AUTONOMUS AGENTS AND MULTI-AGENT SYSTEMS
INTRODUCTION

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Lukas Esterle I lukas.esterle@ece.au.dk

LECTURER – MIRGITA FRASHERI

Background:

- Bsc.+Msc. In Computer Engineering, Polytechnic University of Tirana, Albania
- PhD in Computer Science, Mälardalen University, Västerås, Sweden
- Postdoc, Digital Twins, Aarhus University
- Assistant Prof @Software Engineering &Computing Systems

Research interests: *autonomous agents and multi-agent systems, self-organisation, agent/robot collaboration, digital twins and co-simulation, ethics in AI &MAS*

LECTURER - LUKAS ESTERLE

- Associate Professor

- MSc in Computer Science
  at Alpen-Adria University Klagenfurt, Austria
- Dr.–techn. (PhD) in Information Technology
  at Alpen-Adria University Klagenfurt, Austria

- Post-doc at TU Vienna, Austria

- Marie-Skłodowska Curie Fellow
  at the University of Birmingham and Aston University, UK

  Interests: *Autonomous agents and multi-agent systems, self-adaptation, self-organisation and self-awareness Visual Sensor Networks,* Computer games.

WHAT DO YOU THINK THE COURSE IS ABOUT?

MENTIMETER TIME

Go to: https://www.menti.com/

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LEARNING OUTCOMES

- Describe what a multi-agent system is, and the main architectures used to design such systems.
- Interpret the benefits and drawbacks of the different nature inspired algorithms used to achieve self-organisation in multi-agent systems.
- Explain and compare different planning approaches used to coordinate the activities and interactions of agents in the system.
- Interpret how machine learning techniques can be used in an autonomous agents and multi-agent system context.
- Implement and evaluate an architecture and relevant techniques to realise a multi-robot system able to achieve a simple common task.

FOR WHAT COULD MAS BE USED IN/ FOR?

MENTIMETER TIME

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MOTIVATION

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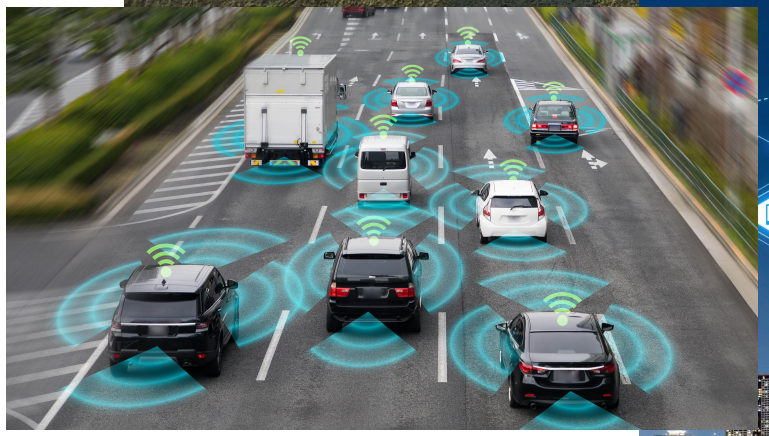

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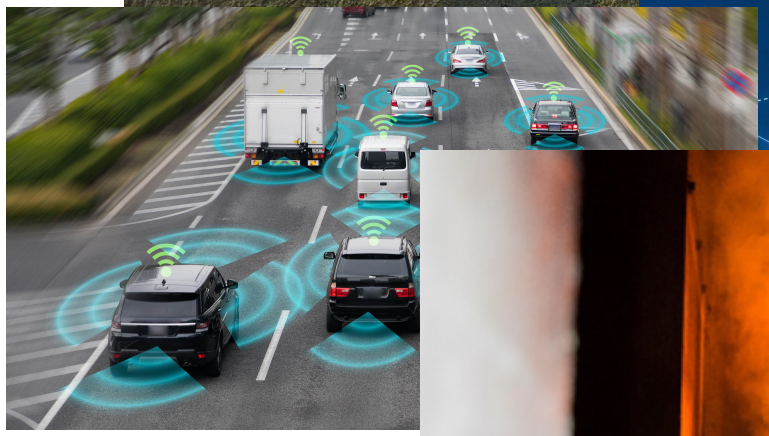

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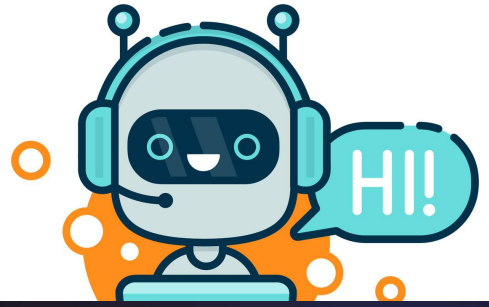

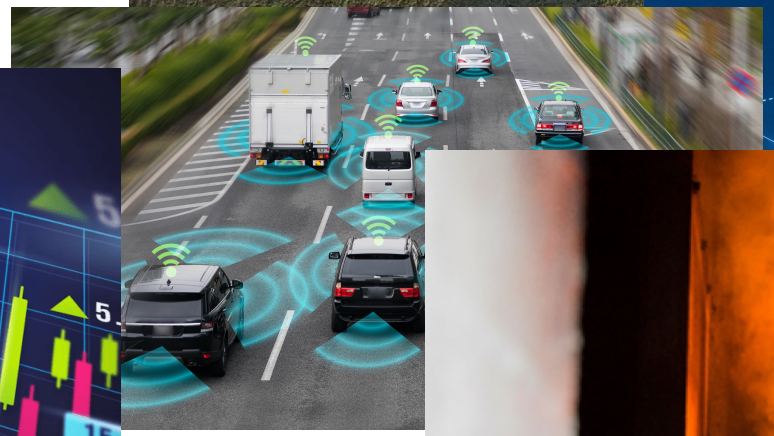

MOTIVATION

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LITERATURE

- An introduction to multi-agent systems – M. Wooldridge
- Scientific (peer-reviewed) Papers

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- An introduction to multi-agent systems – M. Wooldridge
- Scientific (peer-reviewed) Papers
- Be proactive if some particular topic interests you!

COURSE STRUCTURE

- Lectures
  - Either Lukas or I will go over one of the topics
  - Small exercises after each lecture

- Self-study (is not time off :))
  - Work on your own for the exercises and assignments

- Every other week we will have an exam prep (~30min)
  - In groups
  - Random questions on the course material, explain to one another

COURSE STRUCTURE

- chatGPT: the good, the bad, and the ugly

GRADING

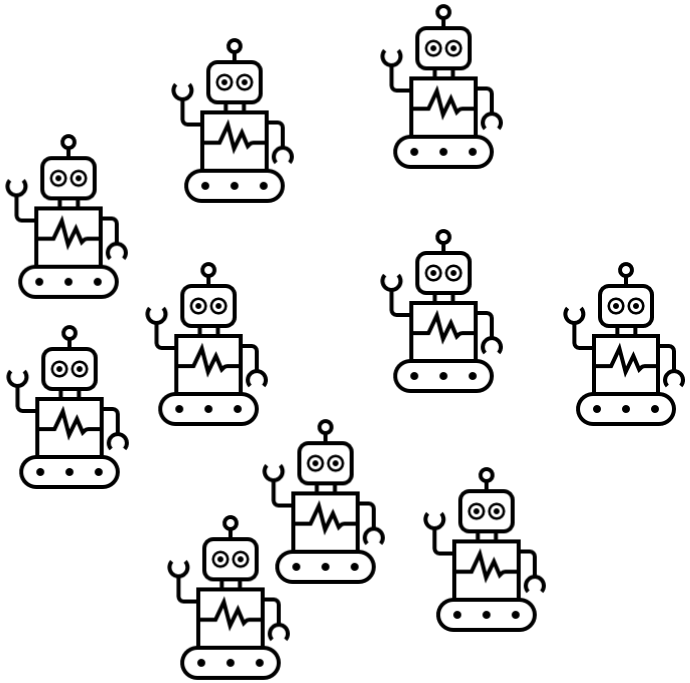
- 3 mandatory assignments
- You can come to the exam **only if you have passed** all 3 assignments
- Final exam
  - Oral
  - Individual
  - 7-point grading scale

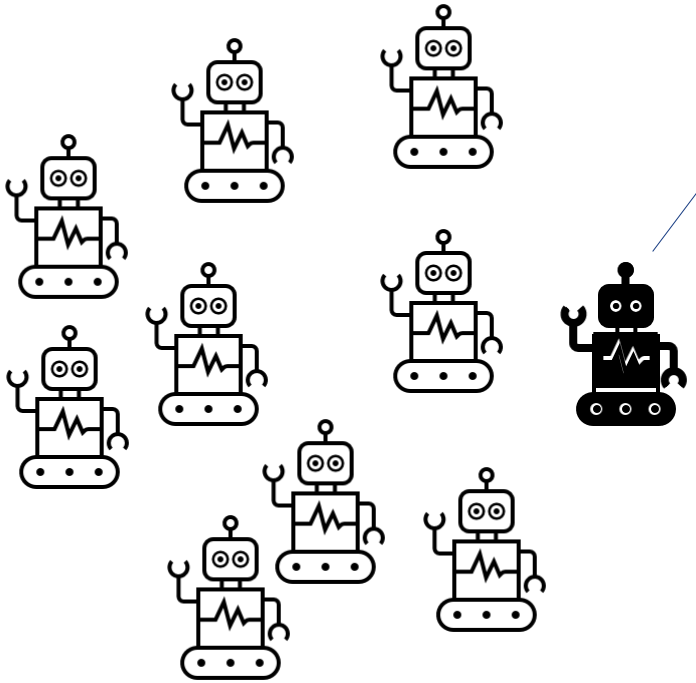
TIMELINE

Week 1- Introduction (GITA)	Week 8 – Planning (GITA)
Week 2 – Architectures (LUKAS)	Week 9 – *Assignment (no lecture)*
Week 3 – Reasoning (GITA)	*Week 10* – MARL (LUKAS)
Week 4 – *Assignment (no lecture)*	Week 11 – *Self-study (no lecture)*
Week 5 – MAS and nature-inspired approaches (LUKAS)	Week 12 – DL and MADL (LUKAS)
Week 6 – *Assignment (no lecture)*	*Week 13 – Assignment (no lecture)*
Week 7 – Coordination (GITA)	*Week 14 – Assignment (no lecture → presentations / demos)*

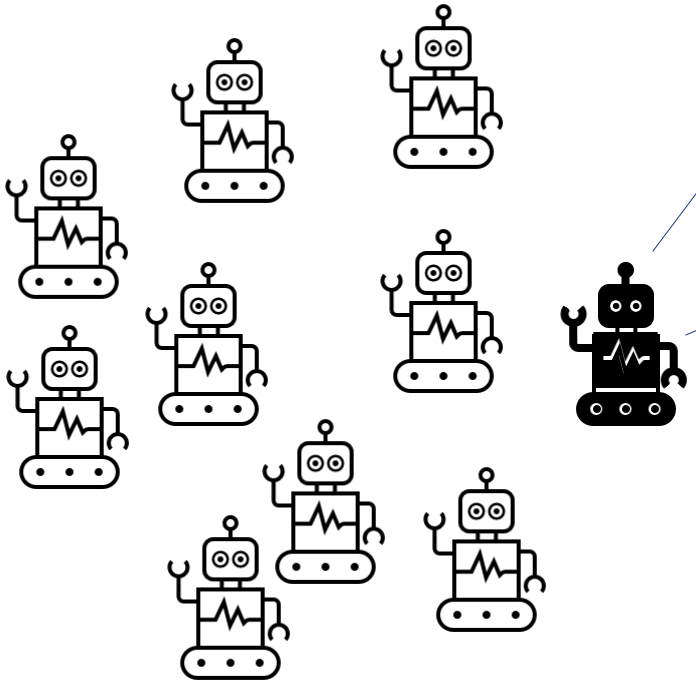
LAB RULES – 5MIN

INTRO TO AGENTS





An agent is a computer system that is situated in some environment, and that is capable of autonomous action in this environment in order to meet its delegated/self-imposed objectives.



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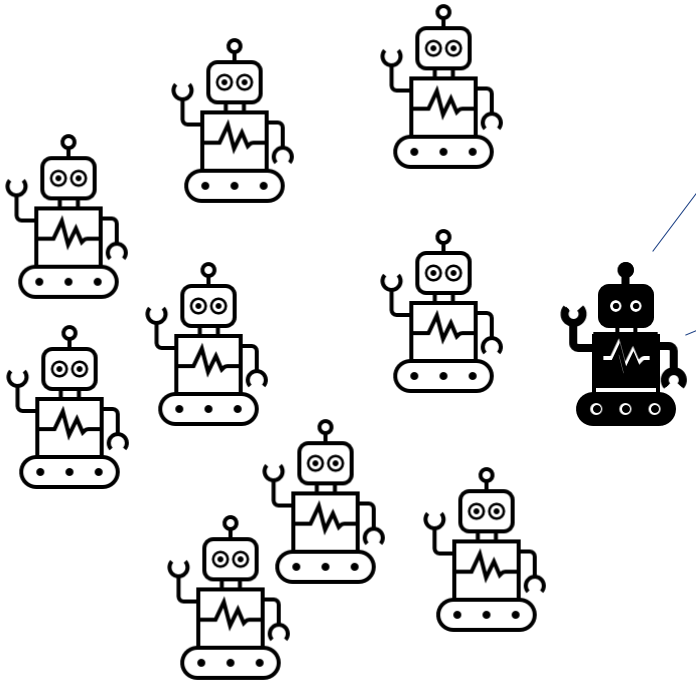
Environment: real or virtual



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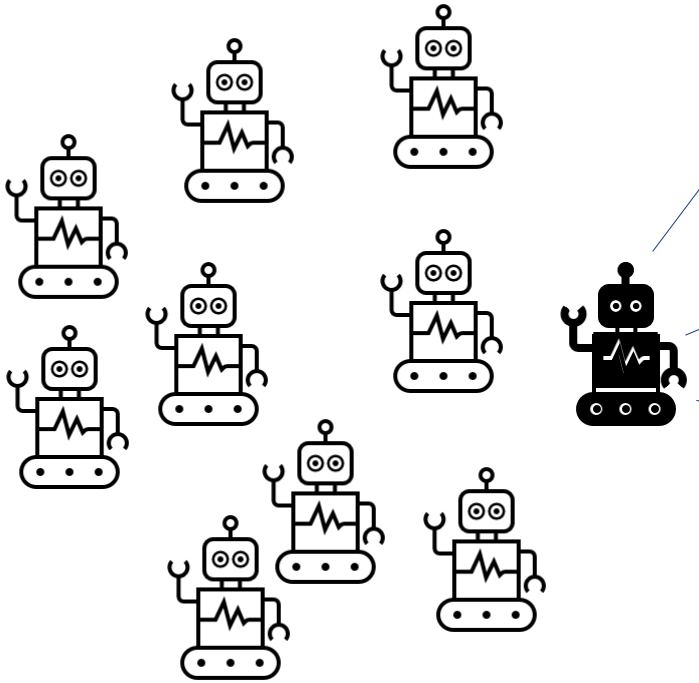
Environment: real or virtual

Agent: physical or not



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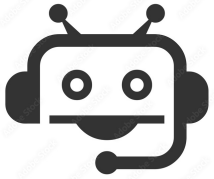


CHATBOT

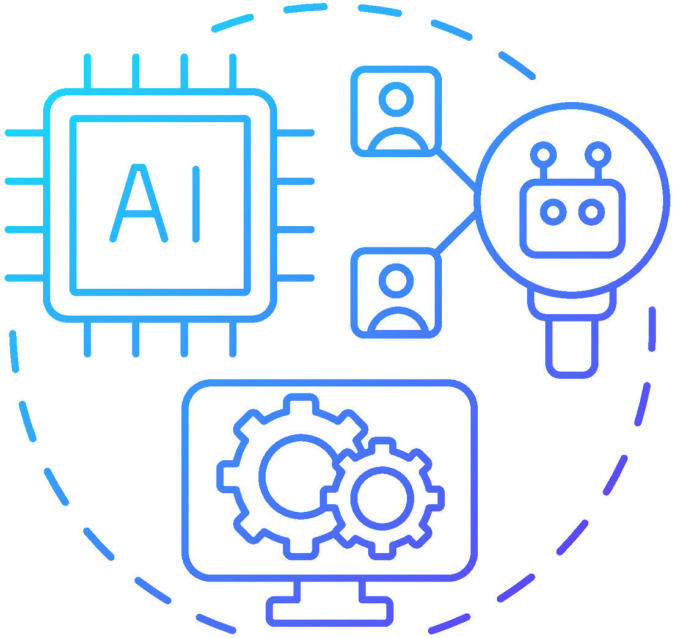
AGENTS VS OTHER THINGS

AGENTS VS OBJECTS

AGENTS VS OBJECTS

- **Autonomy**
- Common goal?

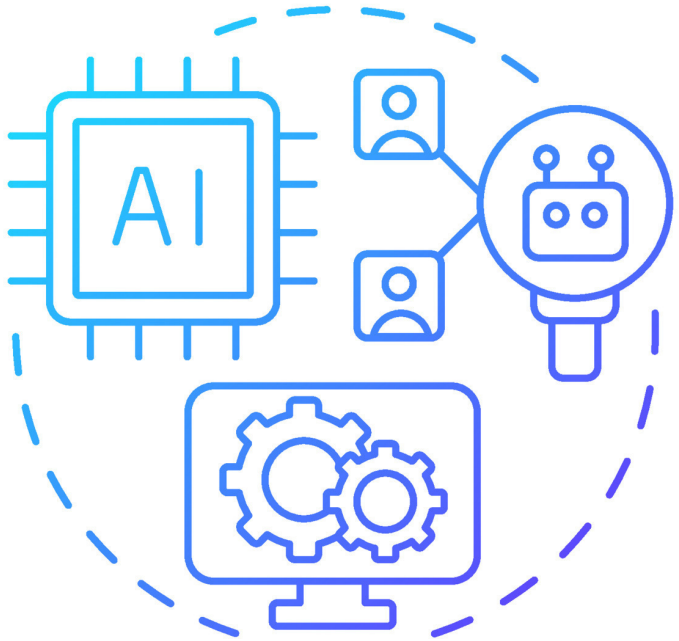
AGENTS VS EXPERT SYSTEMS



EXPERT SYSTEMS

AGENTS VS EXPERT SYSTEMS

- Interaction with the environment
- Common goal



EXPERT SYSTEMS

AGENTS VS DISTRIBUTED SYSTEMS

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- **Autonomy** (no hardwired coordination)

- Self-interest (common goal?)

AGENTS VS AI

AGENTS VS AI

- Intelligence
  - AI: components (learn, plan, vision…)
  - Agents: integration

- **Sociality**
  - Integral in agent research

AGENTS VS GAME THEORY

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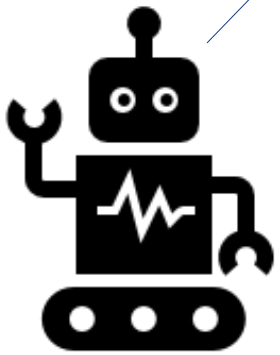
- GT: descriptive
- Rationality assumption

AGENTS VS SOCIAL SCIENCE

- A useful tool for studying human societies

MAIN CHARACTERISTICS

WHAT DOES IT MEAN TO BE AUTONOMOUS



Autonomy

WHAT DOES IT MEAN TO BE AUTONOMOUS?

- Autonomy levels (Parasuraman, self-driving cars)
- Self-sufficiency
- Self-directedness
- Dependence theory (Castelfranchi)

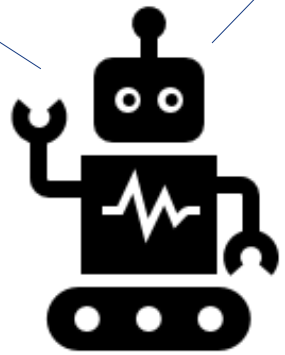
WHAT DOES IT MEAN TO BE AUTONOMOUS?

- Dependence theory (Castelfranchi)
  - Flexible concept
  - It depends on the task, time, who etc.

WHAT DOES IT MEAN TO BE AUTONOMOUS

Social behaviour

Autonomy



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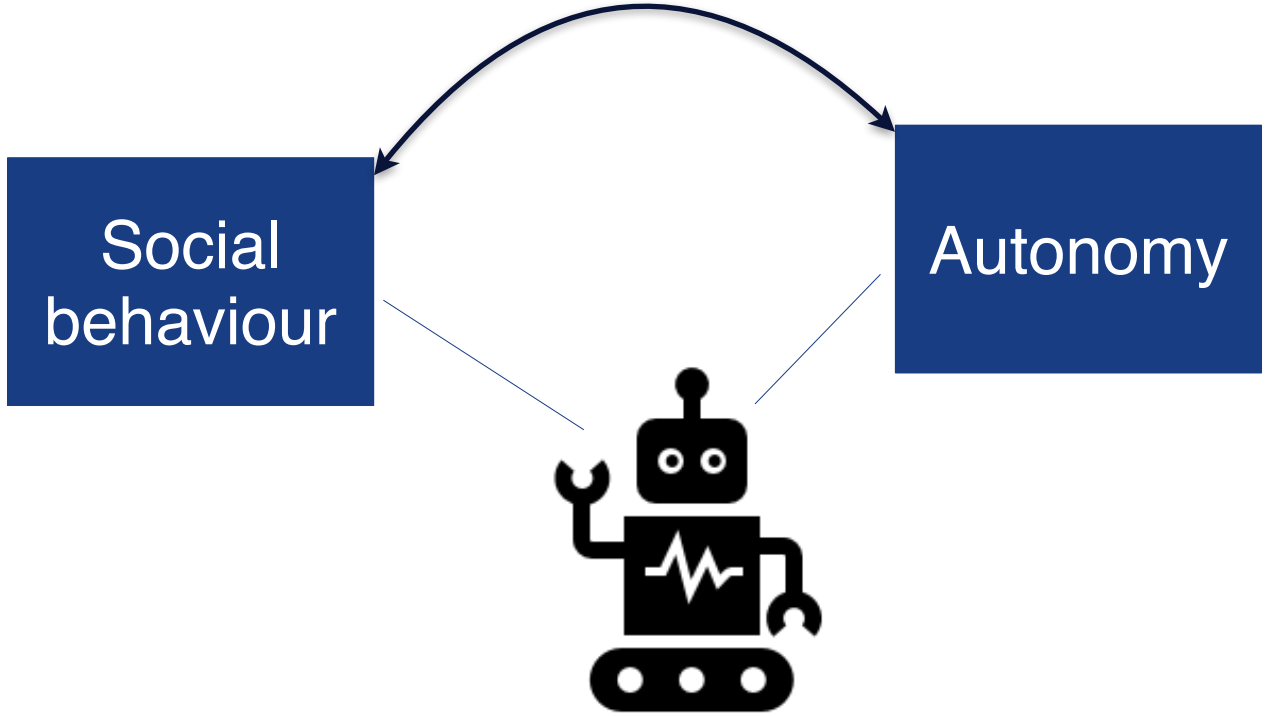
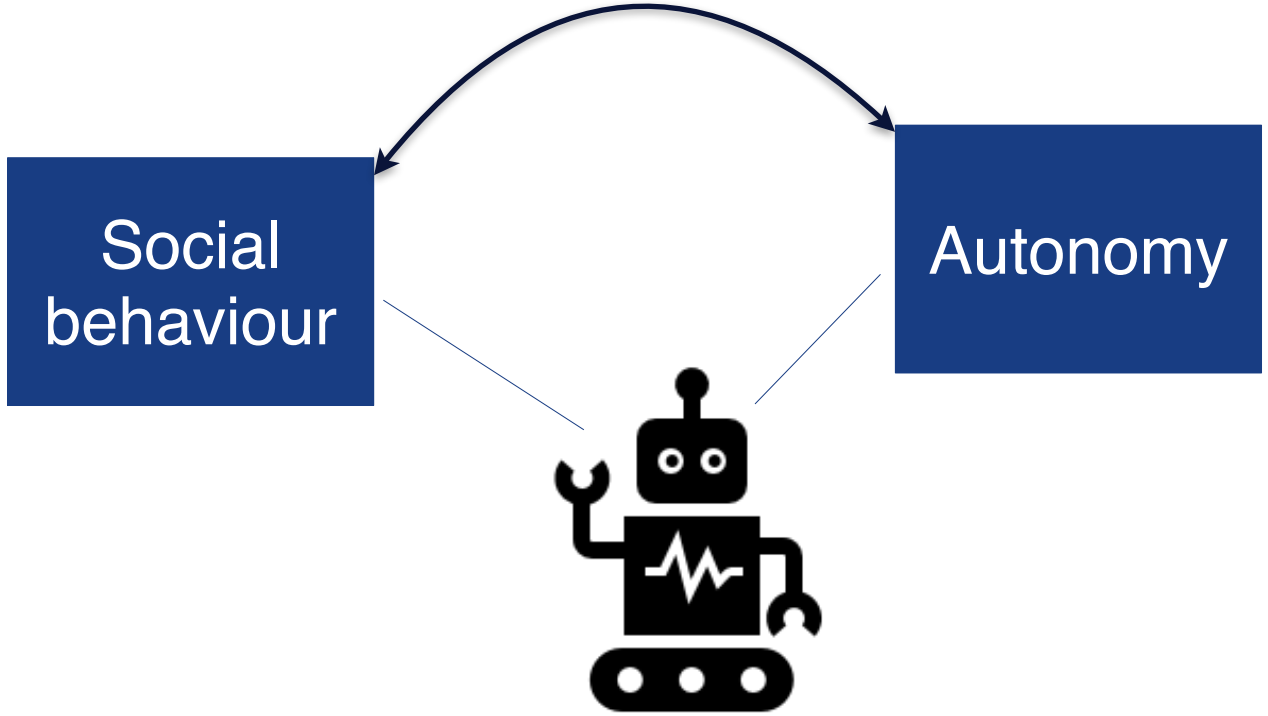


HOW CAN WE MODEL IT?



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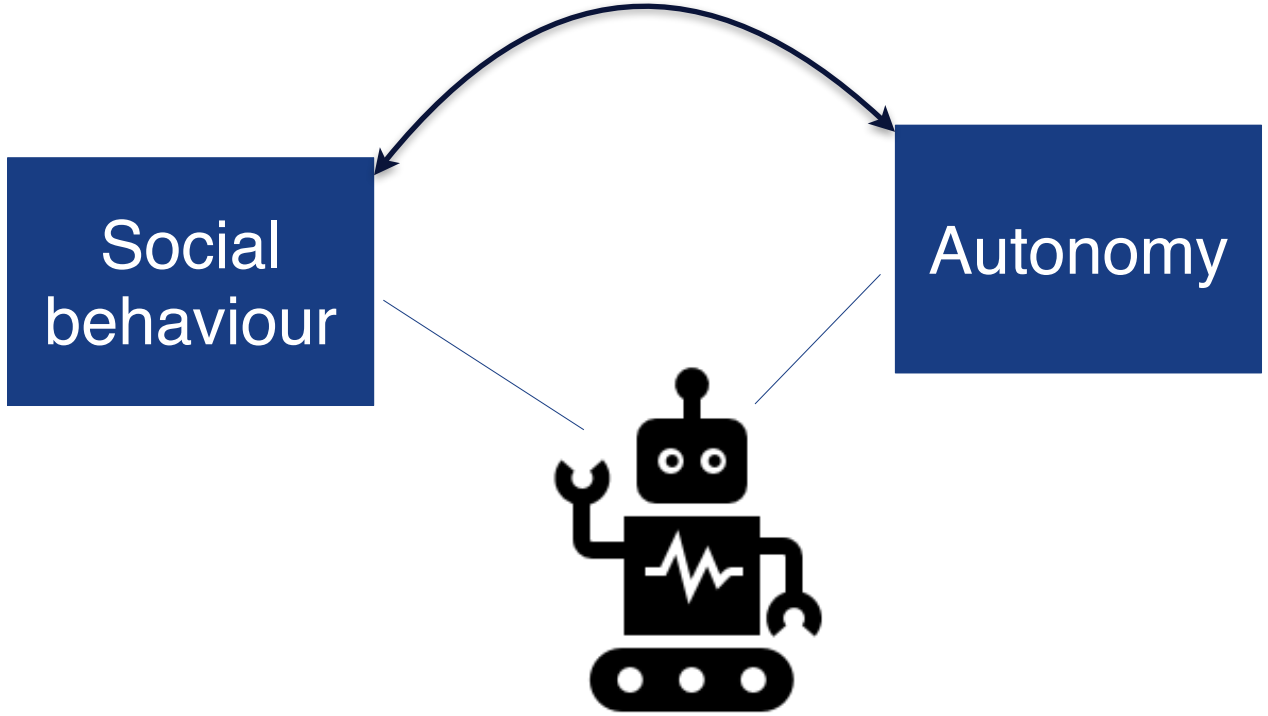
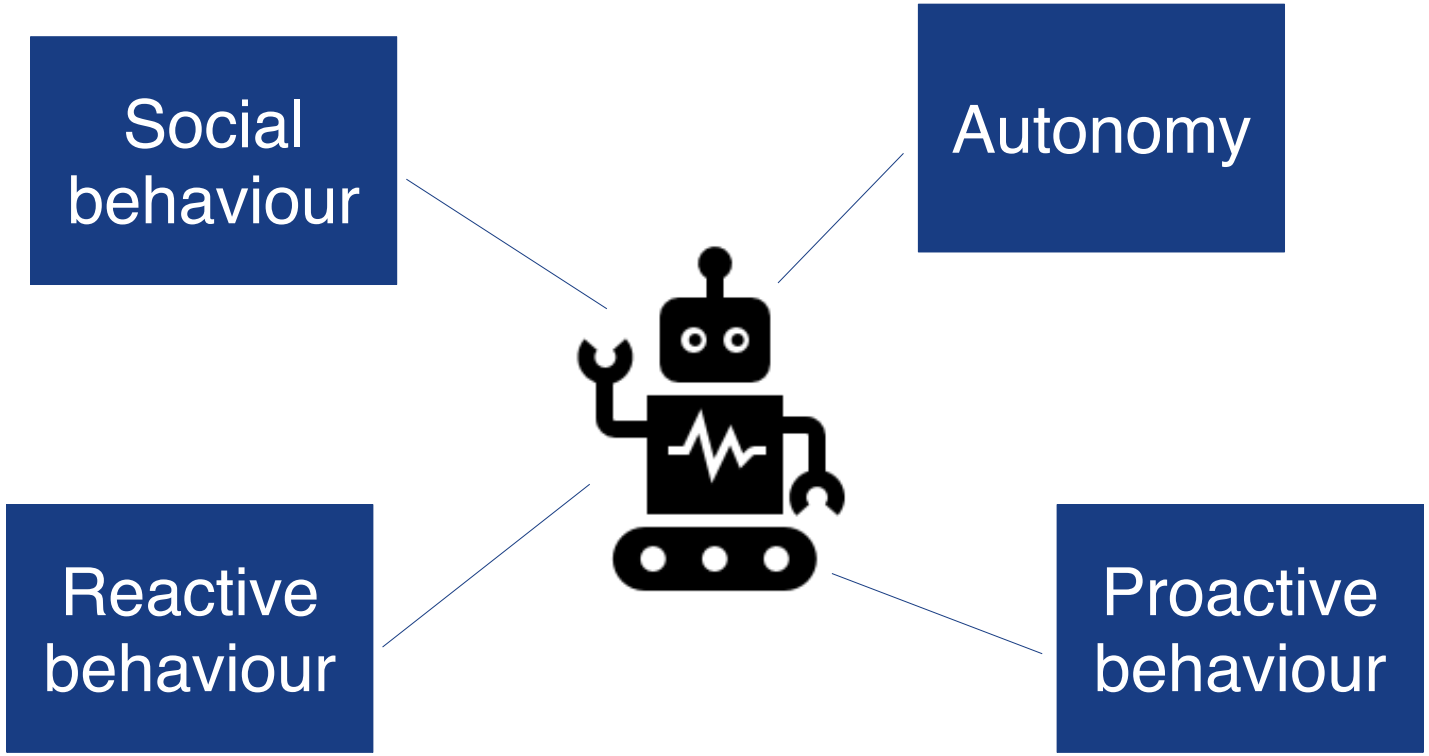
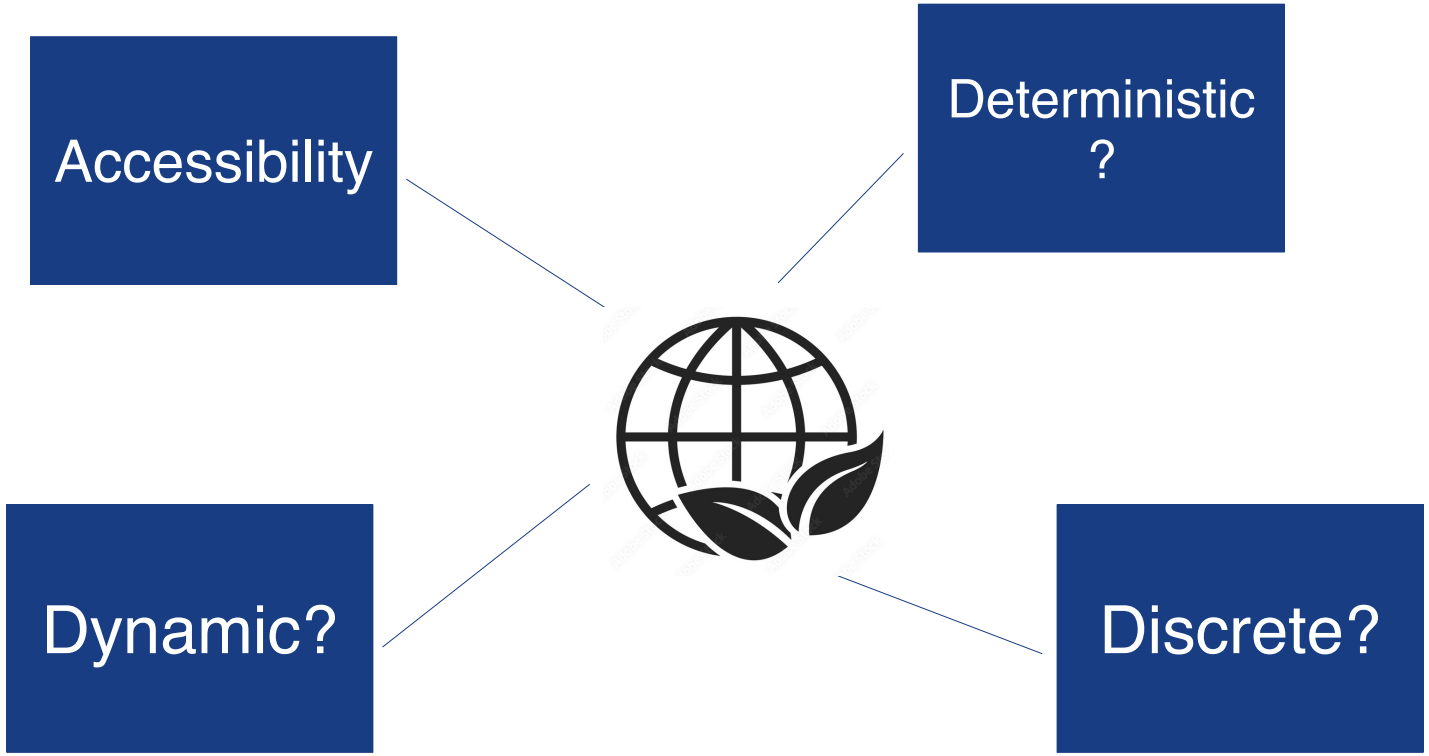


Willingness to interact (who to help and who to ask for help)?

AGENT PROPERTIES



THE ENVIRONMENT



UTILITY FUNCTIONS

- Quantifying the performance

UTILITY FUNCTIONS

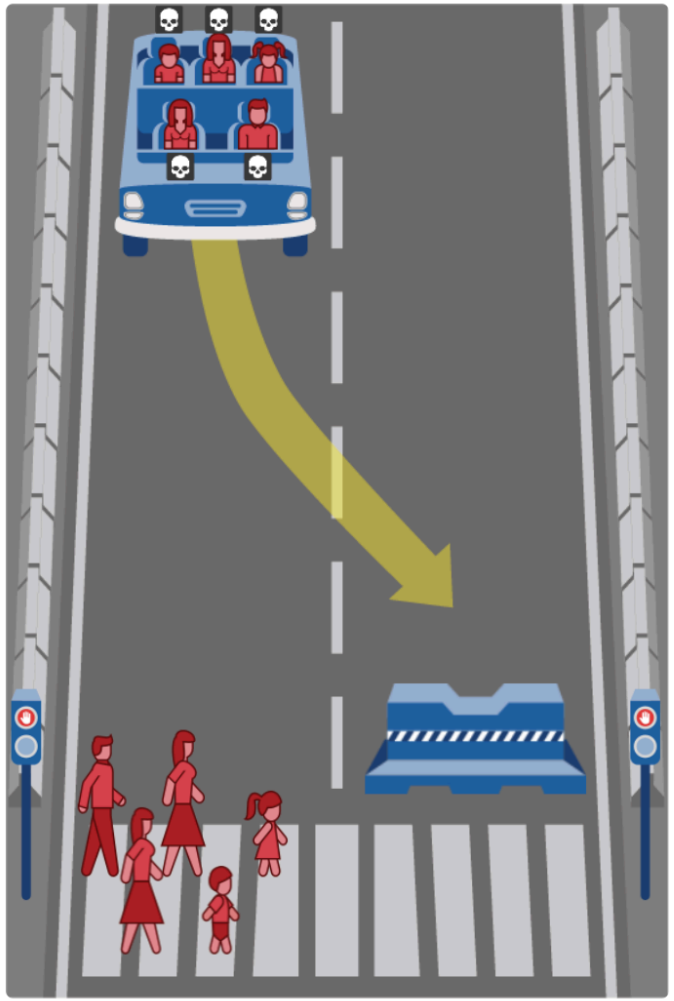
- Quantifying the performance
  - Over states in a run
  - Over runs
- Success criteria in a given environment?

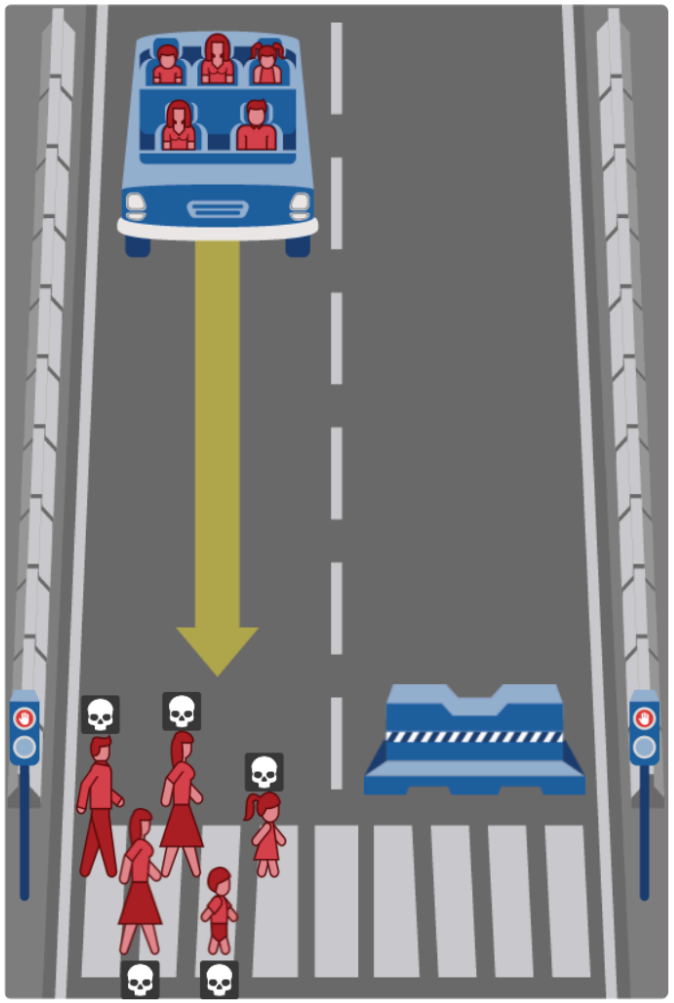
ETHICS IN AI &MAS

KEEP IN MIND

KEEP IN MIND

https://www.moralmachine.net/





ETHICS OF 1 AGENT?

Go to: https://www.menti.com/

Enter code: 8588 8557

ETHICS OF A GROUP OF AGENTS?

Go to: https://www.menti.com/

Enter code: 8588 8557

KEEP IN MIND

- How are agents/AI making these decisions?
  - Bias (e.g., used by employers)
  - Criticality (e.g., autonomous drones in warfare)
  - Data privacy &Transparency (e.g., think twice before sharing your secrets with chatGPT)
  - Regulations, e.g., AI Act (in theory, and practice)

ROBOTS AND SIMULATORS

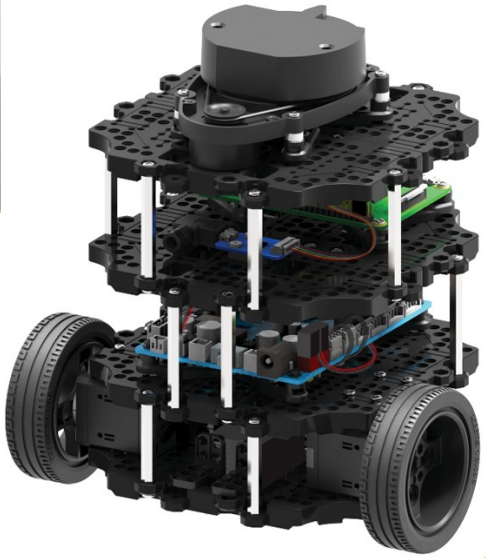
THE PRACTICAL SIDE

- The main simulator to use

  https://github.com/hanruihua/ir-sim

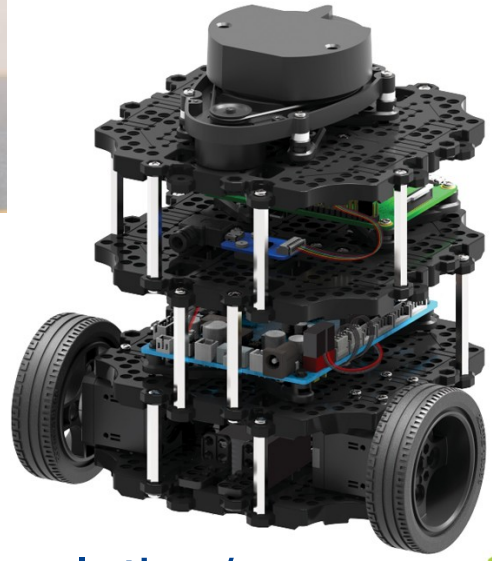
THE PRACTICAL SIDE

- The robots



THE PRACTICAL SIDE

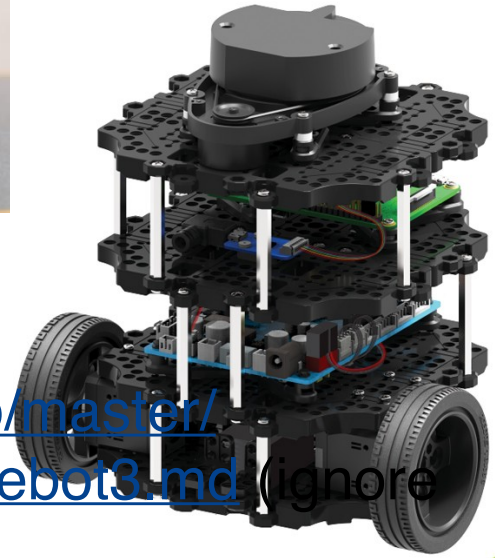
- The robots



- The simulators
  - https://f1tenth.org/build.html
  - https://emanual.robotis.com/docs/en/platform/turtlebot3/simulation/

THE PRACTICAL SIDE

- The robots



- Guides
  - https://github.com/gitting-around/swrob-01-Exercises/blob/master/Matlab%20and%20ROS/ExerciseGettingStartedWithTurtlebot3.md (ignore the camera and matlab parts)

HOW TO START

TODAY’S JOB

- Find your team (Groups of 3 or 4, and no more)
- Install the simulator
- Try out the examples shown on GitHub
- Investigate how you can:
  - Add custom behaviour to your agent
  - Create groups of agents with different characteristics
  - Make agents communicate