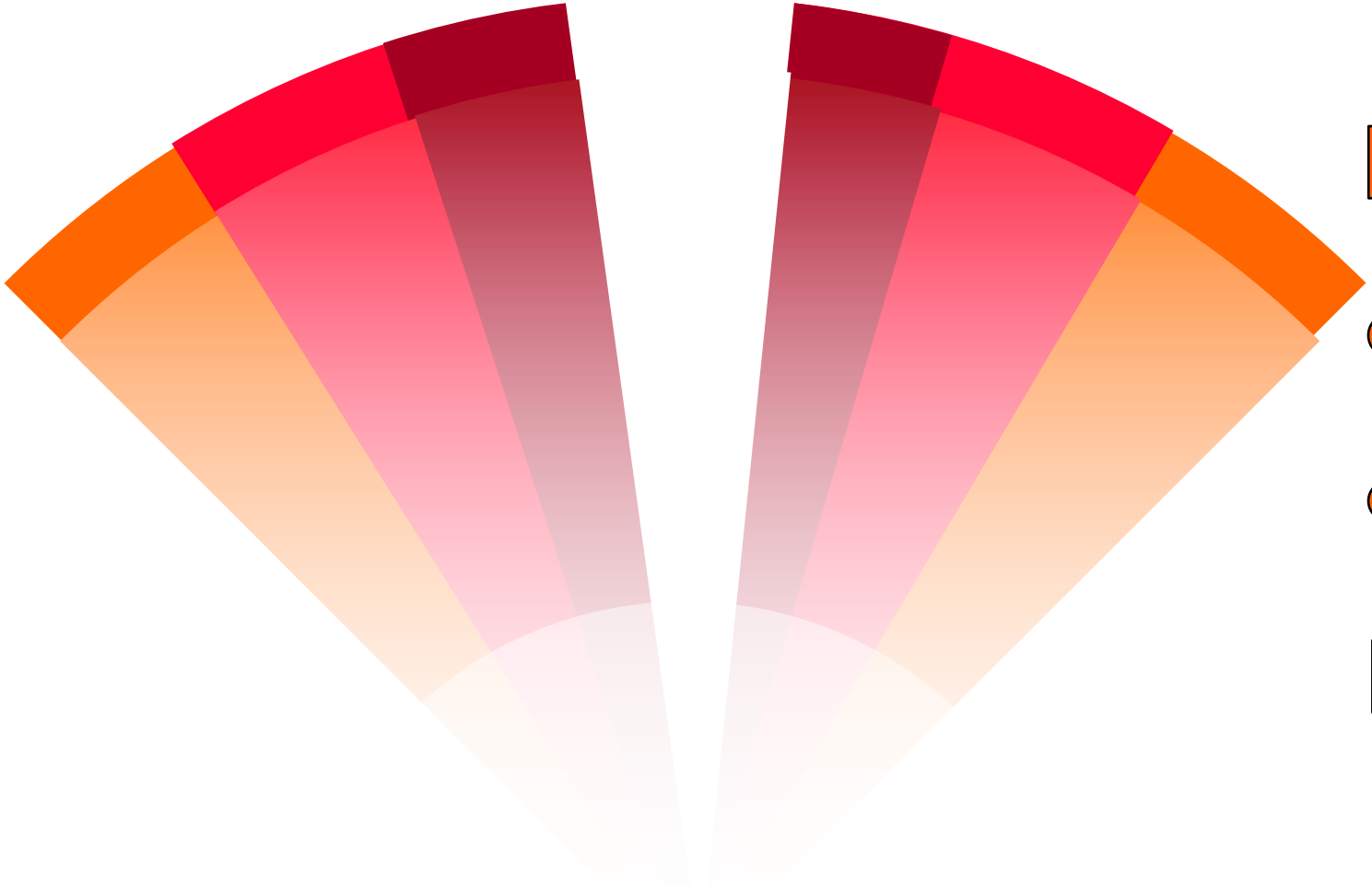


Robots and People

Vlad Estivill-Castro

Robots for People (2016)

--- A project for intelligent integrated systems

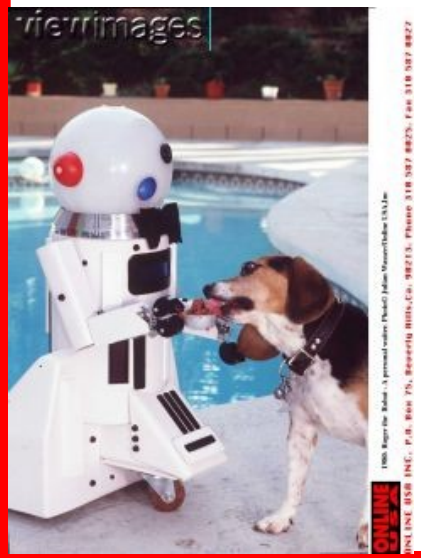
Robots and people

Thanks for your interest

Vlad Estivill-Castro

School of Information and Communication Technology

Institute for Intelligent and Integrated Systems (many collaborators)



What does robotics involve?

- Software Engineering
  - Mechatronics engineering
- Artificial intelligence
  - Agent technology
- Networking
  - Operating systems
- EVERYTHING (physics/physical work)

Software Engineering

- **Software engineering** (SE) is concerned with developing and maintaining
  - software systems that behave reliably and efficiently,
  - software applications that are affordable to develop and maintain, and satisfy all the requirements that customers have defined for them.
- It is important because of the impact of large, expensive software systems and the role of software in safety-critical applications.
- It integrates significant mathematics, computer science and practices whose origins are in engineering.

Building software with capacities we associate with human intelligence
(handle/solve unseen problems well)

- **Artificial**
- **Intelligence**

Artificial intelligence

- plan
- understand language
- learn
- negotiate / work in teams
- be strategic
- optimize (trade-off)
- solve problems
- be creative

A central project for intelligent integrated systems

- The development of autonomous mobile robots for multi-modal interaction with humans
- leading to
  - useful applications integrating
    - agent technology, HCI, AI, image processing, robotics, vision, planing, problem solving, game theory, machine learning, voice recognition, sensor fusion,
  - emotional reactions and advanced research in areas of intelligent integrated systems
  - participation with prototypes in international benchmarks that have academic and industrial recognition
    - RoboCup Soccer, RoboCup@Home, Agent-Poker, Open Game Play

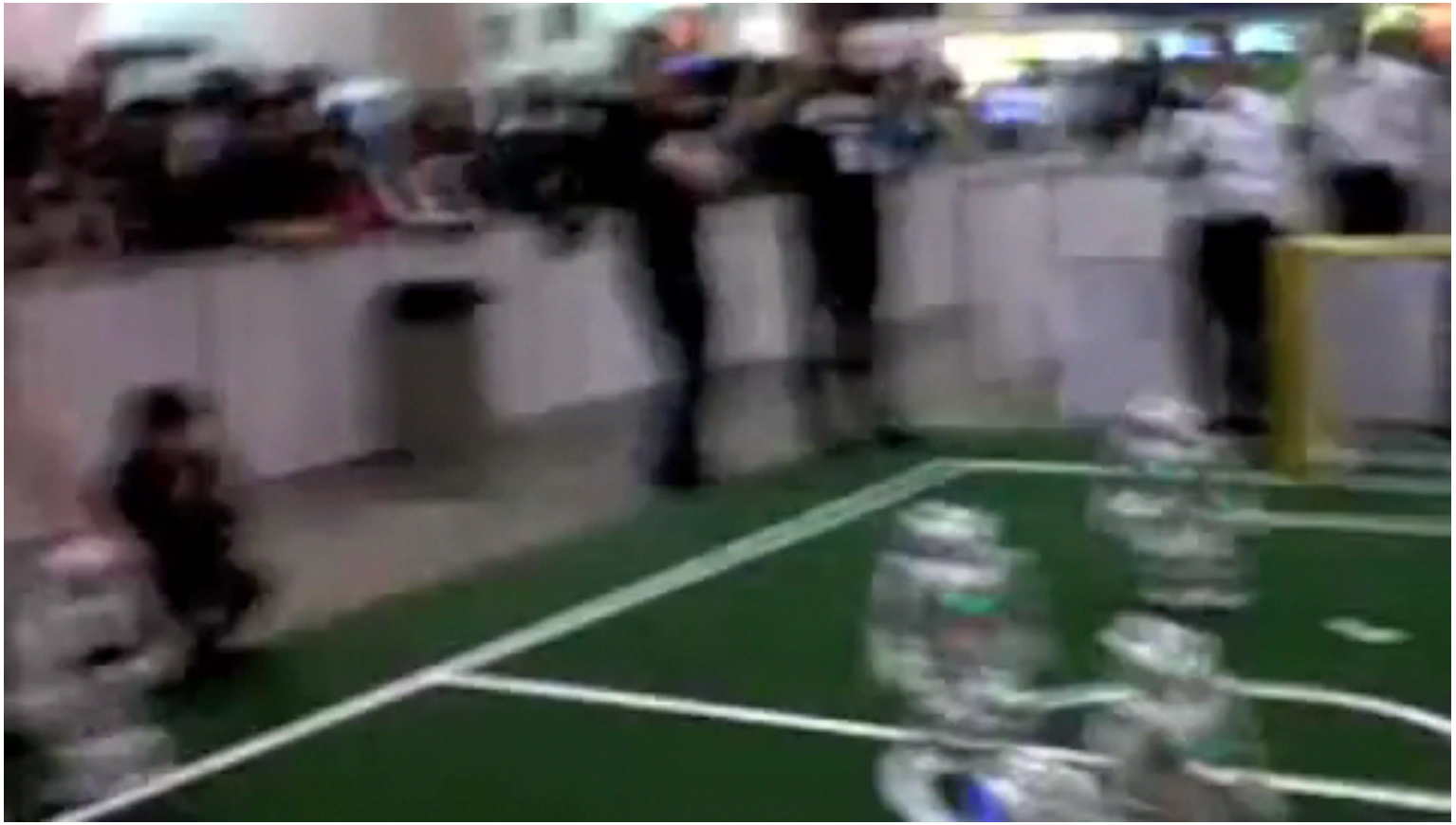
Many many interesting jobs in Software Engineering

- Creative and fun things
  - http://www.youtube.com/watch?v=_sUeGC-8dyk
- Flying Robot Rockstars
  - https://www.youtube.com/watch?v=Qlqe1DXnJKQ
- A presentation of the Giraff robot
  - http://www.youtube.com/watch?v=R-ki6uNptbY

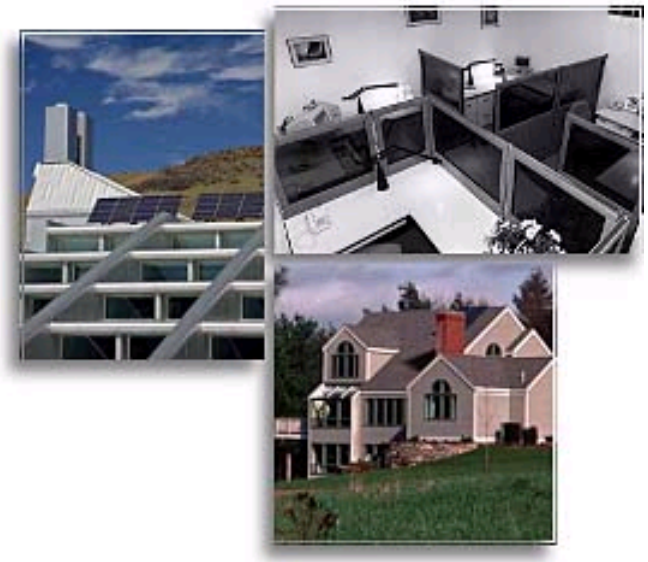
Software Engineering and Robotics

- http://www.youtube.com/embed/XRCIzZHpFtY?rel=0
- http://www.youtube.com/watch?v=9Tmb_IFlzSU
- http://www.youtube.com/embed/XRCIzZHpFtY?rel=0

The satisfaction of achievement



Hypothesis (1)



- In the not so distant future humans will be surrounded by all sorts of `intelligent machines'
  - Intelligent buildings and Sensitive computing
    - **Computing environment intended to assist the user for retrieving, organizing and interpreting available information resources by augmenting and extending the sensory as well as the cognitive capabilities of the user**
  - Ambient Intelligence / Tele-presence

Hypothesis (2)

- The sector of the human population that is to benefit the most from `robots around us' are people with disabilities, sick and rehabilitation patients, the elderly and pupils
  - If technology is to reflect an advance society it should make an impact on improving
    - the life of its weak/disadvantaged/untrained members

Hypothesis (3)

- A convergence is looming on Information and Communication Technologies
  - Mobile phones, PDAs, Wireless/Internet and Intranets through computer watches
  - Wearable computers

Hypothesis (4)

- There is a shift from "***accessible computing***" to "***user centered design***" in the Human-Computer Interaction community
  - Accessibility
    - Providing accessibility means removing barriers that prevent people with disabilities from participating in substantial life activities
  - UCD
    - Focusing on the product's potential users from the very beginning, and checking at each step of the way with these users to be sure they will like and be comfortable with the final design.

Hypothesis (5)

- The fields of artificial intelligence, robotics, machine learning, human-computer interaction are advancing in research that

  - integrates advances from different fields
  - shows deployment of the technology in demonstrable prototypes

Hypothesis (6) The interface may not be a robot

- The actuators and sensors can be remote
  - Not all of them on board of the robot
  - The control may not be on board of the mobile components
- But the technologies developed will have use in all the applications emerging from this flexibility.

Hypothesis (7) Agent technology is influencing everyday life

- Computer Games
  - Age of Empires
  - Age of Mythology
- Xbox/PlayStation/Wii
- Tamagochi/Nintendo DS
- Environments
  - Dofus
  - Runescape
  - Club Penguin
  - 2nd Life
- Automatic assistants
  - eBay

What does robotics provide?

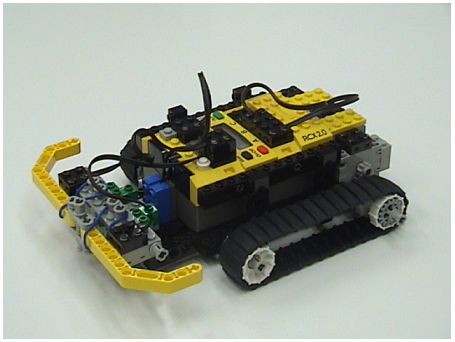
- Mobility/autonomy

- Embodiment
  - Physical presence

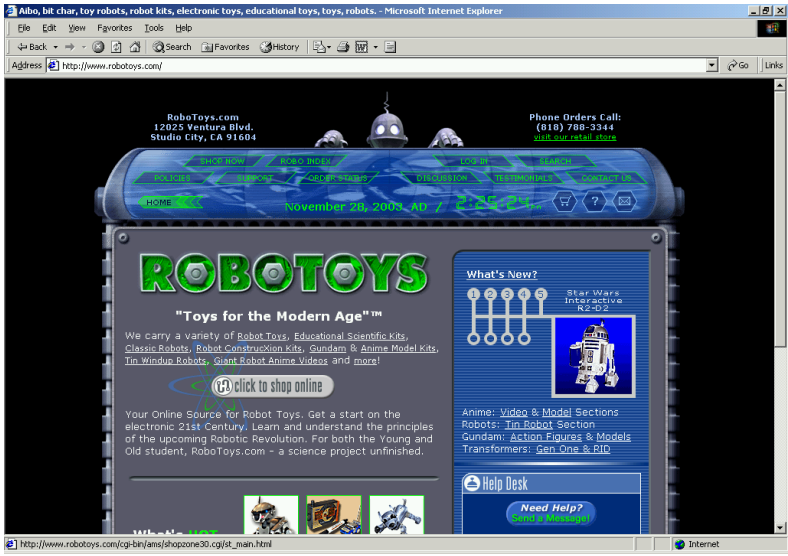
- Teams of robots
  - Collective abilities / remote control

Robotics has penetrated the home market

- Toys
  - Lego Mindstorms™



  - Cindy Smart TM



Robots on children's bedrooms

Robotics has penetrated human environments

- Home artifacts
  - The EUREKA Robo Vac™

  - Electrolux Trilobite ™

- Guides for
  - visitors in museums and the elderly
  - visitors in airports

Autonomous Vehicles / Robotic Cars are penetrating the Urban Environment

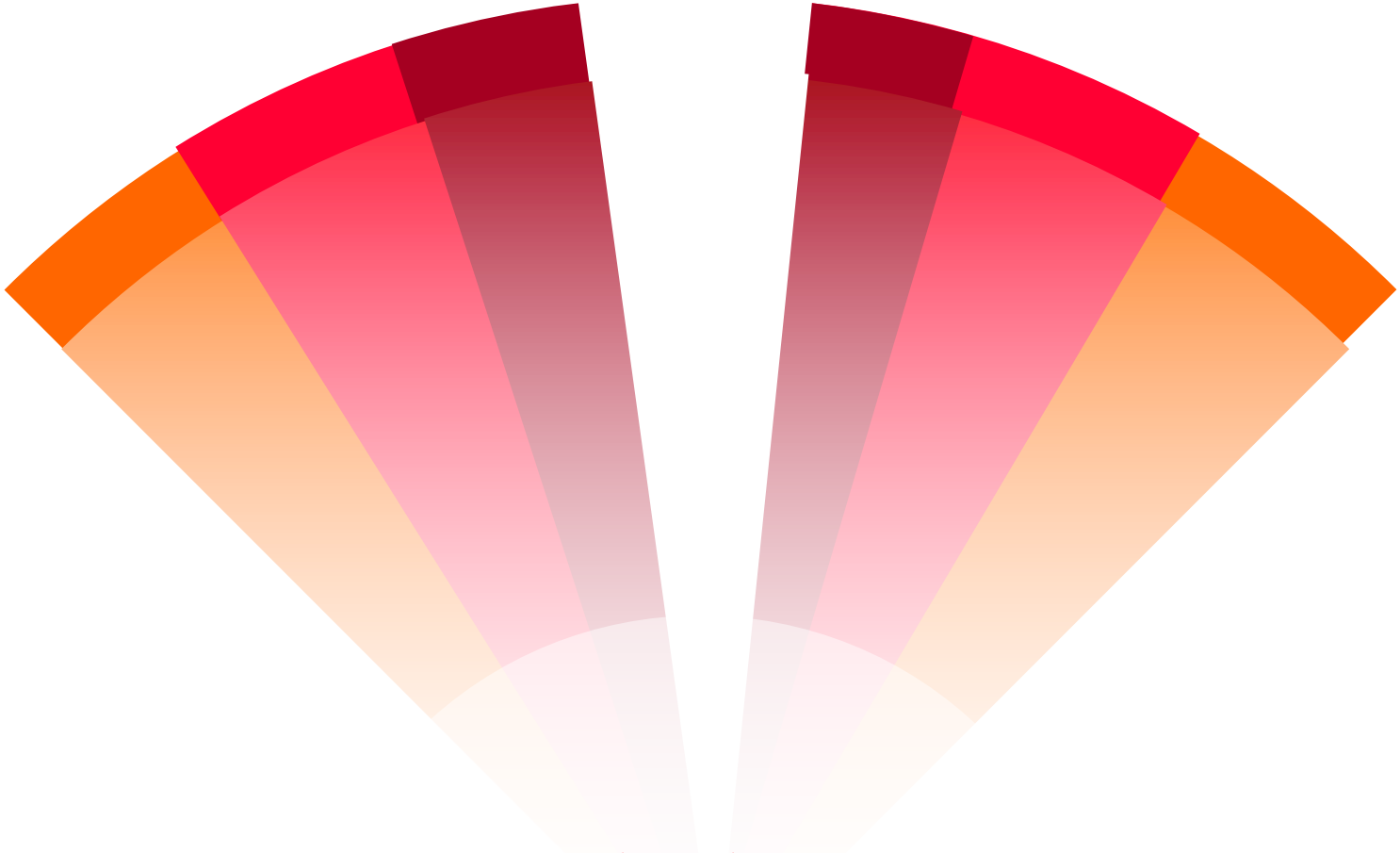
Robots are penetrating the media

- News readers
- Booking agents, traveling agents, eCommerce

- Robotic interfaces are more human-like
  - The uncanny valley
- Environments/Virtual reality/Attractions
  - Opponents are simulated agents
  - Is the matrix possible?
- Movies/Special effects
- Military
- Entertainment parks

Ramifications

- Motion control
  - pick up the cards / move bricks or chips
- Image processing
  - recognize opponents partners
  - actions / gestures
  - cards / figures
- Agent technology
  - reasoning / game play/ knowledge representation
- Multi-modal
  - sound / motion / speech
- Virtual games / tele-presence



Research directions

HCI

Reasoning

Software Engineering for Robots

RoboCup 2013

- Papers produced by Master Students
  - V. Estivill-Castro and J. Ferrer-Mestres “Path-finding for mobile robots in dynamic environments with PDDL-planners” 6th International Conference on Advanced Robotics, ICAR 2013, Montevideo, Uruguay, November 25-29th to appear
  - V. Estivill-Castro and J. Radev “Humanoids Learning who are Teammates and who are Opponents” The 8th Workshop on Humanoid Soccer Robots, at 13th IEEE-RAS International Conference on Humanoid Robots, Atlanta, GA, October 15th, 2013. to appear.

RoboCup

- Goal keeper positioning on lines
- Tracking and messaging with coaching Robot
  - position of the ball
- Goal keeper picking up the ball
- Proper localization
- Team strategies
  - Only one illegal defender
- Smooth motion

Research directions

HCI

Reasoning

Software Engineering for Robots

Robots to guide the blind

- **Can we effectively use multi-modal interfaces in autonomous mobile robots at least to facilitate human-computer interaction?**

WEDNESDAY, JUNE 18, 2003

Visionary plan for robots

ROBOTS that can detect fires and intruders in the home and micro-chipped glasses that can alert the wearer to upcoming objects will soon become tools for the vision impaired if funding is gained for a Griffith University project.

Associate Professor Brendan Bartlett, of the Vision, language and special education school, said the massive project involved the use of specially programmed robots designed to enhance the lives of visually impaired people at all stages of their lives.

With the aim of making robots a familiar and useful object from childhood, a team from Griffith University last week visited Narbethong Special School at Buranda where Johanna Medcalf, 3, was introduced to a modified Sanyo robotic dog nicknamed Miranda.

Johanna's initial caution was quickly overcome as she reached out to investigate the talking, singing, dancing toy.

While the robotic dog (which they plan to turn into a kangaroo called Eye Quede Kangaroo), was designed just to be a toy, the academics carefully observed Johanna's reaction to it.

"The first thing is to see if a young child is capable of changing the battery and turning it on and off to get various outcomes," Dr Bartlett said.

He said while a blind person compensated for the lack of sight by using other senses, it was their tactile sense that was of paramount importance.

"Early days are so important with children," Dr Bartlett said.

"They learn to learn about learning.

"The day they reach out to feel the world is like a breakthrough of literacy.

"What we're looking for here is how long it takes to move from toy to tool — when it becomes something to help build a house (of blocks) with or do sums.

"It takes time and patience."

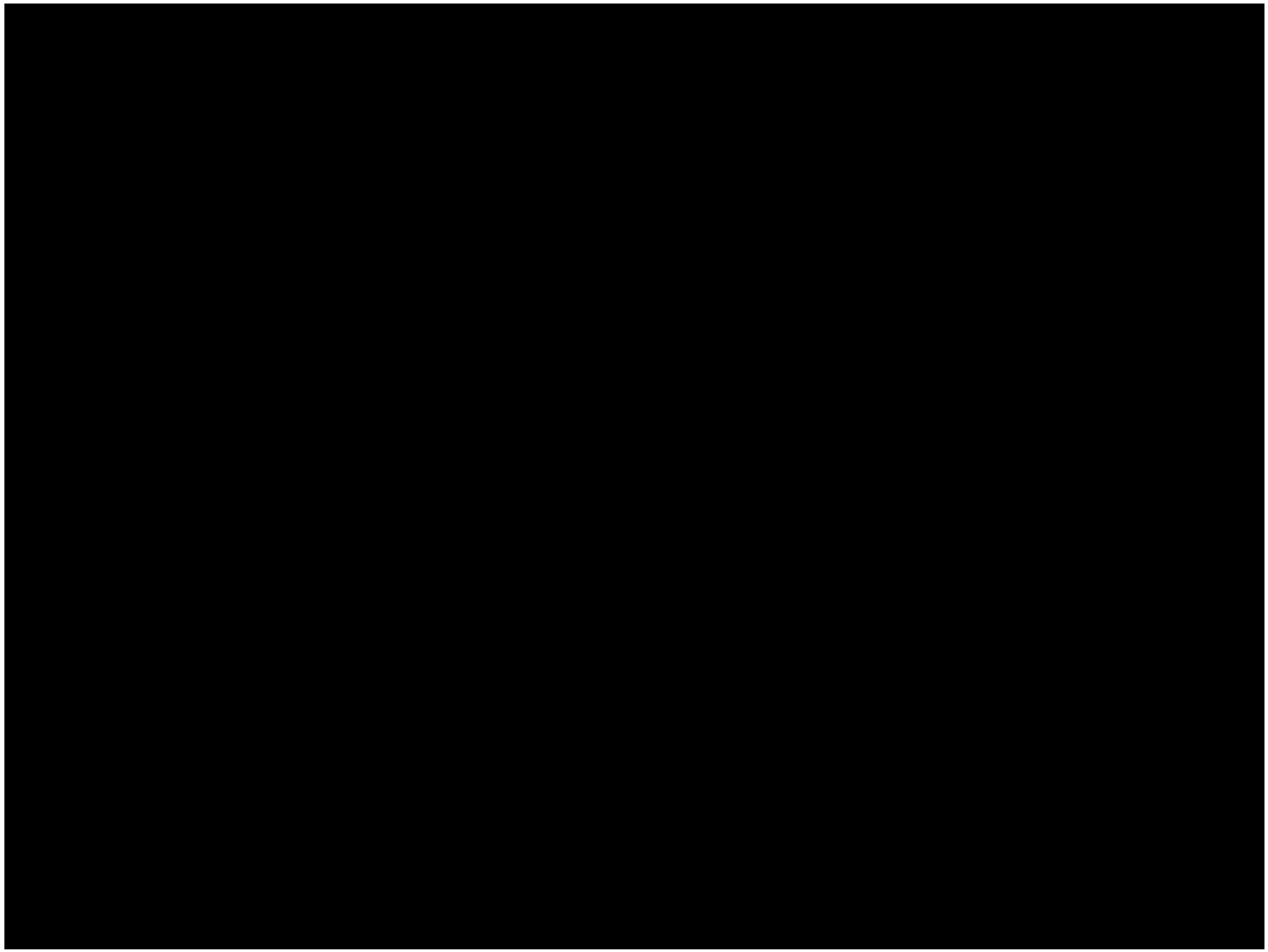
The university team, including computing and information technology school deputy head, Associate Professor Vladimir Estivill-Castro, and six PhD students, studied the reactions of four students from the school as part of their project.

— Margaret Slocombe

● Associate Professor Vladimir Estivill-Castro introduces Johanna Medcalf to Miranda the robot.

Robots and people

Interaction with blind toddlers



Far more complexity for issues of HCI

- The sudden moves in a robot are far more distressing that the sudden actions of programs on a screen.

Multi-modal interactions

A famous example

- Interaction between intelligent system and patients
  - Health Behavior Advisor System
  - Reported in [Kaplan et al 1999]
  - Generated sociable attitudes in the patients to an artificial system
  - Positive effect on health habits

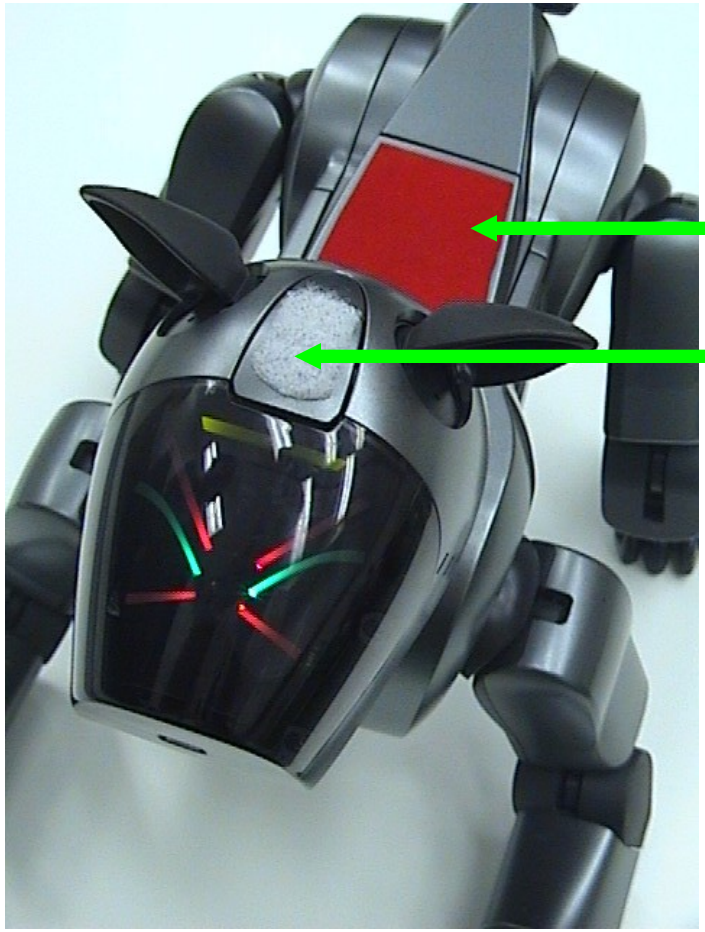
Focusing on a prototype leads to links with other areas

- Research in education
  - Meaningful play is learning

Robots and people

Work on Human-Robot Interaction

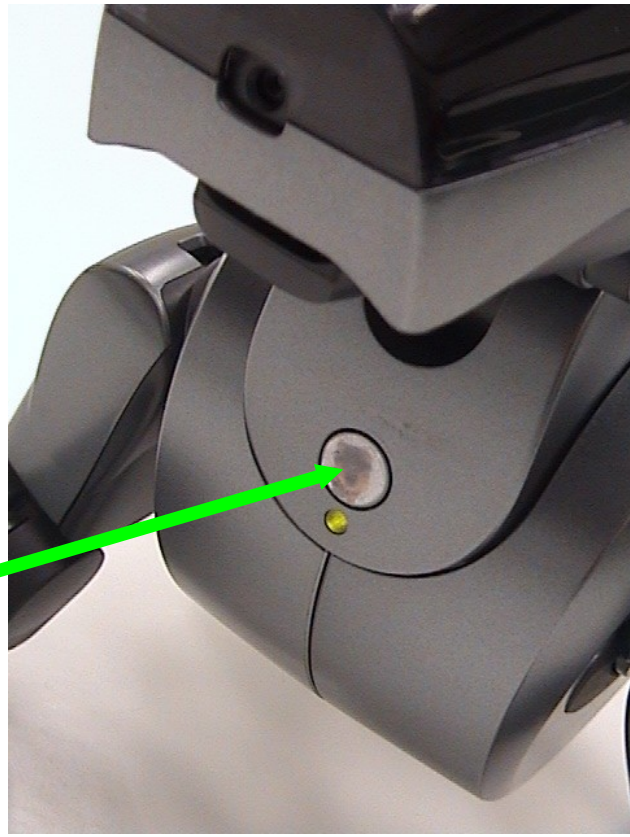
- Tools for advancing education in children who are blind
- Milti-modal interface for blind adults
- A large study of children's attitudes an interactions towards robots
  - acceptability as a companion and rejection of the machine/instrument concept



Our revisions:

Back felt

Fuzzy head



Plastic texture

Robots and people

Robots provide to the blind what was lost when text interfaces where replaced by GUIs

- Mobile robots for an E-mail interface for people who are blind
  - Provide a multi-modal mobile interface for ambient intelligence
  - Enable mnemonic commands
  - Allow rapid learning

Look and feel goes a long way on what the user expect

"Dogs don't sign"- a 6 year old child who is blind. The user of a robot is dissatisfied with the mismatch with the expectations.

Research directions

HCI

Reasoning

Software Engineering for Robots

Reasoning

- Deriving conclusions from facts
  - Apparently, a fundamental characteristic of intelligence
- An expected aspect of intelligent systems
- Withdrawing conclusions in the light of new evidence is a capability usually referred to as non-monotonic reasoning

Non-Monotonic Reasoning

- **A form of Common Sense**
- **Retract previous conclusions in the light of new evidence**

1. Planes usually leave on time.
2. My flight leaves at 11:00 am.
3. Therefore, I should be at the airport at 9:00am.
4. My flight is cancelled.
5. Makes no sense to take actions for going to the airport early.

Our environment

- RoboCup
  - A test-bed for Multi-Agent Systems
  - We know our environment, so one would expect to be able to construct a knowledge base and apply reasoning

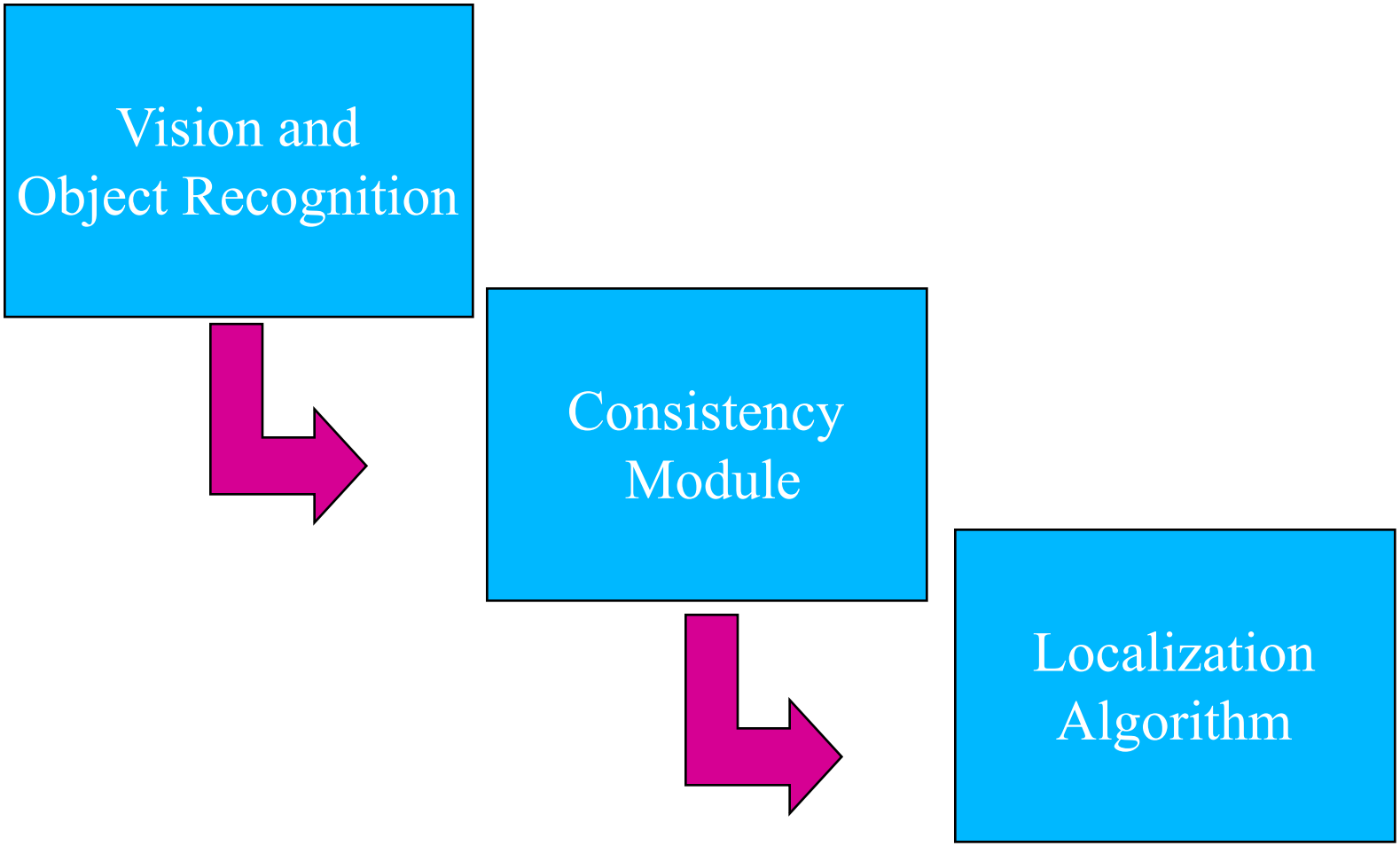
RoboCup soccer is a challenging environment

- Non-deterministic
  - I can not predict the state of the environment after I perform an action
- Not accessible
  - I can not sense all elements of the environment
- Dynamic
  - Environment changes while I decide what action to take
- Teams
  - I need to negotiate, collaborate, distribute tasks and goals
- Adversaries
  - Of unknown capabilities

We demonstrate reasoning within the task of localization

- Dynamically selecting proper inputs for localization
  - The classical example in RoboCup is that
    - A frame where both goals are visible indicates something wrong with the object recognition task

Our approach



Our approach

Consistency
Module

Non-monotonic logic that combines facts known about the environment with what is reported as visible in this frame

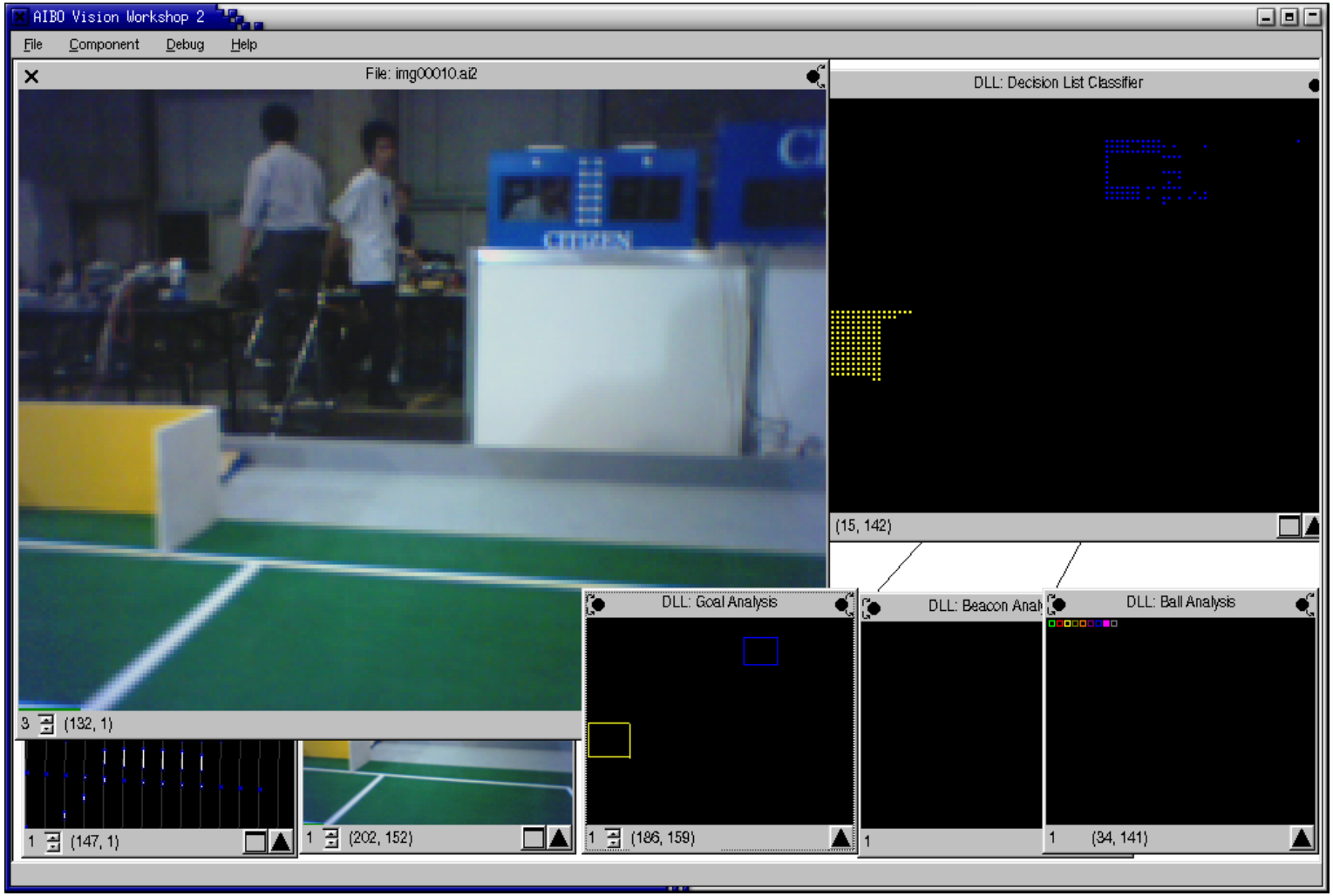
Why non-monotonic logic

- To reason about the inconsistent information provided by the sensors (vision)
- Without reasoning, all localization methods must determine
  - *Prob*(visible scene | position)

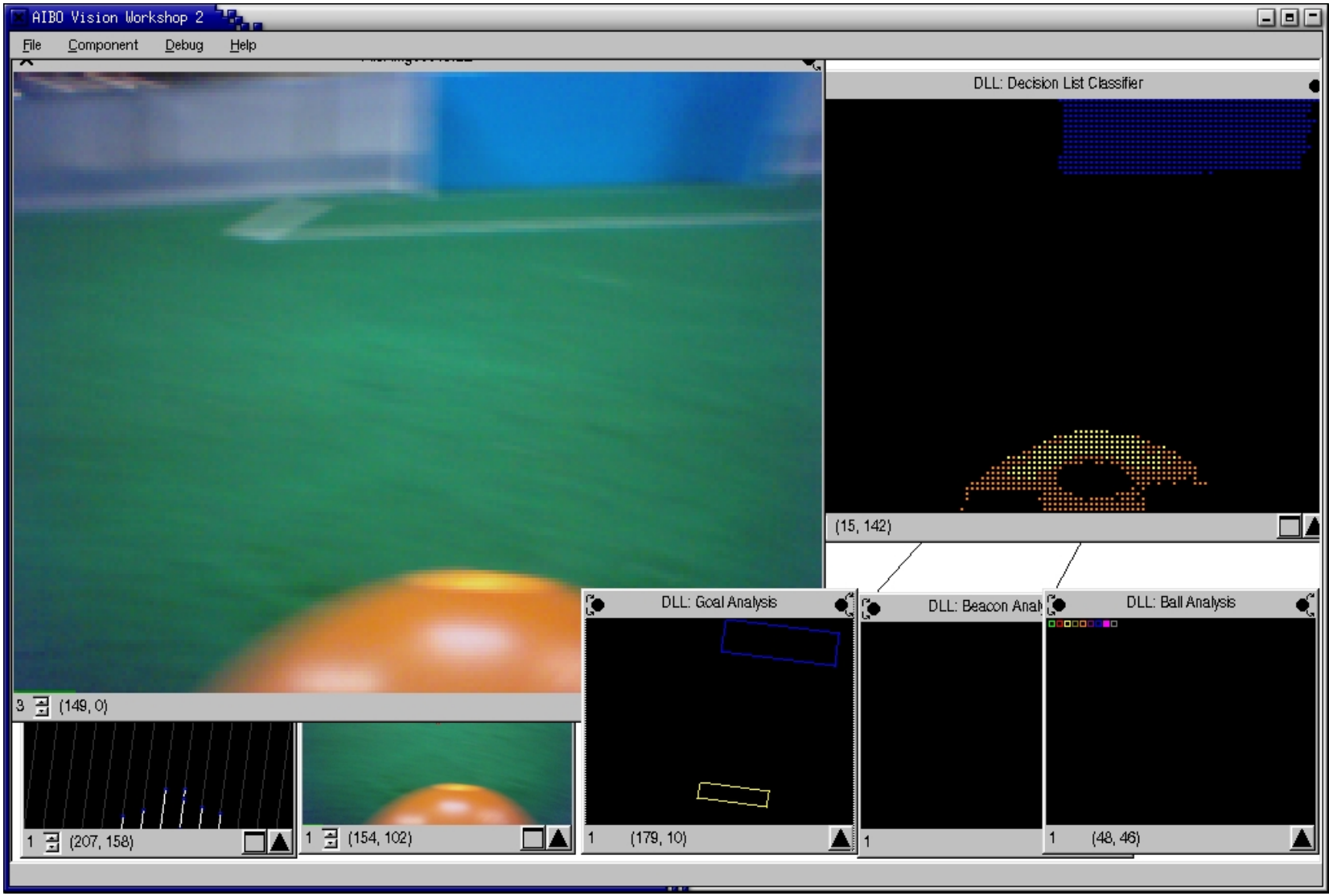
Illustration

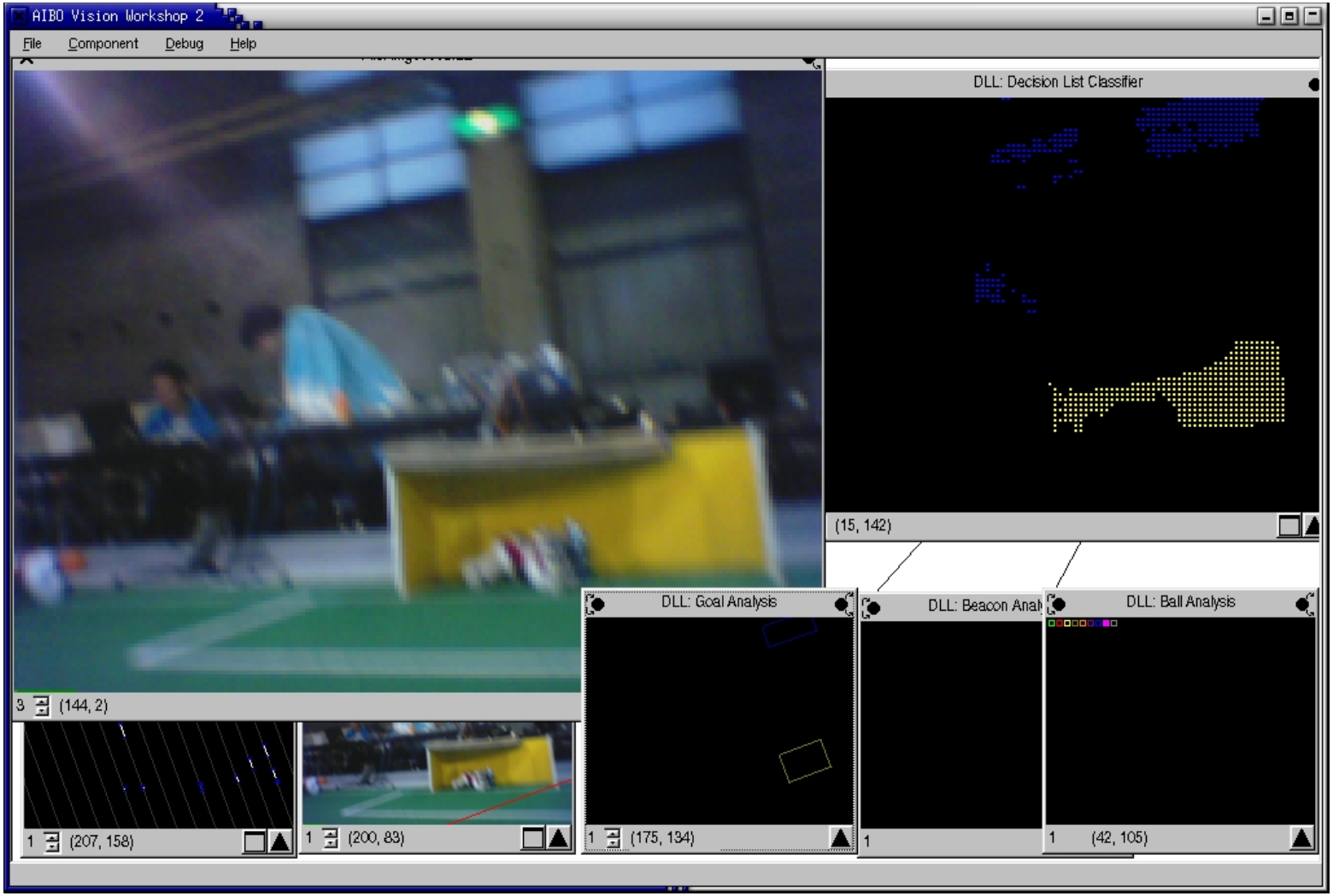
- Naturally to develop rules systems where the new rules redefine exception to the previous ones
  - 3 laws of robotics
    1. A robot may not harm a human
    2. A robot must obey a human unless it contradict law 1
    3. A robot must protect itself unless contradicts rule 1 or 2
  - Ripple down rules
    - Rules are defined and new rules are subsequently added to revise the cases not covered by the more general rules
    - A tree that is a hierarchy of rules
      - No formal reasoning

The module in action



Robots and People




AIBO Vision Workshop 2
File
Component
Debug
Help
DLL: Decision List Classifier
(15, 142)
3
(144, 2)
DLL: Goal Analysis
DLL: Beacon Anal
DLL: Ball Analysis
1
(207, 158)
1
(200, 83)
1
(175, 134)
1
1
(42, 105)

Research directions

HCI

Reasoning

Software Engineering for Robots

Engineering the behavior

- Using visual descriptions of the behaviour that incorporate formal logic
- Engineers use diagrams to model artefacts.
- Software Engineering has traditionally used diagrams to convey characteristics and descriptions of software

Game Controller- RoboCup 2011

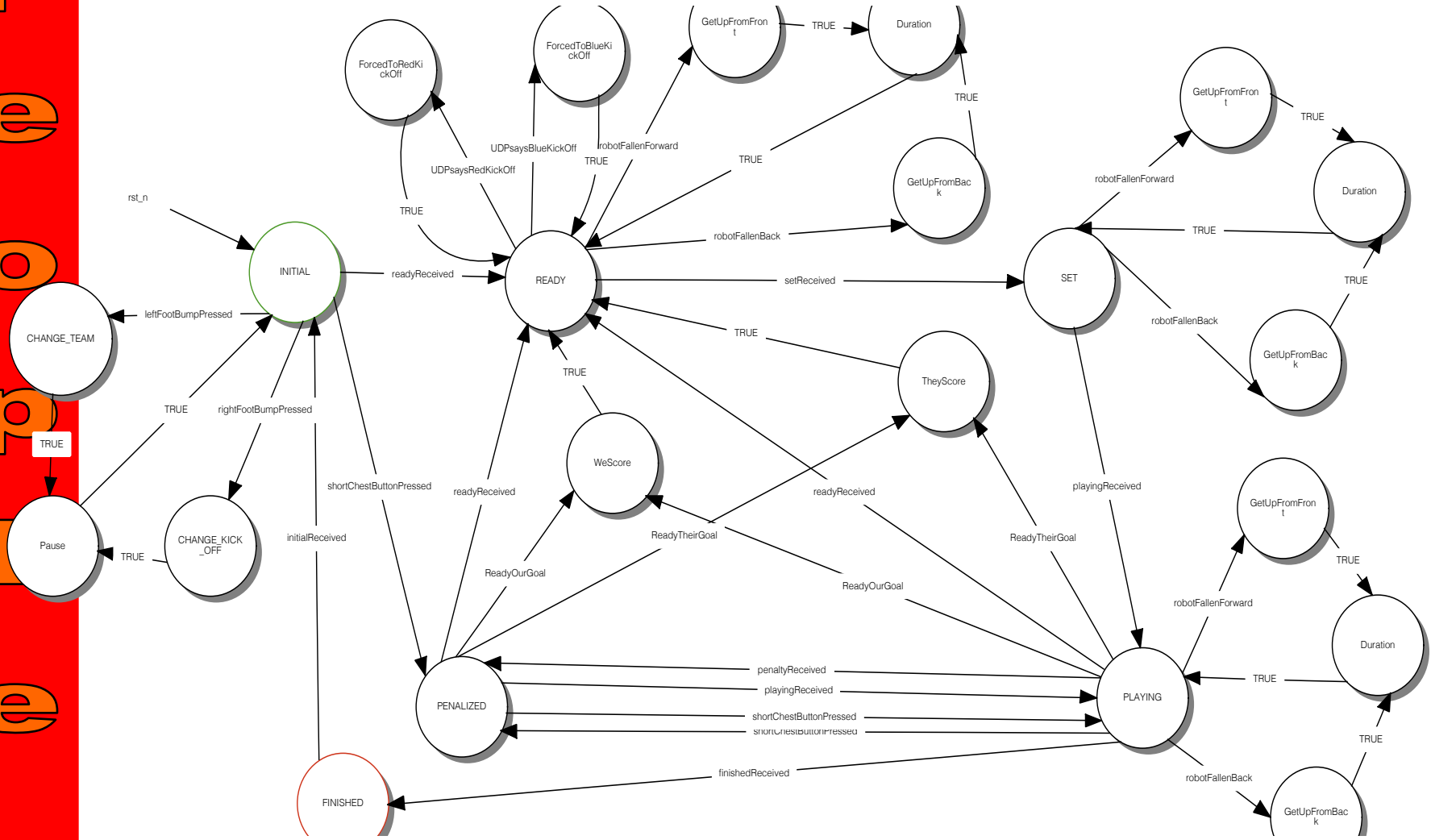
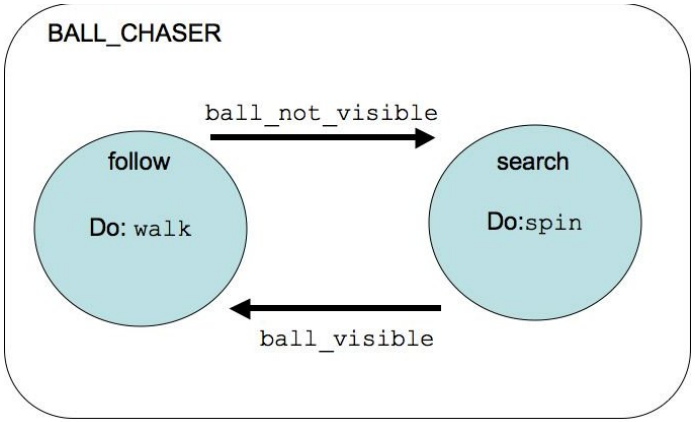
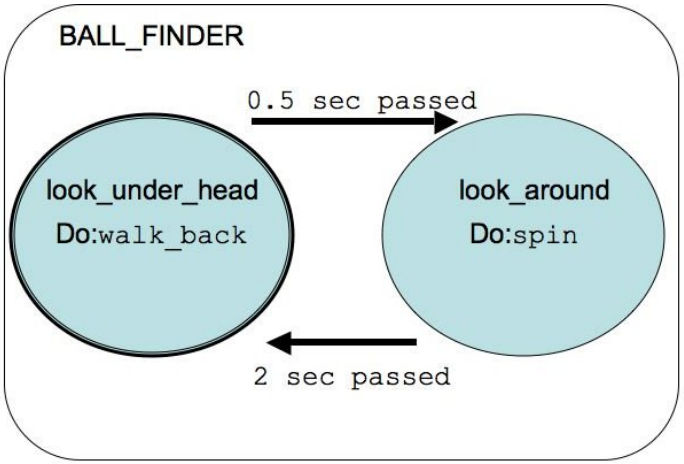


Illustration with state diagrams





s_1	$c_1=event_u$	s_i
s_1	$c_2=event_v$	s_j
s_i	$c_t=event_x$	s_p

- Exclusivity

$c_i \wedge c_j = \textbf{false} \ \forall \ i \neq j$

- Exhaustivity

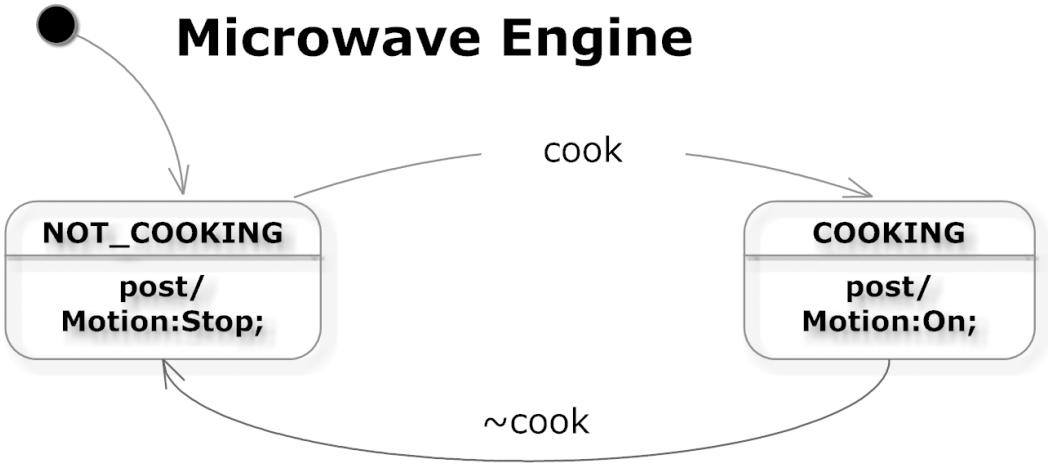
$\bigvee_{i=1}^{n} c_i = \textbf{true}$

Requirements (One-Minute Microwave Oven)

Requirements	Description
R1	There is a single control button available for the use of the oven. If the oven is closed and you push the button, the oven will start cooking (that is, energize the power-tube) for one minute
R2	If the button is pushed while the oven is cooking, it will cause the oven to cook for an extra minute.
R3	Pushing the button when the door is open has no effect.
R4	Whenever the oven is cooking or the door is open, the light in the oven will be on.
R5	Opening the door stops the cooking. and stops the timer and does not clear the timer
R6	Closing the door turns off the light. This is the normal idle state, prior to cooking when the user has placed food in the oven.
R7	If the oven times out, the light and the power-tube are turned off and then a beeper emits a warning beep to indicate that the cooking has finished.

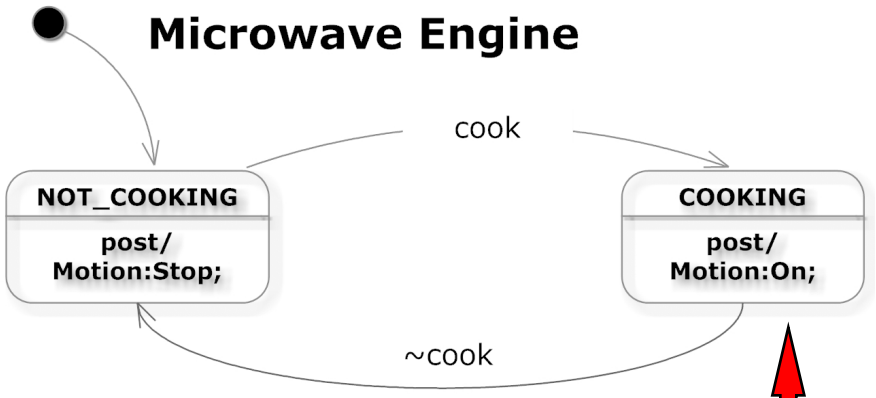
The DPL+State_Machine approach

- Step 1: Consider writing the script of music for an orchestra. Write individual scripts and place together all actuators that behave with the same actions for the same cues
- Example: The control of the tube (energizing), the fan and the spinning plate



Step 2: Describe the conditions that result in the need to change state

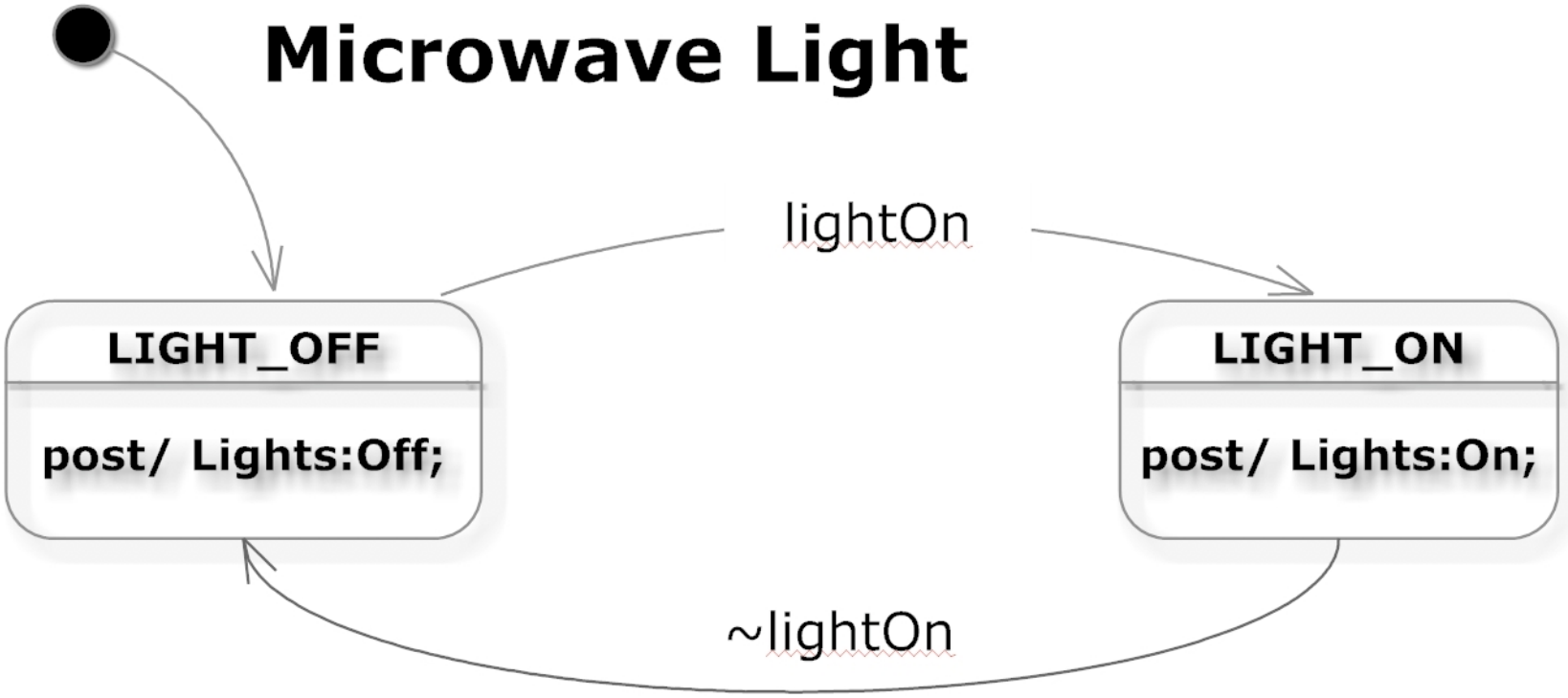
```
% MicrowaveCook.d

name{MicrowaveCook}.

input{timeLeft}.
input{doorOpen}.

C0: {}          => ~cook.
C1: timeLeft =>  cook. C1 > C0.
C2: doorOpen => ~cook. C2 > C1.

output{b cook, "cook"}.
```



Action:
Posting a message
to the whiteboard

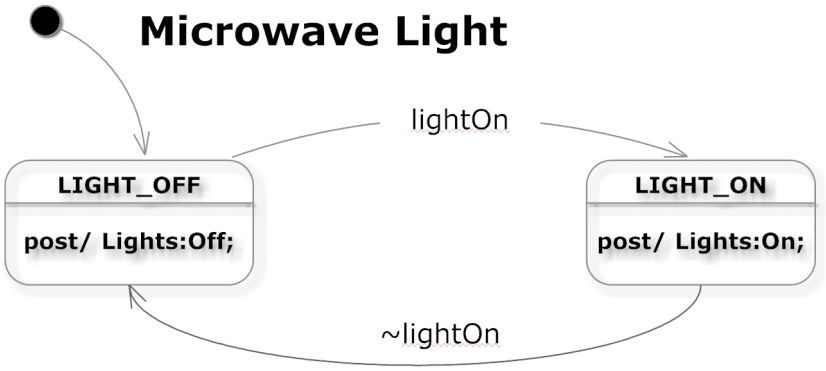
Step 1 (again): Analyze another actuator

- Illustration: The light



Step 2 (again): Describe the conditions that result in the need to change state

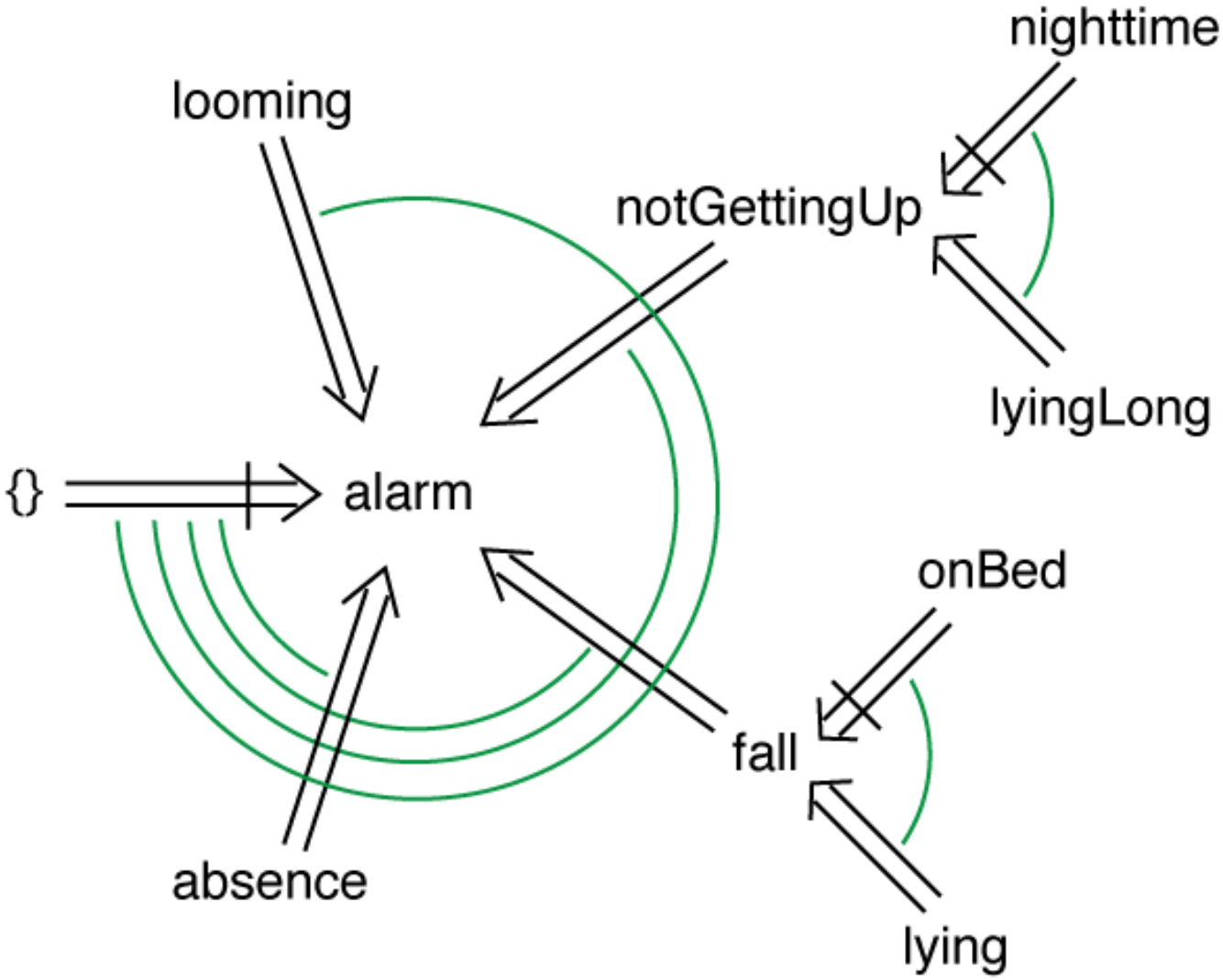
```
% MicrowaveLight.d

name{MicrowaveLight}.

input{timeLeft}.
input{doorOpen}.

L0: {}          => ~lightOn.
L1: timeLeft =>  lightOn. L1 > L0.
L2: doorOpen =>  lightOn. L2 > L0.

output{b lightOn, "lightOn"}.
```



A logic for looking after the lady

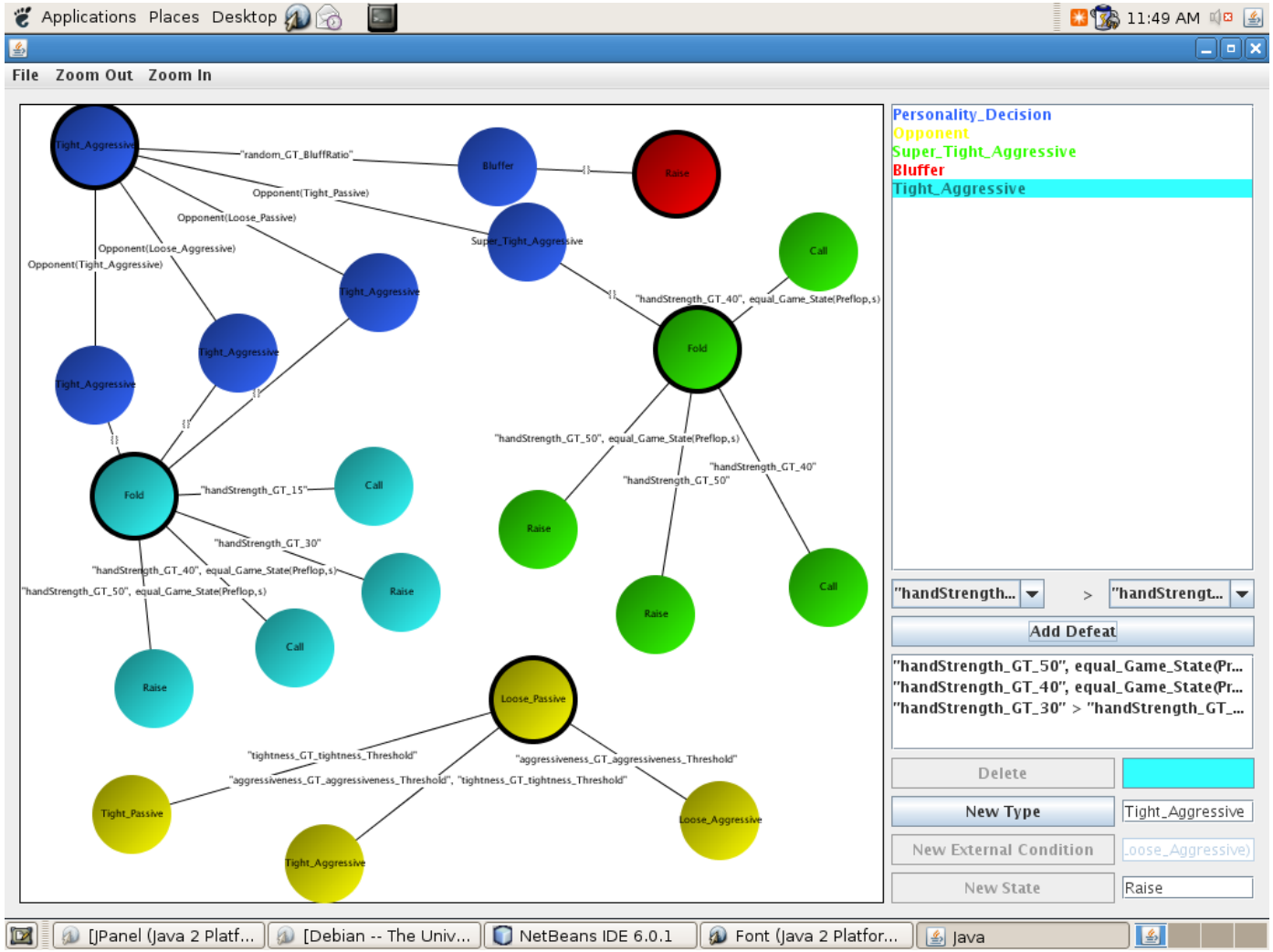
1. Usually there is no reason for alarm
2. The absence of owner for a long time is reason for alarm (this takes precedence over rule 1)
3. Lying usually results from a fall
4. A fall is usually a reason for alarm (this takes precedence over rule 1)
5. Being on bed is not a fall (this takes precedence over rule 4)
6. Lying for a long time means owner is not getting up.
7. Not getting up is a reason for alarm (this takes precedence over rule 1)
8. If it is night, it is fine not to get up (this takes precedence over rule 7)
9. If there is a stranger looming over the lady, it is reason for an alarm (takes precedence over rule 1)
10. Owner can't be absent while on bed, or lying or lying for a long time.
11. Owner can't be lying for a long time without lying for a short time.

Diagrams a la Petri nets



Prototype demonstrated at RoboCup@Home 2007

A diagram for a poker player



Systems interacting with humans

Interaction in games with incomplete information

Robots and people

Summary

- A focused project
  - Humanoid that interactively plays team games of incomplete information with humans
- Enables research on intelligent/smart devices
- We can postulate the use of intelligent capabilities to enhance the life of humans
  - care / assistance / education / tele-presence
- Keep in mind it is more important to improve the condition of human living than to imitate it.

The course

- Five practical challenges
  - NXT idempotent interface
  - Reactive Robot
  - Kalman filter
  - Localization/Navigation
  - Project (free)

Honours (the transition to research)

- Read all the papers in MiPal publications
- Papers of your interest
  - tele-presence /HCI
  - Drop-in Challenge
  - Dynamic middleware for clfsm
  - Mining behaviour of a robot
  - Planning/Modelling Continuous planning
- Immediate objectives
  - localization/navigation for RoboCup
  - Intelligent simulations/planning drop-in challenge
  - clfsm for ROS

What is the course about?

- textbook
- **Introduction to Autonomous Robots**
- second edition

  Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza

THANK YOU