

Seminár Robotika.SK

Ovládanie simulovaného humanoida iCubSim z Python-u

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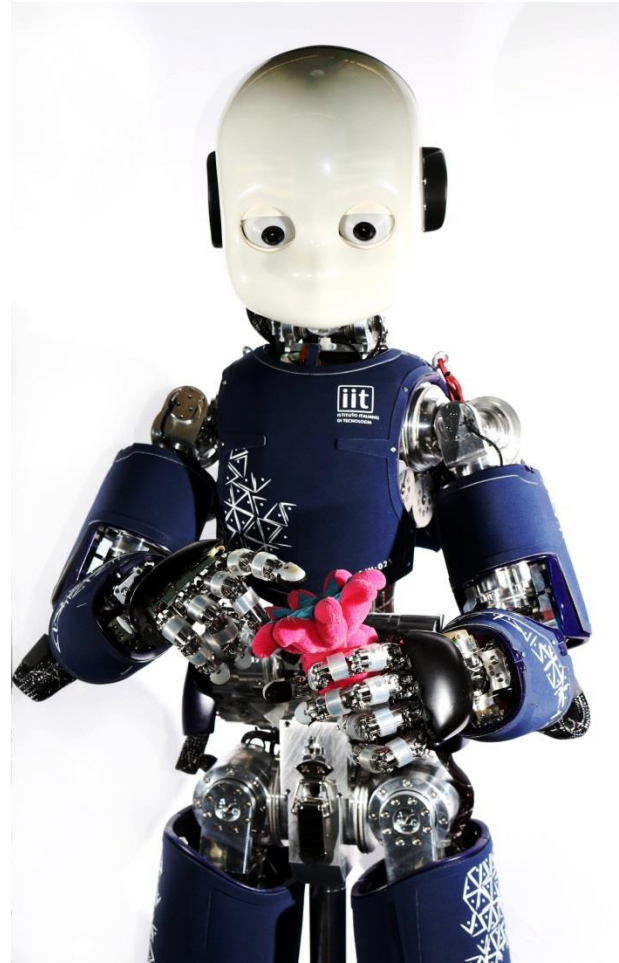
www.robotika.sk/seminar/2020/iCubSim.zip

<https://github.com/andylucny/iCubSimOnWindows.git>

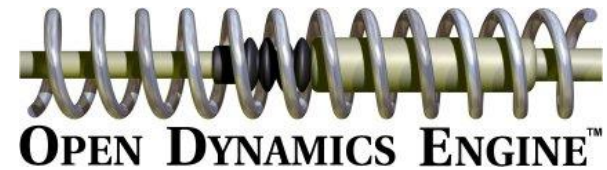
www.robotika.sk/seminar/2020/robotikask-iCubSim.pdf

iCub

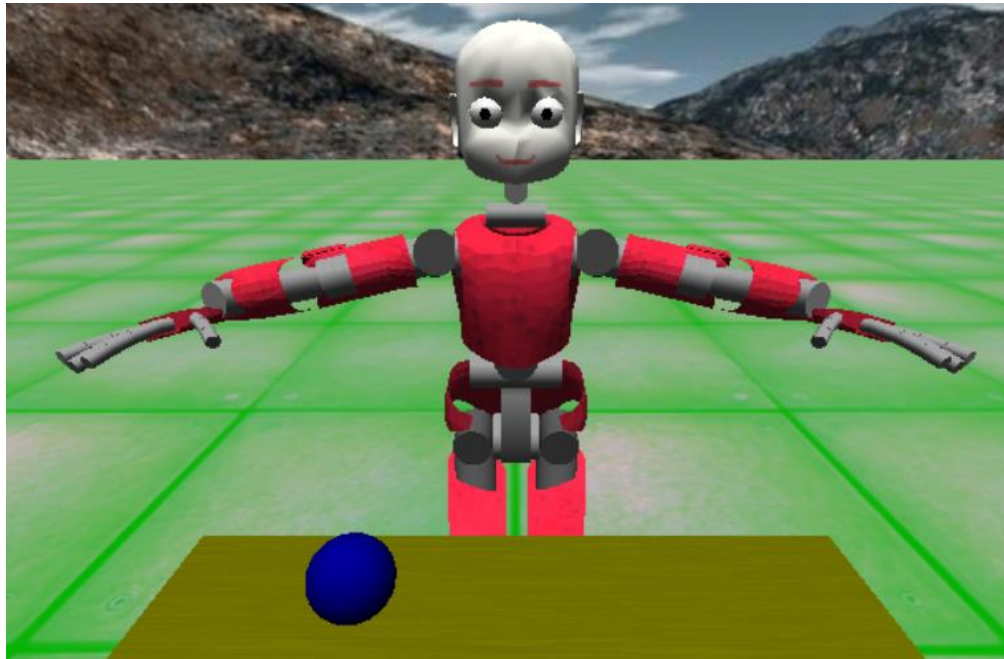
- EU IP RoboCub & NoE
EuCognition I-III
- Humanoidná robotická
platforma s otvoreným
zdrojovým kódom
- 53 stupňov voľnosti
(pozícia, rýchlosť)
- dotykové/tlakové senzory
- kamera z ľavého a
pravého oka



iCubSim



- Simulátor napísaný v C++ používajúci ODE a OpenGL



- (c) 2006-2019 Istituto Italiano di Tecnologia (IIT)
- (c) 2006-2010 RobotCub Consortium

Knižnica **pyicubsim**

- Predstavíme knižnicu, ktorá výrazne uľahčí prácu s týmto simulátorom
- Vyvinuli sme ju pre potreby cvičení predmetu *Introduction to Robotics for Cognitive Science* na Matfyzе v Bratislave
- Poskytuje triedy NoYarp, Yarp, iCubLimb, iCubCamera, iCubEmotion a iCubBall

Spustenie simulátora

- Spustíme ho: `iCubSim/run-iCubSim.bat`
- Čakáme, kým celý nabehne
- Potvrdíme aj štart Motor Control GUI

Protokol YARP

- iCubSim používa Yet another robot platform

d:\cvicenie13\iCubSim\bin\yarpserver.exe

The logo for YARP (Yet Another Robot Platform) is displayed in a stylized, outlined font. The letters are interconnected and have a mechanical, grid-like appearance. Below the logo is a horizontal line of small dashes.

```
Call with --help for information on available options
```

```
Using port database: :memory:
```

```
Using subscription database: :memory:
```

```
IP address: default
```

```
Port number: 10000
```

```
yarp: Port /root active at tcp://192.168.56.1:10000/
```

```
Registering name server with itself:
```

```
* register "/root" tcp "192.168.56.1" 10000
```

```
+ set "/root" offers http name_ser local tcp fast_tcp mcast udp text text_ack bayer mjpeg portmonitor priority tcp  
rossrv shmем xmlrpc
```

```
+ set "/root" accepts http name_ser local tcp fast_tcp mcast udp text text_ack bayer mjpeg portmonitor priority tcp  
rossrv shmем xmlrpc
```

```
+ set "/root" ips "127.0.0.1" "192.168.0.31" "172.17.6.56" "192.168.56.1"
```

```
+ set "/root" process 11204
```

```
* register fallback mcast "224.2.1.1" 10000
```

```
+ set fallback offers http name_ser local tcp fast_tcp mcast udp text text_ack bayer mjpeg portmonitor priority tcp  
rossrv shmем xmlrpc
```

```
+ set fallback accepts http name_ser local tcp fast_tcp mcast udp text text_ack bayer mjpeg portmonitor priority tcp  
rossrv shmем xmlrpc
```

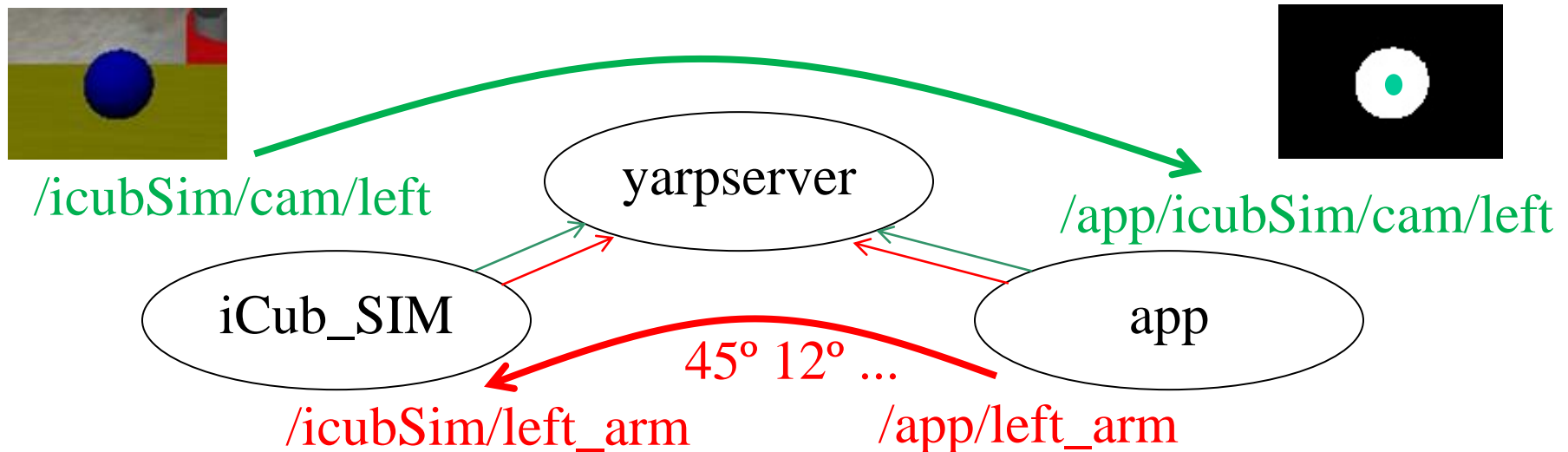
```
+ set fallback ips "127.0.0.1" "192.168.0.31" "172.17.6.56" "192.168.56.1"
```

```
+ set fallback process 11204
```

```
* set "/root" nameserver "true"
```

Protokol YARP

- YARP je komunikačný server, ktorý vytvára yarp porty, na ktoré sa môžu pripojiť klienti
- YARP potom umožňuje nastaviť presmerovanie dát medzi rôznymi portami



YARP – app. protokol nad TCP

- <http://www.robotika.sk/seminar/2020/telnet.zip>
TCP umožňuje vytvoriť datastream medzi klientom, ktorý sa pripája na IP adresu a port a serverom, ktorý na tom porte počúva
- YARP zavedie virtuálnu IP adresu 192.168.56.1, rovnako dobre pracuje však aj na localhost-e 127.0.0.1 a skutočnej IP adrese, pokiaľ to firewall dovolí
- YARP je aplikačný protokol nad TCP
- Používa základný port 10000, na ktorom beží naming service, ktorý vie pre YARP port (napr. /icubSim/cam/left) povedať, aký TCP port mu pridelil (napr. 10019). Okrem toho na tomto porte beží služba, ktorá umožňuje zadefinovať smerovanie dát medzi portami, jej clientom je utilita yarp.exe
- Každému YARP portu prideluje jeden TCP port od 10002

iCubSim je clientom YARP servera

```
d:\cvicenie13\iCubSim\bin\iCub_SIM.exe
[DEBUG]
ODE configuration: ODE ODE_EXT_no_debug ODE_EXT_trimesh ODE_EXT_opcode ODE_OPC_new_colli der ODE_EXT_threading ODE_double
_precision
[DEBUG]SimConfig::configure
||| clearing context
||| adding context [simConfig]
||| configuring
||| default config file specified as simulator.ini
||| checking [d:\cvicenie13\iCubSim\bin\simulator.ini] (pwd)
||| found d:\cvicenie13\iCubSim\bin\simulator.ini
[INFO]default module name: /iCubSim
[INFO]default verbosity level: 0
||| finding file [ode_params.ini]
||| checking [d:\cvicenie13\iCubSim\bin\ode_params.ini] (pwd)
||| found d:\cvicenie13\iCubSim\bin\ode_params.ini
||| finding file [parts]
||| checking [d:\cvicenie13\iCubSim\bin\iCub_parts_activation.ini] (pwd)
||| found d:\cvicenie13\iCubSim\bin\iCub_parts_activation.ini
||| finding file [parts]
[INFO]The iCub simulator will start with the following configuration:

Elevation : off
startHomePos : on
Legs : on
Torso : on
Left arm : on
Left hand : on
Right arm : on
Right hand : on
Head : on
Fixed Hip : on

Self-collisions : off
Collisions for covers : off

Pressure sensors: off
Whole body skin emulation: off
Cameras : on
Objects : on
Head Cover : on
Legs Cover : on
Left arm Covers : on
Right arm Covers : on
Torso Cover : on
Screen : off

||| finding file [Sim_joints.ini]
||| checking [d:\cvicenie13\iCubSim\bin\Sim_joints.ini] (pwd)
||| found d:\cvicenie13\iCubSim\bin\Sim_joints.ini
||| finding file [data/model/iCub_Head.ms3d]
||| checking [d:\cvicenie13\iCubSim\bin\data/model/iCub_Head.ms3d] (pwd)
||| found d:\cvicenie13\iCubSim\bin\data/model/iCub_Head.ms3d
||| finding file [data/model/topEyeLid.ms3d]
||| checking [d:\cvicenie13\iCubSim\bin\data/model/topEyeLid.ms3d] (pwd)
```

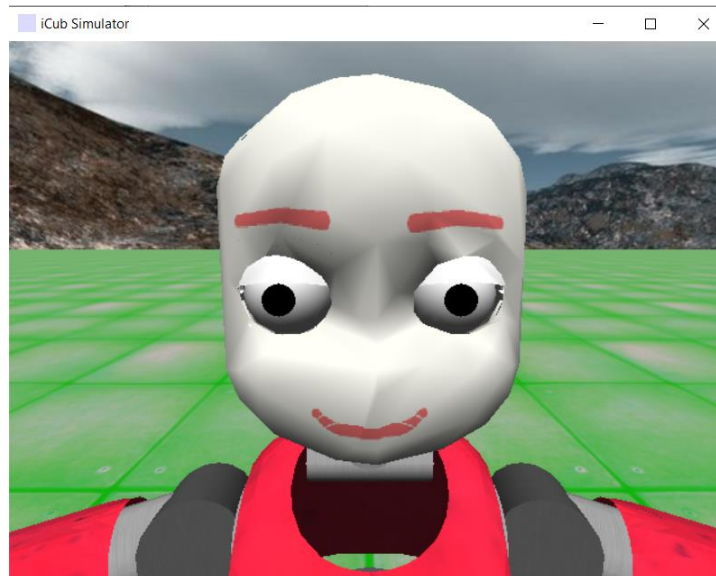
iCubSim zavedie na YARP serveri porty:

```
yarp: Port /icubSim/world active at tcp://192.168.56.1:10002
yarp: Port /icubSim/skin/left_hand_comp active at tcp://192.168.56.1:10003
yarp: Port /icubSim/skin/left_hand_comp/rpc:i active at tcp://192.168.56.1:10004
yarp: Port /icubSim/skin/right_hand_comp active at tcp://192.168.56.1:10005
yarp: Port /icubSim/skin/right_hand_comp/rpc:i active at tcp://192.168.56.1:10006
yarp: Port /icubSim/inertial active at tcp://192.168.56.1:10007
yarp: Port /icubSim/joint_vsens/left_leg:i active at tcp://192.168.56.1:10008
yarp: Port /icubSim/joint_vsens/right_leg:i active at tcp://192.168.56.1:10009
yarp: Port /icubSim/joint_vsens/torso:i active at tcp://192.168.56.1:10010
yarp: Port /icubSim/joint_vsens/right_arm:i active at tcp://192.168.56.1:10011
yarp: Port /icubSim/joint_vsens/left_arm:i active at tcp://192.168.56.1:10012
yarp: Port /icubSim/skinManager/skin_events:o active at tcp://192.168.56.1:10013
yarp: Port /icubSim/skin/left_arm_comp active at tcp://192.168.56.1:10014
yarp: Port /icubSim/skin/right_arm_comp active at tcp://192.168.56.1:10015
yarp: Port /icubSim/skin/left_forearm_comp active at tcp://192.168.56.1:10016
yarp: Port /icubSim/skin/right_forearm_comp active at tcp://192.168.56.1:10017
yarp: Port /icubSim/skin/torso_comp active at tcp://192.168.56.1:10018
yarp: Port /icubSim/cam/left active at tcp://192.168.56.1:10019
yarp: Port /icubSim/cam/right active at tcp://192.168.56.1:10020
yarp: Port /icubSim/cam active at tcp://192.168.56.1:10021
yarp: Port /icubSim/left_arm/rpc:i active at tcp://192.168.56.1:10022
yarp: Port /icubSim/left_arm/command:i active at tcp://192.168.56.1:10023
yarp: Port /icubSim/left_arm/state:o active at tcp://192.168.56.1:10024
```

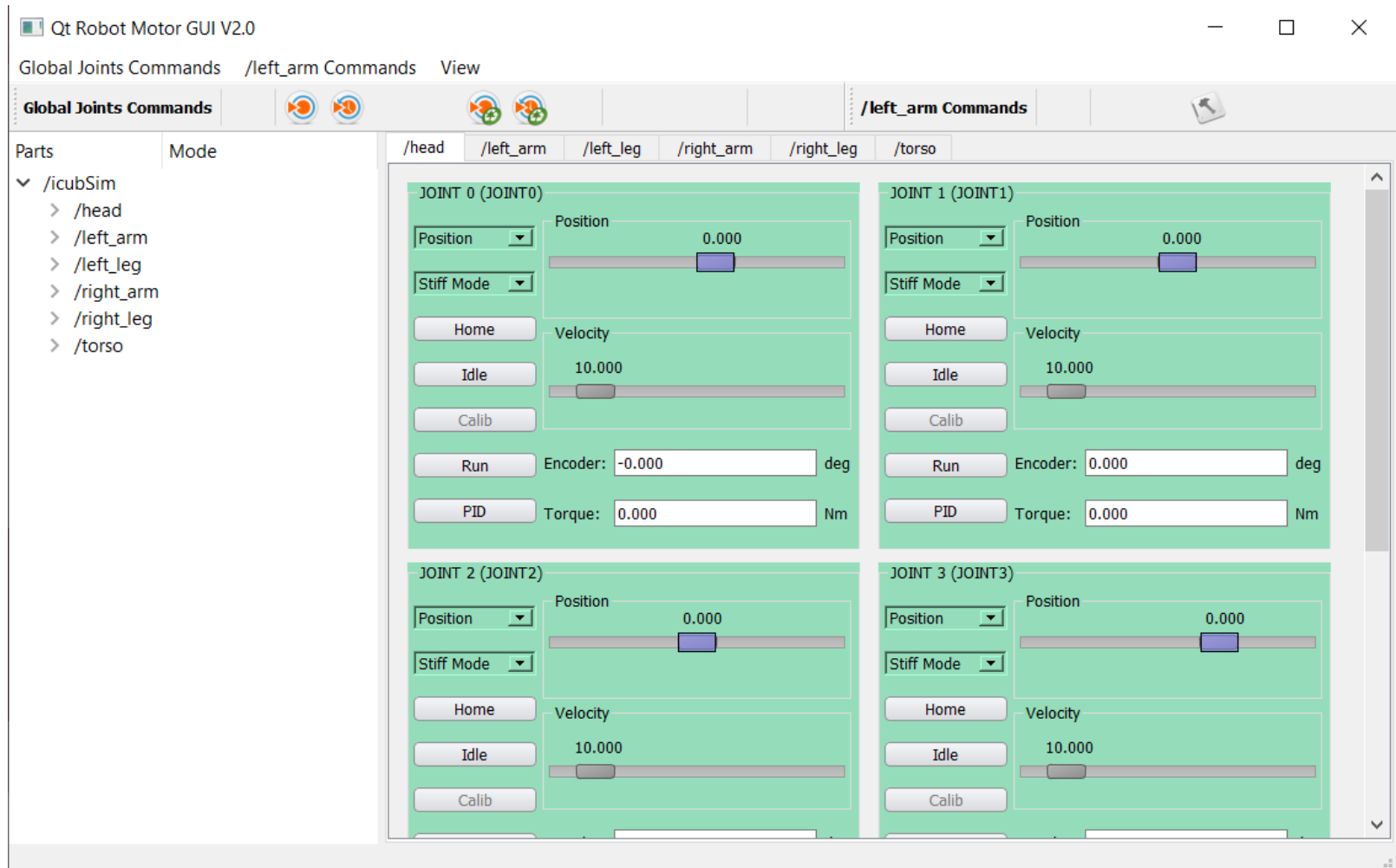
yarp: Port /icubSim/left_arm/stateExt:o active at tcp://192.168.56.1:10025
yarp: Port /icubSim/right_arm/rpc:i active at tcp://192.168.56.1:10026
yarp: Port /icubSim/right_arm/command:i active at tcp://192.168.56.1:10027
yarp: Port /icubSim/right_arm/state:o active at tcp://192.168.56.1:10028
yarp: Port /icubSim/right_arm/stateExt:o active at tcp://192.168.56.1:10029
yarp: Port /icubSim/head/rpc:i active at tcp://192.168.56.1:10030
yarp: Port /icubSim/head/command:i active at tcp://192.168.56.1:10031
yarp: Port /icubSim/head/state:o active at tcp://192.168.56.1:10032
yarp: Port /icubSim/head/stateExt:o active at tcp://192.168.56.1:10033
yarp: Port /icubSim/left_leg/rpc:i active at tcp://192.168.56.1:10034
yarp: Port /icubSim/left_leg/command:i active at tcp://192.168.56.1:10035
yarp: Port /icubSim/left_leg/state:o active at tcp://192.168.56.1:10036
yarp: Port /icubSim/left_leg/stateExt:o active at tcp://192.168.56.1:10037
yarp: Port /icubSim/right_leg/rpc:i active at tcp://192.168.56.1:10038
yarp: Port /icubSim/right_leg/command:i active at tcp://192.168.56.1:10039
yarp: Port /icubSim/right_leg/state:o active at tcp://192.168.56.1:10040
yarp: Port /icubSim/right_leg/stateExt:o active at tcp://192.168.56.1:10041
yarp: Port /icubSim/torso/rpc:i active at tcp://192.168.56.1:10042
yarp: Port /icubSim/torso/command:i active at tcp://192.168.56.1:10043
yarp: Port /icubSim/torso/state:o active at tcp://192.168.56.1:10044
yarp: Port /icubSim/torso/stateExt:o active at tcp://192.168.56.1:10045
yarp: Port /icubSim/texture/face active at tcp://192.168.56.1:10046
yarp: Port /icubSim/texture/screen active at tcp://192.168.56.1:10047
yarp: Port /icubSim/texture/sky active at tcp://192.168.56.1:10048
yarp: Port /icubSim/face/eyelids active at tcp://192.168.56.1:10049

iCubSim VR

- Ovládanie uhl'a pohľadu do simulátora:
- Q W E R A S D F Z X C V
- R – obnoví štandardný pohľad



Manuálne ovládanie



YARP without YARP

- Yarp je miestami aj čitateľný a zapisovateľný človekom
- `/icubSim/left_arm/rpc:i ... telnet localhost 10022`

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

```
CONNECT me
```

```
odozva: Welcome me
```

```
d
```

```
get pos 1
```

```
odozva: <position of joint 1>
```

```
odozva: [ok]
```

```
d
```

```
set pos 1 40
```

```
odozva: <robot set joint 1 of its left arm to position 40 degrees>
```

```
odozva: [ok]
```

```
d
```

```
get pos 1
```

```
odozva: <modified position of joint 1>
```

```
odozva: [ok]
```

`demo_noyarp.py`

YARP via SWIG

- väčšinou však treba použiť zložitejší interface, pri ktorom sú kĺby alebo kamery reprezentované dedikovanými objektami zapuzdrujúcimi YARP protokol
- tieto triedy objektov sa nazývajú „bindings“ a kompilujú sa pomocou SWIG
- správne bindings v podobe `_yarp.pyd` `yarp.py` nakopíruje `iCubSim\init-bindings.bat`

Knižnica pyicubsim

- Zakrýva oba druhy rozhraní (NoYarp a Yarp)
- Odstraňuje potrebu vedomosti protokolu
- Implementuje triedy:
 - iCubLimb ... ovládanie kĺbov
 - iCubCamera ... prijímanie obrazu z kamier
 - iCubEmotion ... ovládanie emočného výrazu
 - iCubBall ... ovládanie guličky

Ovládanie kĺbov (pyicubsim)

```
from pyicubsim import iCubLimb
import time

right_arm = iCubLimb('/demo', '/icubSim/right_arm')

print(right_arm.get())

right_arm.set(joint1=85, joint3=40, joint2=40)
time.sleep(1.5)

right_arm.set((0, 80, 0, 50, 0, 0, 0, 59, 20, 20, 20, 10, 10, 10, 10, 10))
```

Obrazy z kamier (pyicubsim)

```
from pyicubsim import iCubCamera
import cv2

left_camera = iCubCamera(app, '/icubSim/cam/left')
while True:
    left_image = left_camera.grab()

    cv2.imshow('left', left_image)
    if cv2.waitKey(10) == 27:
        break
```

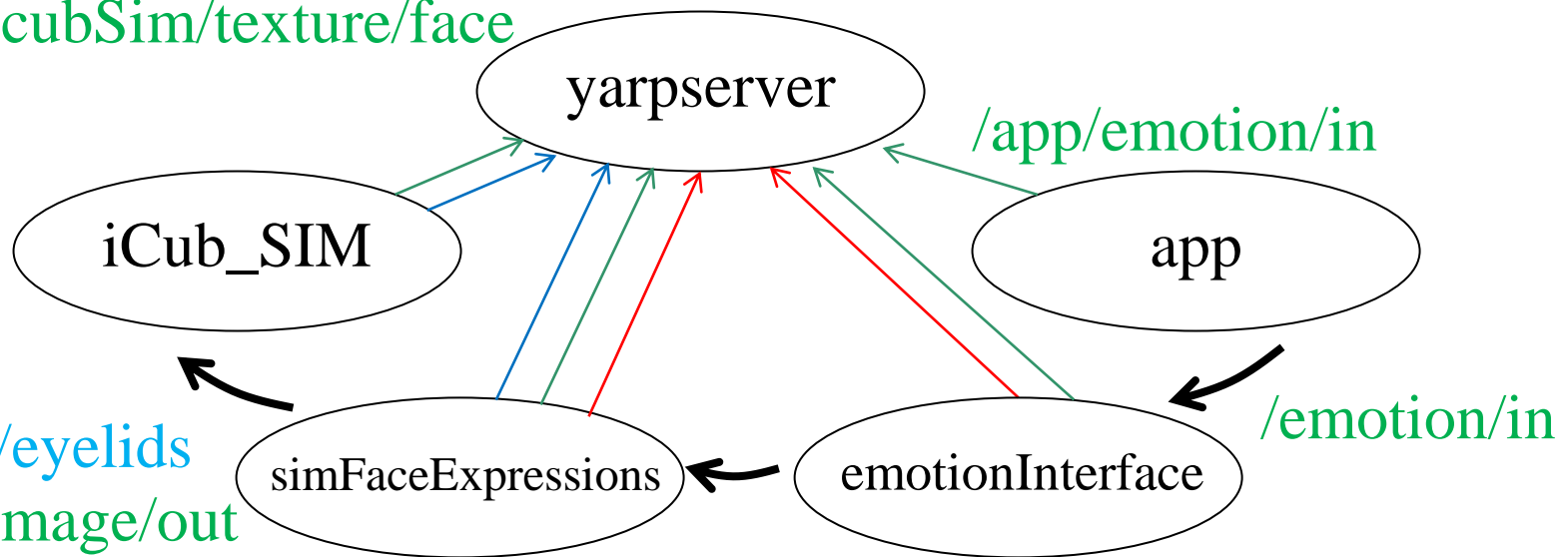
Emócie (pyicubsim)

neutral
happy
sad
surprised
angry
evil
shy
cunning

```
from pyicubsim import iCubEmotion
emotion = iCubEmotion()
emotion.set(emotion.happy)
```

/icubSim/face/eyelids

/icubSim/texture/face



/face/eyelids
/face/image/out

/icubSim/face/raw/in */emotion/out*

demo_emotion.py

Ovládanie guľičky (pyicubsim)

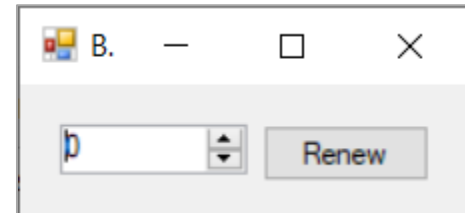
```
from pyicubsim import iCubBall  
import time
```

```
ball = iCubBall()
```

```
position = ball.get()  
ball.set(y=position[2]+1.0)
```

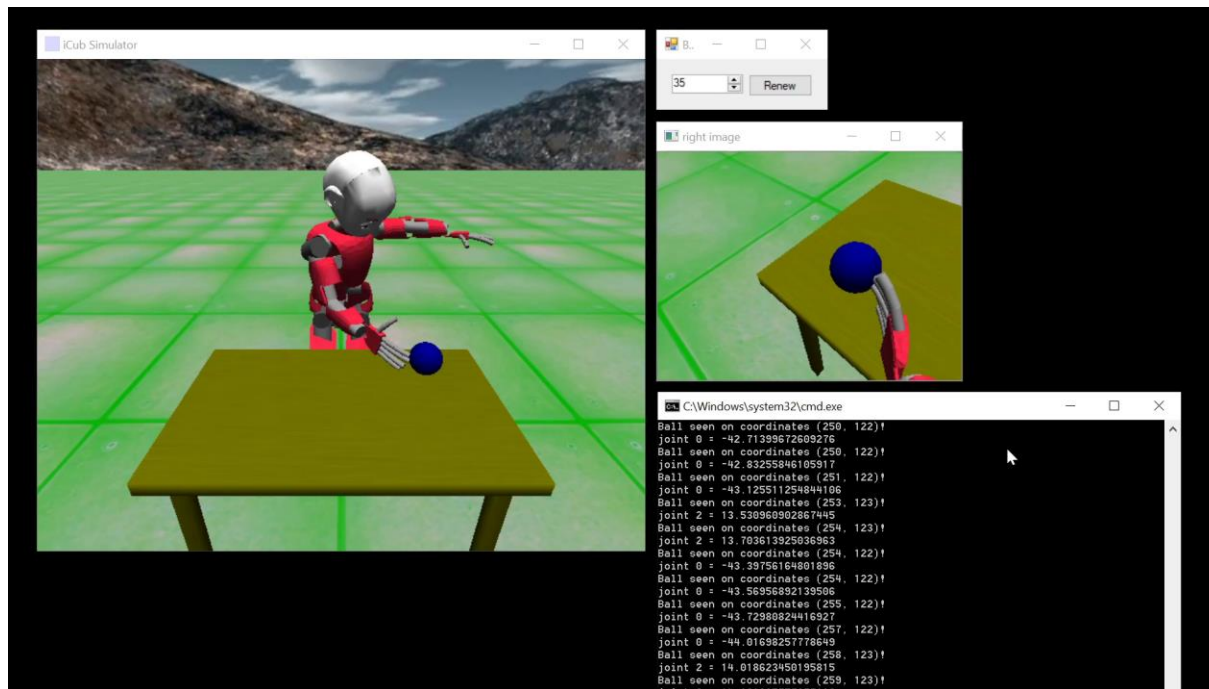
```
time.sleep(1.0)
```

```
ball.set() # default position
```



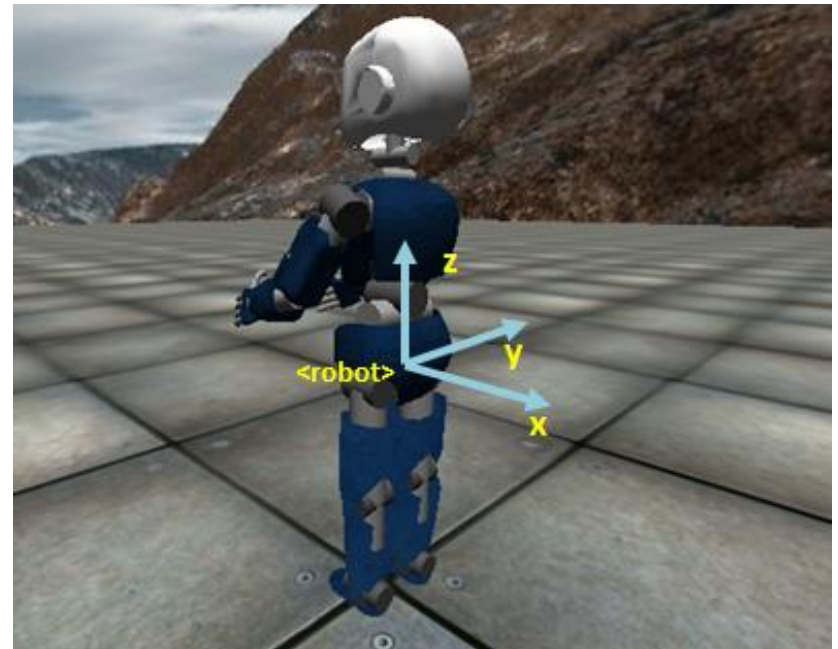
Example: Hit the ball

- Robot zrážajúci guľičku
- Študentský projekt, Michal Kováč 2020
- <https://youtu.be/YDq1k9mVfpQ>



Example: Priama kinematika

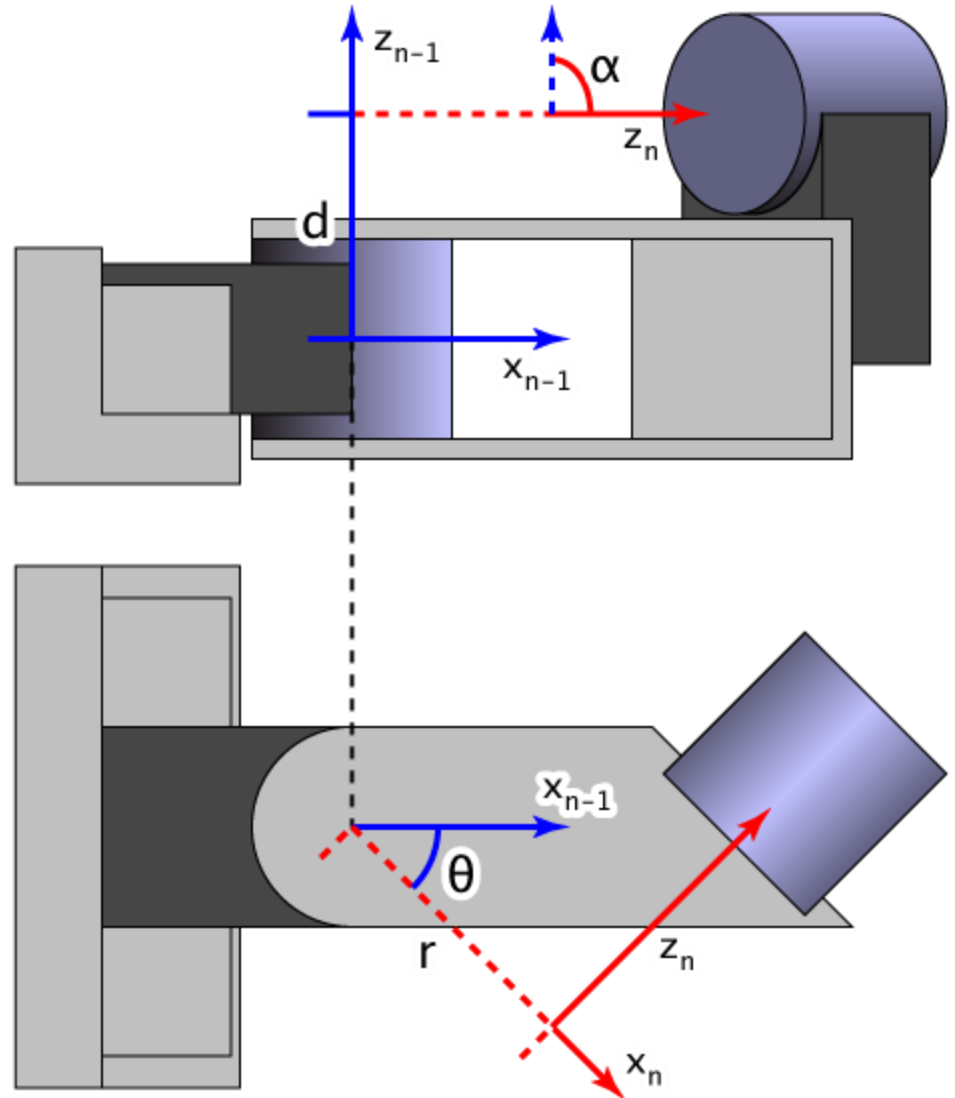
Pre iCubSim sú známe Denavit-Hartenbergove konštanty pomocou ktorých vieme z polôh kĺbov vypočítať 3D súradnicu konca ramena.



Example: Priama kinematika

- Denavit-Hartenbergova (D-H) konvencia popisuje každý kĺb tromi konštantami a jednou premennou:

– d , θ , r , α



Example: Priama kinematika

- Z $D-H$ parametrov kĺbov $i=1,2,\dots,n$, môžeme zostaviť matice Z_i, X_i ktorých násobenie vypočíta koncový bod $T=(x,y,z,1)$ z počiatku $(0,0,0,1)$ – používame projektívne súradnice

$$[T] = [Z_1][X_1][Z_2][X_2] \dots [X_{n-1}][Z_n][X_n],$$

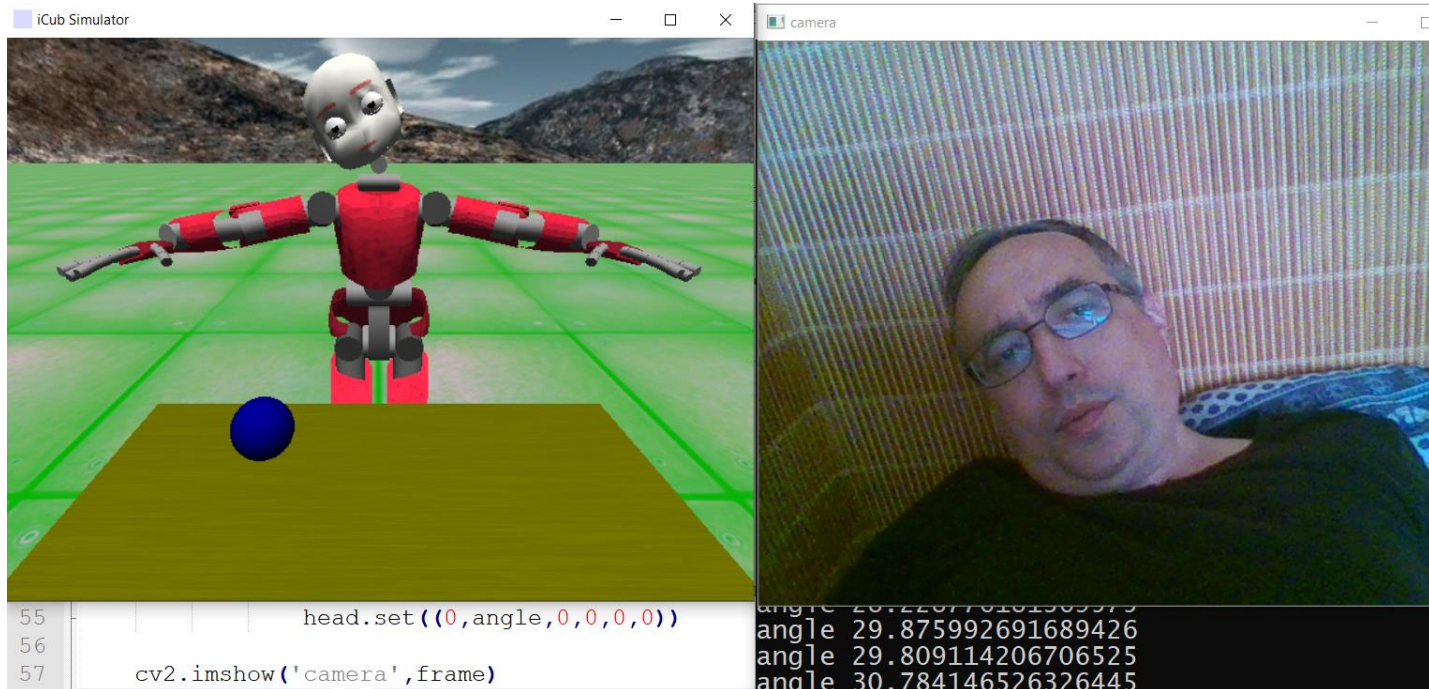
$$[Z_i] = \begin{bmatrix} \cos \theta_i & -\sin \theta_i & 0 & 0 \\ \sin \theta_i & \cos \theta_i & 0 & 0 \\ 0 & 0 & 1 & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}, \quad [X_i] = \begin{bmatrix} 1 & 0 & 0 & r_{i,i+1} \\ 0 & \cos \alpha_i & -\sin \alpha_i & 0 \\ 0 & \sin \alpha_i & \cos \alpha_i & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix},$$

posunutie + otočenie

posunutie + otočenie

Example: Imitácia

- Robot napodobňujúci pohyb hlavy interagujúceho človeka
- <https://youtu.be/y1Se8qlGKng>



Ďalšie možnosti

Pomocou ďalších knižníc ako napr. agentspace je možné iCubSim využiť v komplexnejšom systéme.

<https://youtu.be/NPYS-bLGWdU>



Bakalárska práca
Šimon Drastich
FMFI UK
Bratislava 2020
učí robota
rozvičku,
používa pritom
prirodzený jazyk
(NLP, DL)

Ďakujem za pozornosť!

Seminár Robotika.SK

**Ovládanie simulovaného humanoida
iCubSim z Python-u**

www.robotika.sk/seminar-archiv.php#cvicenie13
www.agentspace.org/kv

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