

AI Lab for Wireless Communications



INTRODUCTION

Logistics



- Instructors: 黃昱智、方凱田、伍紹勳
- Lab time: Monday 6:30pm~9:20pm
- Class type: Hands-on Experiments

How the job is divided?



- Each instructor will focus on one topic in wireless communications
- Each topic will cover 5 weeks
- In the last week of each topic, there will be a small project
- Each topic is worth 33% of grades decided by the instructor.

What is communication?



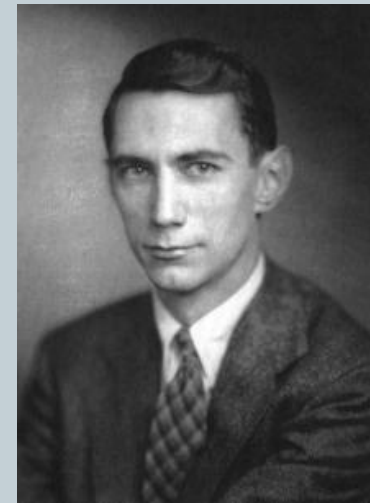
What is communication?



- “The fundamental problem of communication is that **reproducing** at one point either exactly or approximately a message selected at another point”

Claude Shannon (1916-2001)

Father of the information age



In a broad sense



- **Communication systems:** Any system that deals with information representation, storage, transfer and processing
 - ✦ Anything can be broken into **input, channel law, output**
 - ✦ Telegraph
 - ✦ Radio
 - ✦ Telephone
 - ✦ Cell phone
 - ✦ Satellite
 - ✦ Internet
 - ✦ Data storage
 - ✦ DNA sequencing
 - ✦ etc



Remember this figure...



- This is how we describe a communication system

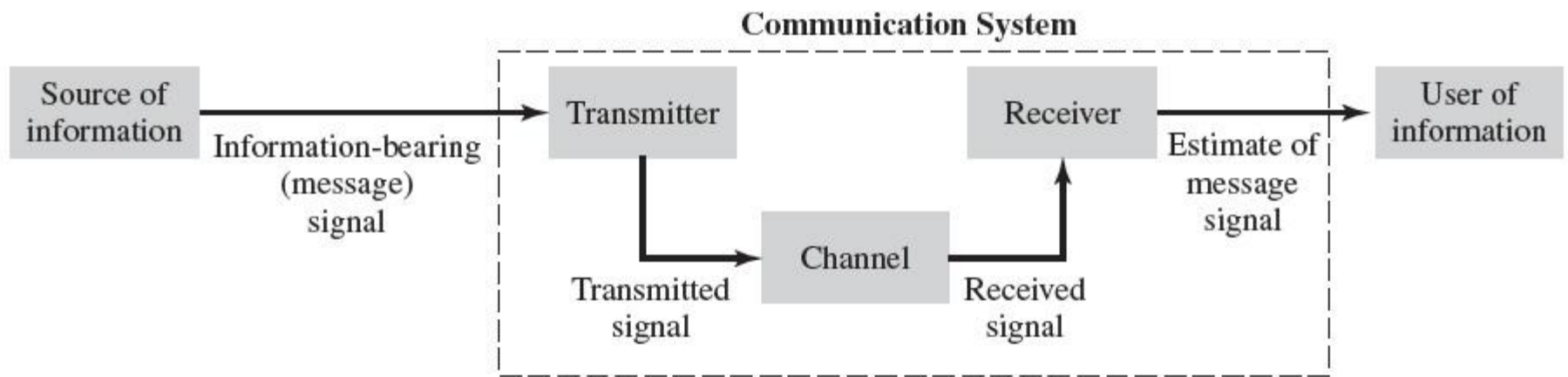


FIGURE 1.1 Elements of a communication system.



- This is one of the most challenging and most profitable industry

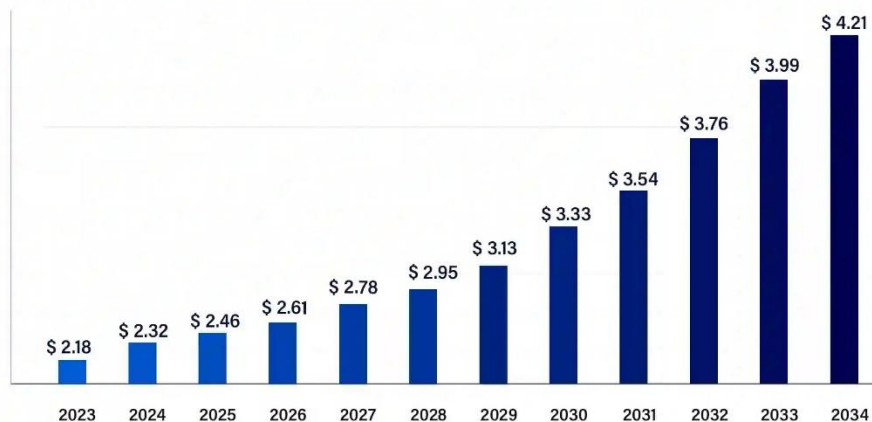


1 trillion = 10^{12}

1 exa = 10^{18}

Precedence
RESEARCH

Telecommunication Market Size 2023 to 2034 (USD Trillions)



Source: <https://www.precedenceresearch.com/telecommunication-market>

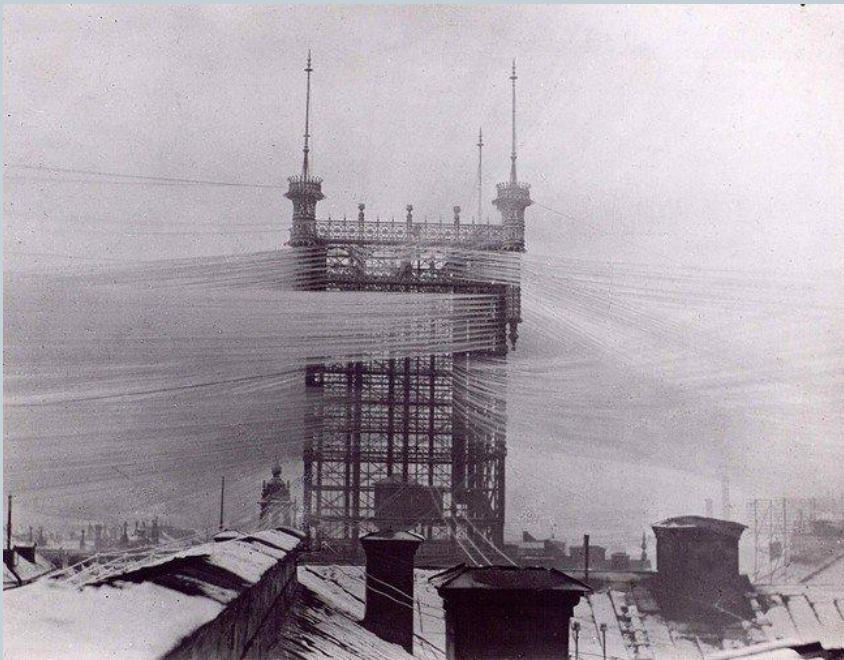
Types of Communications



- Wired
- Wireless
- Analog
- Digital

Communications in 19 and 20 centuries

- Analog + wired



- 1G mobile phone: Analog + wireless



Analog communications?



- Most of the applications in the 19th and early 20th adopt analog communications
 - Easy to implement
 - But is this efficient?
-
- How did ancient people do communication?

Digital + wireless



Easy to reproduce losslessly! Long distance communication with small cost

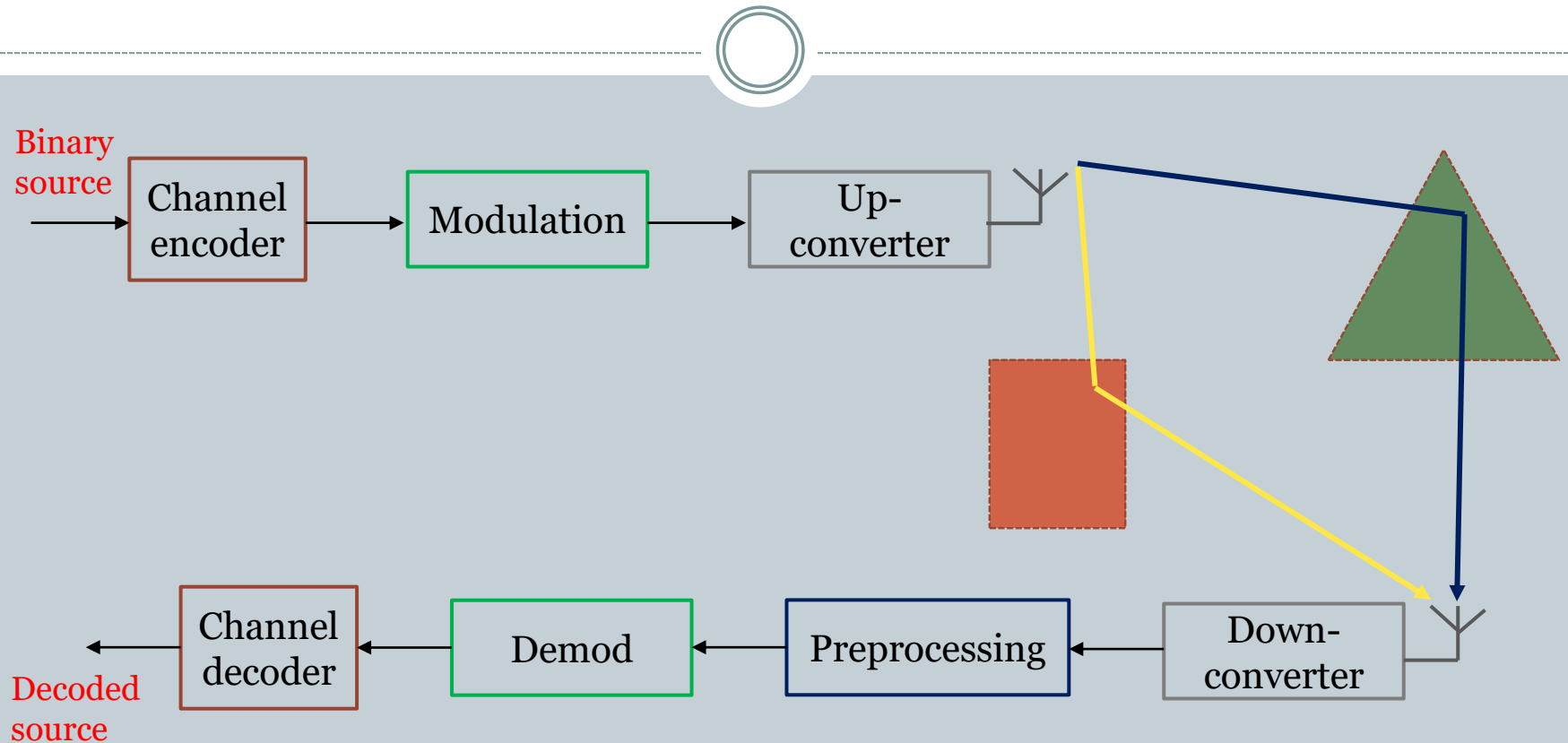
Nowadays



- How do we communicate nowadays?
- Data transmission
 - Data is digital 0's and 1's
 - Cell phone: starting from 2G, Digital + Wireless
 - Internet: Digital + wired from ISP to your home
 - Internet (Wi-Fi): Digital + wireless from modem to your devices
 - Facebook + SpaceX: The last mile of wireless internet



A digital communication system over wireless channel



- Wireless channel introduces uncertainties
- Preprocessing helps us reduce uncertainties
- Mod/Demod enable transmission of data-carry symbols
- Channel enc/dec provides error correction by adding redundancy

AI techniques for wireless communications



- Module 1: Channel decoding (黃昱智)
- Module 2: Denoising (方凱田教授)
- Module 3: Demodulation (伍紹勳教授)

What is Artificial Intelligence?



- A branch of computer science tries to create/simulate **intelligence** for computers



What is Human Intelligence?



- Reasoning
- Planning
- Long-term memory
- Learning
- Communication
- Perception
- Analog
- Etc

What is Artificial Intelligence?

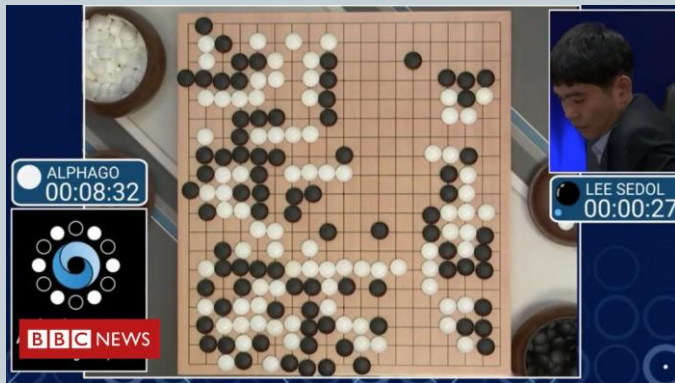


- Solving specific problems
- Mimic human behavior/intelligence
- Outsmart human in games

Weak or narrow AI

State of the Art

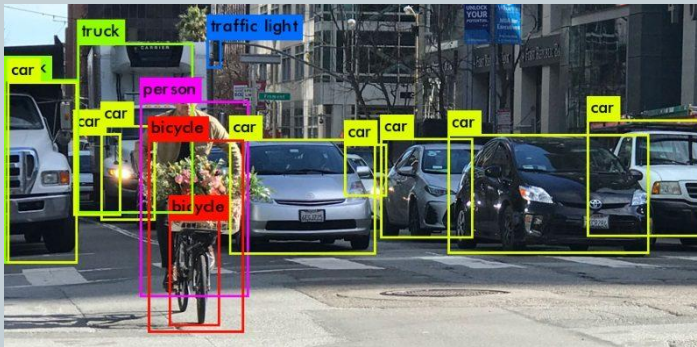
Outplaying human in board games



clean your house



Classify images better than human experts Writing articles/computer programs

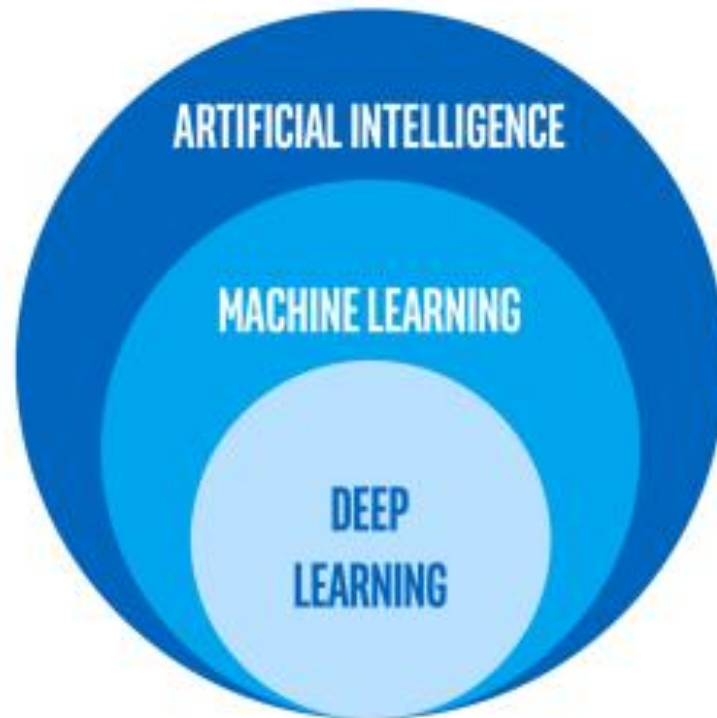


Strong AI



- Aka artificial general intelligence (AGI)
- This requires significant breakthrough about human intelligence and human brains
- Many groups have been seriously working on it
 - Swiss AI lab IDSIA, Nnaisense, Vicarious, Maluuba, the OpenCog Foundation, Adaptive AI, LIDA, Machine Intelligence Research Institute, and OpenAI

Many believe that we are at the brink of strong AI!



Machine Learning



- What is learning?
 - Acquiring expertise from experience
 - Using past to predict future

Types of Learning



- Depends on the relationship between training and testing data
- Supervised learning
 - Training data are labeled with correct answers
 - Testing data are not labeled
 - Learn algorithm to predict labels for testing data
 - EX: Spam emails filter
- Unsupervised learning
 - No difference between training data and testing data
 - Try to come up with some summary of data
 - EX: Anomaly detection

Types of Learning



- Depends on what role the learner plays
- Active learning
 - Learner actively interacts with the environment at training
 - Posing queries or performing experiments
- Passive learning
 - Learner observe information provided by the environment

Types of Learning



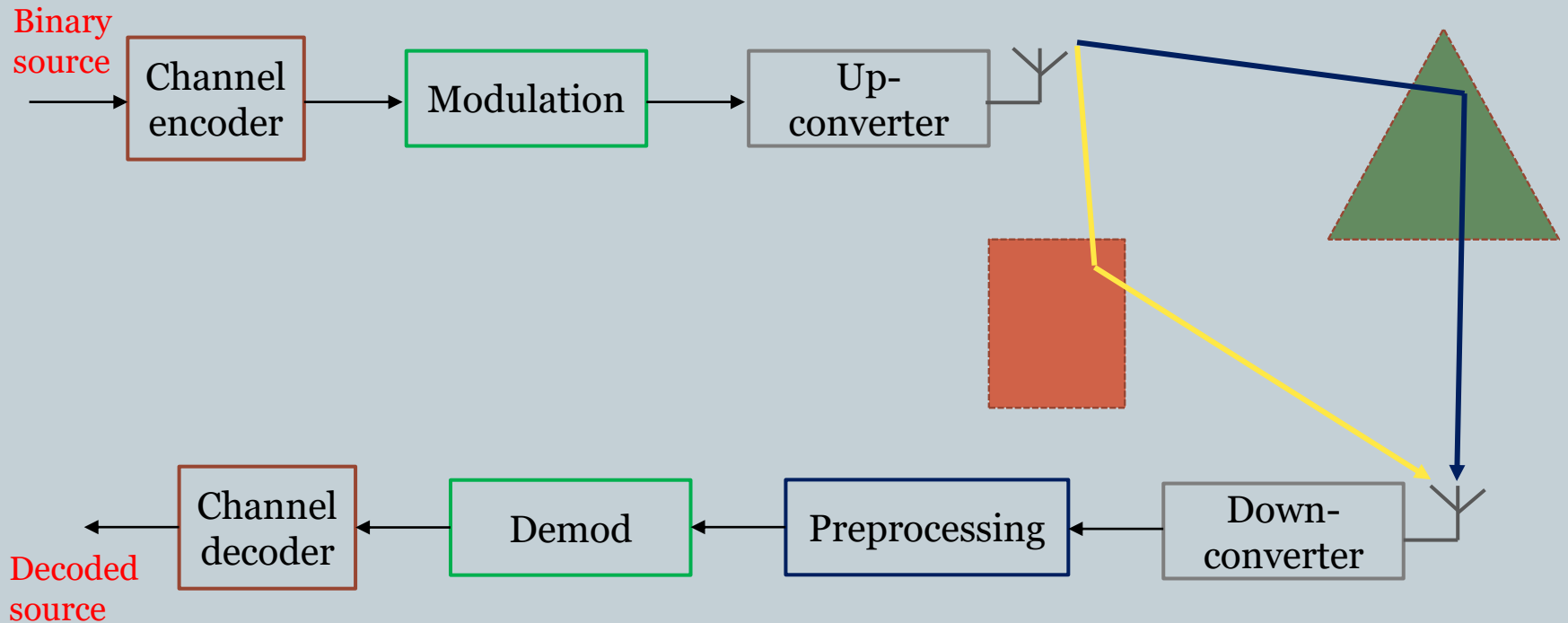
- Depends on how training data are generated
- Statistical learning
 - Training data are assumed to be generated according to some distribution
- Adversarial learning
 - Training data are generated by some adversarial teacher

Types of Learning



- Depends on responding time
- Online learning
 - Training data come in sequentially
 - Learner has to make decisions while learning
- Batch learning
 - Training data come in batches
 - Learner first learns algorithms then makes decisions

In this course...



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