (analog) signals

‡ $x[n], y[n]$: discrete-time (digital) signals

(cf.)
In rigorous sense, discrete-time signals and digital signals are different, but we usually use them interchangeably!!!

$$\text{Discrete-time signals} \xrightarrow[(error)]{\text{quantization}} \text{Digital signals}$$

Note:
We could campare DSP of signals to the food processing of our daily meals: first we get fresh vegetables or raw meats from the farm or supermarket(*analog signals*) $\longrightarrow$ we prepare them into suitable sizes by chopping them(*C/D or digitize*) $\longrightarrow$ then we cook them via either boiling, frying, or baking(*processing*) $\longrightarrow$ we put them in a container such as dish or can(D/C) $\longrightarrow$ and finally we serve them as our meal(*analog signals*).

Remark: DSP is not confined to 1-dimensional processing, and we can extend the concept and theory to multi-dimensional signal processing, e.g. image processing is in two dimensional.

$I(x, y)$: still image
$I(x, y, t)$: moving image

Figure 1.3: Block diagram of typical DPS system.

Course Objective:
Based on the various theories studied in the Signals & Systems class, we mainly focus on the *concept*, *theory*, and *technology* regarding the discrete-time signals (and systems).