Robotic representation, reasoning and learning
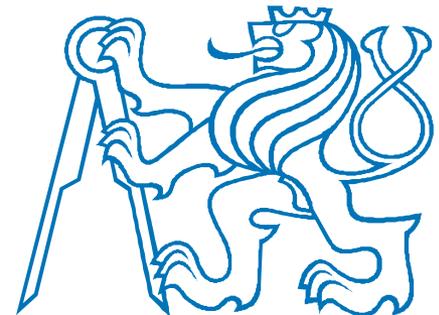## *Assignment for ReaRW 2014*

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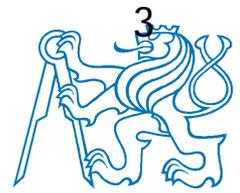http://cmp.felk.cvut.cz/~hlavac

Three EC projects, our motivation

- **NIFTi**, IP, 4 years, finished 2013-12

- TRADR IP, 4 years, takes over since 2013-11

- Both projects led by DFKI Saarbrücken

- Many partners

- **CloPeMa** = Clothes perception and manipulation

- STREP, 2012-02 to 2015-01

- CERTH Thessaloniki, U of Genova, U of Glasgow, CTU Prague, Neovision (integration)
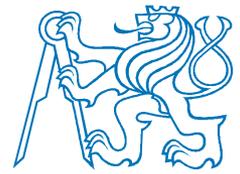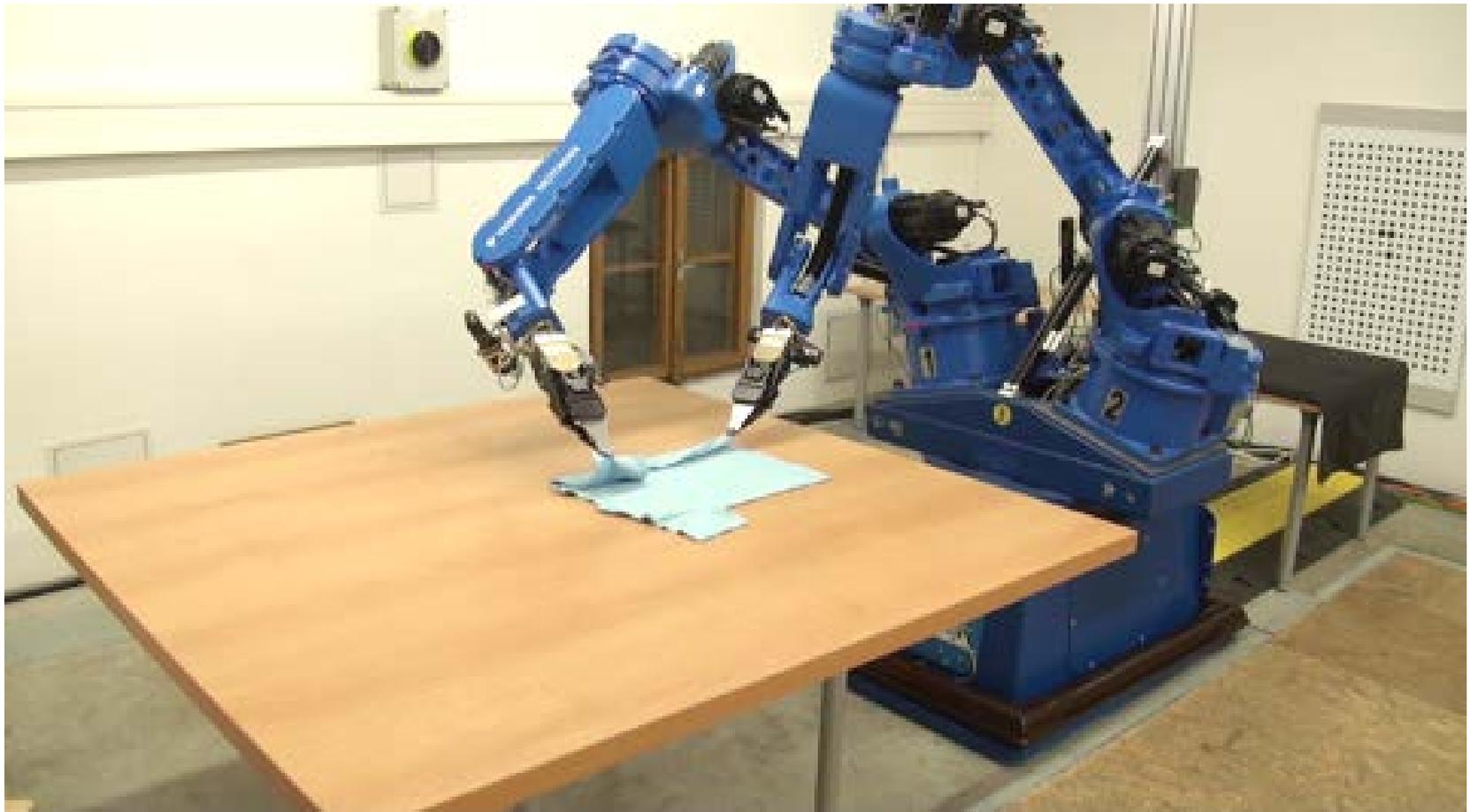
NIFTI practical success

May 20 – June 18, 2012,
Mirandola, Emilia-Romagna region, Italy
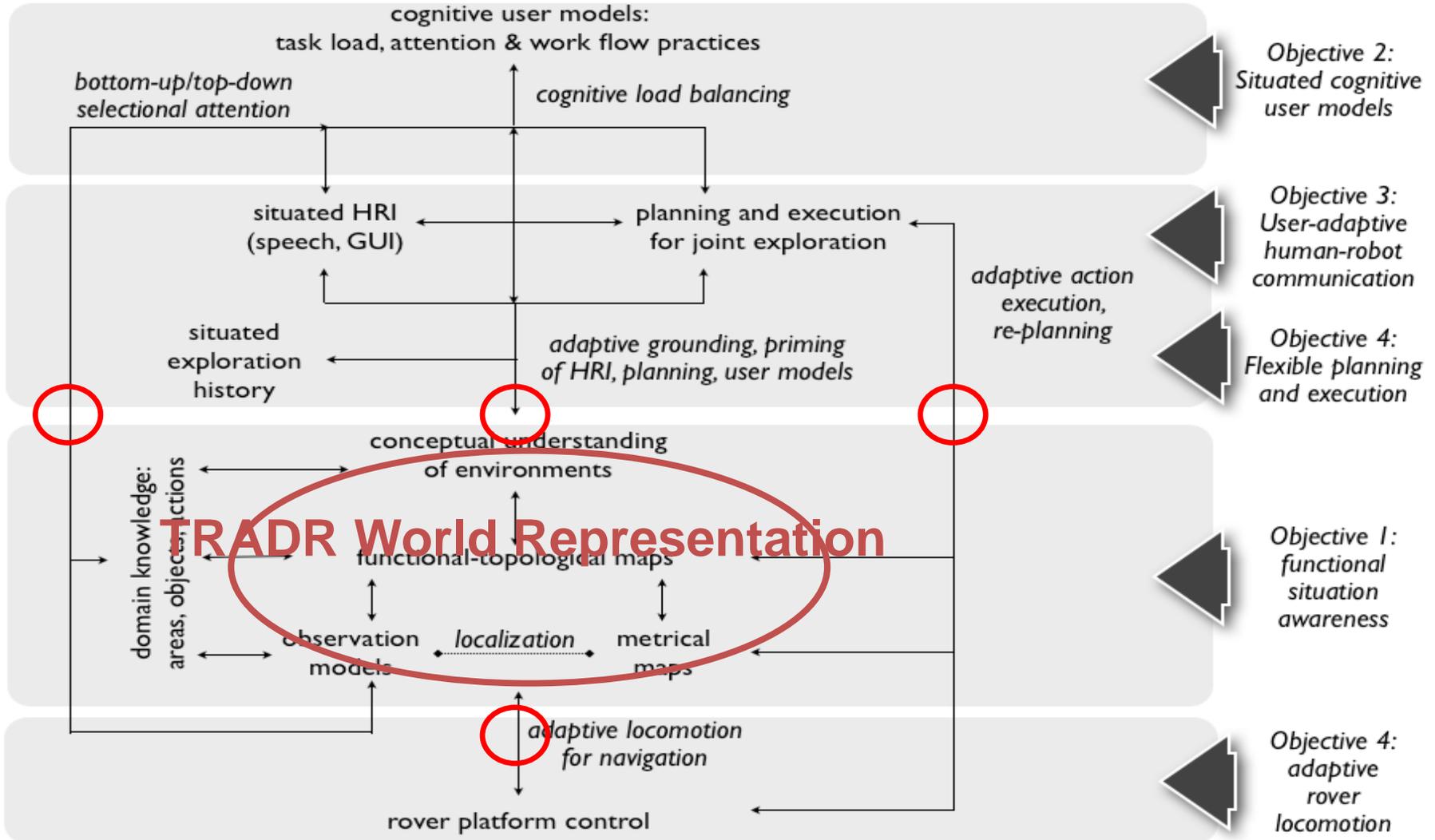246 seismic activities, 3 – 6.1 Richter scale

CloPeMa – current abilities

- Maria Petrou's project, the coordinator
- Maria died on Dec 15, 2012 of cancer

NIFTi knowledge architecture
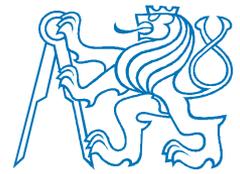
Intelligence needed

Ability to:

- Represent knowledge, including commonsense knowledge.
- Learn
- Reason, plan
- Sense / act
- Salience – the ability to recognize importance

- Metric map
- Topological map
- Functional map
- Detected object (≈ concepts, primitives, function of objects)
- Graph having objects as graph nodes and their relations as graph edges.
- Action representation

Some philosophy

Rationalism

- " the criterion of the truth is not sensory but intellectual and deductive".

- Intelligence stems from (logical) reasoning.

- Many rationalists believe that some part of human knowledge is innate.

- *René Descartes (1596–1650), Baruch Spinoza (1632–1677), Gottfried Leibniz (1646–1716).*

Empiricism

- "An empiricist holds that experience is the source of all human knowledge"

- E.g., all knowledge must be grounded or based in the sensory world.

- *Aristotle (384 BC–322 BC), William of Ockham (1288–1348), Francis Bacon (1561-1626), John Locke (1632-1704), George Berkeley (1685-1753), David Hume (1711-1776), Hermann von Helmholtz (1821-1894), Karl Popper (1902-1994).*

A physical symbol system hypothesis

Harnad, S. (1990) The Symbol Grounding Problem. Physica D 42: 335-346.

- The rule-governed symbol-token manipulation is based purely on the shape of the symbol tokens (not their "meaning"), i.e., it is purely syntactic.

- There are primitive atomic symbol tokens and composite symbol-token strings.

- The syntax can be systematically assigned a meaning e.g., as standing for objects, as describing states of affairs.

- The symbols in an autonomous hybrid symbolic+sensorimotor system would be grounded. (Importance of the perception action cycle.)

AI issues in robotics

- A state space – a set of possible configurations of a robot, usually a discrete one, e.g. a position on a occupancy grid.

- Representation of a robot environment (a practical implementation of the state space), e.g. the robot world model.

- A reasoning engine – usually some type of symbol manipulation mechanism used for search/planning in a state space.

- Ontology (next slide)

Ontology in computer science
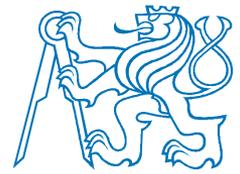
- *Definition:*
  Ontology formally represents knowledge as a set of concepts within a domain, and the relationships between pairs of concepts.

- It can be used to model a domain and support reasoning about entities.

- Ontologies are the structural frameworks for organizing information.

- Serves as the information architecture as a form of knowledge representation about the world or some part of it.

- Used in AI, robotics, semantic web, systems engineering, software engineering, biomedical informatics, library science, enterprise bookmarking,

Czech connections

- **Golem**
  Late 16th century, Prague Rabi Loew (Judah Loew ben Bezalel).

- **Robot**
  Word invented by Czech playwright Karel Čapek (1980-1938)

- **Incompleteness theorem**
  Kurt Gödel (1906 in Brno - 1978)

ReaRW 2014 – The assignment

- A gap remains between low level percepts, robot control ↔ high level reasoning.

- Key issue is scene/knowledge representation.

- Learning is used only within a module to set parameters, not in the entire system to establish structure qualitatively.

- **ReaRW aims at telling: what and how an intelligent robot can be built in practice.**