PREDICTING OBJECT DYNAMICS FROM IMAGE SEQUENCES: A PRECURSOR TO AUTONOMOUS OBJECT MANIPULATION

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B. Tech. EEE

Host Institute:
University of Lincoln, UK

UNIVERSITY OF
LINCOLN

Name of the Mentor: Harit Pandya

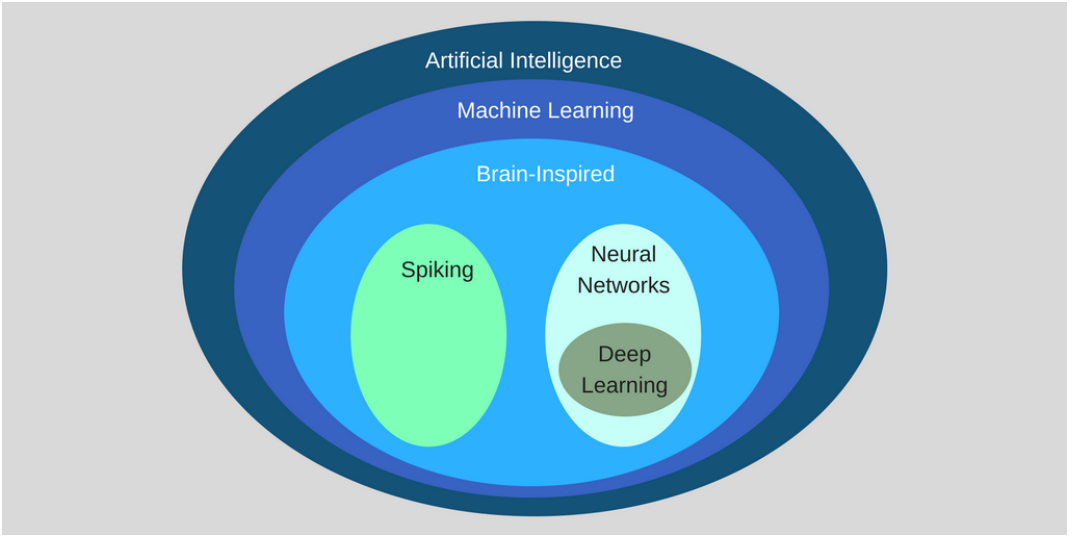
Designation of Mentor: Research Fellow

Name of the Lab: Lincoln center for autonomous systems

Duration of stay: 5 months

INTRODUCTION

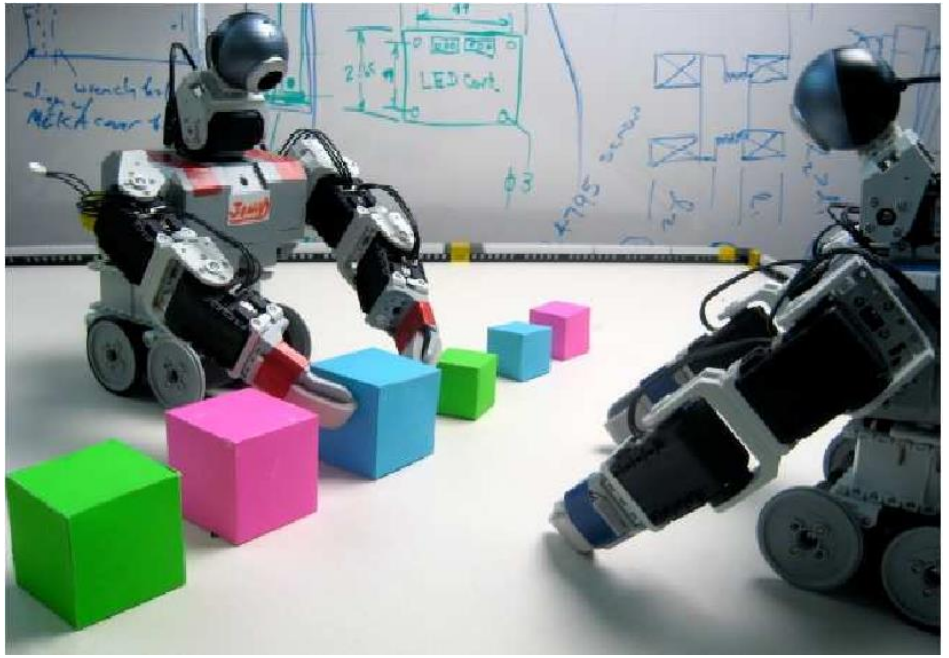
- Robotics
- Robotic manipulation
- Intelligent Robot manipulation
- Artificial Intelligence
- Machine learning
- Neural Networks



References: www.google.com

MOTIVATION

- Robot Interaction with the environment
- Robots – Factories, Workshops, Nuclear environment
- Ability to predict the possible state of the object and interact with it



References: www.google.com

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AUTONOMOUS OBJECT MANIPULATION

Reference: Andy Zeng Visual pushing and grasping using reinforcement learning

OBJECTIVE

- To understand the interaction of a Robotic arm with its environment by understanding the underlying physics of simulation environment
- To manipulate the Robotic arm to build and break a tower of blocks by grasping and pushing the boxes
- To record images containing the pose and orientation of the boxes during the process of building and breaking of tower
- To train and test a Recurrent neural network to predict the future possible state of the blocks using the images recorded

References: www.google.com

PREREQUISITES

- Understanding of concepts in Robotics
- Understanding of Recurrent neural networks and training
- Understanding of ROS,GAZEBO,VREP concepts
- Basic knowledge of Python programming, Image processing

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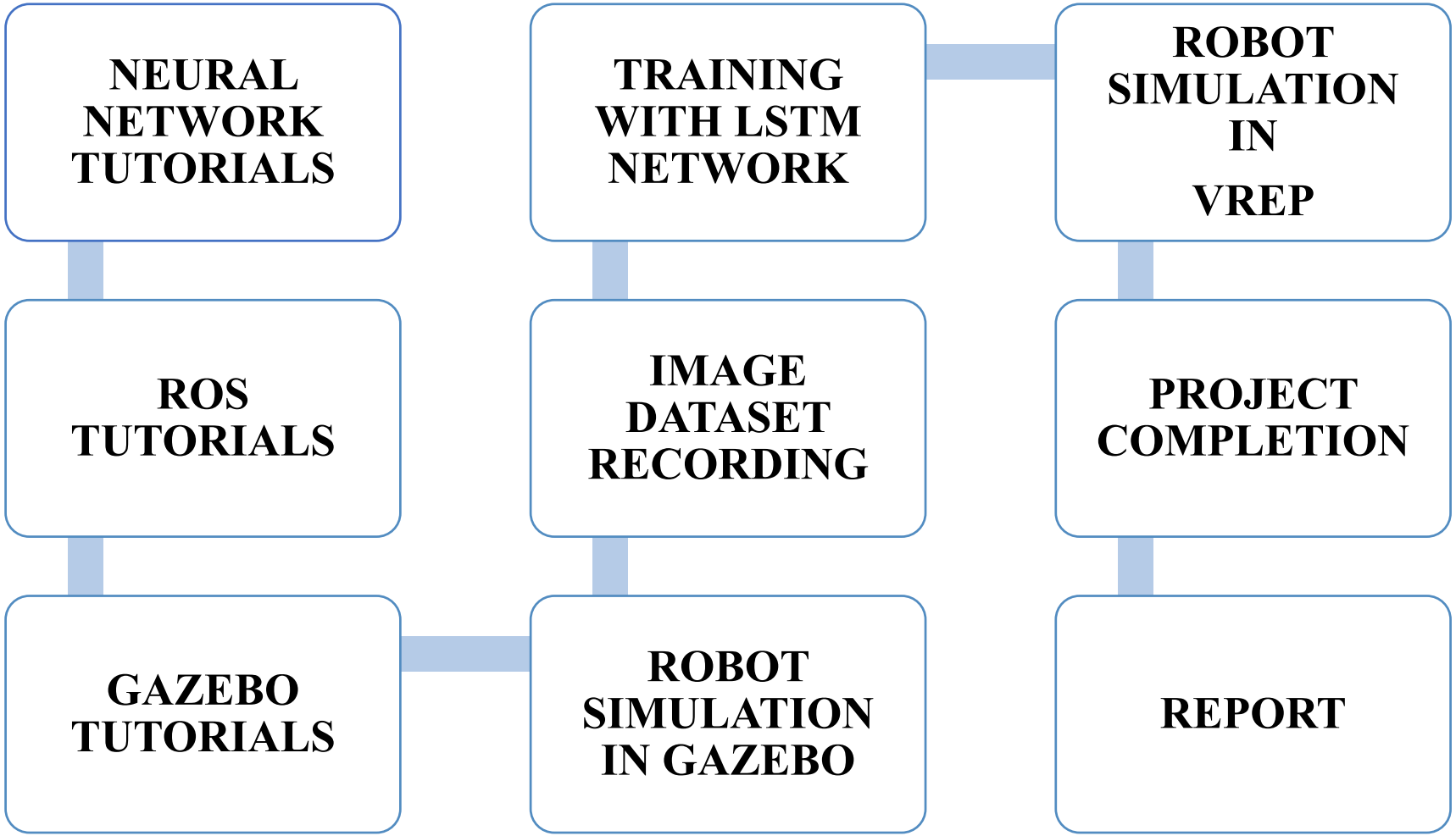
PROJECT FLOW



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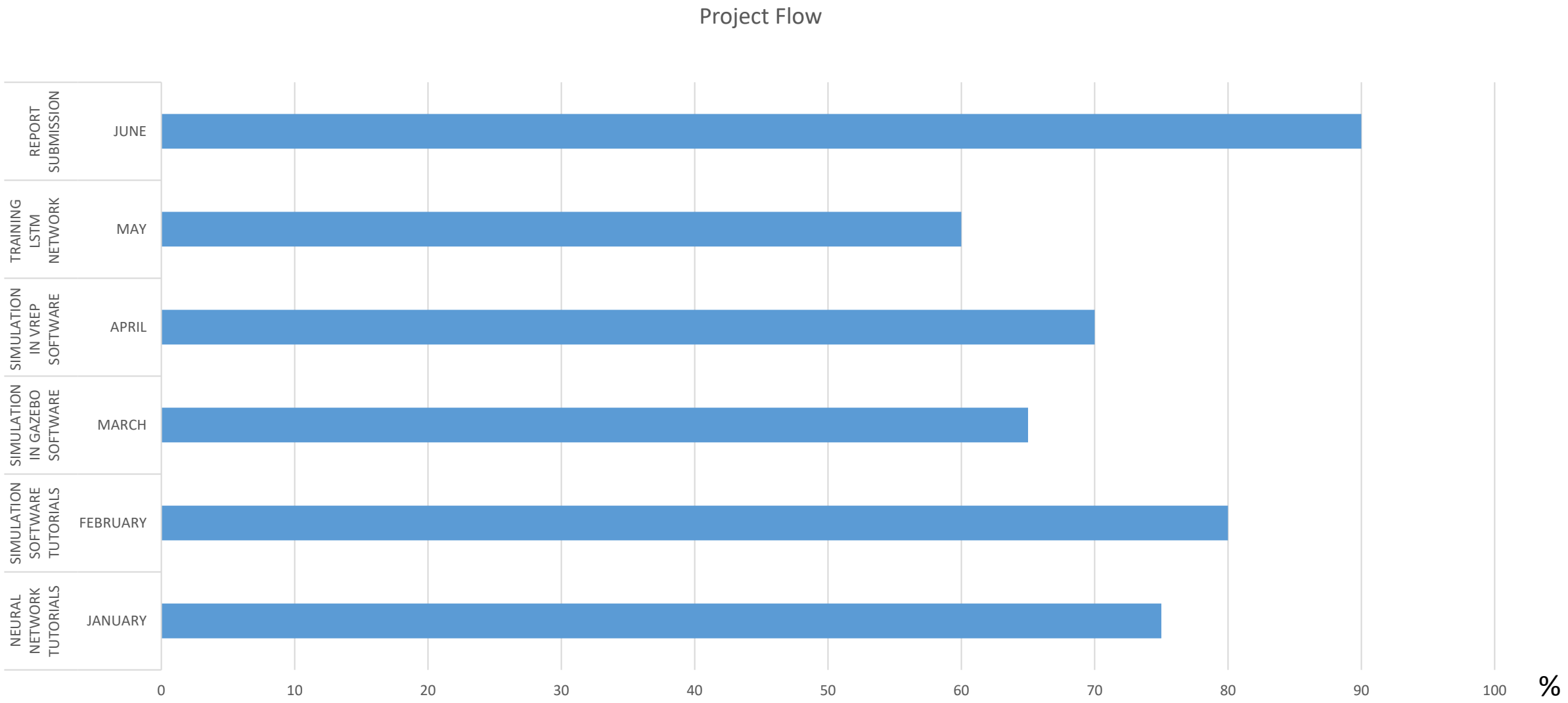
PROJECT FLOW



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METHODOLOGY

SIMULATION

- ROS, Gazebo, Vrep Simulation installation and setup
- Importing Franka Emika Panda robot
- Setting up the joints, links, initial parameters, controllers, dynamic properties
- Programming the push and grasp actions of the robot by controlling the panda gripper

PREDICTION

- Recording images containing pose and orientation of boxes
- Training with LSTM Neural network
- Calculating prediction accuracy using Image segmentation and annotating image labels

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FRANKA EMIKA PANDA ROBOT

Reference: https://www.franka.de/

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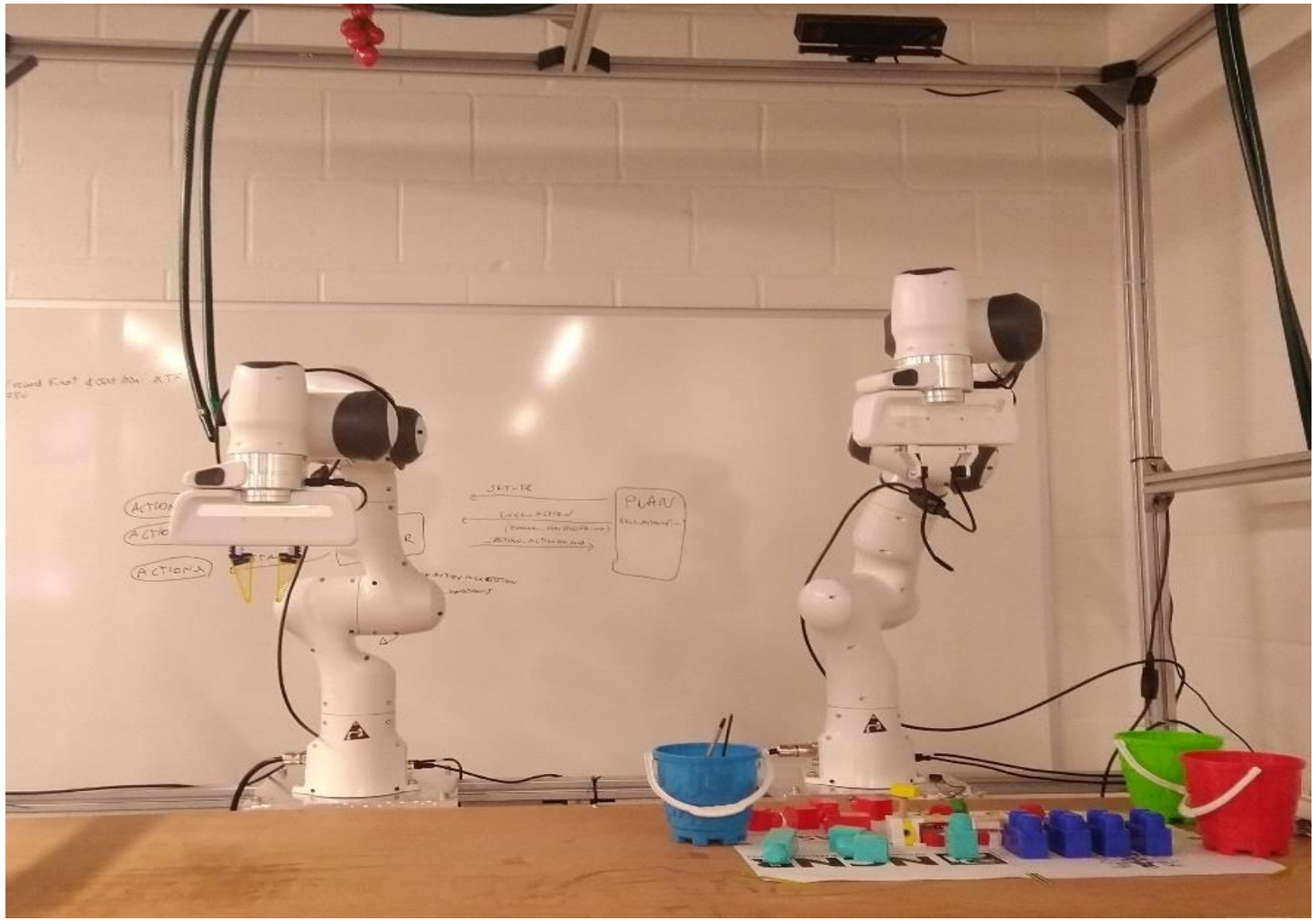
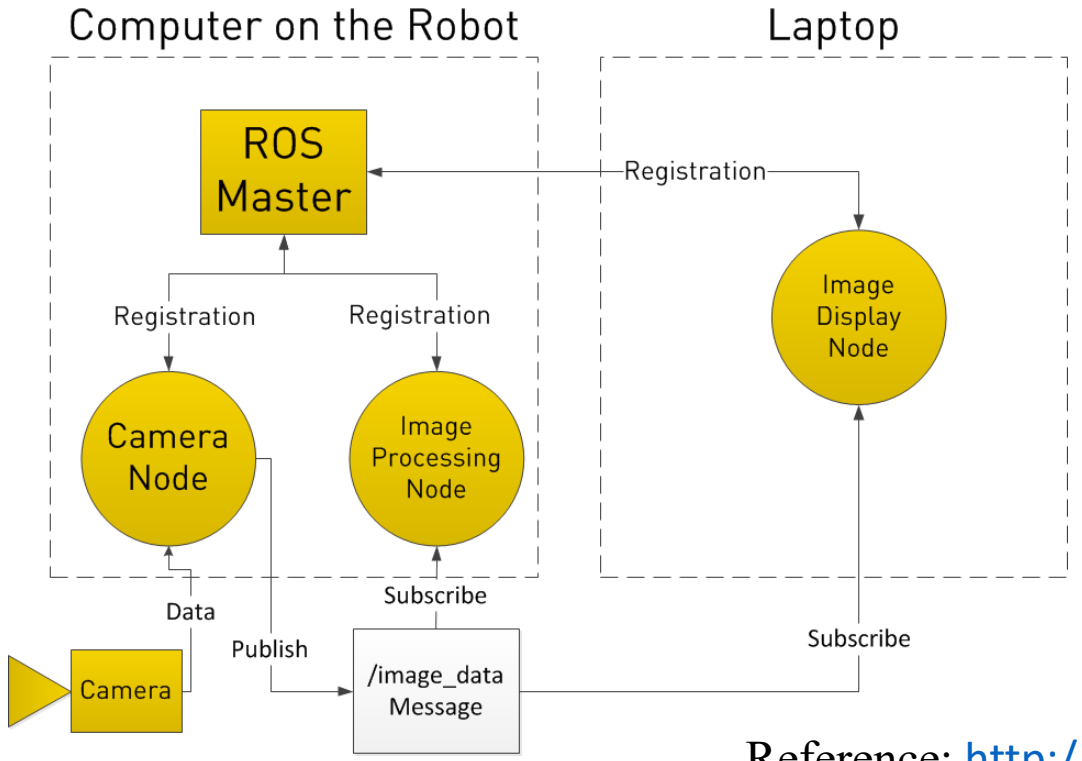
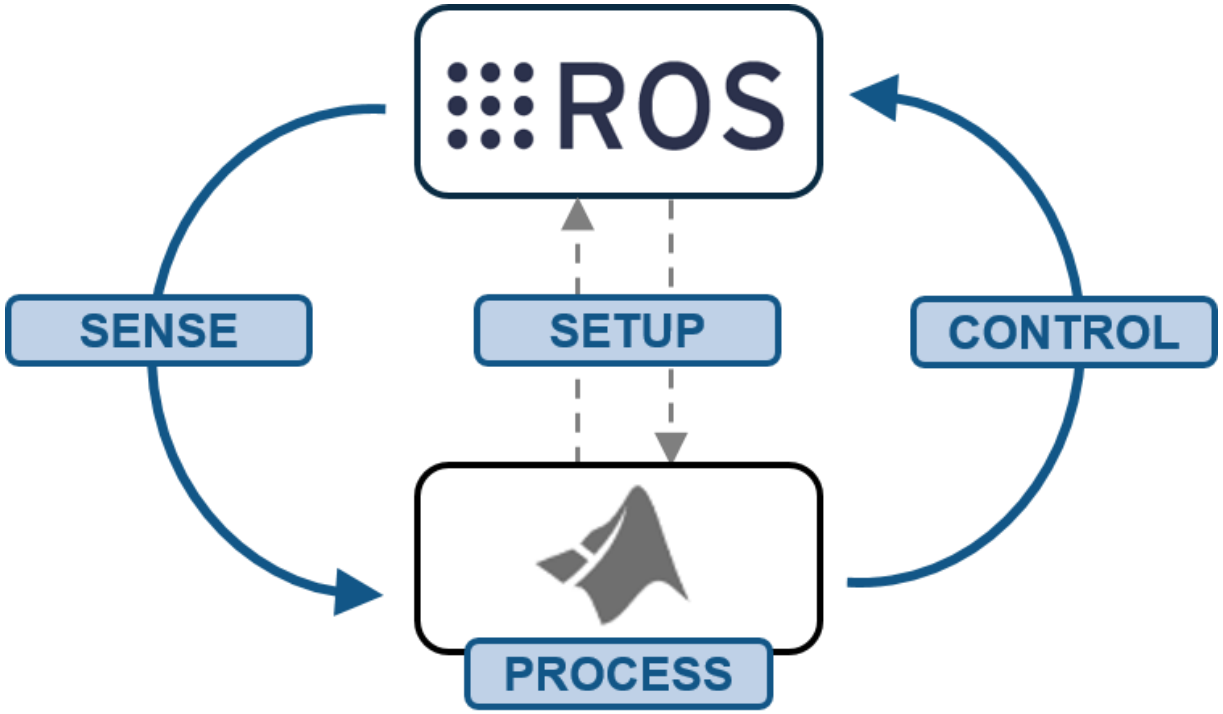
FRANKA PANDA SETUP



ROBOT OPERATING SYSTEM





Reference: http://wiki.ros.org/

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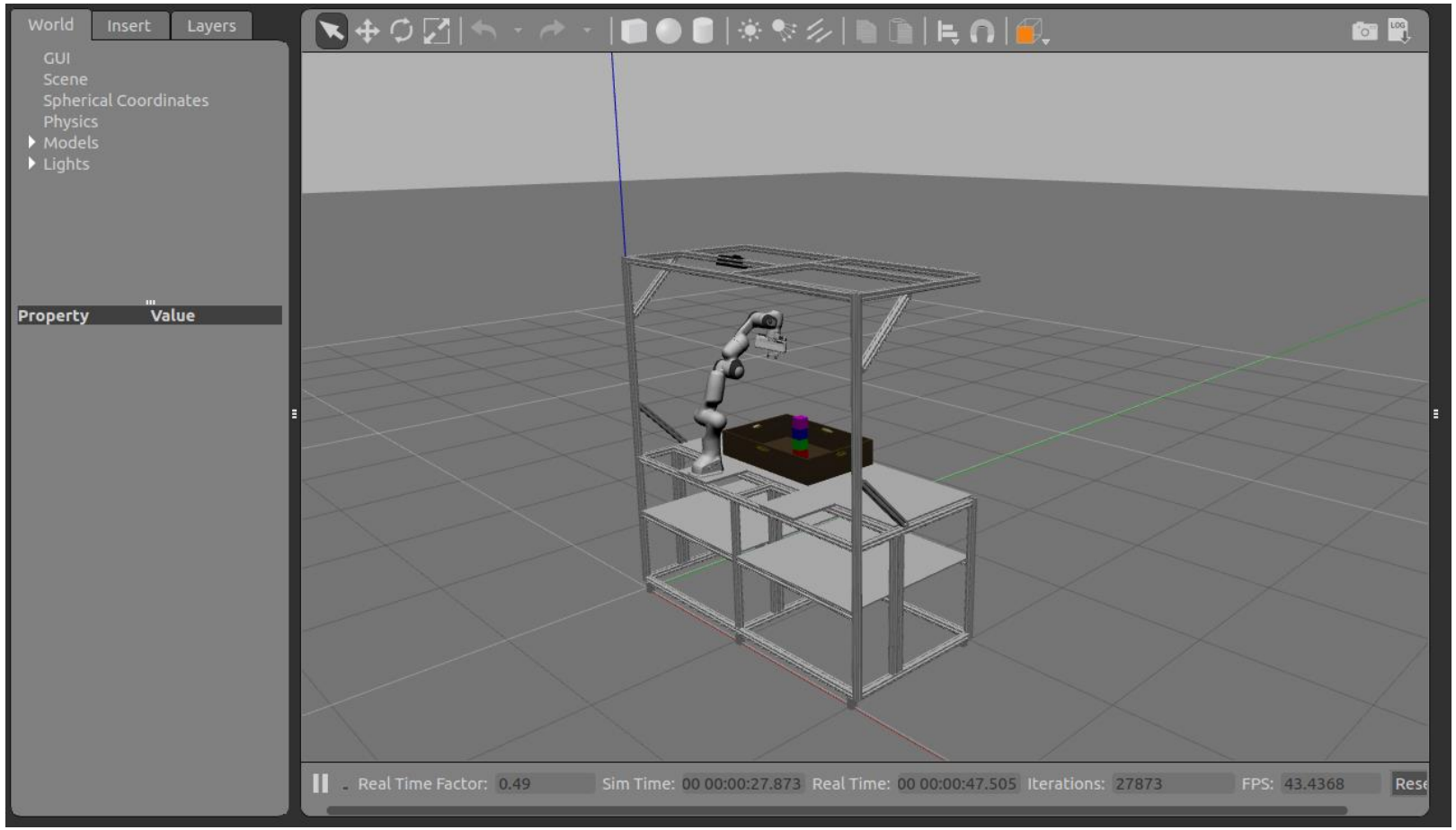
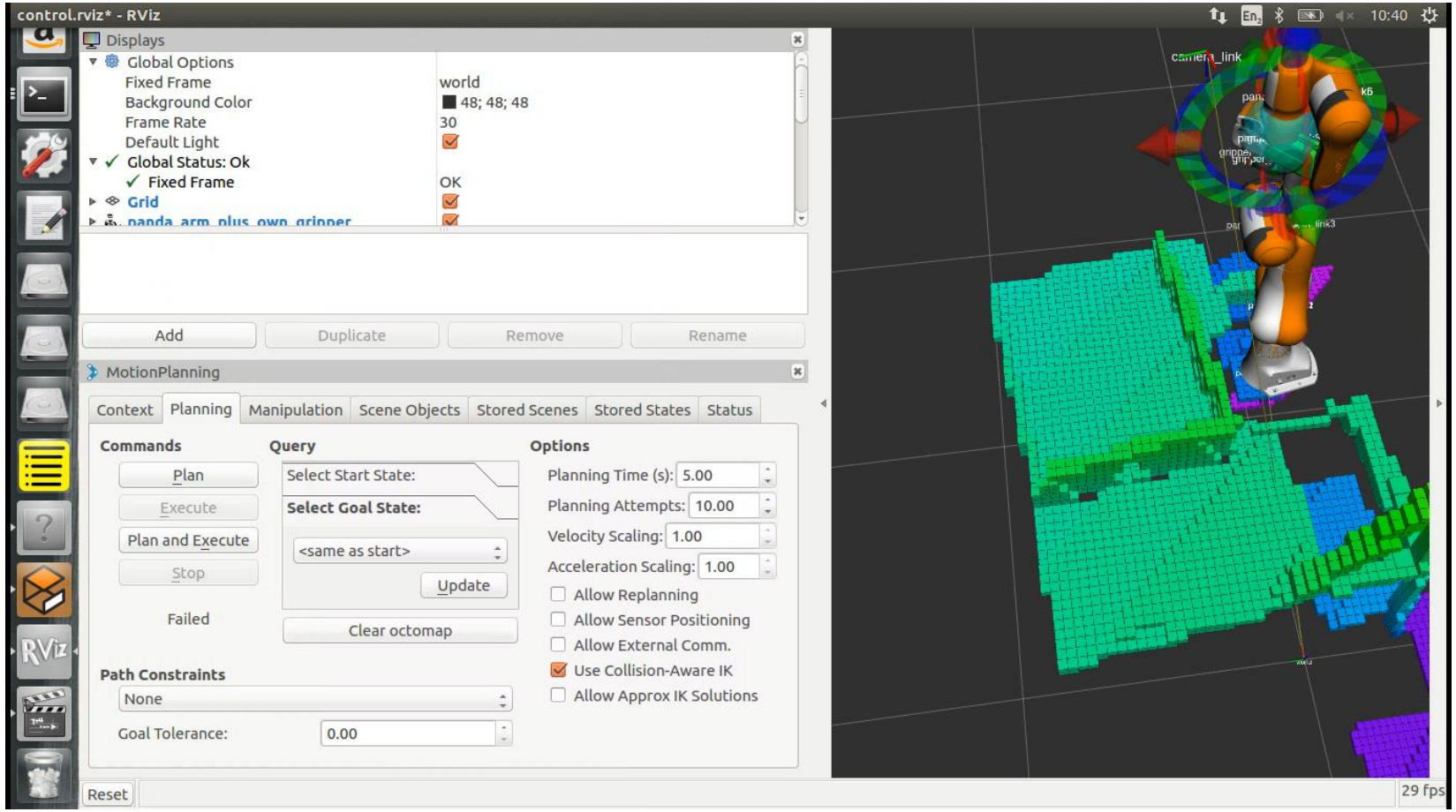
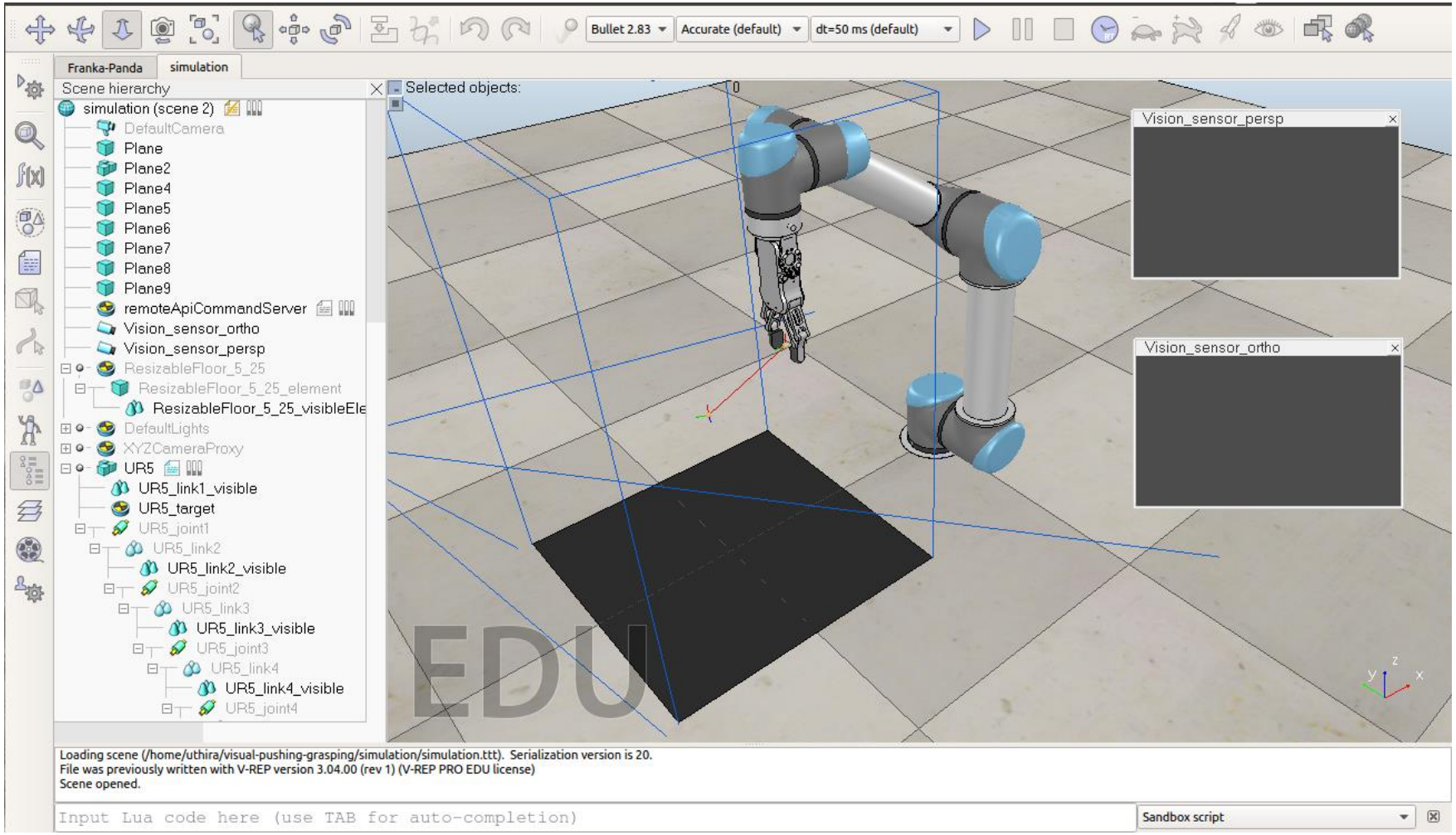
FRANKA PANDA IN GAZEBO



GAZEBO and RVIZ



UR5 IN VREP


Bullet 2.83
Accurate (default)
dt=50 ms (default)
Franka-Panda
simulation
Scene hierarchy
simulation (scene 2)
DefaultCamera
Plane
Plane2
Plane4
Plane5
Plane6
Plane7
Plane8
Plane9
remoteApiCommandServer
Vision_sensor_ortho
Vision_sensor_persp
ResizableFloor_5_25
ResizableFloor_5_25_element
ResizableFloor_5_25_visibleEle
DefaultLights
XYZCameraProxy
UR5
UR5_link1_visible
UR5_target
UR5_joint1
UR5_link2
UR5_link2_visible
UR5_joint2
UR5_link3
UR5_link3_visible
UR5_joint3
UR5_link4
UR5_link4_visible
UR5_joint4
Selected objects:
Vision_sensor_persp
Vision_sensor_ortho
EDU
Loading scene (/home/uthira/visual-pushing-grasping/simulation/simulation.ttt). Serialization version is 20.
File was previously written with V-REP version 3.04.00 (rev 1) (V-REP PRO EDU license)
Scene opened.
Input Lua code here (use TAB for auto-completion)
Sandbox script

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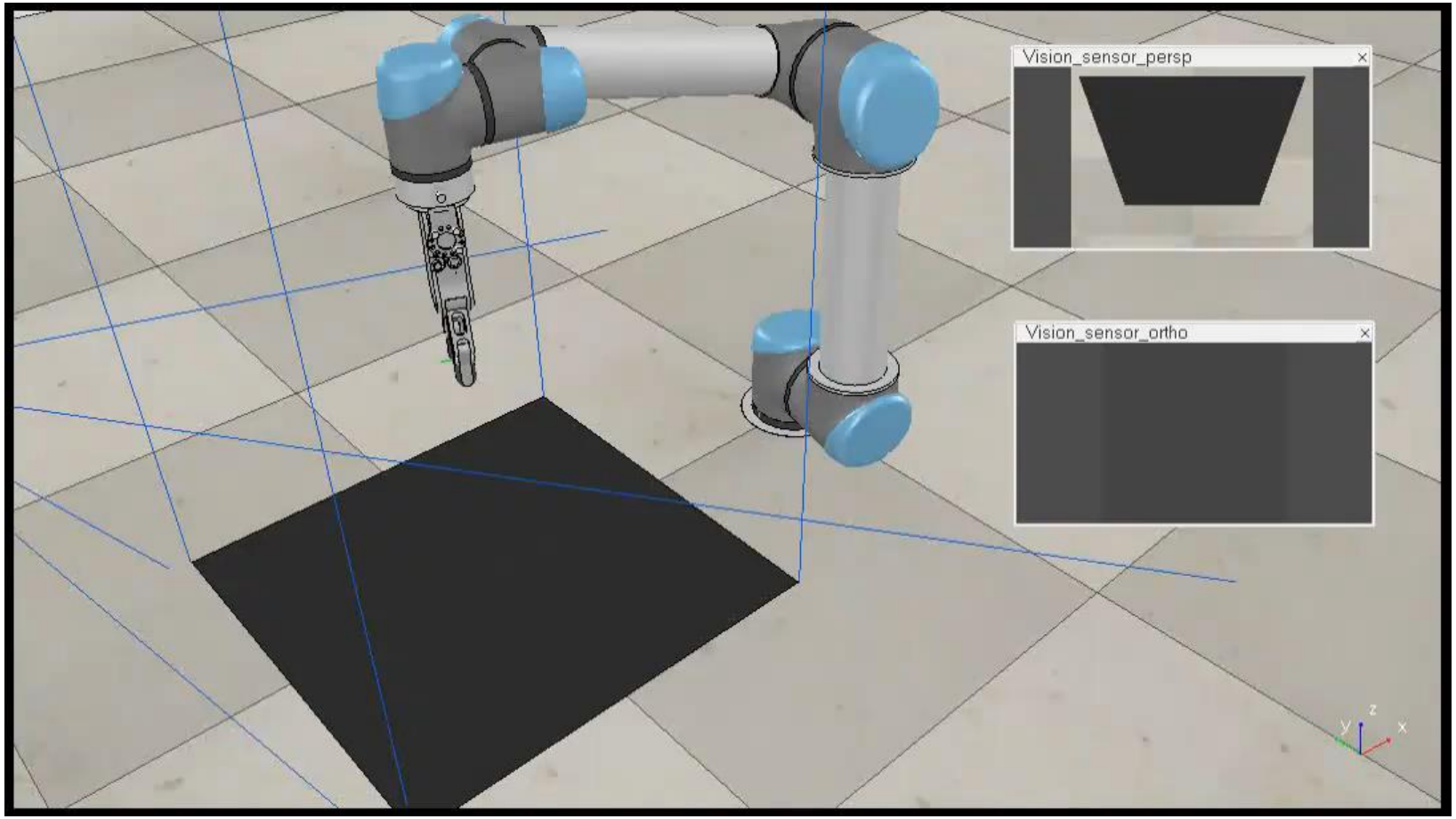
UR5 ROBOT BUILDING TOWER AND BREAKING



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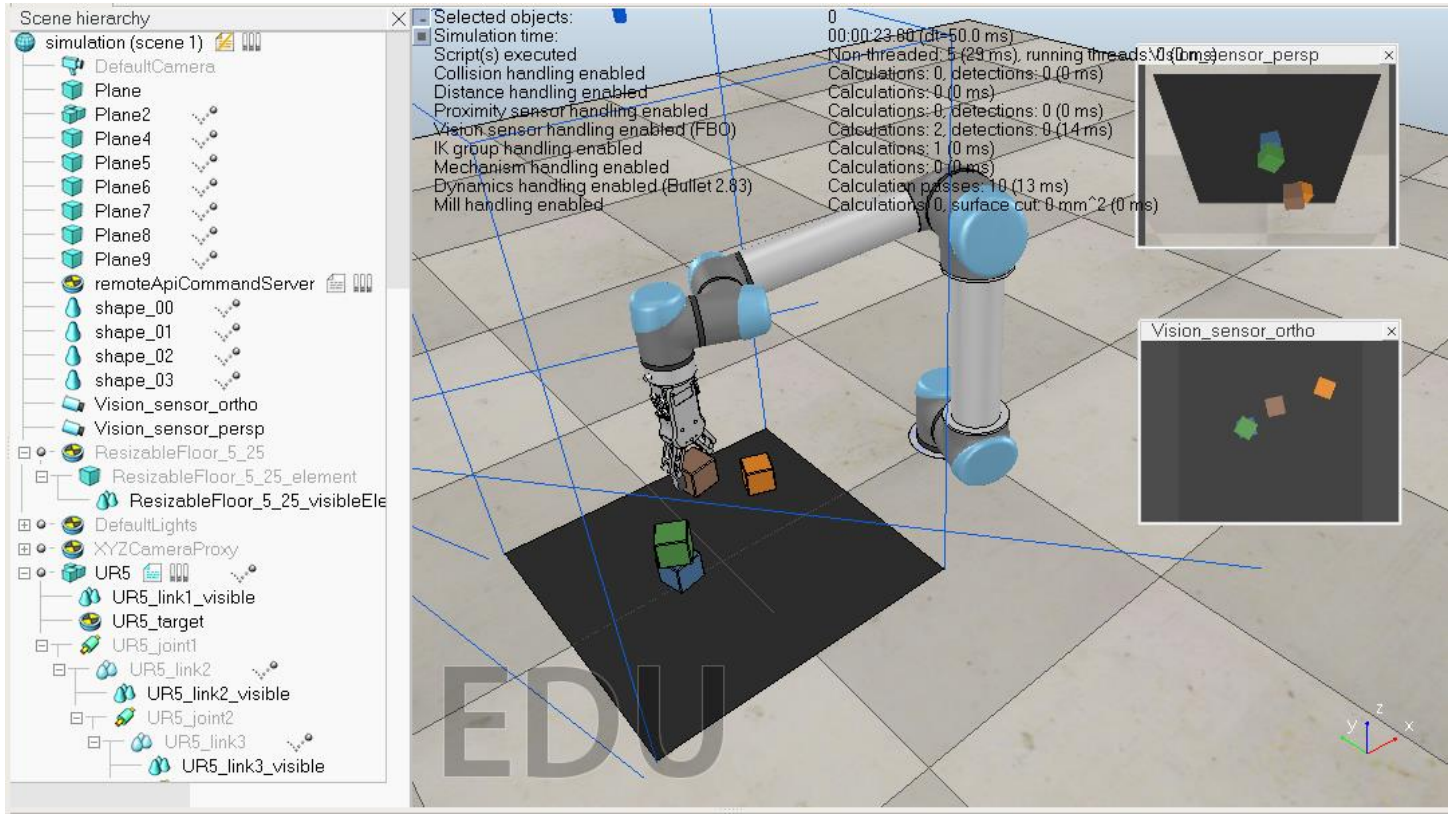
BUILDING AND BREAKING



GRASP FUNCTION

OPEN THE GRIPPER

MOVE THE GRIPPER TO THE POSITION OF THE BOX

CLOSE THE GRIPPER TILL BOX IS INSIDE THE GRIPPER

MOVE THE GRIPPER ABOVE THE POSITION

MOVE THE GRIPPER TO POSITION ON TOP OF BASE BOX

OPEN GRIPPER TO PLACE THE BOX

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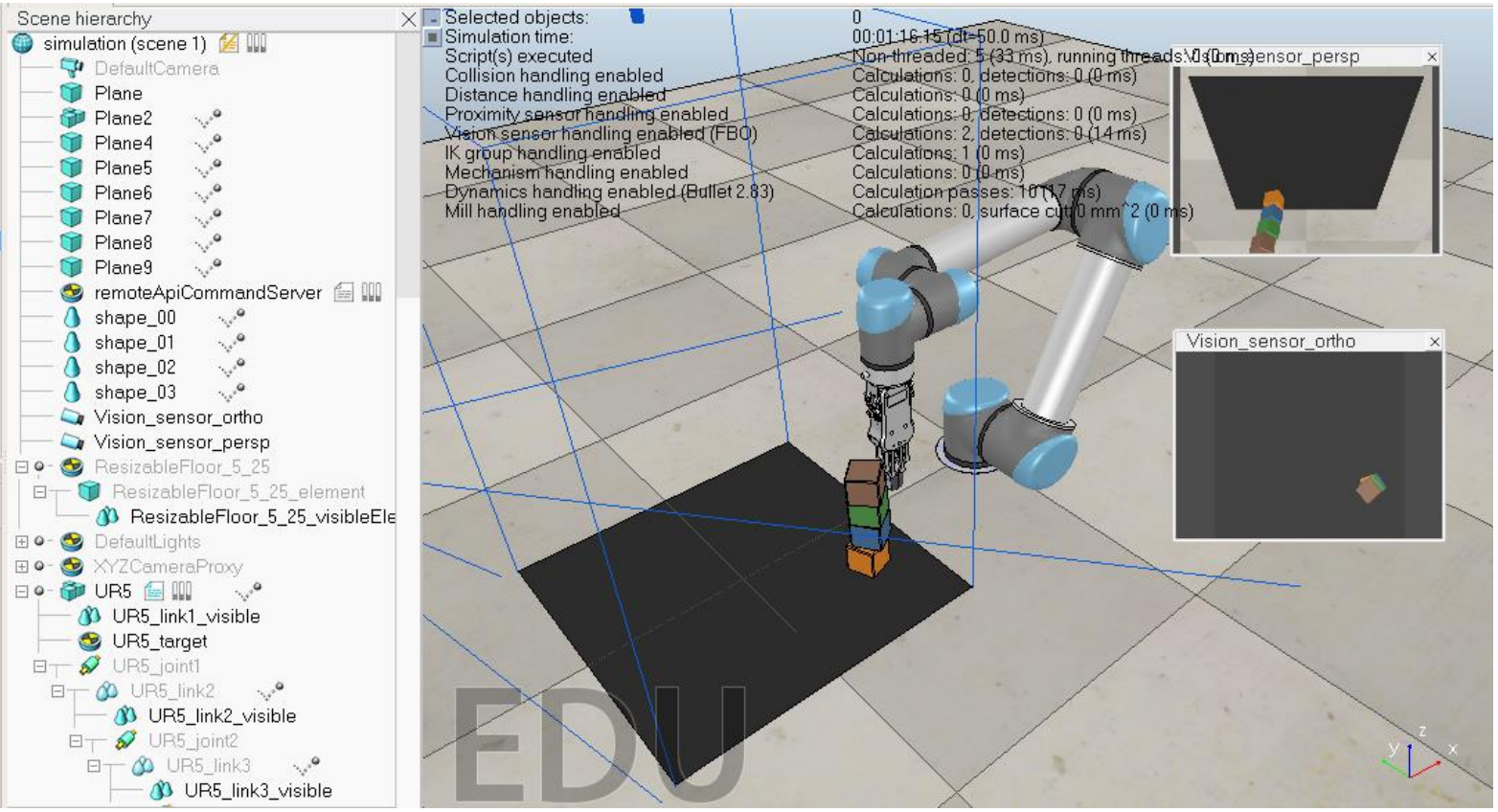
BUILDING AND BREAKING

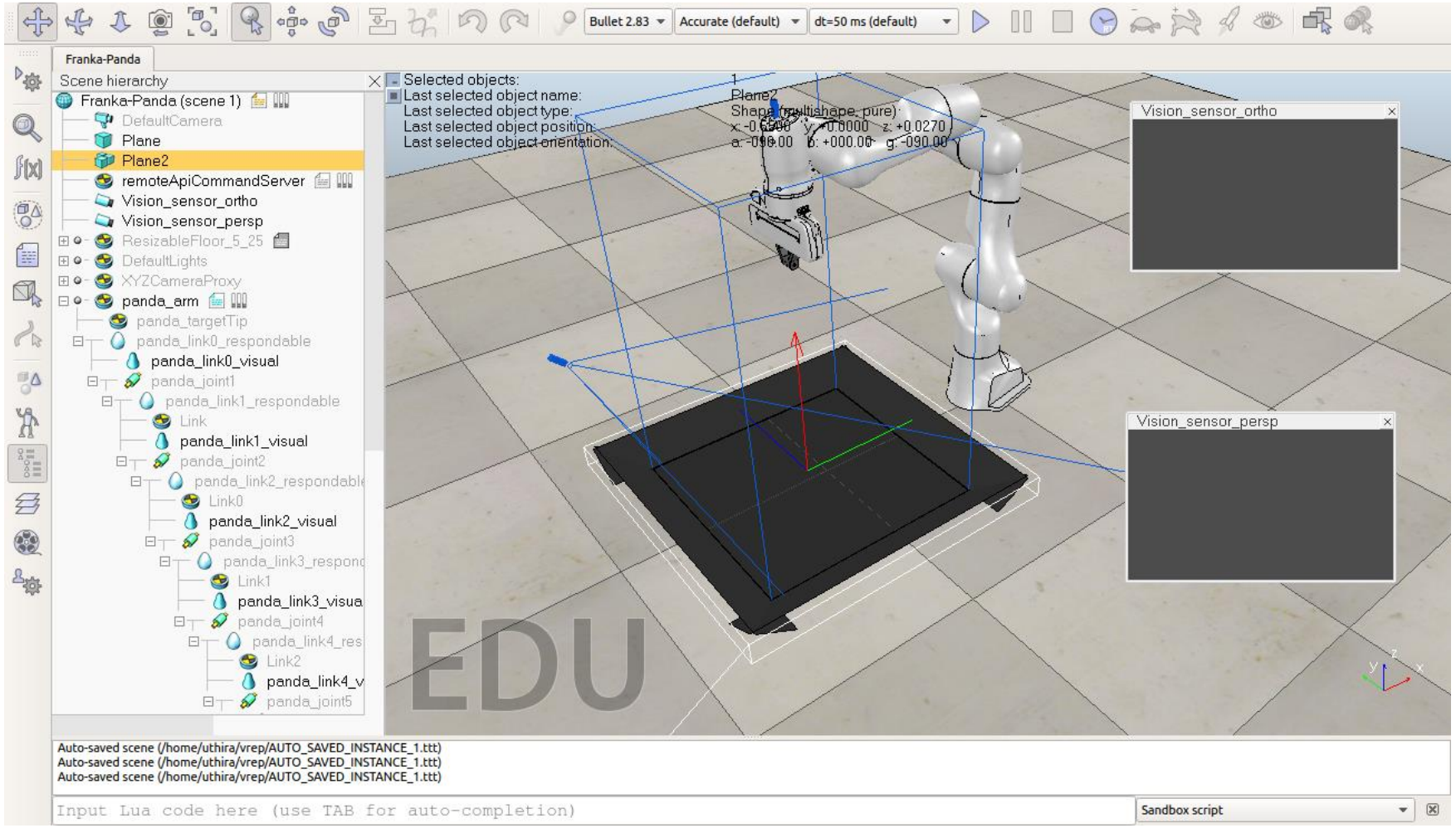


PUSH FUNCTION

MOVE THE GRIPPER NEAR TO THE TOWER

MOVE THE GRIPPER TOWARDS THE DIRECTION OF THE TOWER

FRANKA PANDA IN VREP



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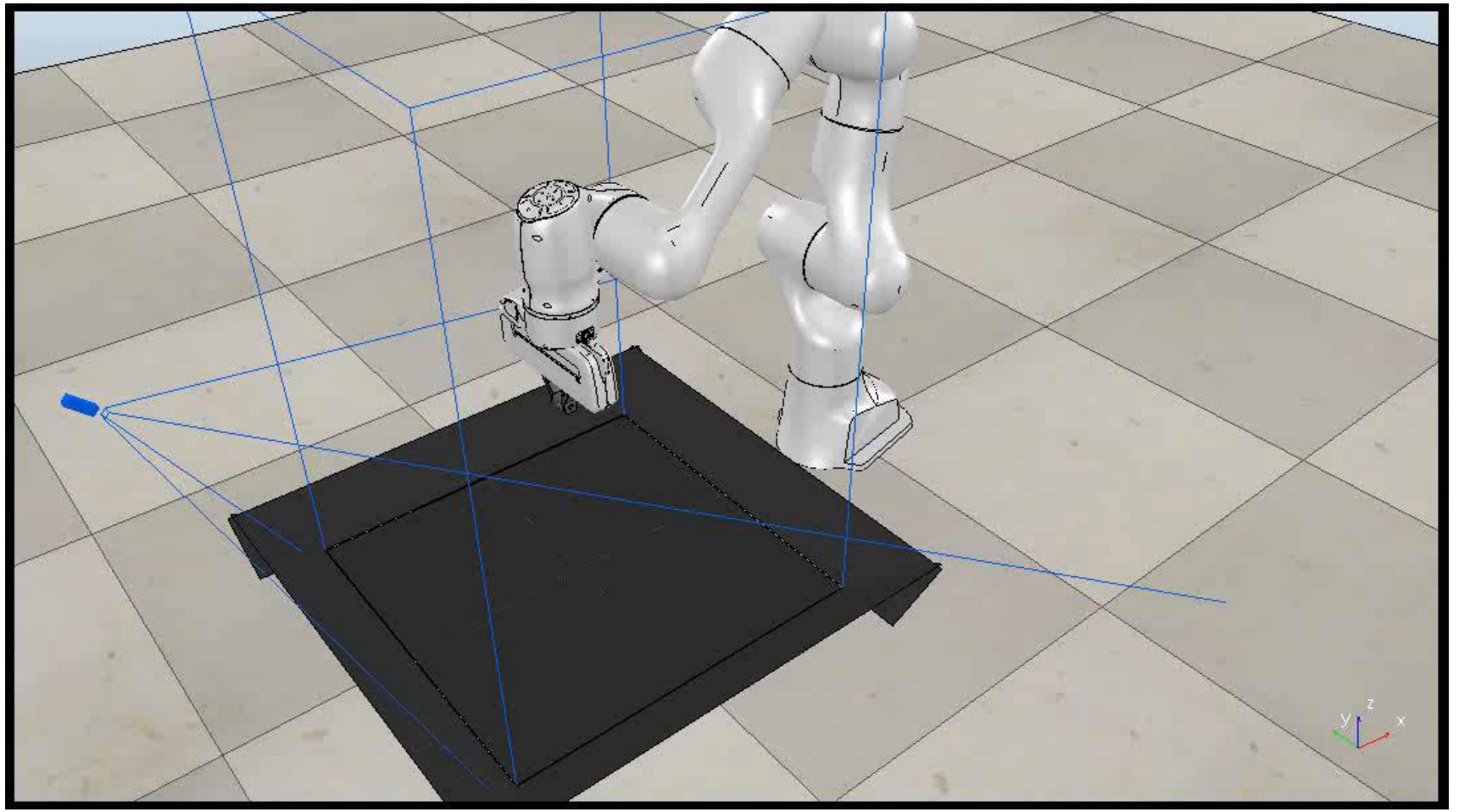
FRANKA PUSHING IN VREP



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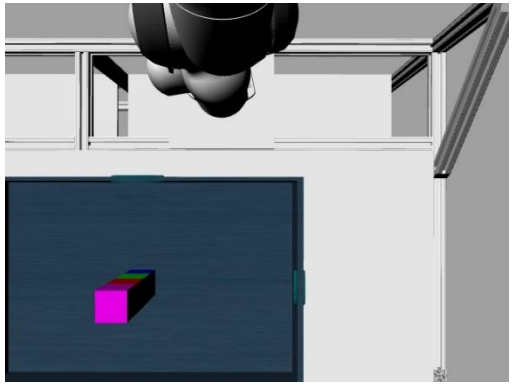
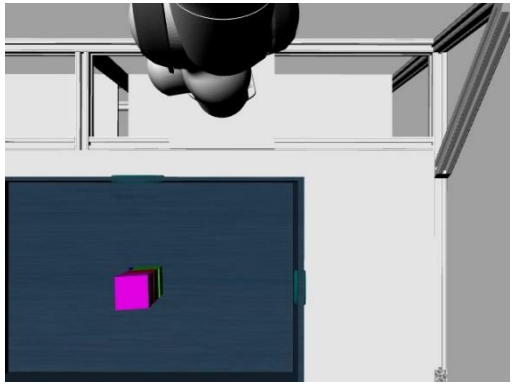
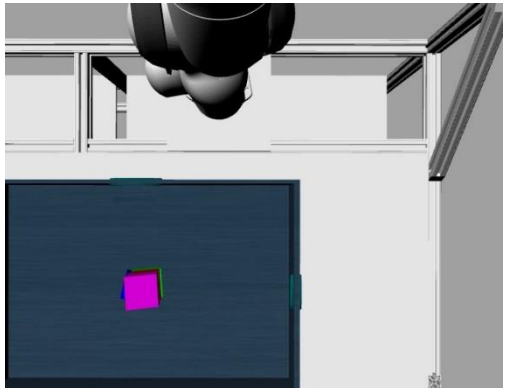
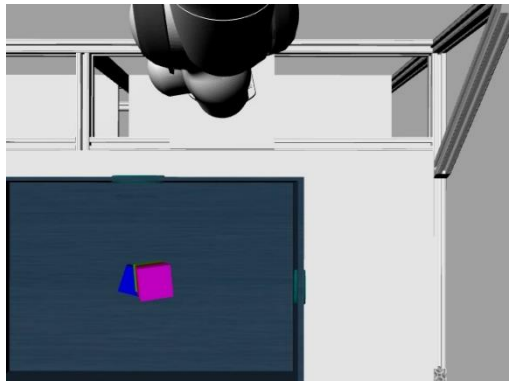
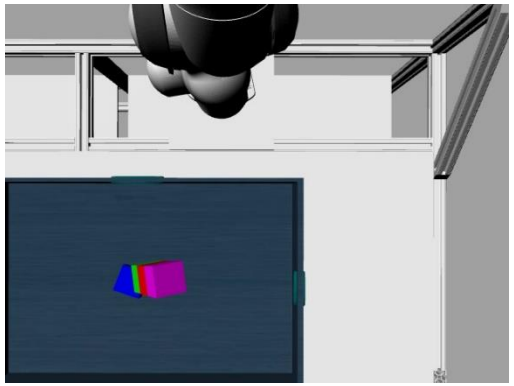
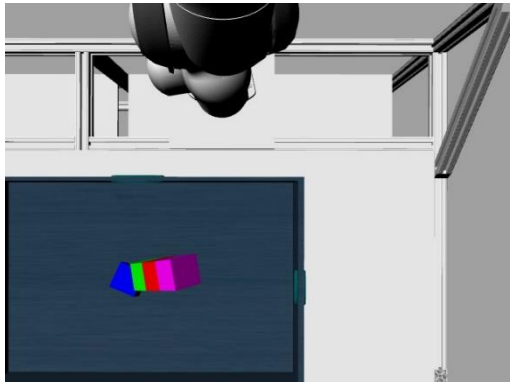
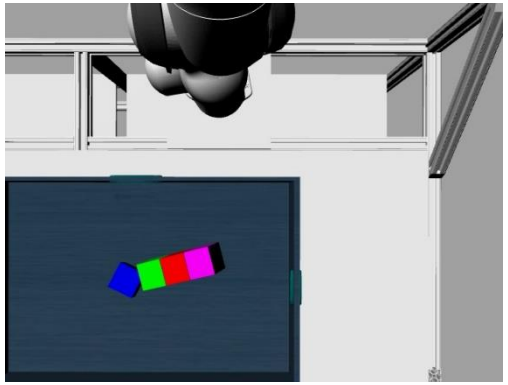
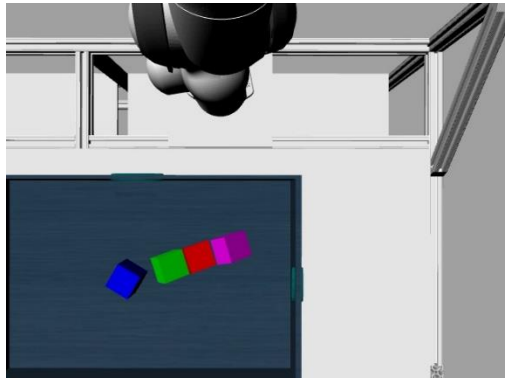
DATASET

SEQUENCE PREDICTION WITH NEURAL NETWORK

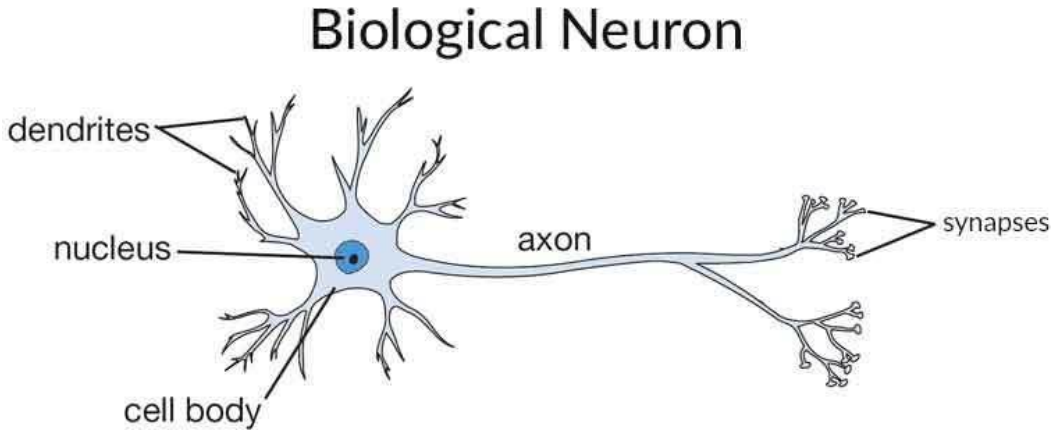


Fig. 1

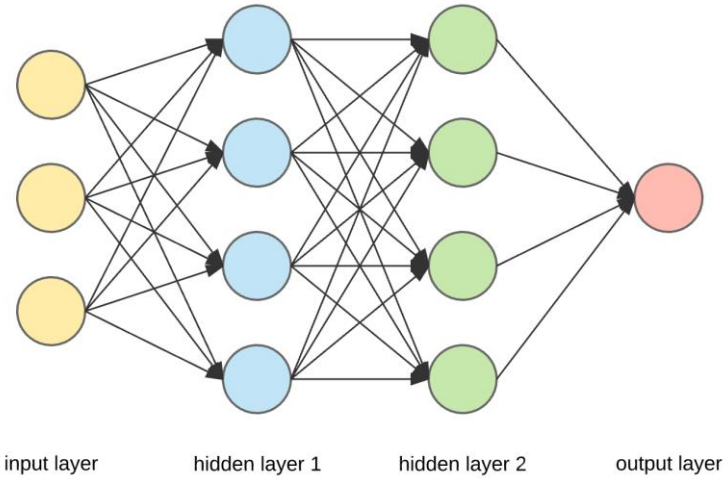


Fig. 2

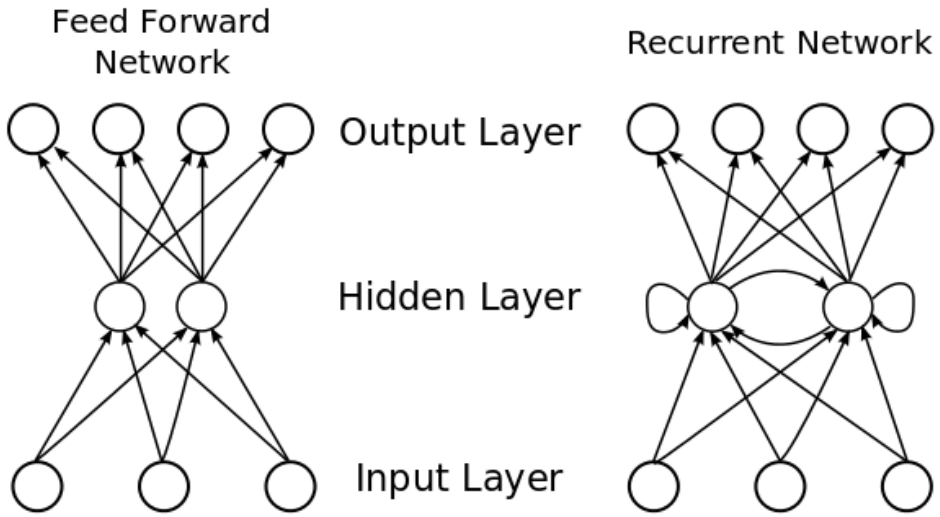
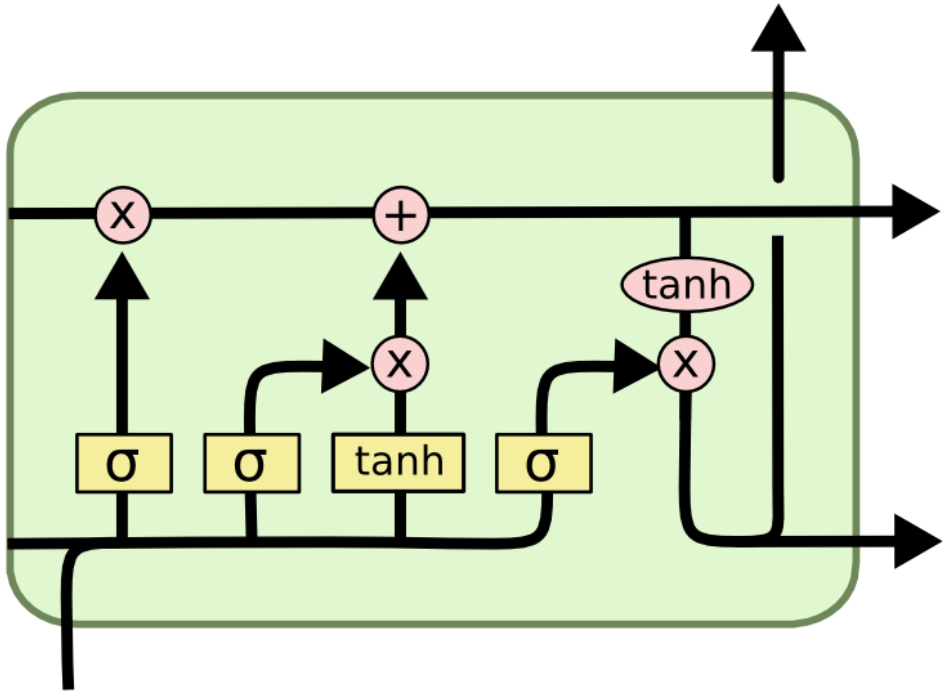


Fig. 3

References: Fig 1,2 http://cs231n.github.io/
Fig 3 www.researchgate.net

LSTM



LSTM

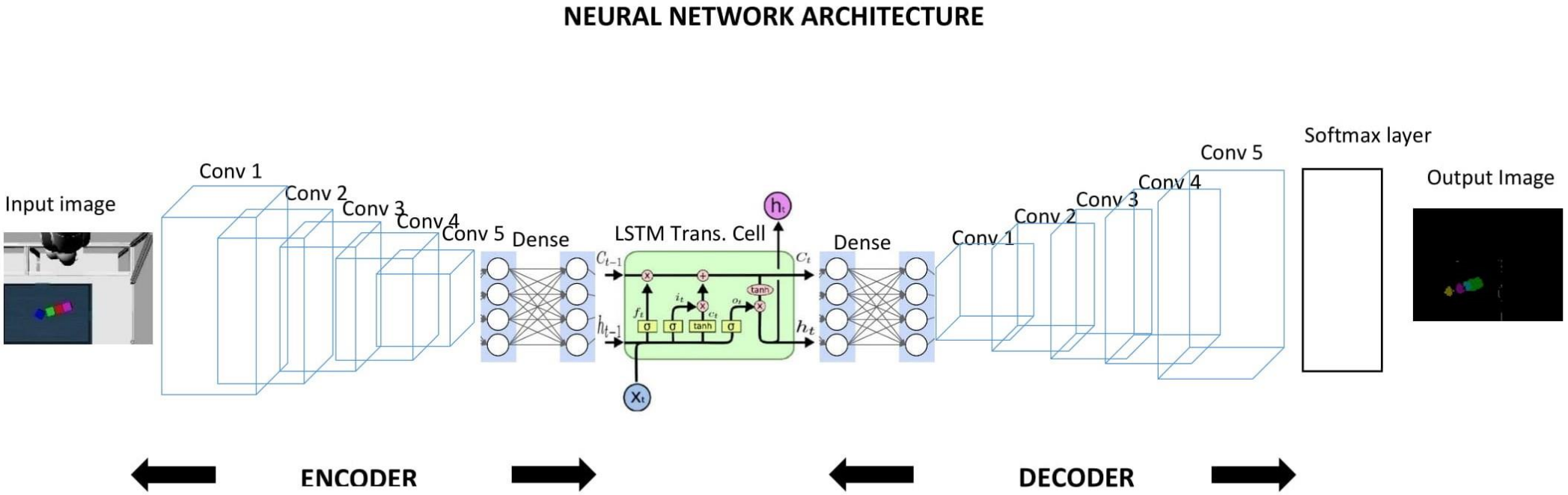
$$\begin{pmatrix} i \\ f \\ o \\ g \end{pmatrix} = \begin{pmatrix} \sigma \\ \sigma \\ \sigma \\ \tanh \end{pmatrix} W \begin{pmatrix} h_{t-1} \\ x_t \end{pmatrix}$$

$$c_t = f \odot c_{t-1} + i \odot g$$

$$h_t = o \odot \tanh(c_t)$$

Reference: colah.github.io

NEURAL NETWORK ARCHITECTURE



Reference: LSTM cell - colah.github.io

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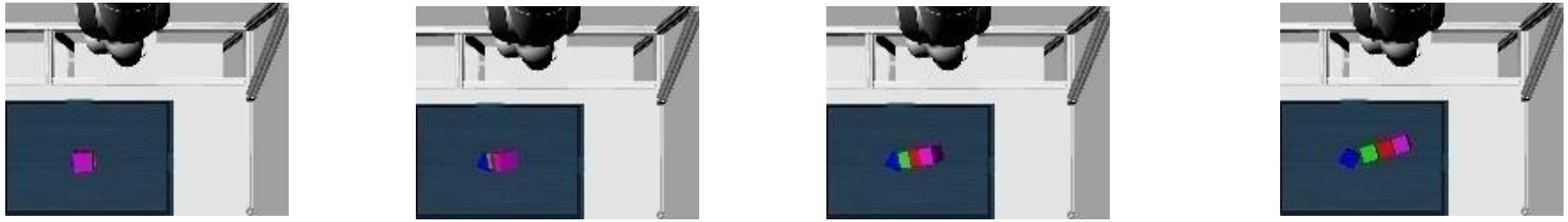
PREDICTION RESULTS

OBSERVATIONS



LABELS

PREDICTIONS

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SUMMARY

CS231n convolutional neural network lectures	☑
ROS, Gazebo, Vrep tutorials	☑
Simulating Franka robot work cell assembly in Gazebo	☑
Building and breaking a tower of blocks in Gazebo	☑
Simulating UR5 robot in Vrep	☑
Building and breaking a tower of blocks with UR5	☑
Simulating Franka robot work cell assembly in Vrep	☒
Building and breaking a tower of blocks with Franka	☒
Recording image dataset as the tower of blocks are being broken	☑
Train and test the dataset using LSTM based neural network architecture	☑
Train and test the dataset using advanced version of LSTM based neural network architecture	☒
Combine simulation and prediction to achieve self learning of Franka robot in simulation	☒
Implement self learning of Franka robot in real time	☒

FUTURE SCOPE

- Predicting the sequences using advanced versions of Long short term memory network
- Learning Push, Grasp actions using Reinforcement learning algorithms
- Implementing building and breaking of tower in real time

Workplace at the Host Institute/Lab

THANK YOU !