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

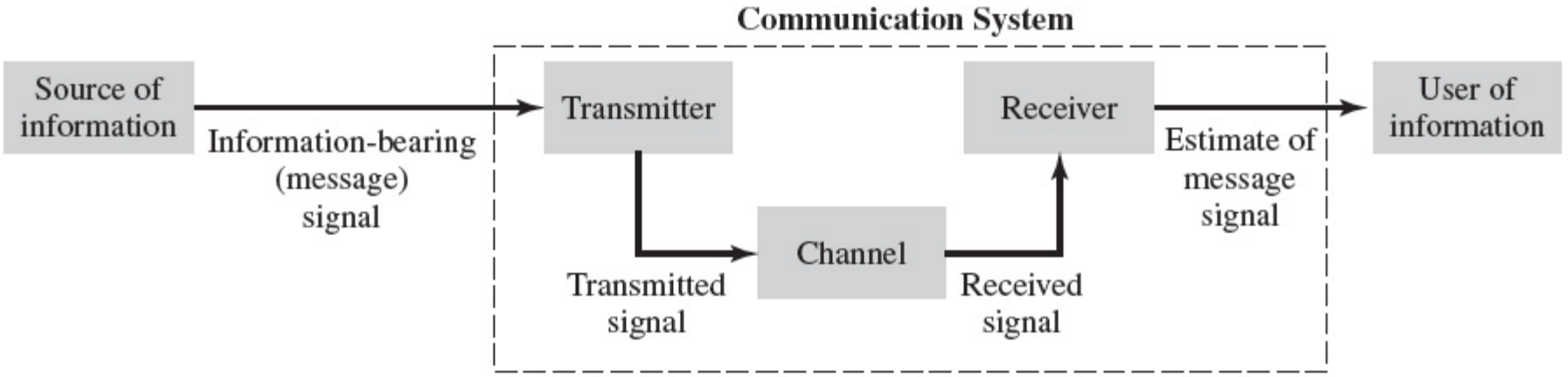
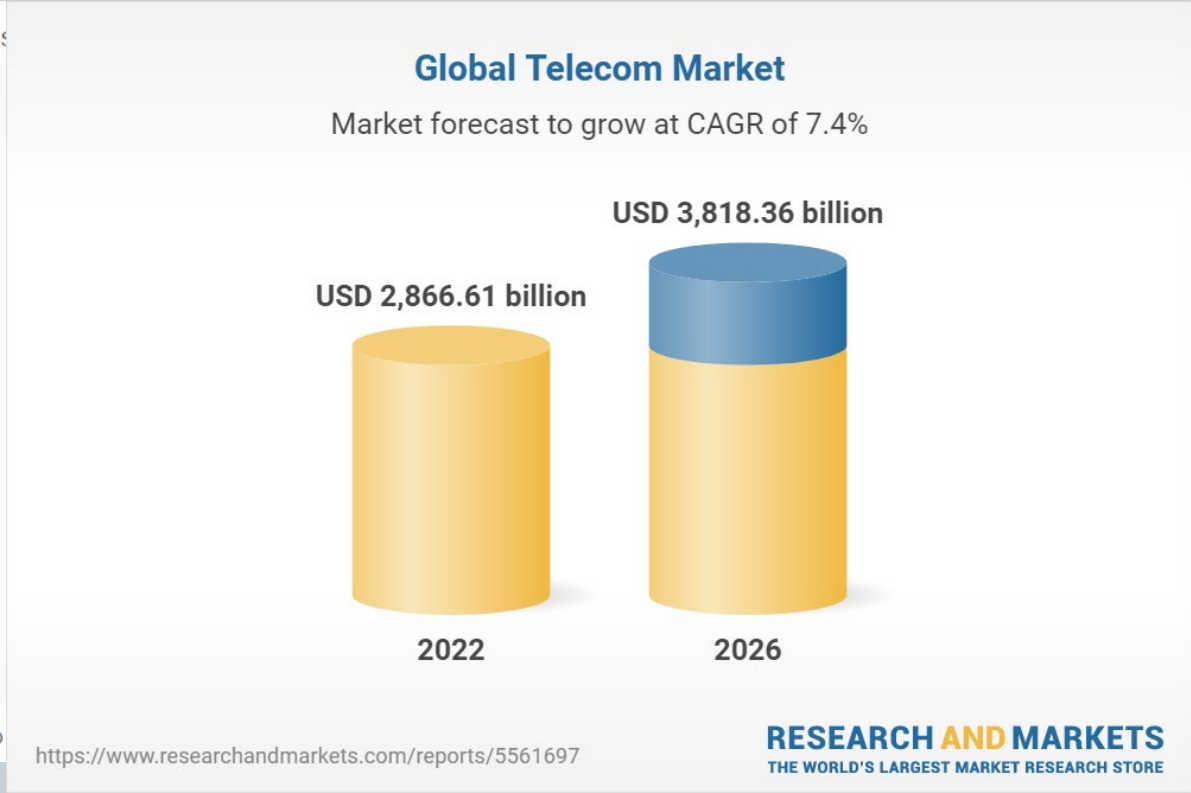


FIGURE 1.1 Elements of a communication system.

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

Figure 2. Cis



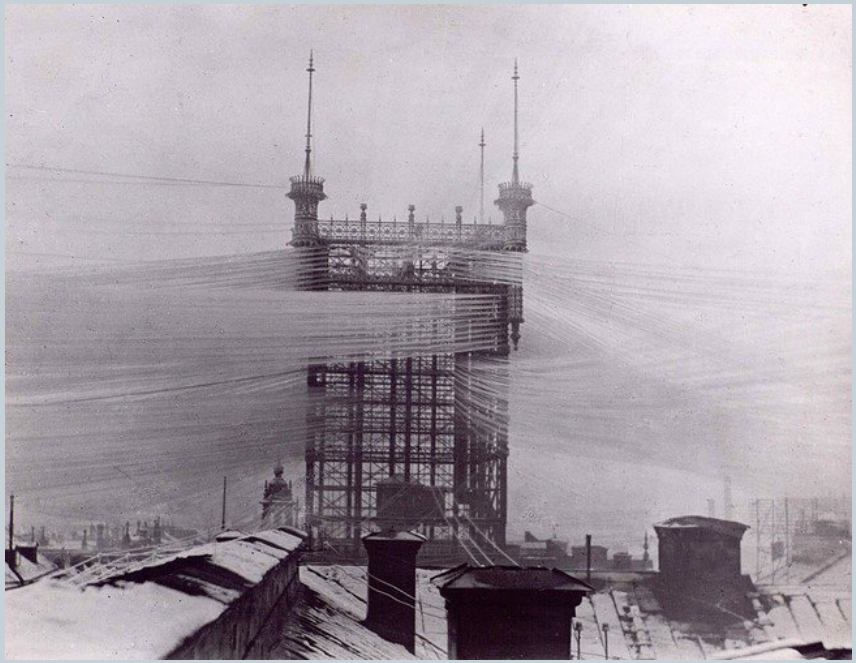
Source: Cisco

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?

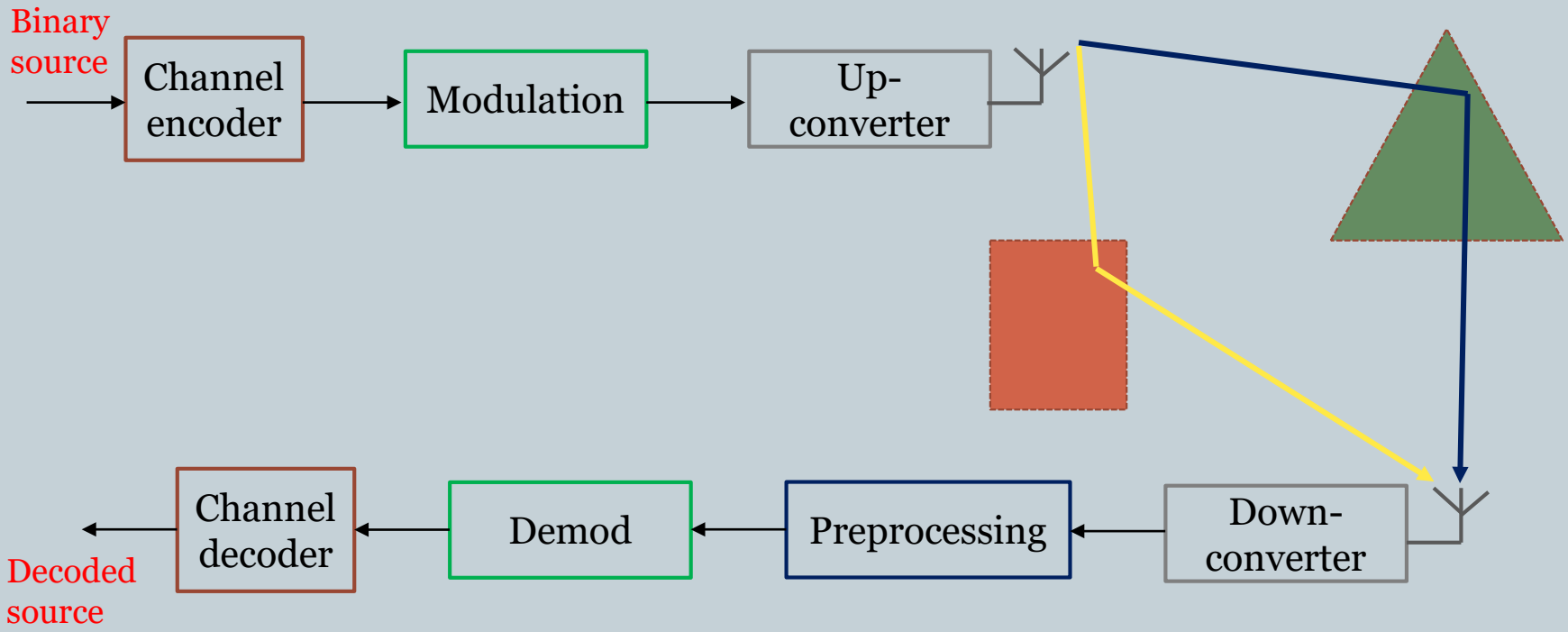
Digital + wireless

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 reduces 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 (黄昱智)
- 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

Approaches

Thinking humanly

- Try to reverse engineer our brains
- More about cognitive science
- Human brains are not perfect
- Human brains are not machine-friendly

Thinking rationally

- 1980s algorithms
- This requires us to have complete understanding about the tasks

Acting humanly

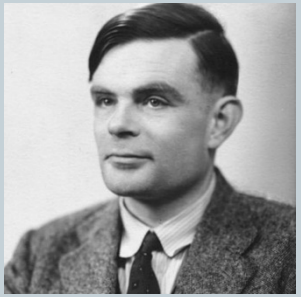
- Starting from Alan Turing
- Teach us more about people rather than machines
- Mainly for machine-human interactions

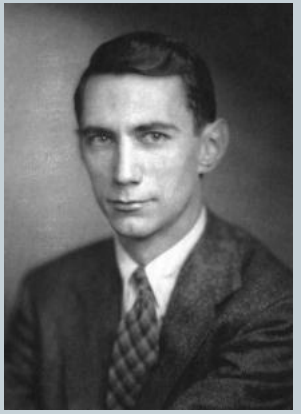
Acting rationally

- Acting optimally
- Maximizing expected utility
- Currently popular

Brief History

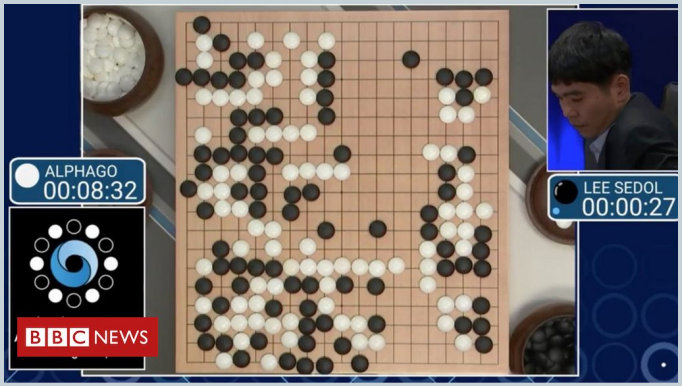
- 1940-1950: Early days
  - Alan Turing's "Computing machinery and intelligence"
  - Claude Shanoon's "Theseus"
- 1950-1970: Excitements
  - Samuel: Checkers program
  - Newell and Simons: Logic Theorist (prove 38/52 theorems)
  - Dartmouth workshop: Adopted "Artificial Intelligence"
- 1970-1990: Knowledge-based approaches
  - Early: Expert systems industry boom
  - Late: Expert systems industry busts. AI winter…
- 1990-2012: Statistical approaches
  - Using statistical approaches, focus on uncertainty
  - Deepen the theoretical foundation
  - Machine learning. AI spring…
- Current: Excitements again
  - Deep learning
  - Reinforcement learning
  - AI spring or AI winter?





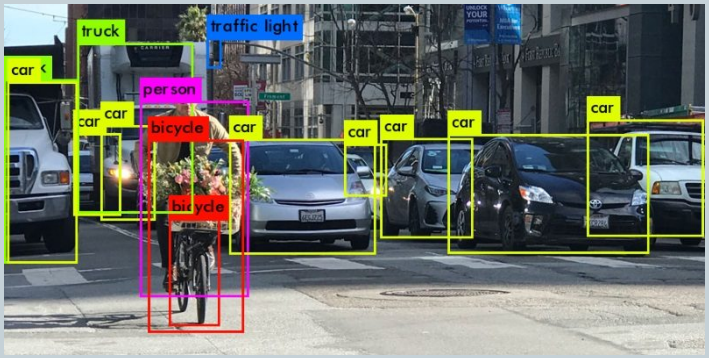
State of the Art

Outplaying human in board games

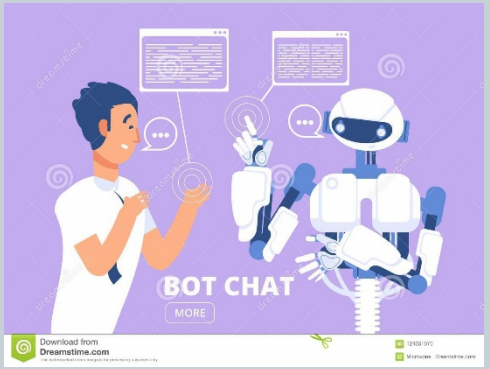


clean your house

Classify images better than human experts

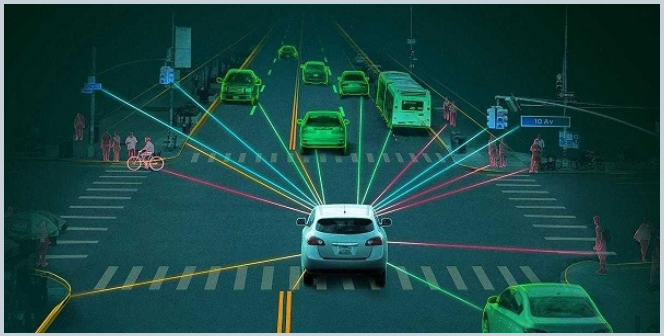


customer service chat bot

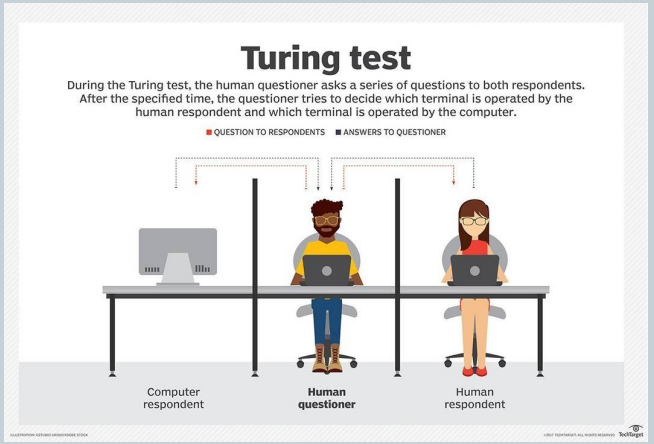


What AI can’t do now

Autonomous driving safely



Pass Turing test



Understanding what they are doing

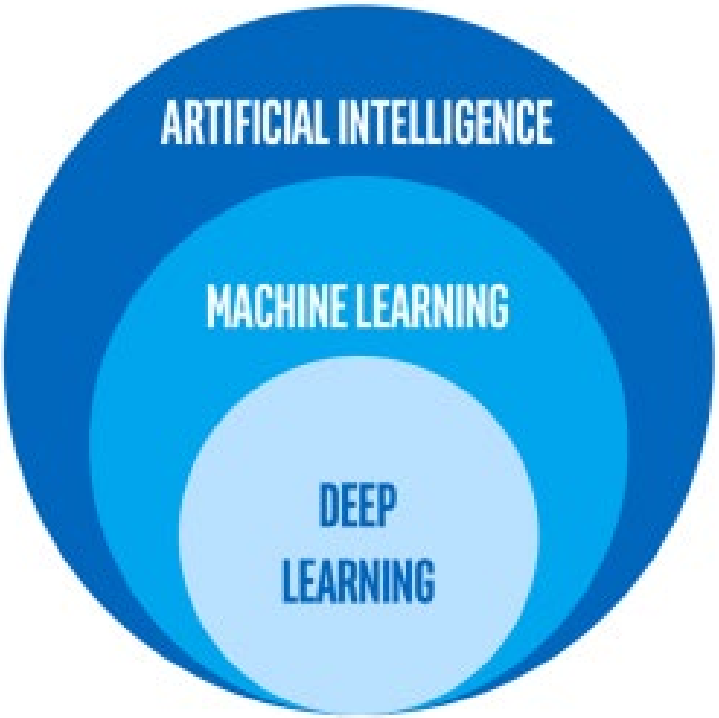
Discover and prove new mathematic theorems

Strong AI

Being intelligent…

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


ARTIFICIAL INTELLIGENCE
MACHINE LEARNING
DEEP
LEARNING

Machine Learning

- What is learning?
  - Acquiring expertise from experience
  - Using past to predict future
- When do we need learning instead of programming?
  - When the task is too complex to extract a well defined program
  - When environment is changing

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