ROBOT ACTION ANTICIPATION FOR COLLABORATIVE ASSEMBLY TASKS

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Dissertation Proposal - MRSI

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PROBLEM INTRODUCTION

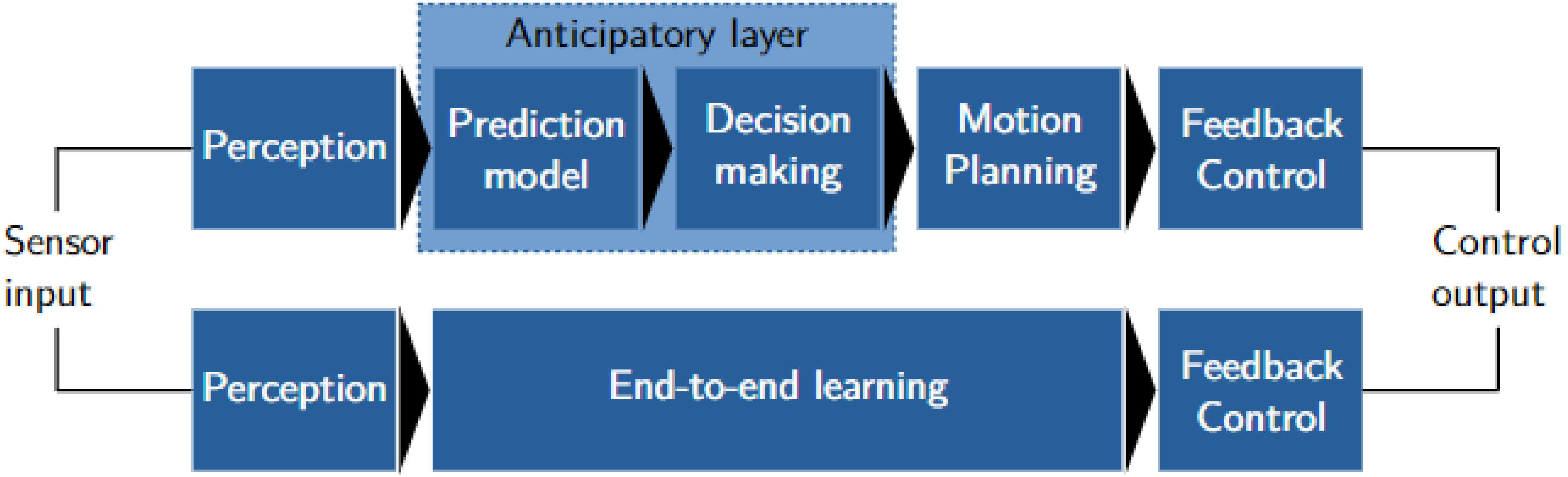
INTRODUCTION

The concept of Human-Robot Collaboration (HRC) involves the research of mechanisms that allow humans and robots to work together to achieve a shared goal.

However, to achieve true collaboration, it is not enough to react to the partner's movements and intentions, the robot must anticipate them.

WHAT IS ANTICIPATION?

- Anticipation is viewed as the impact of predictions on the current behavior of a system, be it natural or artificial;
- Anticipatory robots make decisions based on current states and predicted future states using predictive models of the environment.

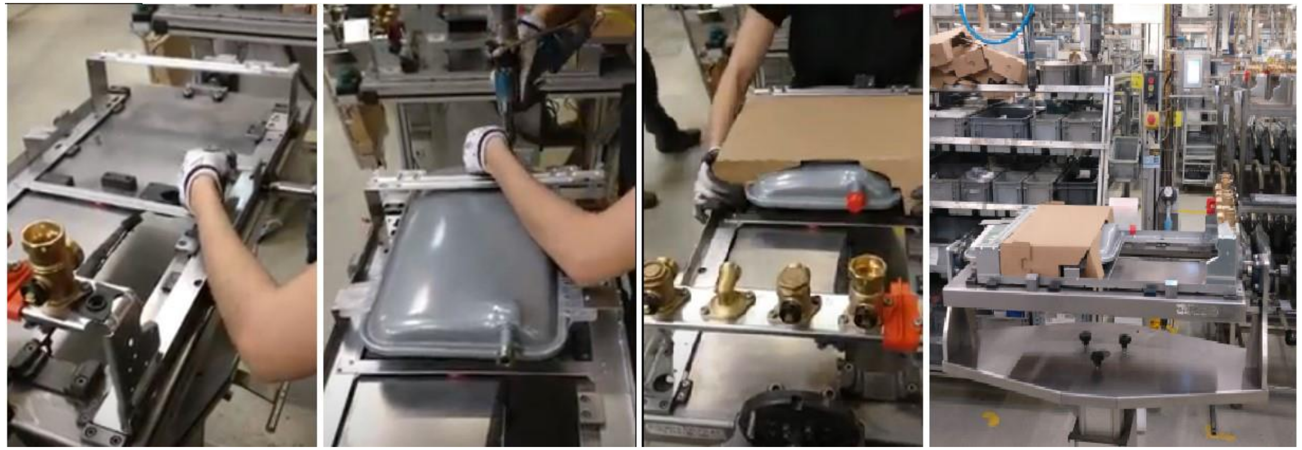


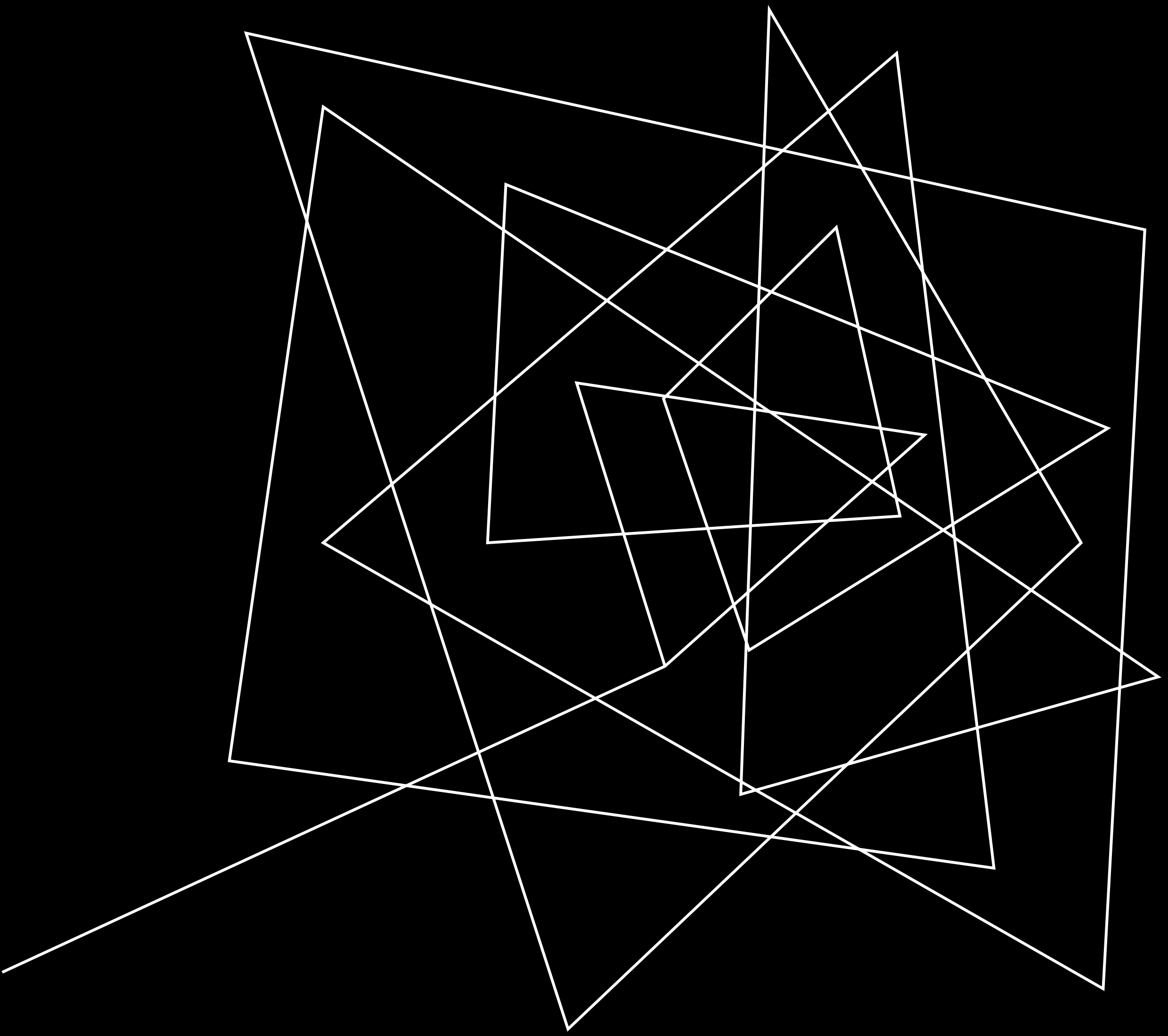
PROBLEM DEFINITION

This dissertation aims at the development of an anticipatory system that allows to enhance human-robot collaboration in industrial settings under the AUGMANITY mobilizing project.

Use case: The collaborative robot's main function will be to assist with the assembly task by placing the parts of gas boiler for water heating in the jig while coordinating its actions with those of the human operator.

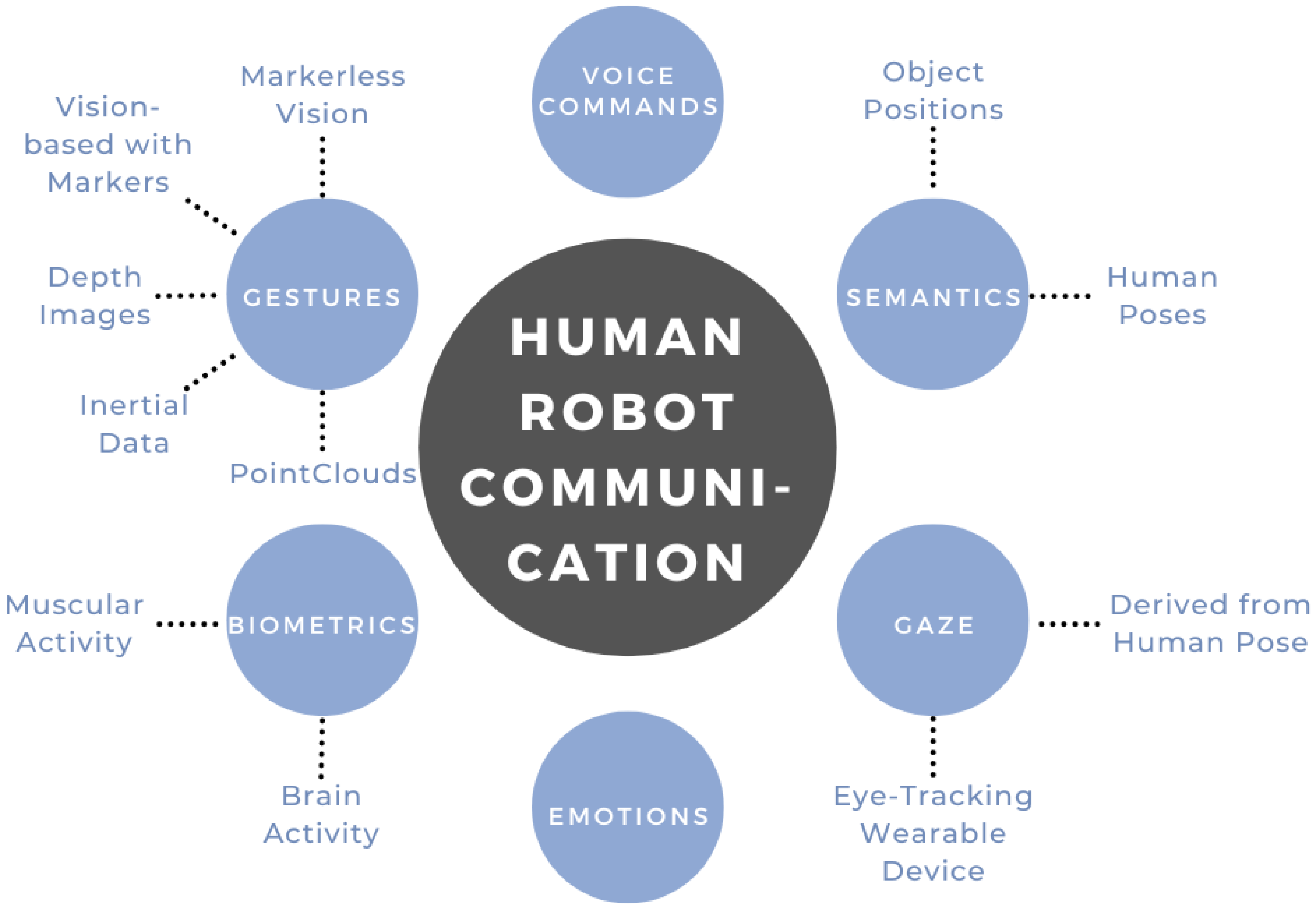
AUGMANITY
AUGMENTED HUMANITY





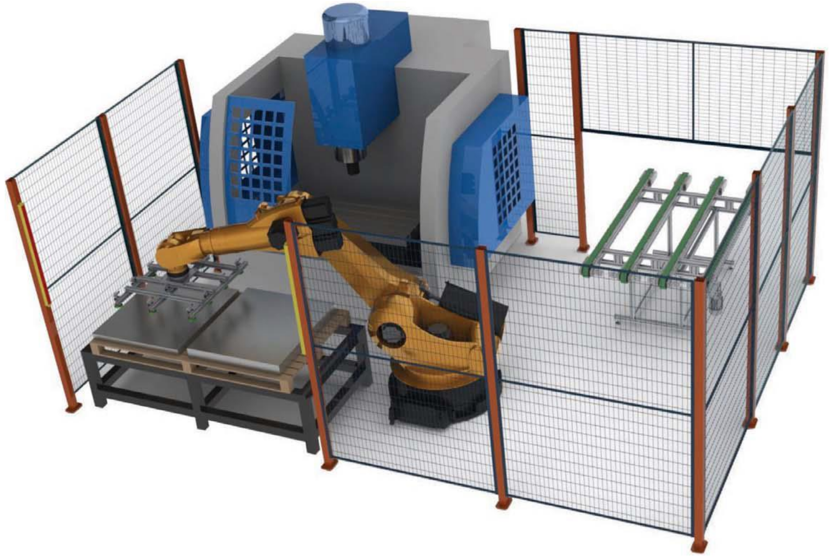
COLLABORATIVE ROBOTICS

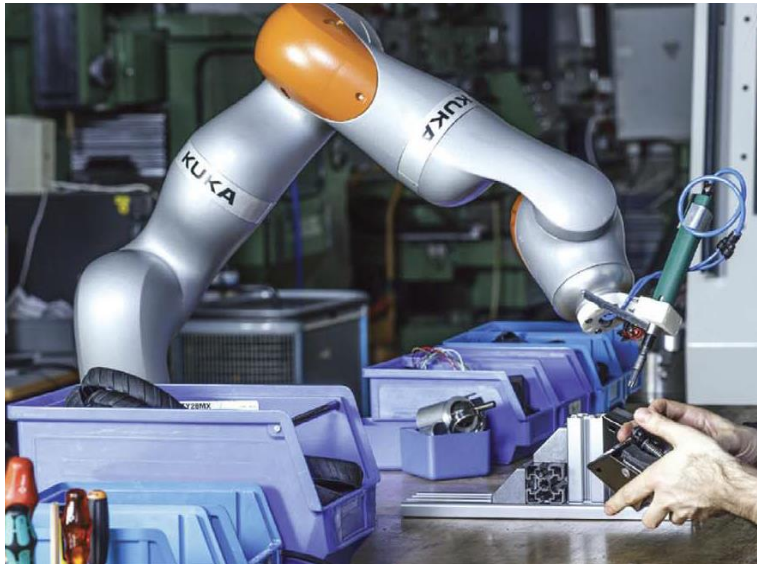
HUMAN ROBOT COMMUNICATION



SAFETY IN COLLABORATION

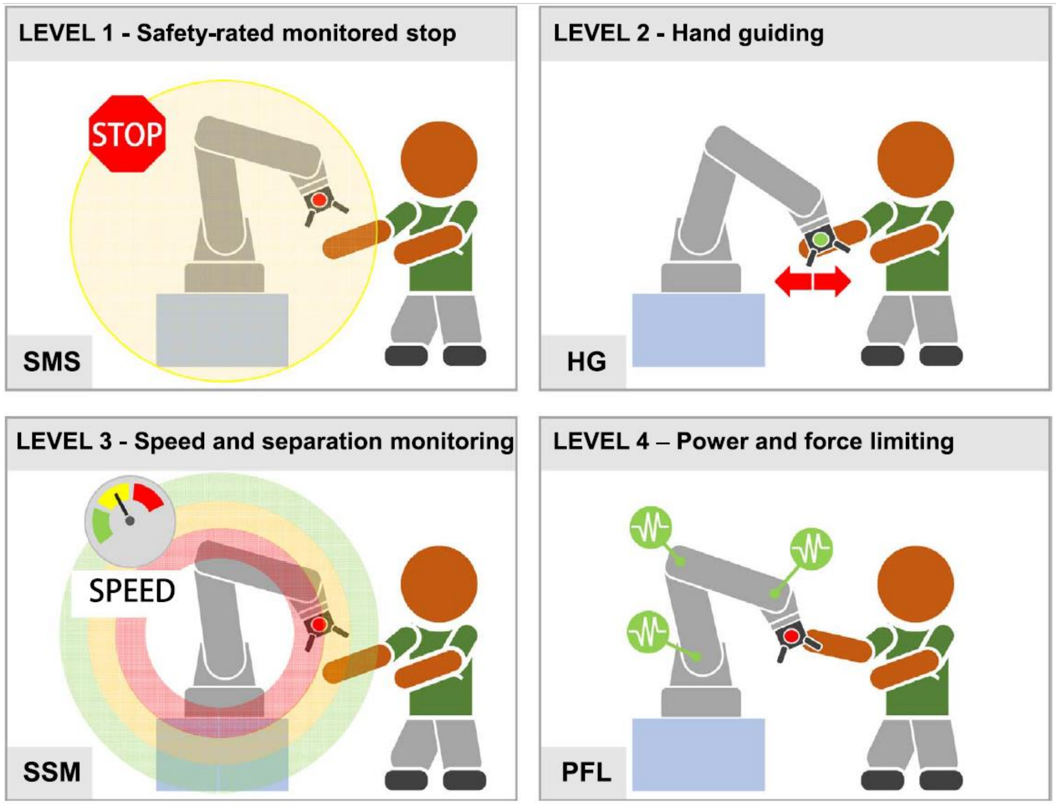
- Safety is a critical topic in Human-Robot Collaboration;
- Traditional robots are in an isolated workspace so that they do not injure humans;
- Collaborative robots need to be able to work with humans without injuring them;
- ISO 10218-1 and 10218-2 are two norms created for this.





ISO 10218-1 AND 10218-2 NORMS

1. Safety-rated monitored stop: when a human enters the cobot's workspace, it completely stops;
2. Hand guiding: when an operator manually moves the cobot, it is compliant;
3. Speed and separation monitoring: as the human moves closer to the cobot, it becomes gradually slower;
4. Power and force limiting: the cobot has its operation restricted in terms of force and torque.



STATE OF THE ART METHODS

PERCEPTION

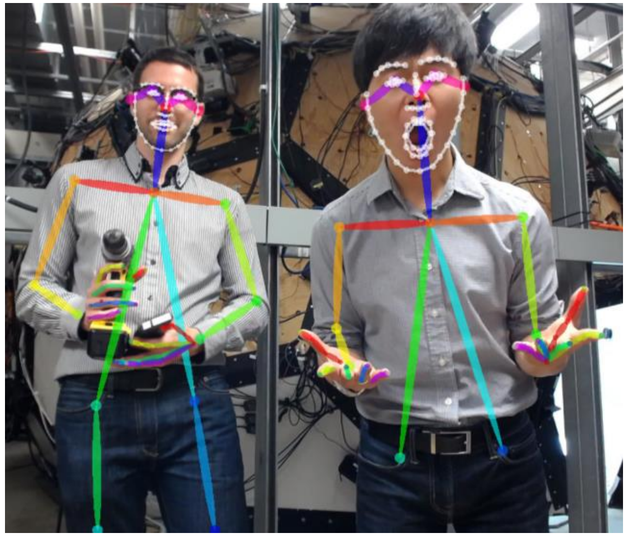
- Humans and robots can communicate through several methods;
- In action anticipation, passive and indirect communication methods are used;
- The user should not need to do anything for the robot to act, the robot must be able to understand the worker's body language, such as his involuntary pose, gestures or gaze.

SENSORS

Sensor	Nº Occurrences
RGB Camera	9
RGB-D Camera	1
Inertial Measurement Unit (IMU)	1
Electromyography (EMG) Sensors	1
Wearable Gaze Detector	1

RGB Images can be used in different ways:

- Directly in the model;
- Process optical flow;
- Process marker positions;
- Input to key point detection frameworks.



PREDICTIVE MODELS

- Predicting the next action of the worker is a supervised learning problem;
- It is possible to use a sequence of images that must be classified as a particular future action class.

PREDICTIVE MODELS

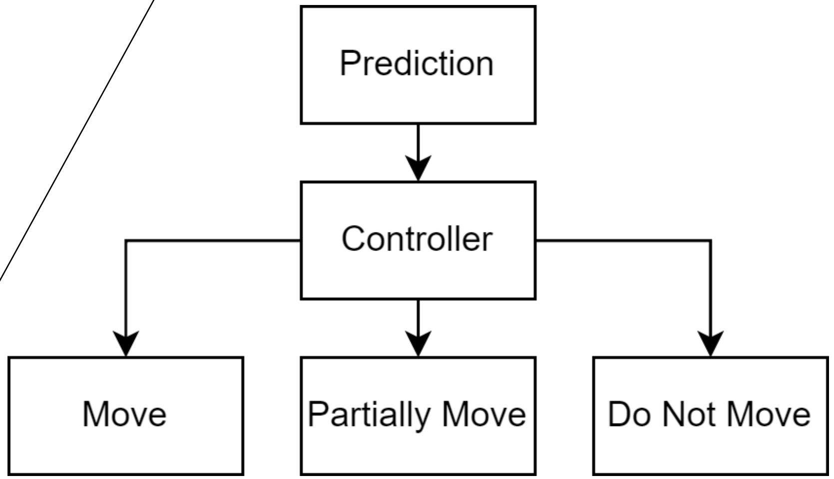
Model Name	Nº Occurrences
LSTM	7
CNN	3
TSN	1
Nearest Neighbor	1
SVM	1

Model Name	Nº Occurrences
ResNet-34	1
ResNet-50	1
VGG-16	1
TS	1
ConvNet	1

DECISION-MAKING

Two options were found to decide when to move:

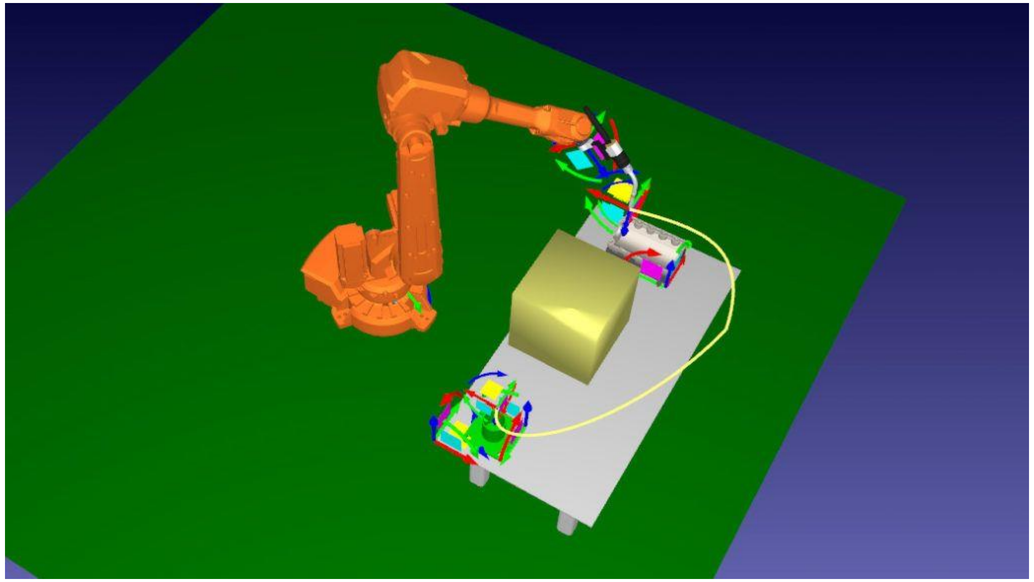
- Wait until a certain level of certainty about the prediction to make the needed action;
- As soon as it makes a prediction with a certain certainty threshold start slowly moving towards the target, do the entire action after it reaches a second threshold.

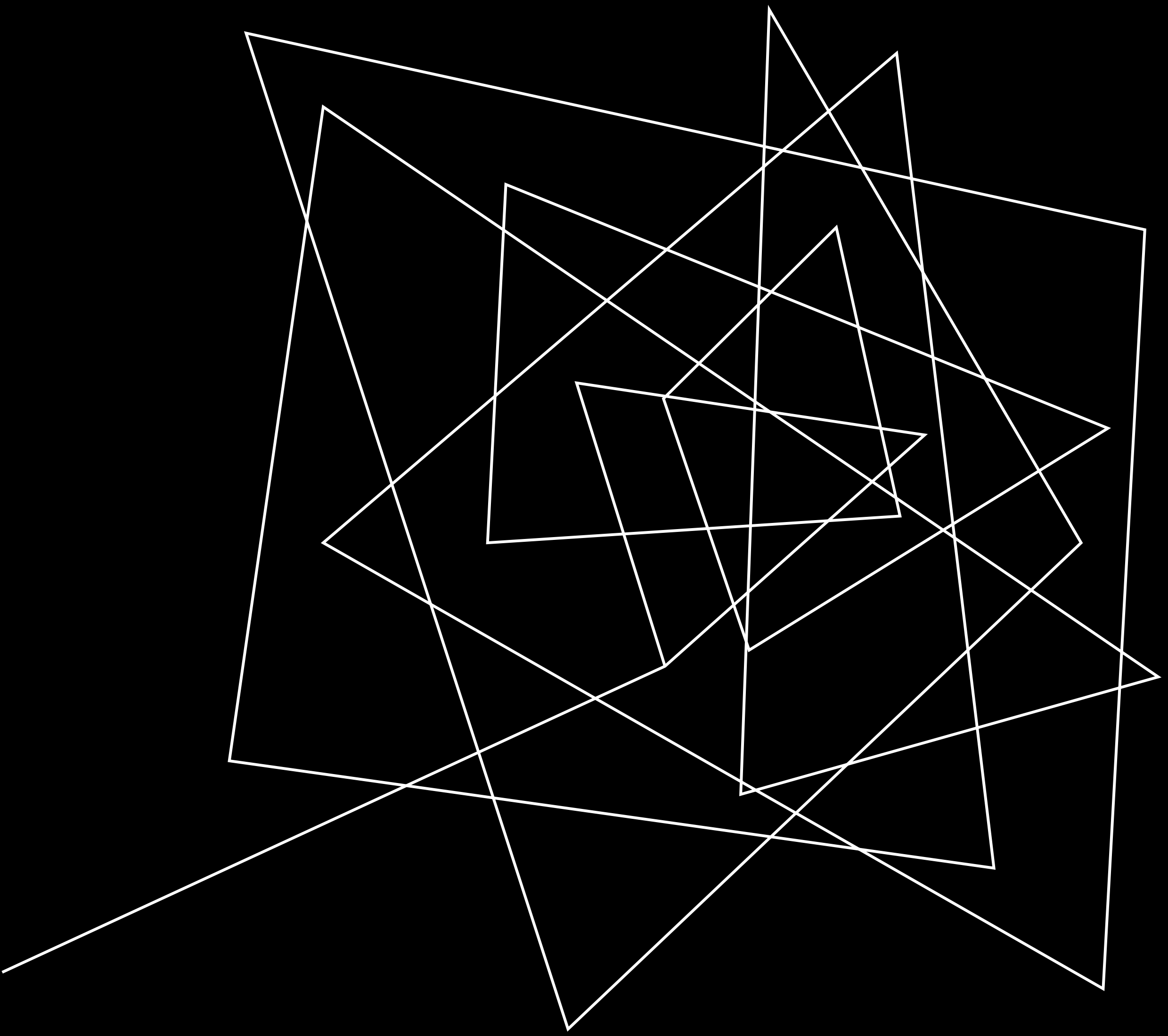


MOTION PLANNING

Two options were found to decide when to move:

- Use ROS Open Motion Planning Library (OMPL) and MoveIt! to handle the trajectory planning jobs;
- Plan trajectories considering previous poses when doing this interaction to avoid collisions.





TOOLS REVIEW

EXPERIMENTAL SETUP

- The experimental part of this thesis will be developed using the setup available at the Laboratory for Automation and Robotics (LAR);
- The available setup contains a collaborative robot surrounded by several sensors and a powerful computer that can be used to train machine learning models;
- All communication is established using ROS making it a compulsory tool.

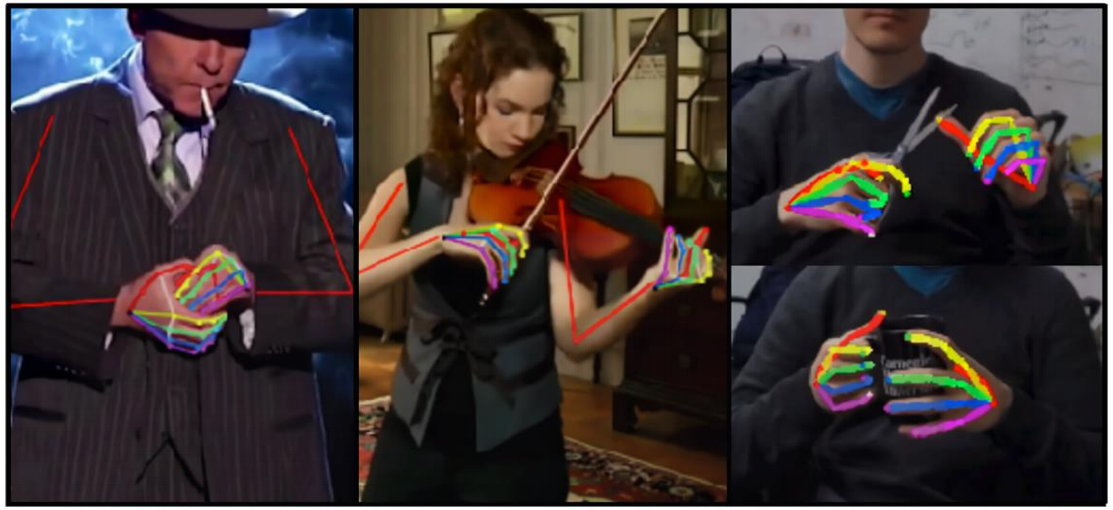
MACHINE LEARNING FRAMEWORKS

Two options were reviewed for the development of the machine learning models and data pre-processing:

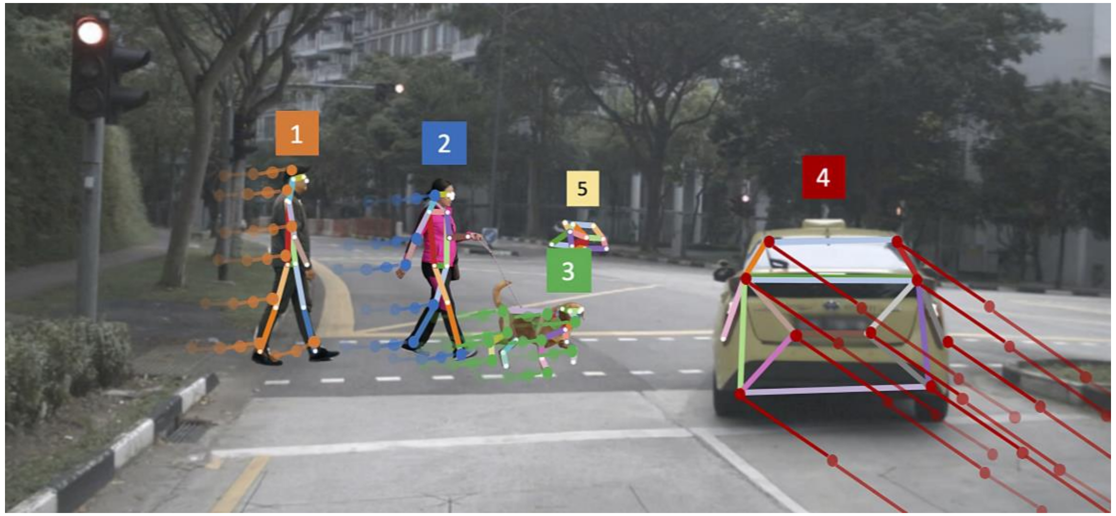
- TensorFlow
- PyTorch

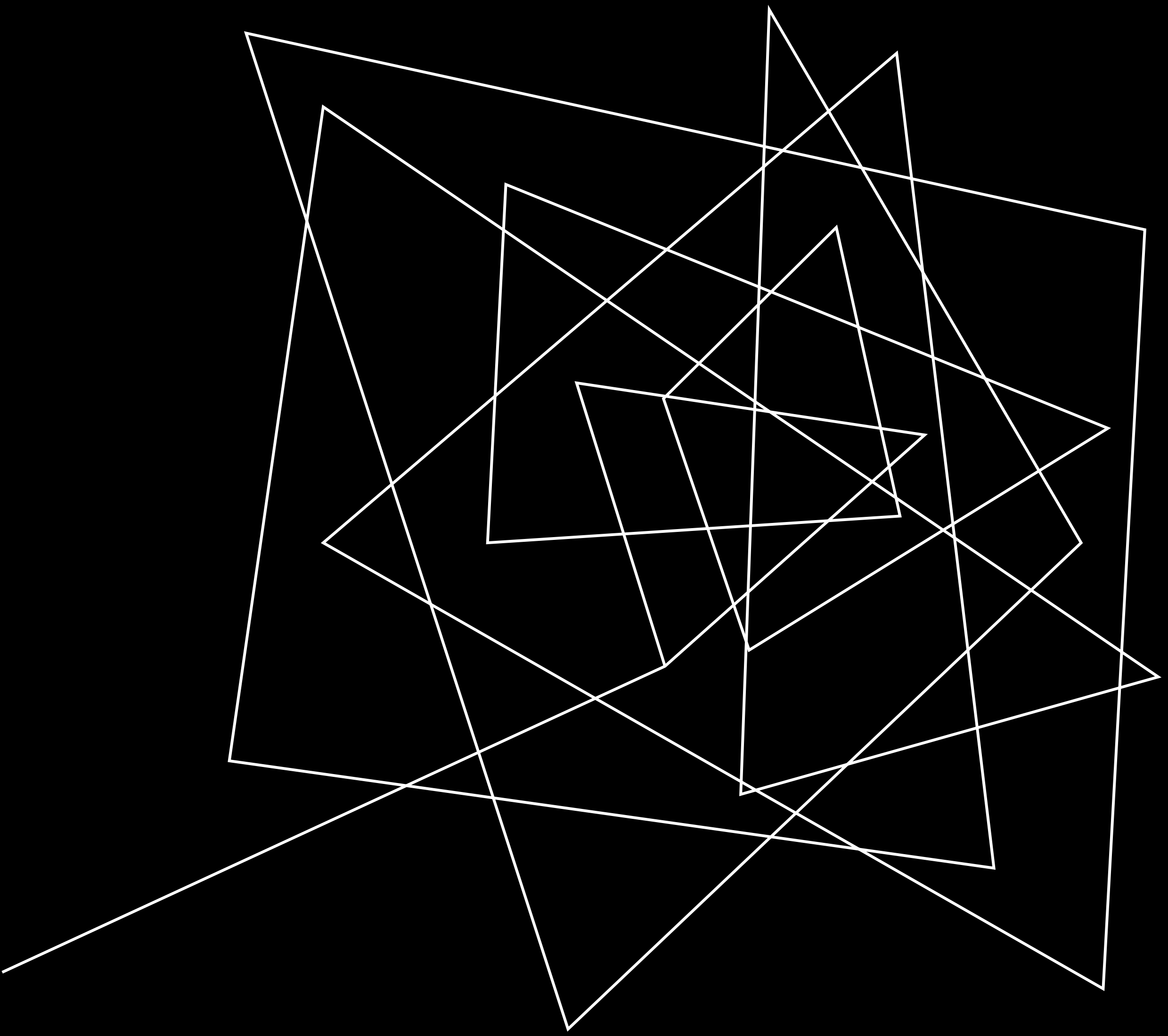
KEY POINT DETECTION FRAMEWORKS

OpenPose



OpenPifPaf





WORK PROGRESS

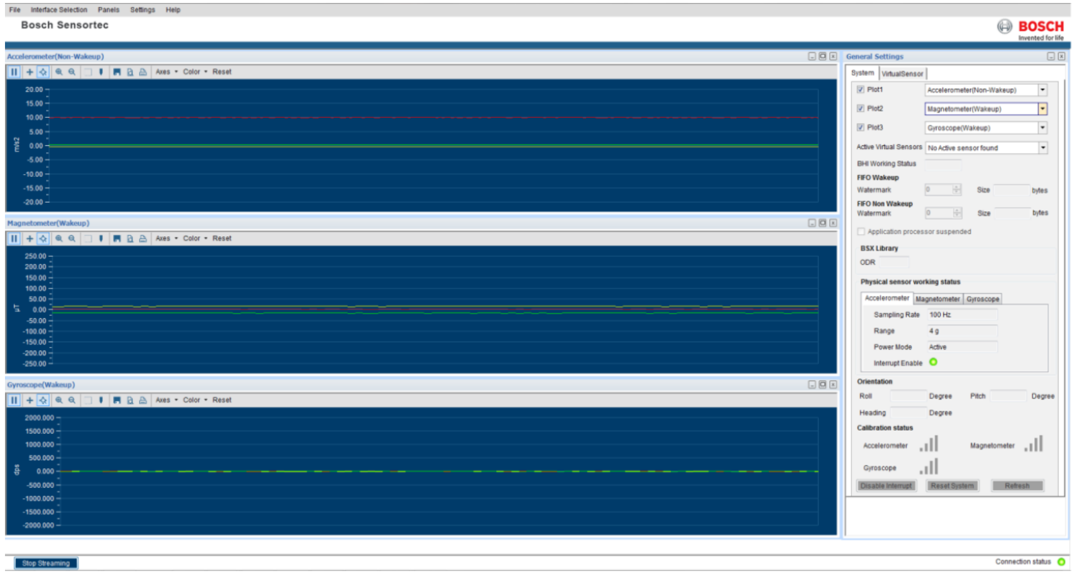
SENSOR BHI260AP

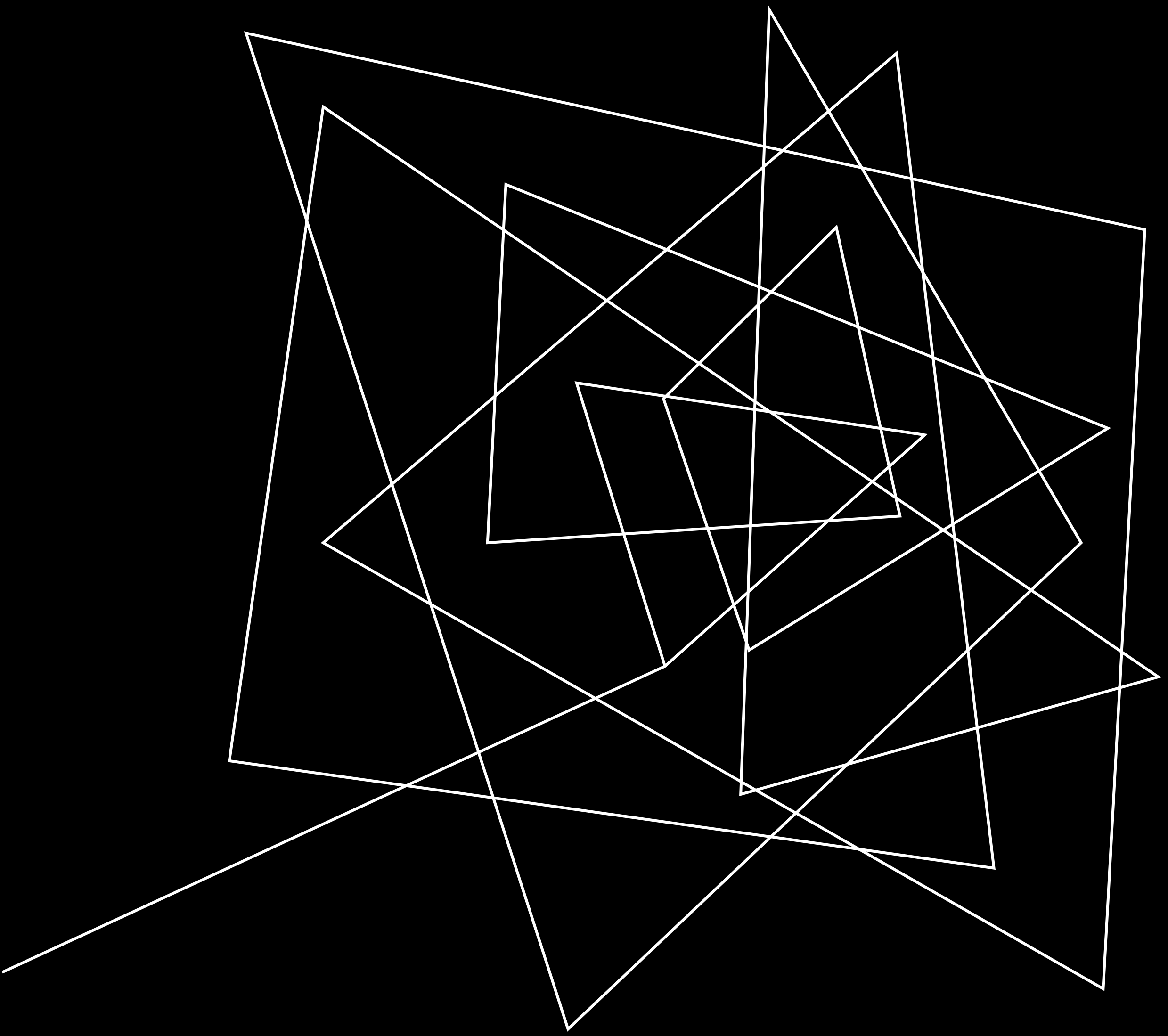
- BHI260AP is a smart sensor with integrated Inertial Measurement Unit (IMU) from Bosch Sensortec.
- It could be used to help detect gestures with the end goal of helping and automating the labeling of the model training data.

COMMUNICATION APPROACHES

Three options were tested for establishing communication with the sensor:

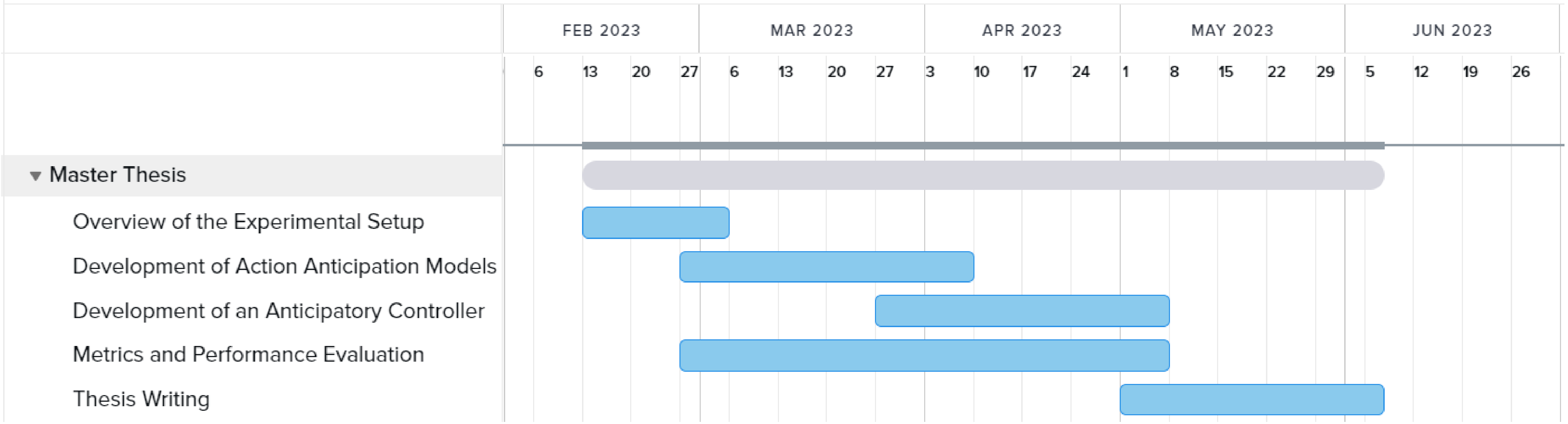
- C++ API – does not compile;
- Python API – connects but there is no documentation;
- Development Desktop 2.0 – collects data but only works in windows.





WORK PLANNING

FUTURE WORK PLANNING



CONCLUSION

CONCLUSION

- There was a clear predominance of RGB cameras for perception;
- LSTMs and CNNs were the most common predictive models;
- Some relevant tools were reviewed;
- An inertial sensor was tested although further work is necessary for it to be useful;
- The tasks for the second semester are scheduled.

THANK YOU