Systems Analysis

Systems Analysis & Design

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2025-III

Outline

1. Basic Concepts
2. Chaos and Dynamic Systems
3. Abstraction and Modularity

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What is a System?

- A **system** is a set of interacting components that *work* together to achieve a common goal.
- A **system** is a collection of elements organized in a specific way.
- A **system** is a structure designed to perform a specific function.

Systems Analysis Process

- **Systems analysis** is the *process* of studying a system in order to `identify` its components, interactions, and goals.
- **Systems analysis** is the *process* of understanding how a system works and how it can be improved.
- **Systems analysis** is the `first step` in the systems development lifecycle.

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Systems Development Lifecycle

- The **systems development lifecycle** is a *process* that *guides* the development of a system.
- It includes planning, analysis, design, implementation, and maintenance phases.
- It is a **structured approach** to *developing* a system that ensures it meets the needs of its users.

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Systems Analysis Techniques

- **Systems analysis** uses a *variety* of techniques to *study* a system.
- These *include* interviews, surveys, observations, and document analysis.
- It also *includes* data modeling, process modeling, and requirements analysis.

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Systems Analysis Tools

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- It also *includes* `software tools` such as spreadsheets, databases, and simulation software.

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Lateral Thinking

- **Lateral thinking** is a creative problem-solving technique that involves thinking outside the box.
- It is a non-linear approach to problem-solving that *encourages* innovation and creativity.
- It is a *useful* technique for *generating* new ideas and solving complex problems.
- Examples:
  - How can you improve the design of a product?
  - What are the benefits of failure?
  - Why is ignorance important?
  - When is failure better than success?

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Lateral Thinking Training

- **Lateral thinking** is a *skill* that can be learned and developed through `training` and `practice`.
- It involves exercises, games, and activities that encourage creative thinking.
- Examples of lateral thinking exercises:
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  - Mind mapping exercises.
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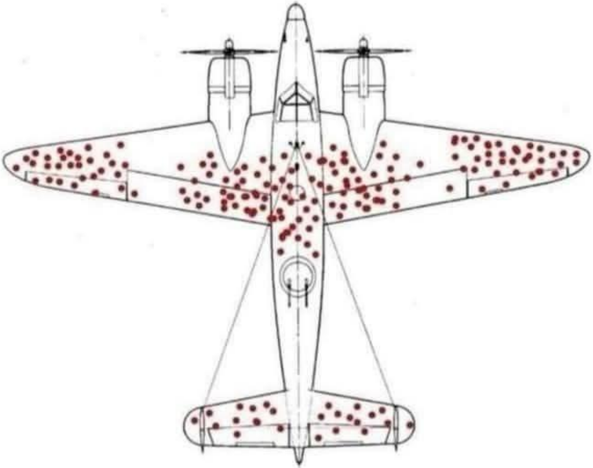
Lateral Thinking Exercise

World War II, the perspective of Abraham Wald:



Uncertainty and Risk

- **Uncertainty** is the lack of knowledge about the future outcome of a decision or event.
- **Risk** is the probability of a negative outcome or loss associated with a decision or event.
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Complexity and Emergence

- **Complexity** is the degree to which a system is difficult to understand.
- **Emergence** is the appearance of unexpected properties in a system that arise from the interactions of its components.
- **Complexity** and **emergence** are *common* in dynamic systems that are non-linear and chaotic.
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What is Chaos?

- **Chaos** is a *branch* of mathematics that *studies* the sensitivity of dynamical systems to initial conditions.
- **Chaos** is a non-linear behavior that is highly sensitive to initial conditions.
- **Chaos** is a deterministic behavior that is not predictable in the long term.
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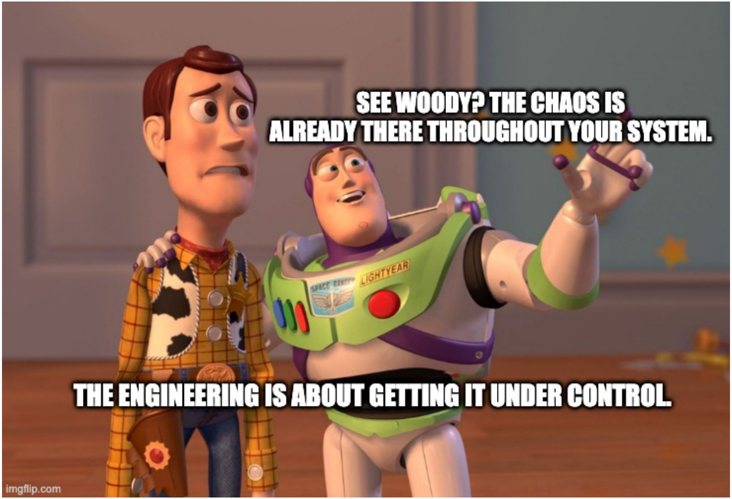
Chaos is Everywhere!


SEE WOODY? THE CHAOS IS ALREADY THERE THROUGHOUT YOUR SYSTEM.
THE ENGINEERING IS ABOUT GETTING IT UNDER CONTROL.
imgflip.com

What is a Dynamic System?

- A **dynamic system** is a system that changes over time.
- A **dynamic system** is sensitive to initial conditions.
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Chaotic Attractors

A **chaotic attractor** is a set of points in a phase space that attracts the trajectories of a dynamical system.

Fractals in Nature

Watch this video: https://www.youtube.com/watch?v=kkGeOWYOFoA

Swarm Intelligence I

- Swarm intelligence is the collective behavior of *decentralized*, **self-organized systems**, natural or artificial.
- The concept is employed in work on artificial intelligence.
- The expression was introduced by *Gerardo Beni* and *Jing Wang* in 1989, in the context of cellular robotic systems. For example, watch this **video**.

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Swarm Intelligence II

- The idea is: if you see an **individual**, it may seem random; **however**, several **individuals interacting** with each other and the environment show smart behaviors.
- **Yu Takeuchi** said: one colombian is more intelligent than one japanese, but two japanese are smarter than two colombians.
- There are interesting **population behaviors** in nature, specially in insects: bees, ants, termites, among others.
- There are also many examples in nature: schools of fish, birds, wolves.

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Emergent Behaviors

- Emergent behavior is the **appearance** of **complex patterns** and behaviors from **many** simple interactions.
- Emergent behavior **results** from the **collective** behavior of the **individuals** in the system.
- Emergent behavior is **not planned** or **designed** by any individual, but **arises** from their **interactions**.
- Emergent behavior is **not** the **sum** of the **individual** behaviors, but **something more**: synergy.
- **Swarm intelligence** refers to interesting emergent behaviors.

School Fish Algorithm

Don't Panic
Organize!

School Fish Algorithm

- **School fish** are interesting. When a predator attacks, they become confused by the large number of individuals and their diverse movements.
- The idea is simple: *"Don't touch me, don't come too close, but stay somewhat close."*
- This behavior is a chain of action and reaction. It confuses predators and helps the school move uniformly.
- Do you remember Nemo? The fish with a sword snout, the pirates, or Marlin's imitation of talking-all are somewhat similar. Watch **here**.
- The school fish algorithm is a **multi-agent system** that **simulates** the behavior of a **school of fish**.

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Thanks!

Questions?

Repo: *https://github.com/EngAndres/ud-public/tree/main/courses/systems-analysis*