Development of Training Tools for Haptic Teleoperation of a Humanoid Robot.

Master Thesis Presentation

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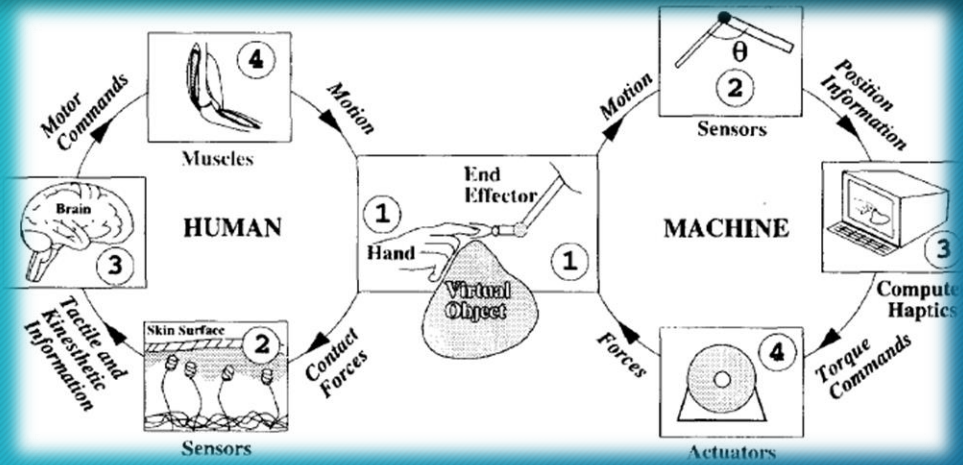
Presentation Structure

- Introduction
- Objectives
- Experimental Setup
- User Trainer Interface
  - IK User Trainer Interface
  - Torque User Trainer Interface
- Experiments & Results
- Conclusions

Haptic and Haptic's applications

- What is Haptics?
- Teleoperation with haptics.
- Haptic Guidance



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Humanoid Project-PHUA

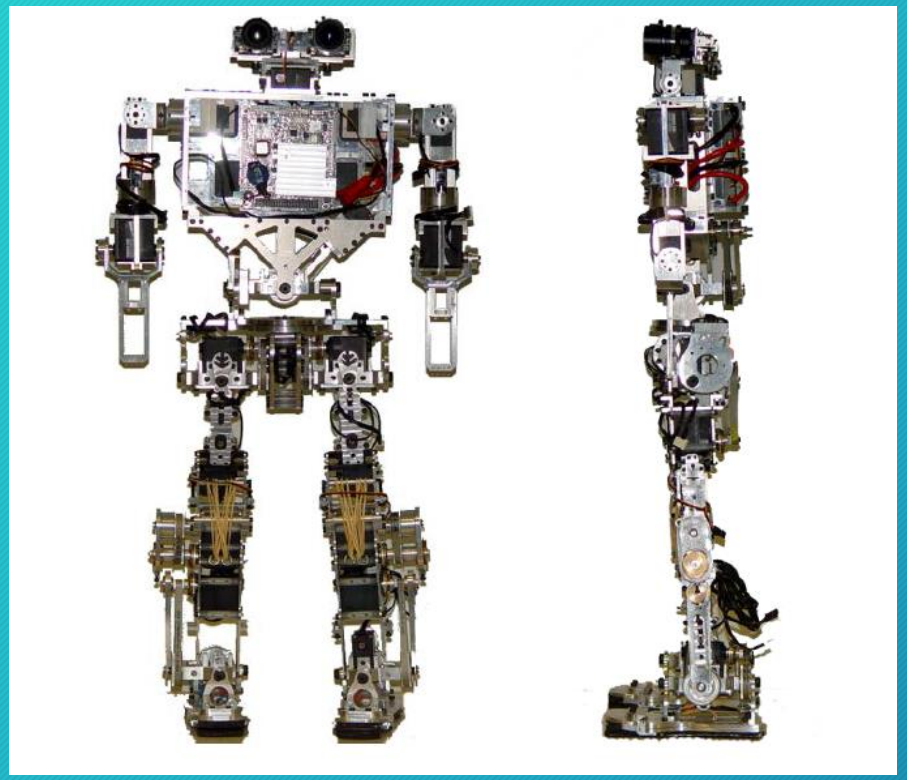
PHUA main objective is the development and integration of hardware and software components in a functional low-budget platform, to perform studies in balance and locomotion tasks.

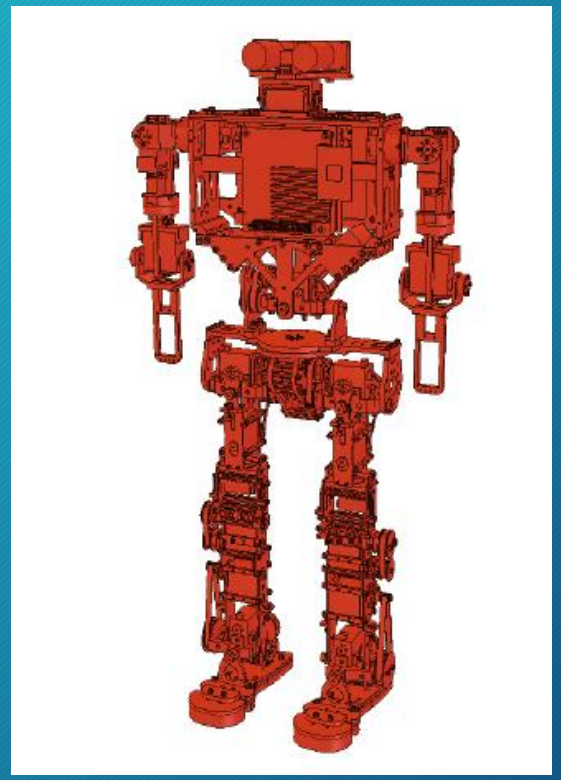
- The platform aims for a kinesthetic teaching interaction, in which the user uses one or two haptic devices to interact with the platform, thus demonstrating a specific motion, while receiving feedback of the system's dynamics.

Humanoid Project-PHUA

- Anthropometrically built
- 27 degrees-of-freedom (25 active, 2 passive)
- Hybrid actuation system
- Force sensors
- Artificial vision system
- Inertial sensors

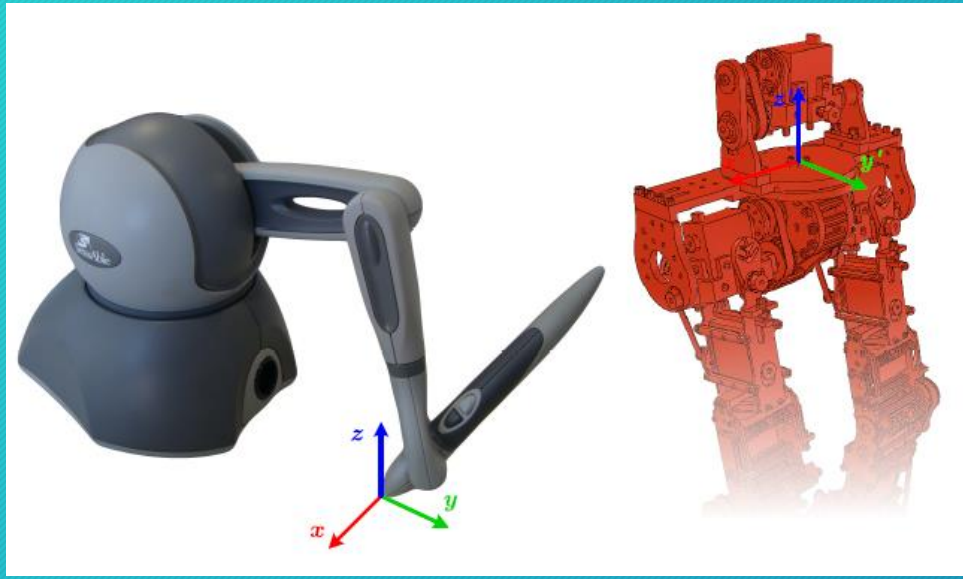
Humanoid Project-PHUA



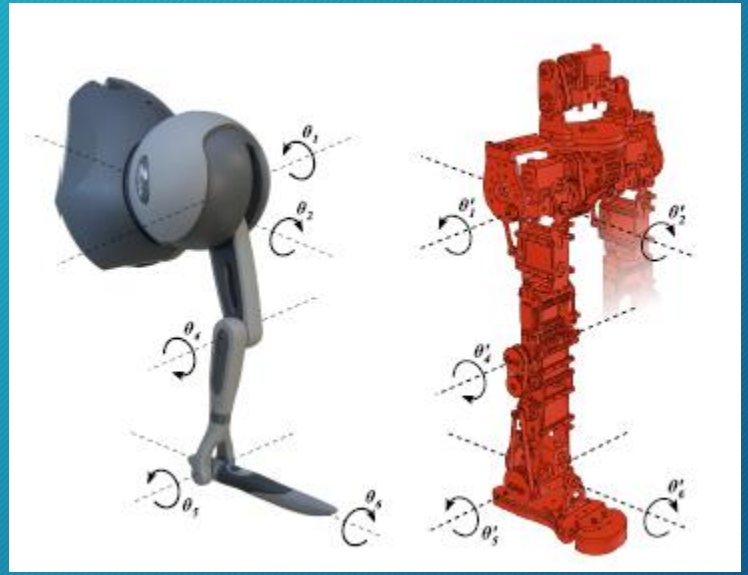


Humanoid Project-PHUA

Inverse Kinetics Control (IK mode)



Joint-by-joint Control (Torque mode)



Objectives

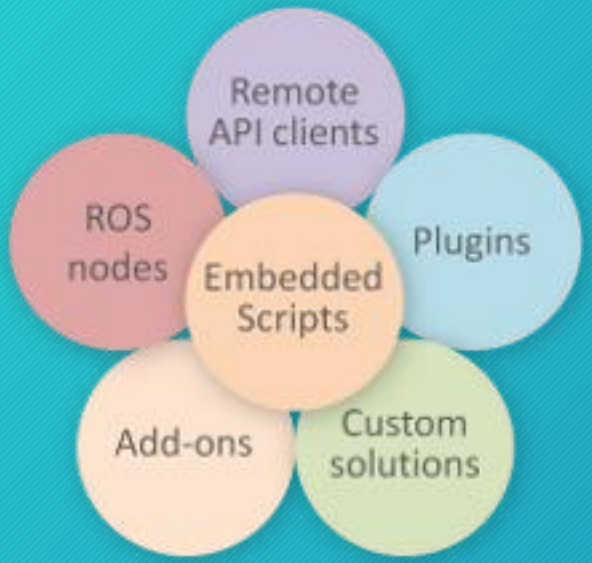
- Teleoperation of the V-REP model with one haptic device
- Analysis of the fundamentals of the reproduction of maneuvers
- Development, implementation and evaluation of a trainer interface
- Extend the previous objectives to a two haptic devices configuration
- Teleoperation of the V-REP in one leg balance task

Experimental Setup

- Haptic Device PHANToM Omni
  - 6 revolution joints
  - Torque activation on the first 3 joints
  - Two activation buttons
  - Force 0.75 lbf/3.3 N
  - IEEE 1394 FireWire

Experimental Setup

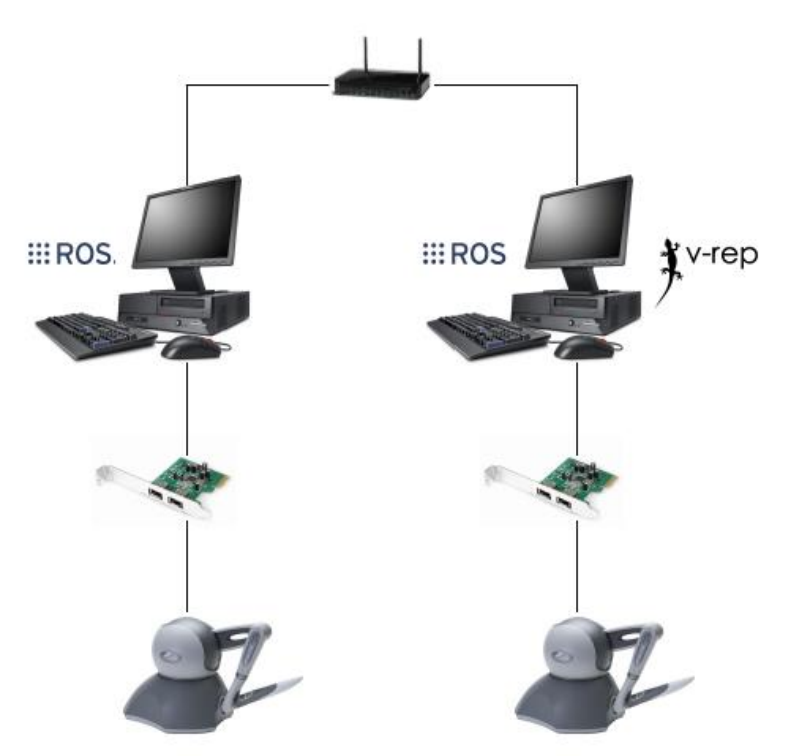
- Virtual Robot Experimentation Platform (V-REP)



Experimental Setup

ROS Framework:

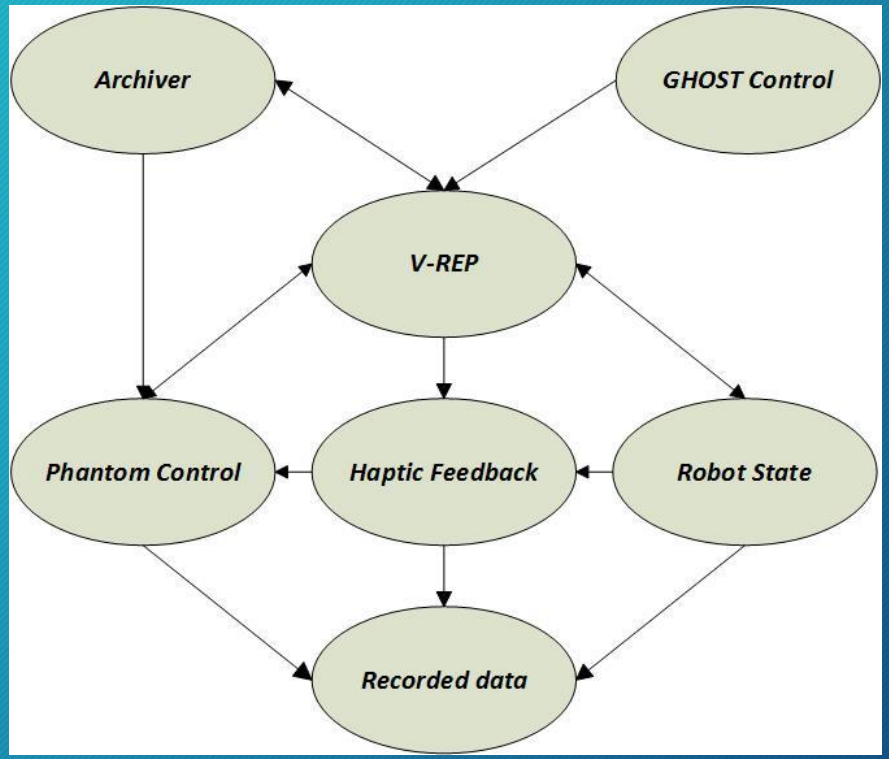
- Hardware Setup



Experimental Setup

ROS Framework:

- Nodes Interaction



User Trainer Interface

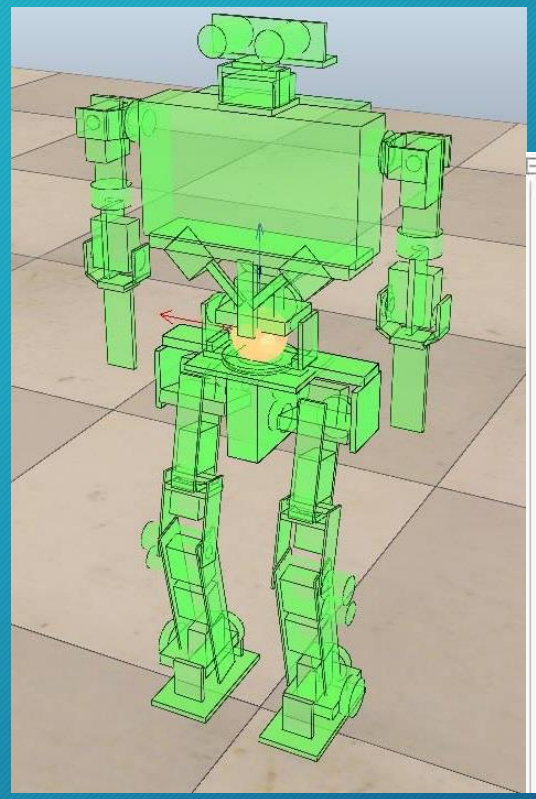
IK Control mode issues

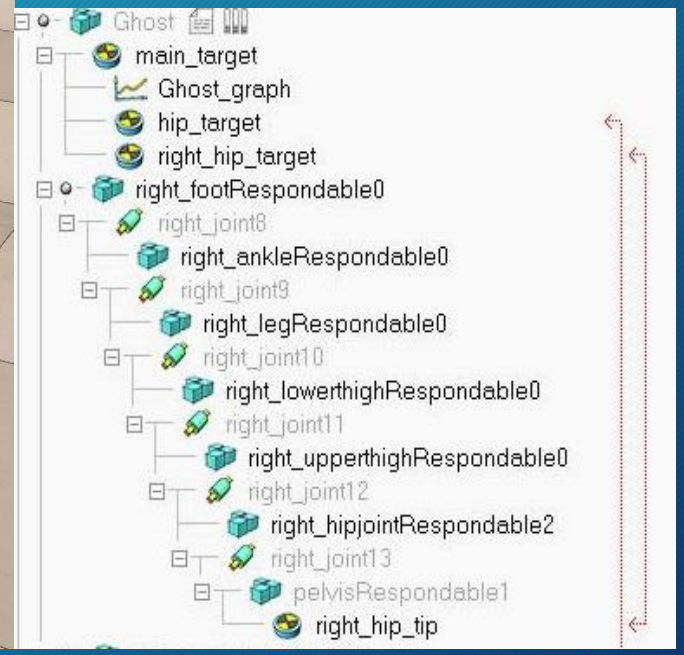
- Increase of mass, addition of the upper body to the maneuvers.
- Increase in the model's inertia.
- Non perceived force feedback.

User Trainer Interface

IK User Trainer Interface

- GHOST the visual guidance tool
  - Replica from the PHUA model
  - No Dynamics Proprieties
  - New Object Hierarchy
  - Autonomous Movement
  - Color Green

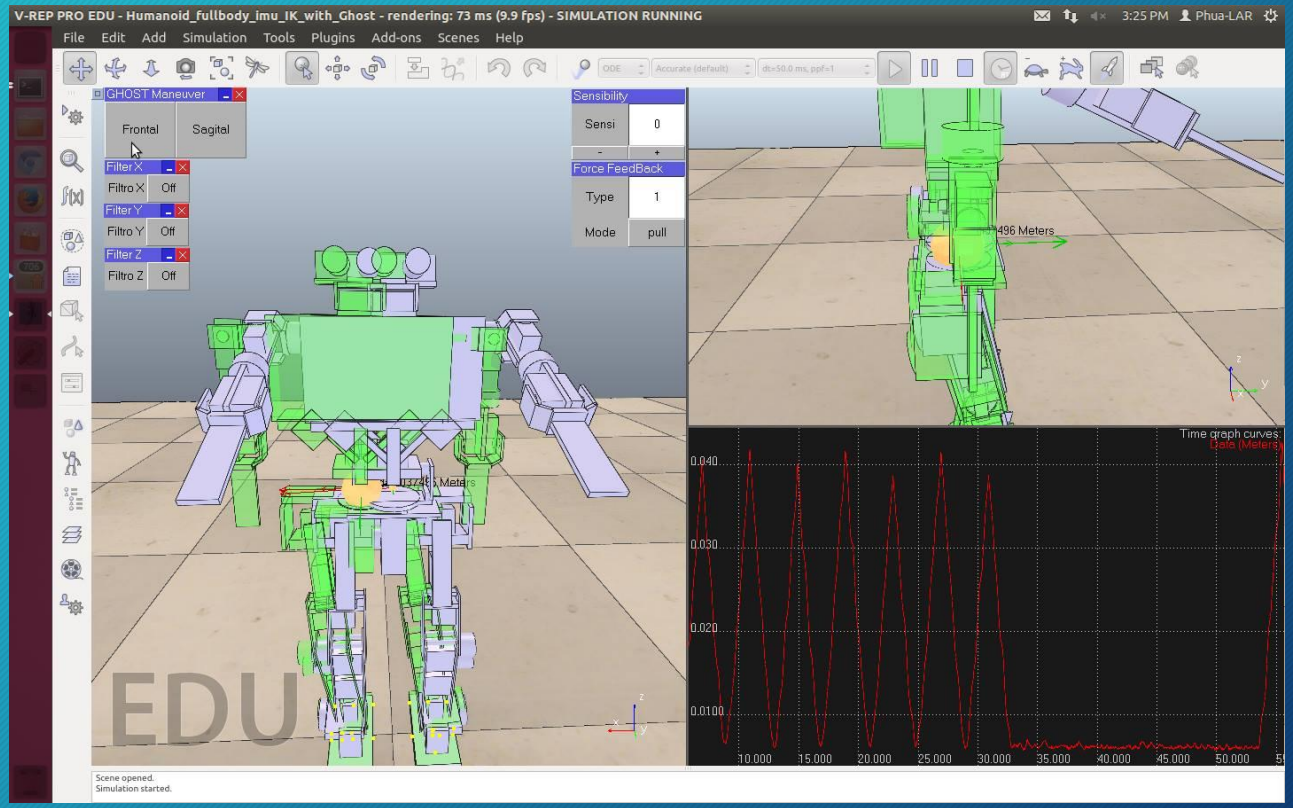




User Trainer Interface

IK User Trainer Interface

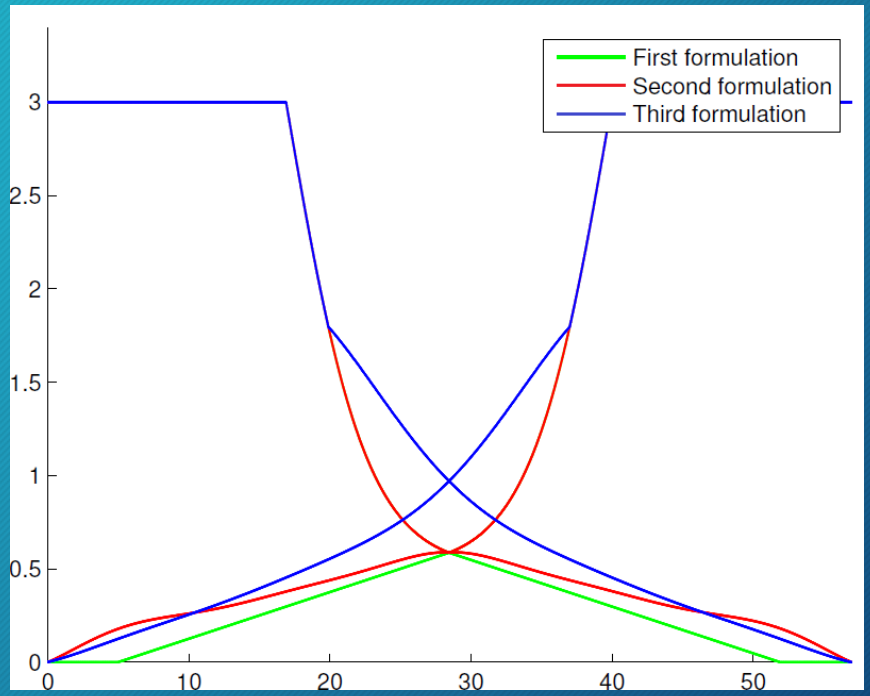
- Interface
  - Multi window display
  - Custom UIs
  - Online personalization



User Trainer Interface

IK User Trainer Interface

- New force formulations
  - Multi formulation configuration
  - Easy Online Selection
  - Four different formulation
  - Two possible directions



User Trainer Interface

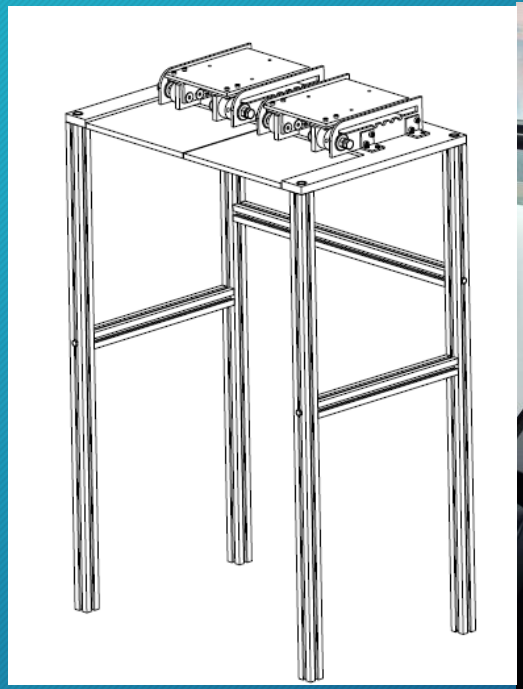
Torque Control mode issues

- Non intuitive position of the device for the teleoperation.
- Difficult synchronation between the initial configurations of the haptic device and the model configuration.
- Rigid upper body.
- Non perceived force feedback.

User Trainer Interface

Torque User Trainer Interface

- Haptic Interaction Workstation
  - Easy Configuration Change
  - Ergonomic Build
  - Light Weight



User Trainer Interface

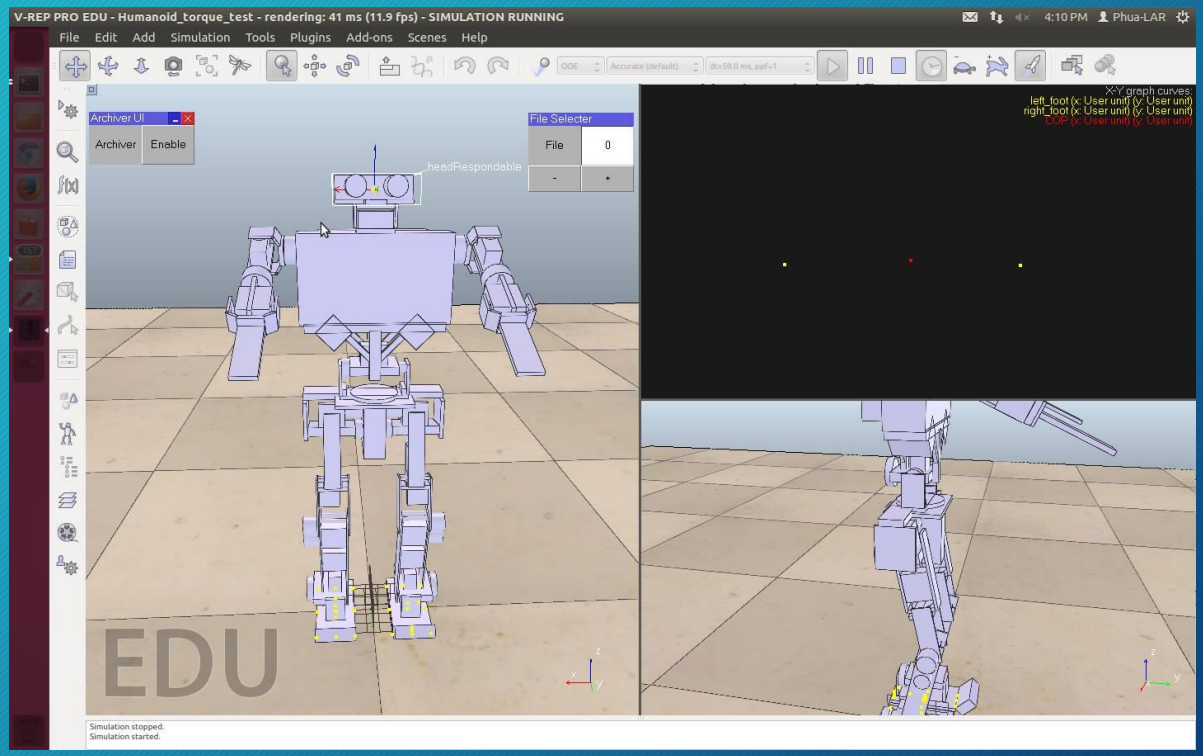
Torque User Trainer Interface

- Haptic guidance tool
  - Reproduces archived maneuvers
  - Guides the user throughout the configurations needed to replicate the archived maneuver

User Trainer Interface

Torque User Trainer Interface

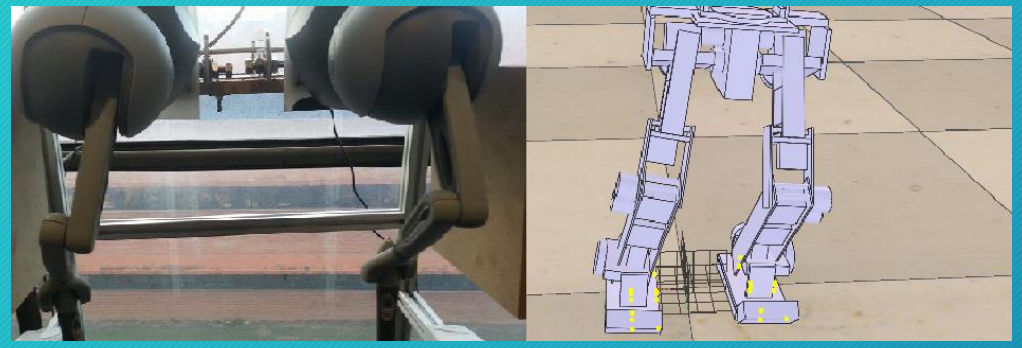
- Interface
  - Multi window display
  - Custom UIs
  - Online Interaction



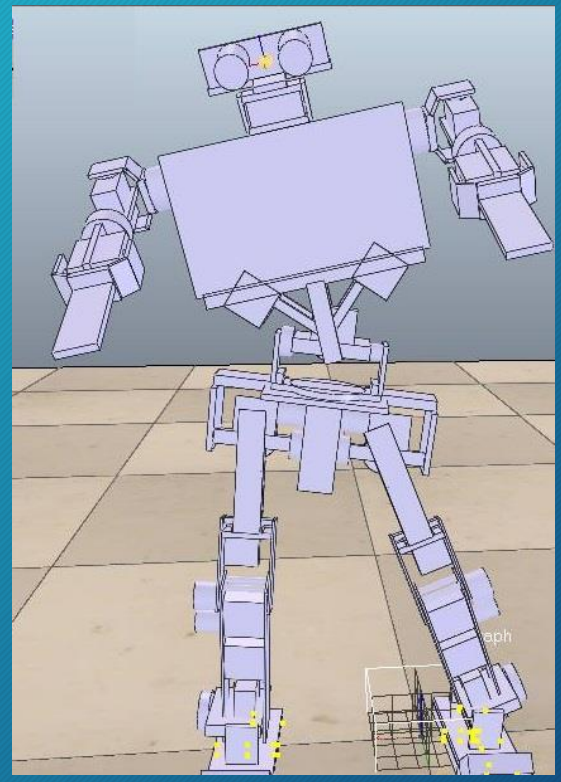
User Trainer Interface

Torque User Trainer Interface

- Auxiliary tools
  - Joint Configuration Finder



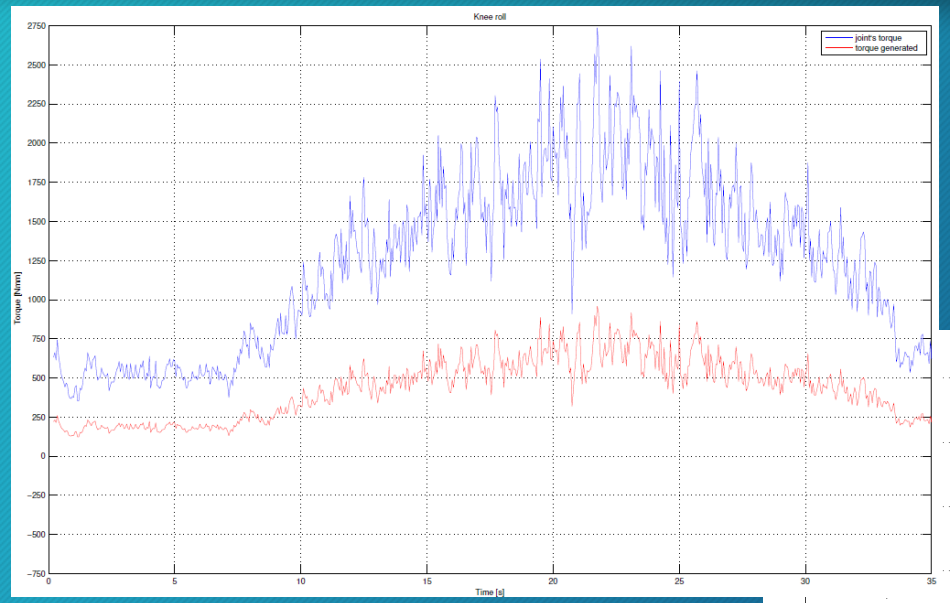
- Assisted Torque Configuration

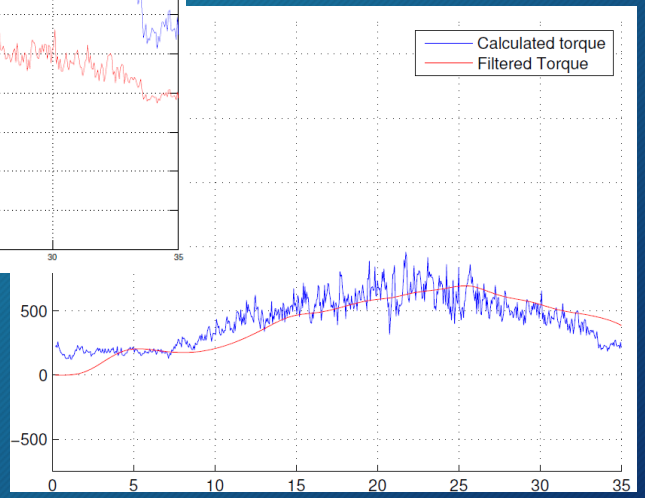


User Trainer Interface

Torque User Trainer Interface

- Force Feedback
  - Individual Joint Application
  - Intuitive Perception
  - Capable of Object Perception

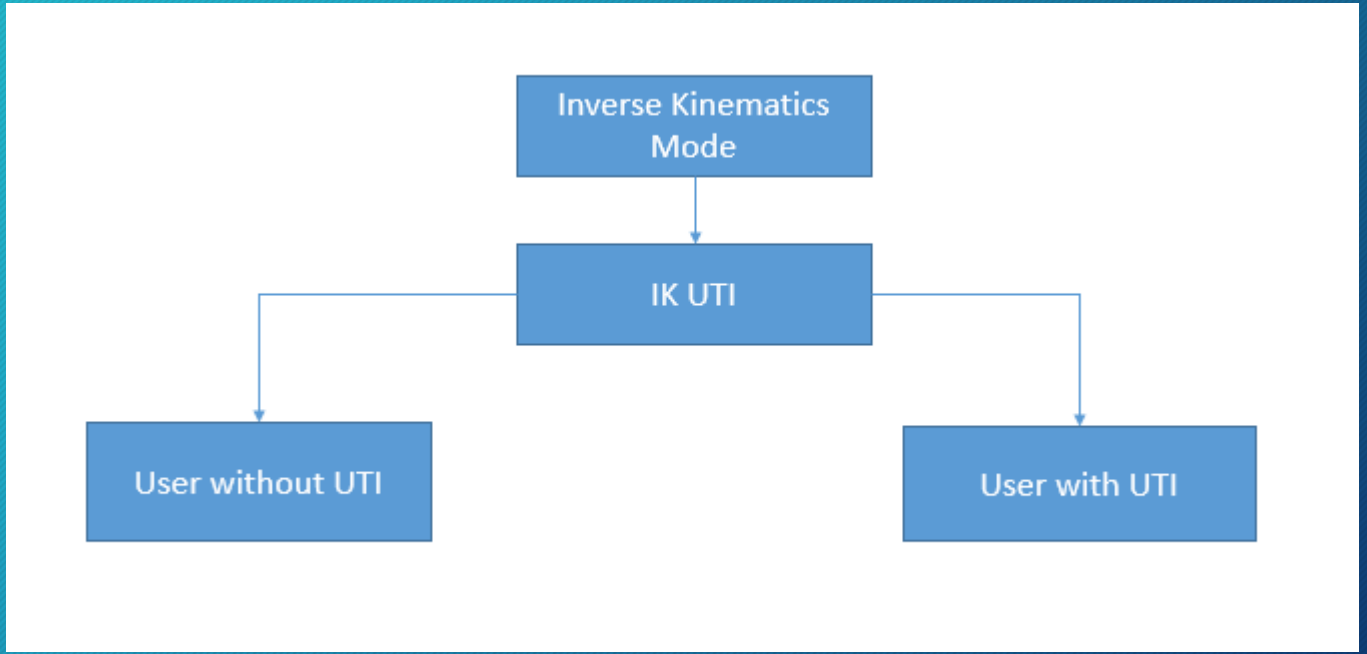




Experiments & Results

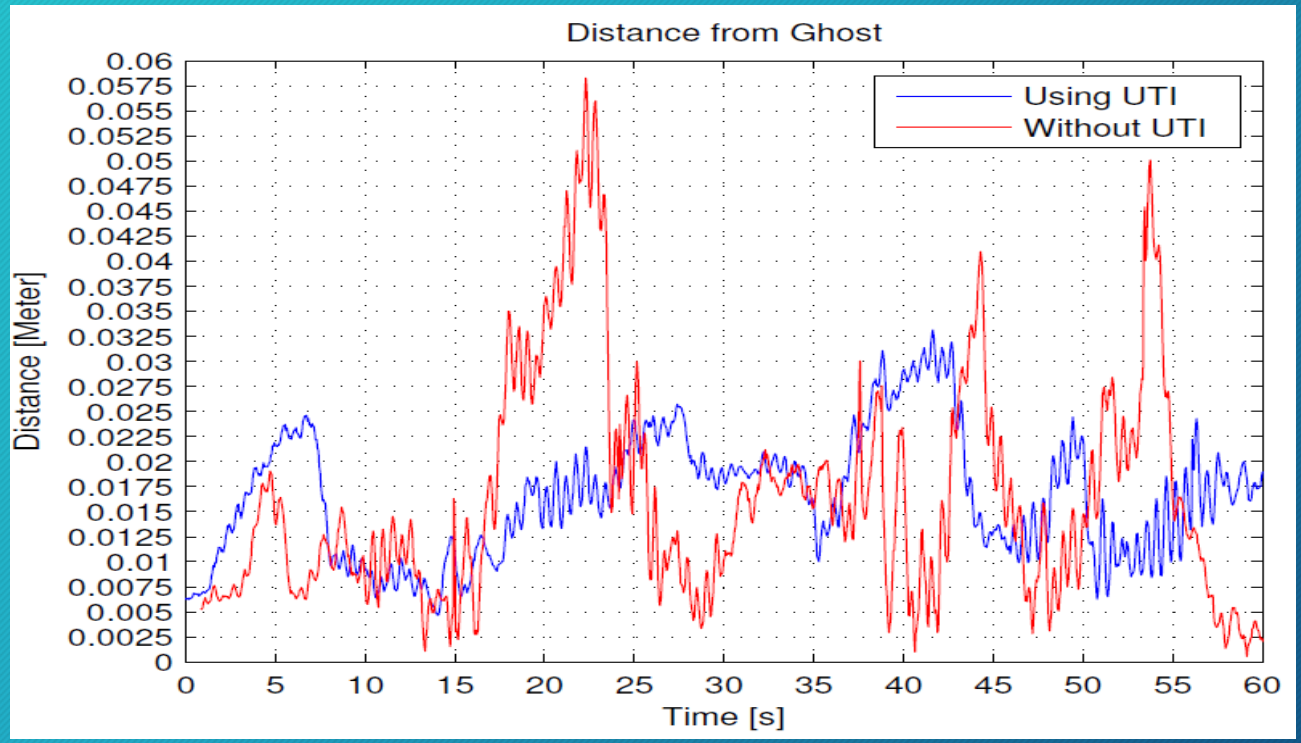
IK UTI Experiments

- Two users
- 20 minutes of training
- GHOST control by expert user



Experiments & Results

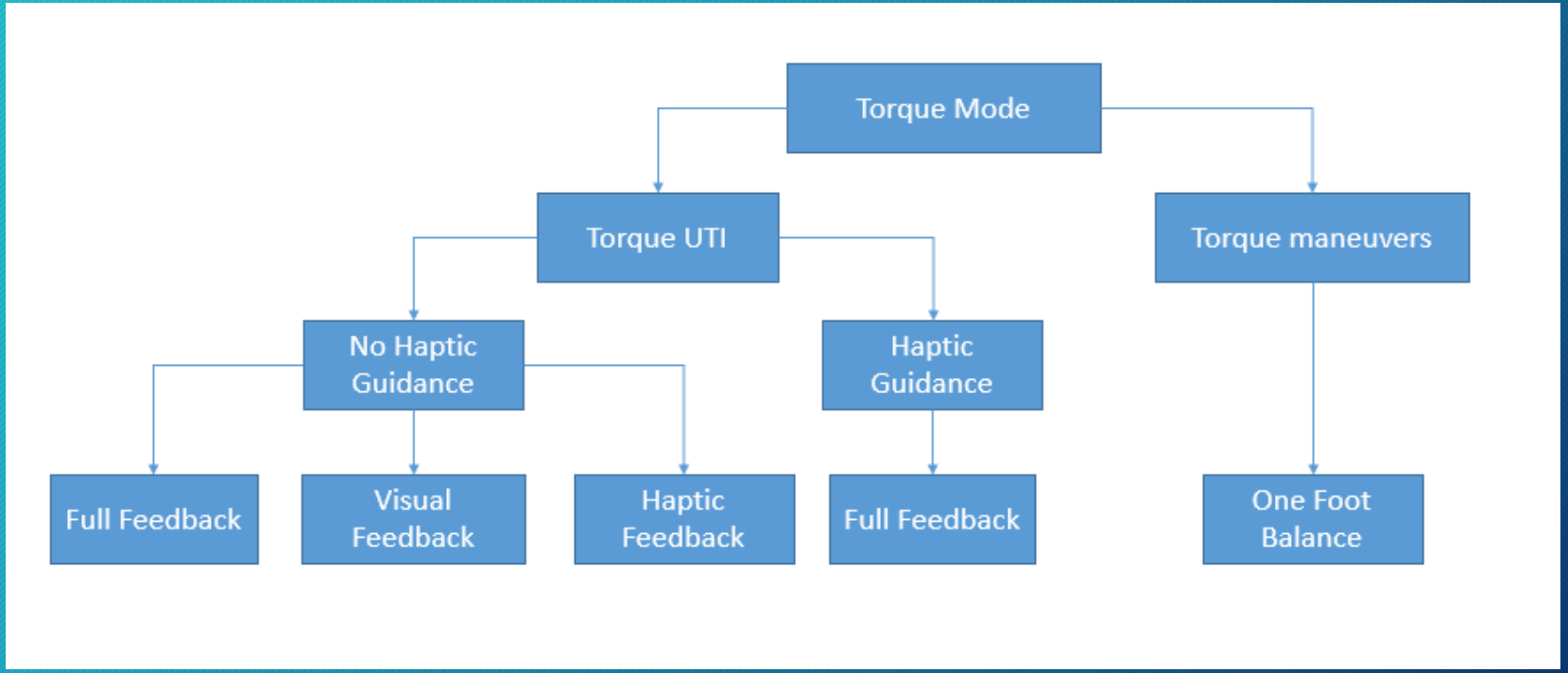
IK UTI Results



Experiments & Results

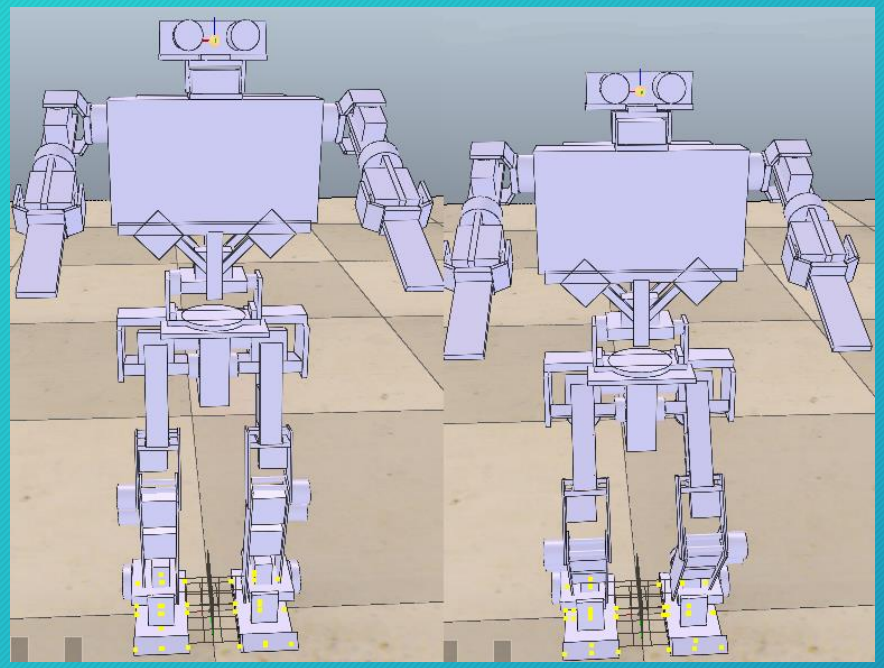
Torque UTI Experiments

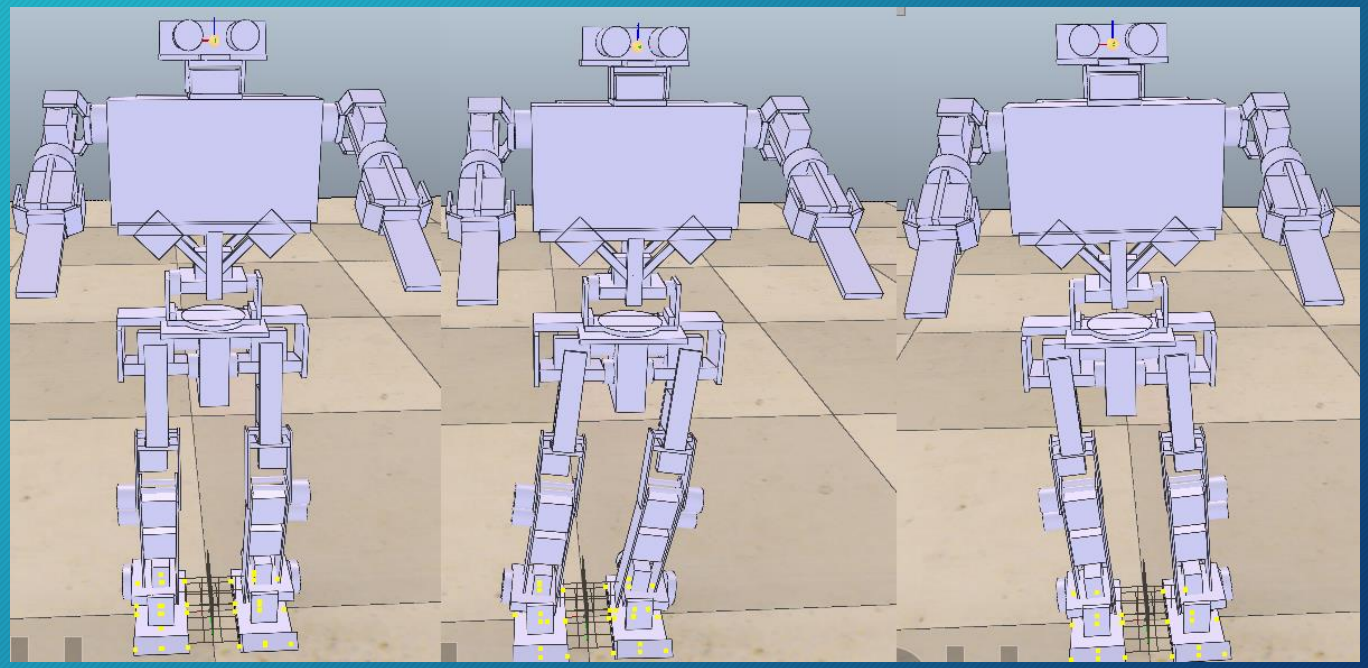
- Two Maneuvers
- 45/20min training
- 15/10min reproduction



Experiments & Results

Maneuvers executed:





Experiments & Results

Torque UTI Without Haptic Guidance Results

- Knee flexion/extension maneuver

Subject	Max deviation (m)	Mean deviation (m)	Time (s)
A	0,0558	0,0162	70
B	0,0678	0,0186	100
C	0,075	0,0235	120

- Hip leaning maneuver

Subject	Max deviation (m)	Mean deviation (m)	Time (s)
A	0,0359	0,0083	50
B	0,0593	0,0366	80
C	0,0358	0,0127	140

Experiments & Results

Torque UTI With Haptic Guidance Results

- Knee flexion/extension maneuver

Subject	Max deviation (m)	Mean deviation (m)	Time (s)
A	0,0558	0,0162	70
D	0,0544	0,0195	20

- Hip leaning maneuver

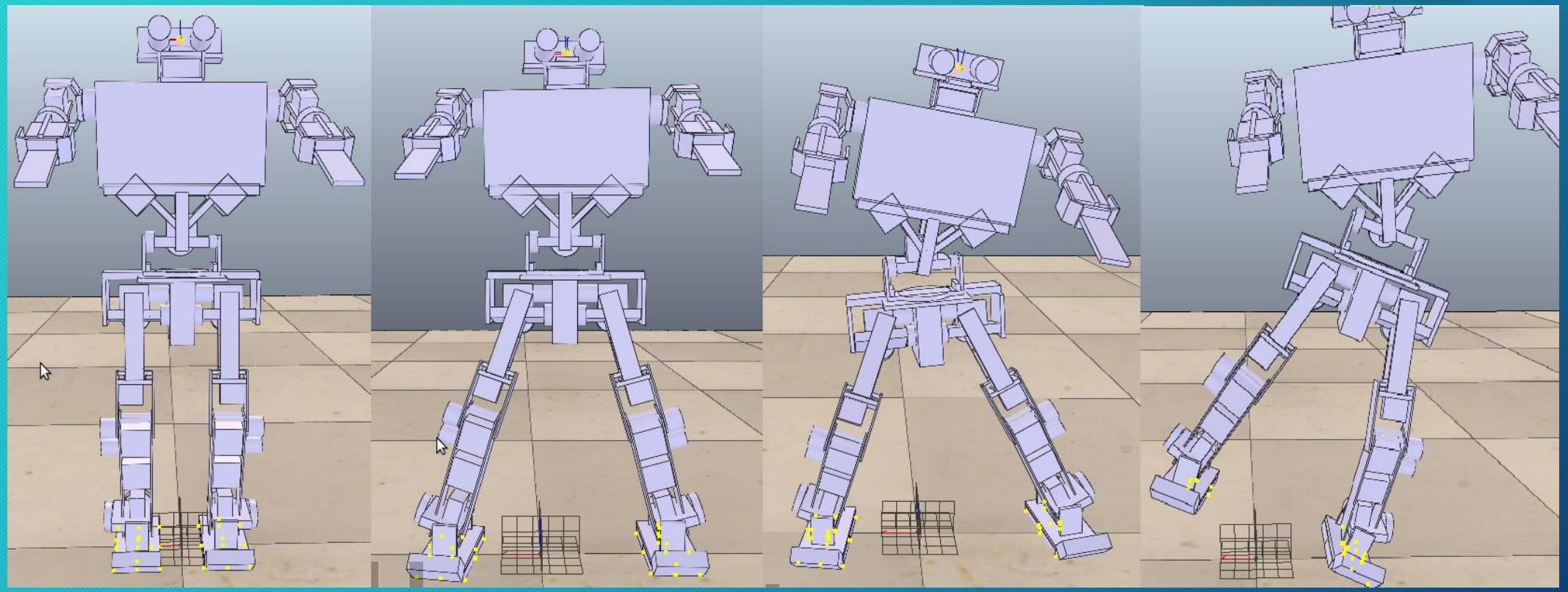
Subject	Max deviation (m)	Mean deviation (m)	Time (s)
A	0,0359	0,0083	50
D	0,0345	0,0063	30

Experiments & Results

One foot Balance Maneuver

- Steady balanced configuration?
- Foot lifting maneuvers

Experiments & Results



Conclusions

- Developed and built devoted workstation for both control configuration.
- Implementation of a training interface for each control configuration, which reduced the time required to gain affinity over the humanoid platform.
- Renewed approaches for the force feedback formulation, as well as implementation of auxiliary tools which provide support over the control of the model.
- Training plans and procedures projected for each interface.

Future Work

- Refinement over the IK element implemented on the upper body in the Assisted Torque configuration.
- Implementation of maneuvers in the haptic guidance mechanism throughout a outside source, *e.g.*, motion caption models.
- Implementation of the intuitive force feedback in medicinal mechanism, *e.g.*, exoskeletons or rehabilitation projects.

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