Finanziato dall'Unione europea
NextGenerationEU

Ministero dell'Università e della Ricerca

Italiadomani
PIANO NAZIONALE DI RIPRESA E RESILIENZA

Future Artificial Intelligence Research

Spoke 4
Adaptive AI

Nicola Gatti

Politecnico di Milano

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Future Artificial Intelligence Research

People

POLITECNICO MILANO 1863

Scientific Sector	Critical mass	RTDA
Computer engineering	16	6
Control engineering	3	1
Bioengineering	2	1
Mathematical engineering	2	1
Philosophy	1	1
Electronic engineering	1	
Energy engineering	1	
Computer science	1	

Bocconi

Scientific Sector	Critical mass	RTDA
Theoretical physics	2	1
Statistics	1	1
Economic statistics	1	
Bioengineering	1	

osservatori.net digital innovation

Market research and trends

POLIHUB STARTUP DISTRICT & INCUBATOR

Entrepreneurship (TRL 5 — 9)

AIRIC | POLITECNICO MILANO 1863

Artificial Intelligence Research and Innovation Center

Applied research (TRL 3 — 5)

ellis | MILAN

European Laboratory for Learning and Intelligent Systems

Foundational research (TRL 1 — 3)

UNIVERSITÀ DEGLI STUDI DI MILANO BICOCCA

AI Seminars: 2023

- 22 seminars in 2023 (one seminar every 2 weeks)
- speakers: every researcher working in/with AI
- guest speakers: MIT, Cambridge, Pompeu Fabra
- open to: students, PhDs, industries
- >100 physical attendees per seminar
- online streaming on YouTube channel

Adaptive AI

Adaptivity The algorithm changes its behavior

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Why? Several reasons

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agent level

agent level: the agent's goals change or new information is collected

Adaptive AI

Adaptivity The algorithm changes its behavior

Why? Several reasons

agent level

Online learning

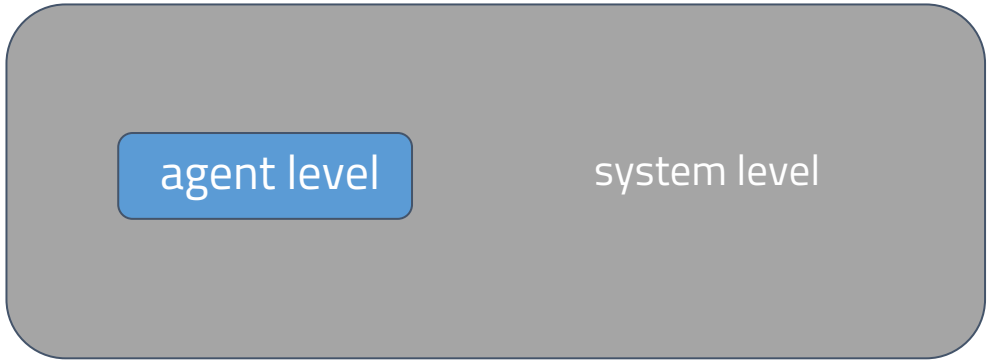
- The learner collects information during its execution
- *Exploration* and *exploitation* are simultaneous
- The learner adapts its decision to the acquired information dealing with uncertainty
- Applications: *advertising*, *pricing*

agent level: the agent's goals change or new information is collected

Adaptive AI

Adaptivity The algorithm changes its behavior

Why? Several reasons



agent level: the agent's goals change or new information is collected

system level: the performance of the system is degrading

Adaptive AI

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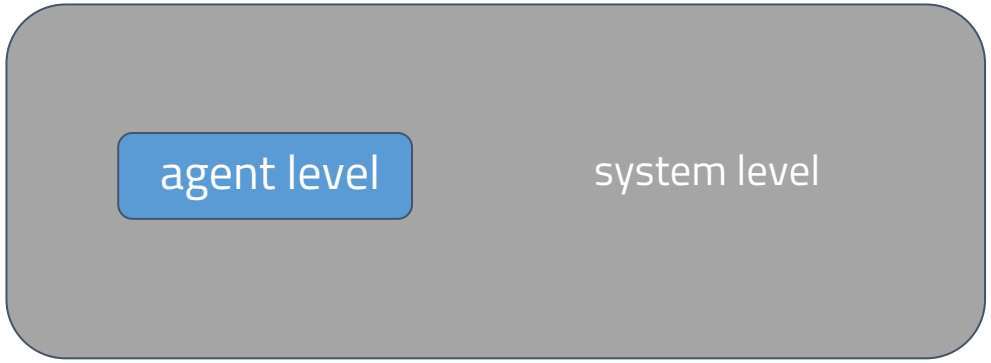

Adaptive maintenance

- The system functioning may degrade at operation time
- *The algorithm aims at correcting the system change*
- In other case, the system can use a different hardware
- Applications: *manufacturing*

agent level: the agent's goals change or new information is collected

system level: the performance of the system is degrading

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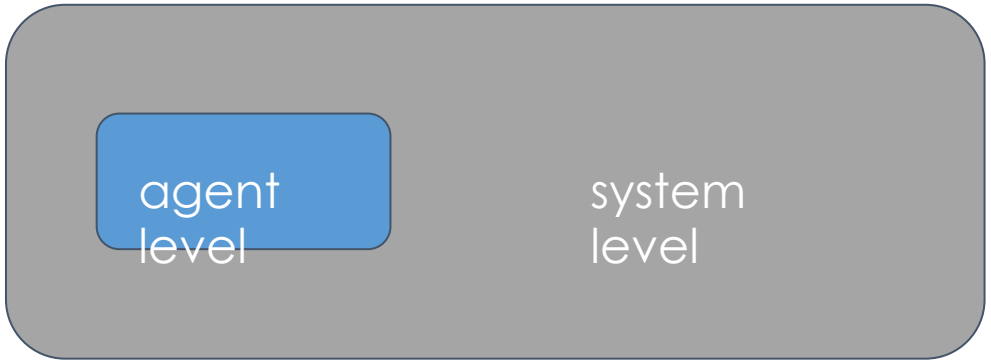

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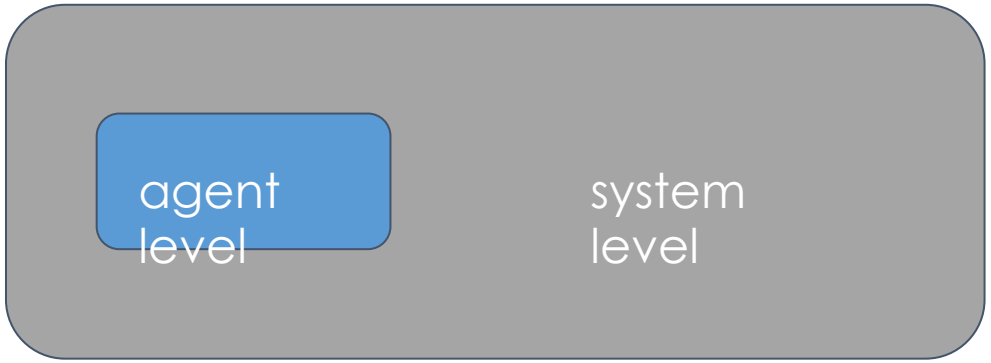

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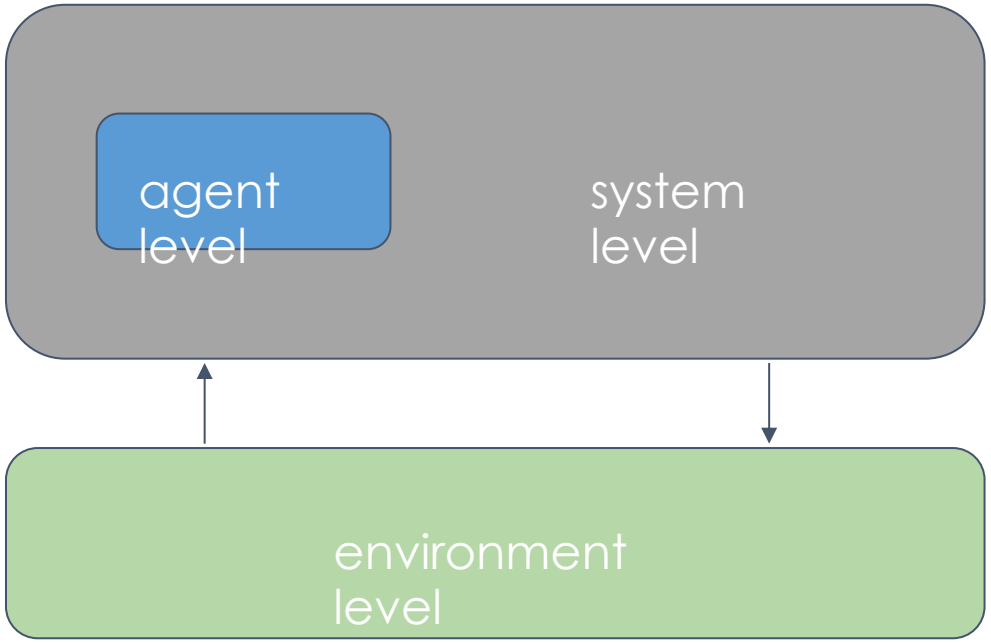

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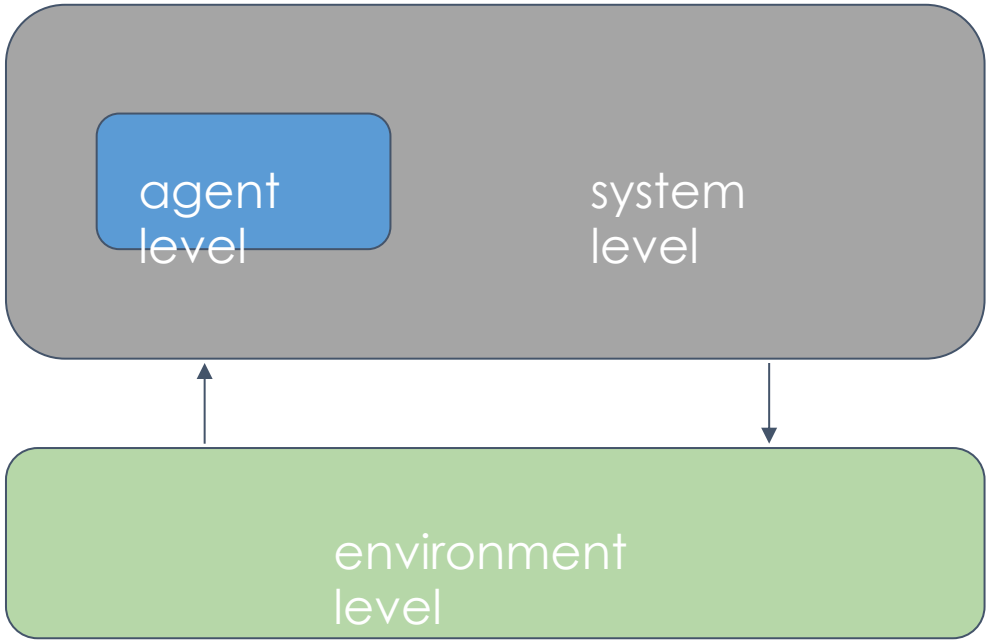

Stochastic environment

Forecasting

- The environment can change
- *New state prediction*
- Applications: *time-series, trading*

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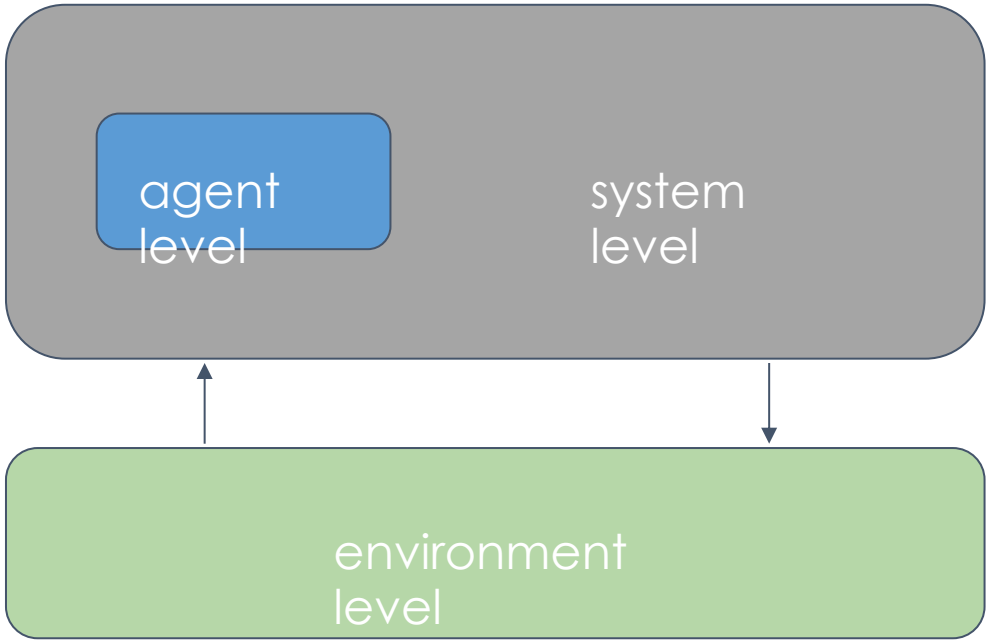


Stochastic environment

Forecasting

- The environment can change
- *New state prediction*
- Applications: *time-series, trading*

Adversarial environment

Strategic interaction

- Multiple agents play simultaneously
- *Optimal strategy*
- Applications: *real-time bidding, games*

agent level: the agent's goals change or new information is collected

system level: the performance of the system is degrading

environment level: the environment changes

Robust Adaptive AI

Adaptivity

↓

Dynamics

↓

Properties

Robust Adaptive AI

Adaptivity

↓

Dynamics

↓

Properties

- **Convergence**
- **Speed**
- **Constraints**

- **Last-iterate**
- **On average**
- **With high probability**

- **Regret bounds**

- **Decentralized dynamics**
- **Distributed dynamics**
- **Centralized dynamics**

- **Communication**

- **Physics-based models**
- **Approximating dynamics**
- **Surrogate models**
- **Overparameterized**

Robust Adaptive AI

Adaptivity → Dynamics → Properties

Properties:
- Convergence
- Speed
- Constraints

- Last-iterate
- On average
- With high probability

- Regret bounds

- Decentralized dynamics
- Distributed dynamics
- Centralized dynamics

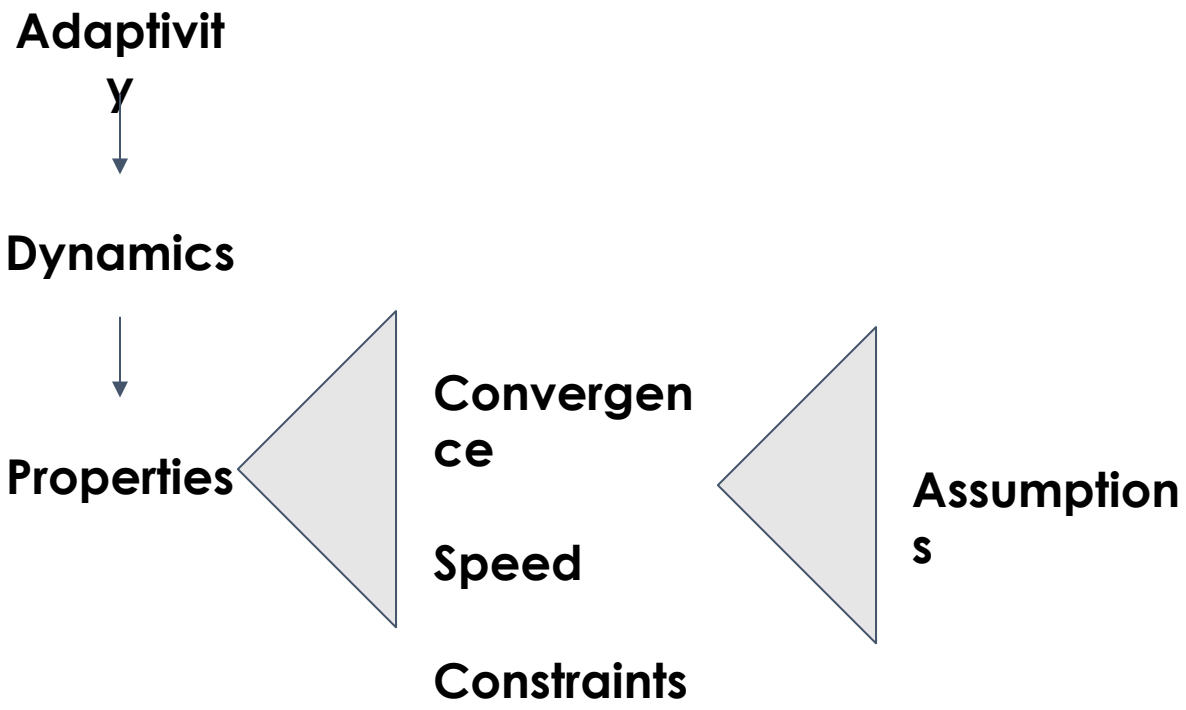
- Communication

- Physics-based models
- Approximating dynamics
- Surrogate models
- Overparameterized

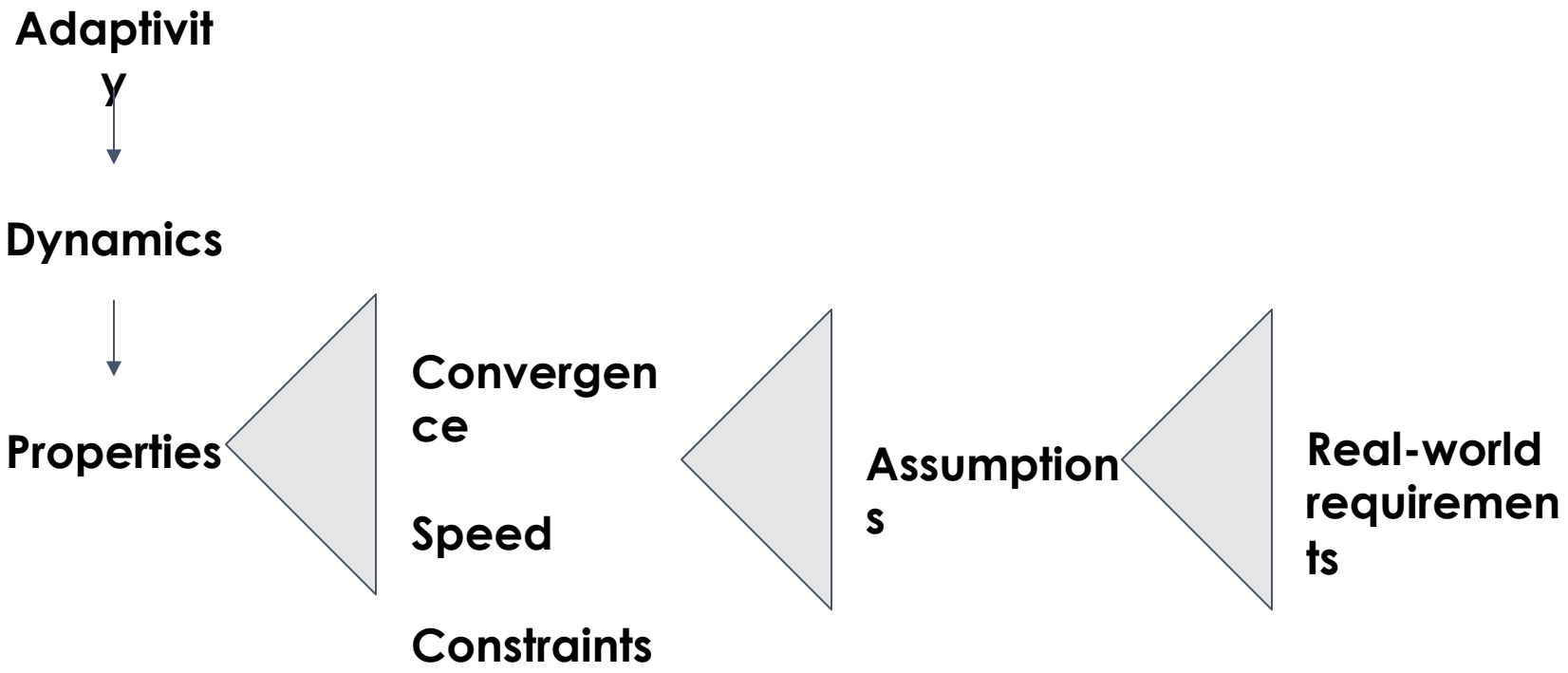
- Reinforcement learning
- Online learning
- Bandit algorithms
- Online convex optimization
- Game theory
- Multi-agent learning
- Deep learning
- Physics-based learning
- Change detection tests

- Computer vision
- Natural language processing

Robust Adaptive AI



Robust Adaptive AI



Foundational questions

Foundational questions

Question 4.1 How to develop a unifying theory of single- and multi-agent adaptivity, where adaptivity at different levels (environment, system, agent) are harmonized?

WP4.1 (Roveri, Dedè, Mezard)

Adaptive algorithms in

WP4.2 (Amigoni, Schiaffonati, Prandini)

Adaptive algorithms in

Foundational questions

Question 4.1 How to develop a unifying theory of single- and multi-agent adaptivity, where adaptivity at different levels (environment, system, agent) are harmonized?

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WP4.3 (Zecchina, Cesa-Bianchi, Restelli)

Overparameterized problems

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Overparameterized problems

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Adaptive algorithms in single-agent setting

WP4.2 (Amigoni, Schiaffonati, Prandini)

Adaptive algorithms in multi-agent setting

WP4.4 (Ceri, Paganoni, Buffa)

WP4.5 (Matera, Boracchi, Matteucci)

Multimodal interaction

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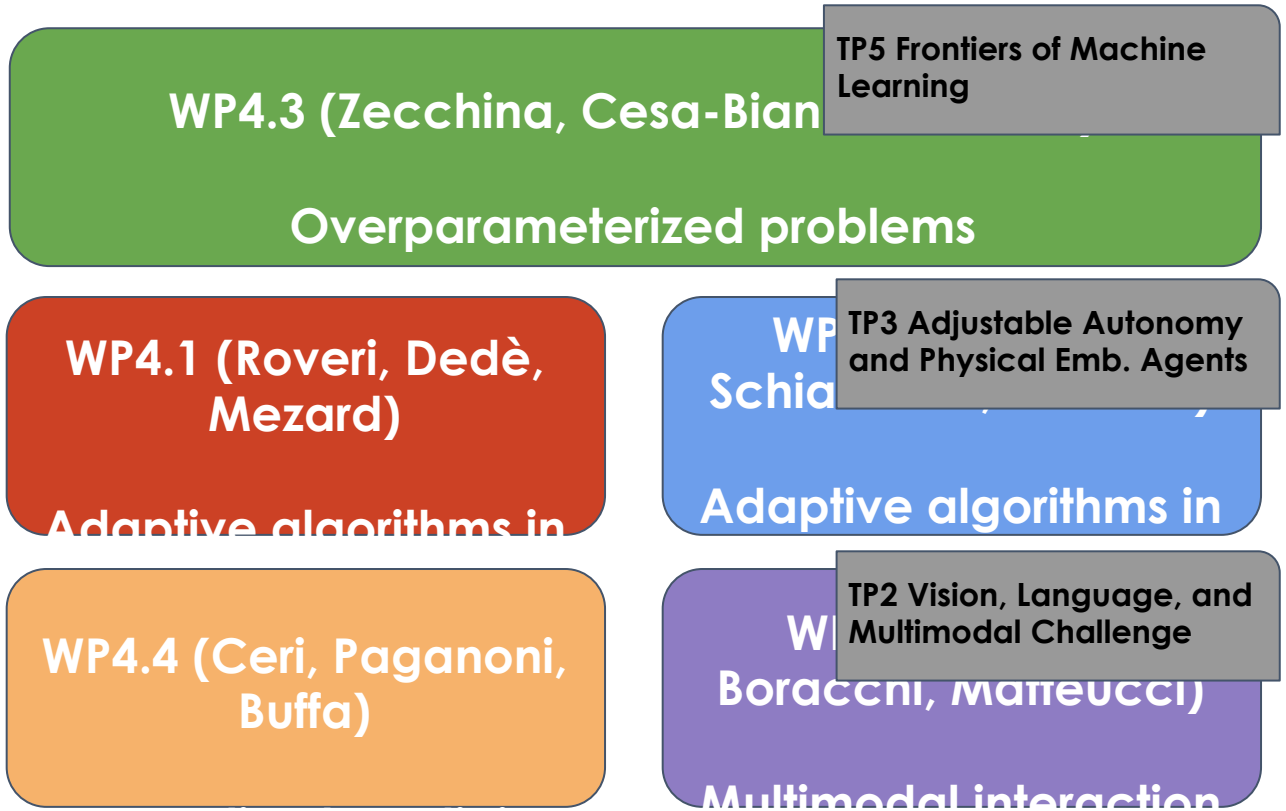
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