The ShanghAI Lectures

人工智能

上海授课

Calling on

- Salford: diversity/compliance
- Xi'an: frame-of-reference (3 issues)
- Shanghai Jiao Tong: emergence (with an example of each type of emergence)
- Osaka: characteristics of physically embodied agents
- SKKU, Korea: characteristics of real-world environments

The ShanghAI Lectures by the University of Zurich
An experiment in global teaching

Today from the University of Zurich, Switzerland
Budapest University of Technology and Economics
EPFL, Switzerland

13 December 2012

欢迎您参与

“来自上海的人工智能系列讲座”

Lecture 10:
Summary and conclusions

"How the body shapes the way we think -
principles and insights"

Rolf Pfeifer

13 December 2012

Today's schedule

09.00 - 09.20 Lecture 10 (wrap-up_

09.20 - 09.50 Guest lecture 1: Tamas Haidegger, Budapest University of Technology and Economics

09.55 - 10.25 Guest lecture 2: Jamie Paik, EPFL

10.30 - 11.00 Guest lecture 3: Aude Billard, EPFL

11.05 - 11.15 NAO competition results

11.15 - 11.25 EmbedIT competition

11.25 - 11.45 The future of the ShanghAI Lectures (Rolf and Nathan)

Today's topics

- steps toward a theory of intelligence
  - "Mind set"
  - Properties of real world and embodied agent
  - Design principles
- for self-study
  - Illustration of selected design principles
  - Seeing things differently
  - Epilogue

Steps toward a theory of intelligence

1. Meta-considerations: “Mind Set”
2. Properties of physically embodied agents
3. Characteristics of real world
4. Design principles

Steps toward a theory of intelligence

1. **Meta-considerations: “Mind Set”**
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Steps toward a theory of intelligence

- level of generality and form of theory
- diversity-compliance: —> Salford
- frame-of-reference: —> Xi'an (3 issues)
- synthetic methodology: clear
- time perspectives: clear
- emergence: —> Shanghai Jiao Tong (with an example of each type of emergence)

Steps toward a theory of intelligence

- level of generality and form of theory
- diversity-compliance
- frame-of-reference
- synthetic methodology
- time perspectives
- emergence

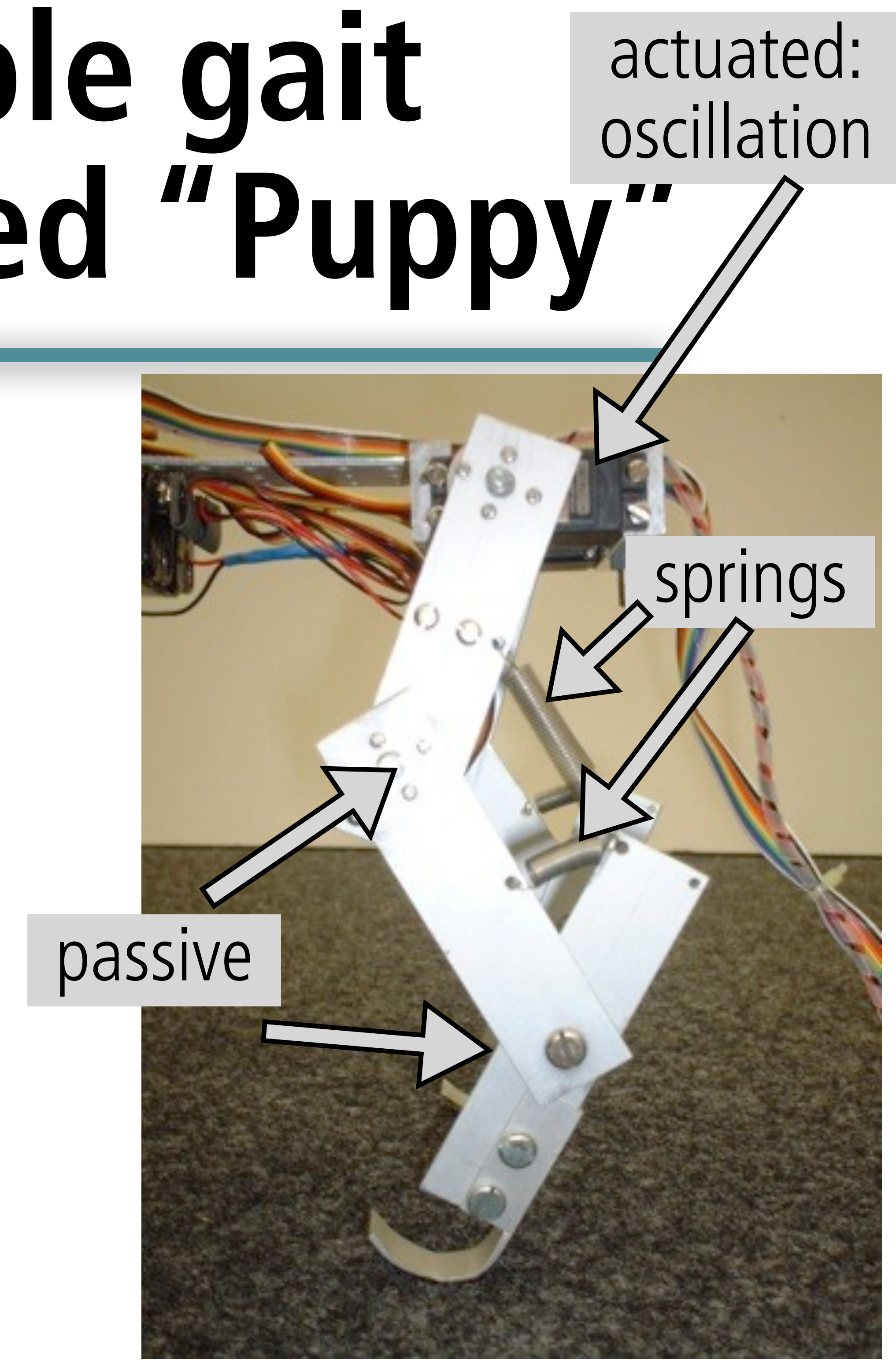
Level of generality and form of theory:
design principles; theory of complex dynamical systems
diversity/compliance:
here and now: comply/exploit — diversity in behavior
learning and development: plasticity — stability trade-off
evolution: exploration — exploitation
frame-of-reference:
- perspective
- behavior vs. mechanism
- complexity

synthetic methodology:
“Understanding by building” — don’t merely copy nature, make abstractions and extract principles;
we can also go beyond nature — “life as it could be”, and in many respects, engineering has gone far beyond nature.
time perspectives:
- here and now
- learning and development
- evolutionary time scale

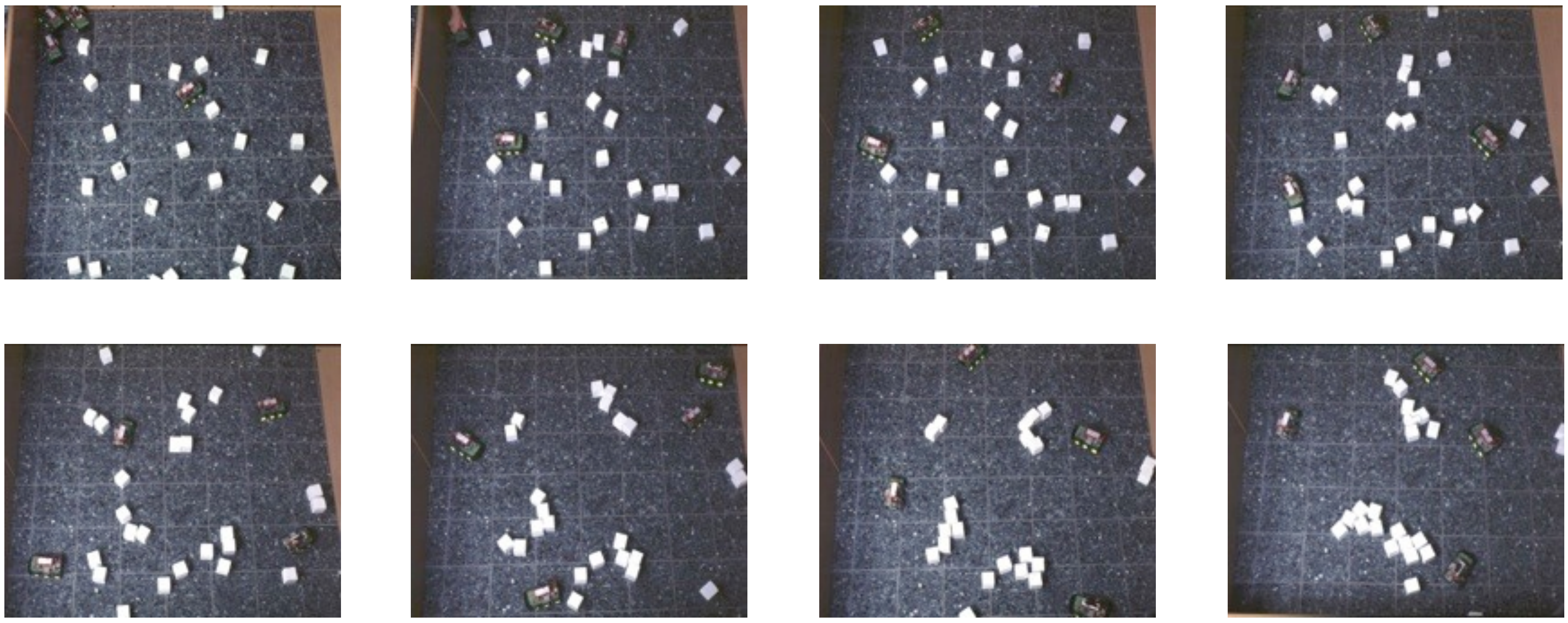
(different mechanisms, but tight interaction)
emergence:
- behavior of individual (especially with soft, compliant materials)
- global patterns from local interactions
- from time scales

Emergence of stable gait patterns: the quadruped "Puppy"

- simple control (oscillations of "hip" joints)
- spring-like material properties ("under-actuated" system)
- self-stabilization, no sensors
- "outsourcing" of functionality



Emergence of clustering



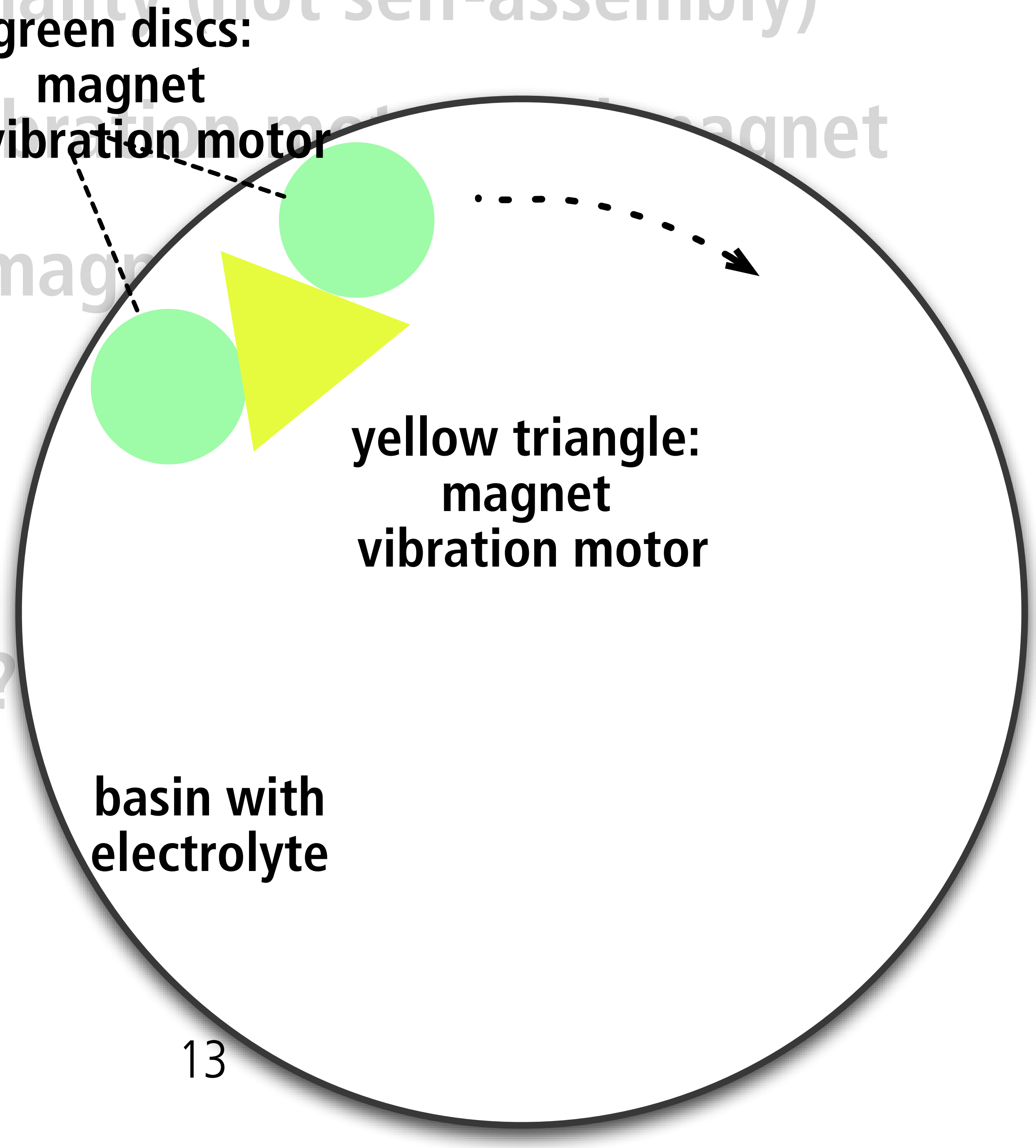
entire process: ~20min
frames: 2-3min

Design for emergence: a “bicycle” following the wall

emergent functionality (not self-assembly)

yellow triangle: vibration mo… agnet

green discs: only magn…



how does it work?

The vibrations of the triangle are propagated to the passive green discs, which then cause the entire structure (held together by the magnets) to follow the wall of the container.

Emergence of global patterns from local rules — self-organization

bee hive

termite mound

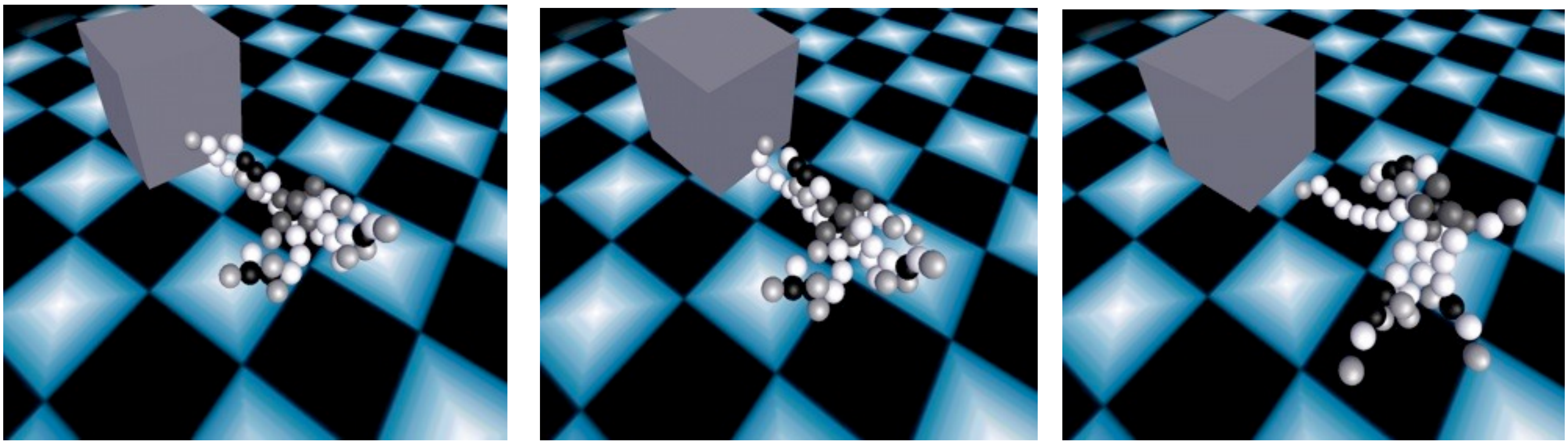
"wave" in stadium

open source development community

Emergence of behavior from time scales: locomotion and pushing

Bongard's "Block Pushers"

- **development (morphogenesis) embedded into evolutionary process, based on GRNs**
- **testing of phenotypes in physically realistic simulation**



Emergence as a continuum

Steps toward a theory of intelligence

1. Meta-considerations: “Mind Set”
2. **Properties of physically embodied agents —> Osaka**
3. Characteristics of real world
4. Design principles

Properties of physically embodied agents, e.g. “Puppy”

- subject to the laws of physics
- generation of sensory stimulation through interaction with environment
- influencing physical environment through behavior
- complex dynamical systems (with attractor states)
- performingmorphological computation
-

Characteristics of real-world environments

- —> **SKKU, Seoul, Korea**

- information acquisition takes time
- information always limited
- noise and malfunction
- no clearly defined states
- multiple tasks
- rapid changes — time pressure
- non-linearity: intrinsic uncertainty

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Herbert Simon's concept of "bounded rationality"

Design principles for intelligent systems

Agent design principles

Agent design principles	**Description**
Three constituents	ecological niche, behaviors/tasks, and agents
Complete agent	complete agent, not only isolated components
Parallel, loosely coupled processes	parallel, asynchronous, processes, largely coupled through interaction with environment
Sensory-motor coordination	behavior sensory-motor coordinated with respect to target; self-generated sensory stimulation
Cheap design	exploitation of niche and interaction; parsimony
Redundancy	partial overlap in functionality based on different physical processes
Ecological balance	Balance in complexity of sensory-motor and neural system; task-distribution: morphology, materials, control, environment
Value	driving forces, developmental mechanisms, self-organization

Design principles for development

Principles for development	**Description**
Integration of time scales	many time scales need to be integrated into one agent
Development as an incremental process	start simply, build successively on top of what has already been learned
Discover	agent must have ability to explore and evaluate, which implies that agent can discover through its own activites
Social interaction	sensory-motor coordination together with social interaction provides most powerful engine for development
Motivated complexity	why complexity increases during ontogenetic development (driving force)

Design principles for evolution

Principles for evolution	**Description**
Population	Population is the prerequisite for evolution to function
Cumulative selection and self-organization	Cumulative selection will produce interesting results only if evolutionary process exploits processes of self-organization
Brain-body co-evolution	"Brain" (neural control) and body must be evolved simultaneously
Scalable complexity	In order for complex organisms to emerge, the ontogenetic developmental processes must be encoded in the genome
Evolution as a fluid process	Agents should be modeled with a large number of cells: evolution should make only small modifications (at the genome)
Minimal designer bias	Design as little as possible and let evolution do as much work as possible

Design principles for collective intelligence

Principles for collective systems	**Description**
Level of abstraction	Proper level of abstraction must be chosen, and the implications (of abstraction) important
Design for emergence	Find local rules of interaction that lead to desired global behavioral patterns (holds also for individual agents)
From agent to group	Agent design principles often applicable to collective systems (e.g. parallel, loosley coupled processes)
Homogeneity-heterogeneity tradeoff	Find compromise between systems using only one type of module/robot and systems emplying several specialized types

Illustrations of design principles

see slides for self-study

Epilogue

David Payne *Confessions of a Taoist on Wall Street*
Sun I: little boy growing up in monastery
Wu: chef (cook) of monastery and Sun I's mentor

The little boy, Sun I, is born of a Chinese mother and an American fighter pilot in China. His mother dies at birth and his father returns home to the United States; he is left alone and grows up in a monastery. His mentor and teacher is the chef, Wu, who takes good care of him. The monastery is on a high rock upon a river. One of their daily chores is to carry water from the river to the monastery up a rocky path. The boy remembers that whenever they arrived at the top of the rock his buckets were empty, all the water spilled, whereas Wu's were always full.

Yoke with water buckets

Courtesy Purdue University Libraries, Archives and Special Collections

Conversation between Sun I and Wu

It was true. By some extraordinary luck or skill Wu never seemed to lose a drop, though he hurried along the treacherous stair at twice my pace. (I tried to cut my losses by moving slowly, plotting my course in advance and picking each footrest with deliberate care.)

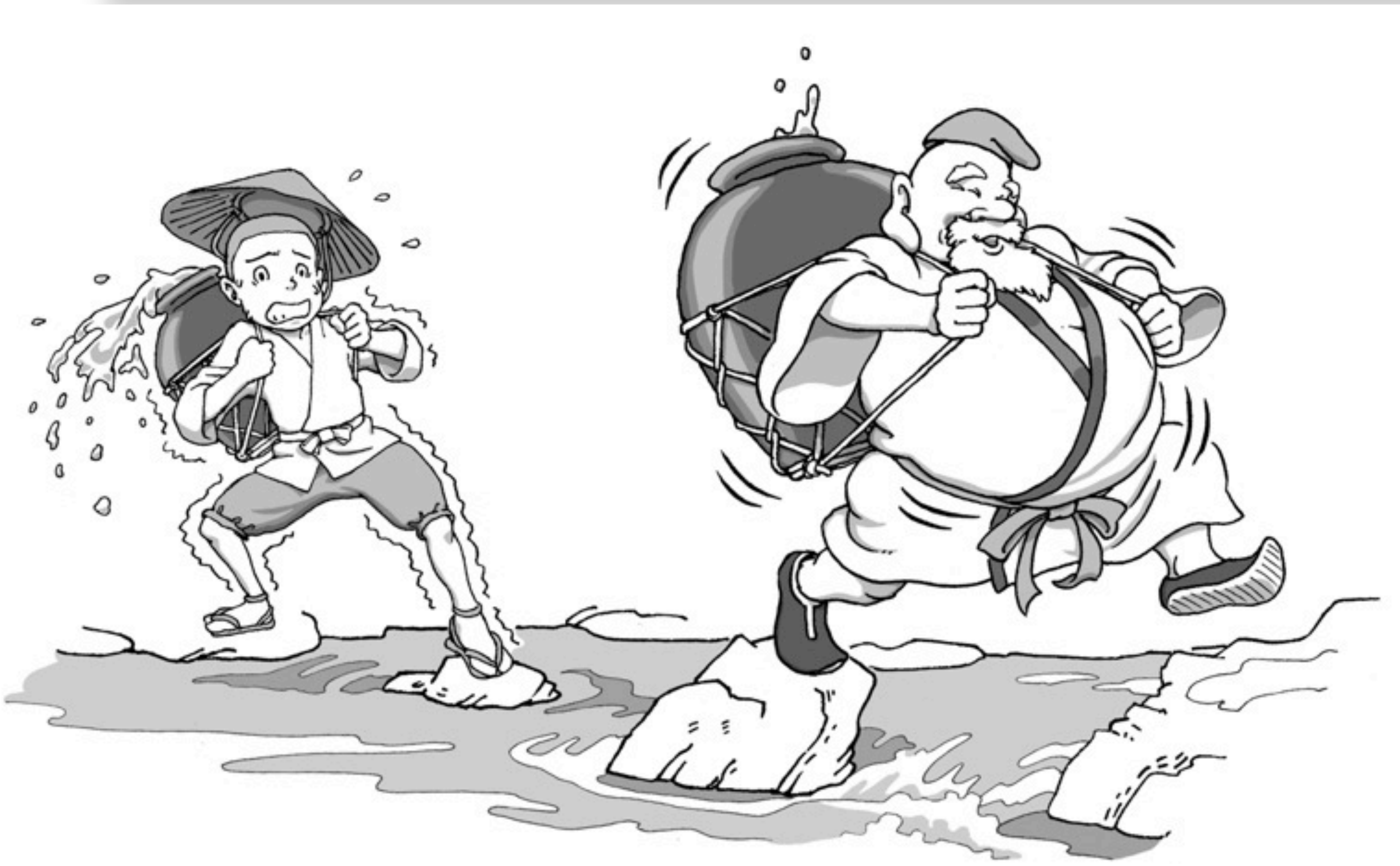
"I don't understand it," I confessed to him. "You must know some kind of trick. Explain your method." ...

"You haven't yet caught on. It's precisely this—excess of method—that confounds you, leaves the buckets nearly empty …"

"If you're so smart, how do you do it then?"

"How do I do it? . . . I close my eyes and think of nothing. My mind is somewhere else. My legs find their way without me, even over the most uneven ground. How can I tell you how I do it? . . . I can't even remember myself!" (Payne, 1984, pp. 18–19)

Sun I and Wu carrying water buckets



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Cartoon: **Shun Iwasawa, Studio Ghibli, Tokyo, Japan**

That's it!

Thank you for your attention!

Before the guest lectures:

short announcement of "Robots on Tour"

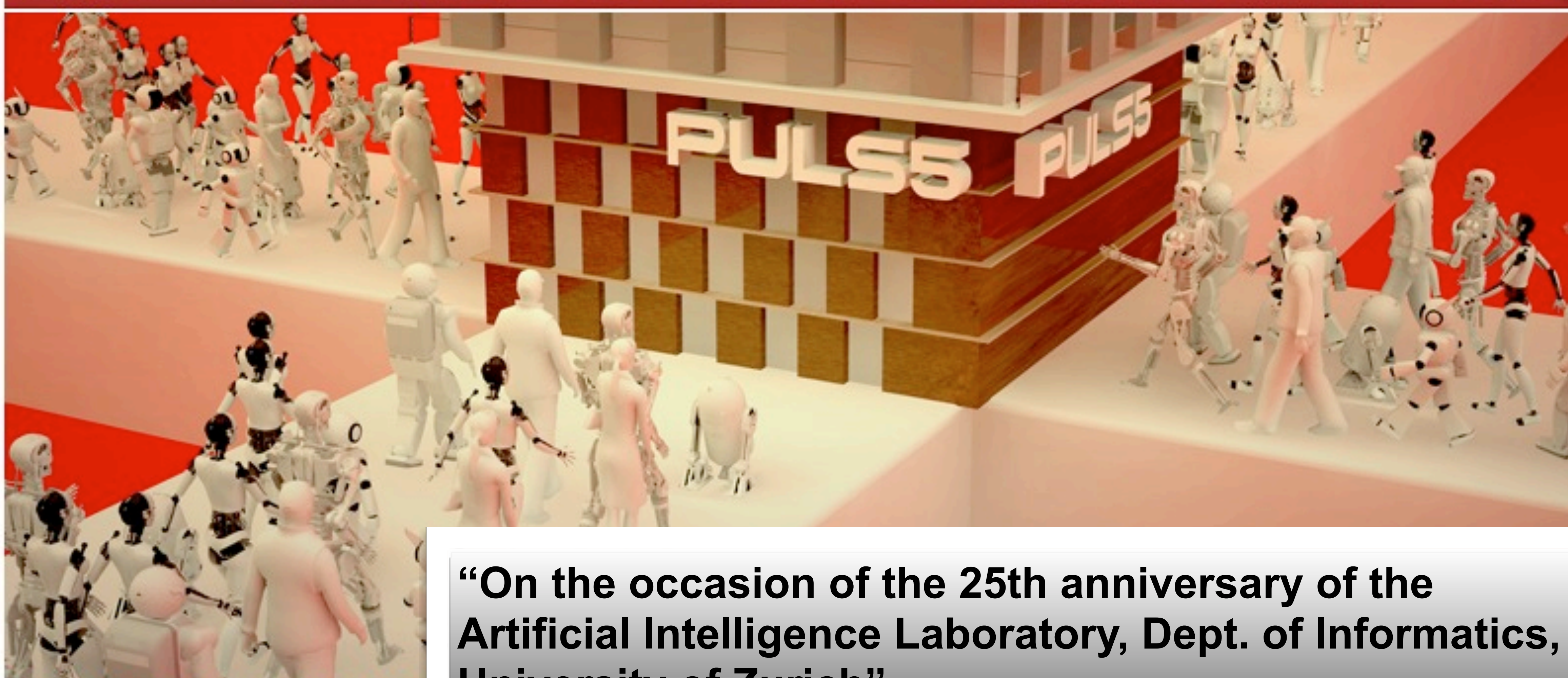
http://www.robotsontour.com/en/

Visit:
“Robots on Tour”
9 March 2013
Zurich, “Puls 5”

ROBOTS ON TOUR

World Congress and Exhibition of Robots, Humanoids, Cyborgs and more

ROBOTER PROGRAMM REFERENTEN LOCATION INFOS TICKETS KONTAKT ENGLISH



“On the occasion of the 25th anniversary of the Artificial Intelligence Laboratory, Dept. of Informatics, University of Zurich”

World Congress and Exhibition of Robots, Humanoids, Cyborgs and more am 9. März 2013 in Zürich

Univ
Zuri

Aktuelle News

31.07.2012: Nun ist es offiziell: Das AI Lab arbeitet an einem neuen Roboter! Mehr zu Roboy erfahren Sie auf www.roboy.org.

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a few highlights

"On the occasion of the 25th anniversary of the Artificial Intelligence Laboratory, Dept. of Informatics, University of Zurich"

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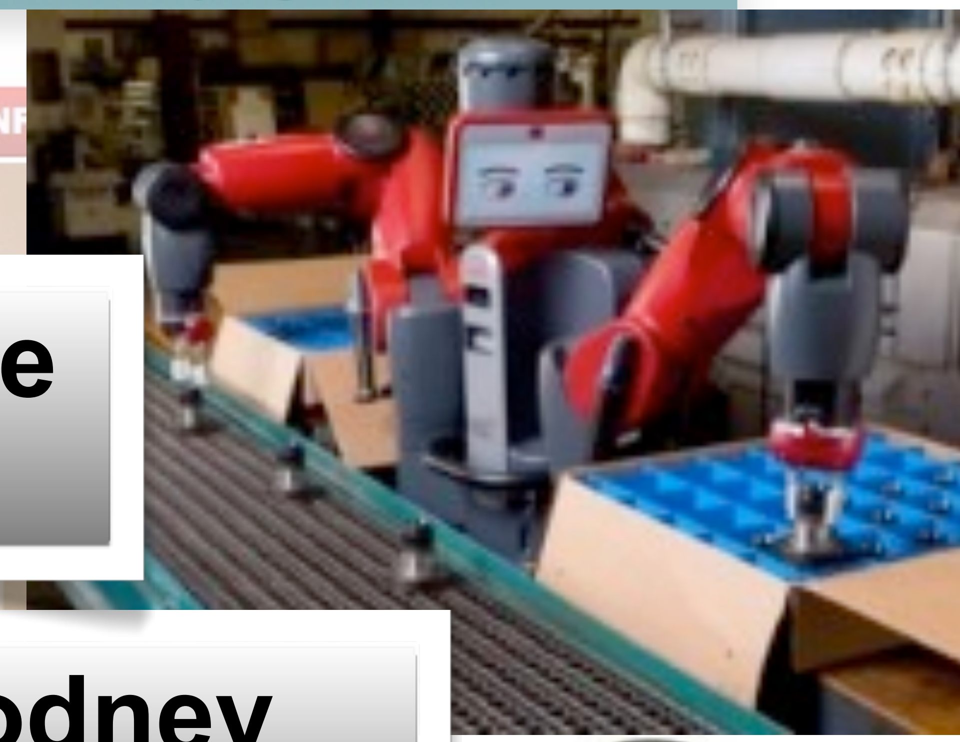
The emotional humanoid "Affetto"

Minoru Asada
Osaka University, Japan

“Robots on Tour”
9 March 2013
Zurich, “Puls 5”

The factory “humanoid” robot “Baxter”



announced one month ago!

Rodney Brooks

The next “industrial revolution”

rethink robotics

Visit:

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The "Cornell Ranger"

World Congress and Exhibition of Robots, Humanoids, Cyborgs and more

conception et construction:
Andy Ruina
Cornell University

attempt at new world record

World Congress and Exhibition
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Hiroshi Ishiguro's "Geminoid"

World Congress and Exhibition of Robots, Humanoids, Cyborgs and more

Mensch-Roboter?

World Congress and Exhibition
of Robots, Humanoids, Cyborgs and more
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University of Zurich[UZH]

robotics Swiss National Centre of Competence in Research

ai lab

Visit:

"Robots on Tour"
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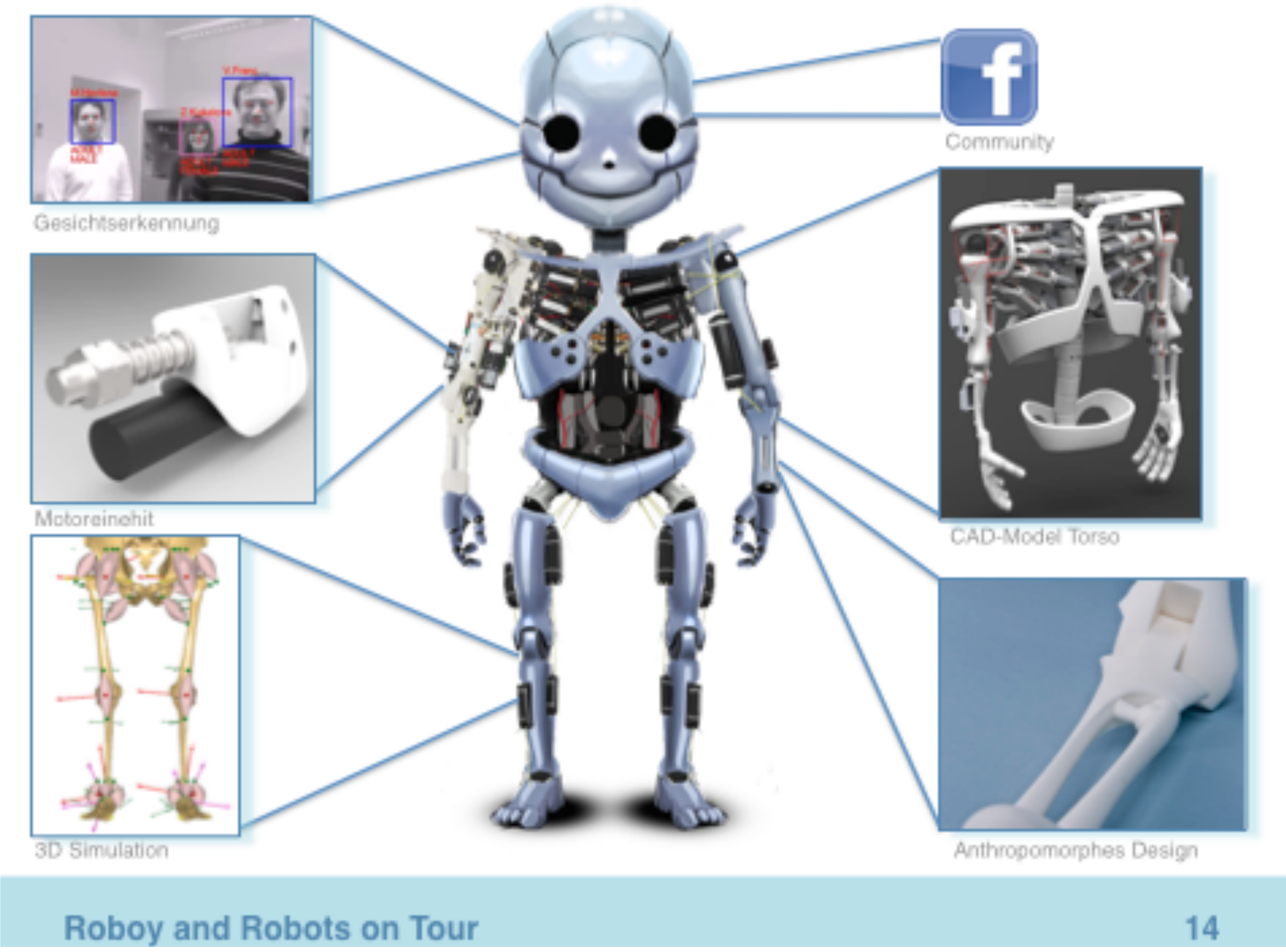
Zurich, "Puls 5"

"Roboy Junior"

conception et construction:
AI Lab
University of Zurich



“Roboy Junior”

Visit:

“Robots on Tour”
9 March 2013
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conception et construction:
AI Lab
University of Zurich

University of Zurich[UZH]

robotics
Swiss National Centre of Competence in Research

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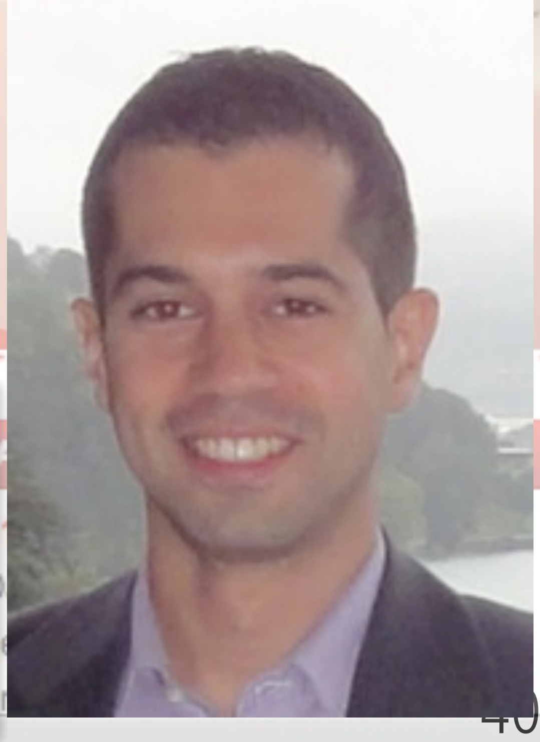
Scaramuzza’s flying robots (quadrocopters)

World Congress and Exhibition of Robots, Humanoids, Cyborgs and more

rescue robots



Davide Scaramuzza

“Robots on Tour”
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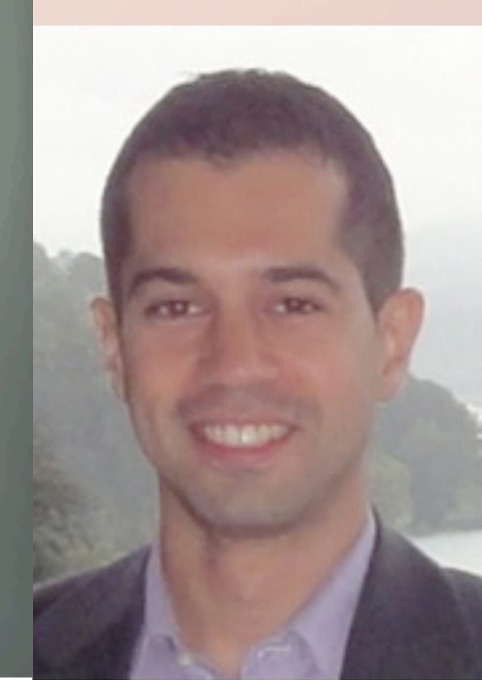

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World Congress and Exhibition of Robots, Humanoids, Cyb-

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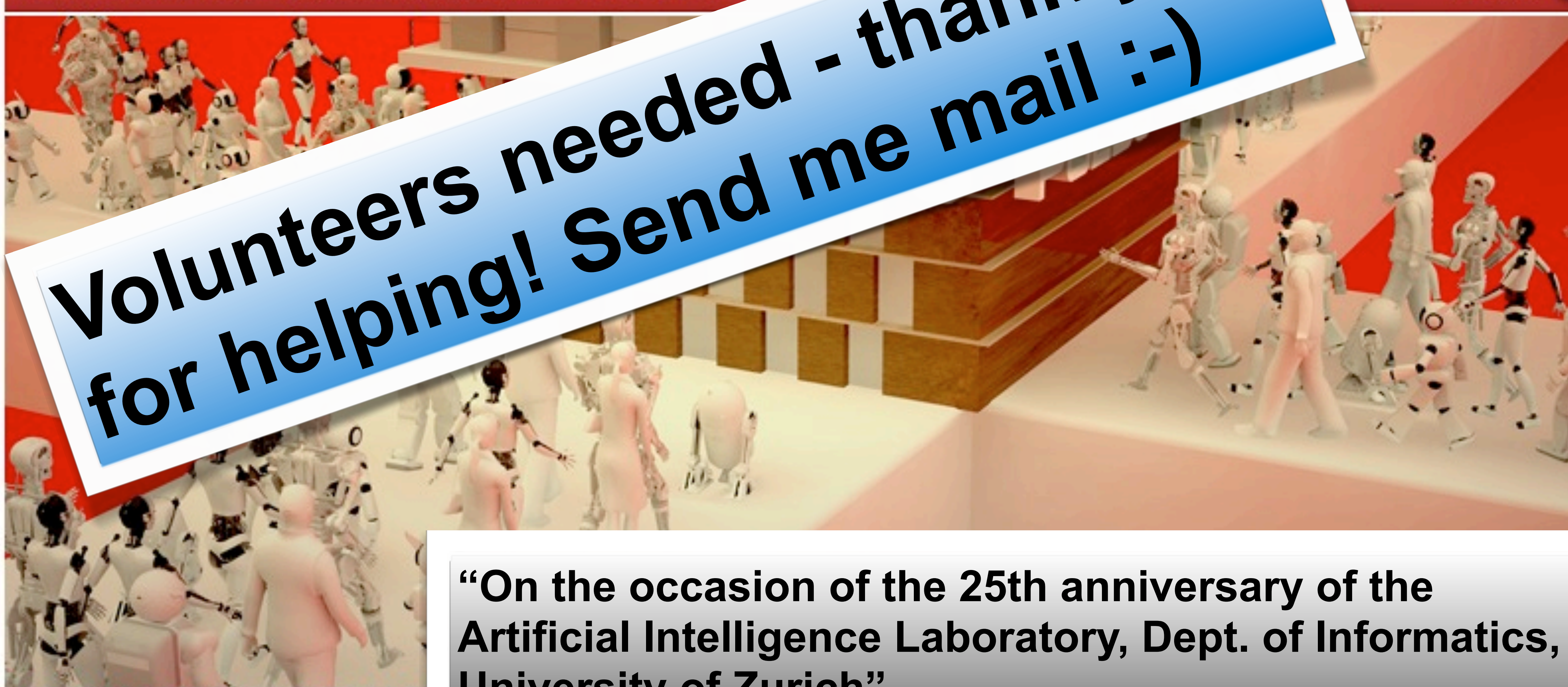

Volunteers needed - thank you for helping! Send me mail :-)

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That's it!

Thank you for your attention!

stay tuned for

Tamas Haidegger
Aude Billard
Jamie Paik

Lecture 10: Guest speaker

from the Budapest University of Technology and Economics

Prof. Tamas Haidegger
“Human skills for robots: Transferring human knowledge and capabilities to robotic task execution in surgery”

09.20 Zurich time

University of Zurich

robotics Swiss National Centre of Competence in Research

ai lab

The ShanghAI Lectures 人工智能 上海授课

Tamás Haidegger received his M.Sc. degrees from the Budapest University of Technology and Economics (BME) in Electrical Engineering and Biomedical Engineering in 2006 and 2008, respectively. His Ph.D. thesis (2011) was based on a neurosurgical robot he developed when he was a visiting scholar at the John Hopkins University. His main field of research is control/teleoperation of surgical robots, image-guided therapy and supportive medical technologies.

Currently, he is an adjunct professor at BME and a research area manager at the Austrian Center of Medical Innovation and Technology (ACMIT), working on minimally invasive surgical simulation and training, medical education and the technological improvement of gynecological brachytherapy.

Tamás is the CEO/CTO of a university start-up—Clariton Ltd.—focusing on objective hand hygiene control. They are working together with Semmelweis University, the National University Hospital Singapore and the World Health Organization.

Lecture 10: Guest speaker

from EPFL, Switzerland

Prof. Jamie Paik
"tba"

09.55 Zurich time

Prof., EPFL (previously Harvard University)

Unconventional types of robots: "soft robots"

"robotic origami"

Lecture 10: Guest speaker

from EPFL, Switzerland

Prof. Aude Billard
“How the body shapes the way we move and how humans can shape the way robots move”

10.30 Zurich time

University of Zurich

robotics Swiss National Centre of Competence in Research

ai lab

Associate professor, School of Engineering, EPFL

Human-robot interaction

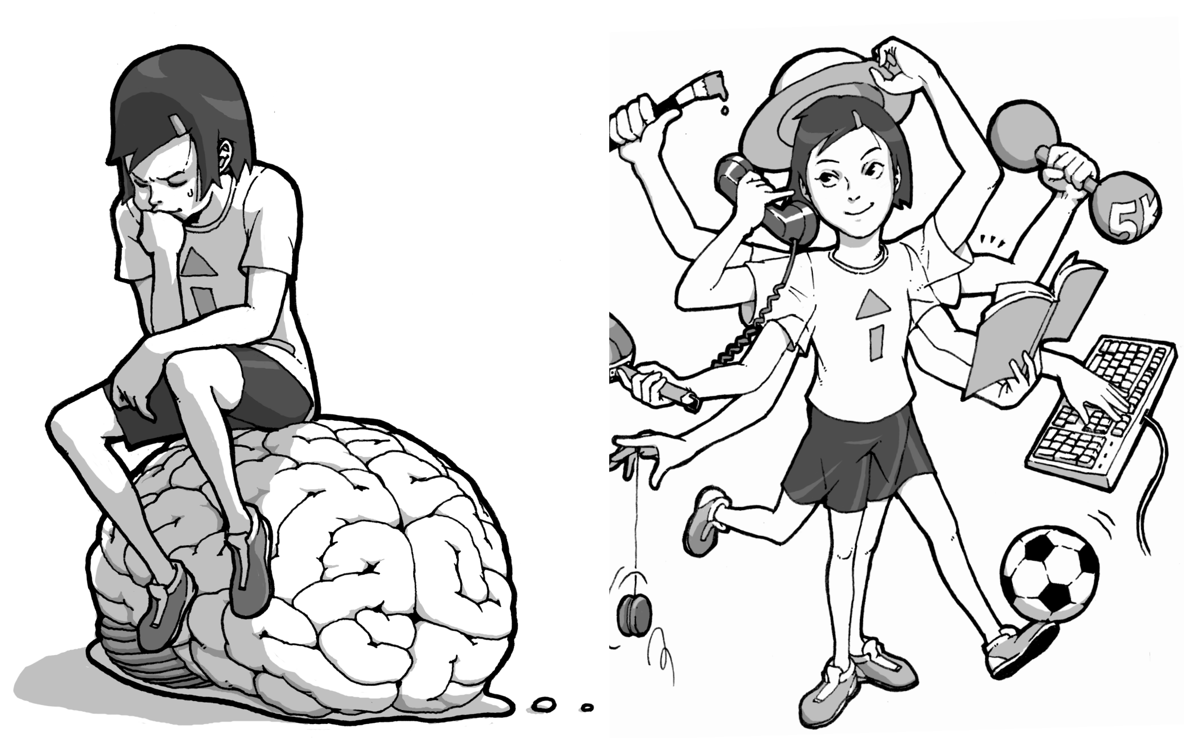
Learning by demonstration

End of week 11

Thank you for your attention!

Now, enjoy: “Future Trends”

(with various guest speakers)



University of Zurich

lab