RobotCub

Open Source hardware and software for robotics

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Cogsys
Cognitive Systems

A collaborative project

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U. Herthfordshire	IST - Lisbon	U. Sheffield	EPFL	Telerobot S.r.l
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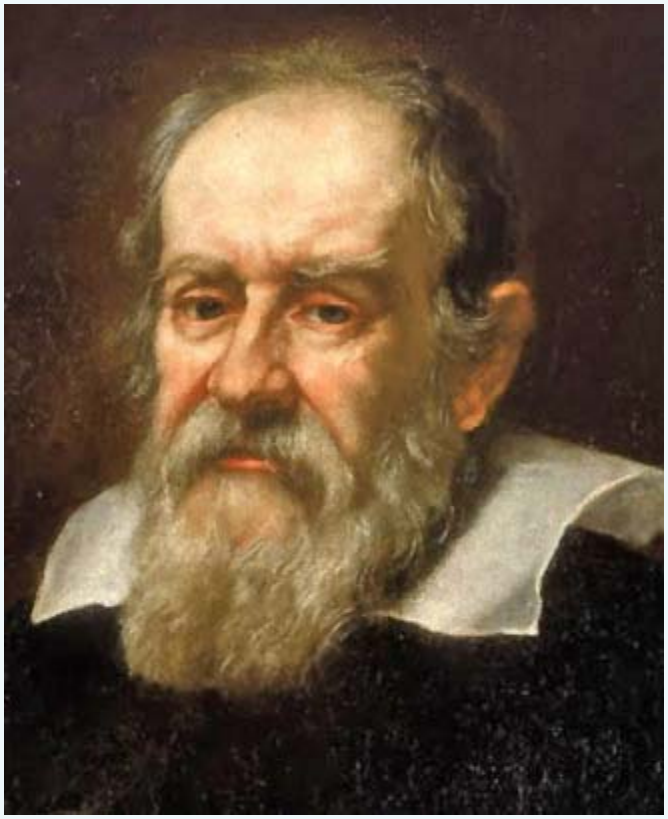
The Hardware

- Goals:
  - Quality design, industry level…
  - … with research-driven specifications
  - Consequences: dexterous manipulation, tendon driven robot, difficult to control, extensive sensorization



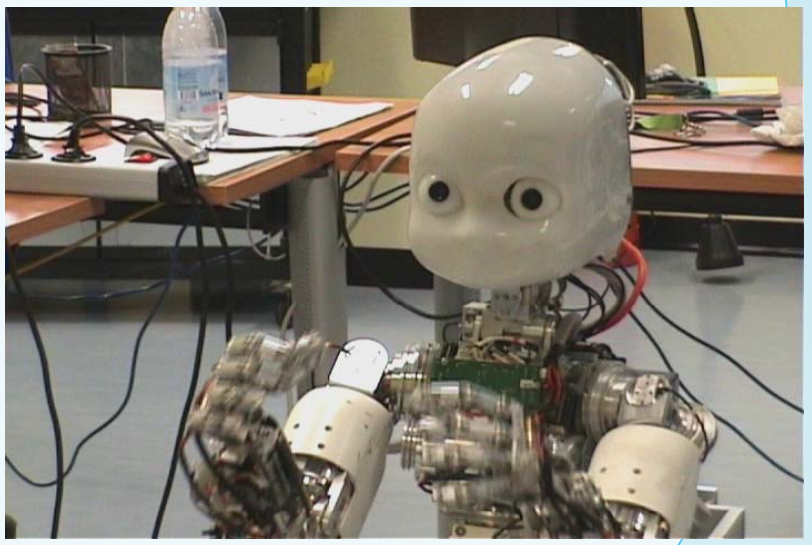
The iCub: quick summary

The **iCub** is the humanoid baby-robot designed as part of the **RobotCub** project

- The iCub is a full humanoid robot sized as a three and half year-old child.
- The total height is 104cm.
- It has 53 degrees of freedom, including articulated hands to be used for manipulation and gesturing.
- The robot will be able to crawl and sit and autonomously transition from crawling to sitting and vice-versa.
- The robot is GPL/FDL: software, hardware, drawings, documentation, etc.

Degrees of freedom

- Head: vergence, common tilt + 3 dof neck
- Arms: 7 dof each
  - Shoulder (3), elbow (1), wrist (3)
- Hands: 9 dof each ► 19 joints
  - 5 fingers ► underactuated
- Legs: 6 dof each
  - Hip (3), knee (1), ankle (2)
- Waist: 3 dof



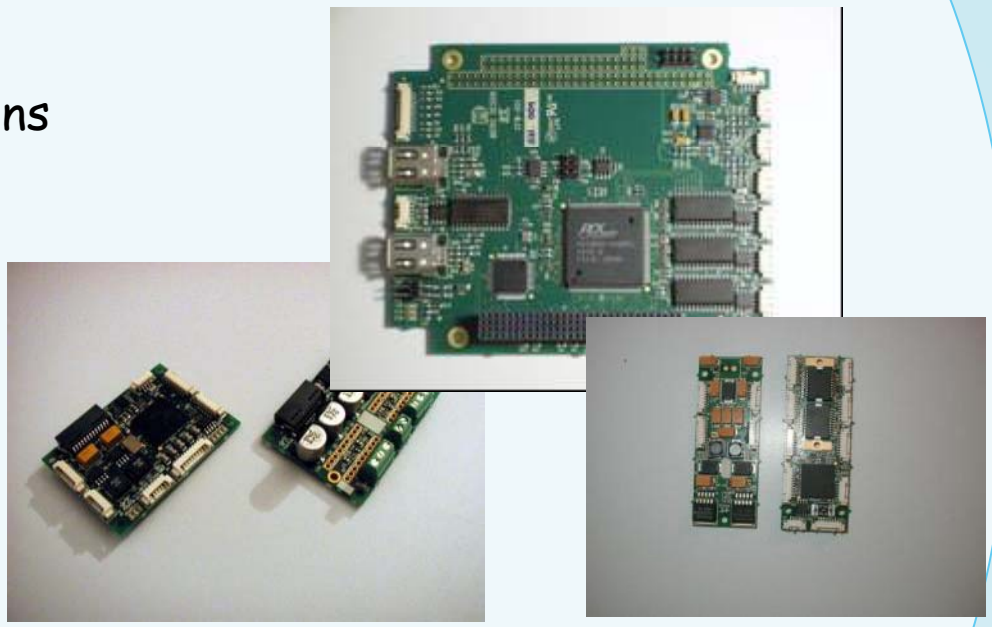
Σ = 53 dof (not counting the facial expressions)

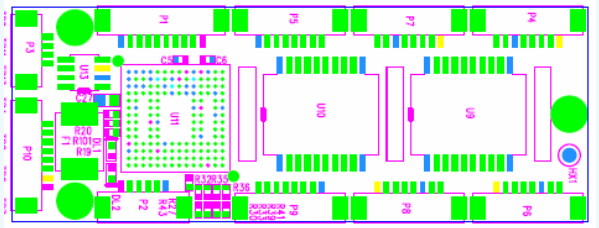
Sensorization

- Absolute position
  - On most joints, AMS magnetic encoder
- Cameras
  - Pointgrey Dragonfly firewire cameras
- Microphones, speaker
  - Standard condenser electrect miniature microphones
  - Pinnae
- Gyroscopes, linear accelerometers
  - Xsense: Mtx

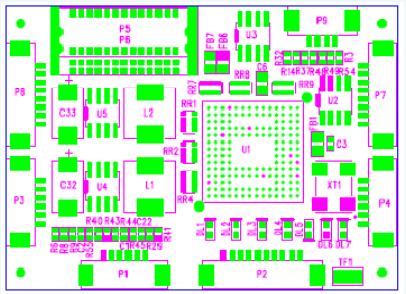
Custom electronics

- ADC card
  - Special connectors (40 pins < 1cm length)
  - 200µm stainless steel wires, coated in Teflon
- Motor control
  - C programmable DSP 40 MIPS
  - Up to 4A DC motor





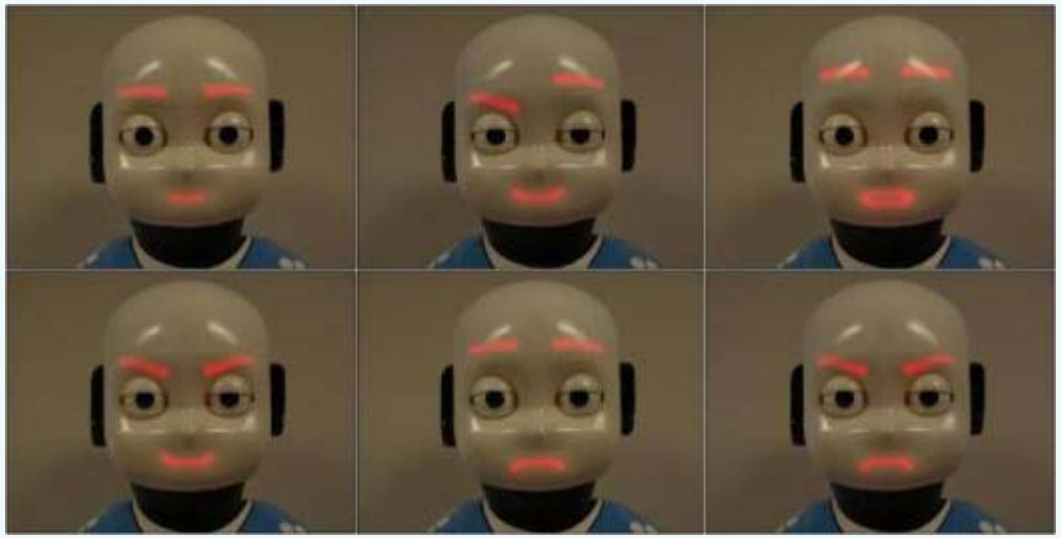
80x30mm

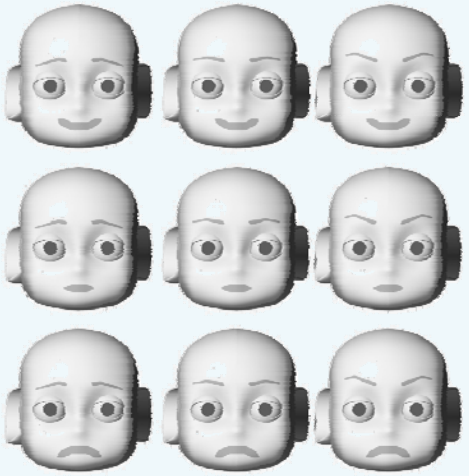


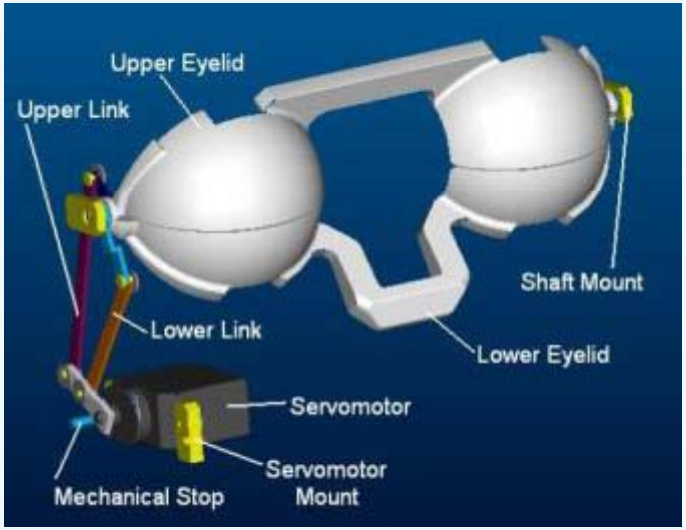
58x42mm

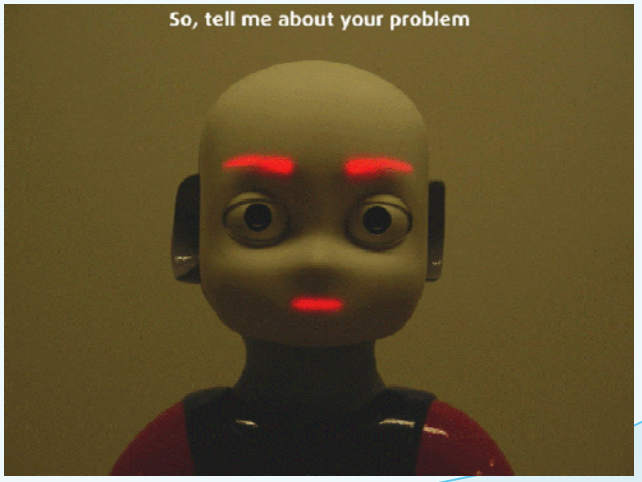
Motorola DSP56F807 (5680x family)
MAC instructions
PWM generation
ADC
Digital I/O
Can bus
C programmable

Facial expressions



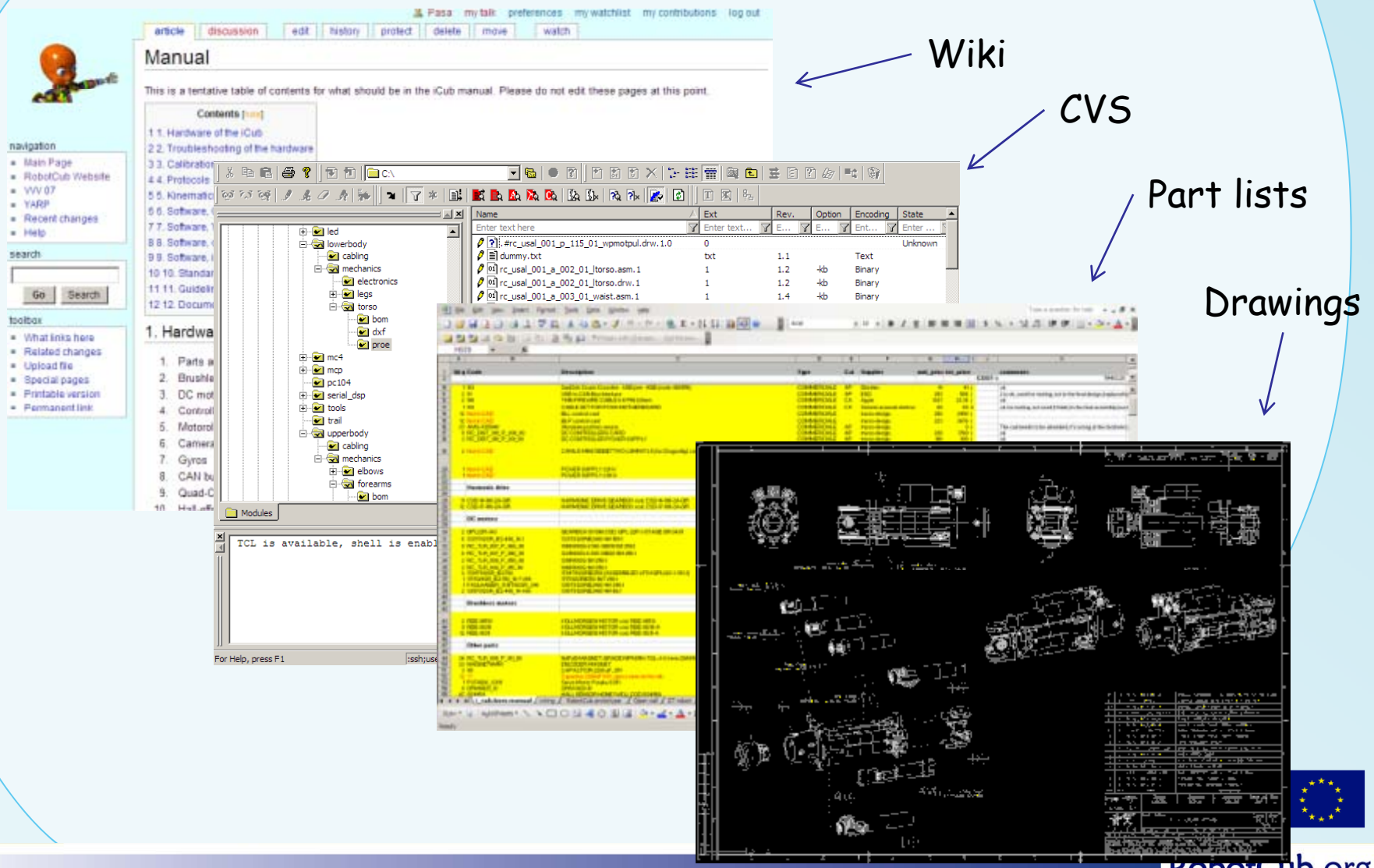






RobotCub

open source



RobotCub

At the end of Y5 we will have 18 working platforms

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Promoting the iCub

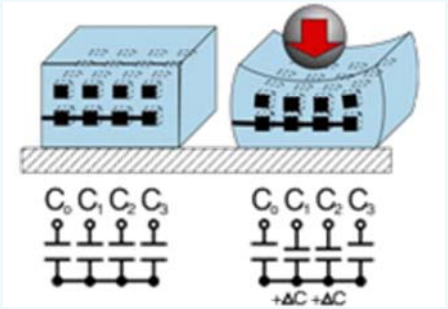
- RobotCub Open Call
  - 31 participants, 7 winners will receive a copy of the iCub free of charge
  - UPMC Paris, Imperial London, Inserm Lyon, TU Munich, METU Ankara, Pompeu Fabra Barcelona, Urbana-Champaign USA, IST Lisbon, EPFL Lausanne
- Further development…
  - EU project ITALK: 4 iCub's have been built
  - EU project ImClever: 3 iCub's will be built
  - EU project RoboSkin: a skin system compatible with iCub
  - EU project CHRIS: safety features for the iCub
- Collaborations
  - Univ. of Karlsruhe: new and longer legs
- Simulator:
  - Open Source simulator based on ODE and as a model in Webots

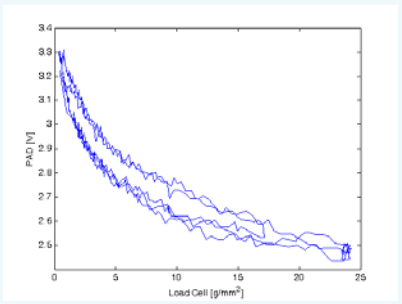
In the pipeline…

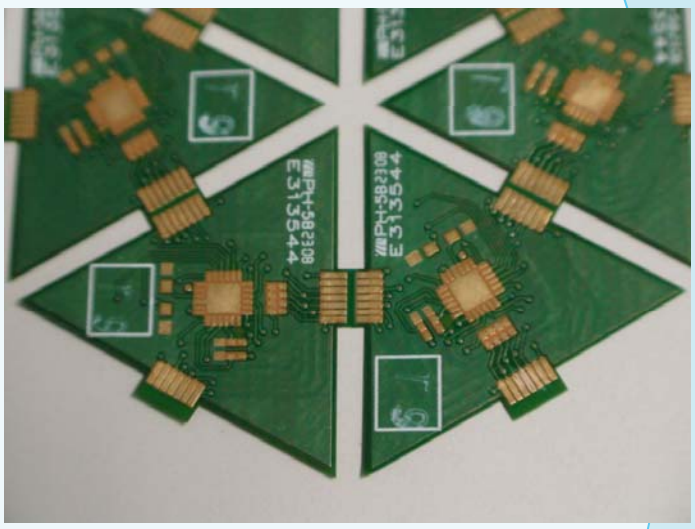
- Force control: joint level sensors, SEA or stain gauges based sensing
- Skin/tactile sensors: almost everywhere on the robot surface
- Robot general improvements: e.g. zero-backlash everywhere, better control electronics, higher resolution position sensors

The skin

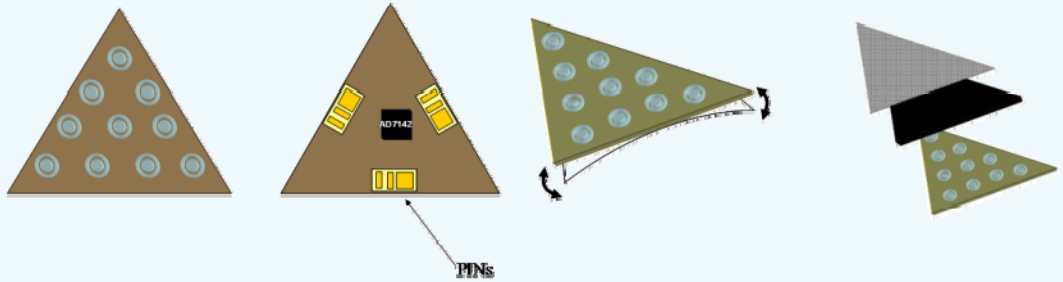
Principle

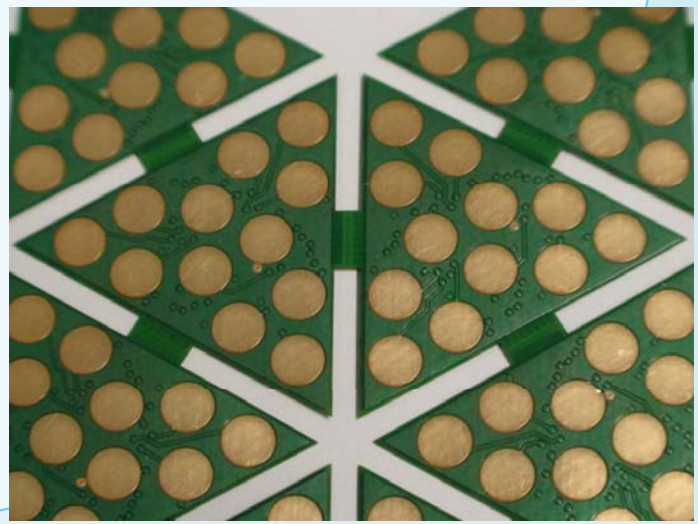




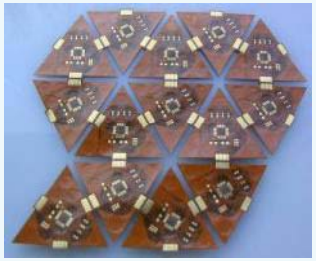


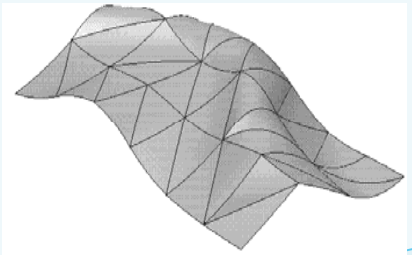
Lot of sensing points



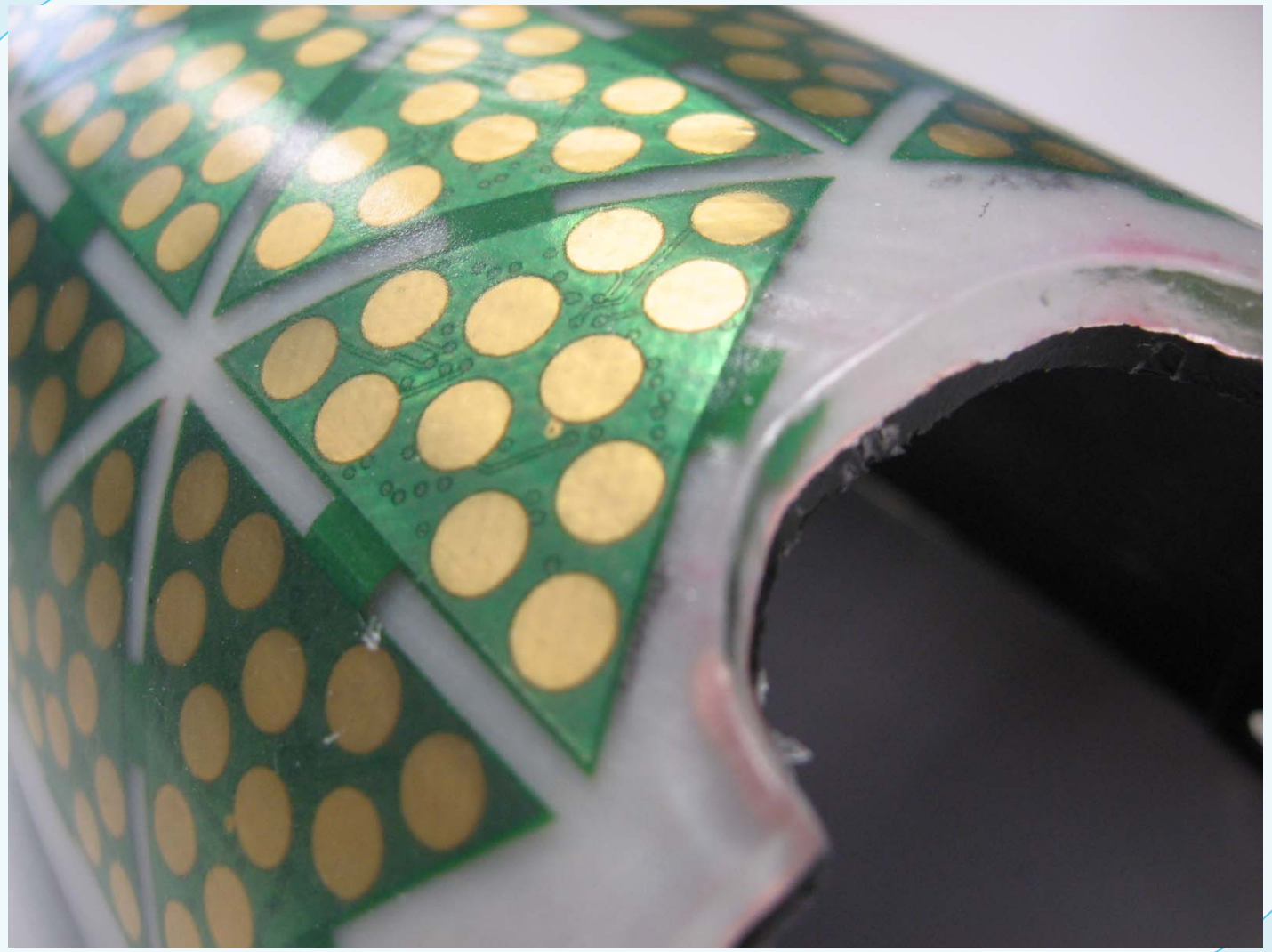


Structure of the skin





RobotCub



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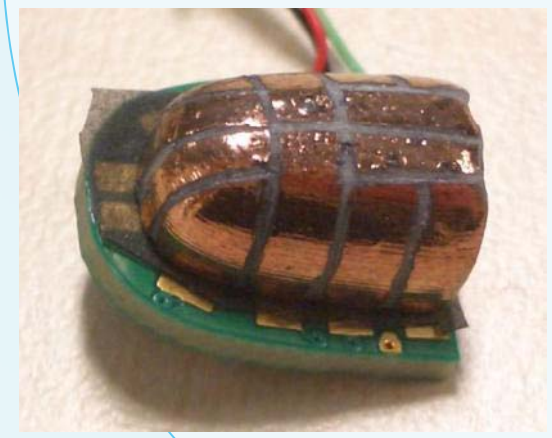
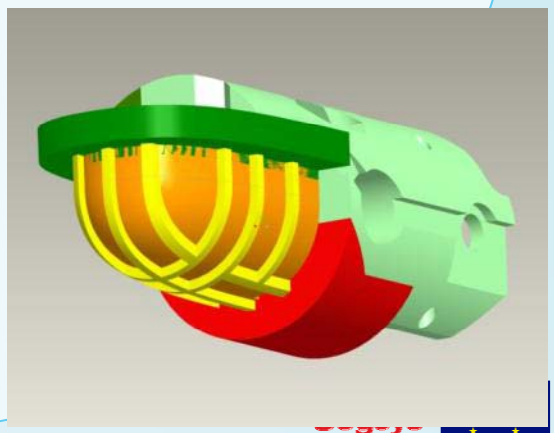
Fingertips

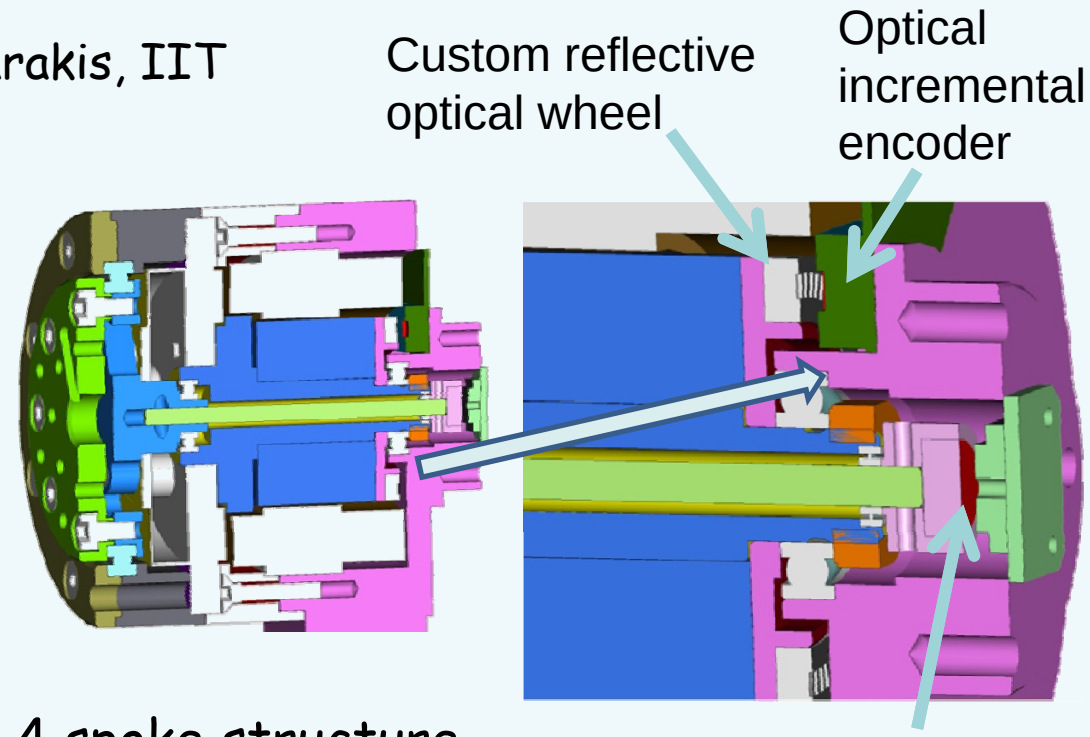
- Capacitive pressure sensor with 12 sensitive zones
- 14.5 mm long and 13 mm wide, sized for iCub
- Embedded electronics: twelve 16 bit measurements of capacitance
  - either all 12 taxels independently at 50 Hz or an average of the 12 taxels at about 500 Hz





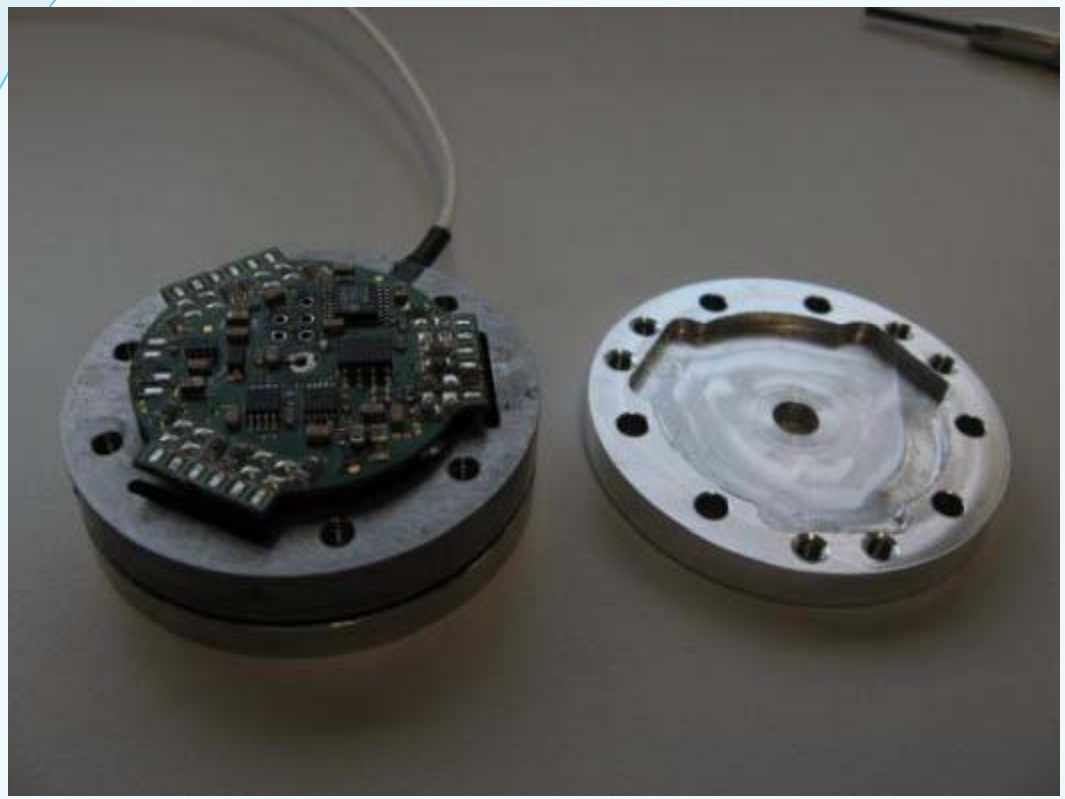
Joint-level torque sensing

Design: Nikos Tsagarakis, IIT



- Torque sensing - 4 spoke structure
- Position sensing – absolute (12bit) + incremental (19bit)
- Respect the original motor size
- Allow active compliance regulation

6-axial force/torque sensor



- Semiconductor strain gauges
- On board signal conditioning, sampling, and calibration
- Digital output: CAN bus

By Nikos Tsagarakis and Darwin Caldwell
Electronics: Claudio Lorini

RobotCub

The Software

- Goals:
  - Foster collaboration in "space" and "time"…
  - … since we're a large Consortium and we don't want to re-invent the wheel too often
  - Manage the complexity of the hardware…
  - … since humanoid robots are complicated

  - Consequence: improved on existing Open Source libraries supporting a major overhaul of YARP to the iCub

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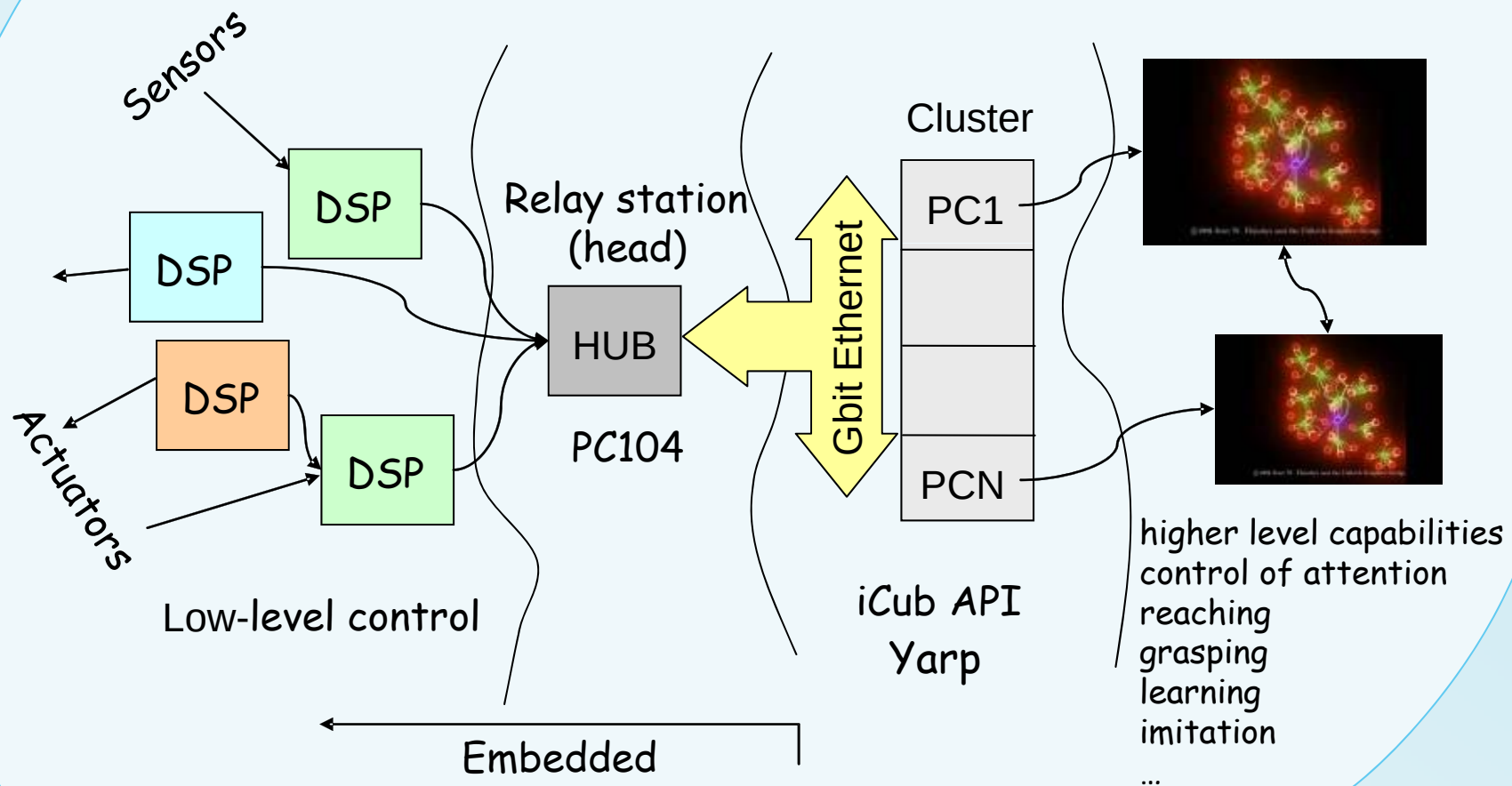
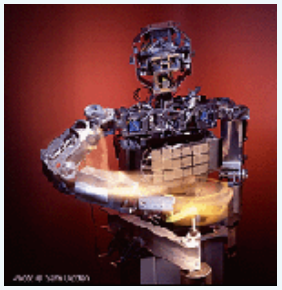
Let's start from the hardware



RobotCub

YARP



- YARP is an open-source middleware for humanoid robotics
- History
  - An MIT / Univ. of Genoa collaboration
  - Born on Kismet, grew on COG
  - With a major overhaul, now used by RobotCub consortium
  - Exists as an independent open source project
  - C++ source code
- In short: it's the plumbing

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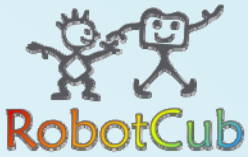
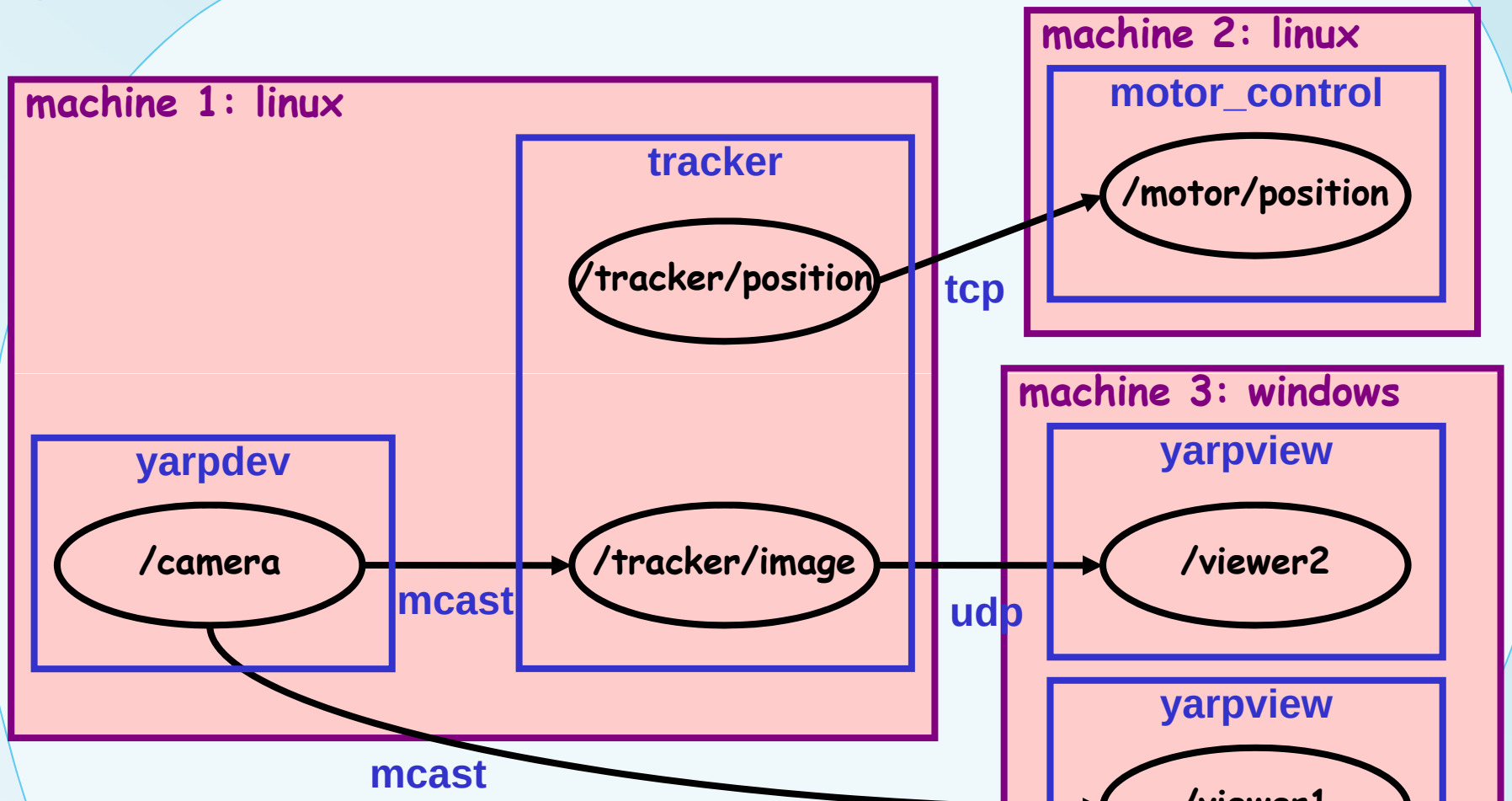


- It factors out:
  - the data flow: inter-process communication
    - it is often useful to keep algorithms away from the plumbing
  - the hardware: device drivers model
    - it is useful to avoid references to the hardware in the source code
- …while being portable:
  - across OS and development tools
  - across languages
    - libs in C++, bindings for many other languages

YARP Ports

- We follow the **Observer** design pattern.
- Special "Port" objects deliver data to:
  - Any number of observers (other "Port"s) ...
  - ... in any number of processes ...
  - ... distributed across any number of computers/OSes ...
  - using any of several underlying communication protocols with different technical advantages, streaming or RPC
- This is called the YARP Network

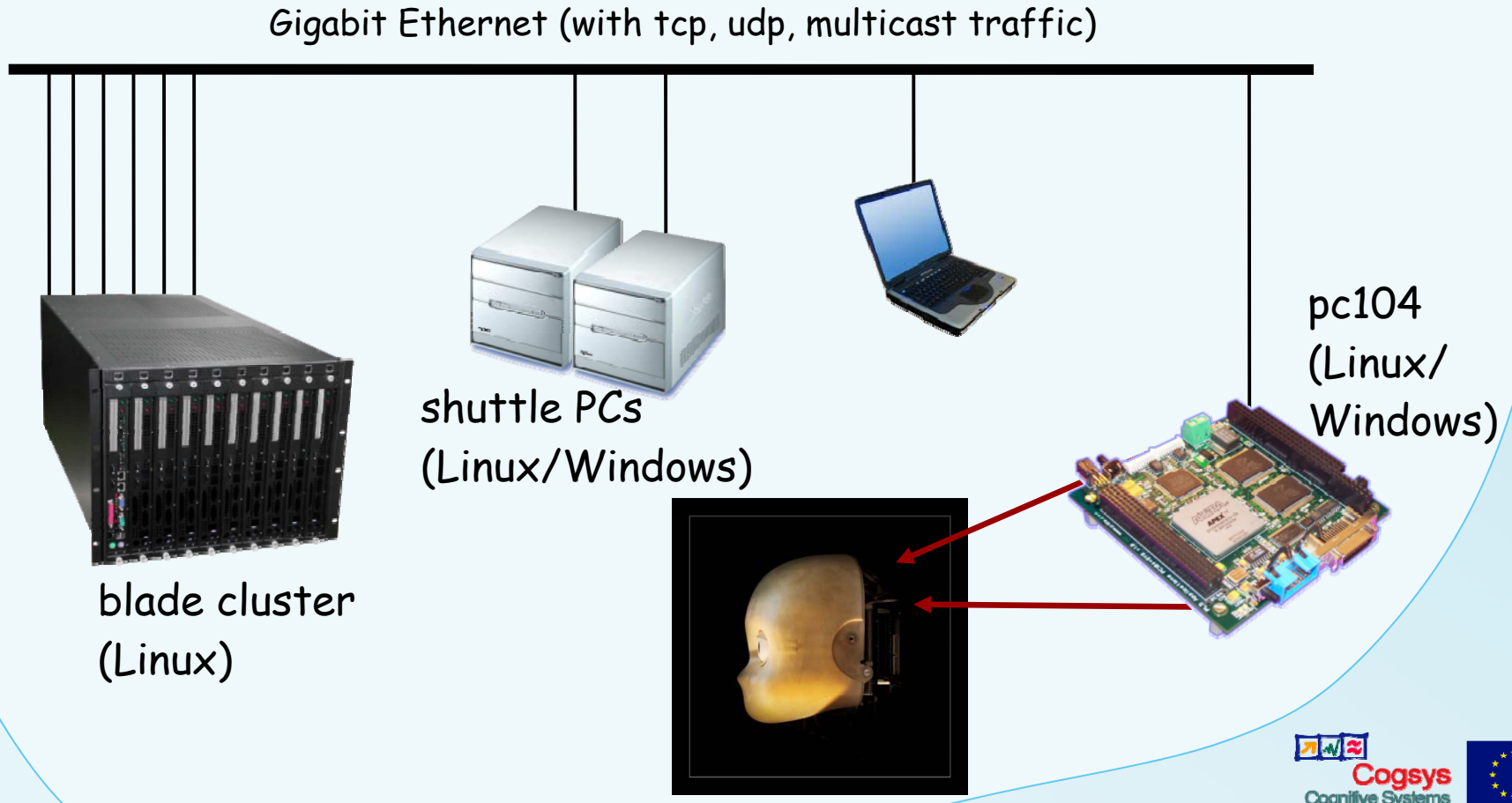
Typical YARP Network



- Connections can use different protocols
- Ports belong to processes
- Processes can be on different machines/OS

Physical Network

Example: iCub



RobotCub

Why is all this useful?

- We've separated out most of the plumbing
- We get to change it dynamically (handy)
- More importantly, we have better modularity
  - Programs can be moved around as load and OS/device/library dependencies dictate
  - Fundamental protocol for communication can be changed without affecting programs
  - Better chance that your code can be used by others (even just within your group)

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YARP Devices

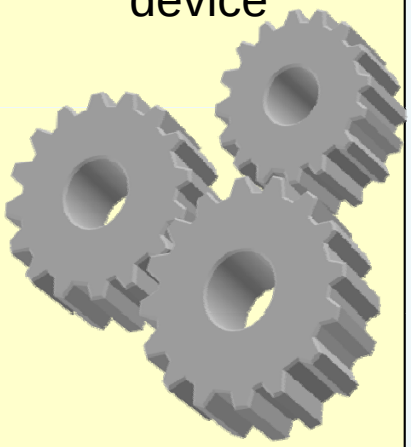
- Basic idea: if you view your devices **through well thought out interfaces**, the impact of device change can be minimized.
- There are three separate concerns related to devices in YARP:
  - Defining interfaces for **device families**
  - Implementing **specific drivers** for particular devices
  - Implementing **network wrappers** for interfaces

YARP Devices

- New devices come out all the time – needs to be easy to connect them to existing code
- YARP needs a minimal "wrapper" class to match vendor-supplied library with relevant interfaces that capture common capabilities
- YARP encourages separating configuration from source code
- Devices and communications remain distinct concerns

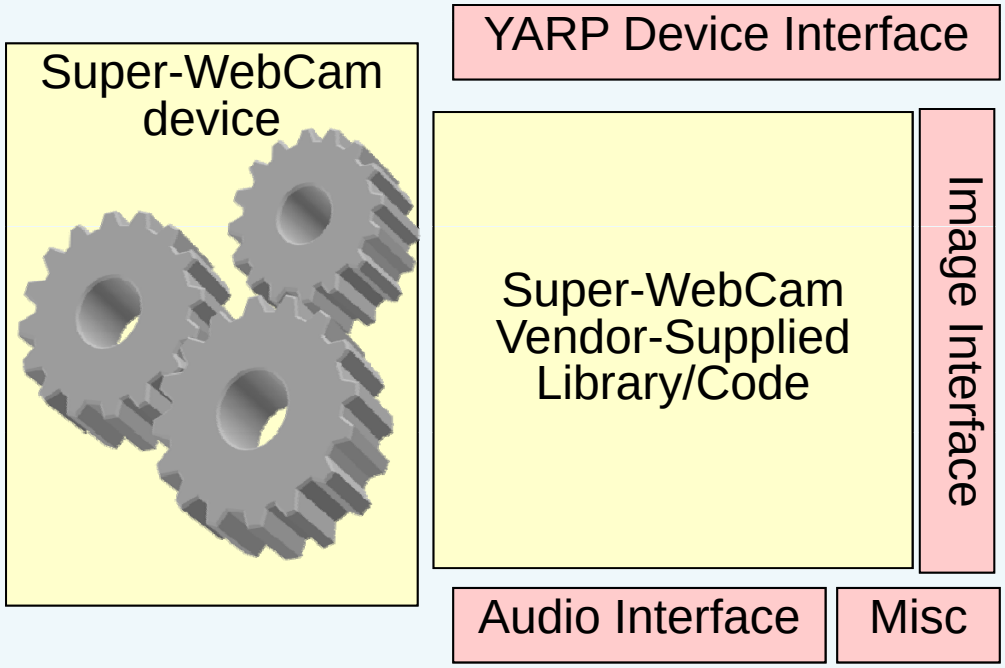
Example: New WebCam

Super-WebCam device

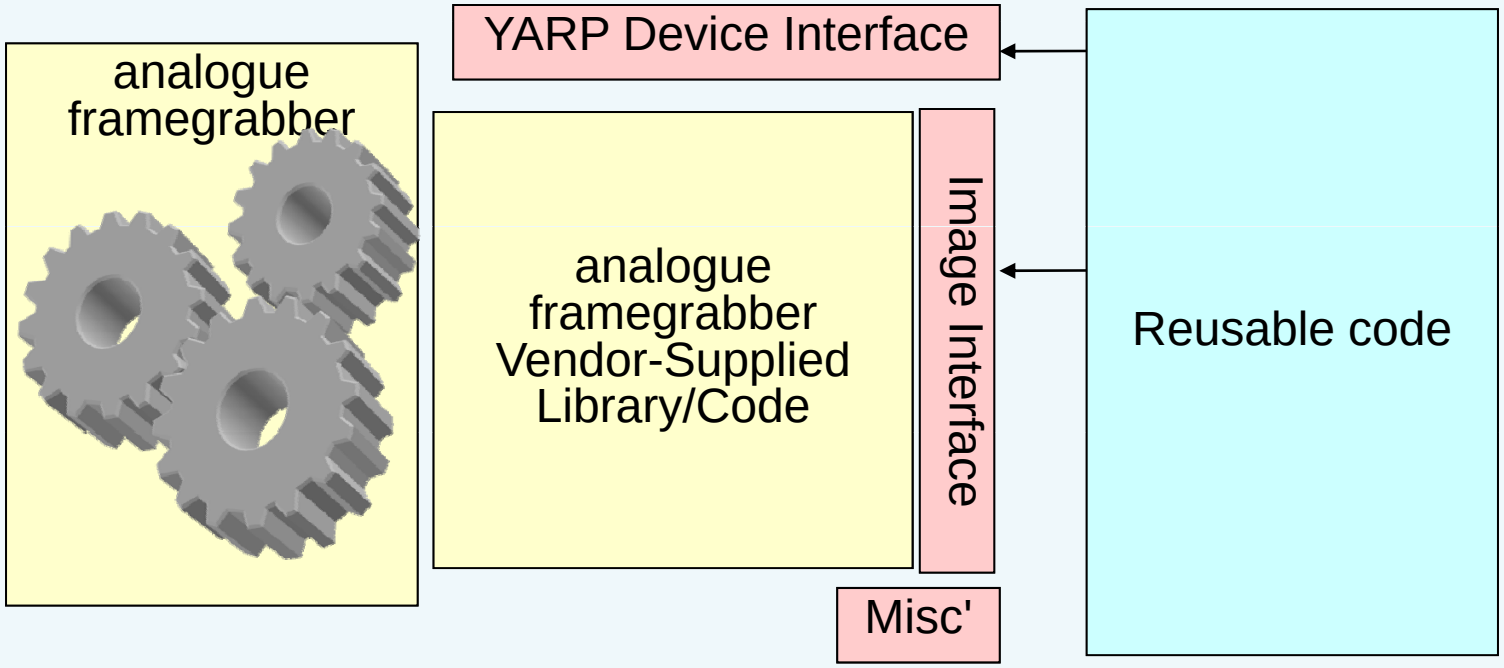


Super-WebCam Vendor-Supplied Library/Code

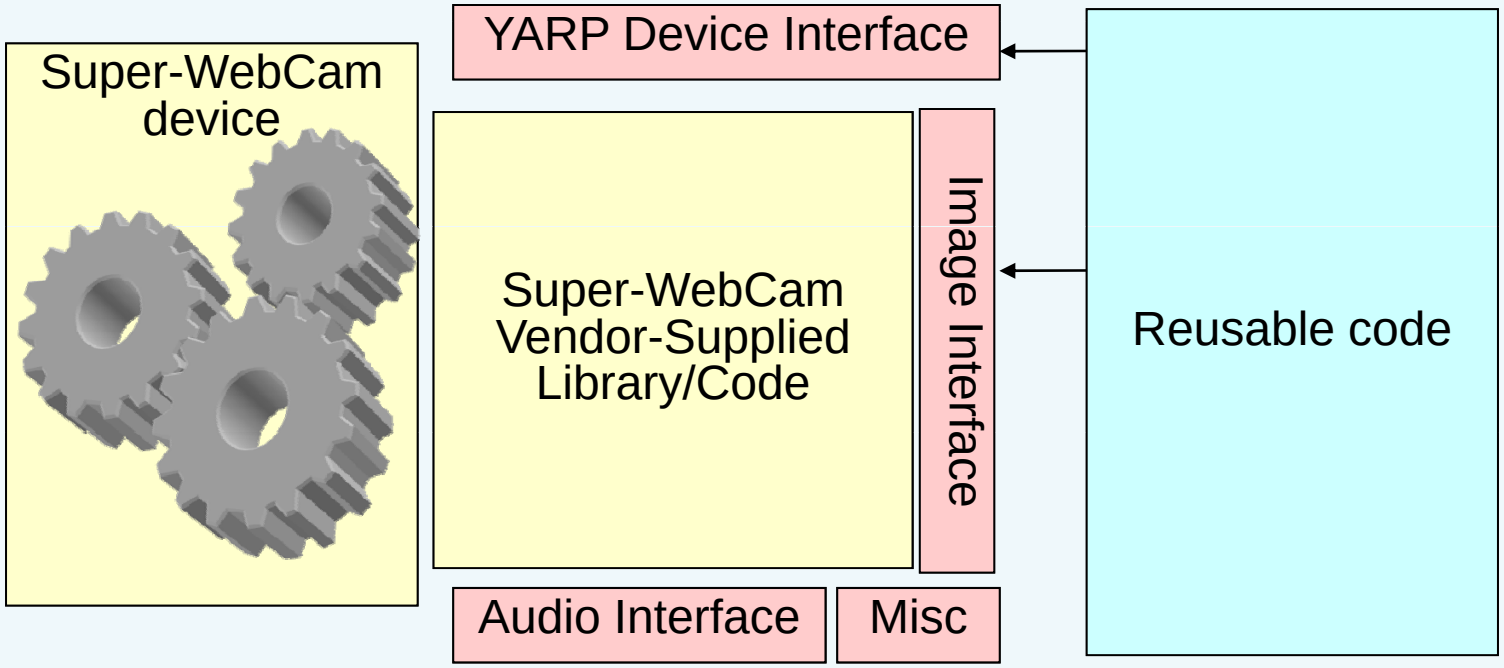
Example: New WebCam



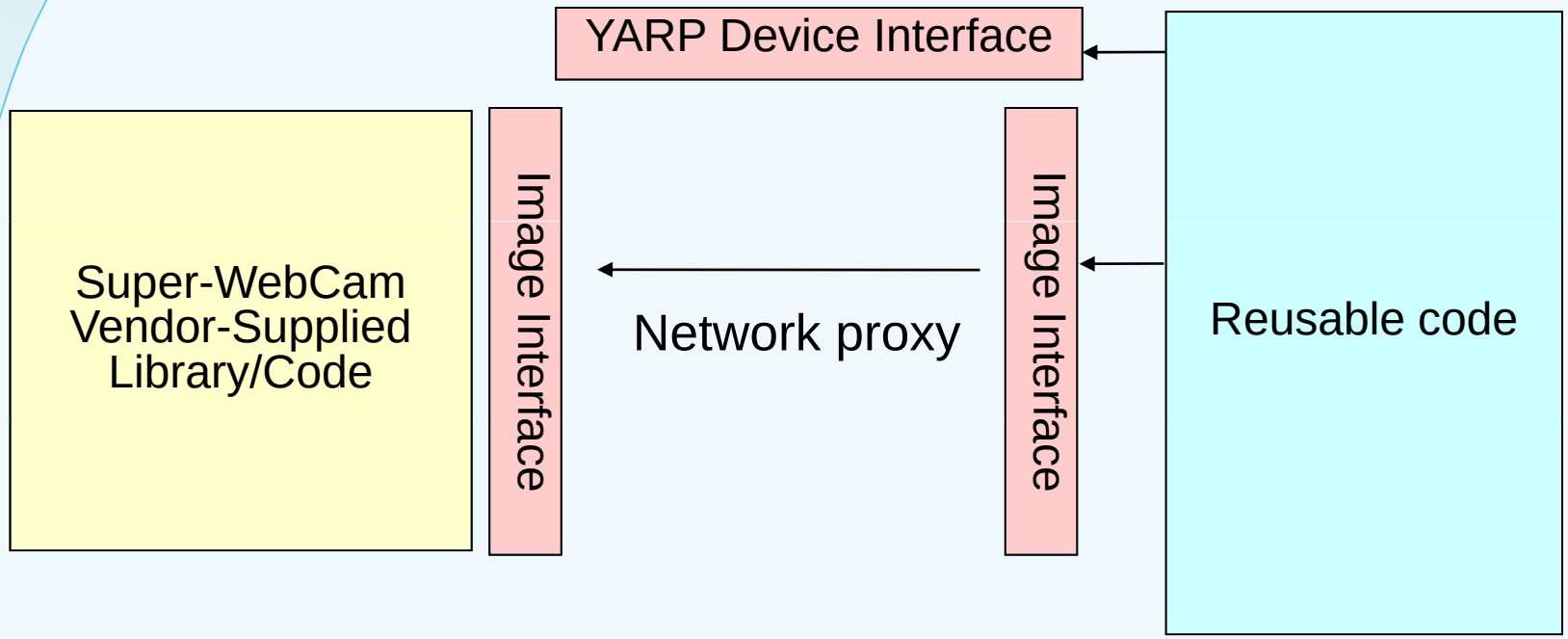
Example: Old Framegrabber



Example: New WebCam



Example: Networking



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Why is this useful?

- Allows collaboration between groups whose robots have different devices
- Makes device changes less painful
- Devices and communications are orthogonal features
  - Can switch from remote use of device to local use and vice versa without pain
  - Local use can be very efficient, just an extra virtual method call

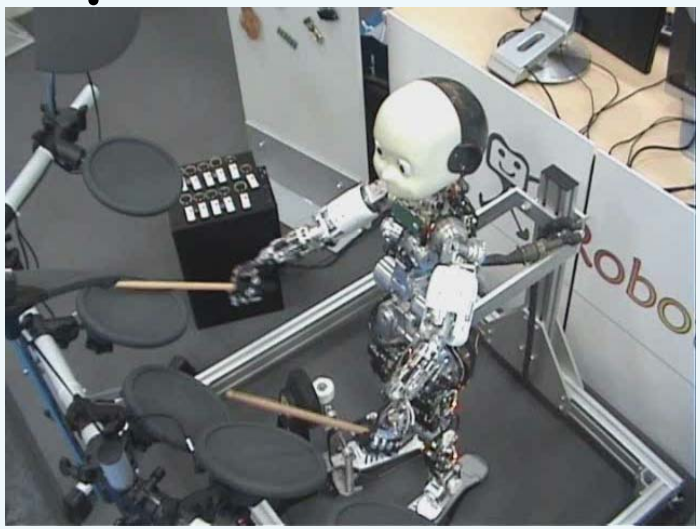
Final thoughts

Publication of software

- The literature of a research community both expresses its ideas, and aids in their evolution
  - Published ideas are read, evaluated, and built upon
  - Useful advances get published
- Publication of hardware and software can speed progress
  - Facilitates evaluating and comparing approaches
  - Brings new research topics into reach

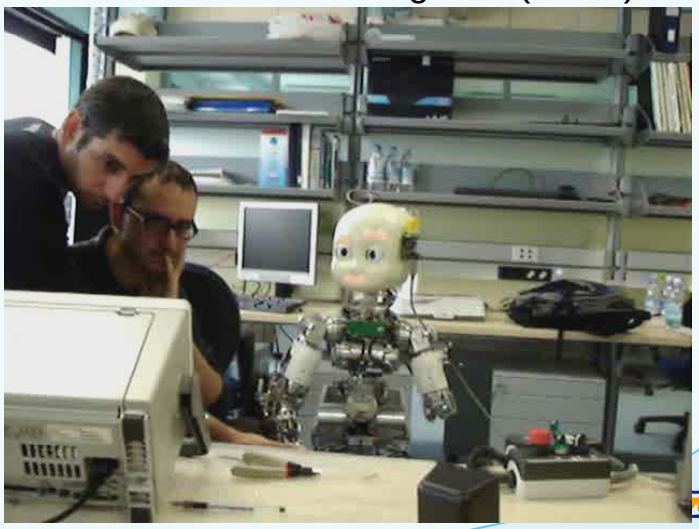
Examples…

With Peter Ford-Dominey (INSERM, Lyon)



With Auke Ijspeert, Ludovic Righetti, Sarah Degallier (EPFL)

With a lot of students
@ RobotCub summer school 2008



With VisLab (IST Lisbon)

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