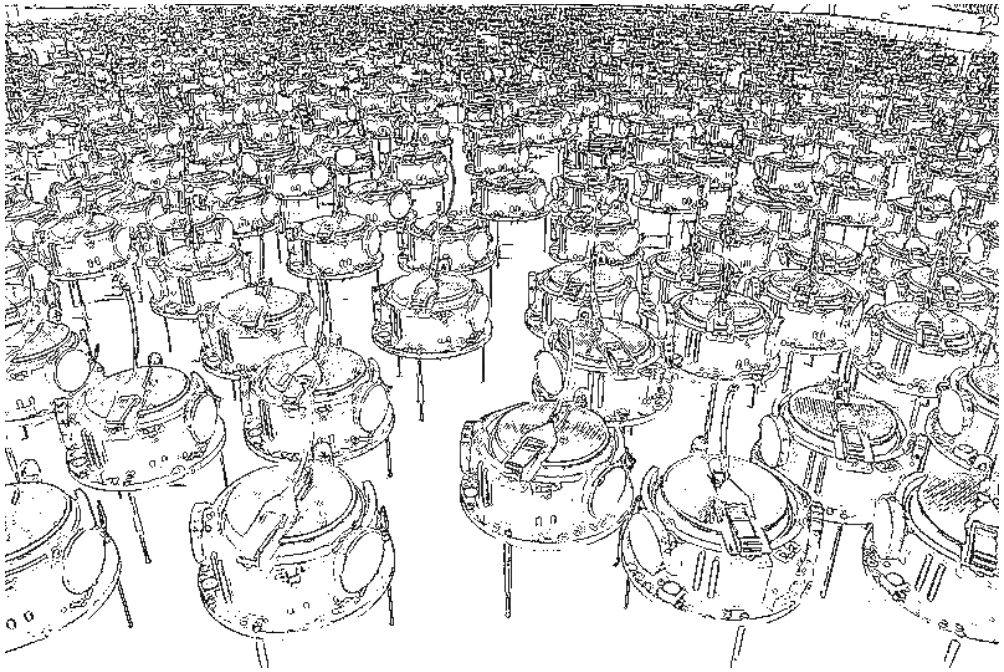
Intelligent Multi Agent Systems



Introduction

Gerhard Neumann

TECHNISCHE UNIVERSITÄT DARMSTADT

Today‘s Agenda

- Organization
- Introduction

Autonomous System Labs @ TUDa

Homepage: http://www.ausy.informatik.tu-darmstadt.de/

Computational Learning for Autonomous Systems (CLAS)

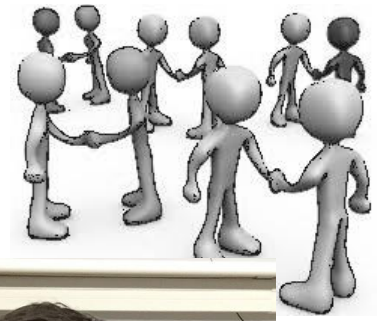
- **Head: Gerhard Neumann (geri@robot-learning.de)**
- Founded in Sept. 2014
- Focus on ***Algorithms for Autonomous Learning Systems, Multi-Agent Systems***

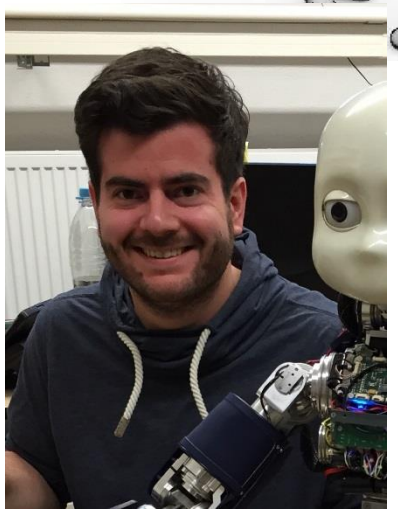
Intelligent Autonomous Systems (IAS)

- **Head: Jan Peters (mail@jan-peters.net)**
- Founded in June 2011
- Focus on ***Robotics and Machine Learning***

15 Team members, 4 international projects, many top publications and awards

Teaching Assistants…





Gregor Gebhardt started his PhD at the Fachgebiet Computational Learning for Autonomous Systems (CLAS) in the beginning of 2015. His research is focusing on non-parametric inference and kernel-based methods.

Oleg Arenz started his PhD at the Fachgebiet Computational Learning for Autonomous Systems (CLAS) in May 2015. His research is focusing on inverse reinforcement learning and learning from human instructions.

Organizational Issues: Website & Moodle

***Website*:**

http://www.ausy.tu-darmstadt.de/Teaching/IntelligentMultiAgentsSystemsLecture

Slides: Password :`Mult1Ag3ntsL3ctur3`, ***User:*** `imas`

***moodle* PW:** `MrSm1th`

Course Language

...will be (Austrian) **ENGLISH**

Why?

- Austrian is beautiful
- Essentially *all* machine learning literature is in English.
- Knowing the proper *terminology* is essential!
- It's a good training for you

- Questions and answers in emails/homework/exams may be given in **German** (However, this is not encouraged...).

Exam & Bonus Points from Homework

There will be a written exam ...

- Approximate date: The week after the end of classes...
- Homework will count as bonus points!
- 80% of Homework = + 1.0 grade

Homework Exercises:

- We only use them for bonus points!
- However, expect that details are asked in the exam.

Homework

There will be **four homework** assignments!

Each assignment will contain

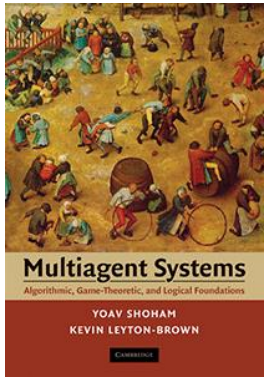
- a few multiple choice questions,
- a few essay questions,
- and programming exercises (Matlab).

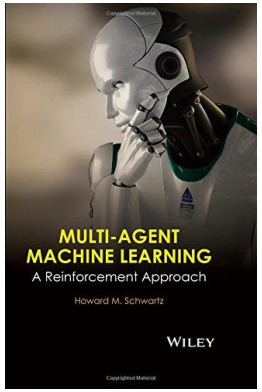
Course Overview

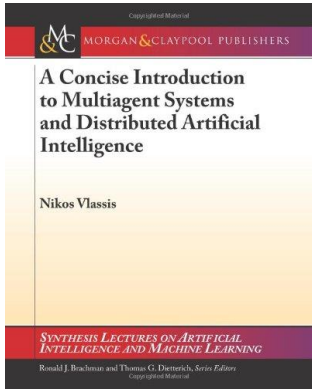
- Introduction, Characteristics, Agents, Utility Theory…
- Game Theory, Nash Equilibria and Other Solution Concepts
- Finding Solution Concepts
- Games in Extensive Form, Sequential Games
- Learning with a Single Agent
- Deep Reinforcement Learning
- Learning with Multiple Agents
- Learning for Games
- Partial Observable Markov Decision Processes (POMDP)
- Decentralized POMDPS
- Swarm Intelligence

Background reading

- **More than half of the lecture will follow 3 books …**
  - *Multi-Agent Systems: Algorithmic, Game-Theoretic, and Logical Foundations (Y. Shoham, K. Leyton-Brown)*
  - *Multi-Agent Machine Learning: A Reinforcement Approach (H. Schwartz)*
  - *A Concise Introduction to Multi-Agent Systems and Distributed AI (N. Vlassis)*







- **Remaining content will be from papers & tutorials (see homepage)!**

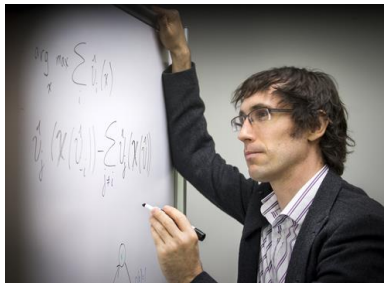
- **Other classical background reading...**

  C.Bishop: Pattern Recognition and Machine Learning, Springer, 2006.
  R. Sutton, S. Barto: Reinforcement Learning, MIT Press, 1998.

Background reading

Some slides are also borrowed from the VUB ARTIFICIAL INTELLIGENCE LAB in Brussels

- Tom Laenerts (Uni Brussels)
- Nikos Vlassis (now Adobe Research)
- Kevin Leyton-Brown (Stanford)



... so they should get the proper credit

How does it fit do your course plan?

Related Classes:

- **More Agent-Based Learning:**
  - Lernende Roboter (WS)

- **More (un-)supervised learning:**
  - Maschinelles Lernen: Statistische Methoden (SoSe),
  - Maschinelles Lernen: Statistische Methoden 2 (WS),
  - Maschinelles Lernen: Symbolische Ansätze (WS).

- **More on Distributed Systems:**
  - Distributed Reactive Software Systems (DReSS) (SoSe)

Your way to the thesis…

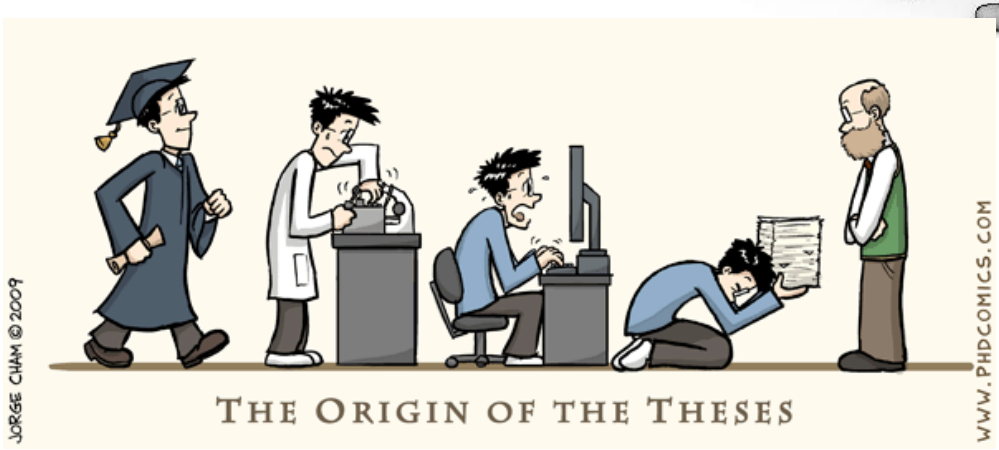
Theses:

- Our classes bring you right to **B.Sc. or M.Sc.** Thesis level (checkout our homepage)
- Currently 15 Thesis are supervised by the Autonomous Systems Labs
- Many Master and Bachelor Theses end up in a **Publication!**
- If you want to do your Ph.D. (=Dr) in Machine Learning for Autonomous Systems our classes and a thesis with us are an optimal preparation.

Your way to the thesis…

Among the most important questions ever:

continue the research road to a Ph.D. (=Dr.)?



An exciting life:

- follow *your* ideas & dreams...
- actively acquire knowledge and refine it...
- never stop challenging your brain
- enjoy international conferences and visits with collaborators around the world…

But also a lot of work…

- You need commitment …
- … and talent

It isn't for everybody:

➡ Want to find out whether it's the right thing for you?

Your way to the thesis…

Preparation for the thesis

Lernende Roboter

Intelligent Multi-Agent Systems

Lernende Roboter:
Integriertes Projekt Teil 1
Literature Review and
Simulation Studies

Lernende Roboter:
Integriertes Projekt Teil 2
Evaluation and Submission to a
Conference

Integriertes Projekt (1 and 2)

Mini-Class

- Perfect preparation for master thesis
- … or prolong your Bachelor's thesis to get a publication
- The lecture serves as background!
- Work on interesting research ideas
- We give you a few suggestions on platforms and algorithms.

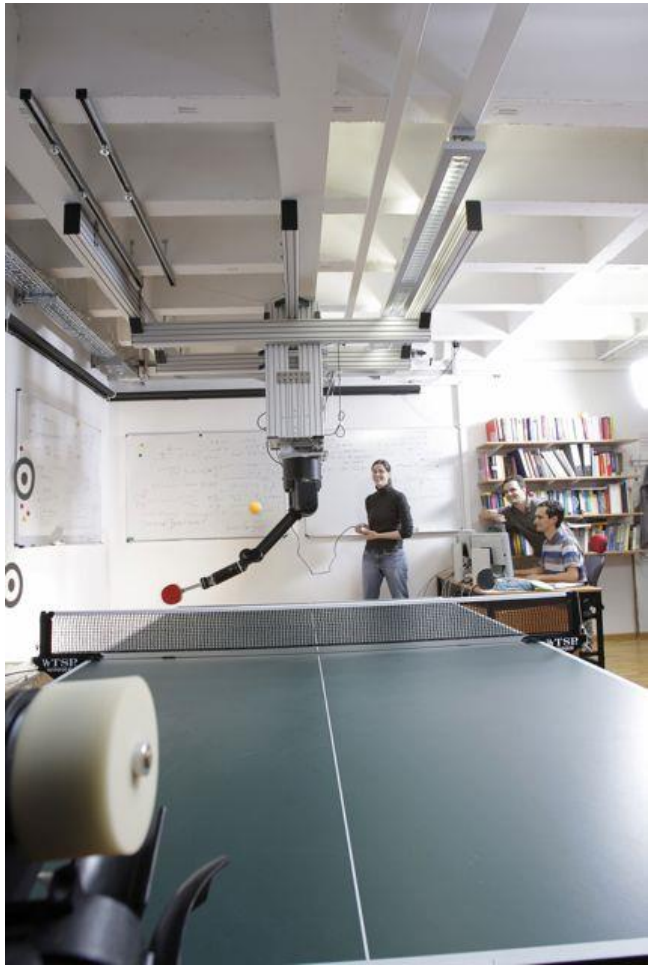
Your idea becomes your project! This can only be fun!

Your creativity is what will make it an amazing experience for both you & us!

Master and Bachelor Thesis

Topics from Multi-Agent Systems / Robot Learning / Machine Learning

Checkout our homepage!



Today‘s Agenda

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Introduction

Why?

Studying Multi-Agent Systems helps us understand situations in which decision-makers need to interact

Introduction

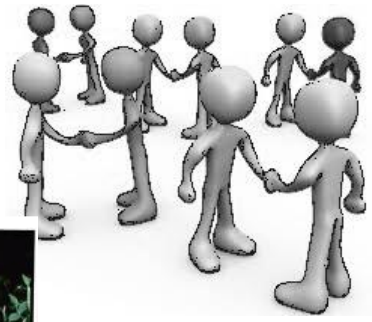
We do it everyday...

Games

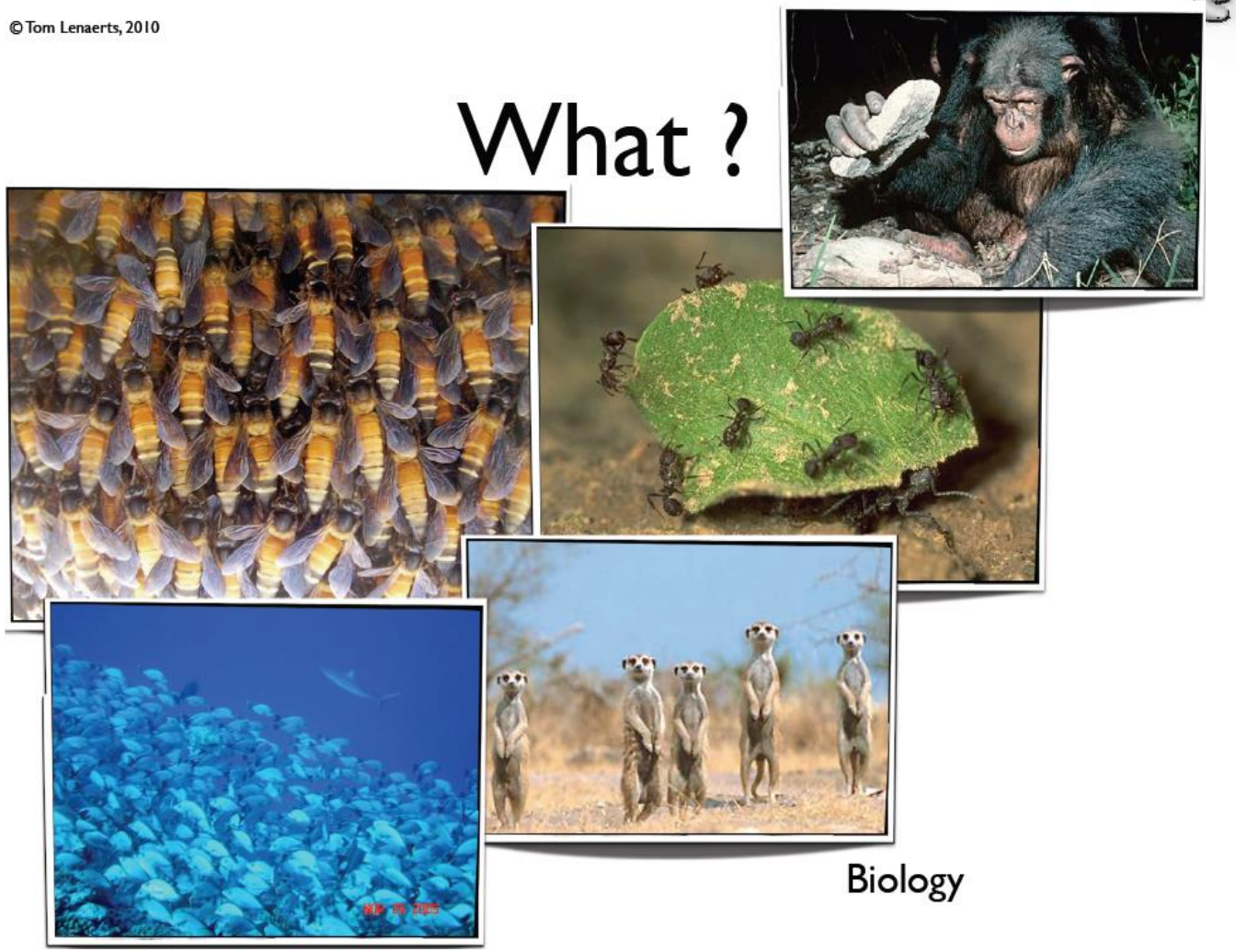
Economics

Politics

Introduction



Nature does it too...



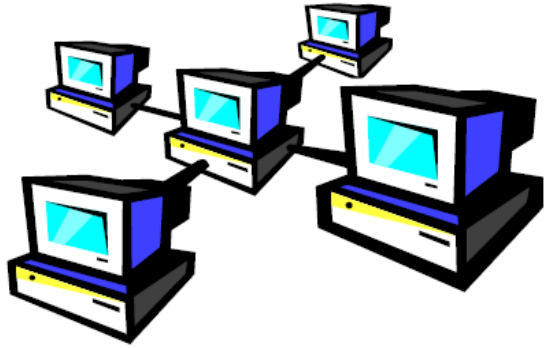
Why Multi-Agent Systems?

- Some domains require it.
- Interoperation of legacy systems
- Parallelism
- Robustness
- Scalability
- Simpler programming.

"Intelligence is deeply and inevitably coupled with interaction." – Gerhard Weiss

Interesting applications

Distributed Systems:



- Networked Systems
- Packet routing
- Sensor networks
- Traffic systems

Interesting applications

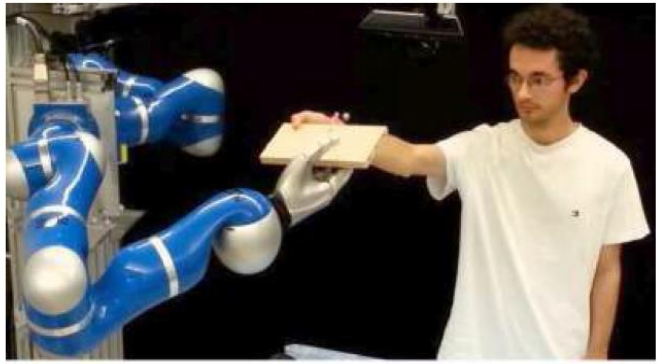
Computer Games:

- Human-like behavior
- Strategy Games
- Poker

Interesting applications

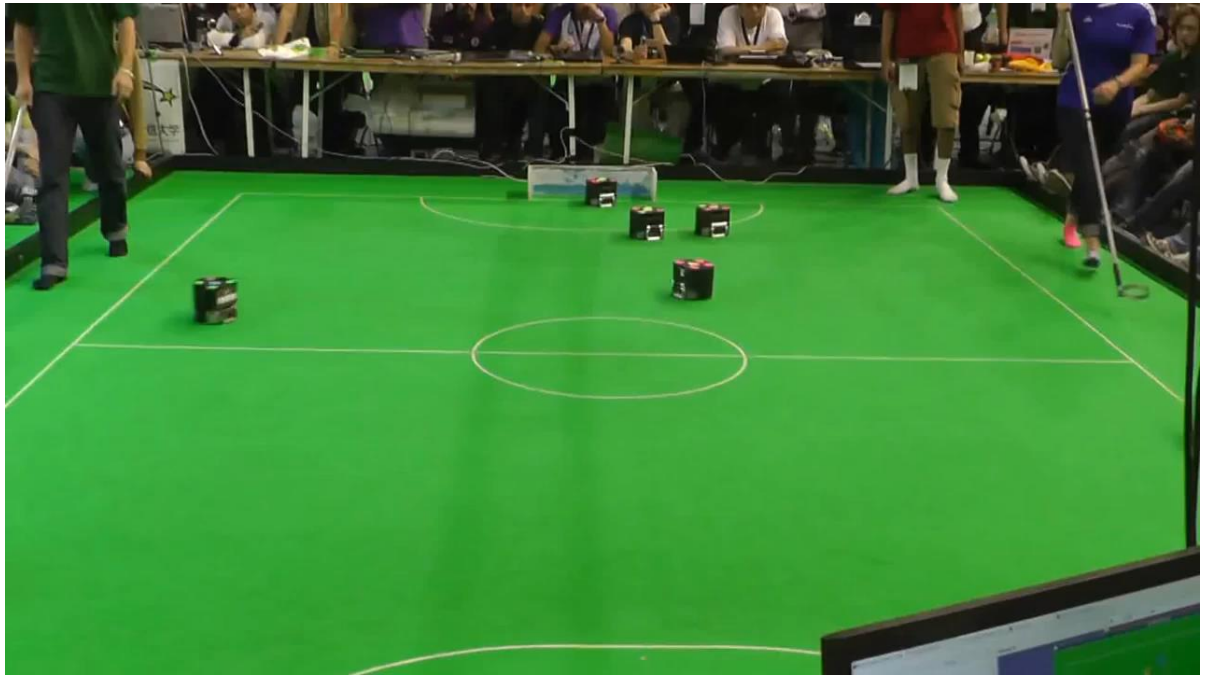
Robotics:

- Human-Robot Interaction
- Plenatary exploration
- Search and Rescue
- Robot Soccer



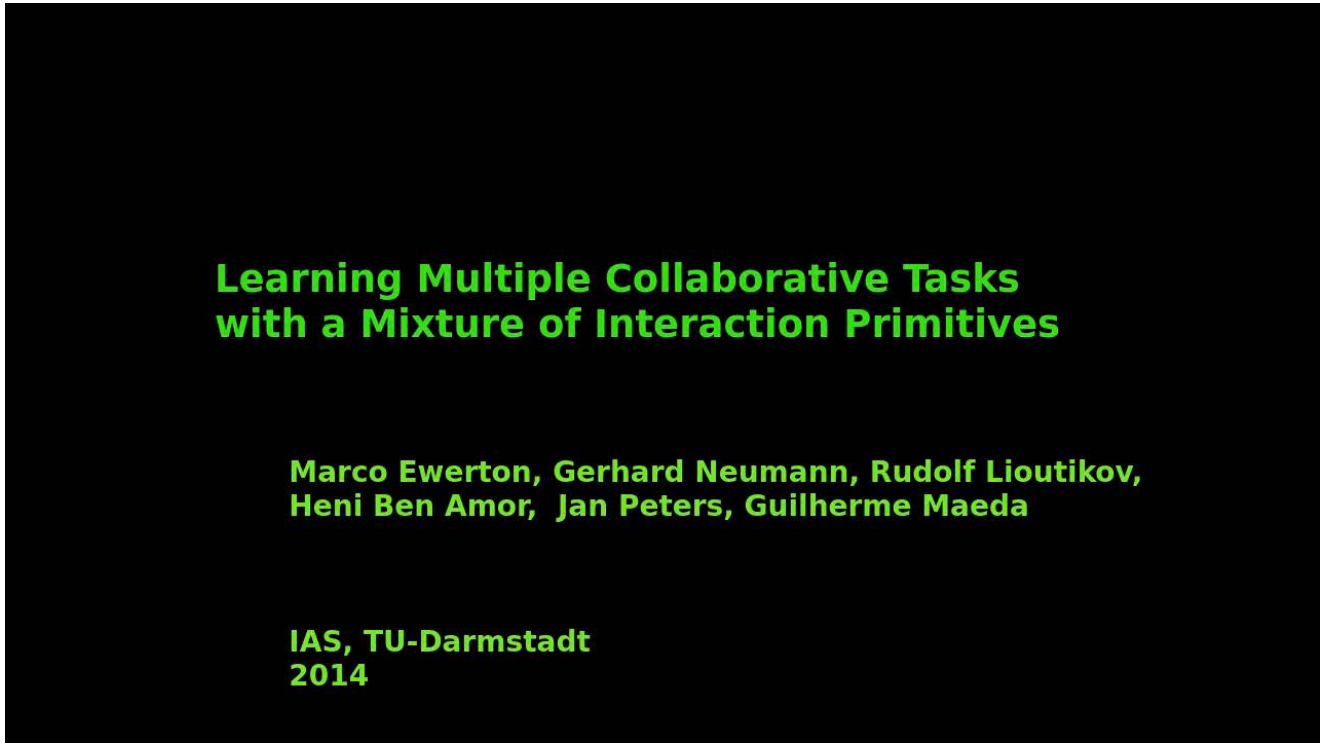
Interesting applications

Robot Soccer



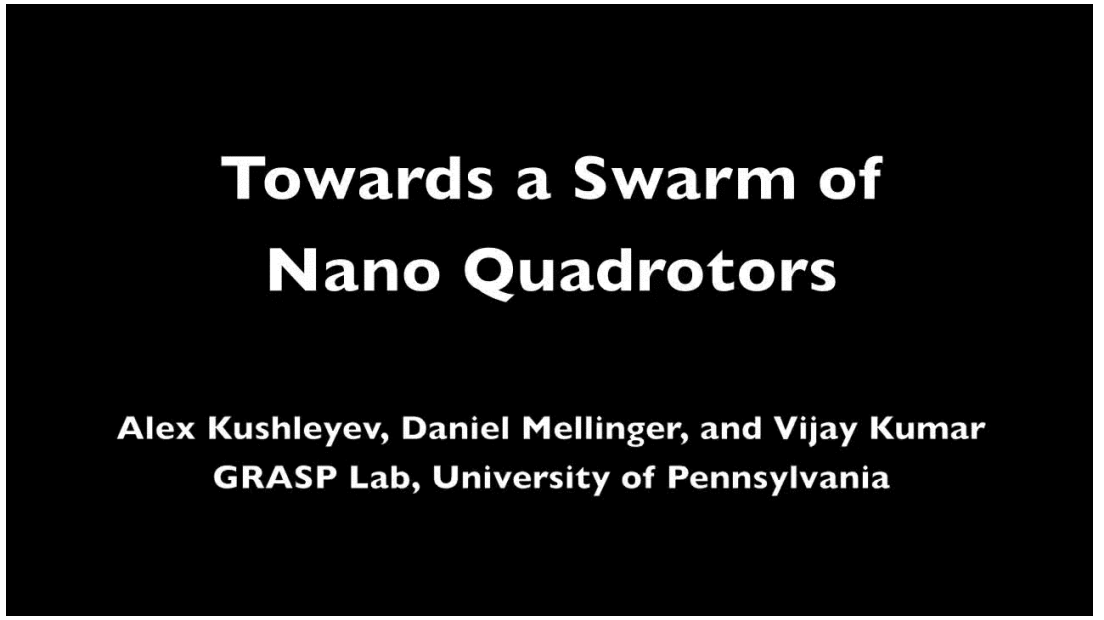
Interesting applications

Human-Robot Interaction



Interesting applications

Unmanned Aerial Vehicles



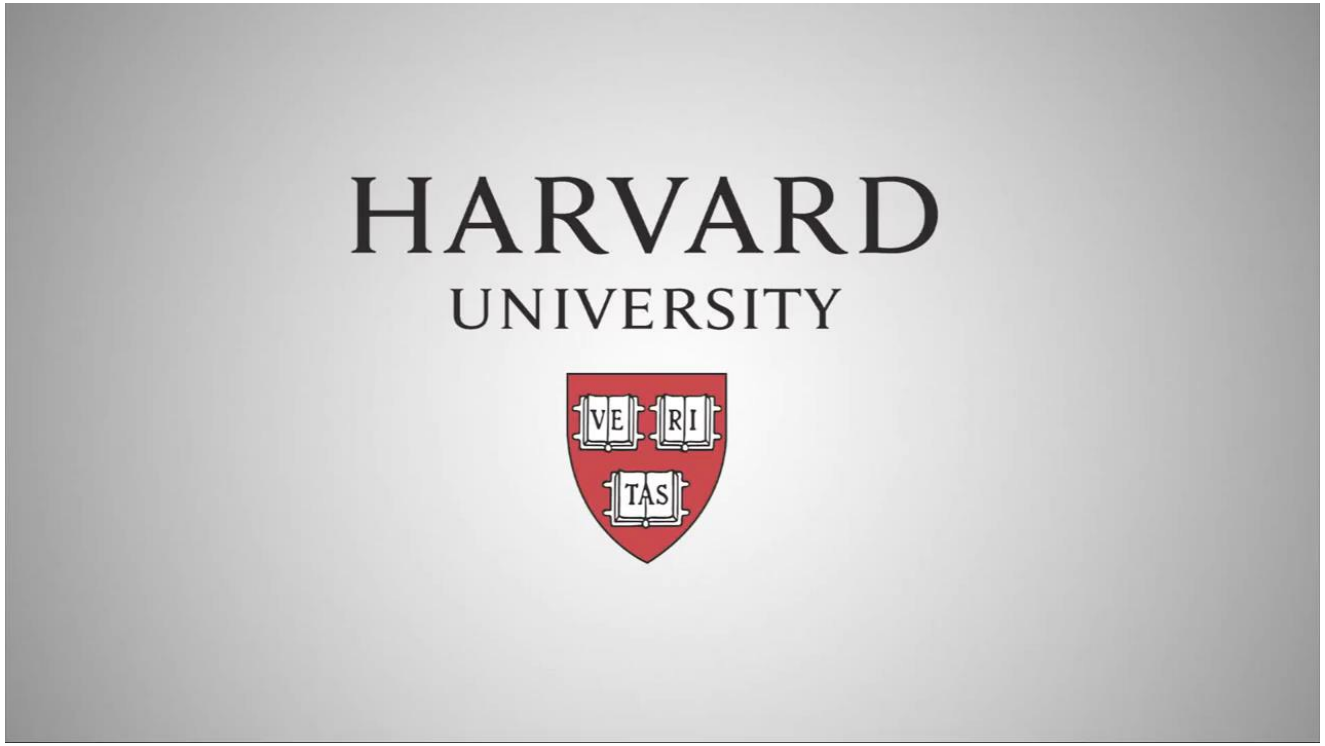
Interesting applications

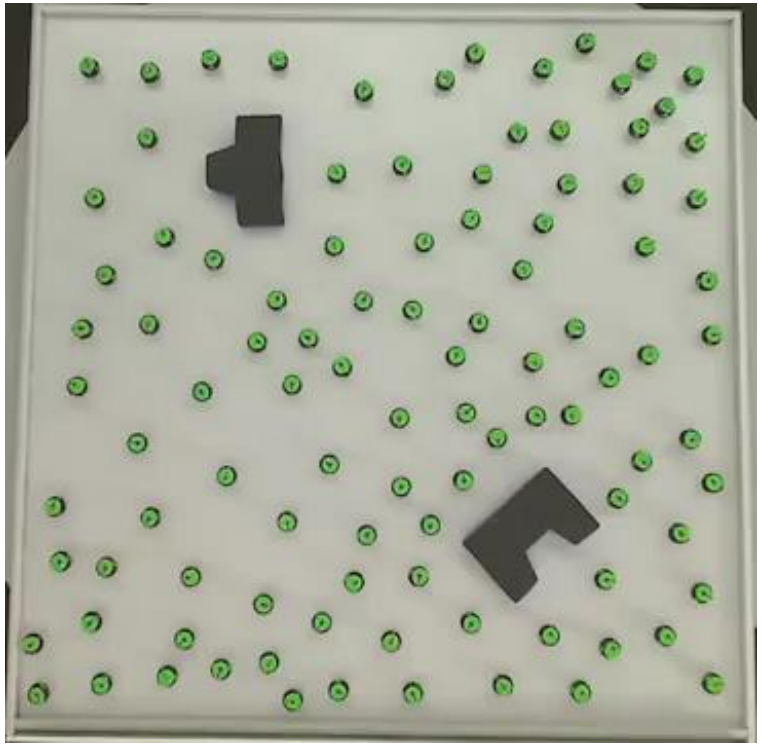
Swarm-Robotics (Robotics x 100):

- Massive Manipulation
- Nano-Robotics
- Building Structures
- UAV‘s

Interesting applications

Kilobots: Do a fun project with us!





Conclusion

- With the rise of intelligent robotics, multi-agent systems will become more and more important
- Interesting topic which is a lot of fun to study
- But also some serious math…
- The “serious” part of the lecture will start next week

We hope you enjoy it ☺