Swarm Intelligence

Systems Analysis

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Outline

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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, let's watch this **video**.

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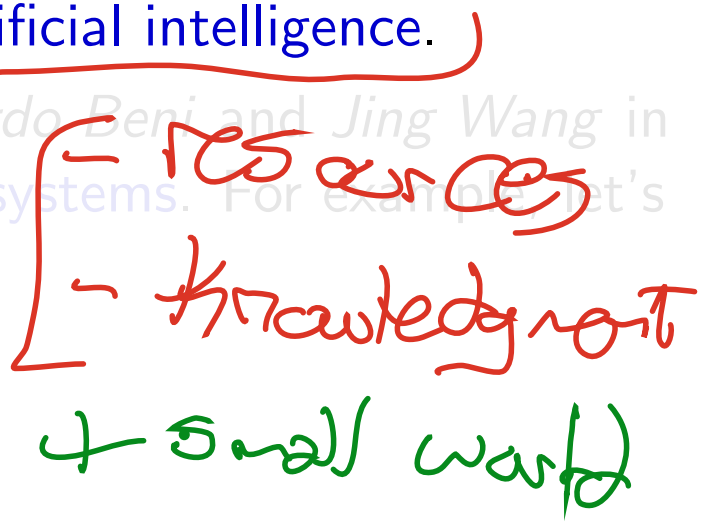

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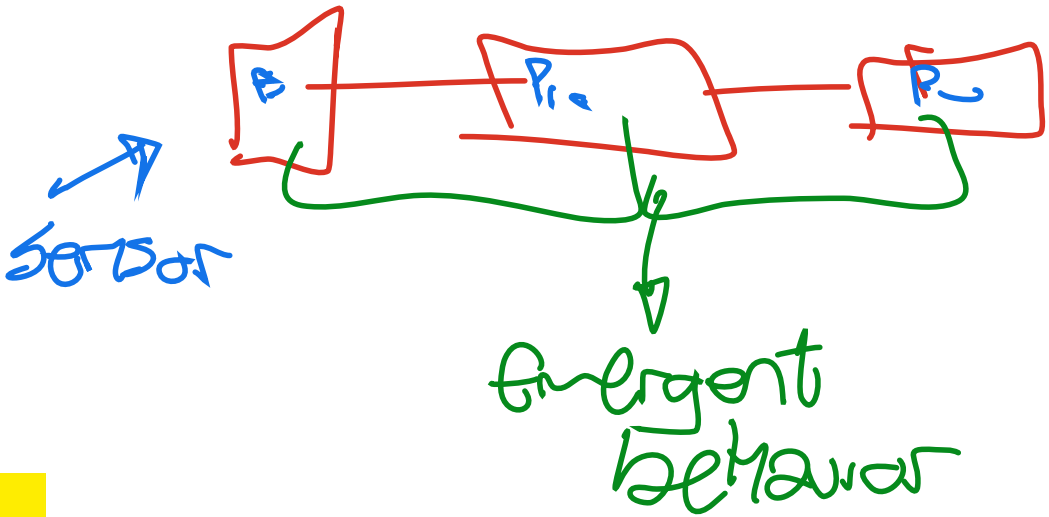
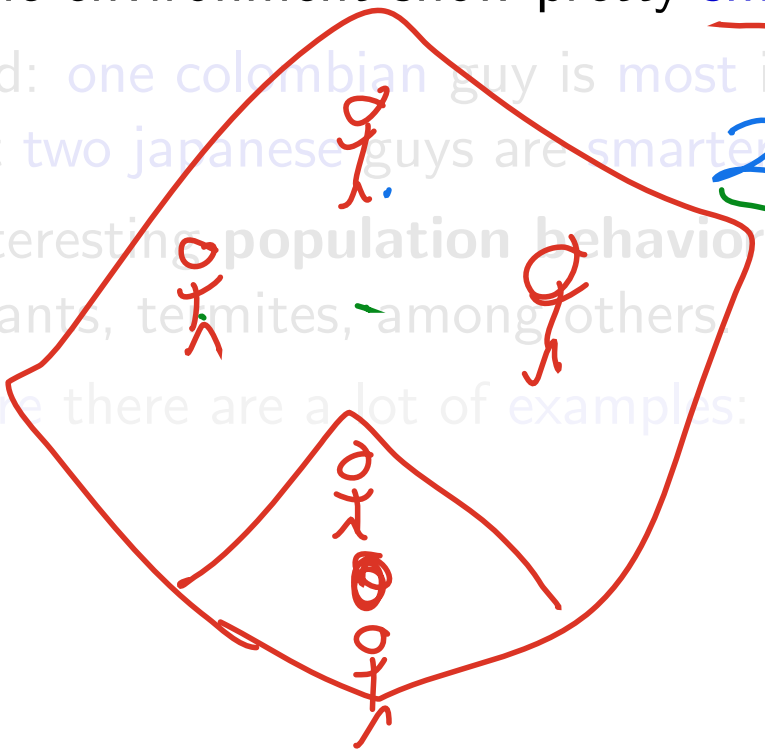


Swarm Intelligence II

- The idea is: if you see an **individual**, a part, it looks not interesting, even like random; **however**, several **individuals interacting** between each other and the environment show pretty smart behaviors.
- **Yu Takeuchi** said: one colombian guy is most intelligent than one japanese guy, but two japanese guys are smarter than two colombians.
- There is some interesting **population behaviors** in nature, in special at insects: bees, ants, termites, among others.
- However, in nature there are a lot of examples: school fish, birds, wolfs.



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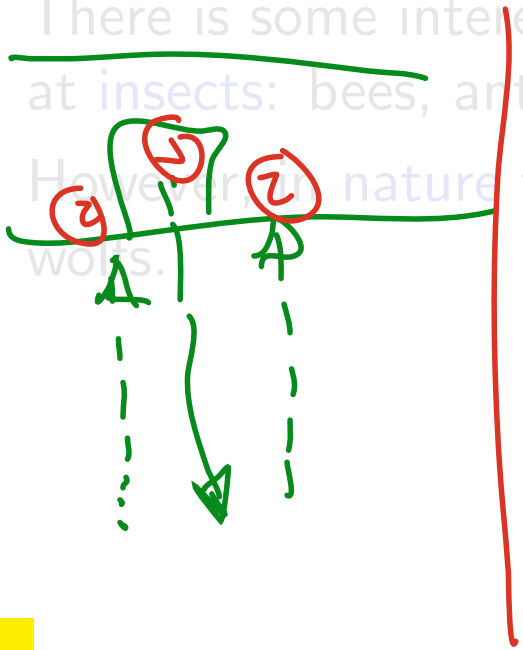

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Antz

Bugs

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Bio-inspired

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Emergent Behaviors

- Emergent behavior is the **appearance** of **complex patterns** and behaviors from a **multiplicity** of relatively simple interactions.
- The emergent behavior is the **result** of the **collective** behavior of the **individuals** of the system.
- The emergent behavior is not **planned** or **designed** by any individual, but **arises** from the **interactions** of the individuals.
- The emergent behavior is **not** the **sum** of the **individual** behaviors, but **something more**. In summary: **synergy**.
- Swarm intelligence makes reference to some interesting emergent behaviors.

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How is to be intelligent?

- Intelligence is the **ability** to **learn**, **understand**, and **make decisions**.
- Artificial intelligence is the **simulation** of **human intelligence** in machines.
- Artificial agents are **software** or **hardware** systems that **act** autonomously, typically in a **dynamic environment**.
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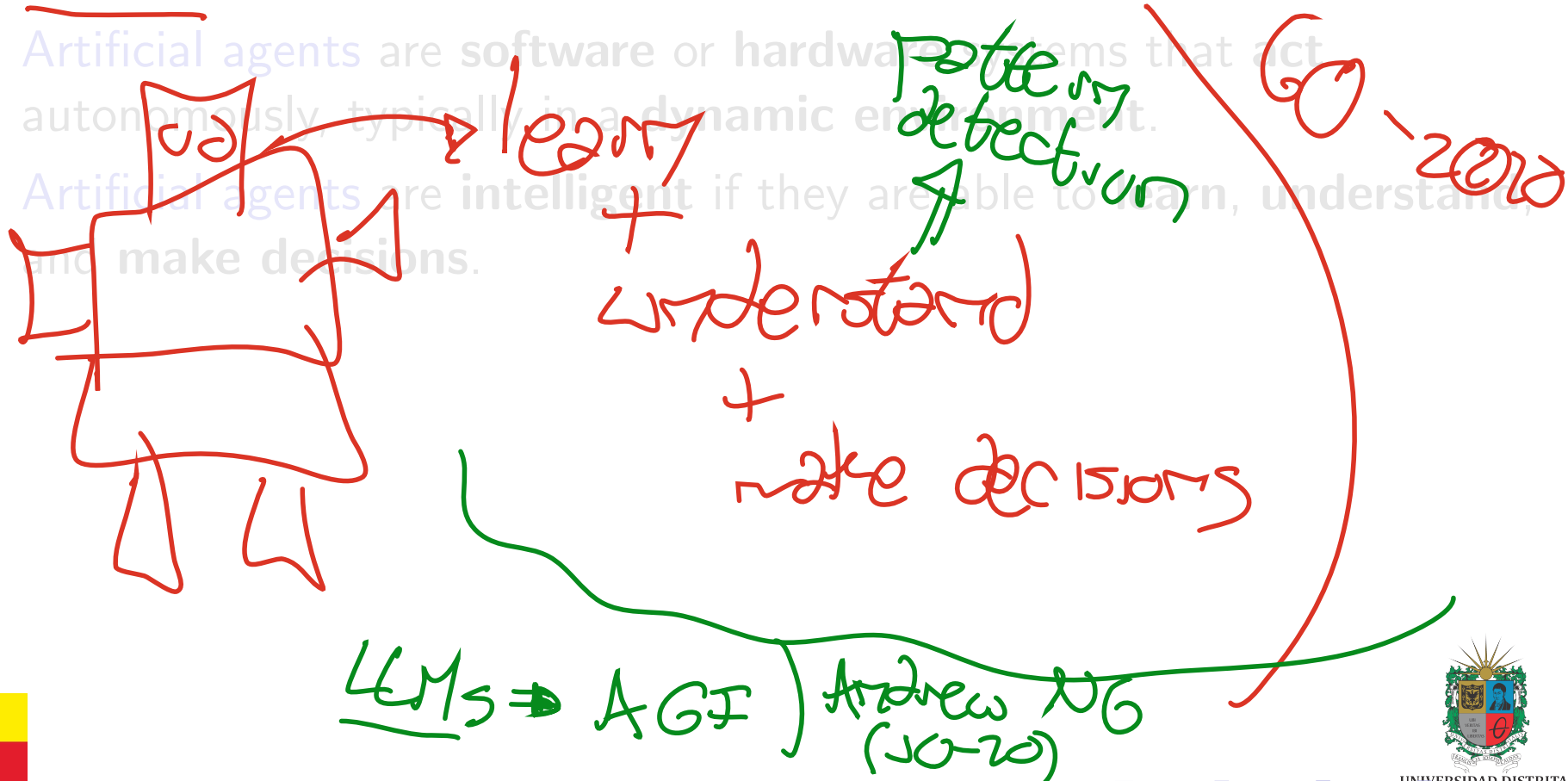

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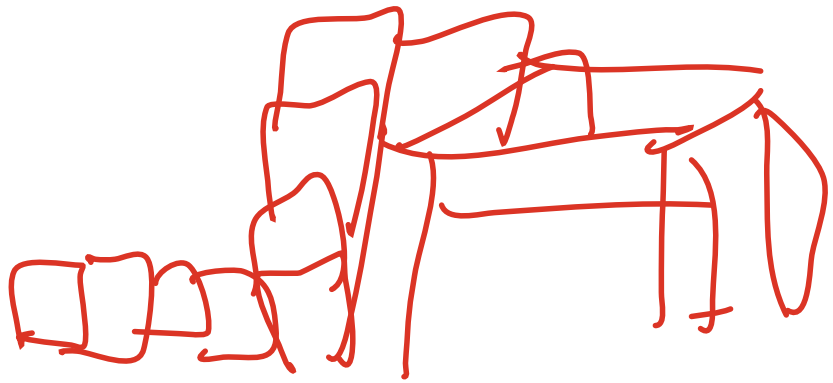
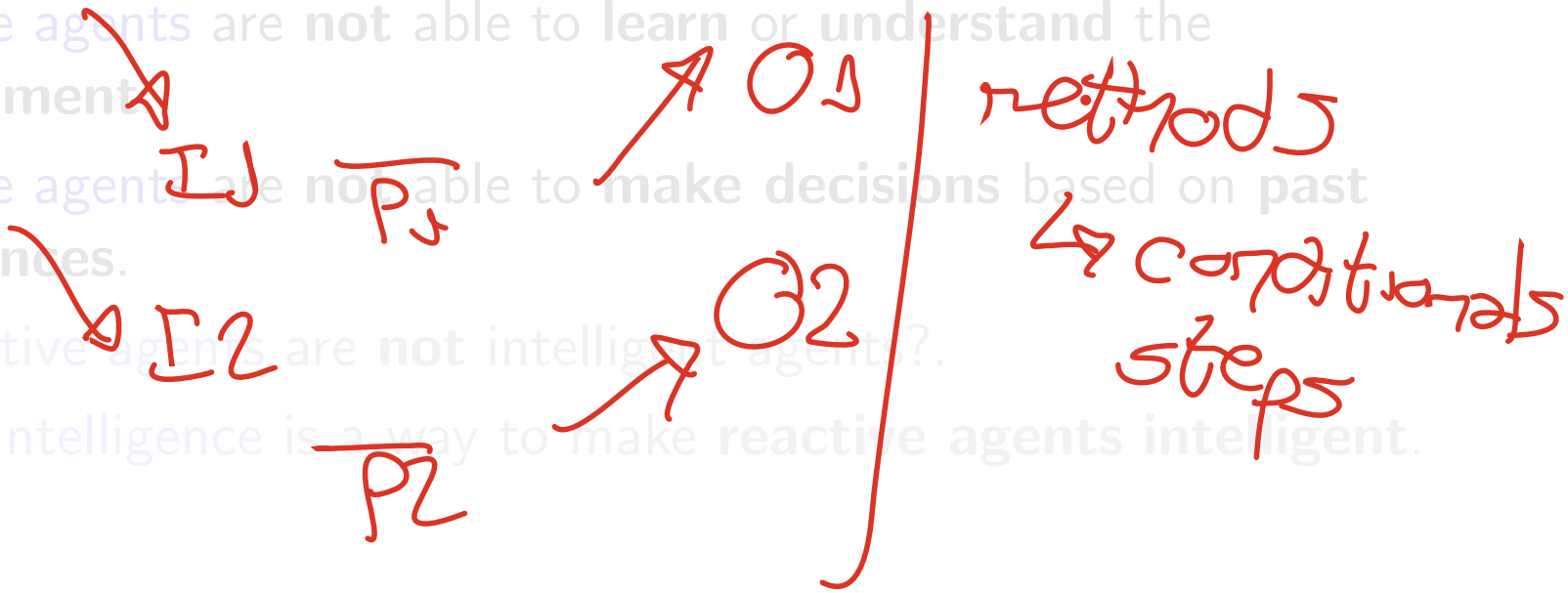


Artificial Reactive Agents

- Reactive agents are **simple** and **fast** agents that **react** to the **environment**.
- Reactive agents are **not** able to **learn** or **understand** the **environment**.
- Reactive agents are **not** able to **make decisions** based on **past experiences**.
- Do reactive agents are **not** intelligent agents?.
- Swarm intelligence is a way to make **reactive agents intelligent**.



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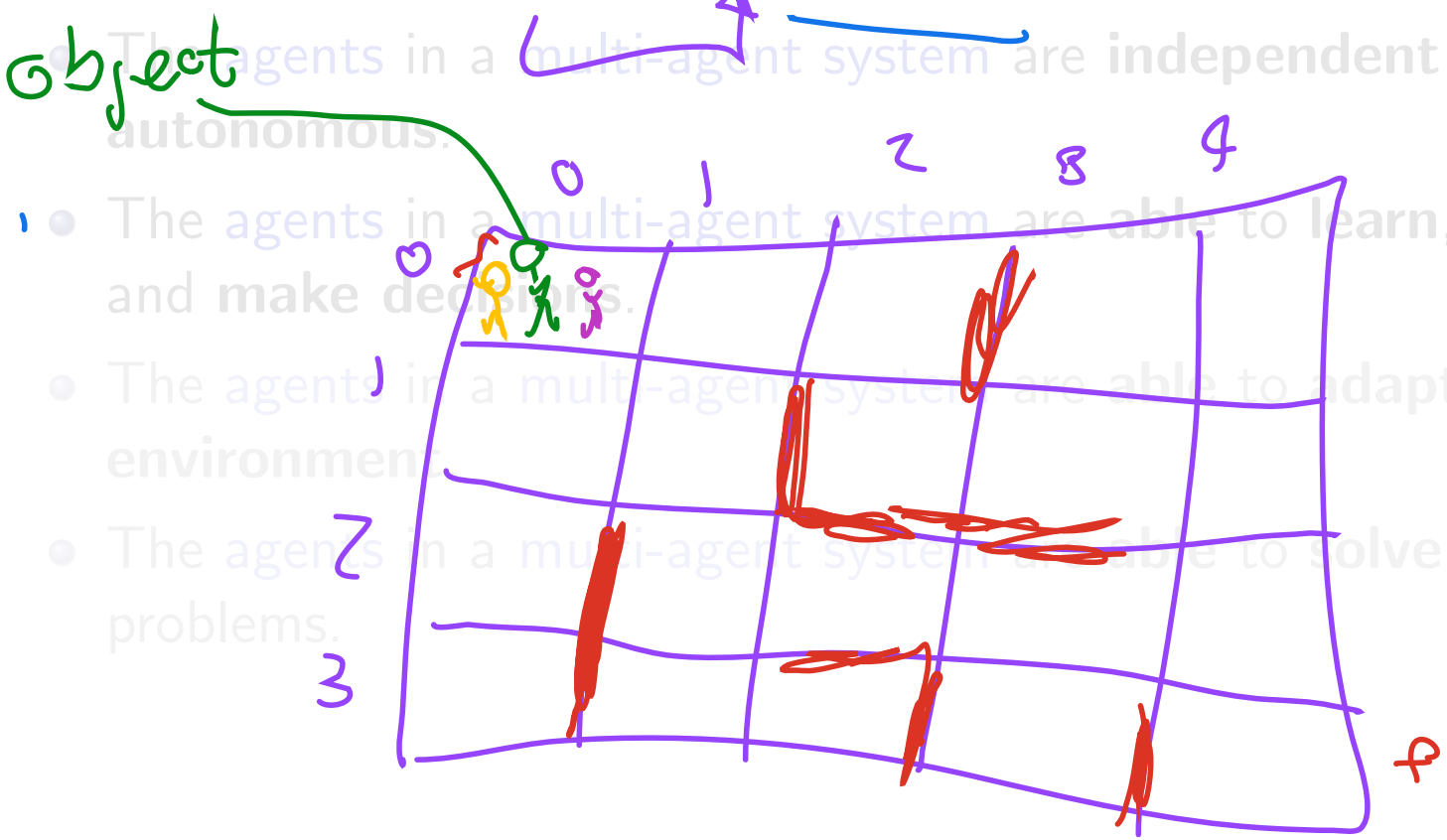

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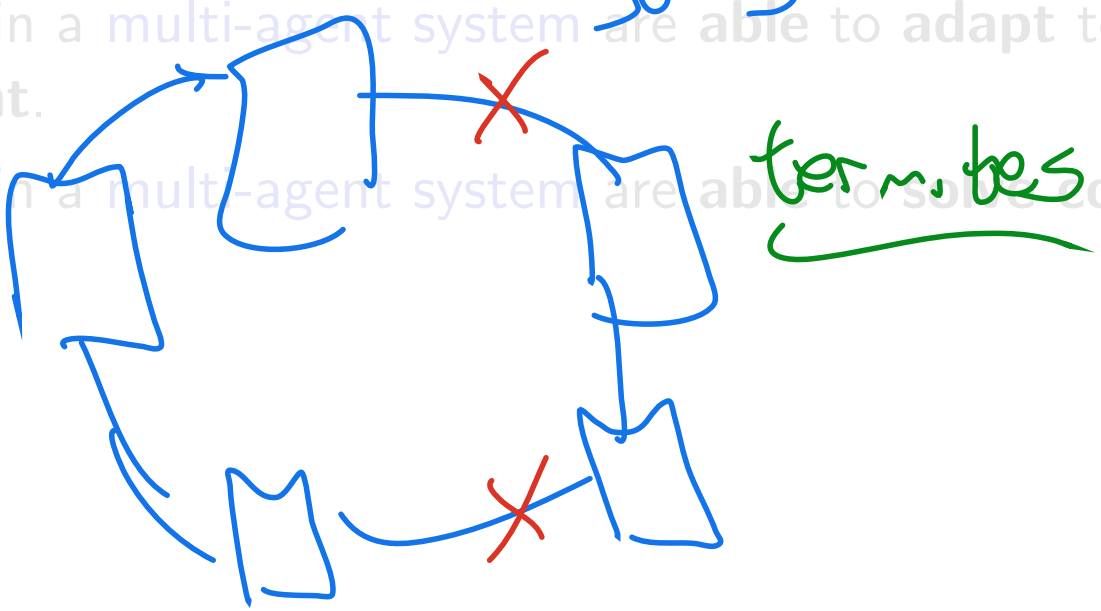

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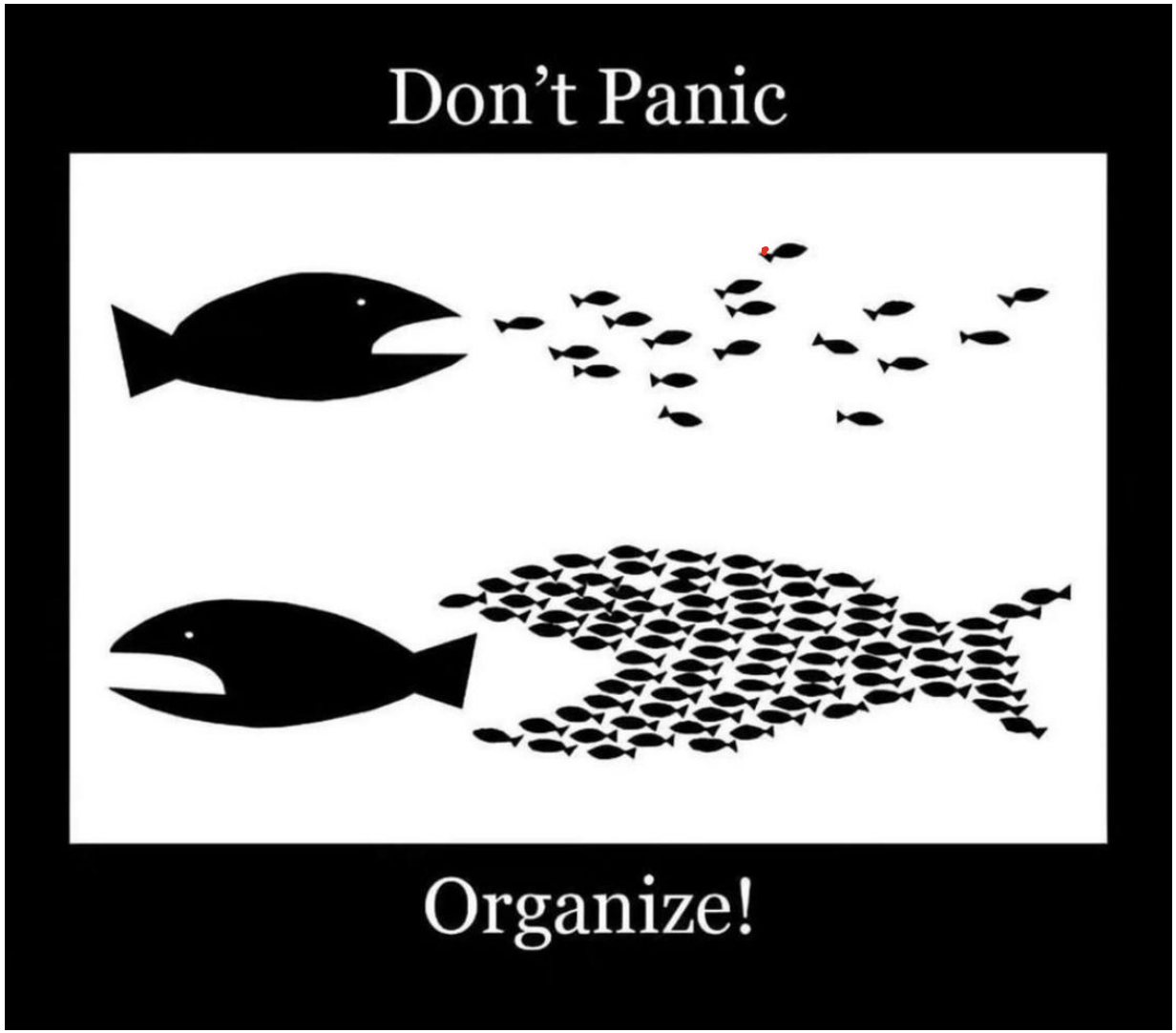
School Fish Algorithm



School Fish Algorithm

- **School fish** are pretty interesting. When a predator attack, it gets confused by the amount of individuals and the different movements.
- The idea is pretty simple: *don't touching me, don't be so close to me, but stay a little bit close.*
- This behavior is a chain of action/reaction, it confuses predators, helps to move uniformly.
- Do you remember Nemo? Fish with sword nose, or the pirates, or the imitation of Marlin talking. That is something similar, look **here**.
- The school fish algorithm is a **multi-agent system** that **simulates** the behavior of a **school of fish**.

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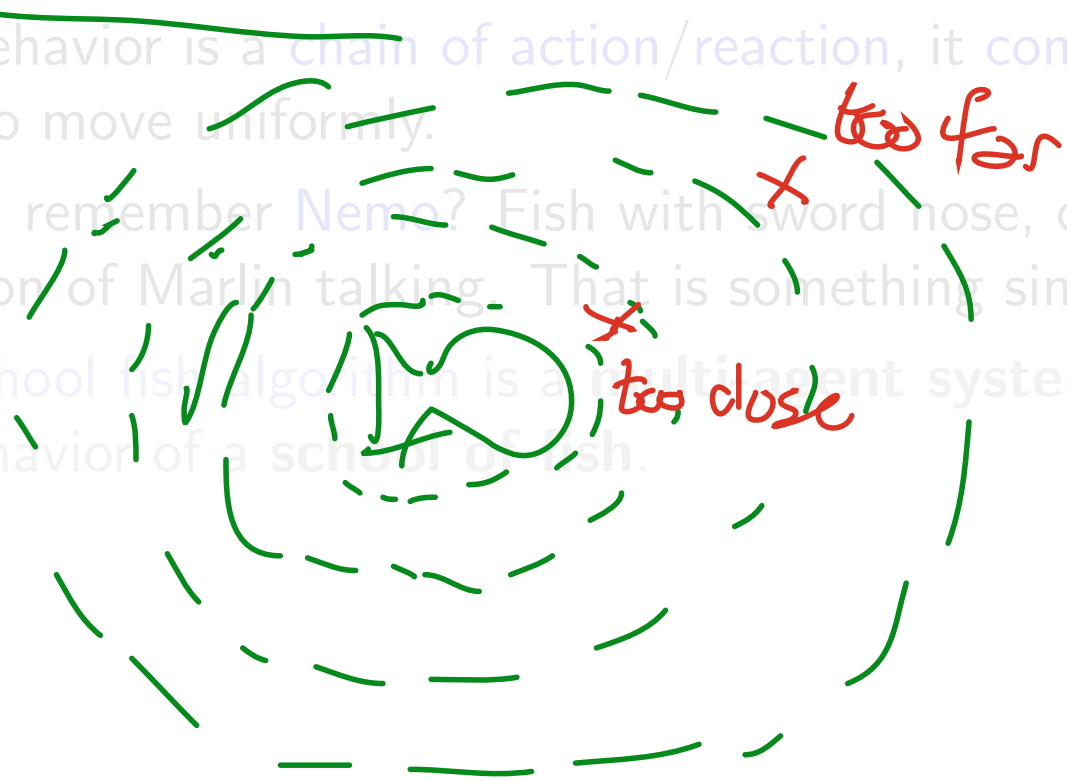

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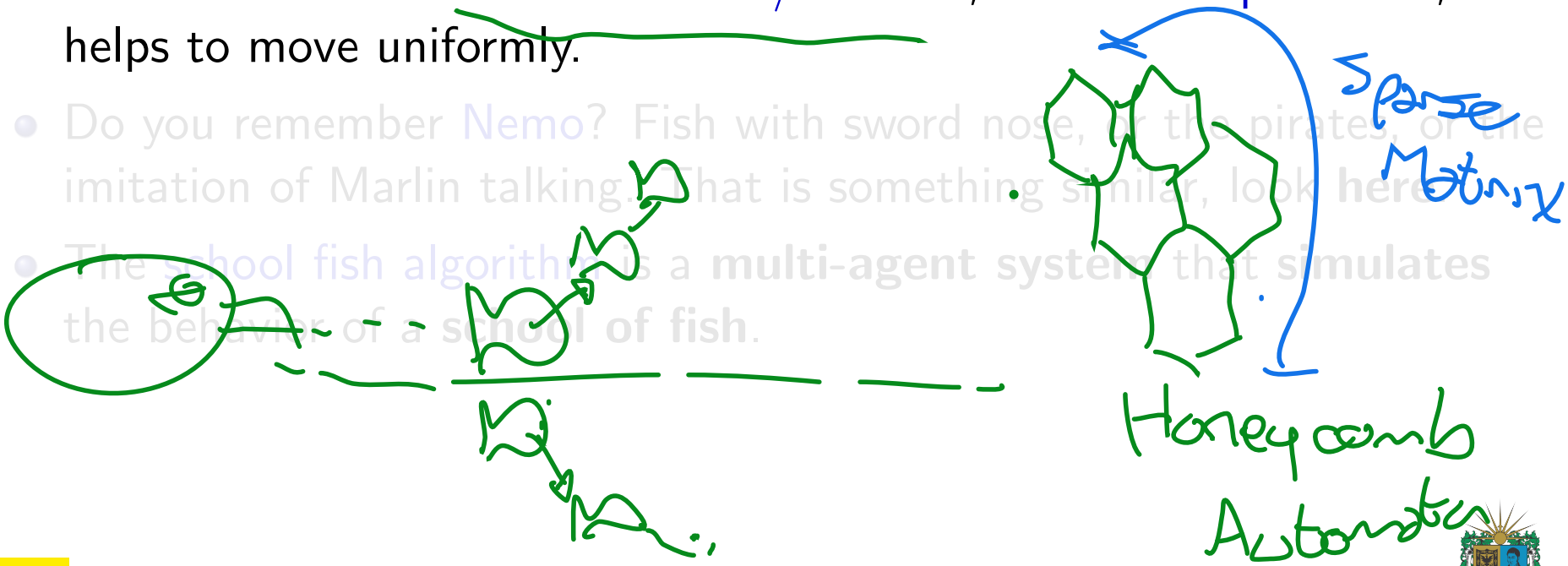

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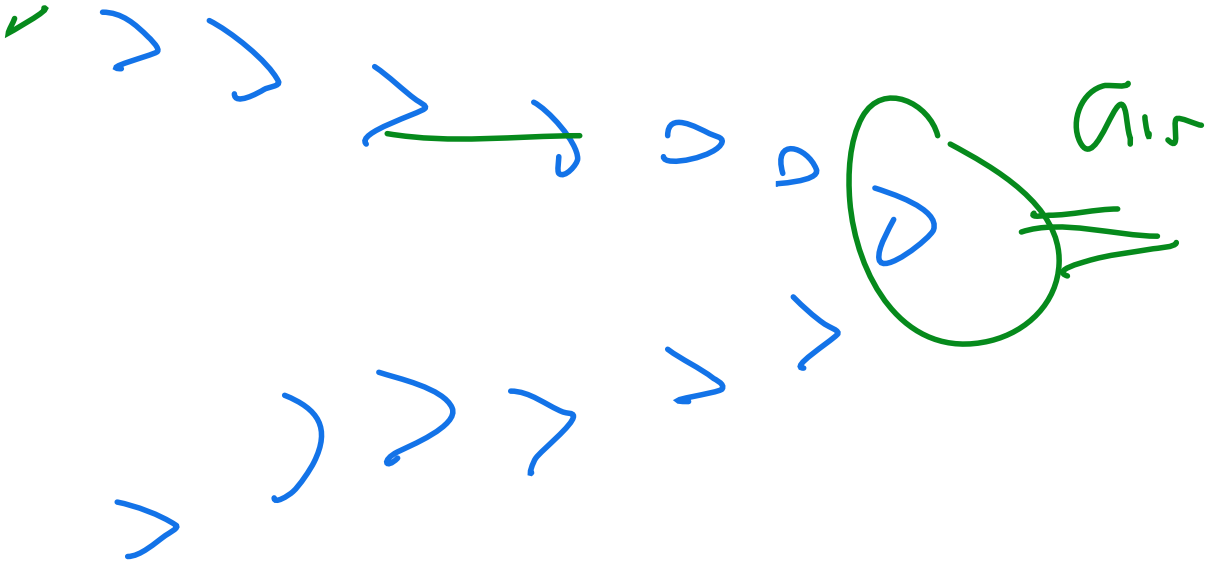
Bird Flock Algorithm

- Birds are pretty interesting. They are able to **fly** in a **group** without **colliding**.
- Bird flock is a **multi-agent system** that **simulates** the behavior of a **flock of birds**.
- Bird flock algorithm just emulates movements, following leaders, but in a **stochastic way**.



Particle Swarm Algorithm

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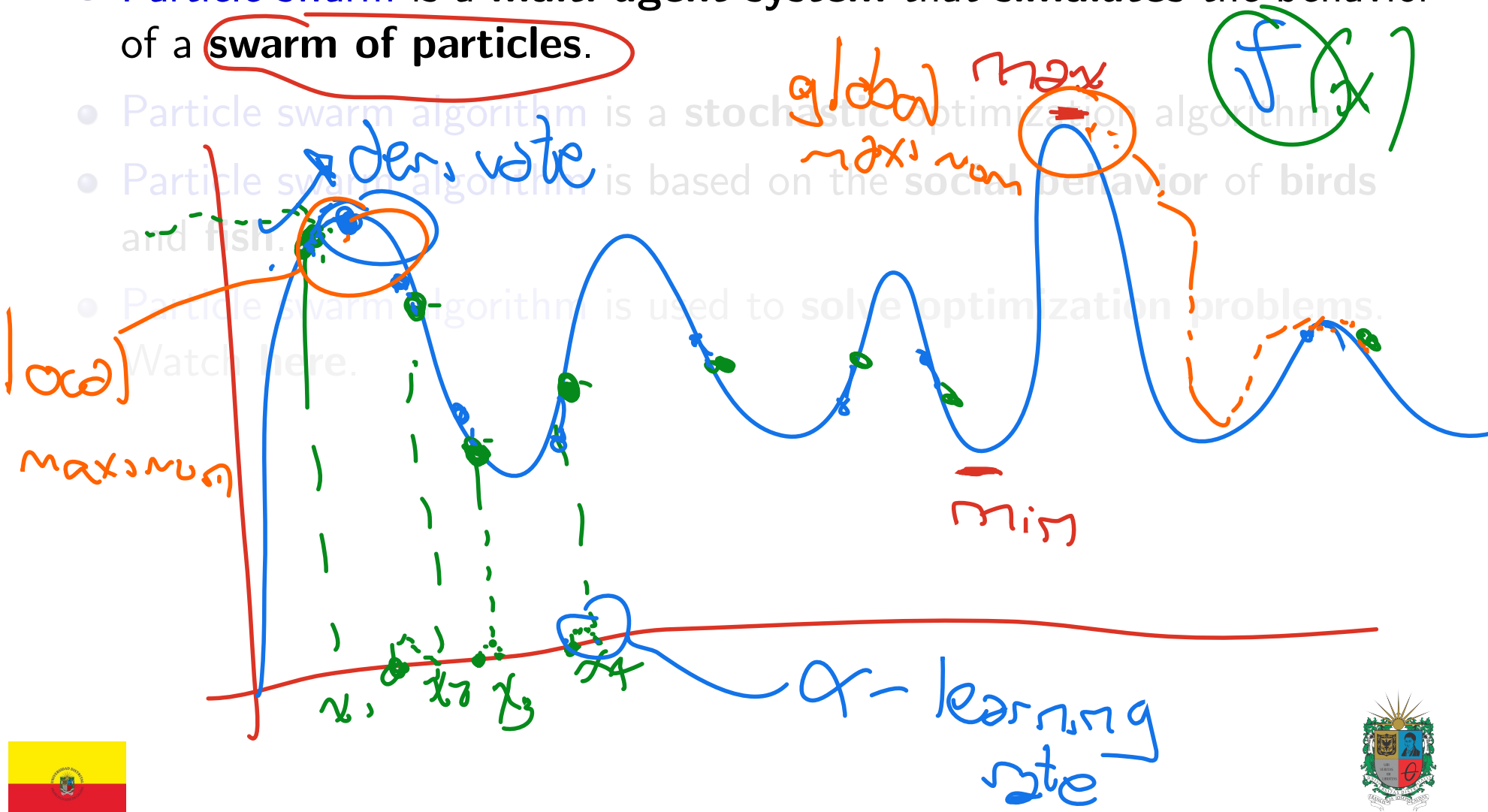

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- Particle swarm algorithm is a **stochastic** optimization algorithm.
- Particle swarm algorithm is based on the **social behavior** of **birds** and **fish**.
- Particle swarm algorithm is used to **solve optimization problems**. Watch **here**.

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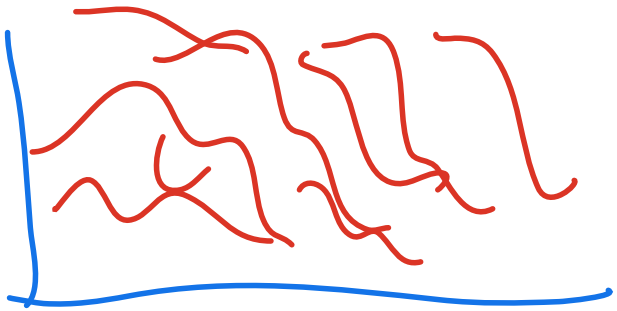
PSO ⇒ Particle Swarm Optimization



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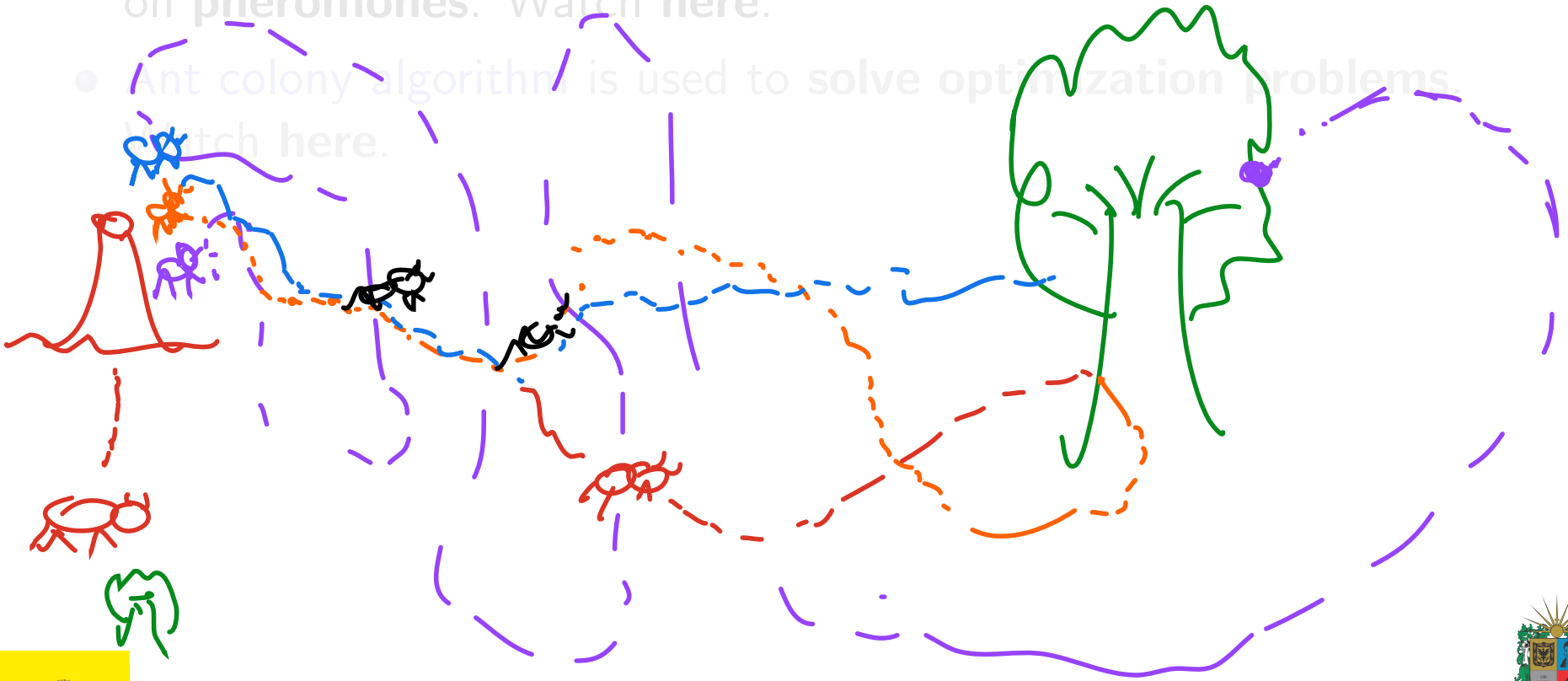

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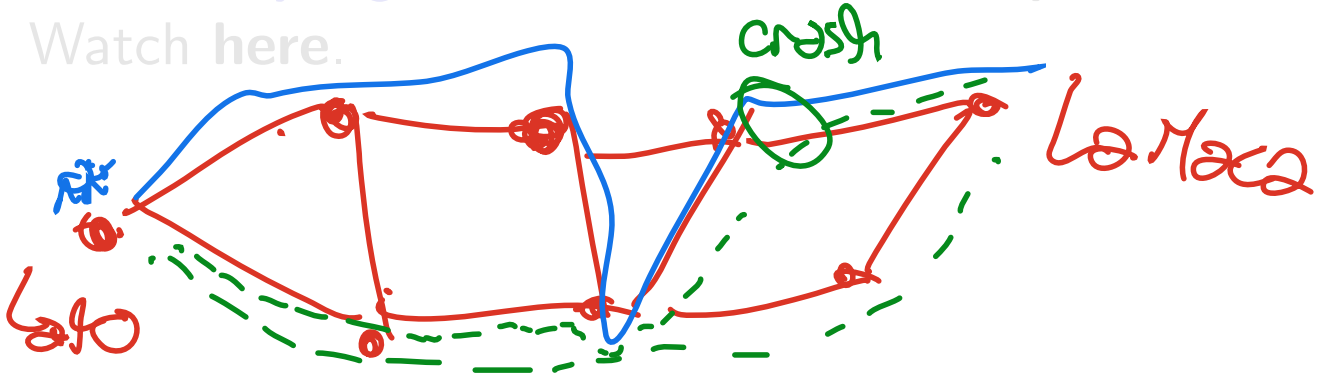

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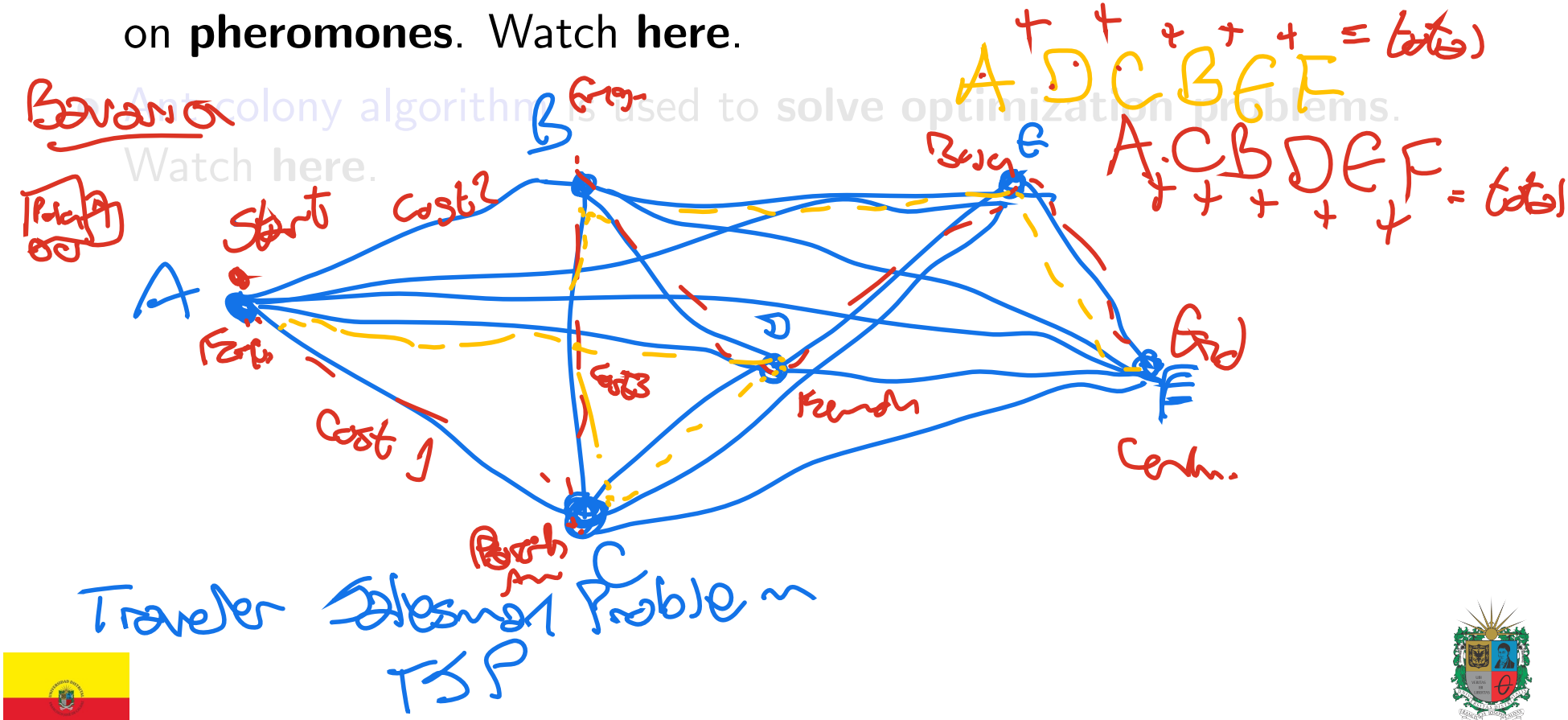

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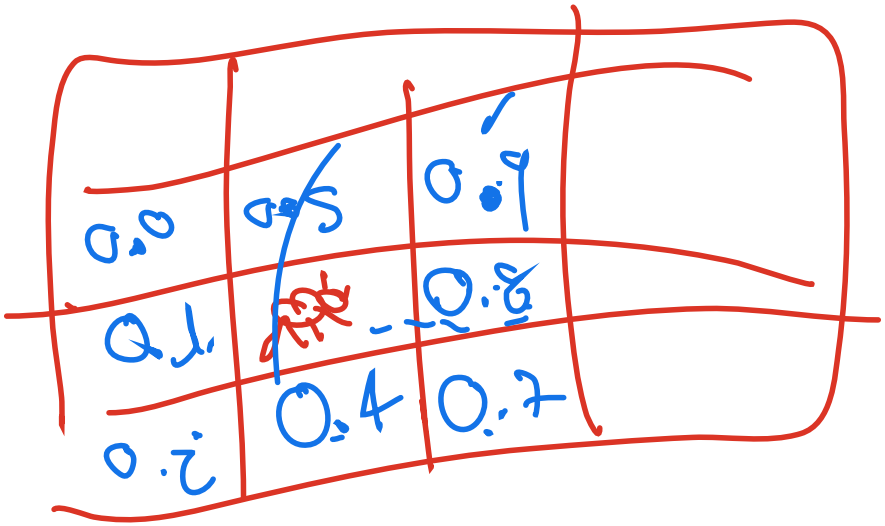

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Questions?

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

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