

Systems

- a combination of parts that interact and produce some new quality of functions in their interactions
- characteristics of systems

① system are made of parts or elements
ex. wheel in car

② these elements are in interaction
ex. put all elements of car together
(it won't be a car if we don't put it together)

③ the interactions bet. elements result in new features of the whole
ex. driving

- * - elements of system differ from each other (not identical)
- elements have particular order/position

Interaction

- relationship bet. elements can be described as flows
- type of i - actions
 - ↳ positive feedback loops → ex. larger pop lead to more births (more new borns)

- ↳ negative feedback loops → ex. larger pop and limited food supply lead to less food per person
- ↘ system tries to stabilize itself

Complex system

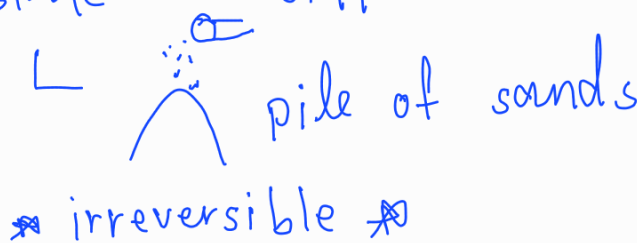
- system that consist of many interconnected components where the behavior of system as a whole can't be predicted from the behavior of individual components
- 4 characteristics of complex system
 - ①. hierarchy
 - ②. non-linearity
 - ③. connectivity
 - ④. emergence

hierarchy

- ex. cells → organism → fish → school of fish
→ fish interact w/ vegetation (fish is part of ecosystem) → or environments

non-linearity

- ① state transitions



At some points, the pile will be unstable (landslide occurs)

↓
stable sys to unstable sys

② small change w/ large effect

ex. butterfly effect

↳ when butterfly flap its wing at some part of the world, it can cause hurricane somewhere

③ scale-less behavior

- show the same patterns at different scale

ex. covid-19

↳ locally spread to large city

↳ still confuse a bit, how?

④ tipping points

- critical threshold → when we cross this threshold, it can cause the severe impacts

ex. climate change → increasing in earth temp.
(2.5 °C)

connectivity

- form the network

- each elements has different degree of connectivity and position in network structure



A and B have diff degree of connectivity

(A has 2 connections, B has 1 connection)

Emergence

- connection bet. elements lead to emerging of new properties of system



new props (ex. pattern, structure, behavior)
ex. flocking of birds emerge due to adaption
 pattern

Link bet. complex systems & agent-based model

- Components of ABM

└ agents, environments, and time

↓
ABM is like the complex system

└ agents → can form group of agents

└ interaction bet. individual agents, group of agents, agent and environment

↓
ABM can provide unexpected outcomes (depend on the type of model that we create)

hierarchy
properties