Introduction to Robotics for cognitive science

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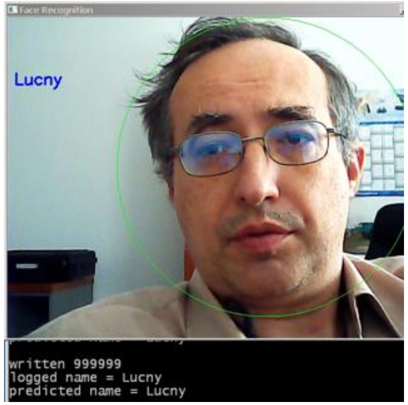
www.agentspace.org/kv

Lecturer



```
written 999999
logged name = Lucny
predicted name = Lucny
```

RNDr. Andrej Lúčny, PhD.

- Dealing with real-time AI
- Co-founder of world-wide operating company dealing with hardware & software of monitoring systems
- Developer in its daughter company (computer vision)
- Co-founder of civil society robotika.sk
- Former judge on ACM Scholastic Programming Contest
- Judge on mobile robot contest ISTROBOT

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www.agentspace.org/andy

Web page of the subject

www.agentspace.org/kv

Evaluation

50% work during term
0-20 at mid of term: project specification
specification is selected from offer or proposed by student
it can be exchanged or replaced
more complicated projects can be performed in group
before exam: project submission

50% exam: randomly selected test related to one exercise
0-20 select correct choices, complete sentence, find a mistake,
localize where there is something implemented in program,
propose a solution for extension (by words or a code)

A: 37-40, B: 33-36.5, C: 29-32.5, D: 25-28.5, E: 21-24.5, Fx: 0-20.5

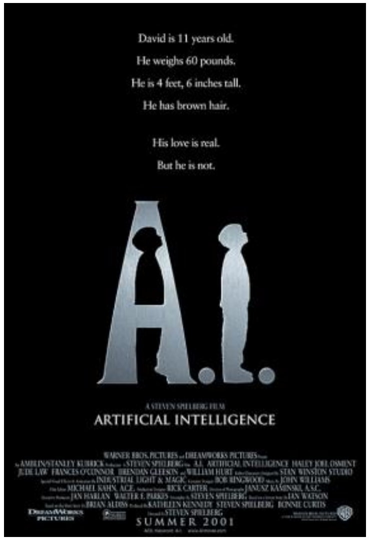
Goal

We deal with robot programming
It is not obligatory to become engineer

We aim to have a good imagination about how to

- involve robotics into study of cognition
- how much robotics lies when it claims that it implements cognition
- how stupid is our imagination about future development of technology and society

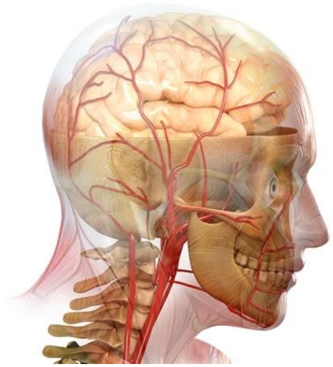
Yes, our imagination about future development of technology and society is really stupid


David is 11 years old.
He weighs 60 pounds.
He is 4 feet, 6 inches tall.
He has brown hair.
His love is real.
But he is not.
A.I.
A STEVEN SPIELBERG FILM
ARTIFICIAL INTELLIGENCE
WARNER BROS. PICTURES DREAMWORKS PICTURES
AMBLIN/STANLEY KUBRICK STEVEN SPIELBERG A.I. ARTIFICIAL INTELLIGENCE HALEY JOEL OSMENT
JUDE LAW FRANCES O'CONNOR BRENDAN GLEESON WILLIAM HURT STAN WINSTON STUDIO
INDUSTRIAL LIGHT & MAGIC BOB RINGWOOD JOHN WILLIAMS
MICHAEL KAHN, A.C.E. RICK CARTER JANUSZ KAMINSKI, A.S.C.
JAN HARLAN WALTER F. PARKES STEVEN SPIELBERG IAN WATSON
BRIAN ALDISS KATHLEEN KENNEDY STEVEN SPIELBERG BONNIE CURTIS
STEVEN SPIELBERG
DREAMWORKS PICTURES
SUMMER 2001

Stuff to install

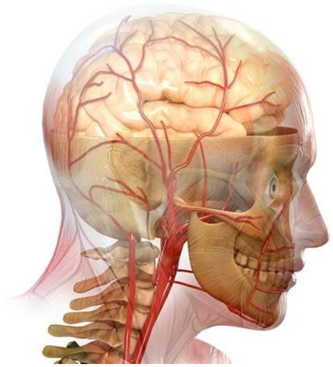
windows 64bits
Visual Studio latest redistributable 64bit 2013 2012 2010
Java JDK 1.8.0_231
python.exe 3.7 (3.5-3.11)

pip install numpy
pip install matplotlib
pip install opencv-contrib-python
pip install playsound
pip install requests
pip install urllib3
pip install pyaudio



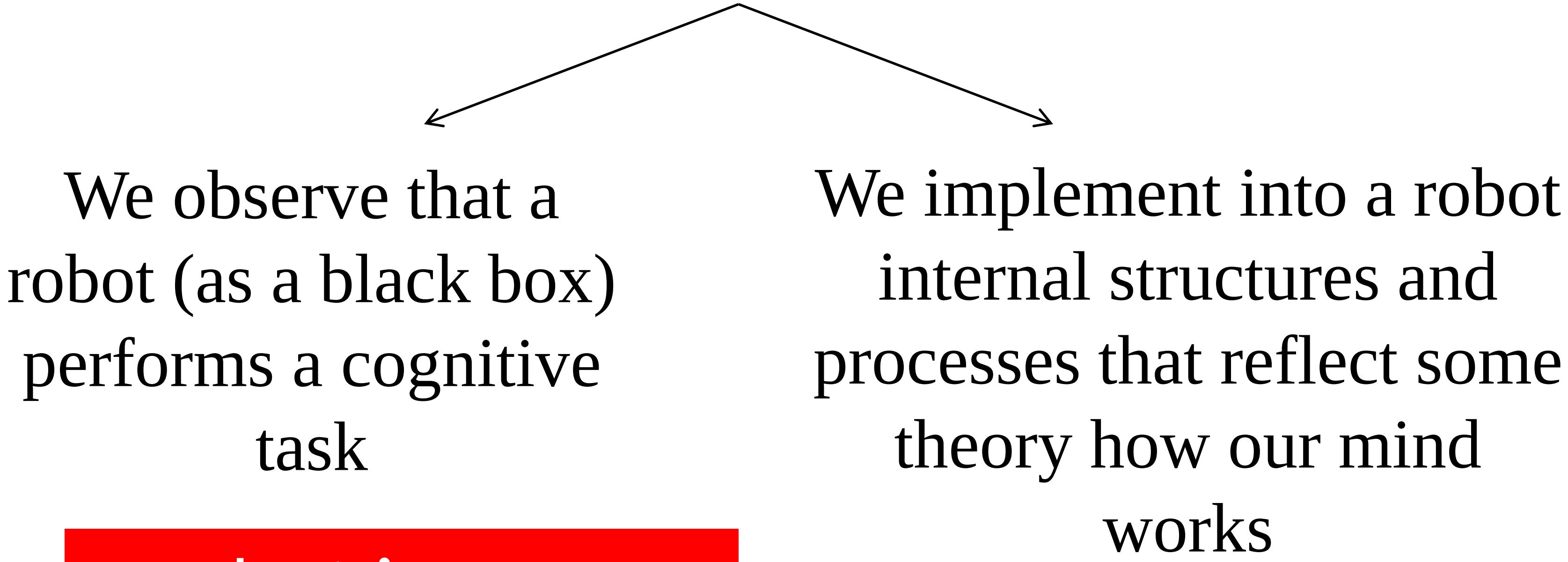
Cognition

- is what?



Cognition

- Capability to process information analogically to processing information in human mind

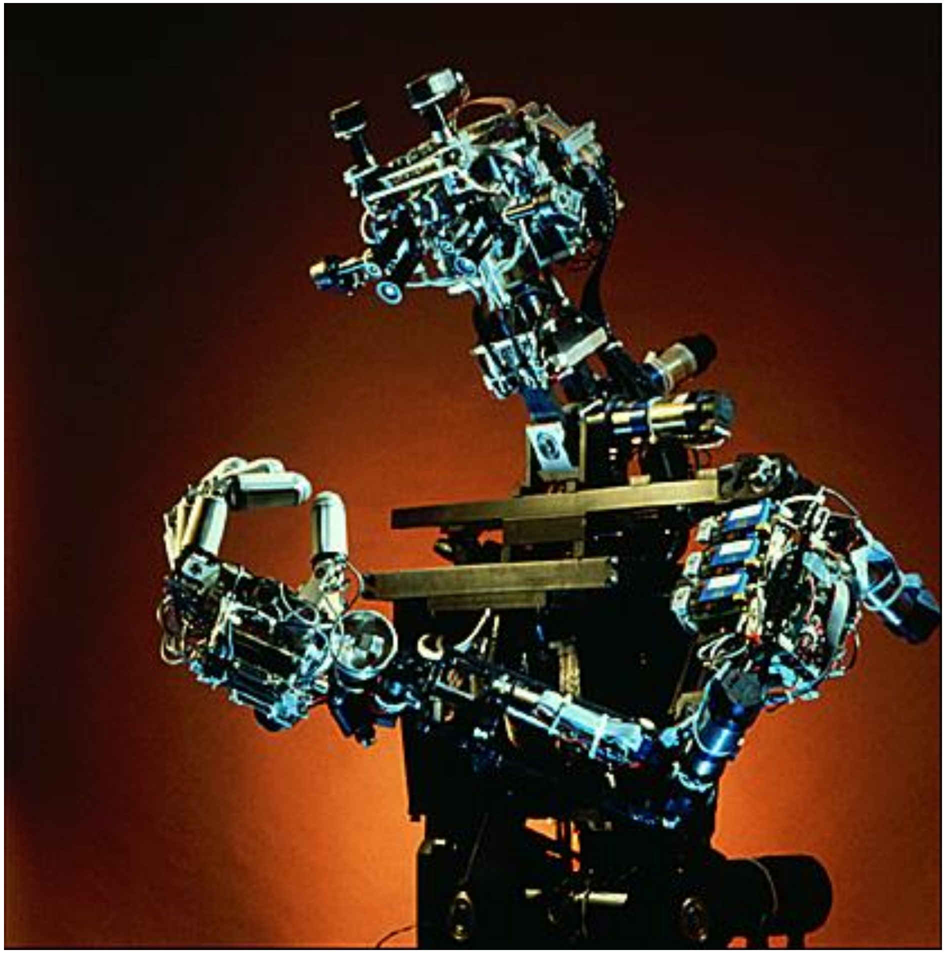


We observe that a robot (as a black box) performs a cognitive task

We implement into a robot internal structures and processes that reflect some theory how our mind works

Robot

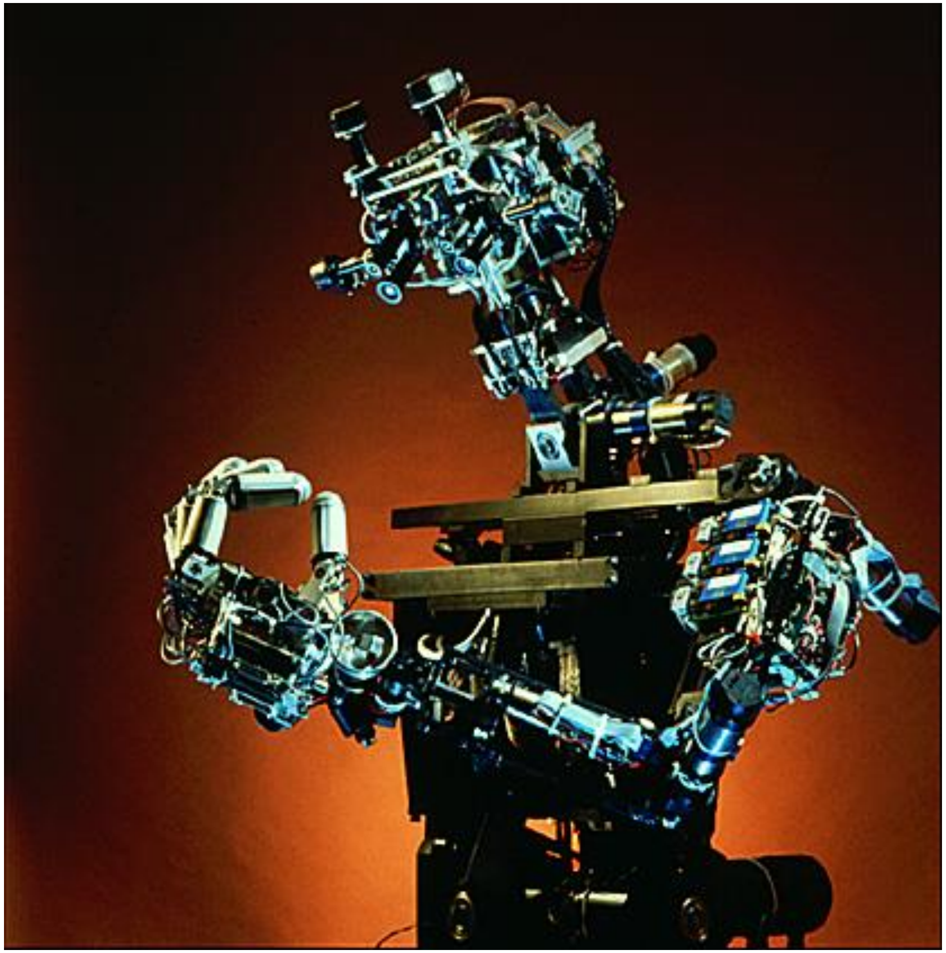
- is what?



COG, 1993, MIT

Robot

- Machine controlled by computer



COG, 1993, MIT

word „robot“

- have born one hundred years ago (Summer 1919) in ...

word „robot“

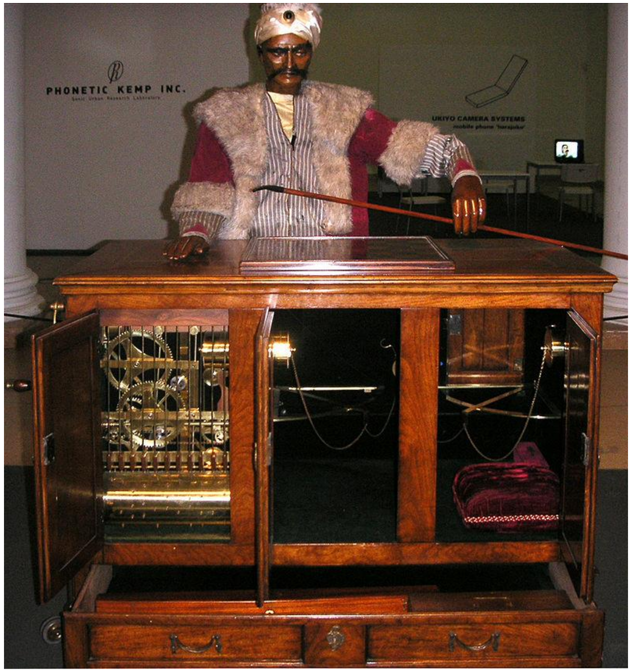
- … in Trenčianske Teplice (small village in Slovakia)

word „robot“

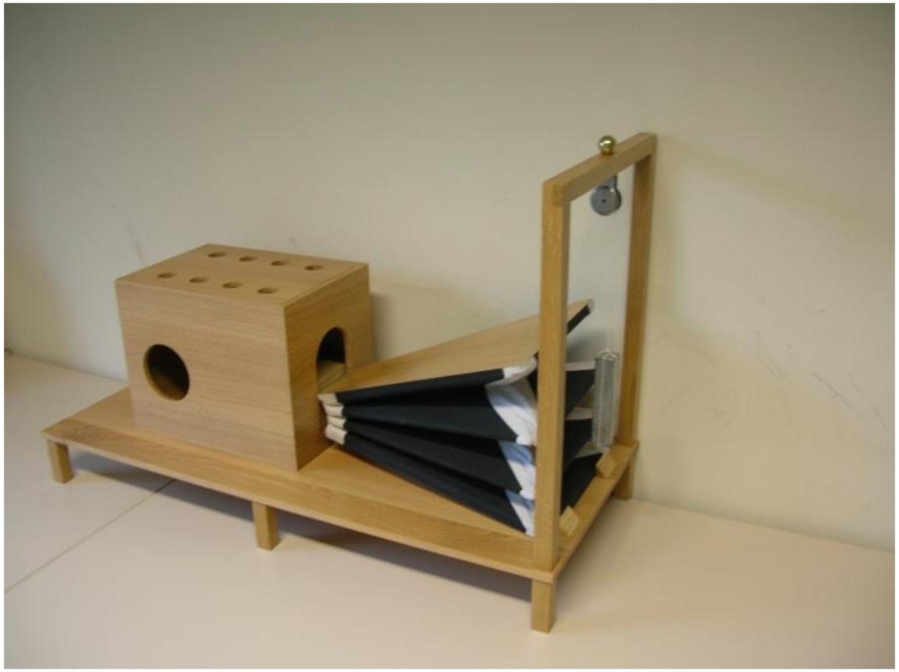
- it was proposed by brother of Czech writer Karel Čapek for his drama R.U.R.
- it is derived from Czech language
  - – robota = work
  - – robot = artificial worker

Ancient robotics in Bratislava

- Wolfgang von Kempelen

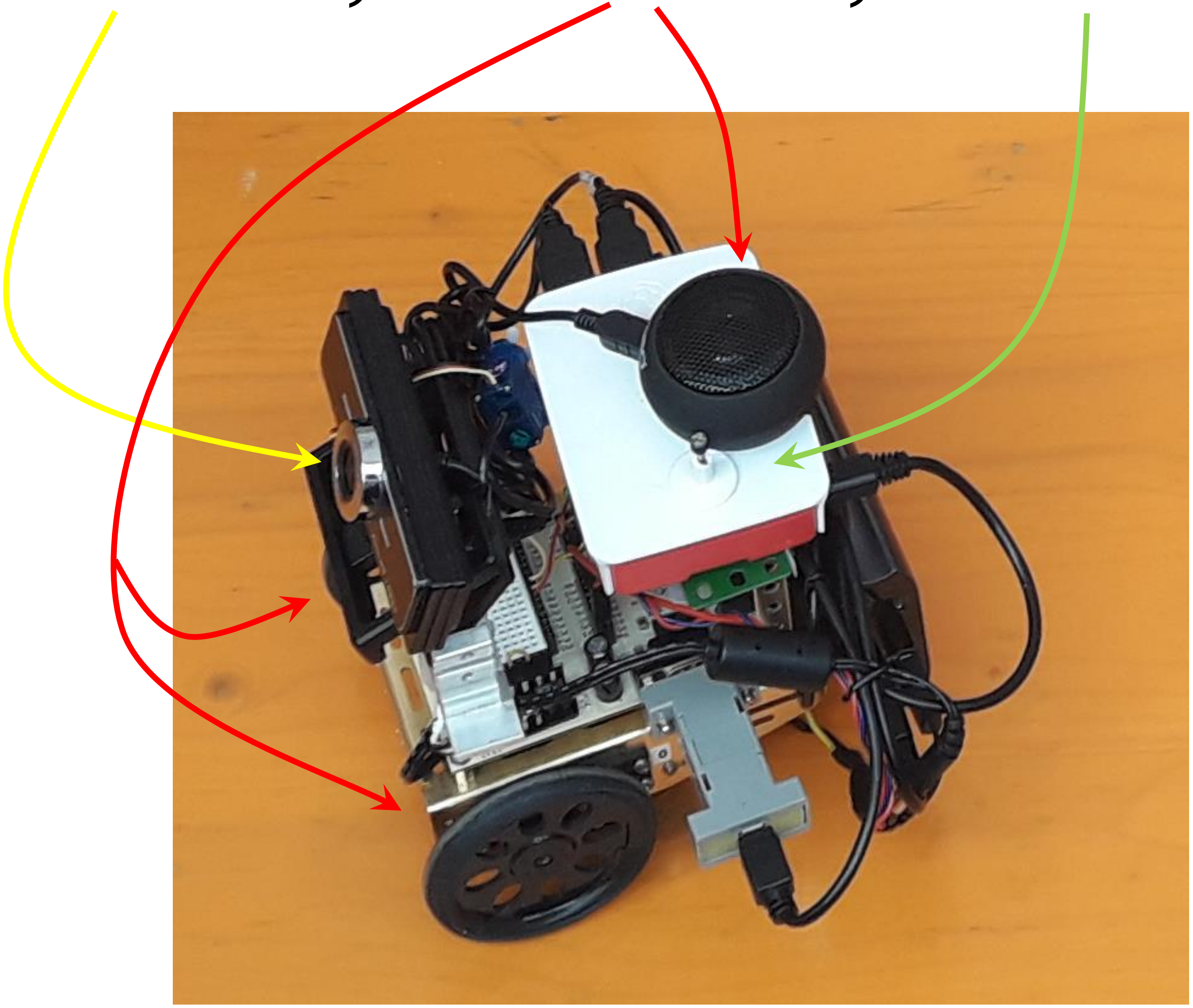


Turk (chess machine), 1771



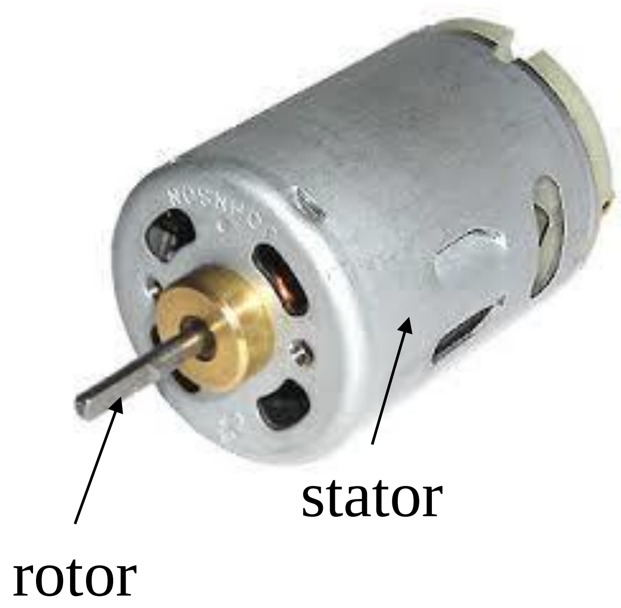
Speaking machine, 1769 - 1789

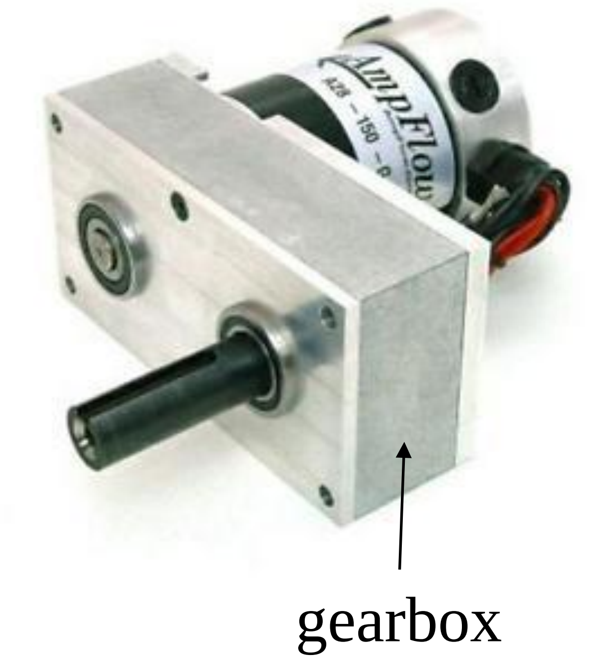
Sensors, Actuators, Controller

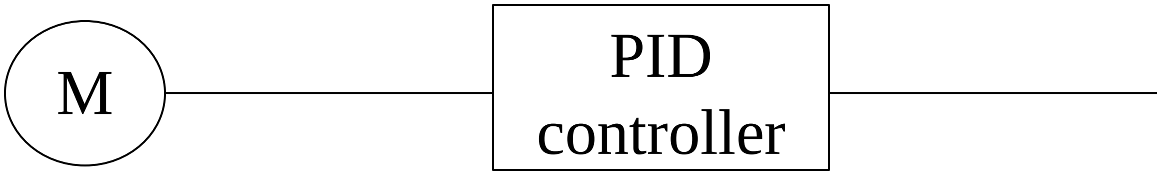


Actuators

- Motors (controlled by voltage/current)



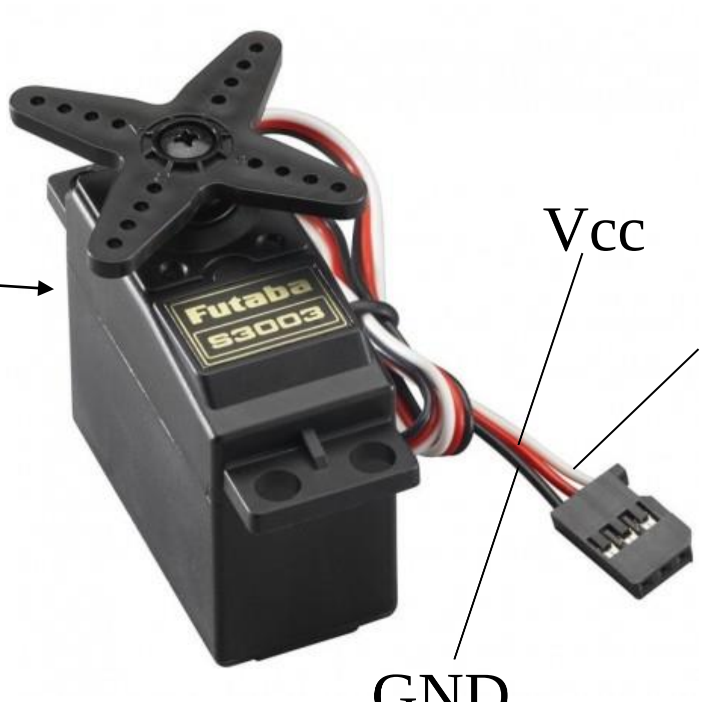




proportional–integral–derivative

Actuators

- Motors (controlled by current)
- Servomotors (controlled by frequency, positioning provided by system of gear wheels)



gear and controller inside

Vcc

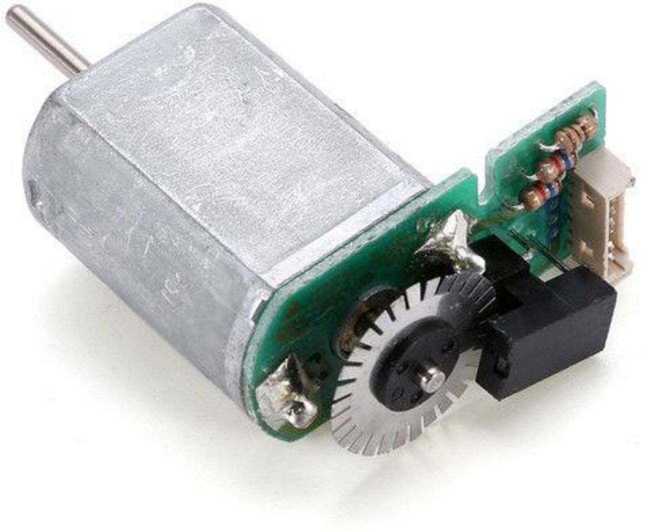
frequency

GND

we set position

Encoder

Motors can be equipped with position sensor



we get position

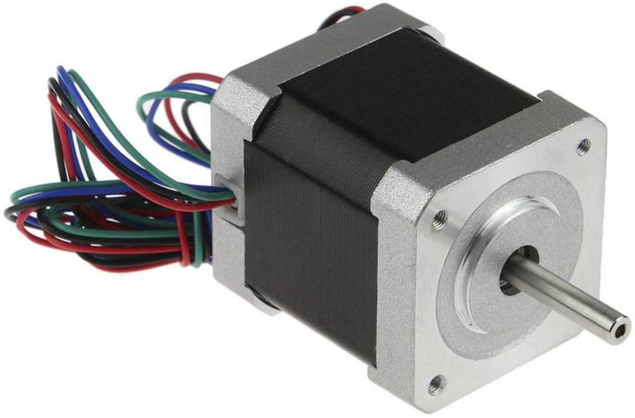
Torque

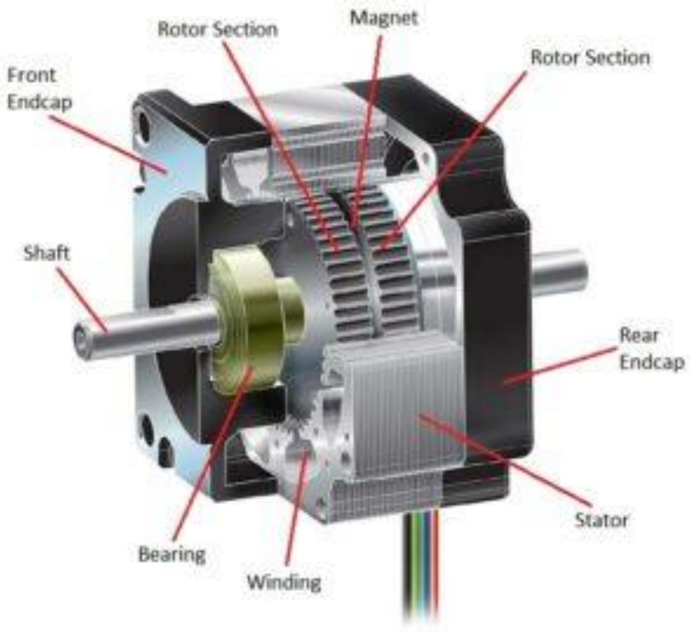
Servomotors can operate in stall mode without overheating.

The stall mode can be switched on / off

Actuators

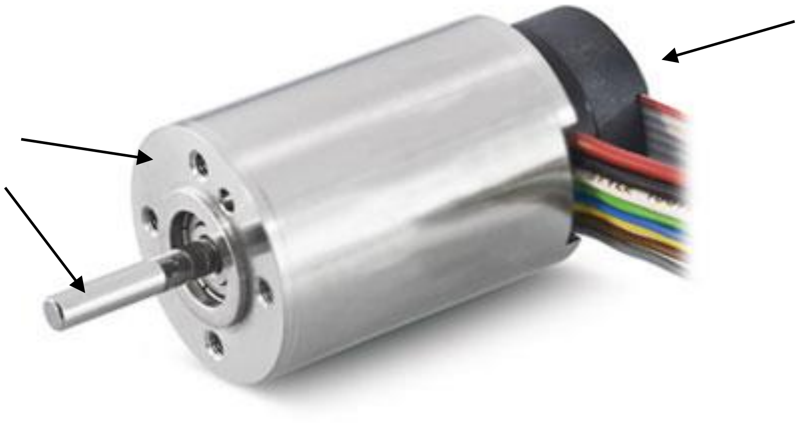
- Motors (controlled by current)
- Servomotors (controlled by frequency, positioning provided by system of gear wheels)
- Stepper motors (positioning provided by rotor)





Actuators

- Motors (controlled by current)
- Servomotors (controlled by frequency, positioning provided by system of gear wheels)
- Stepper motors (positioning provided by rotor)
- Brush-less motors ("fixed rotor")



Actuators

- Motors (controlled by current)
- Servomotors (controlled by frequency, positioning provided by system of gear wheels)
- Stepper motors (positioning provided by rotor)
- Brush-less motors ("fixed rotor")
- Speaker

Actuators

- Motors (controlled by current)
- Servomotors (controlled by frequency, positioning provided by system of gear wheels)
- Stepper motors (positioning provided by rotor)
- Brush-less motors (“fixed rotor”)
- Speaker
- LED

Actuators

nt)

frequency,

tem of gear wheels)

- Stepper motor rotor)
- Brush-less mo
- Speaker
- LED
- Artificial muscles (shape memory alloys, pneumatic, nylon fibers, carbon fibers, …, electroactive polymers)

Actuators

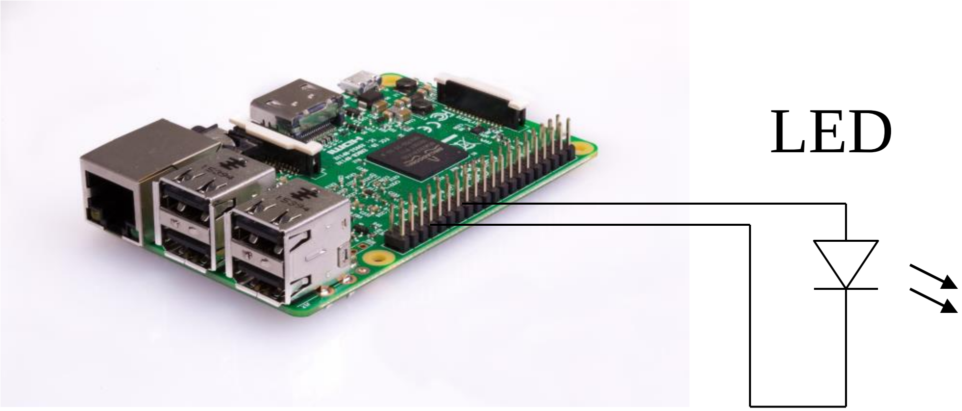
- Motors (controlled by current)
- Servomotors (controlled by frequency, positioning provided by system of gear wheels)
- Stepper motors (positioning provided by rotor)
- Brush-less motors (“fixed rotor”)
- Speaker
- LED
- Artificial muscles

Actuator parameters

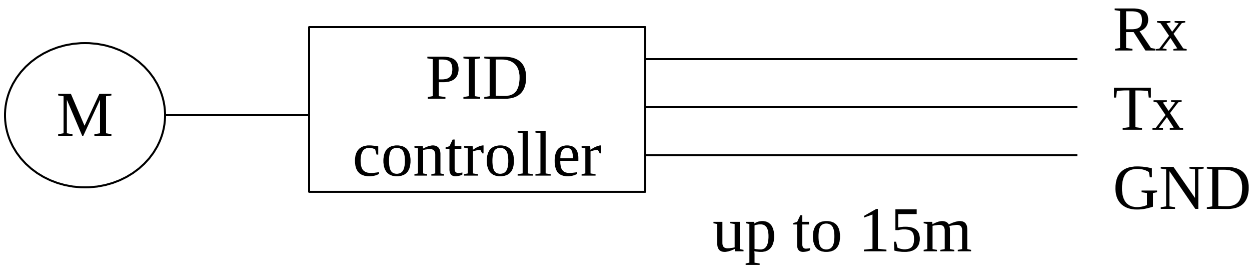
- Lifetime
- Accuracy
- Resolution
- Supply voltage
- Power consumption
- Interface (I2C, RS232, RS485, USB, Ethernet, …)
- Protocols (Dynamixel, TCP/YARP)

Inter-Integrated Circuit (I2C)

- provides mainly several general purpose inputs/outputs (GPIOs)



RS232


M

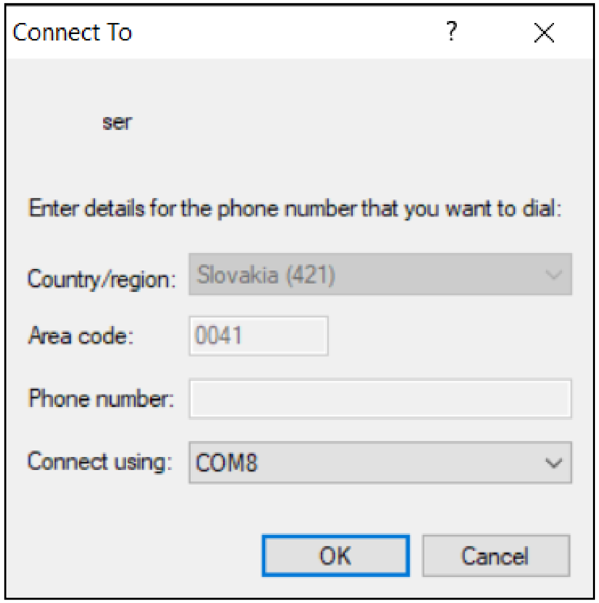
PID controller

Rx

Tx

GND

up to 15m


Connect To

ser

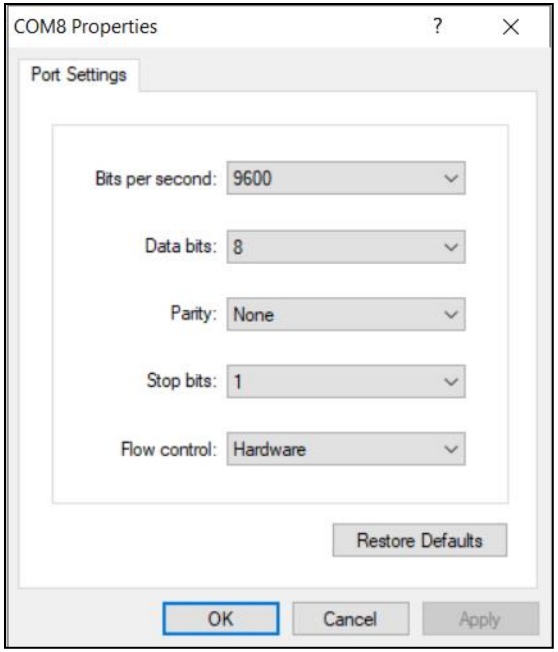
Enter details for the phone number that you want to dial:

Country/region: Slovakia (421)

Area code: 0041

Phone number:

Connect using: COM8


COM8 Properties

Port Settings

Bits per second: 9600

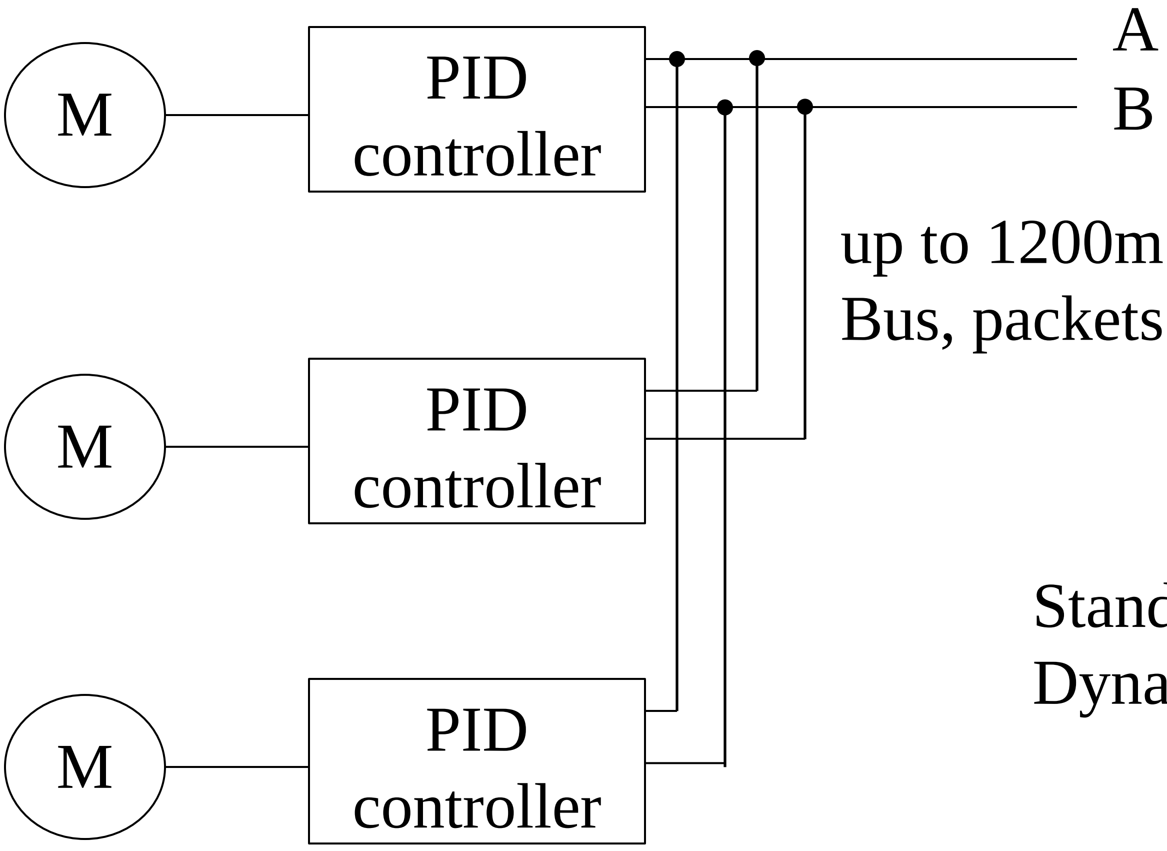
Data bits: 8

Parity: None

Stop bits: 1

Flow control: Hardware

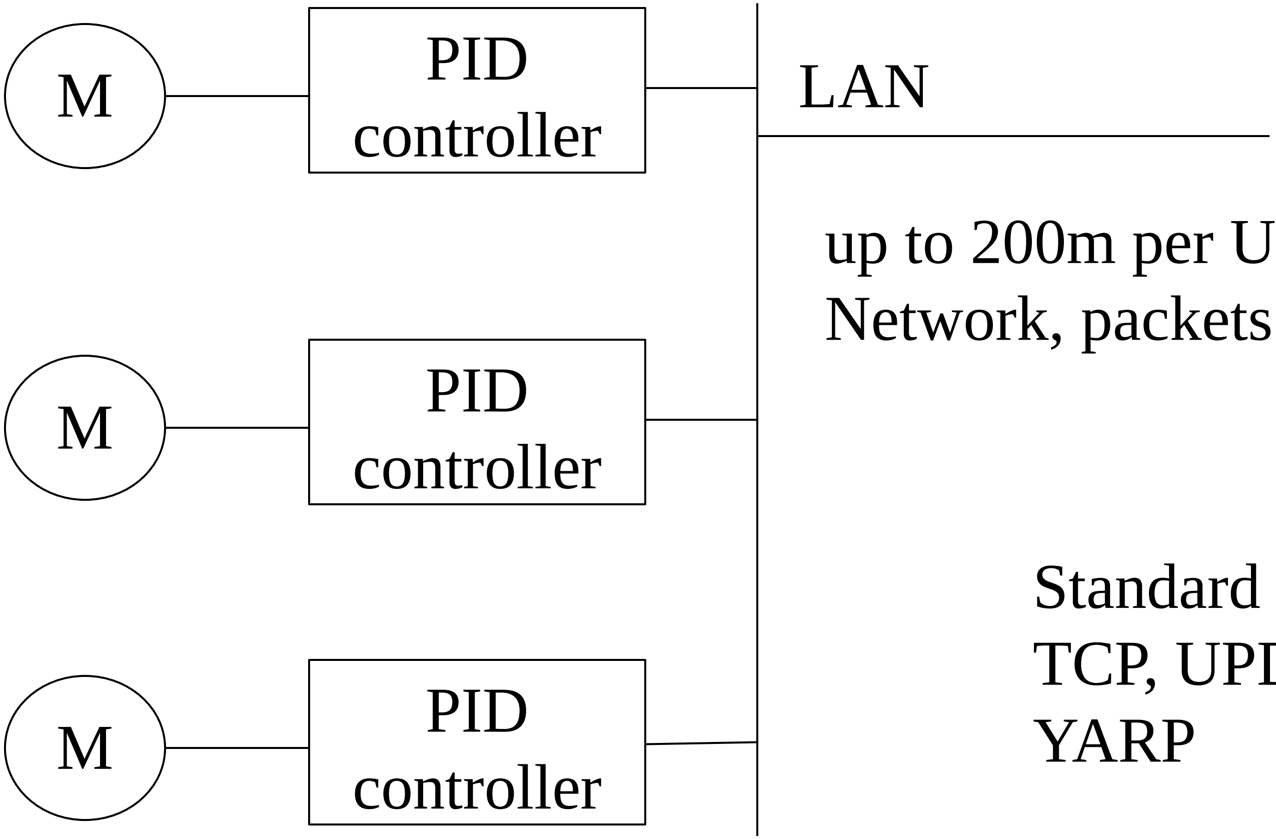
RS485



up to 1200m
Bus, packets

Standard protocols:
Dynamixel

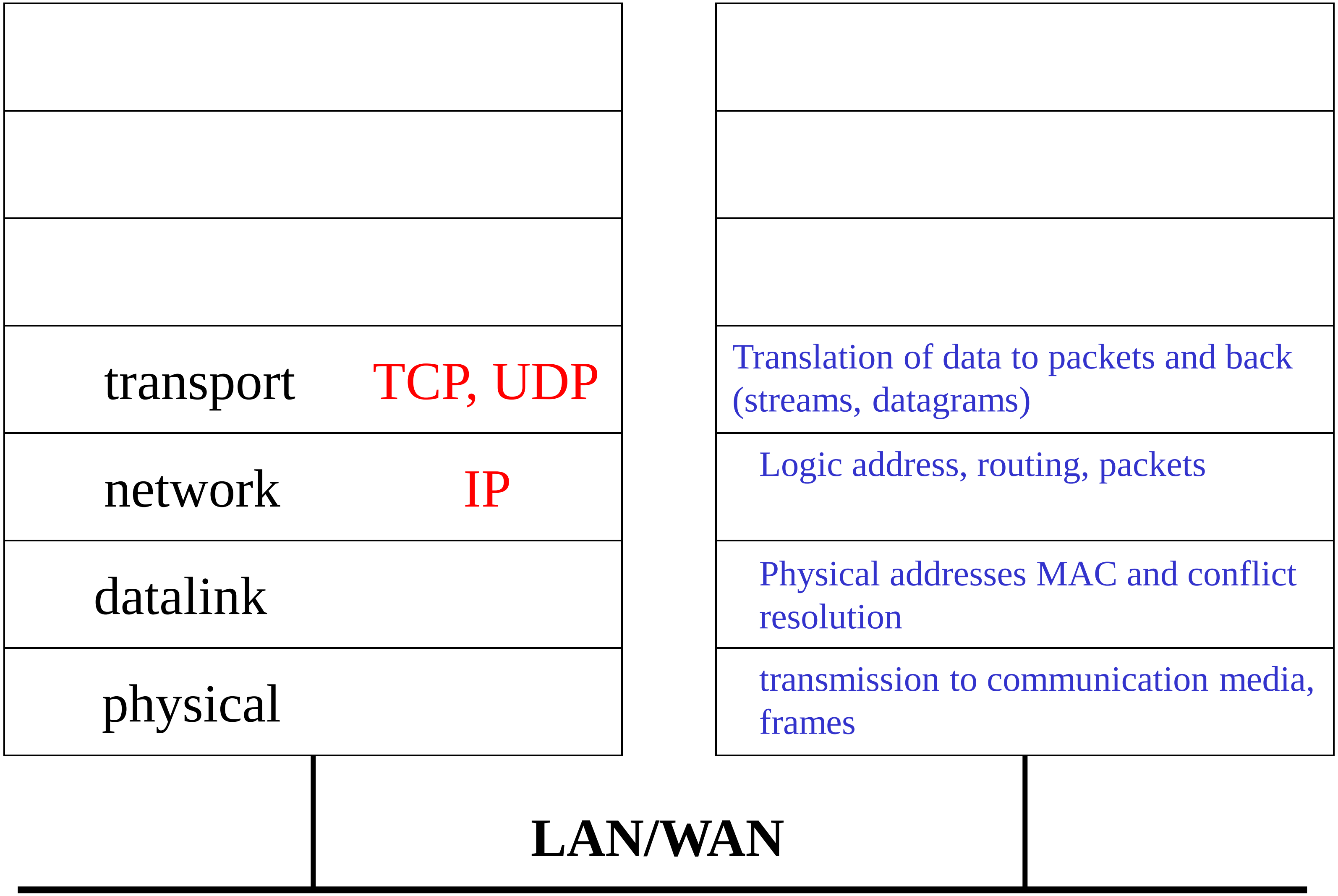
EtherNet



up to 200m per UTP
Network, packets

Standard protocols:
TCP, UPD
YARP

Transmission Control Protocol (TCP)



transport TCP, UDP

network IP

datalink

physical

Translation of data to packets and back (streams, datagrams)

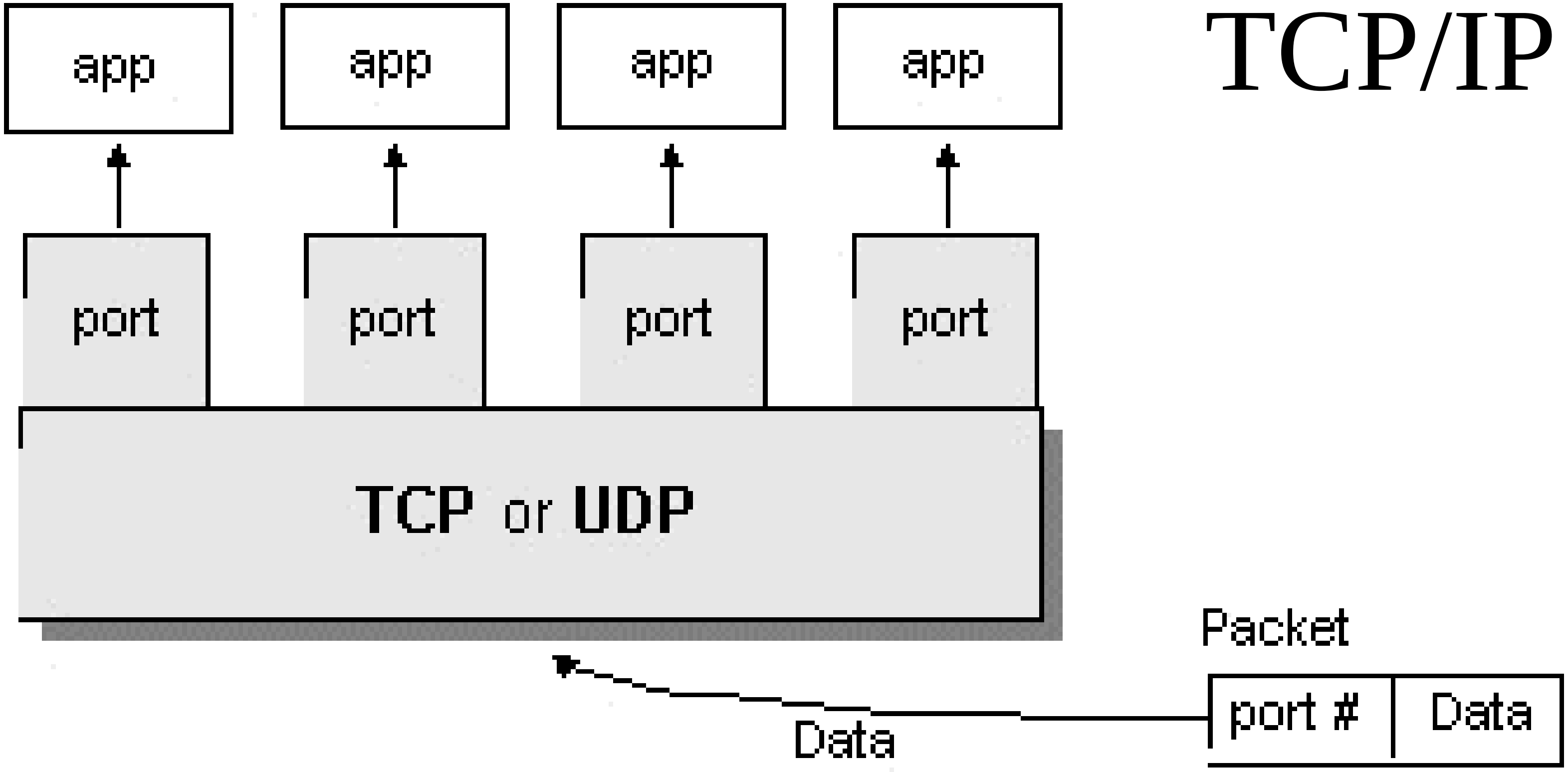
Logic address, routing, packets

Physical addresses MAC and conflict resolution

transmission to communication media, frames

LAN/WAN

TCP/IP



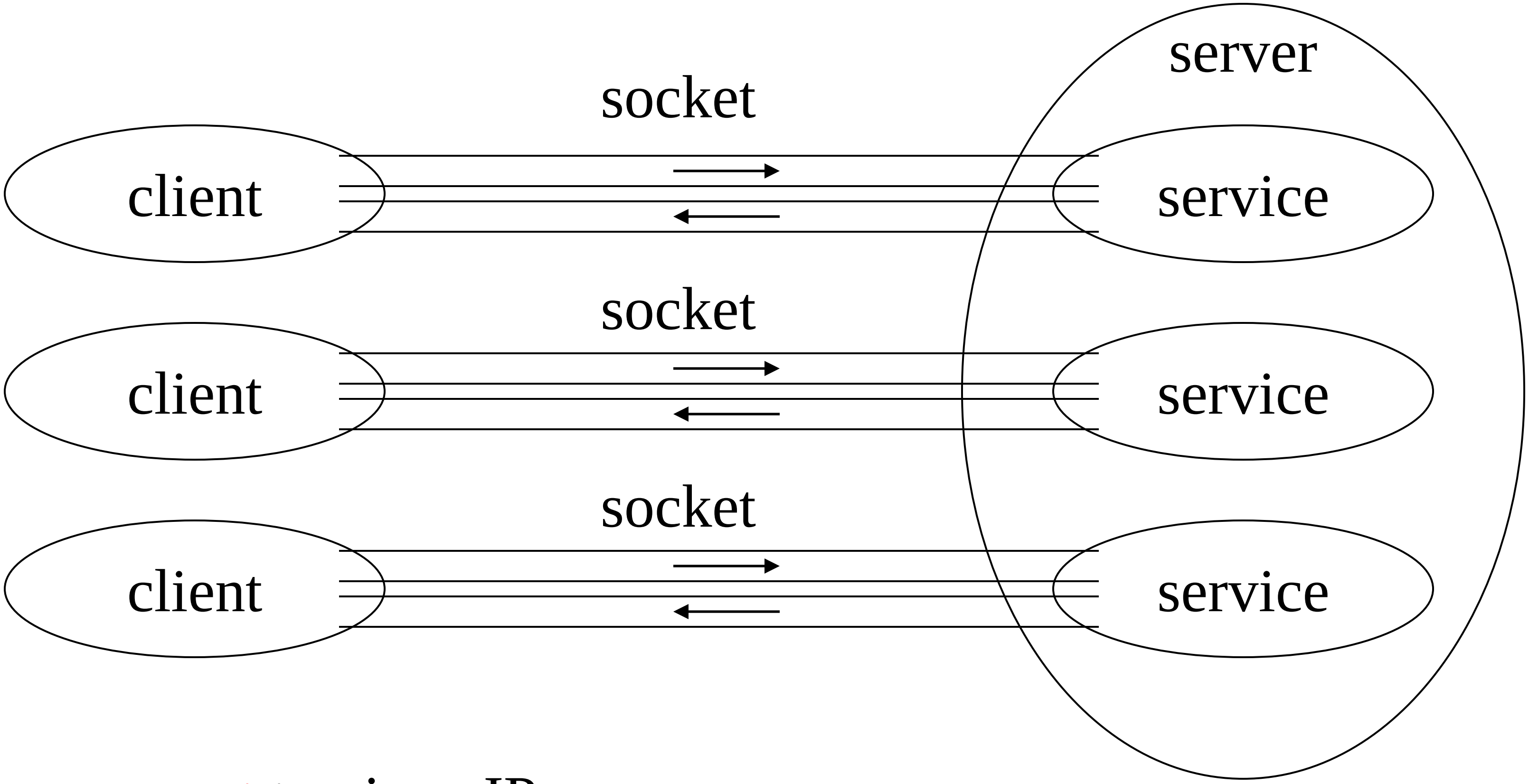
158.168.53.112

0 – 1023 - 65535

IP address specifies node

port specifies application

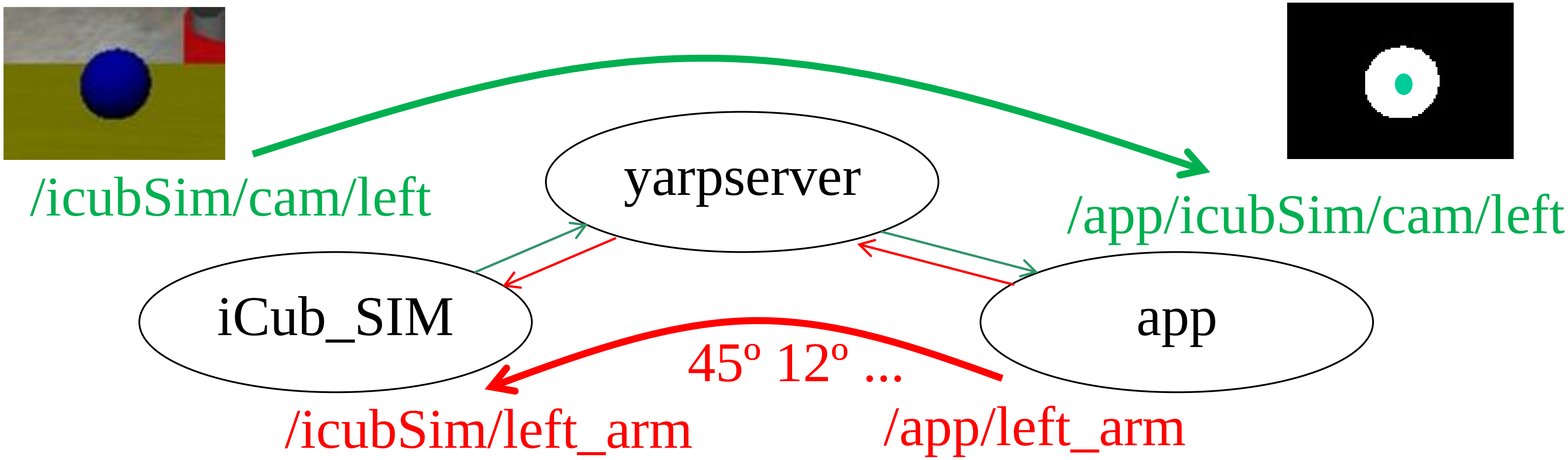
TCP protocol implements datastreams, that are represented (in programming languages) by sockets



connect to given IP address and port

listen to a given port and accept

Yet another robot platform (YARP)



/icubSim/cam/left

yarpserver

/app/icubSim/cam/left

iCub_SIM

app

45º 12º …

/icubSim/left_arm

/app/left_arm

TCP port 10000, …

YARP rpc

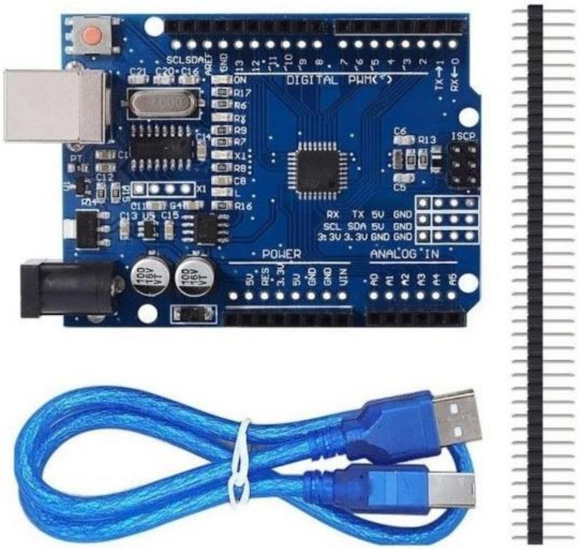
- Yarp rpc is readable part of the YARP protocol
- /icubSim/left_arm/rpc:i … telnet localhost 10022

https://www.yarp.it/yarp_without_yarp.html

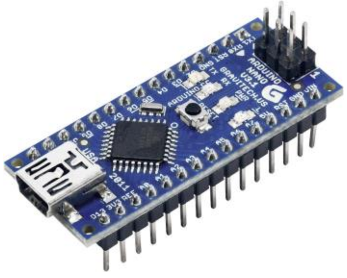
```
CONNECT me
answer: Welcome me
d
get pos 1
answer: <position of joint 1>
answer: [ok]
d
set pos 1 40
answer: <robot set joint 1 of its left arm to position 40 degrees>
answer: [ok]
d
get pos 1
answer: <modified position of joint 1>
answer: [ok]
```

Embeded systems

- Processor based, no operating system



Arduino



Arduino Nano

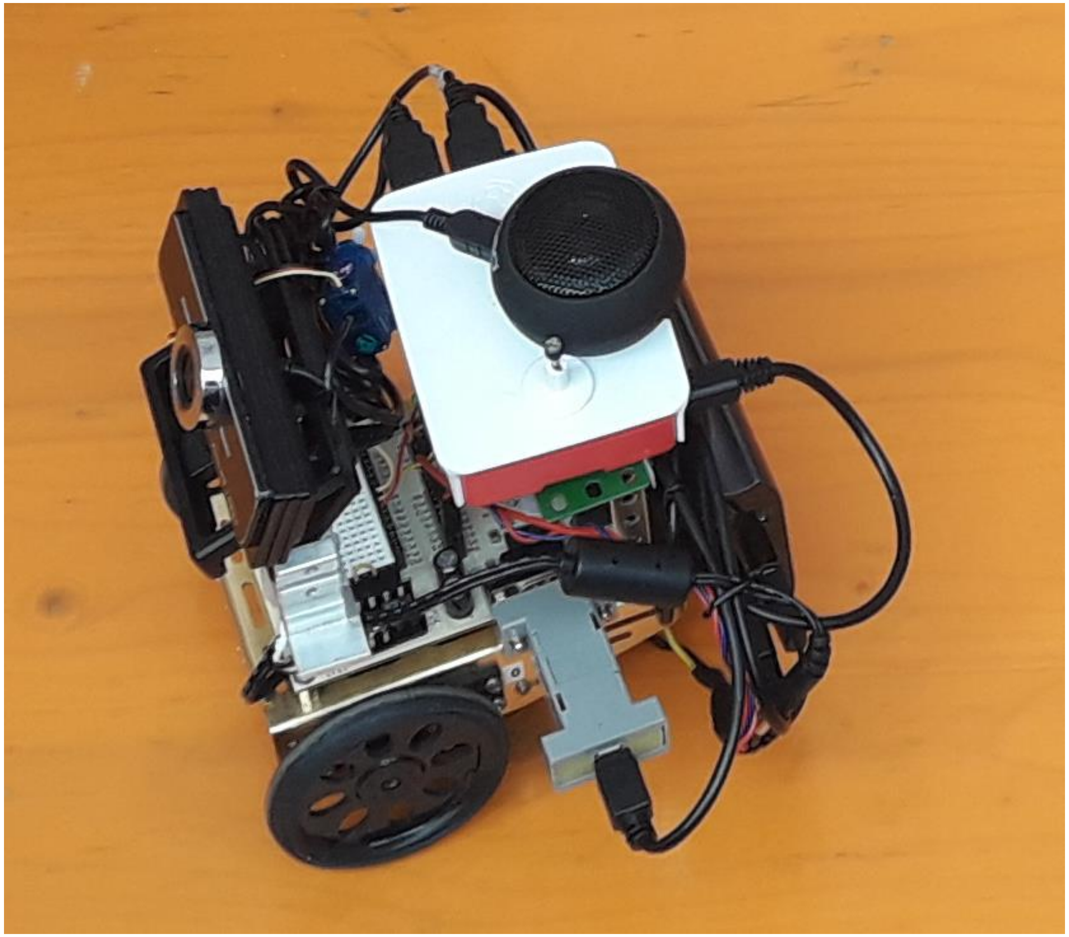
Edge systems

- Various computer units nowadays equipped with operating system Linux, Windows or RTOS (QNX, VxWorks)

Raspberry

Jetson

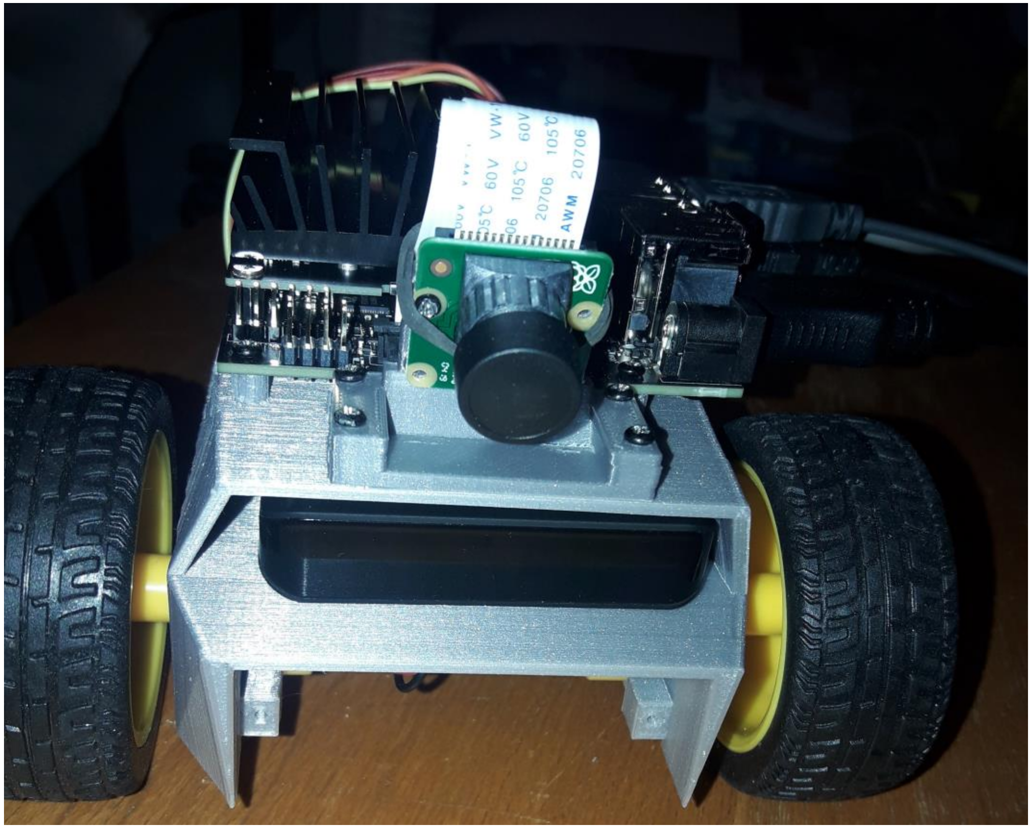
Atom



PingPong

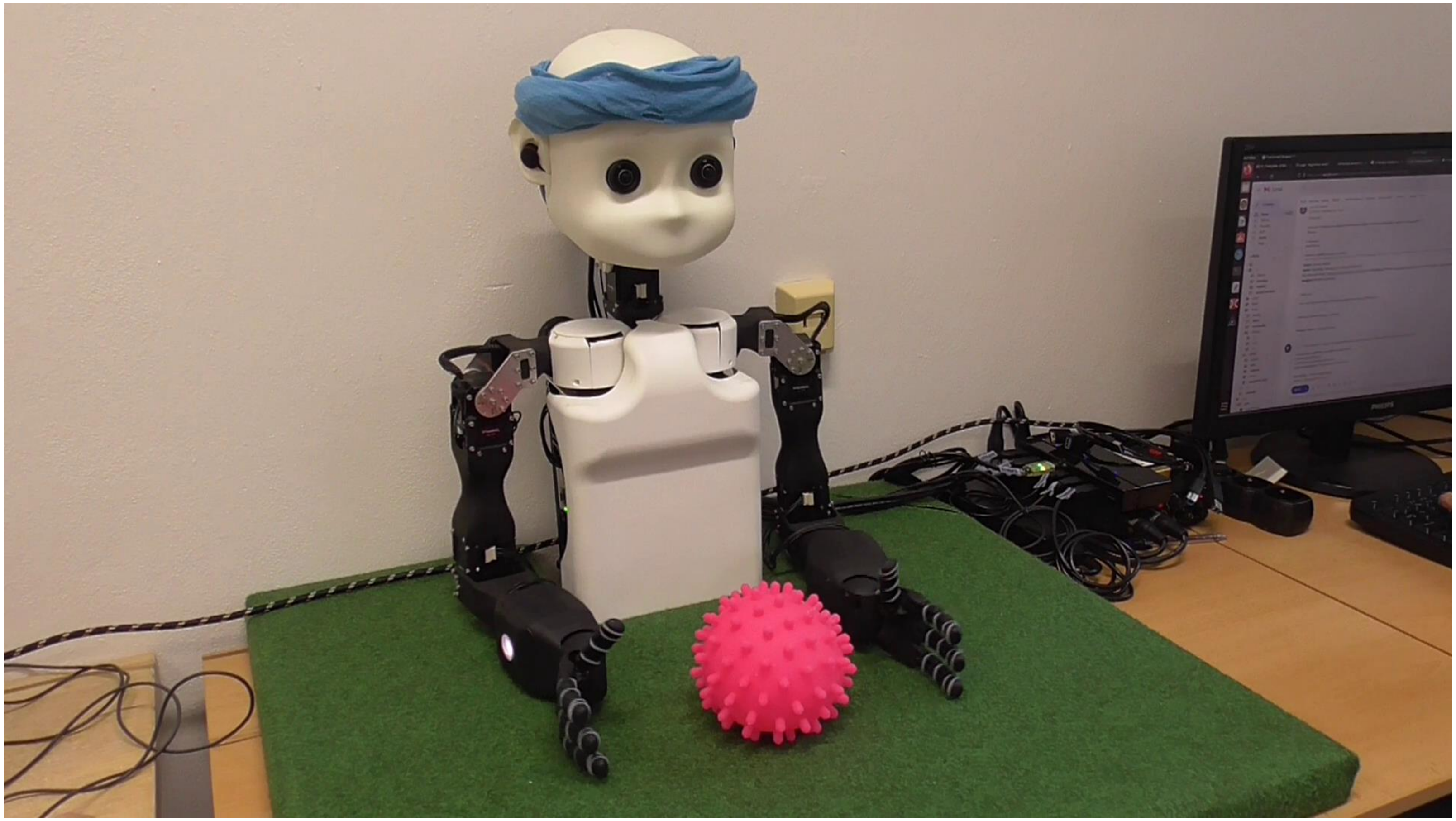
- servomotors
- Interface: RS232
- Proprietary protocol: `pl<CR>, pr<CR>, pz<CR>,…`

JetBot



- electromotors, PID controller
- Interface: I2C

Nico

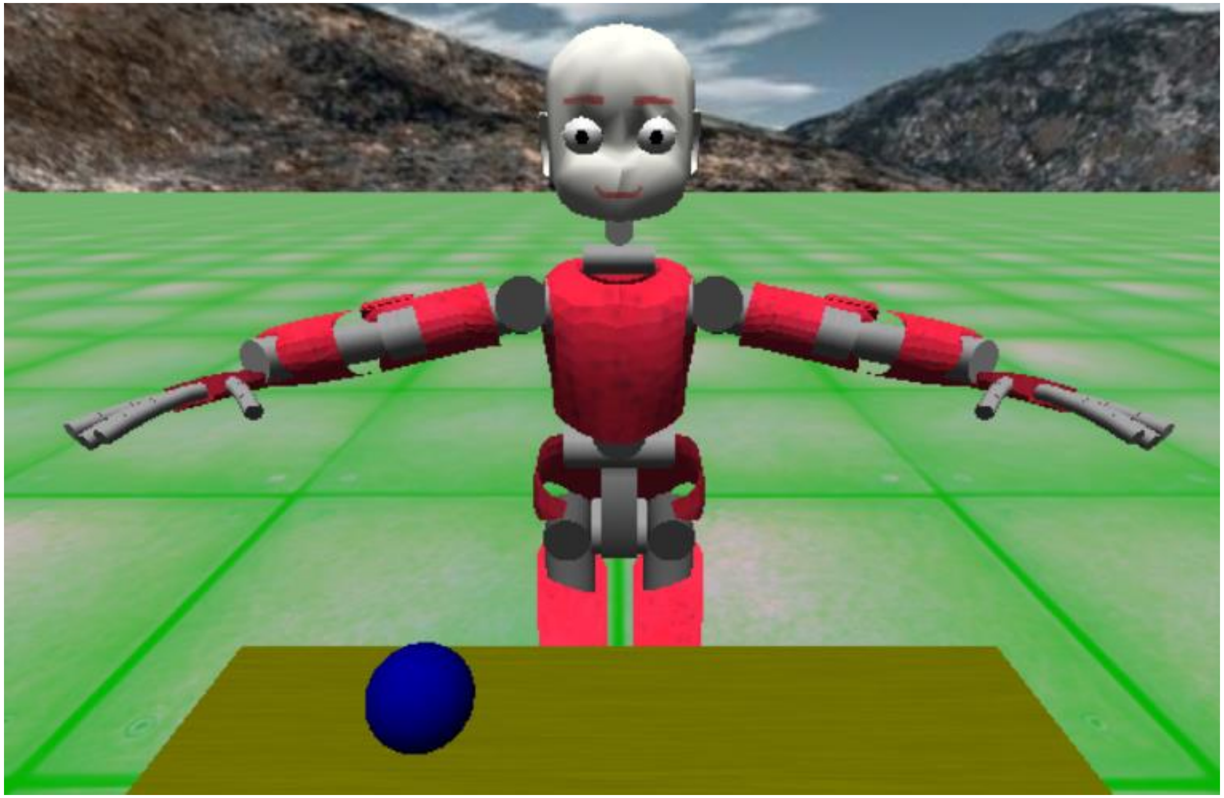


Servomotors with encoders and torque

interface: RS485 (USB converter)

protocol: Dynamixel

iCubSim



- iCub: Servomotors with encoders and torque,
- interface: EtherNet
- protocol: TCP, YARP

Library **pyicubsim**

- Implemented for the course *Introduction to Robotics for Cognitive Science* at Matfyz in Bratislava
- provides classes `iCubLeftEye`, `iCubRightEye`, `iCubLeftArm`, `iCubRightArm`, `iCubLeftLeg`, `iCubRightLeg`, `iCubHead`, `iCubTorso`, `iCubEmotion` and `iCubBall`