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Enrico Torres, Filippo Marri

AN INCLUSIVE SOLUTION FOR LIGHT CONTROL

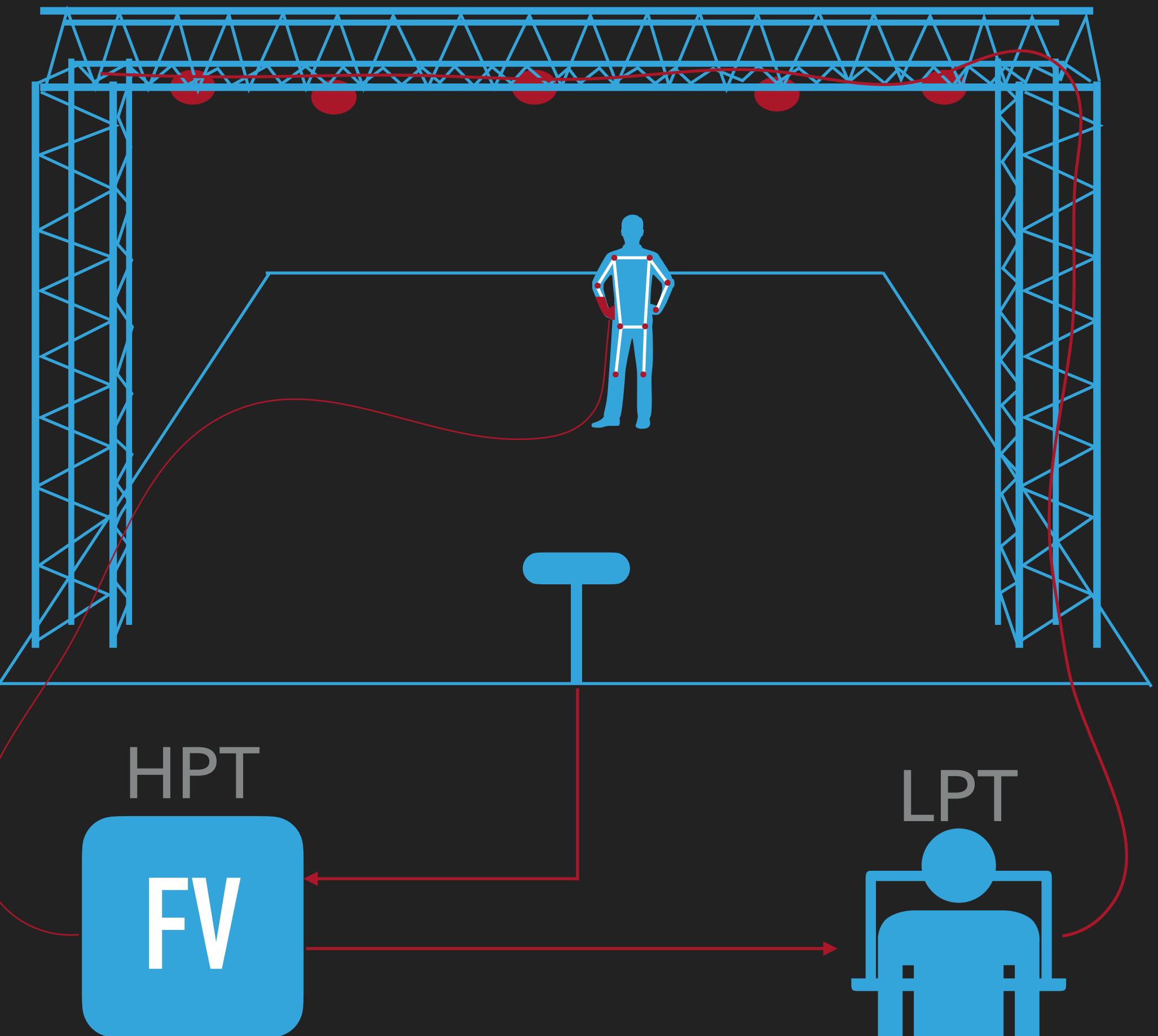
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# FLOWVISION

# CONCEPT

## CONCEPT

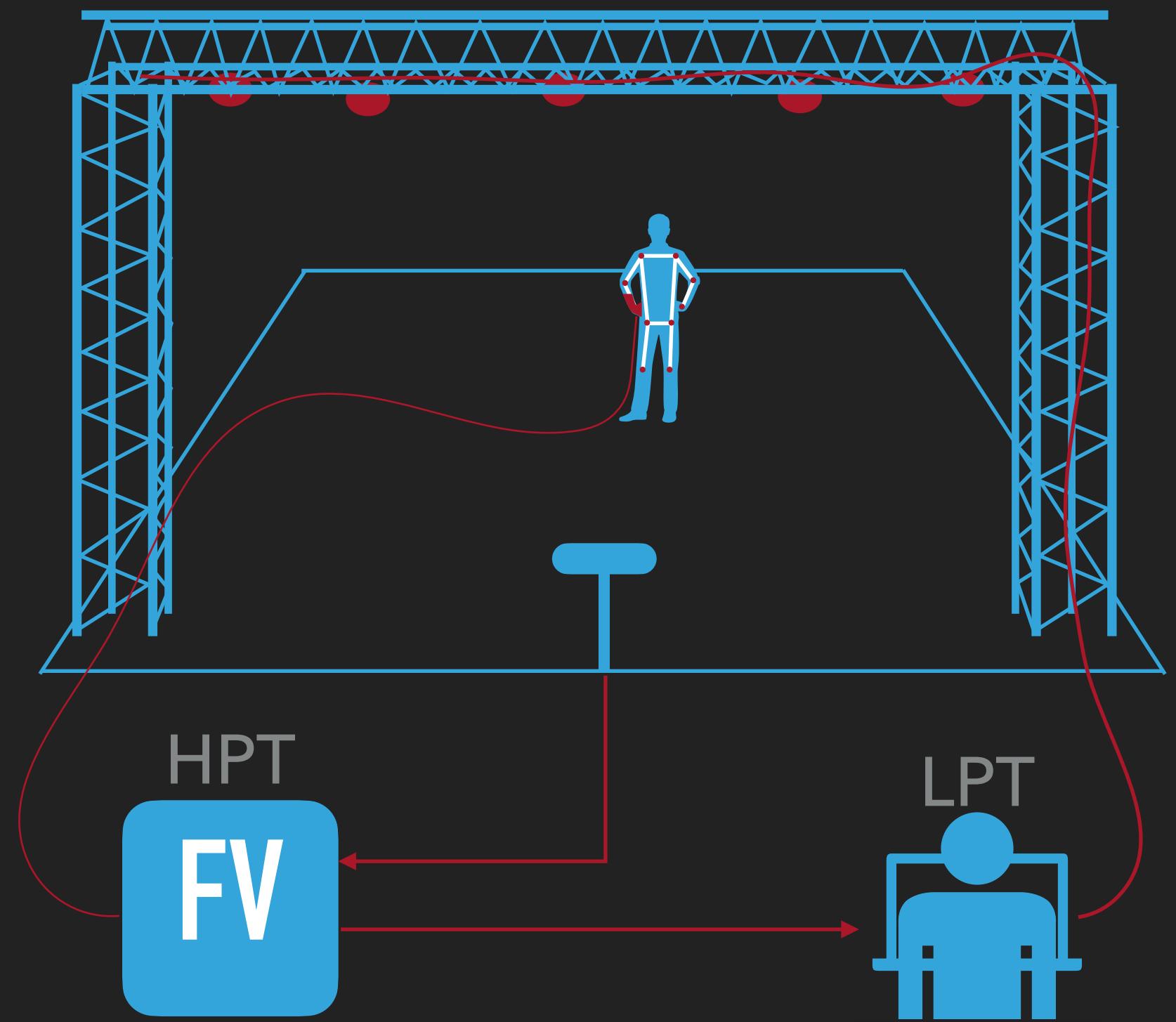
- ▶ A software able to control simple light settings according to the performer's movements
- ▶ Inclusivity: provide haptic feedbacks to the performer in order to give the perception of control



# FROM THE HACKATHON TO THE FINAL VERSION

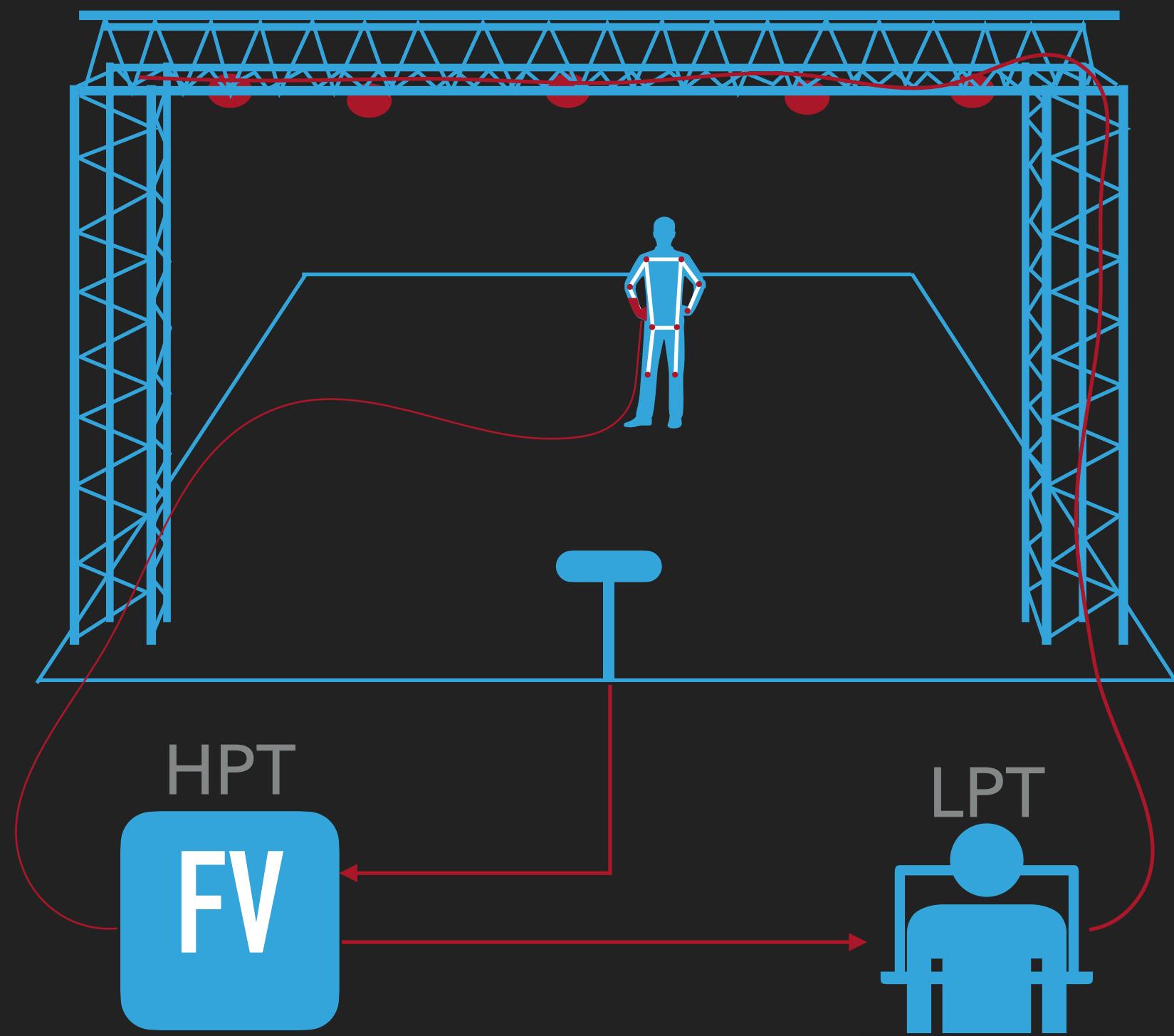
## ON STAGE

BEHIND THE SCENE

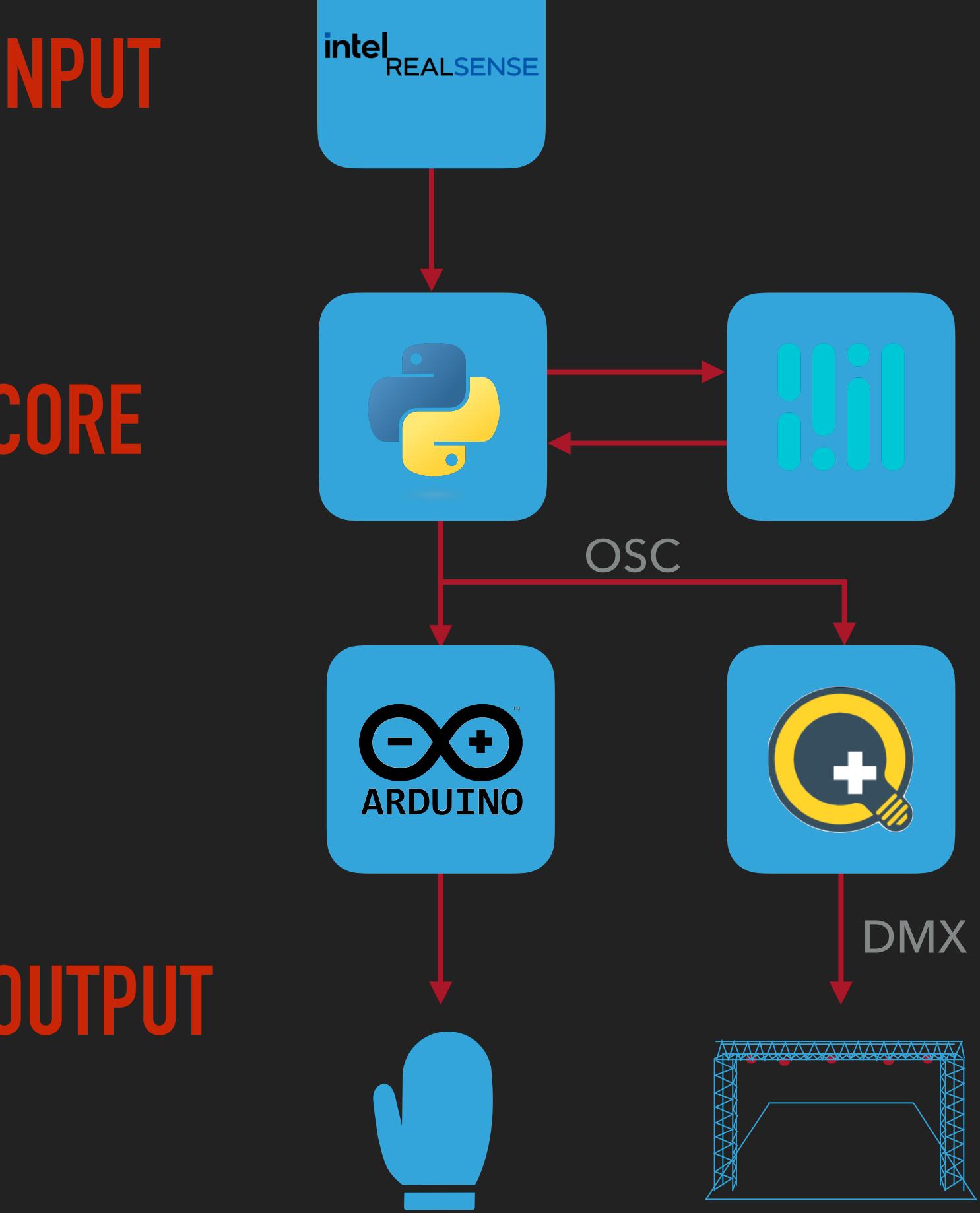


# FROM THE HACKATHON TO THE FINAL VERSION

## ON STAGE

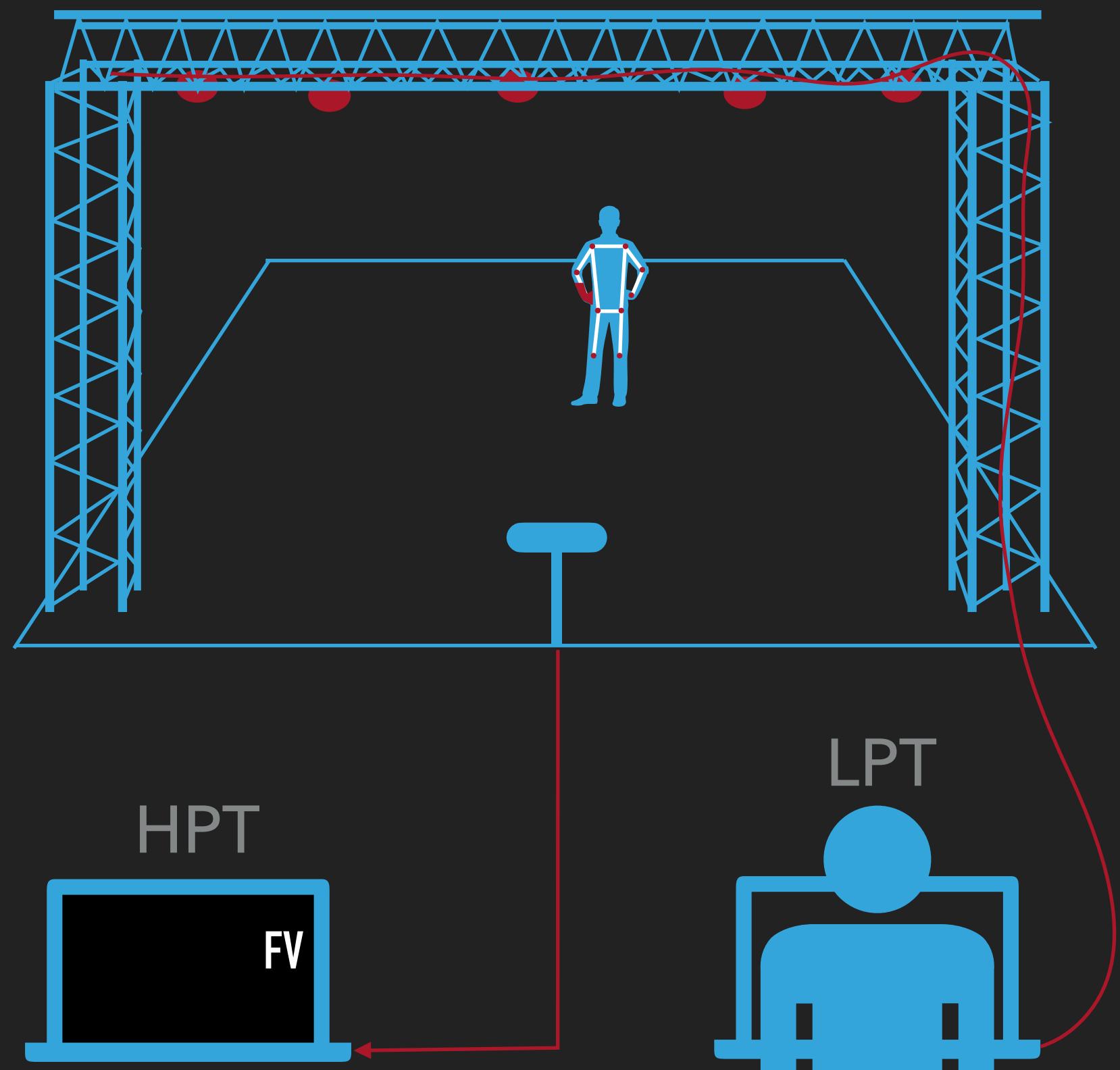


## BEHIND THE SCENE



# FROM THE HACKATHON TO THE FINAL VERSION

ON STAGE

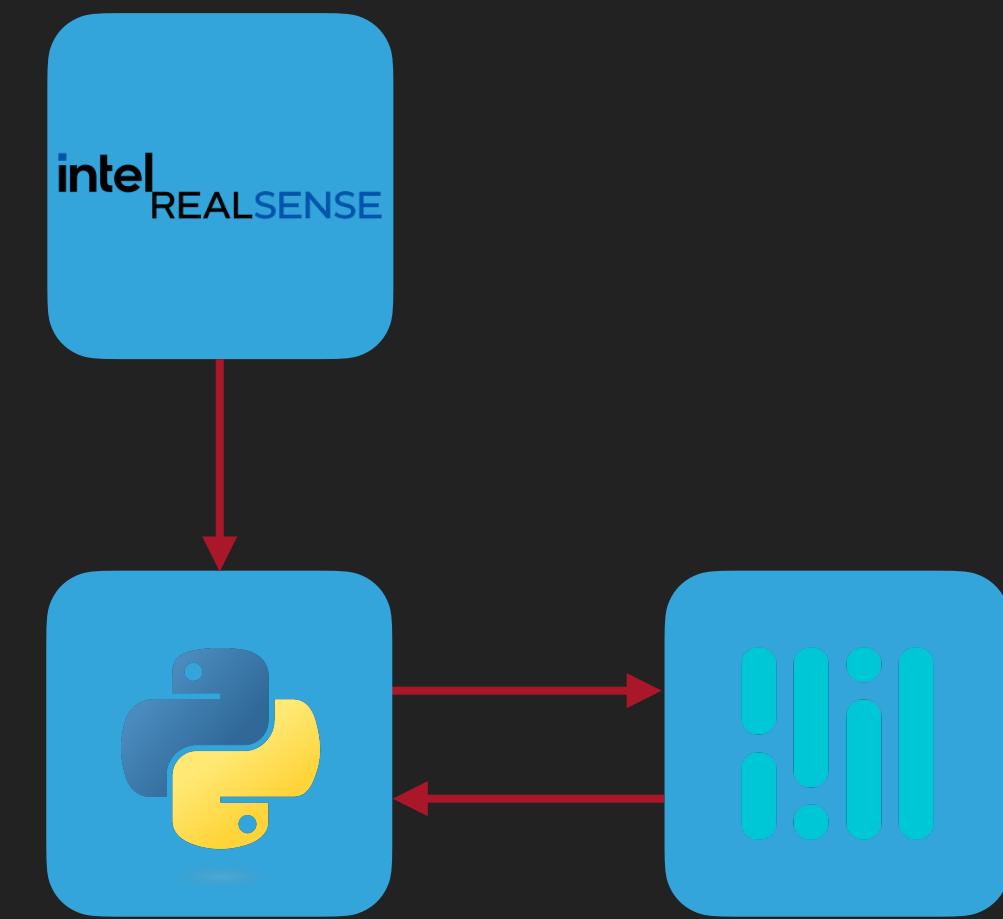


INPUT

CORE

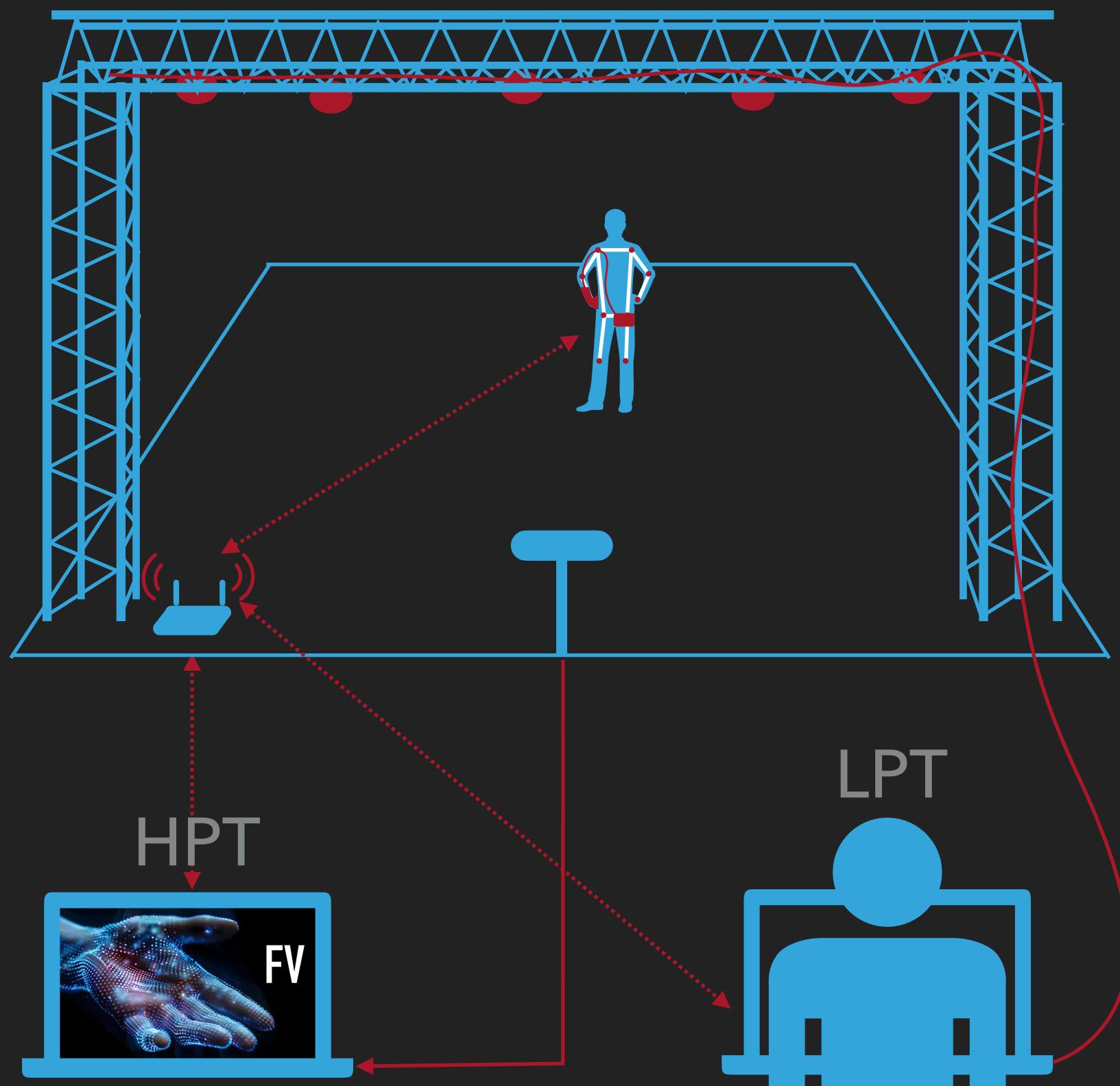
OUTPUT

BEHIND THE SCENE



# FROM THE HACKATHON TO THE FINAL VERSION

ON STAGE

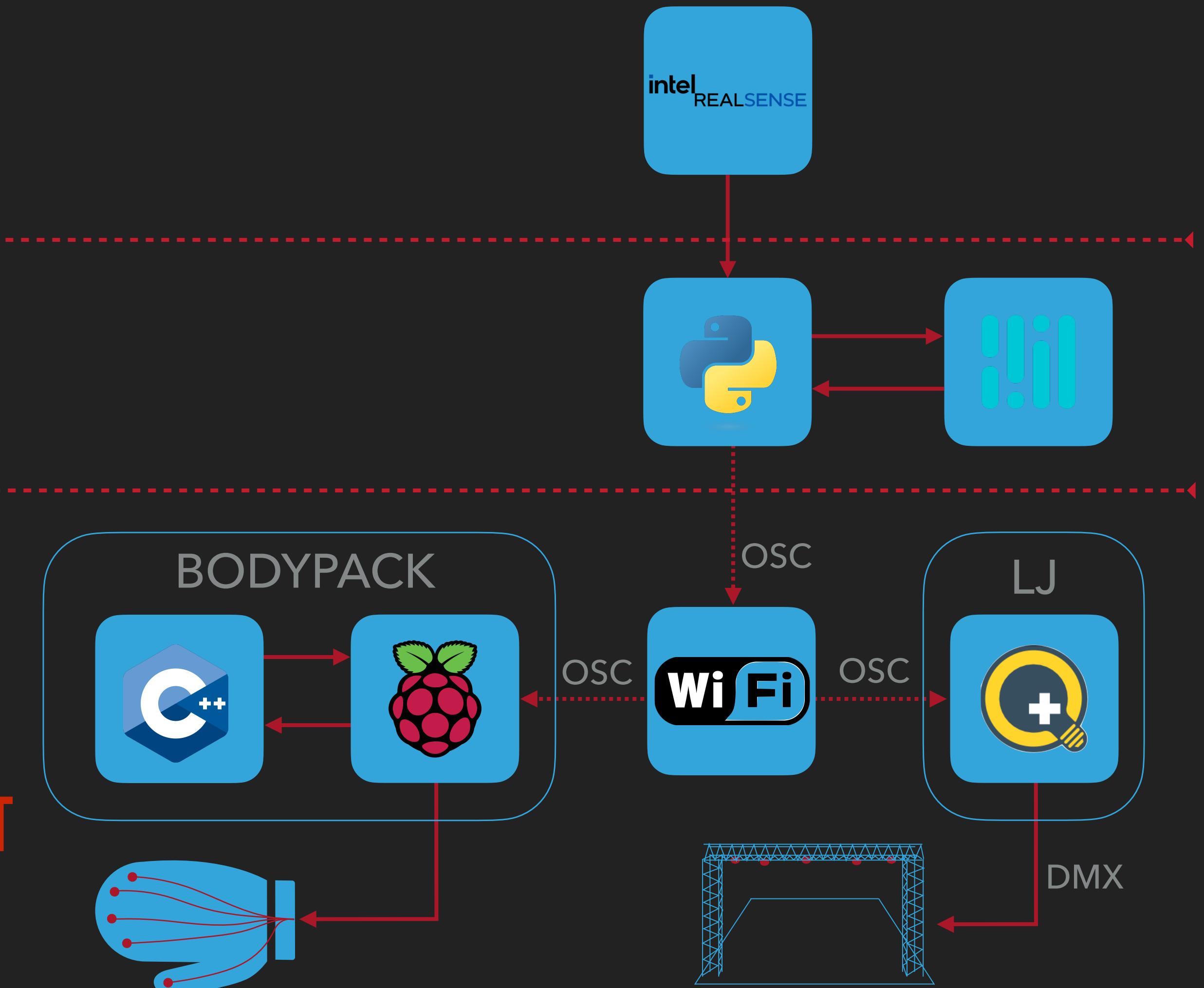


INPUT

CORE

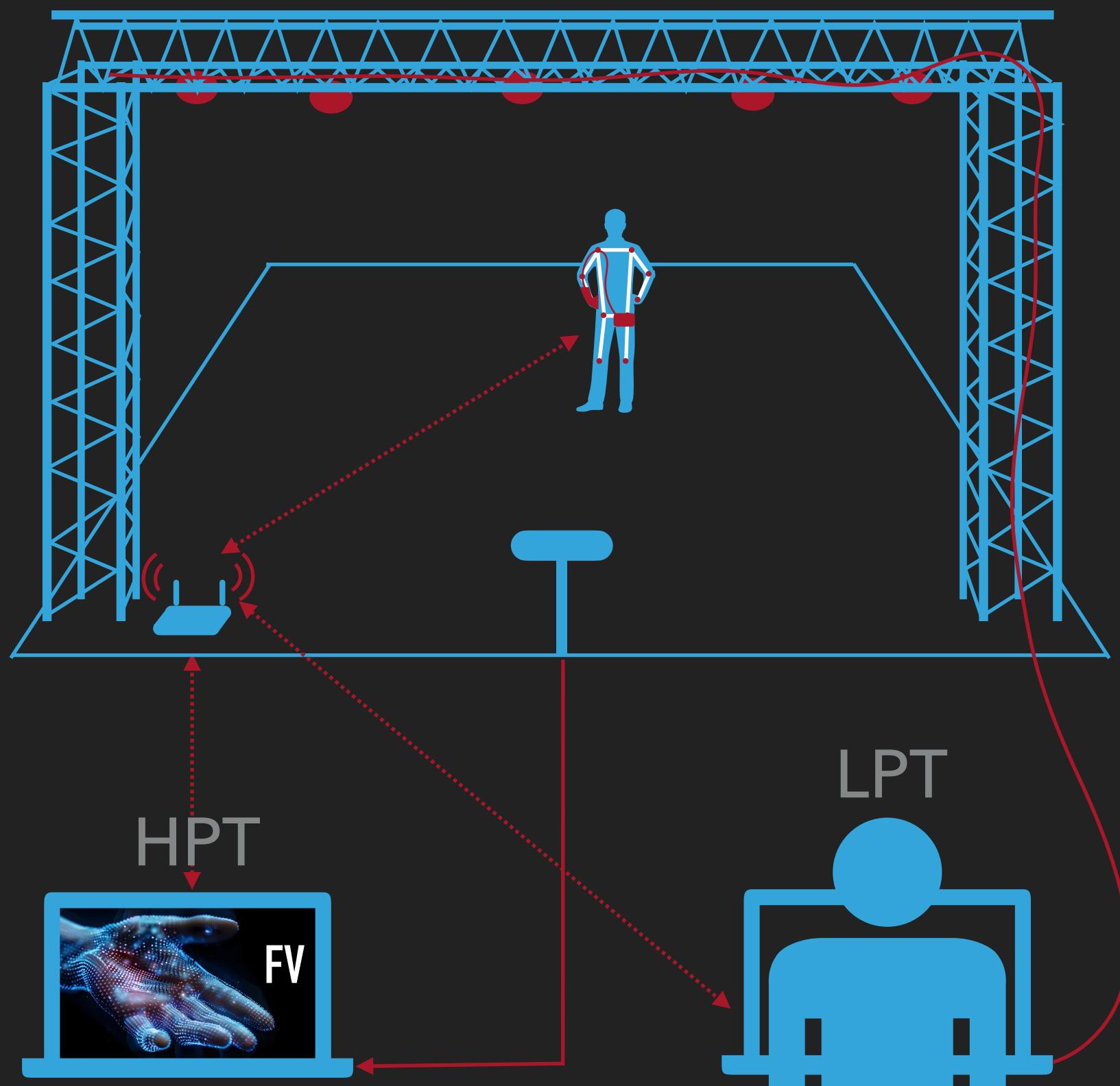
OUTPUT

BEHIND THE SCENE



# FROM THE HACKATHON TO THE FINAL VERSION

ON STAGE



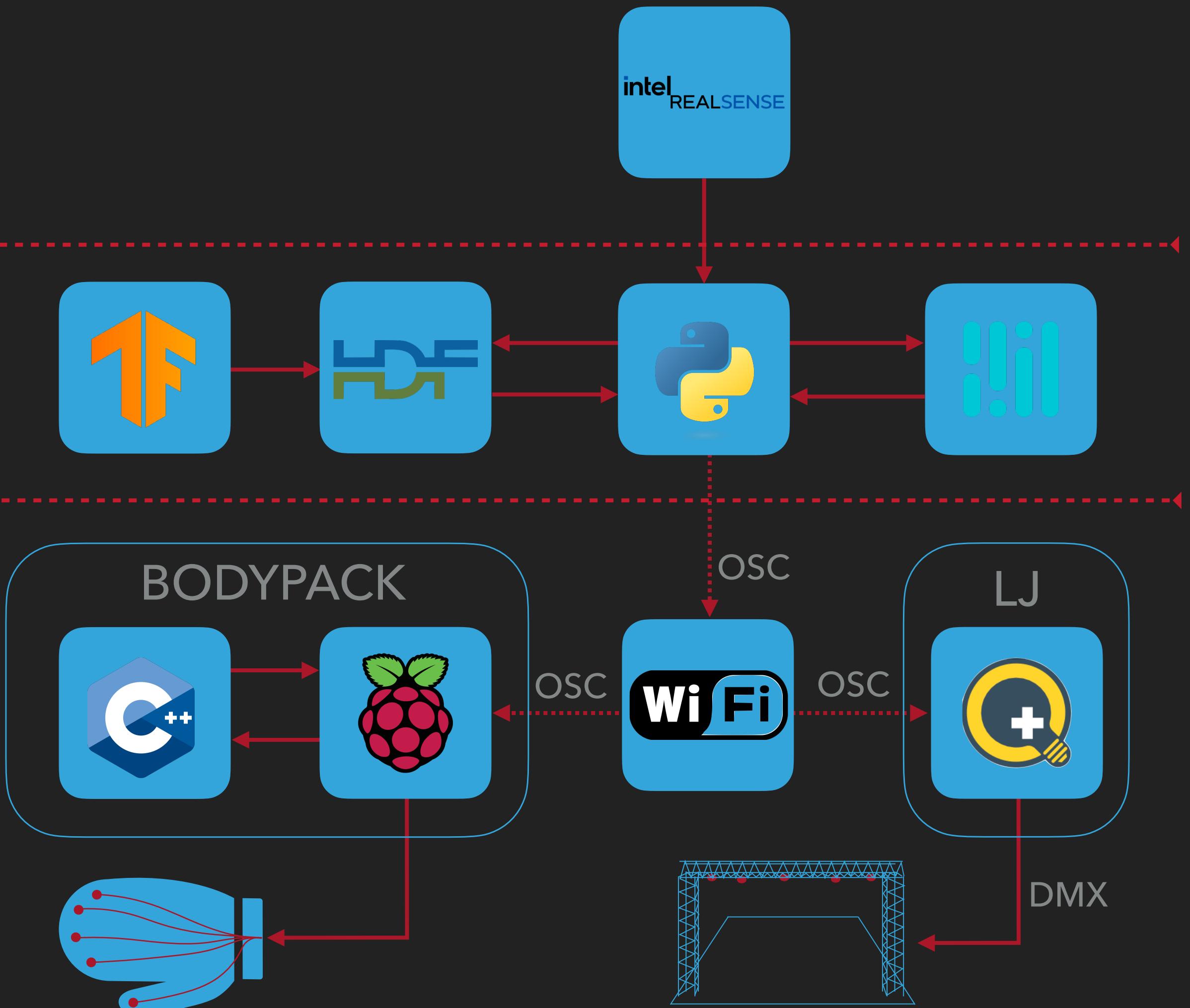
INPUT

CORE

OUTPUT

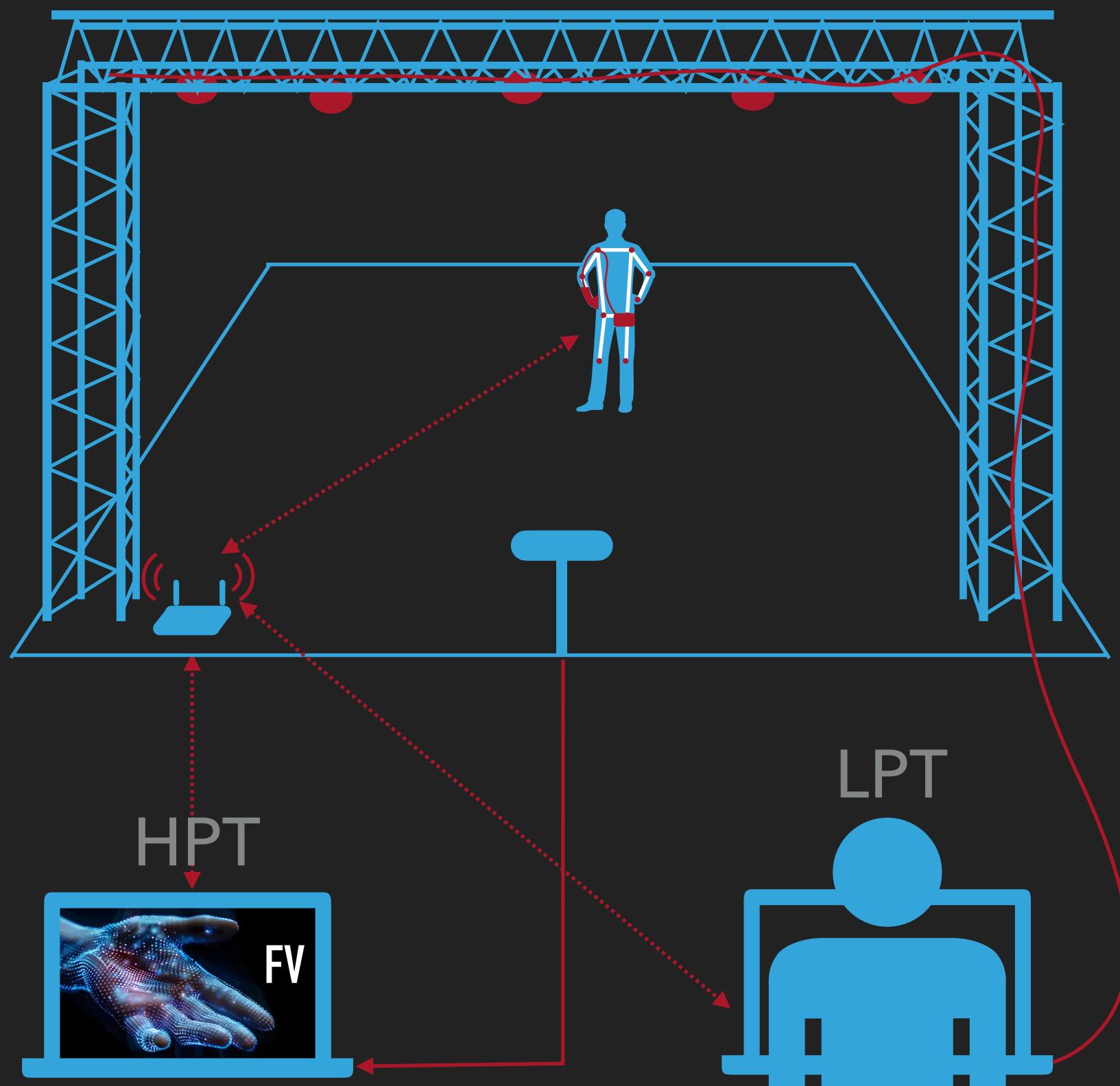
BEHIND THE SCENE

BODYPACK



# FROM THE HACKATHON TO THE FINAL VERSION

ON STAGE



INPUT

CORE

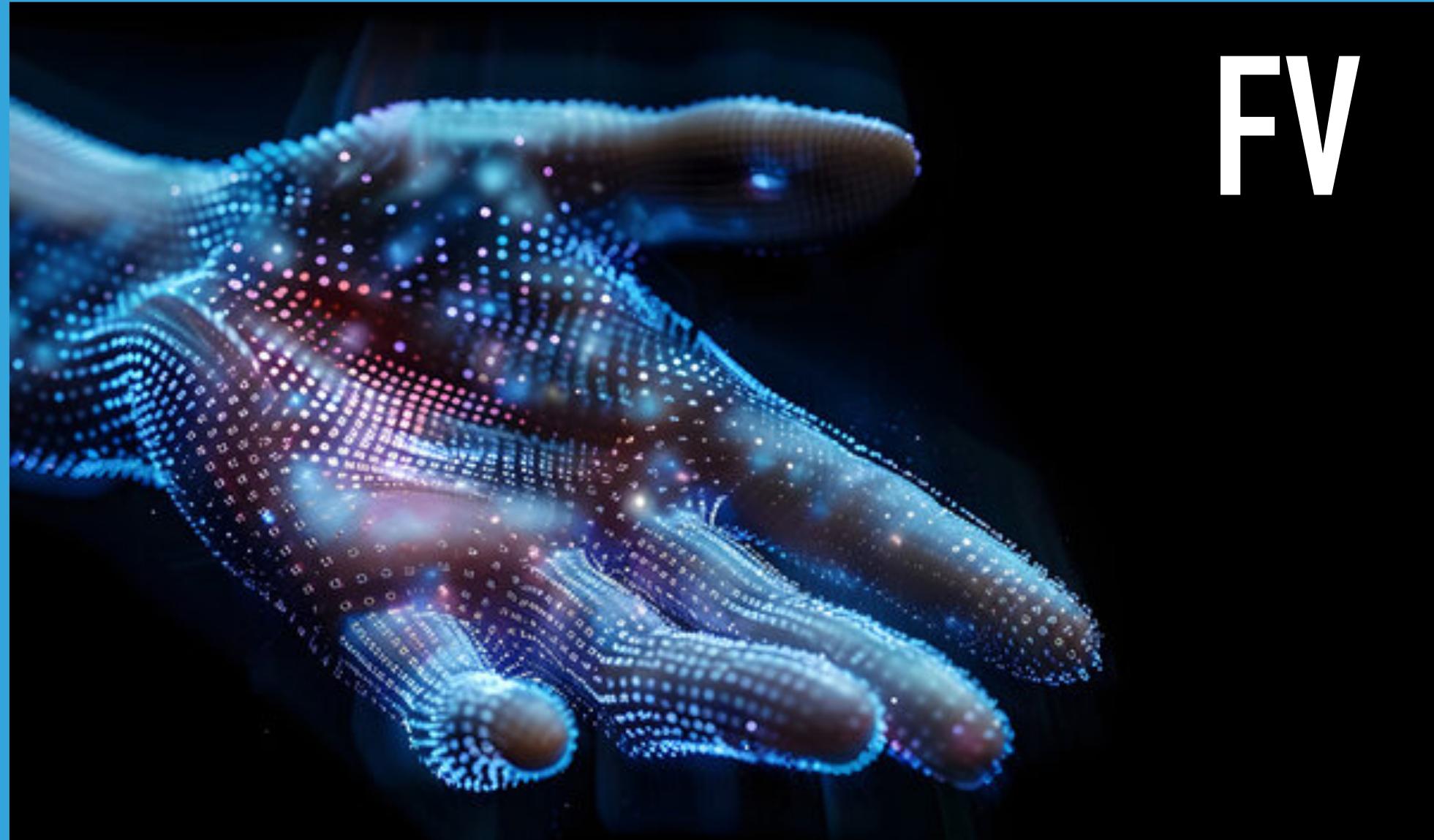
OUTPUT

BEHIND THE SCENE

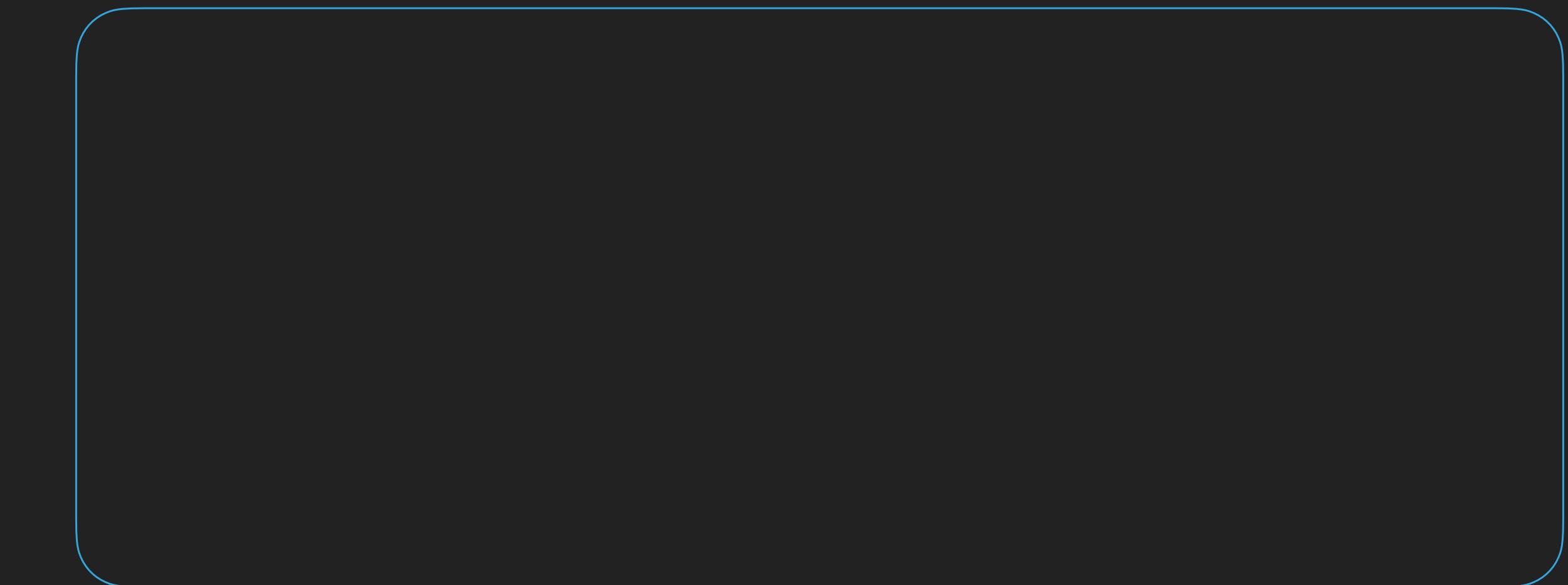


FLOWVISION

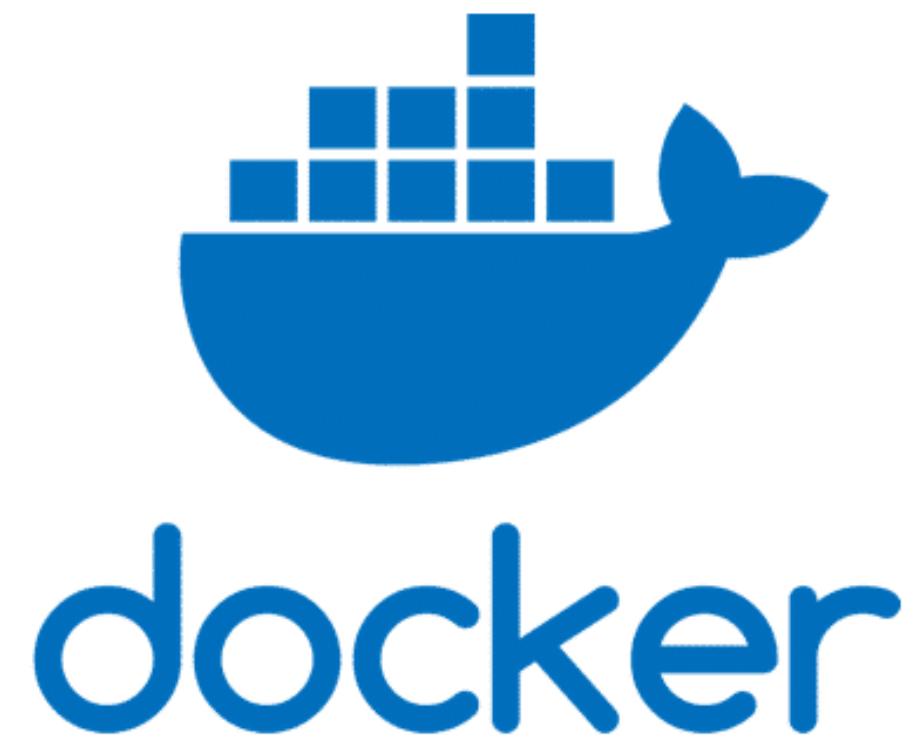
# GRAPHIC USER INTERFACE



FV

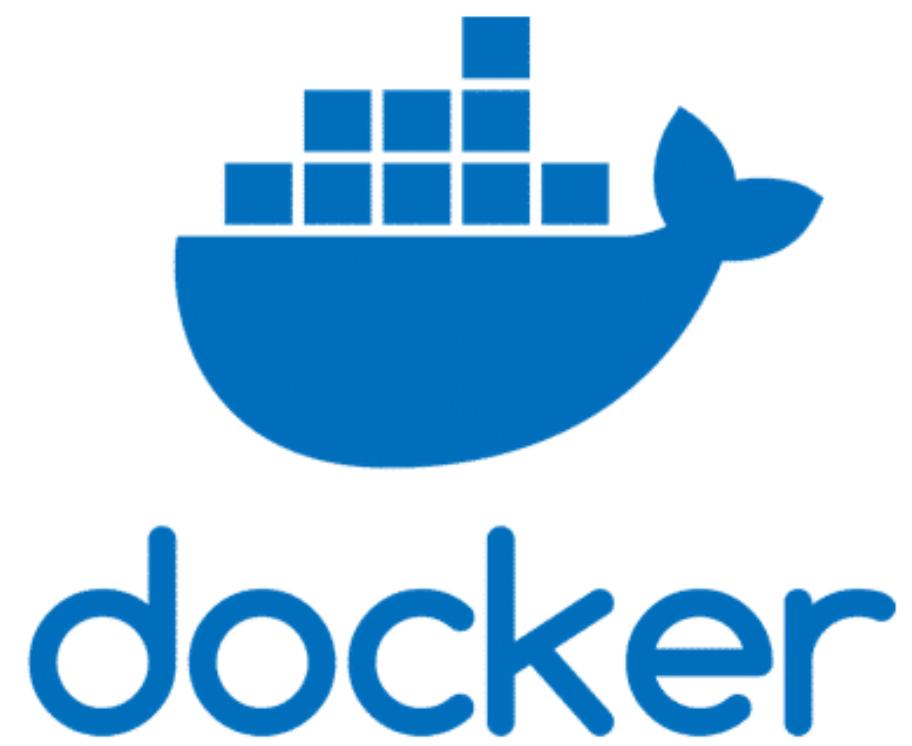


## GRAPHIC USER INTERFACE



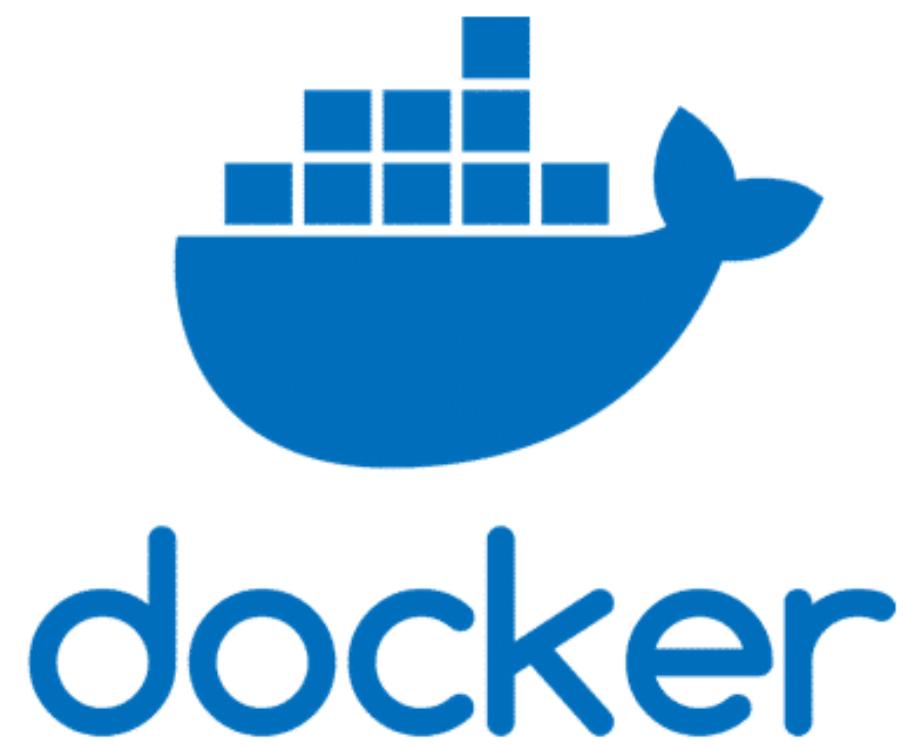
- ▶ Generation of a docker file to make the execution as handy as possible

# GRAPHIC USER INTERFACE



► **CHALLENGE:**  
MACOS RESTRICTIONS ON EXTERNAL DEVICES ON DOCKER

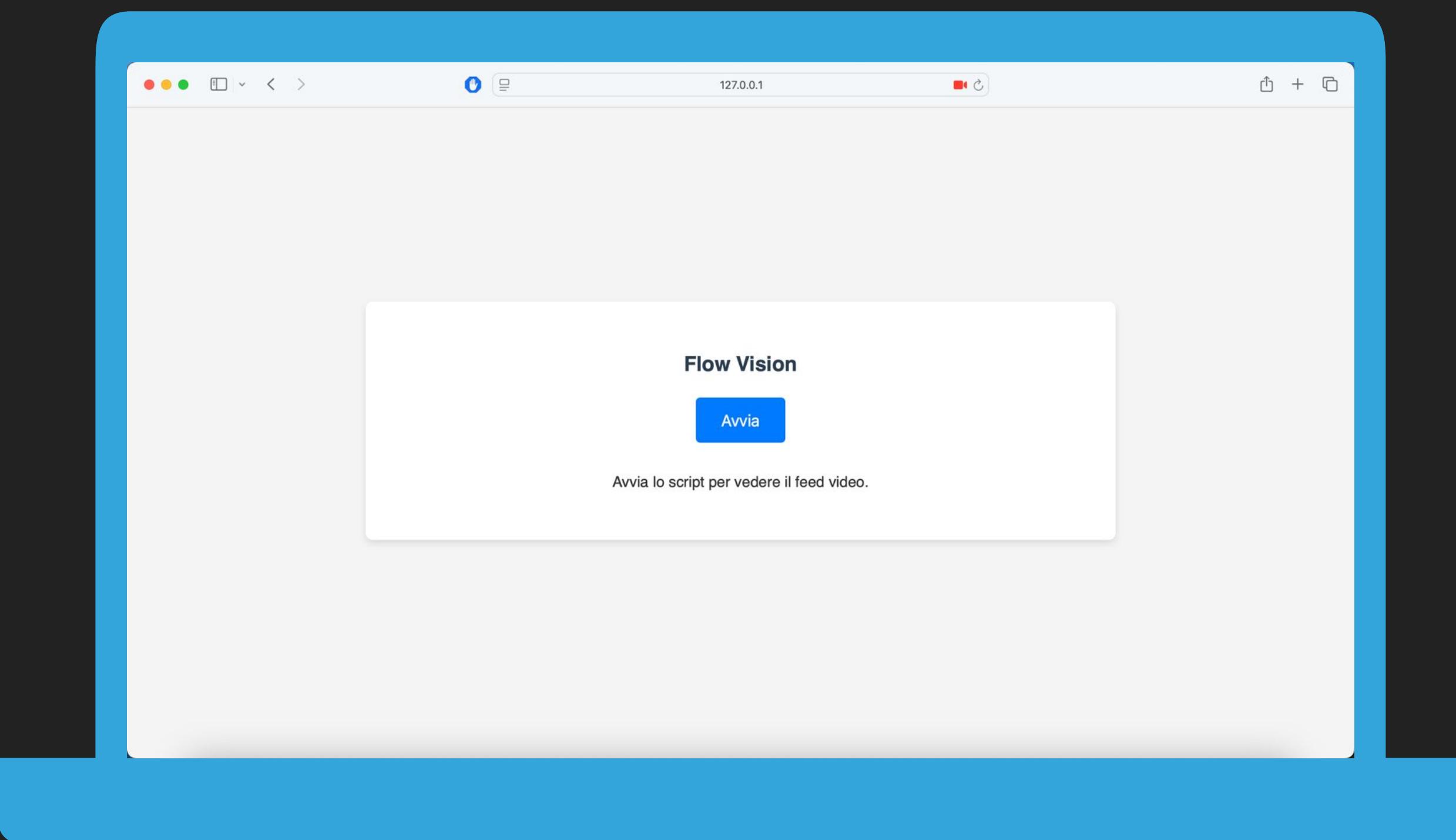
## GRAPHIC USER INTERFACE



### TRADE-OFF:

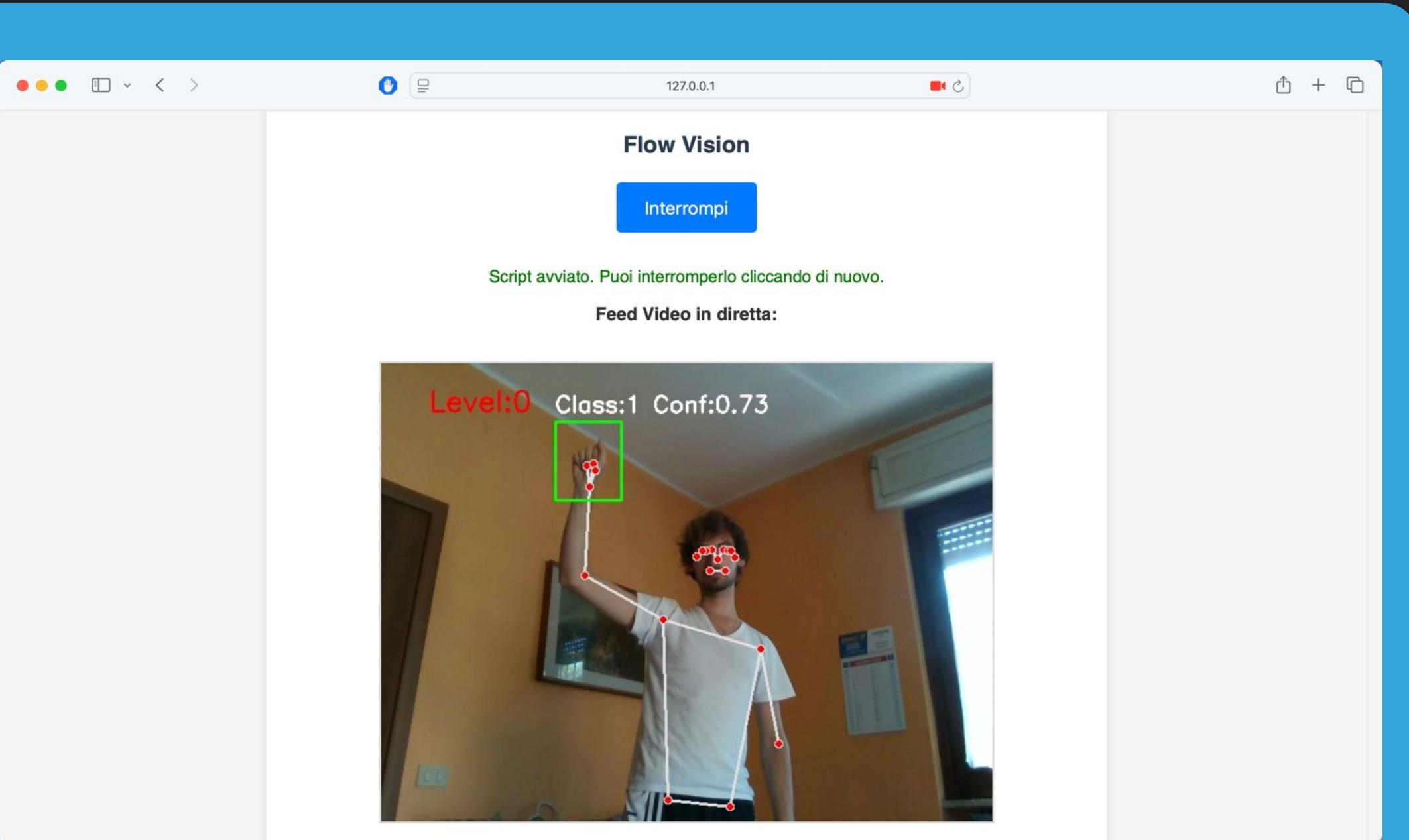
WE DECIDED NOT TO USE DOCKER AND TO IMPLEMENT A SIMPLE GUI FROM WHICH TO RUN EVERYTHING

# GRAPHIC USER INTERFACE



- ▶ Implementation of just a simple GUI from which to run the entire application smartly

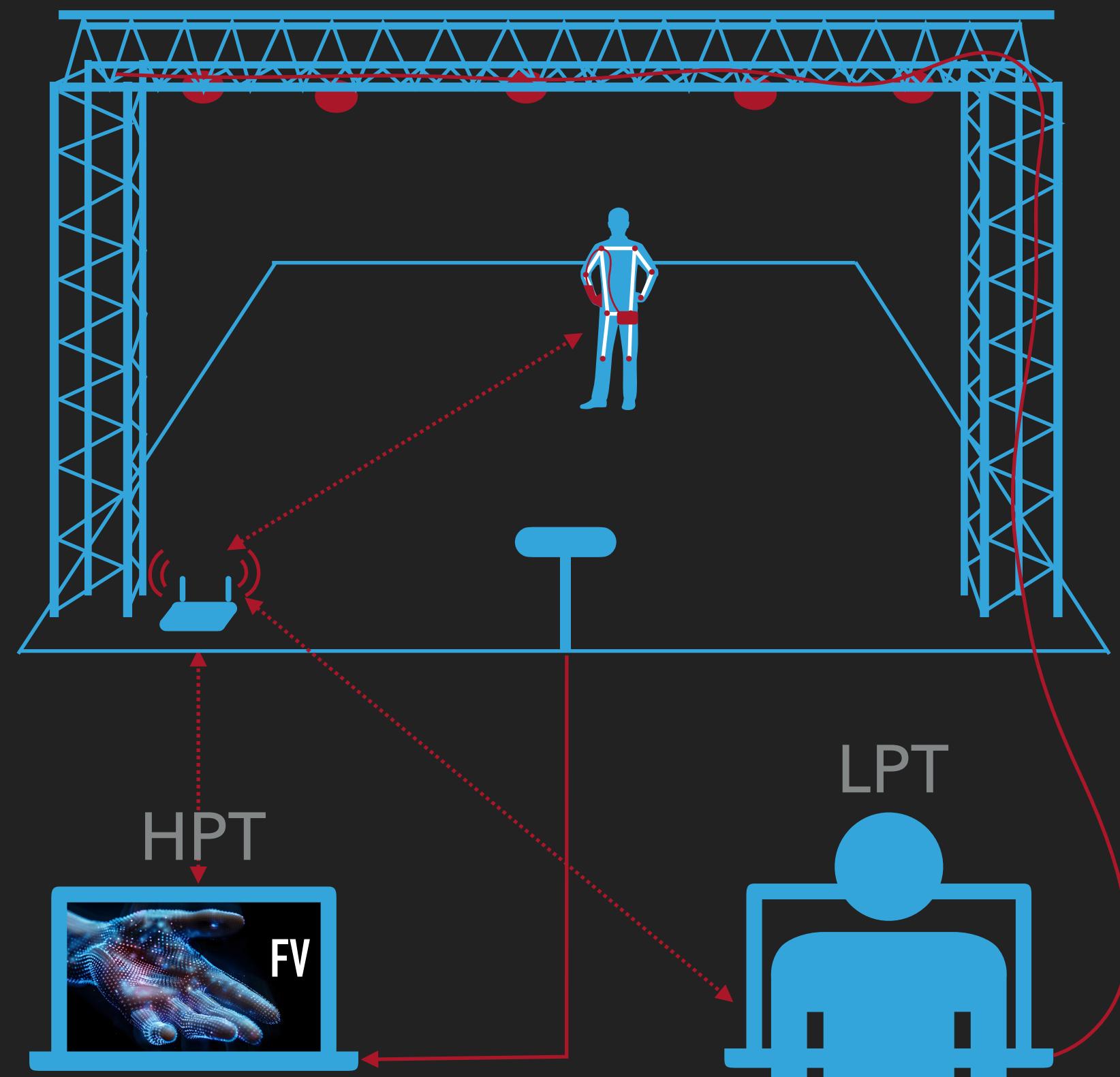
# GRAPHIC USER INTERFACE



- ▶ Implementation of just a simple GUI from which to run the entire application smartly
- ▶ Once the code is started, it is possible to control the execution with a video stream

# ARCHITECTURE

ON STAGE

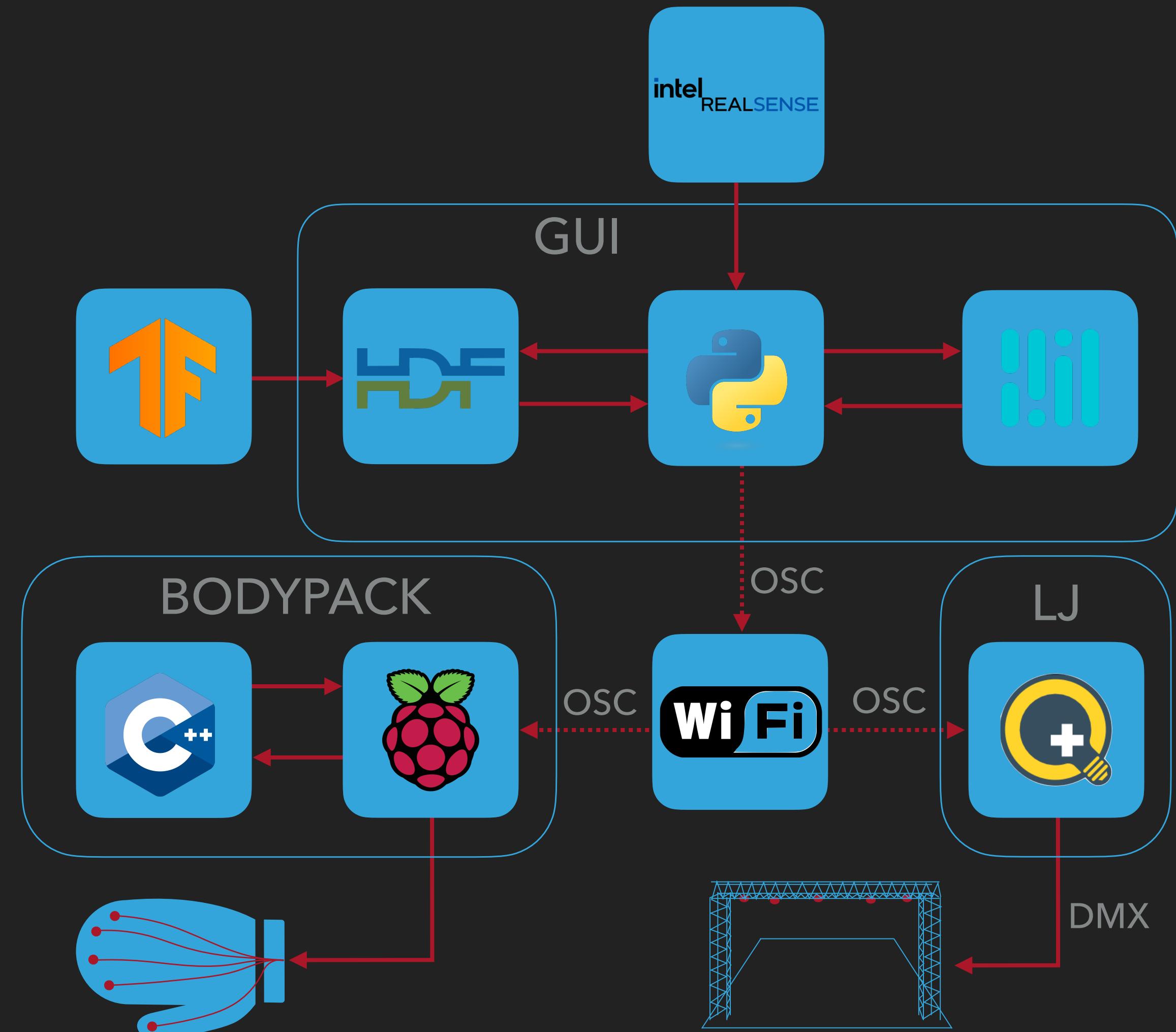


INPUT

CORE

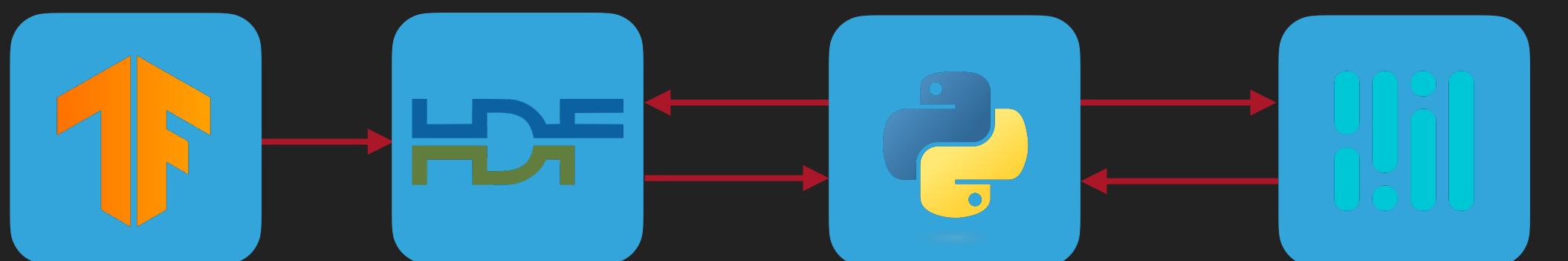
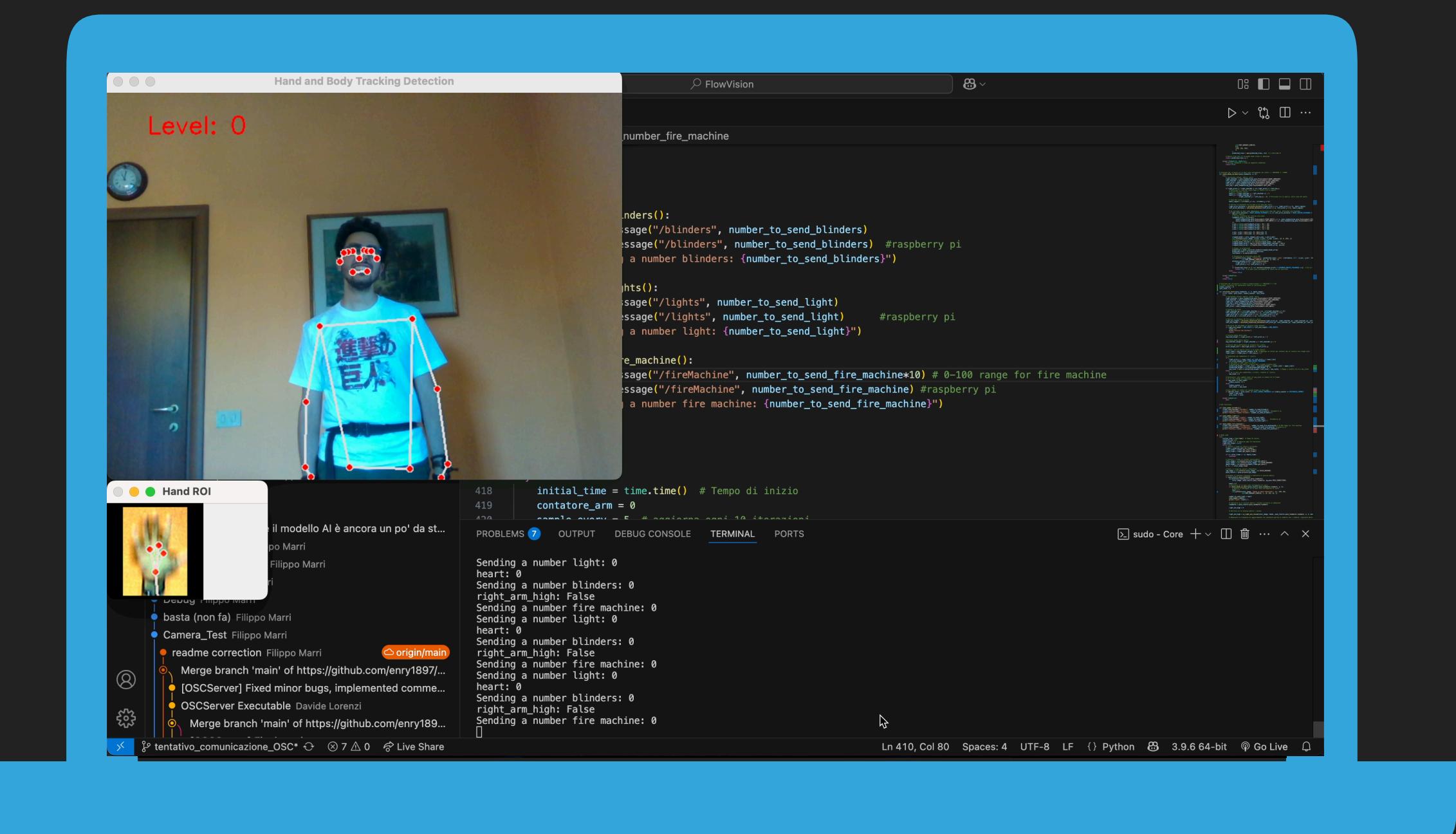
OUTPUT

BEHIND THE SCENE



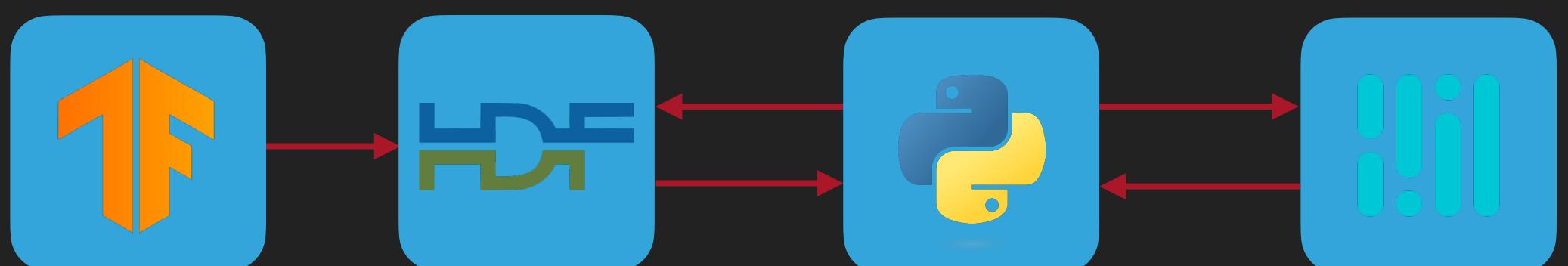
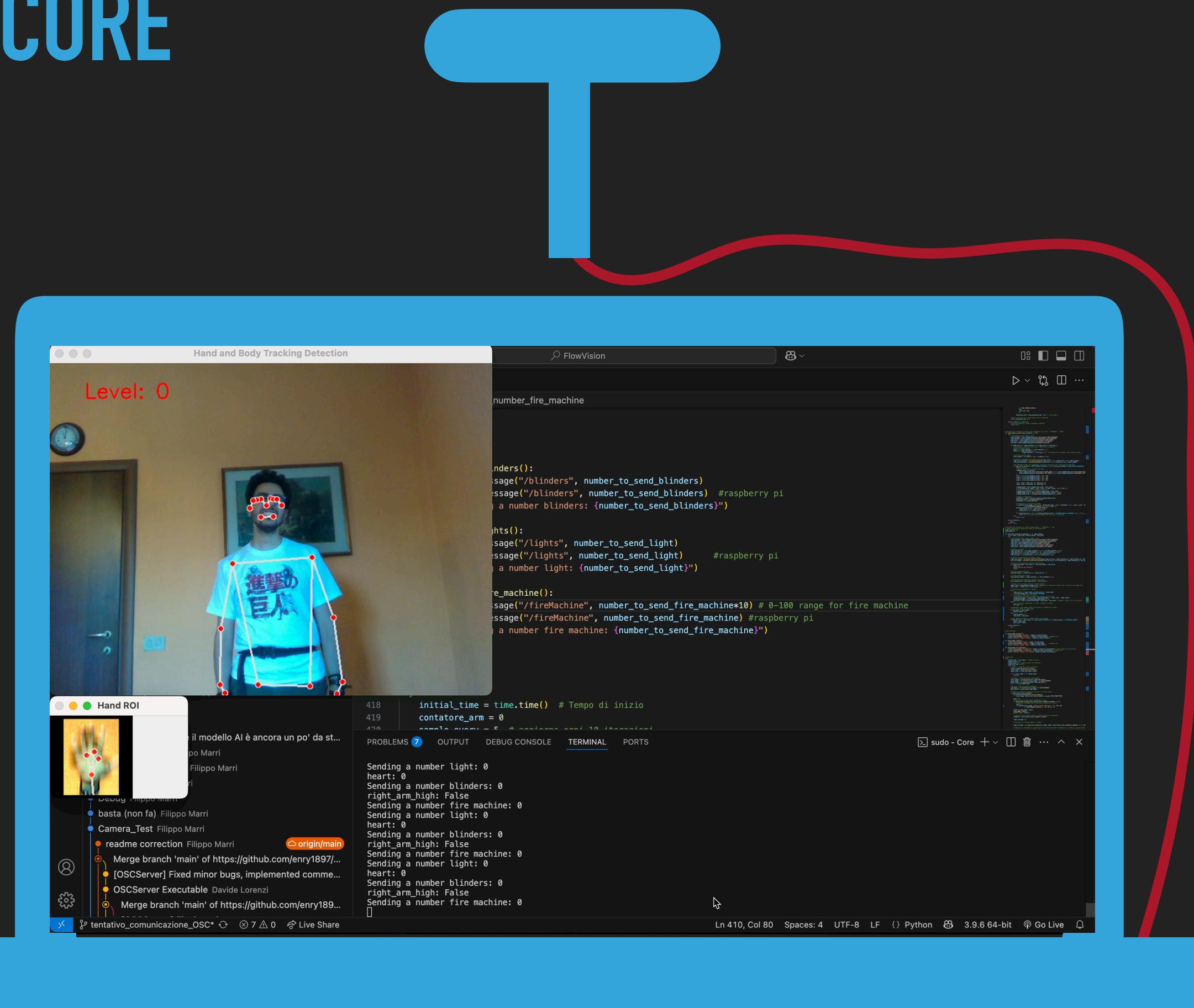
# FLOWVISION

## CORE



# FLOWVISION

## CORE

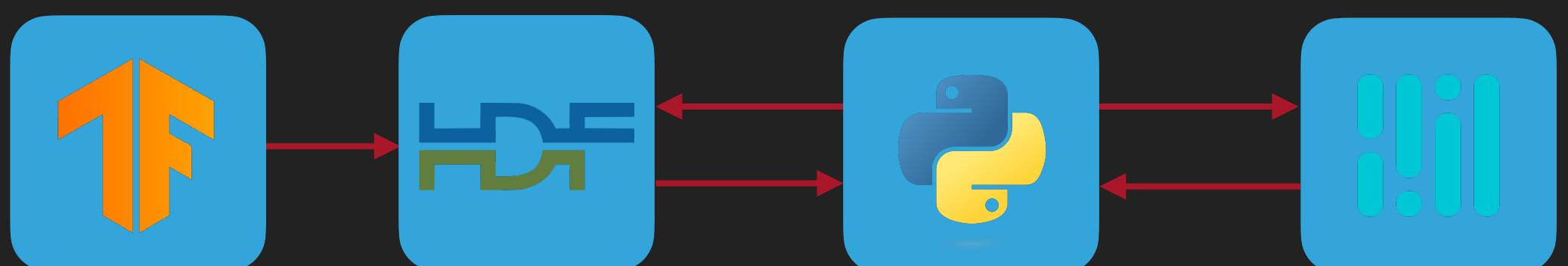
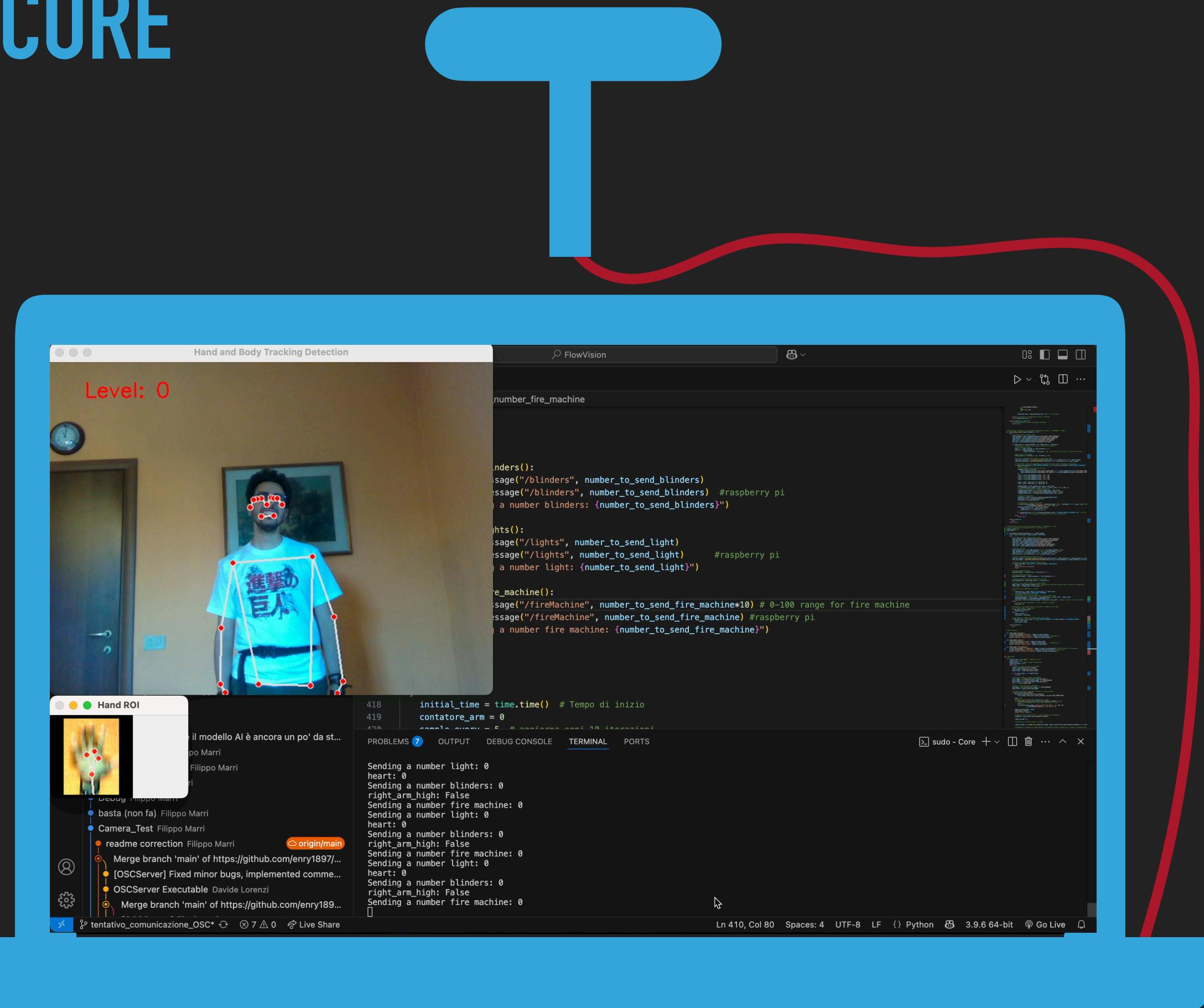


- ▶ MediaPipe module that allows the system to target the position and posture of the user
- ▶ Triggering system
  - ▶ Bigger movements -> Thresholds
  - ▶ Details -> AI models fed with cropped images

Movement	Trigger	Type
Arm lifting on the side	Threshold	Progressive
Heart Gesture	Threshold + AI	ON/OFF
Fist Gesture	Threshold + AI	ON/OFF

# FLOWVISION

## CORE



- ▶ Medium movements -> Thresholds
- ▶ target movement -> AI
- ▶ WHEN THE HAND IS CLOSED, ITS COORDINATES ARE NOT AVAILABLE
- ▶ Triggering system
- ▶ Bigger movements -> Thresholds
- ▶ Details -> AI models fed with cropped images

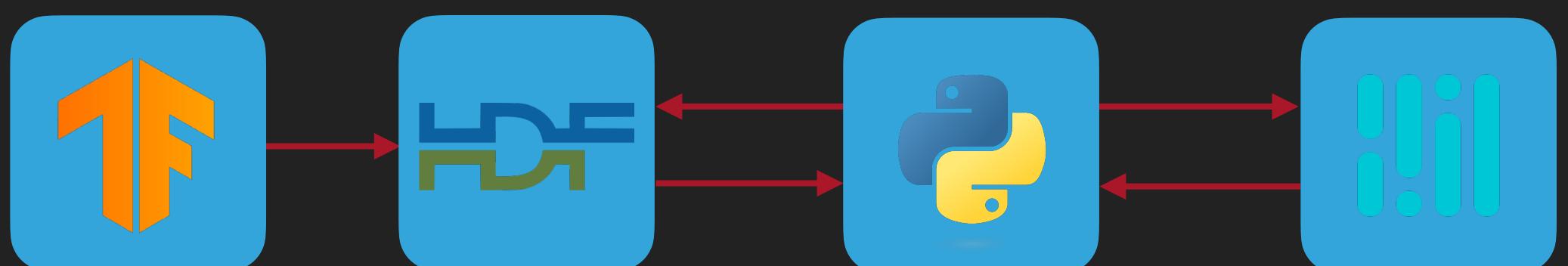
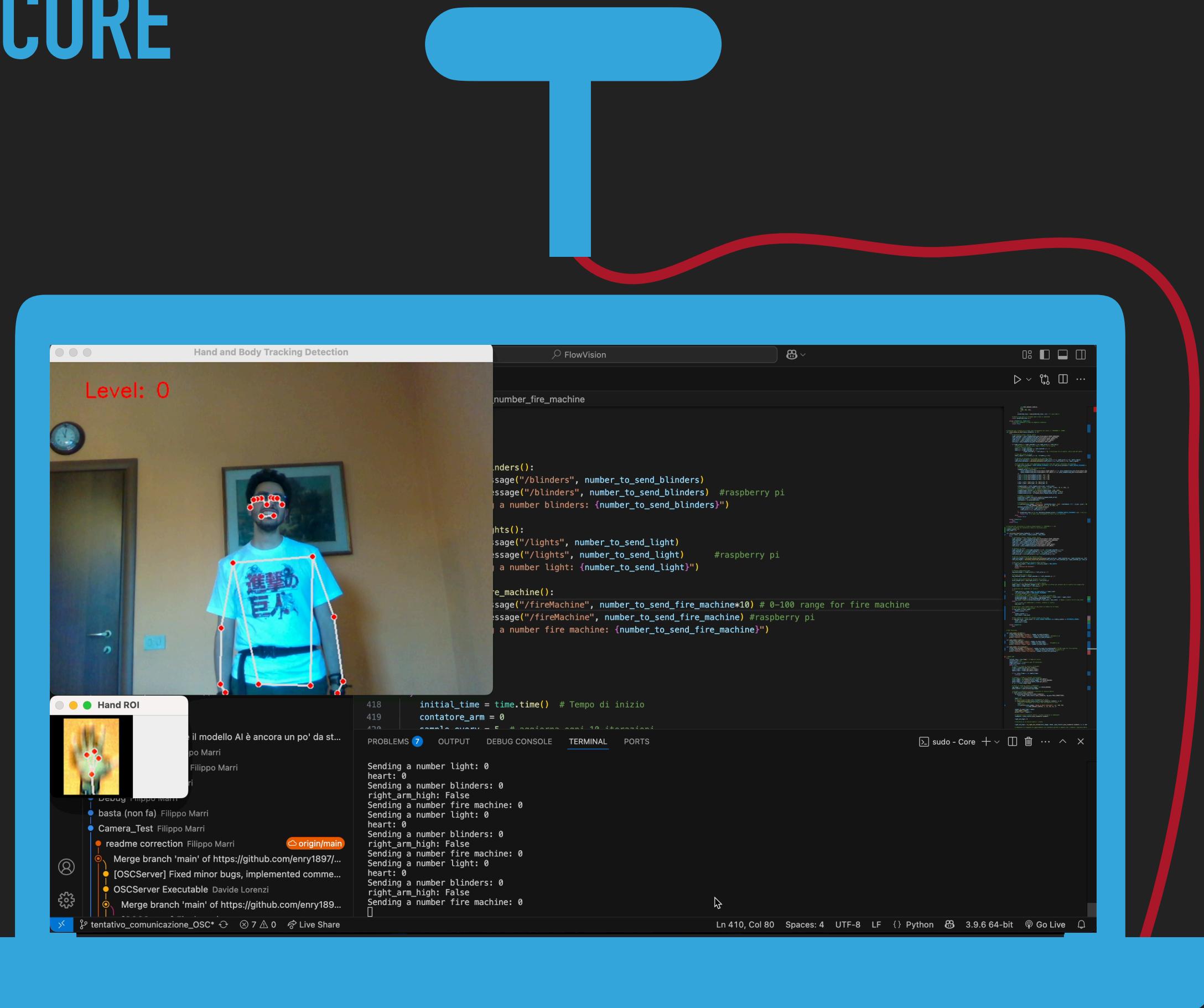
Movement	Trigger	Type
Arm lifting on the side	Threshold	Progressive
Heart Gesture	Threshold + AI	ON/OFF
Fist Gesture	Threshold + AI	ON/OFF

## CHALLENGE:

WHEN THE HAND IS CLOSED, ITS COORDINATES ARE NOT AVAILABLE

# FLOWVISION

## CORE



## SOLUTION:

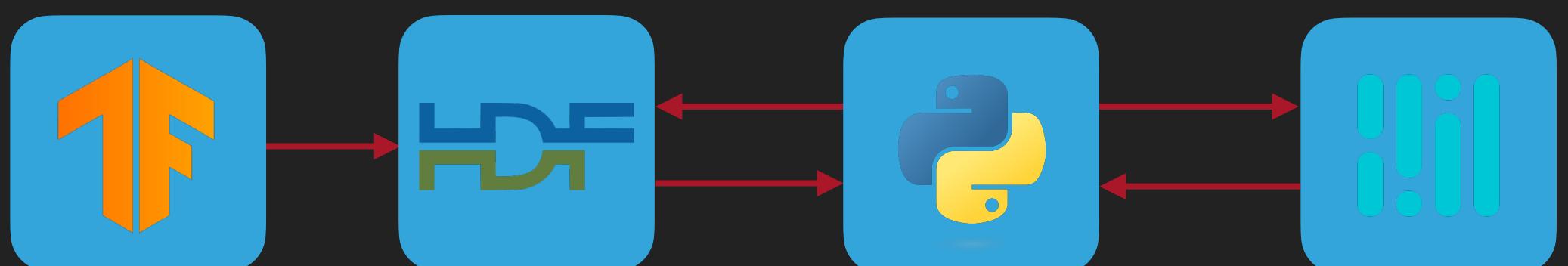
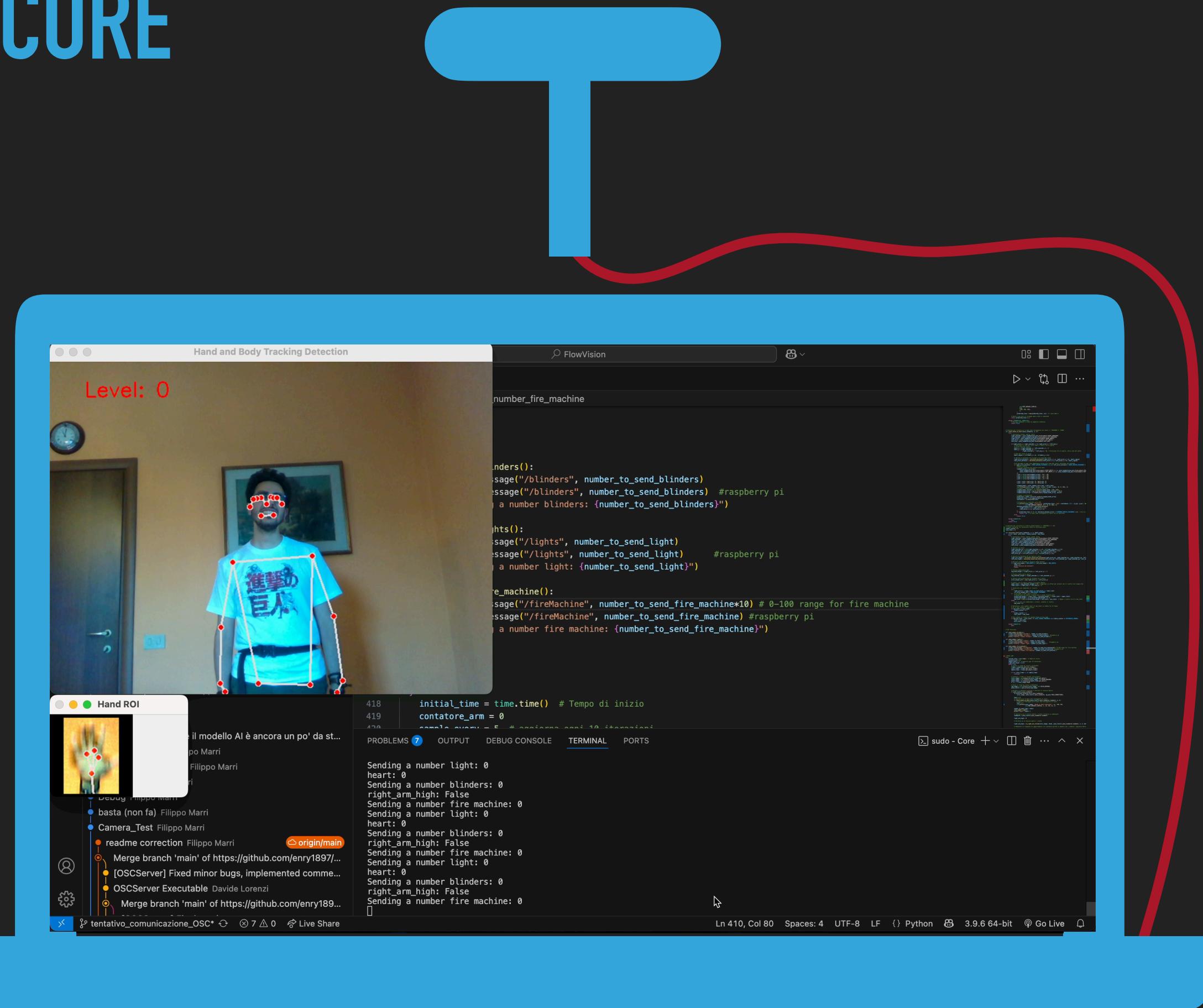
IMPLEMENTATION OF A FALBACK CODE IN WHICH THE  
REFERENCE POINT IS THE WRIST WHEN THE COORDINATE  
OF THE HAND ARE NOT AVAILABLE

- ▶ Median filter to target the hand
- ▶ Triggering system
  - ▶ Bigger movements -> Thresholds
  - ▶ Details -> AI models fed with cropped images

Movement	Trigger	Type
Arm lifting on the side	Threshold	Progressive
Heart Gesture	Threshold + AI	ON/OFF
Fist Gesture	Threshold + AI	ON/OFF

# FLOWVISION

## CORE



- ▶ Median target
- ▶ Triggering system

## SOLUTION:

IMPLEMENTATION OF A FALBACK CODE IN WHICH THE REFERENCE POINT IS THE WRIST WHEN THE COORDINATE OF THE HAND ARE NOT AVAILABLE

- ▶ Buttons
- ▶ Detection

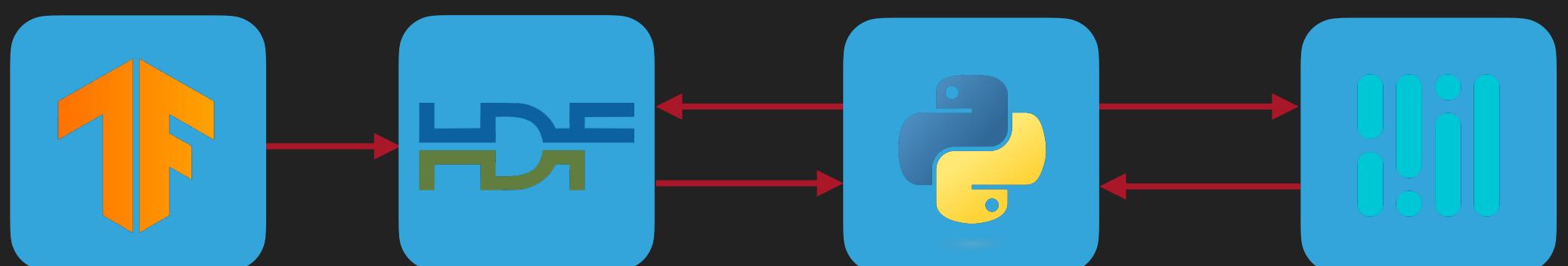
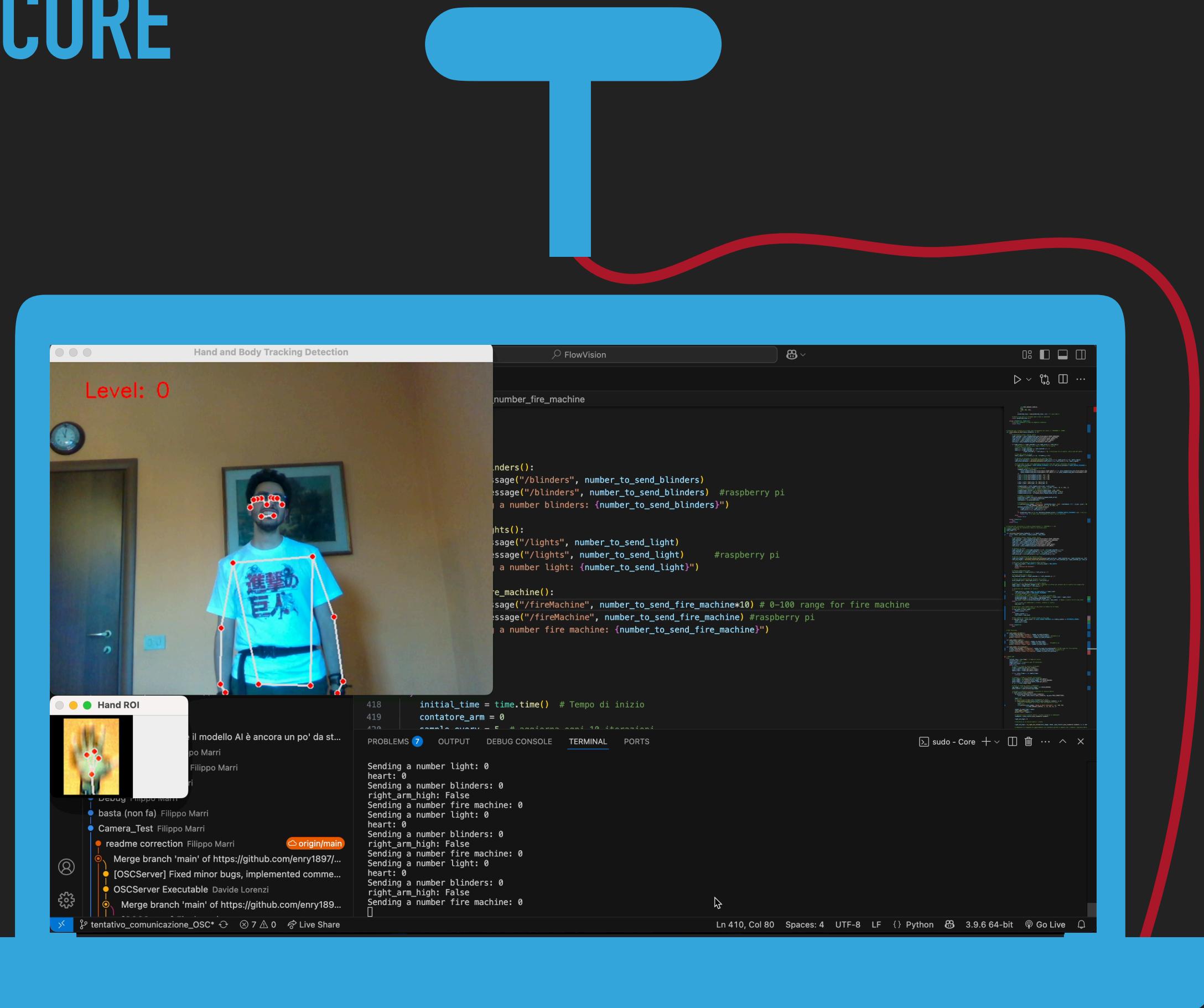
## CHALLENGE:

WHEN THE HANDS ARE PLACED ON THE CHEST, WE GET A MISTAKE: THEY ARE CLASSIFIED AS HEART GESTURE

Movement	Trigger	Type
Arm lifting on the side	Threshold	Progressive
Heart Gesture	Threshold + AI	ON/OFF
Fist Gesture	Threshold + AI	ON/OFF

# FLOWVISION

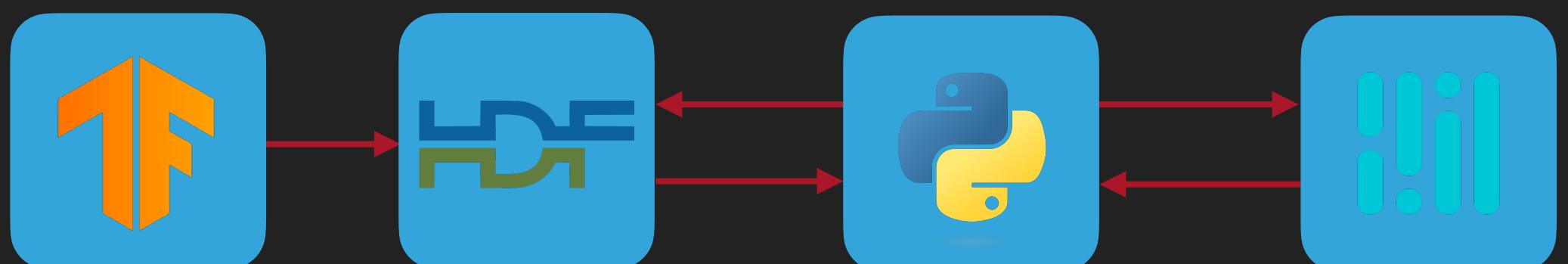
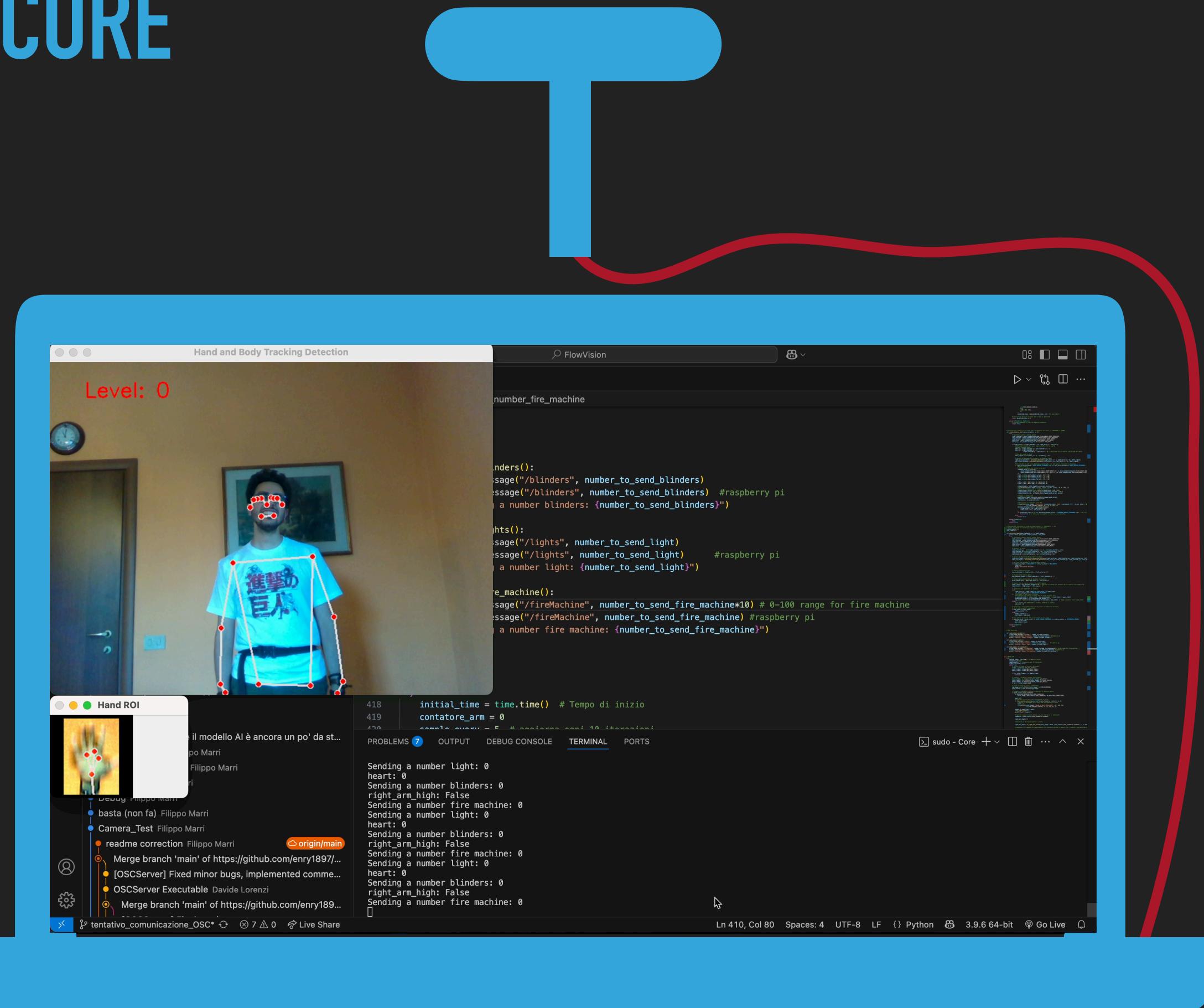
## CORE



▶ Mediapipe	SOLUTION: IMPLEMENTATION OF A FALBACK CODE IN WHICH THE REFERENCE POINT IS THE WRIST WHEN THE COORDINATE OF THE HAND ARE NOT AVAILABLE	
▶ Triggering system	SOLUTION: IMPLEMENTATION OF A SCRIPT THAT IMPOSE THE CONDITION THAT THE WRIST ARE NOT OVERLAPPED DURING THE HEART GESTURE	
▶ Body movement		
▶ Detection		
Movement	Trigger	Type
Arm lifting on the side	Threshold	Progressive
Heart Gesture	Threshold + AI	ON/OFF
Fist Gesture	Threshold + AI	ON/OFF

# FLOWVISION

## CORE



- ▶ Median target
  - ▶ Triggering system
  - ▶ Body detection
  - ▶ Depth camera
- SOLUTION:**  
IMPLEMENTATION OF A FALBACK CODE IN WHICH THE  
REFERENCE POINT IS THE WRIST WHEN THE COORDINATE  
OF THE HAND ARE NOT AVAILABLE
- SOLUTION:**  
IMPLEMENTATION OF A SCRIPT THAT IMPOSE THE  
CONDITION THAT THE WRIST ARE NOT OVERLAPPED  
DURING THE HEART GESTURE
- CHALLENGE:**  
NO AVAILABLE DATASET TO IMPLEMENT A RNN NETWORK

Heart Gesture

Threshold +  
AI

ON/OFF

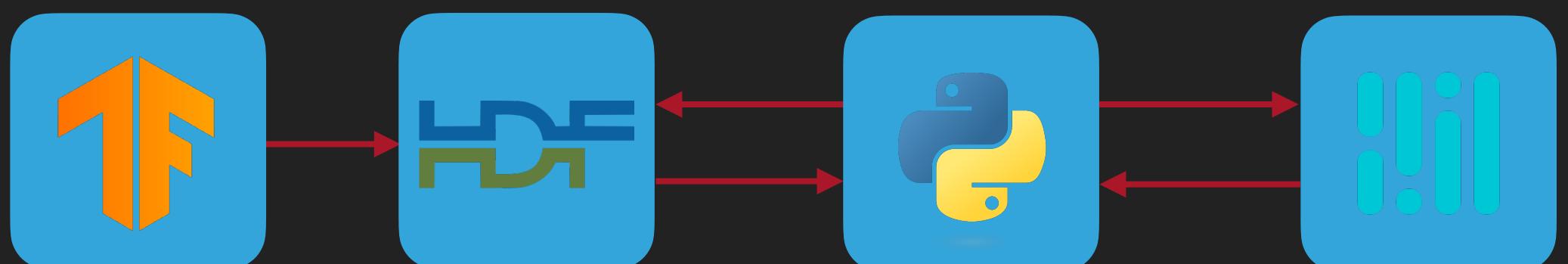
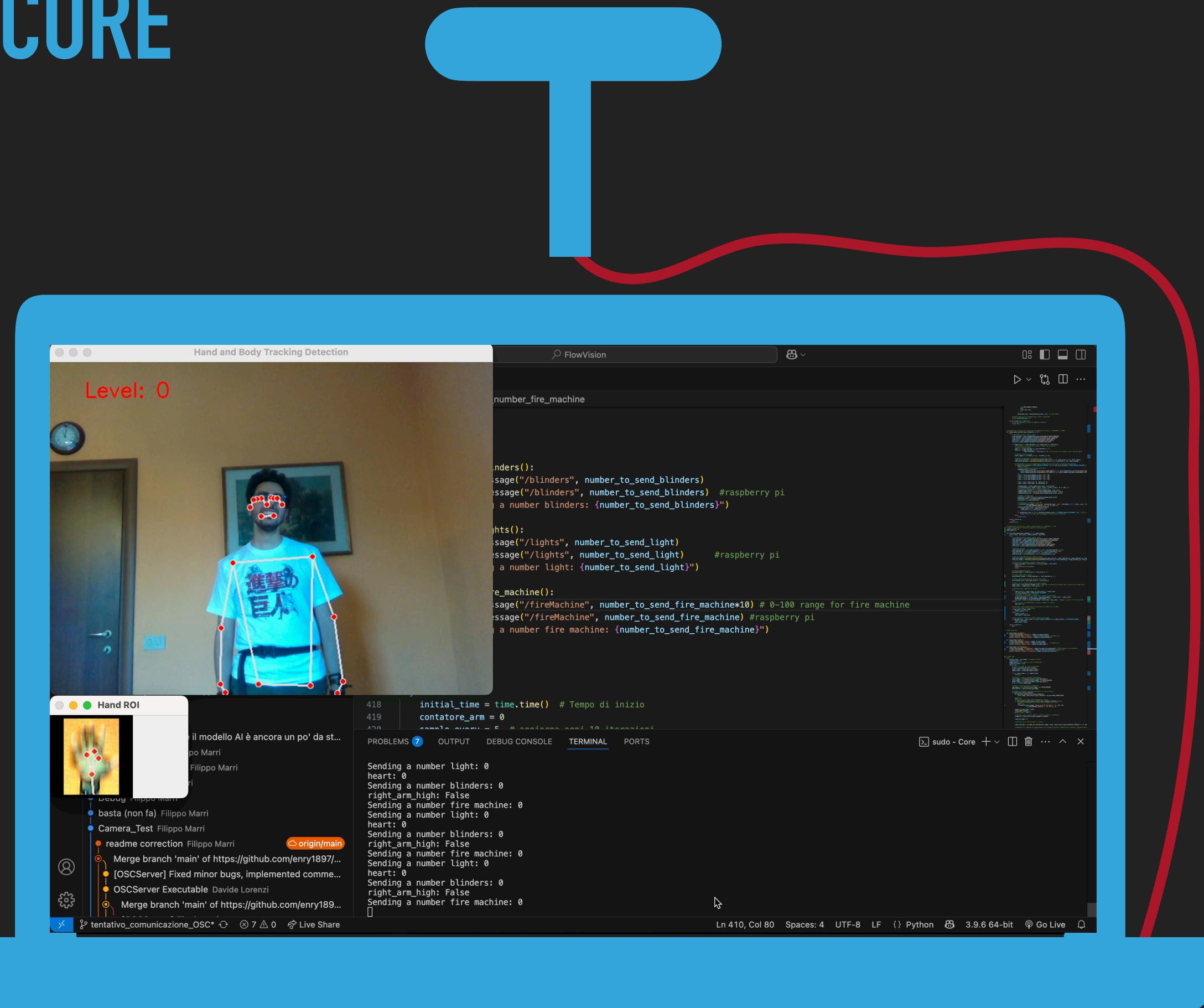
Fist Gesture

Threshold +  
AI

ON/OFF

# FLOWVISION

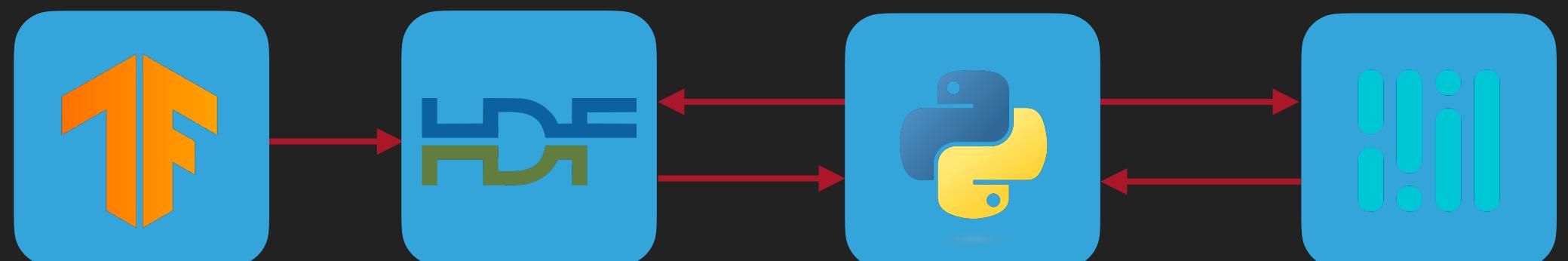
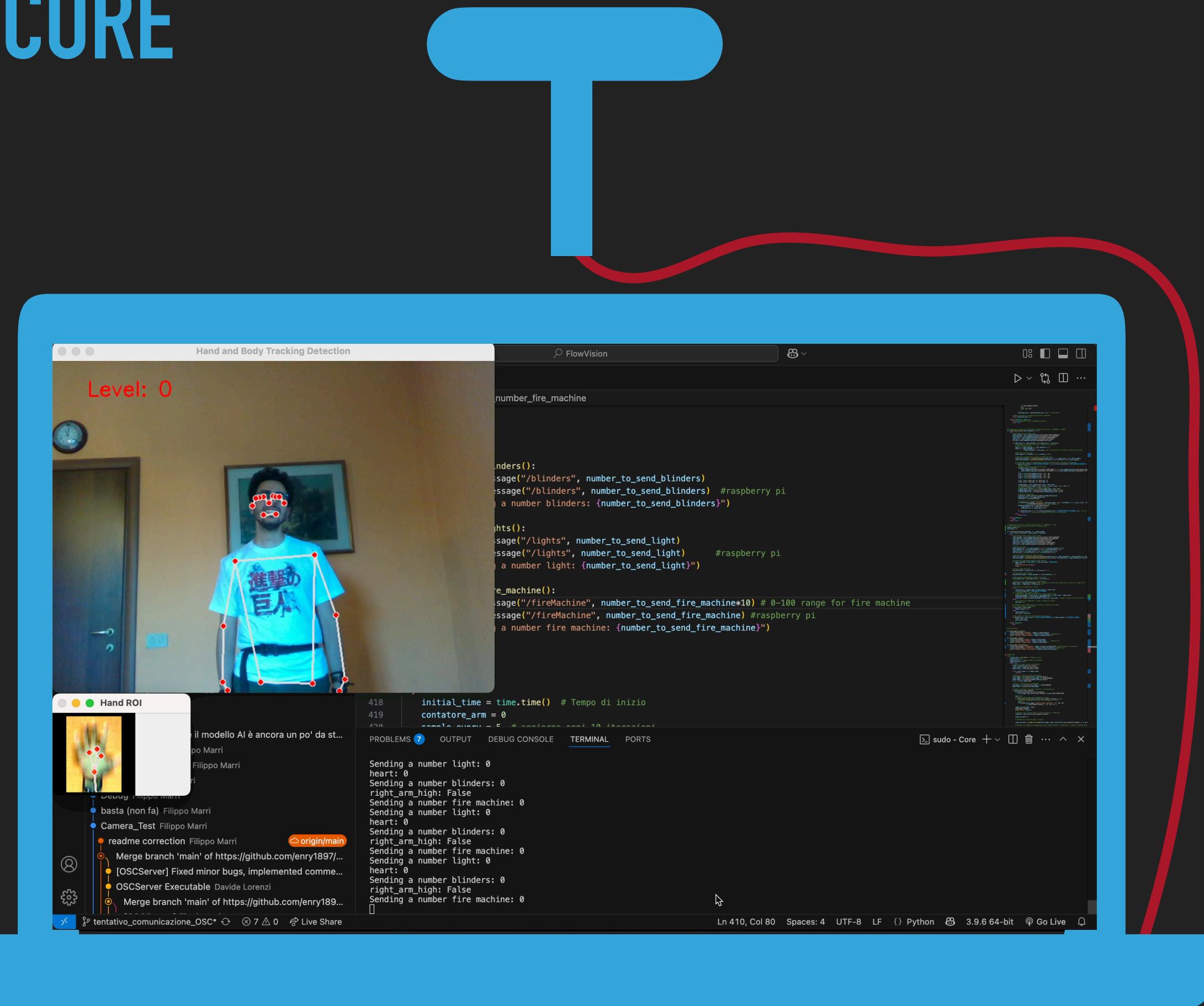
## CORE



- ▶ Median target
- ▶ Triggering system
- ▶ Body detection
- ▶ Depth camera
- ▶ Model
- ▶ Arm lifting on the side
- ▶ Heart Gesture
- ▶ Fist Gesture
- ▶ Solution:  
IMPLEMENTATION OF A FALBACK CODE IN WHICH THE  
REFERENCE POINT IS THE WRIST WHEN THE COORDINATE  
OF THE HAND ARE NOT AVAILABLE
- ▶ Solution:  
IMPLEMENTATION OF A SCRIPT THAT IMPOSE THE  
CONDITION THAT THE WRIST ARE NOT OVERLAPPED  
DURING THE HEART GESTURE
- ▶ Solution:  
HYBRID MODELS (THRESHOLD + CNN)
- ▶ ON/OFF
- ▶ ON/OFF

# FLOWVISION

## CORE



- ▶ Media target
  - ▶ Triggering system
  - ▶ Body
  - ▶ Detection
  - ▶ Model
  - ▶ Arm
  - ▶ Hand
  - ▶ Hearing
  - ▶ Fist Gesture
  - ▶ ...
  - ▶ AI
- ### SOLUTION:

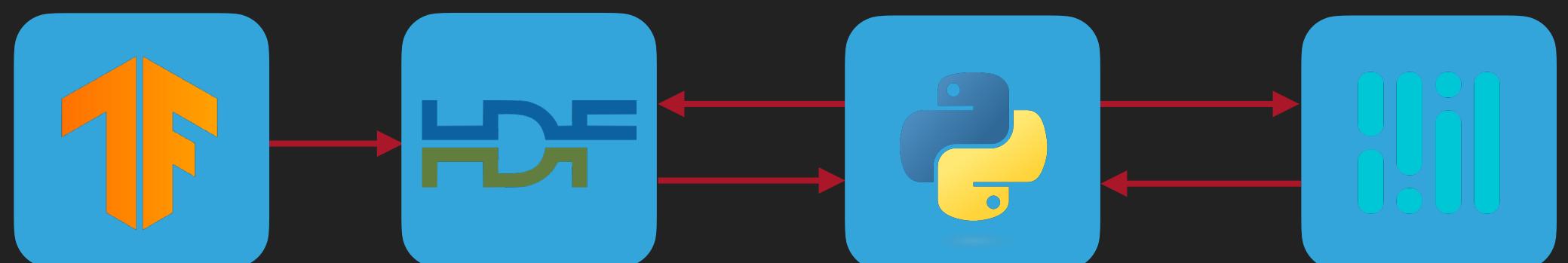
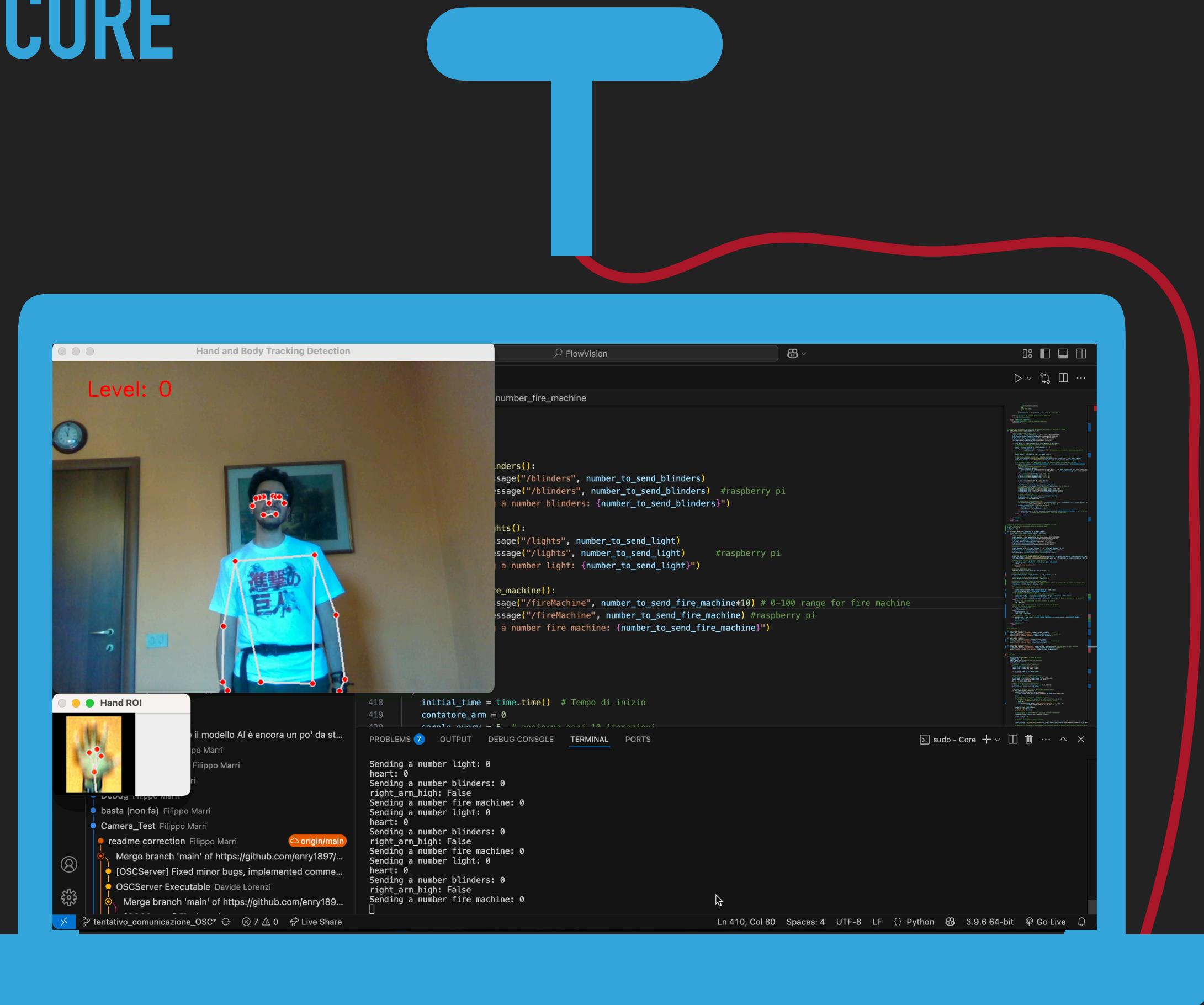
IMPLEMENTATION OF A FALBACK CODE IN WHICH THE REFERENCE POINT IS THE WRIST WHEN THE COORDINATE OF THE HAND ARE NOT AVAILABLE
- ### SOLUTION:

IMPLEMENTATION OF A SCRIPT THAT IMPOSE THE CONDITION THAT THE WRIST ARE NOT OVERLAPPED DURING THE HEART GESTURE
- ### CHALLENGE:

THE MODEL DOES NOT WORK WELL IF THERE IS NO PROPER ILLUMINATION

# FLOWVISION

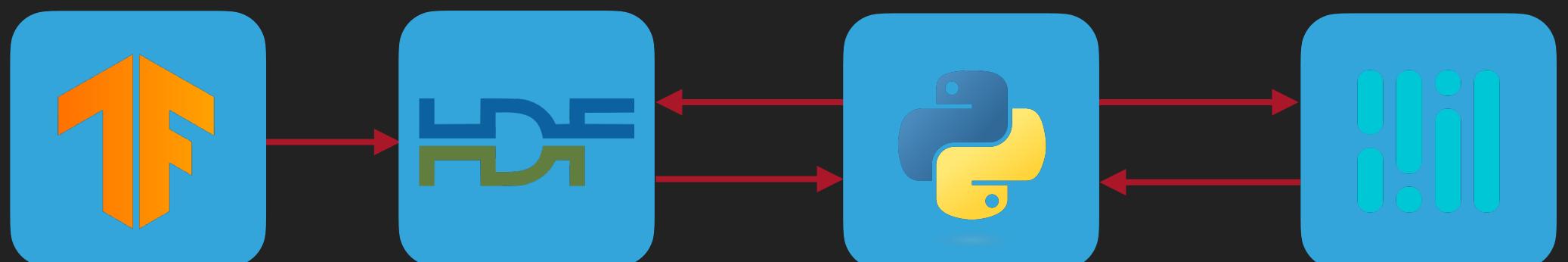
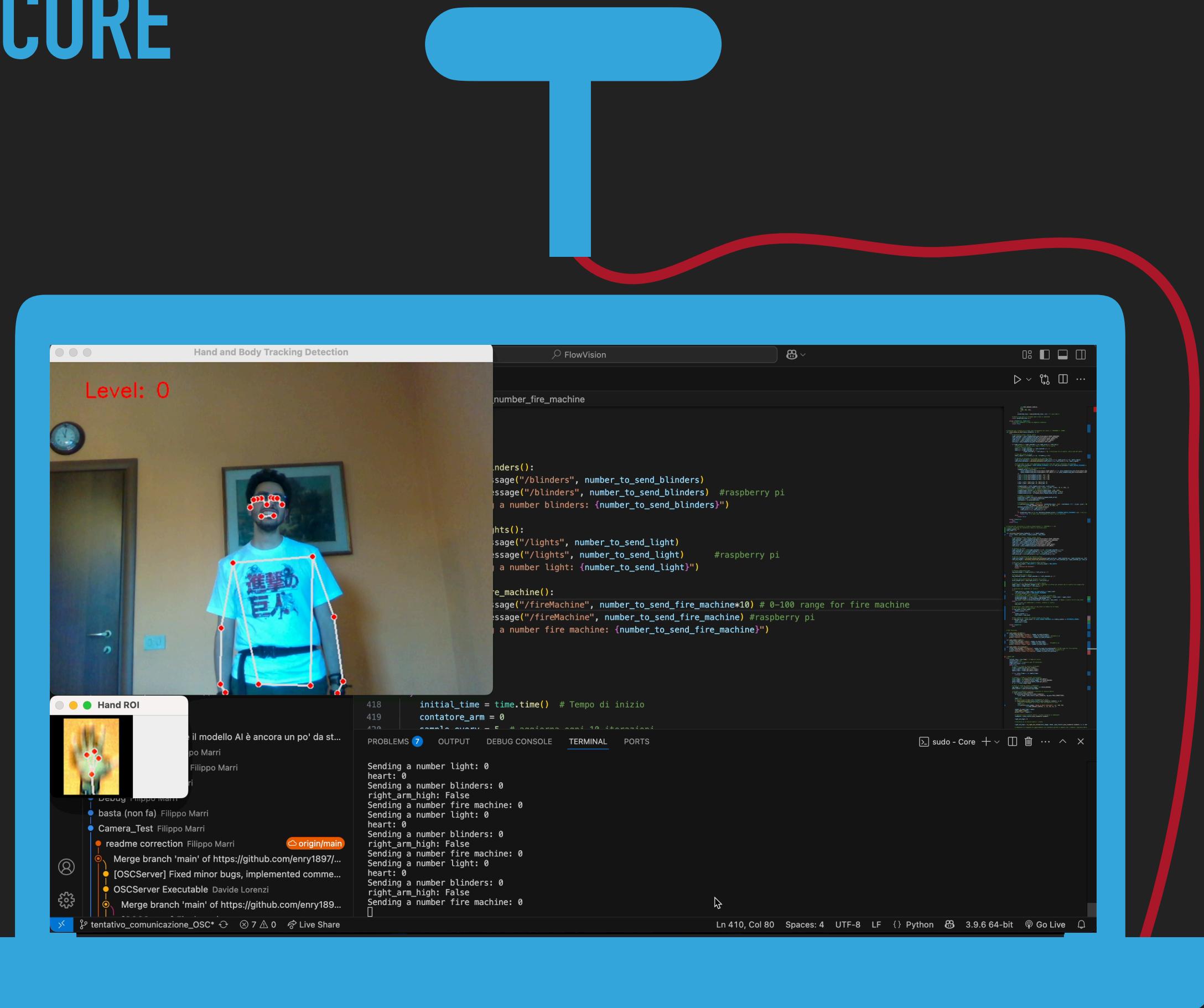
## CORE



- ▶ **SOLUTION:**  
IMPLEMENTATION OF A FALBACK CODE IN WHICH THE  
REFERENCE POINT IS THE WRIST WHEN THE COORDINATE  
OF THE HAND ARE NOT AVAILABLE
- ▶ **SOLUTION:**  
IMPLEMENTATION OF A SCRIPT THAT IMPOSE THE  
CONDITION THAT THE WRIST ARE NOT OVERLAPPED  
DURING THE HEART GESTURE
- ▶ **SOLUTION:**  
HYBRID MODELS (THRESHOLD + CNN)
- ▶ **SOLUTION:**  
INCREASING THE RESOLUTION OF THE IMAGE, WE GET  
BETTER PERFORMANCE

# FLOWVISION

## CORE



- ▶ Median target
  - ▶ Triggering system
  - ▶ Body detection
  - ▶ Depth camera
  - ▶ Motion detection
  - ▶ Arm tracking
  - ▶ Hand tracking
  - ▶ Gesture recognition
  - ▶ Fist detection
  - ▶ Heart detection
  - ▶ AI
- ### SOLUTION:

IMPLEMENTATION OF A FALBACK CODE IN WHICH THE REFERENCE POINT IS THE WRIST WHEN THE COORDINATE OF THE HAND ARE NOT AVAILABLE
- ### SOLUTION:

IMPLEMENTATION OF A SCRIPT THAT IMPOSE THE CONDITION THAT THE WRIST ARE NOT OVERLAPPED DURING THE HEART GESTURE
- ### SOLUTION:

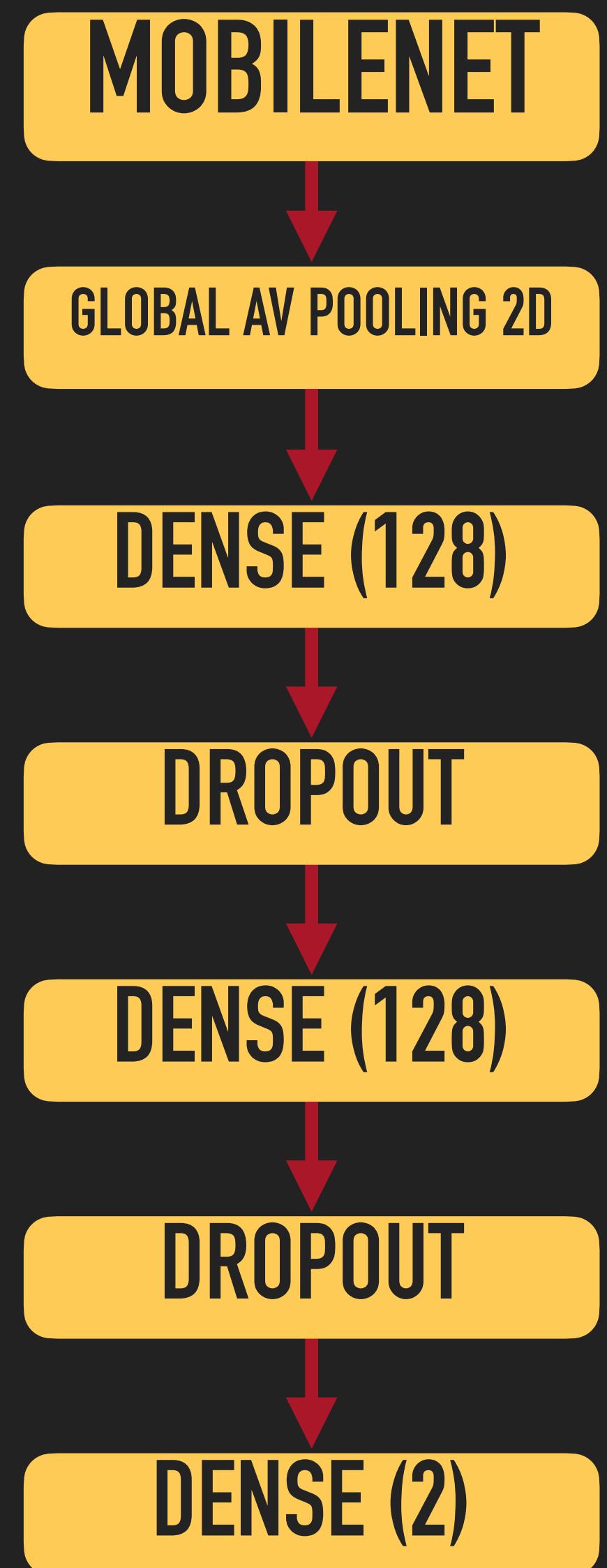
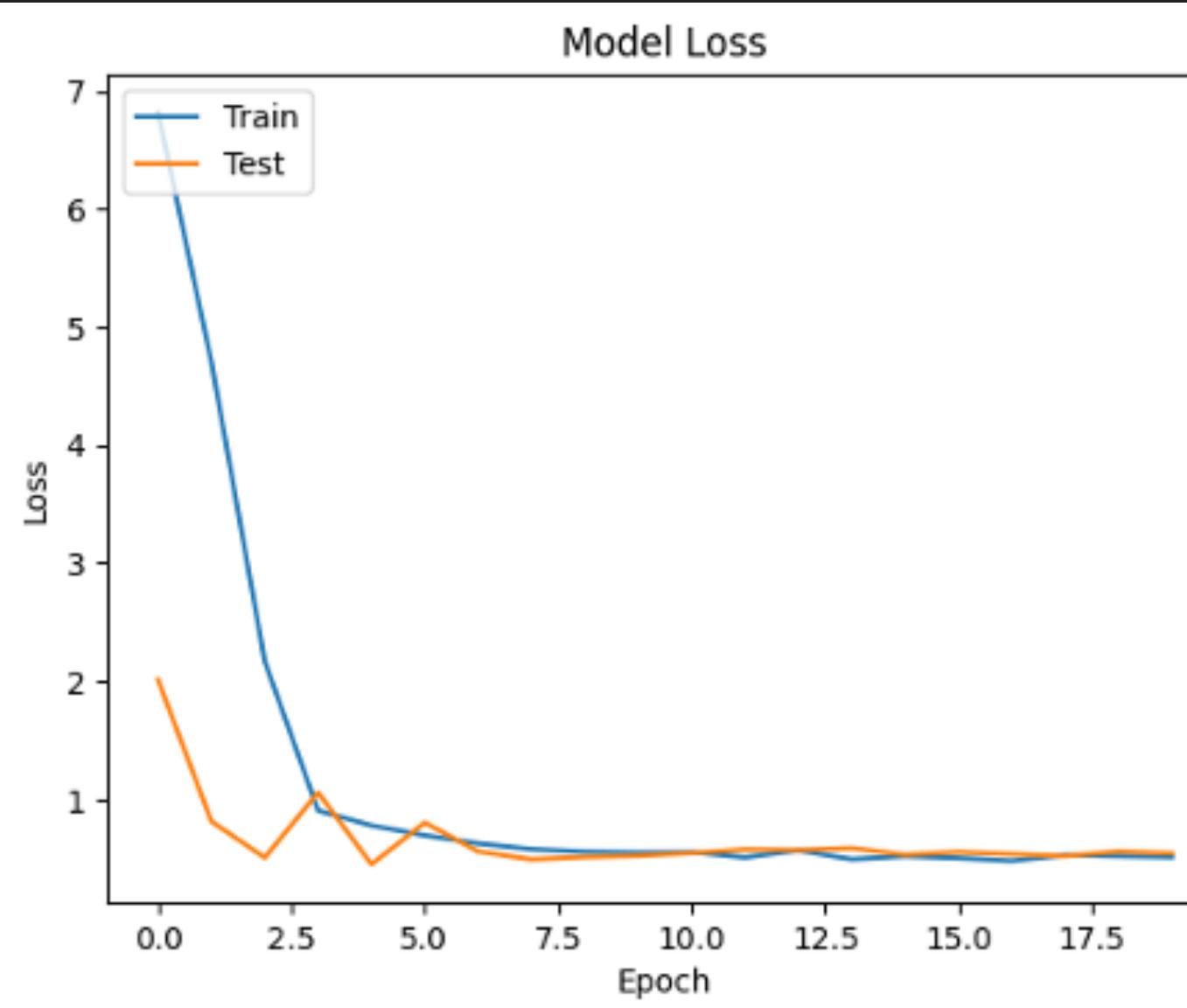
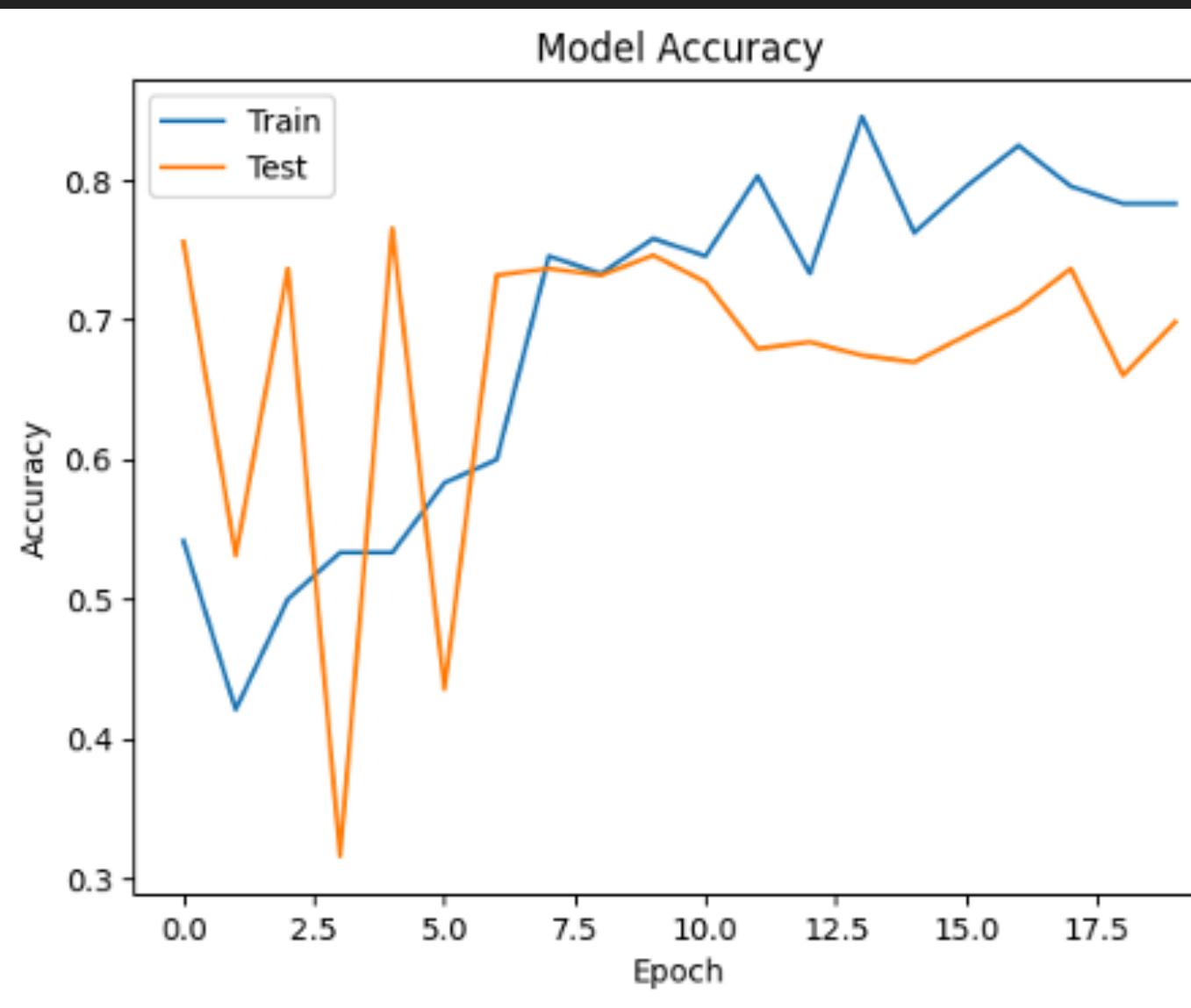
HYBRID MODELS (THRESHOLD + CNN)

TRADE-OFF:

A HIGHER RESOLUTION IS NOT SUPPORTED WITH OUR COMPUTATIONAL POWER SO WE DECIDED TO WORK AS MUCH AS POSSIBLE ON THE IMAGE PRE-PROCESSING

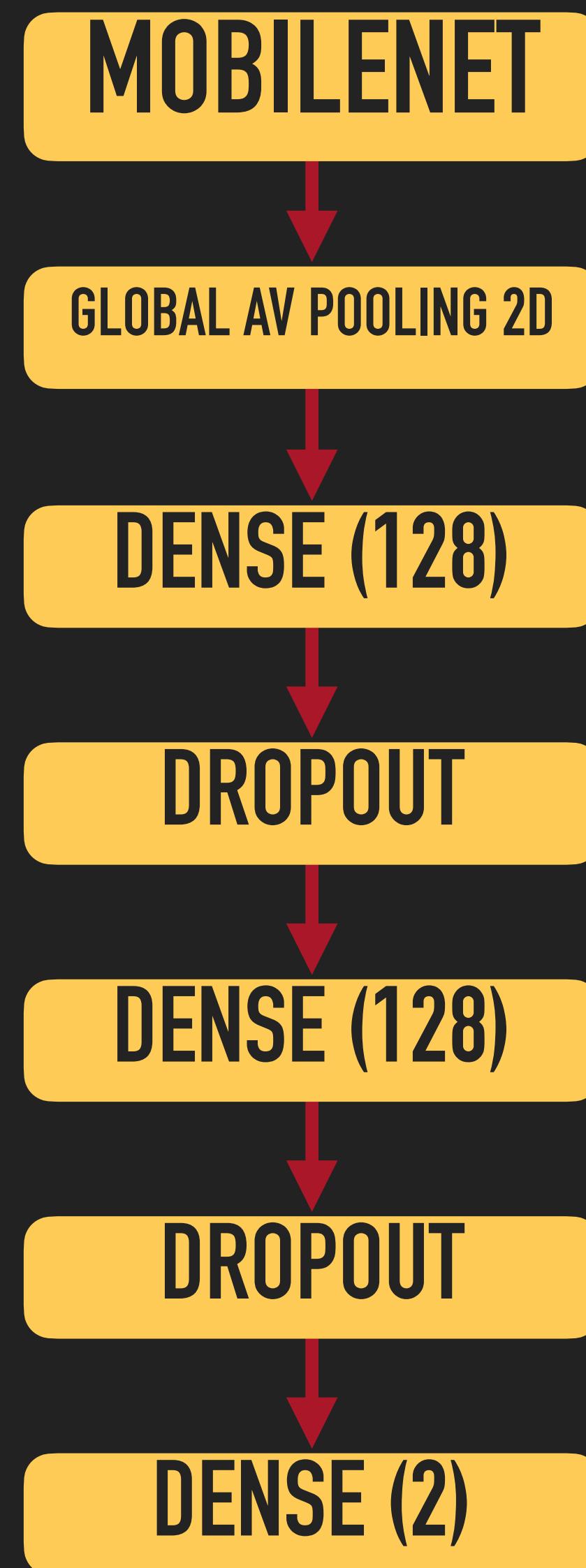
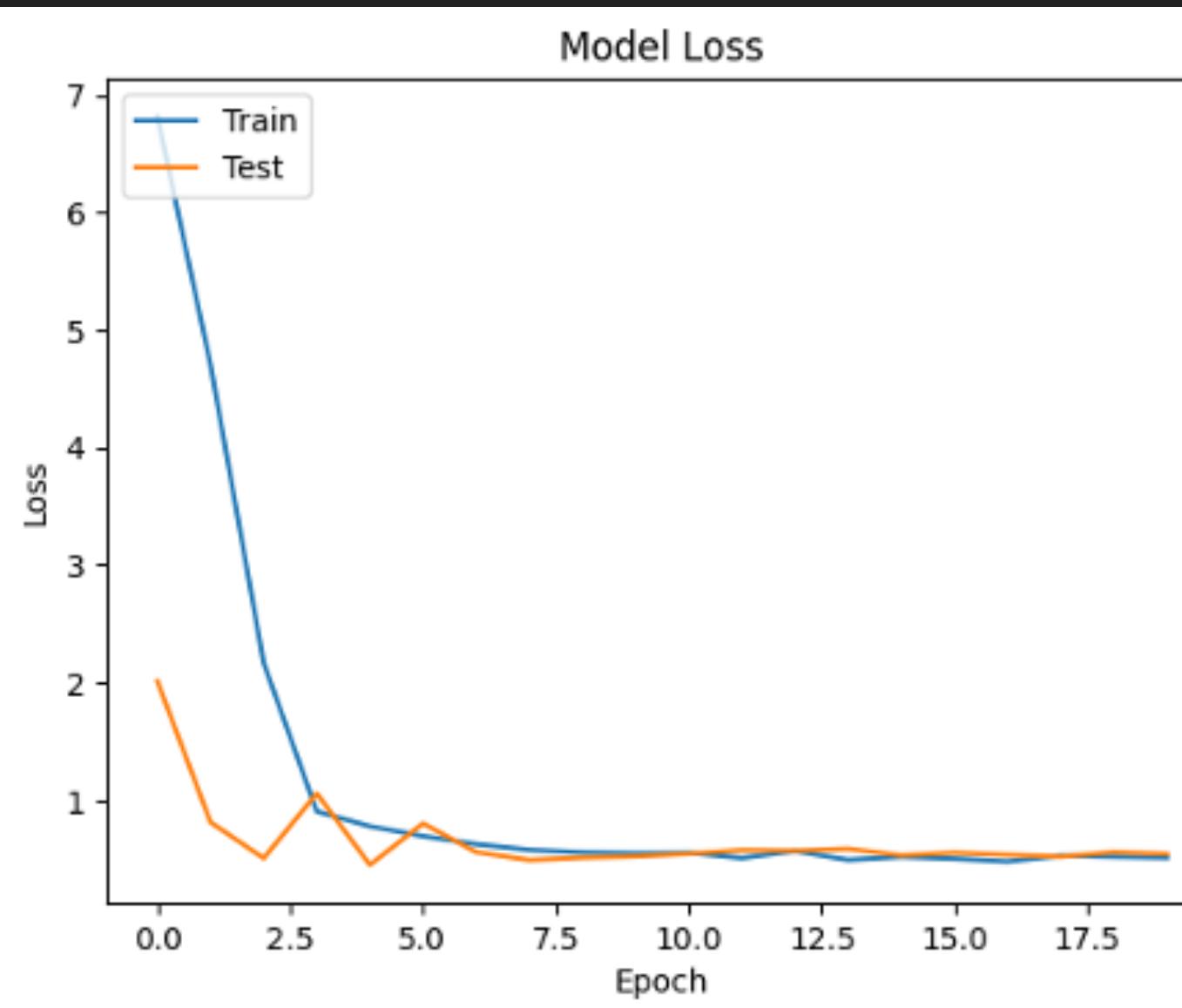
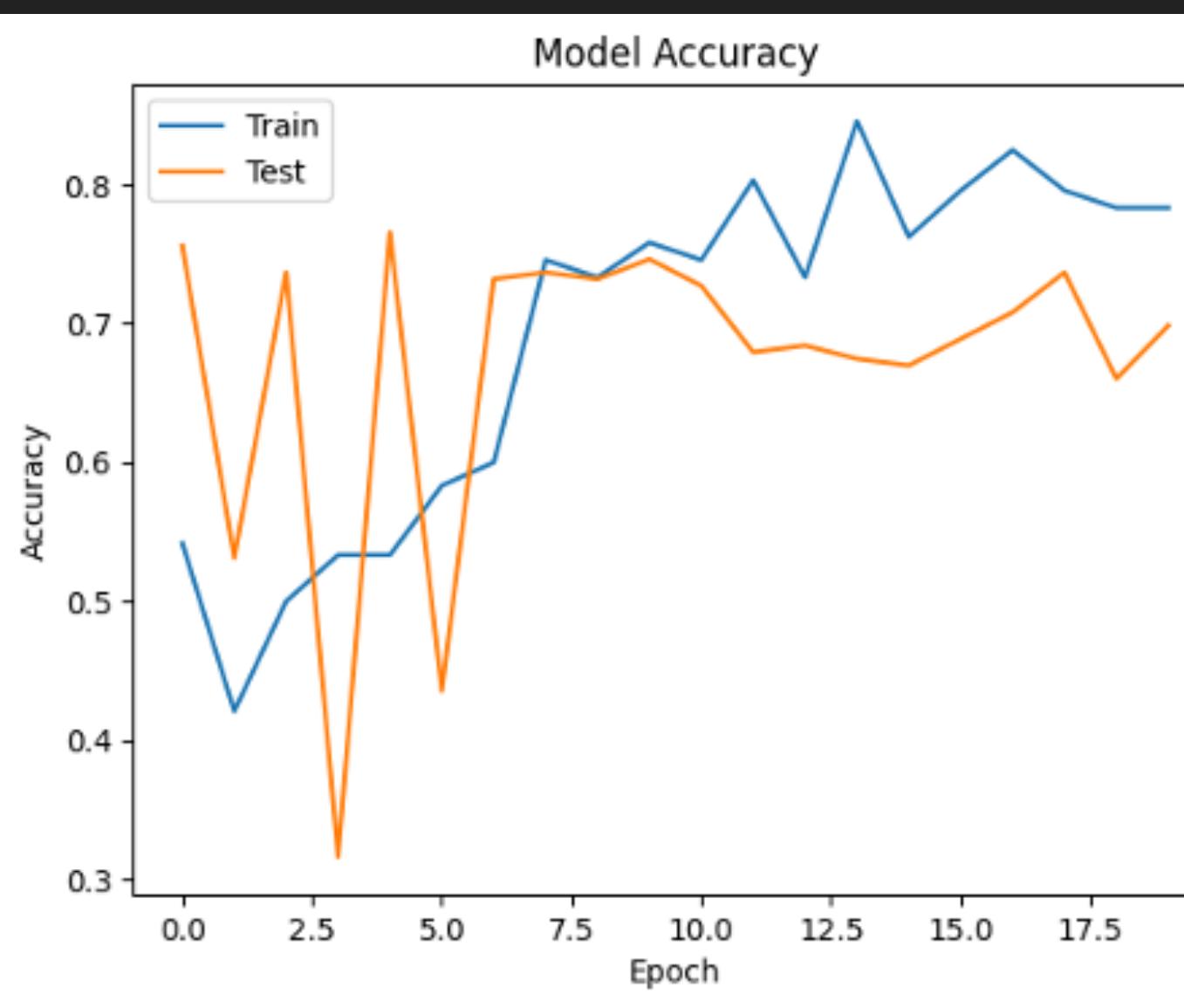
# CORE - AI MODELS: FIST GESTURE

# CORE - AI MODELS: FIST GESTURE



- ▶ Complex model
- ▶ More than 3 million of parameters
- ▶ Strong-pre processing on the image that feeds the Neural Network

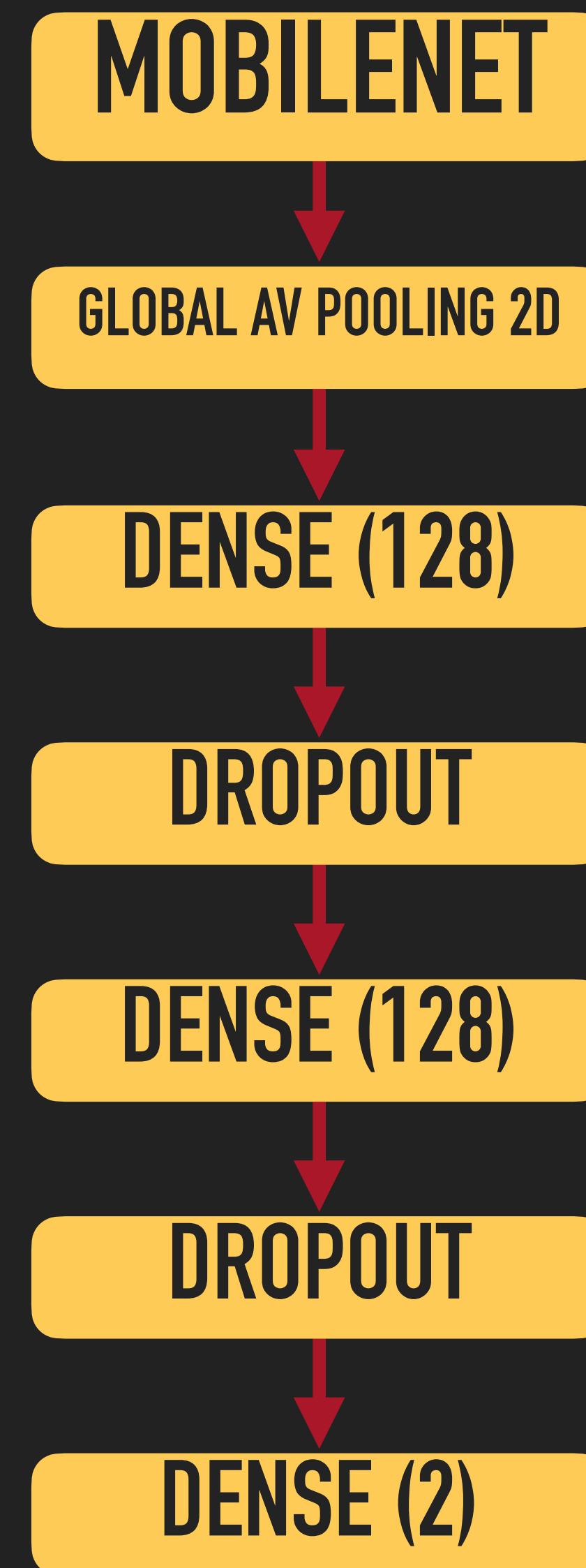
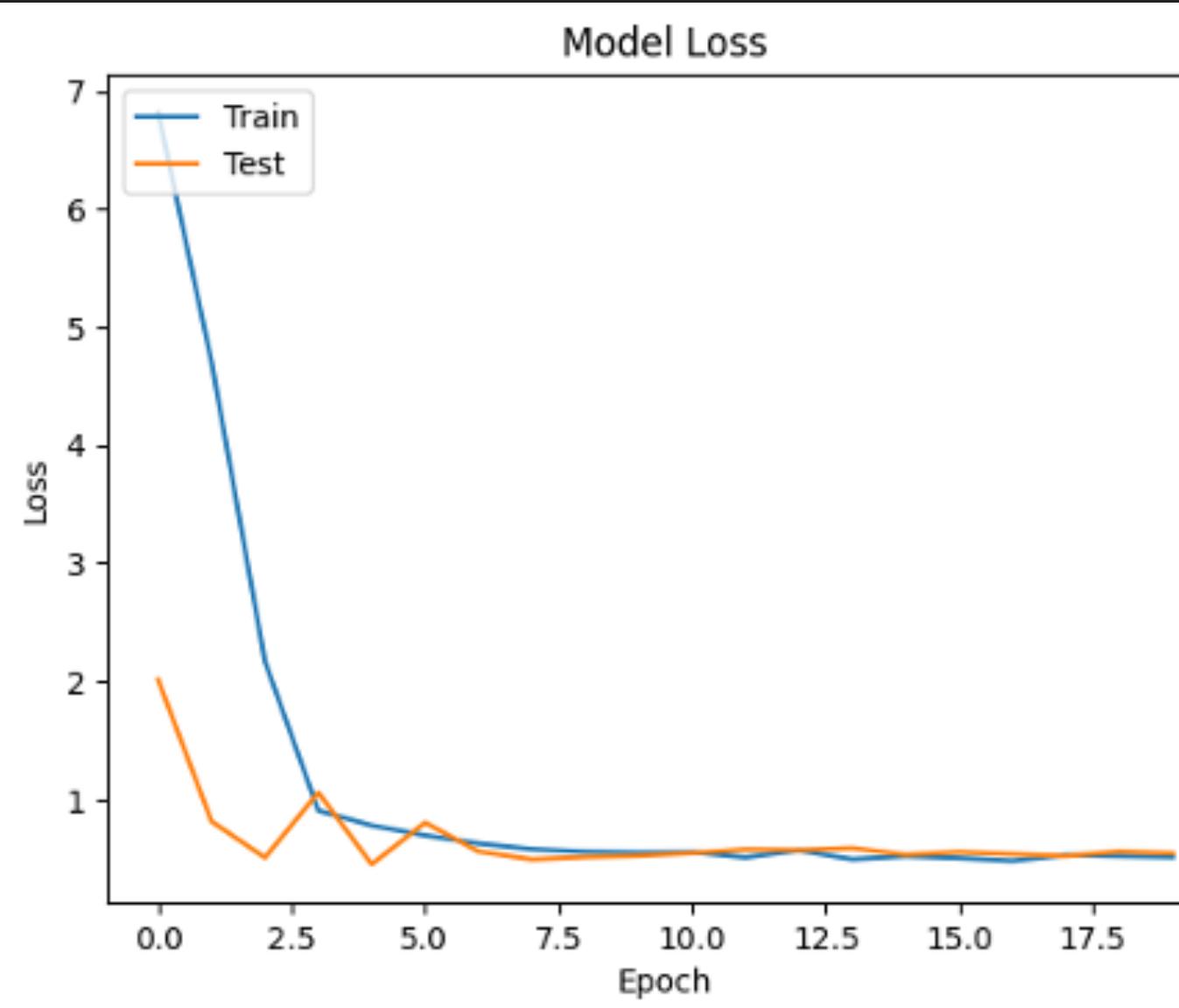
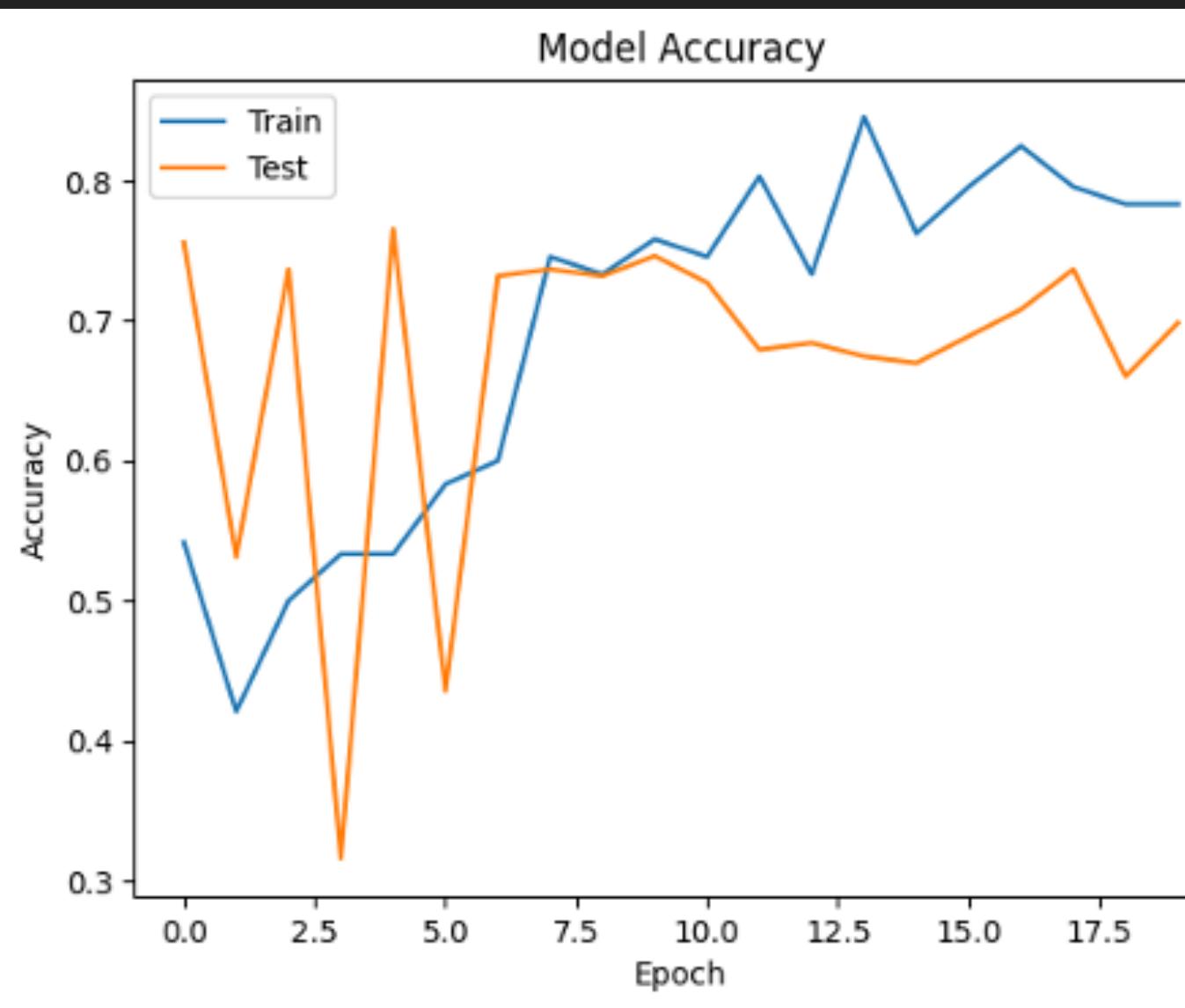
# CORE - AI MODELS: FIST GESTURE



- ▶ Complex model
- ▶ More than 3 million of parameters
- ▶ Strong-pre processing on the image that feeds the Neural Network

**CHALLENGE:**  
AFTER AN UPDATING OF THE LIBRARIES OF KERAS AND TENSOR FLOW, THE FIRST MODEL STOPPED WORKING

# CORE - AI MODELS: FIST GESTURE

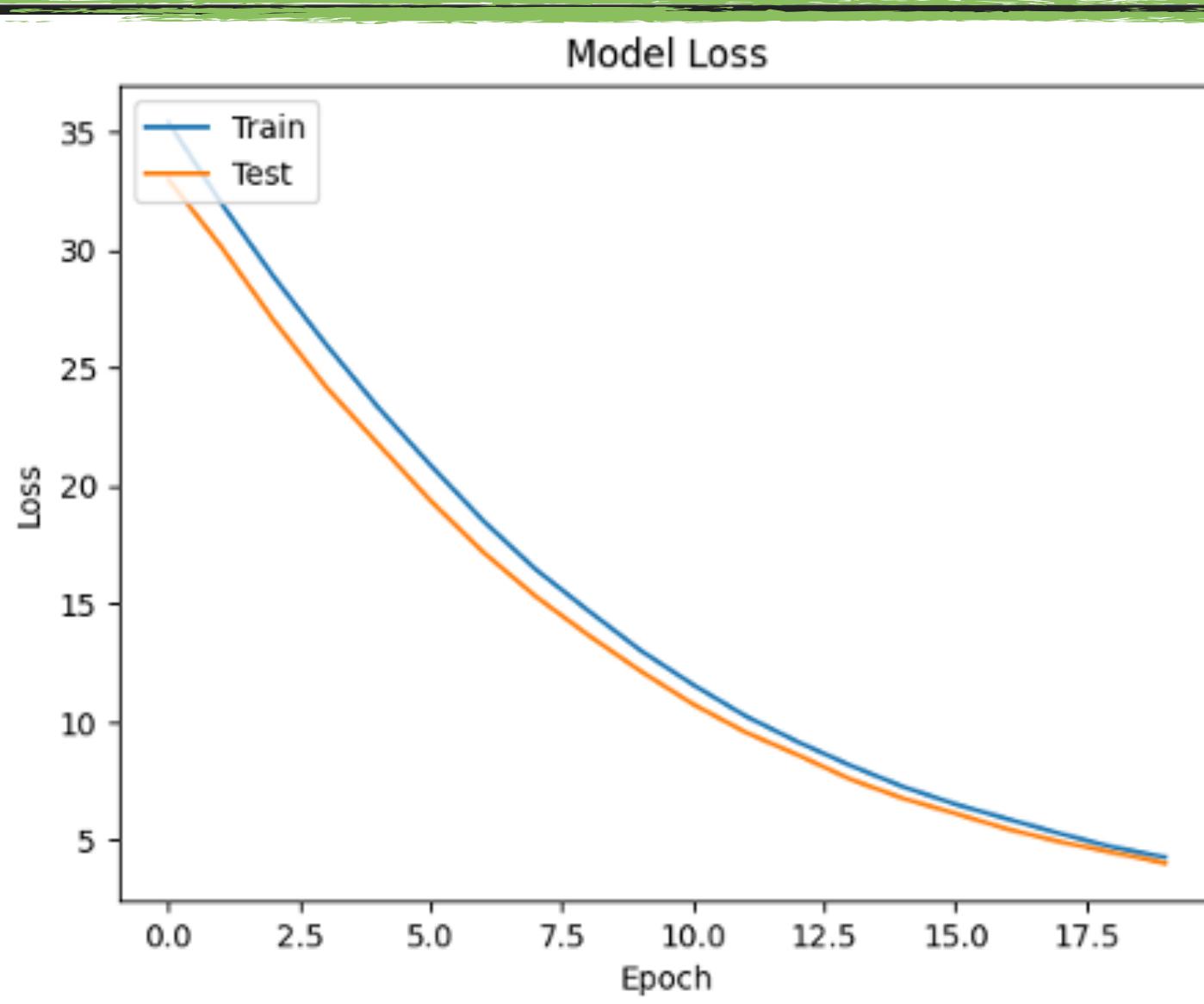
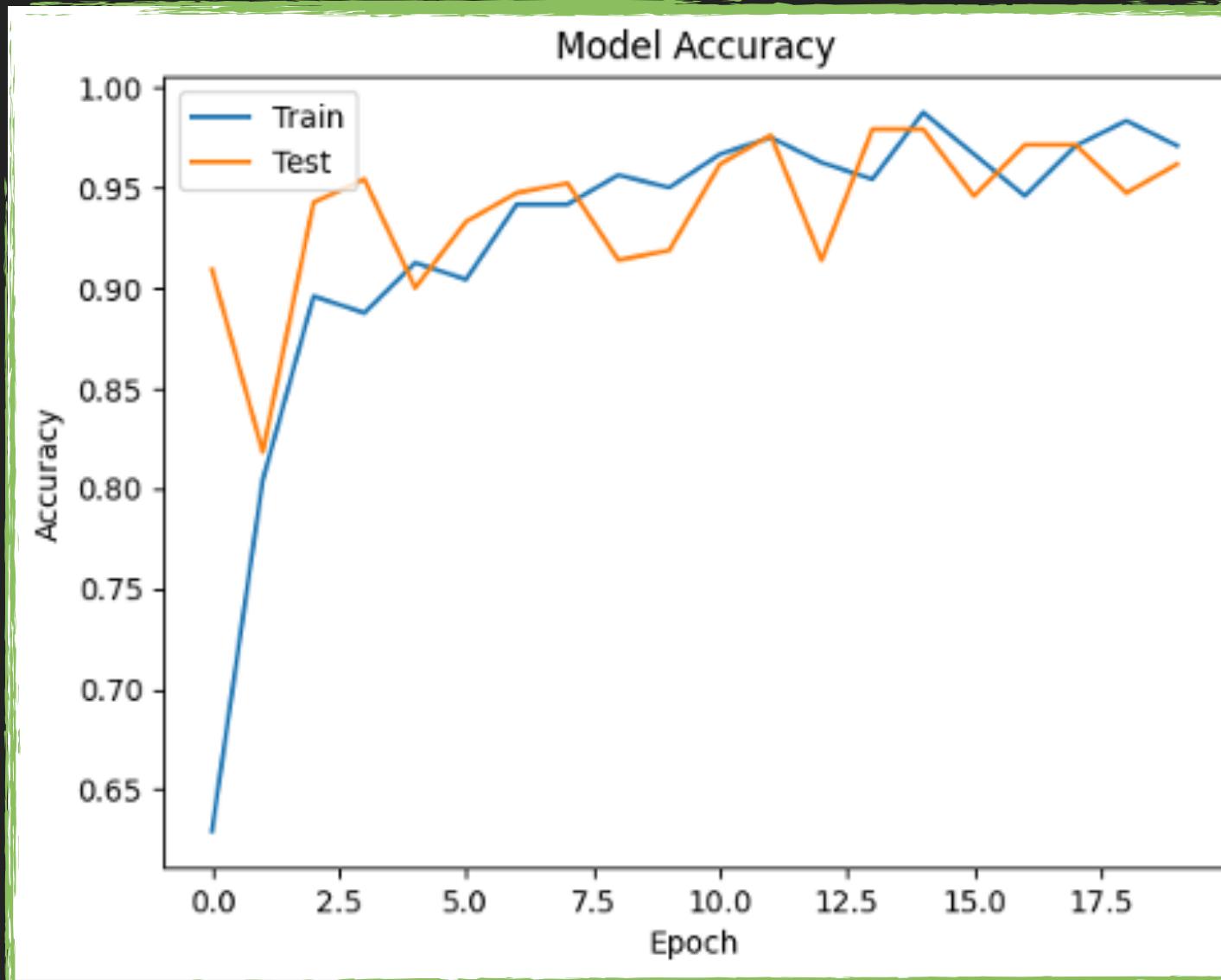


- ▶ Complex model
- ▶ More than 3 million of parameters
- ▶ Strong-pre processing on the image that feeds the Neural Network

## SOLUTION:

GENERATION OF A NEW MODEL AND IMPLEMENTATION OF A REQUIREMENT FILE INCLUDED IN THE GITHUB REPO THAT CONTAINS THE RIGHT VERSIONS OF THE LIBRARIES

# CORE - AI MODELS: FIST GESTURE



**MOBILENET**

**GLOBAL AV POOLING 2D**

**DENSE (128)**

**DROPOUT**

**DENSE (128)**

**DROPOUT**

**DENSE (2)**

- ▶ Complex model
- ▶ More than 3 million of parameters
- ▶ Strong-pre processing on the image that feeds the Neural Network

Layer (type)	Output Shape	Param #
mobilenet_1.00_224 (Functional)	(None, 3, 3, 1024)	3,228,864
global_average_pooling2d_6 (GlobalAveragePooling2D)	(None, 1024)	0
dense_31 (Dense)	(None, 128)	131,200
dropout_16 (Dropout)	(None, 128)	0
dense_32 (Dense)	(None, 128)	16,512
dropout_17 (Dropout)	(None, 128)	0
dense_33 (Dense)	(None, 2)	258

Total params: 3,376,834 (12.88 MB)

FLOWVISION

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# CORE - AI MODELS: HEART GESTURE

# CORE - AI MODELS: HEART GESTURE

**CHALLENGE:**  
DATASET NOT AVAILABLE

## CORE - AI MODELS: HEART GESTURE

### SOLUTION:

WE CREATED A DATASET MERGING SOME RANDOM IMAGES OF  
HANDS AND A SET OF PICTURE OF HANDS GESTURE

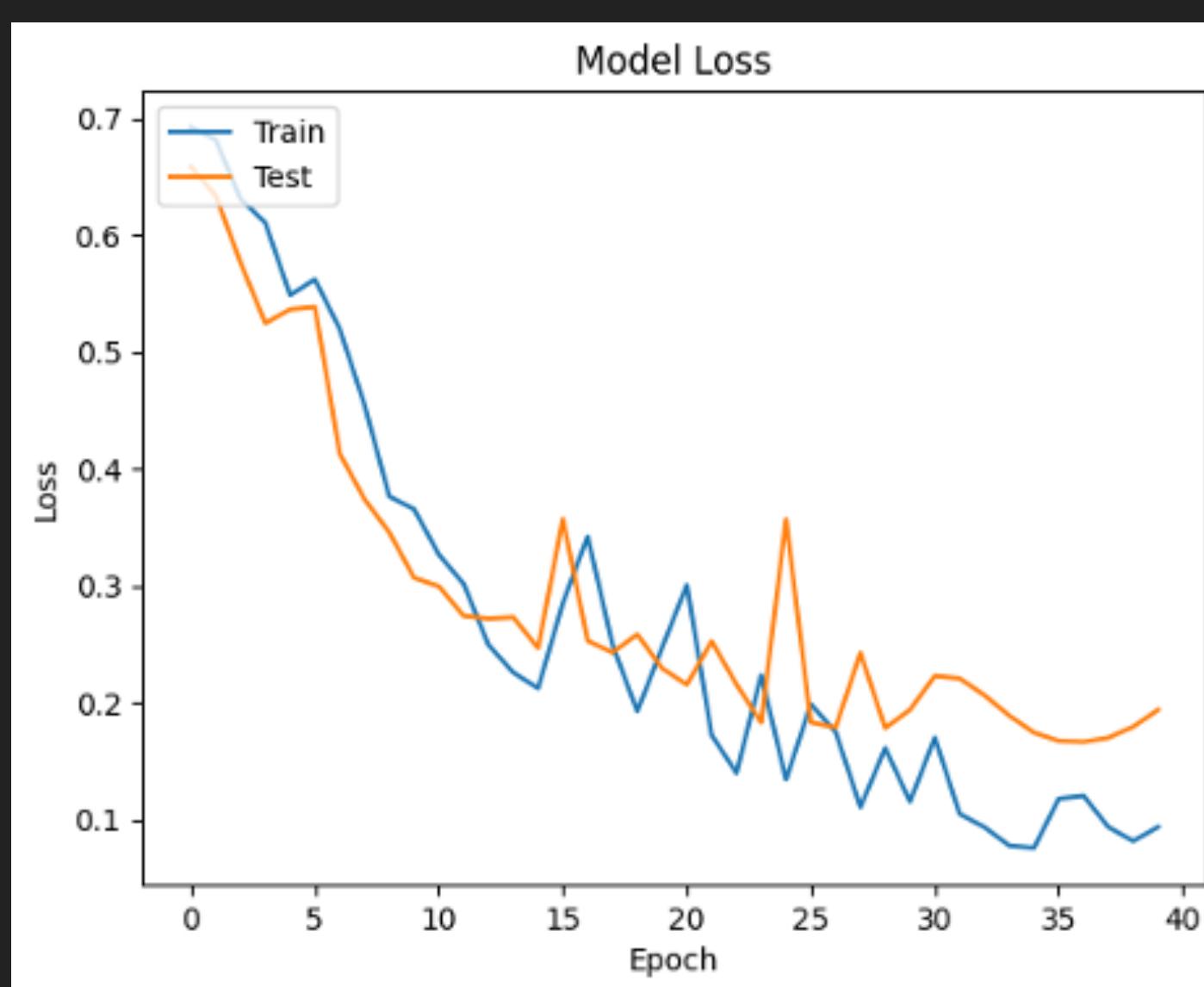
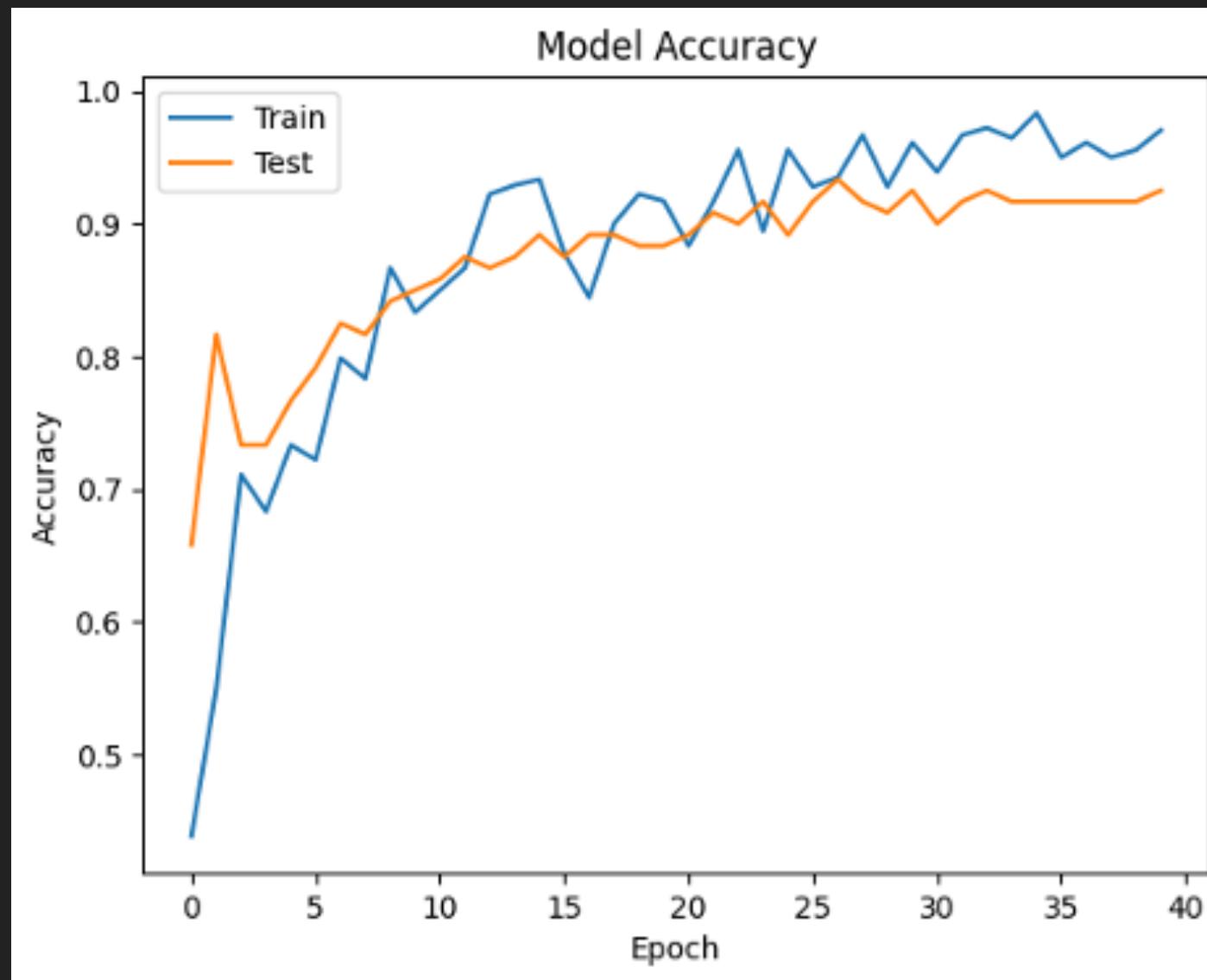
## CORE - AI MODELS: HEART GESTURE

### SOLUTION:

WE CREATED A DATASET MERGING SOME RANDOM IMAGES OF HANDS AND A SET OF PICTURE OF HANDS GESTURE

- ▶ Simpler model
- ▶ Less than 1 million of parameters
- ▶ Light processing on the image that feeds the Neural Network

# CORE - AI MODELS: HEART GESTURE



**CONV2D(16, 118X118)**

**MAXPOOLING 2D**

**CONV2D(32, 57X57)**

**MAXPOOLING 2D**

- ▶ Simpler model

- ▶ Less than 1 million of parameters

- ▶ Light processing on the image that feeds the Neural Network

**CONV2D(64, 26X26)**

**MAXPOOLING 2D**

**FLATTEN**

**MAXPOOLING 2D**

**CONV2D(128, 11X11)**

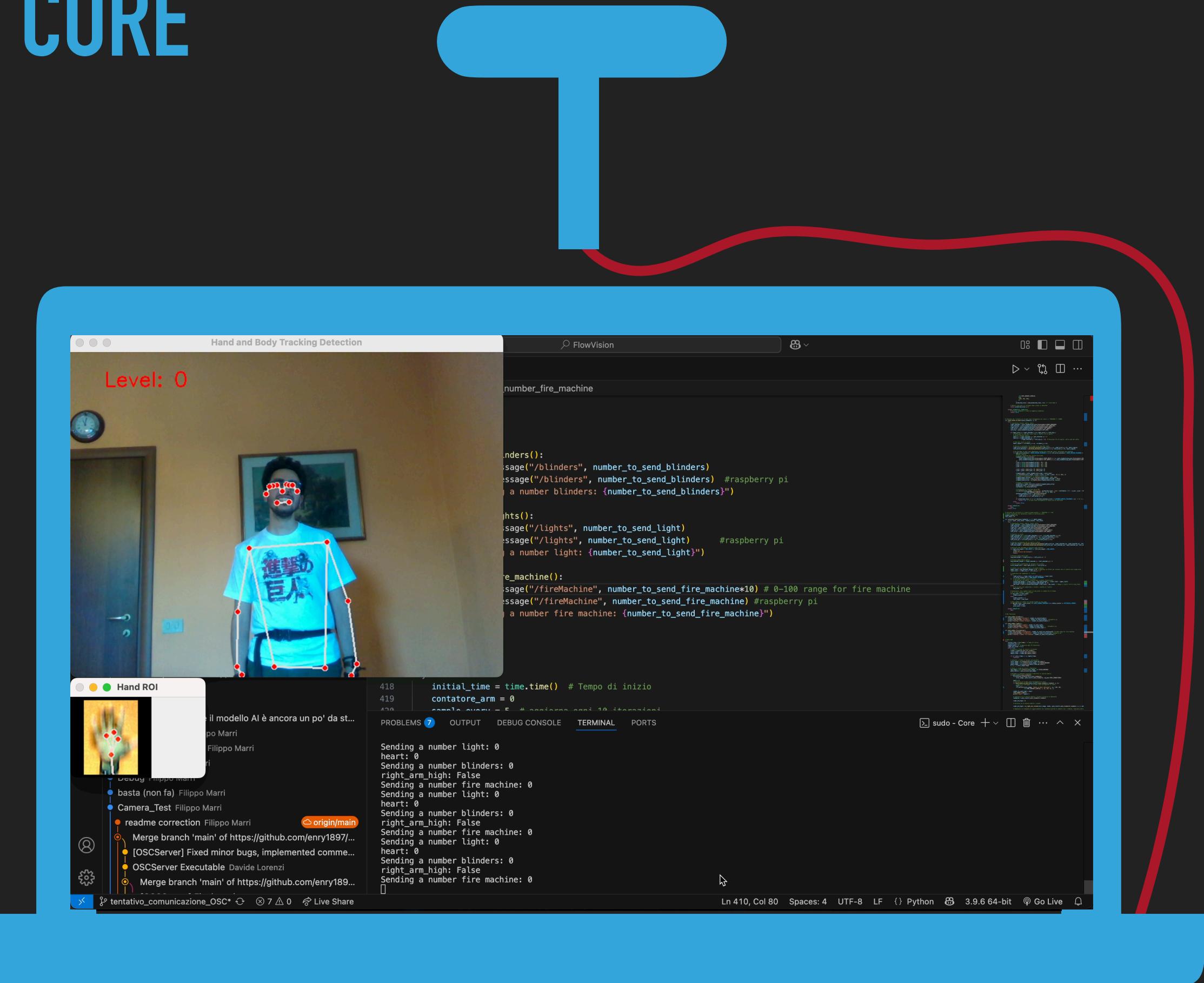
**DENSE (256)**

**DENSE (128)**

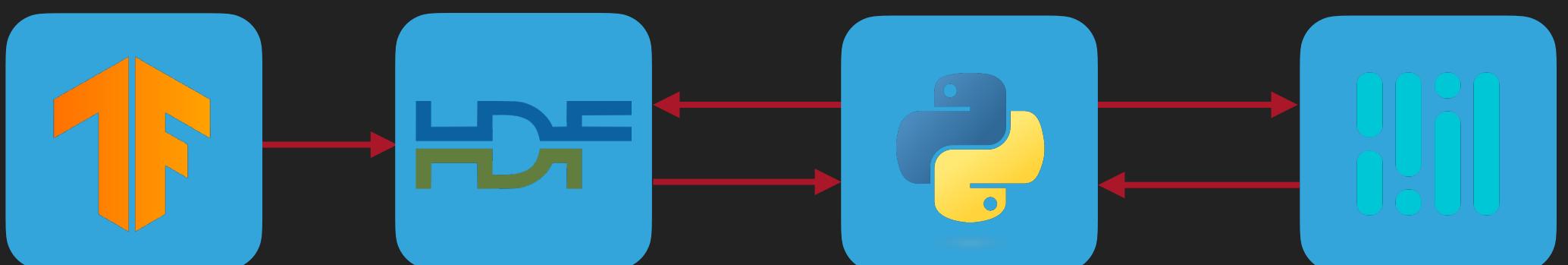
**DENSE (2)**

# FLOWVISION

# CORE

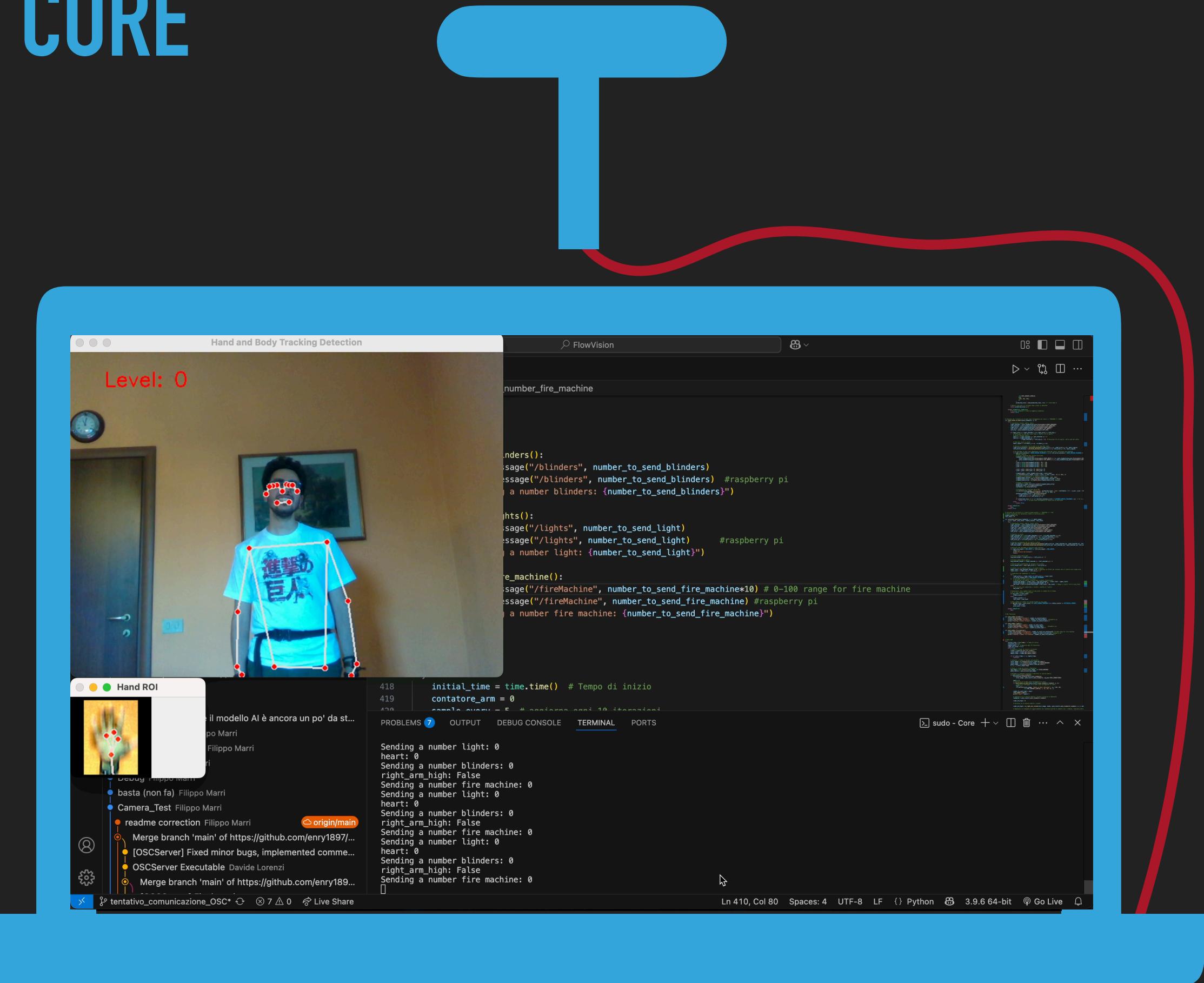


- ▶ MediaPipe module that allows the system to target the position and posture of the user
  - ▶ Triggering system
    - ▶ Bigger movements -> Thresholds
    - ▶ Details -> AI models fed with cropped images

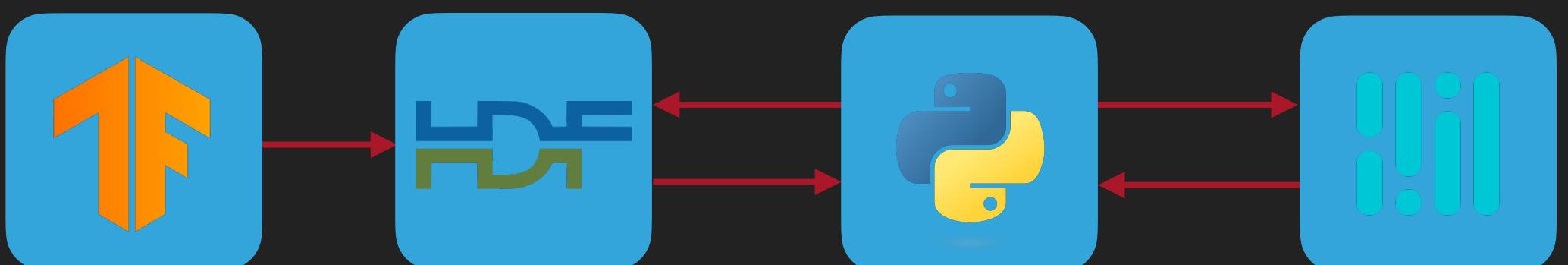


# FLOWVISION

# CORE

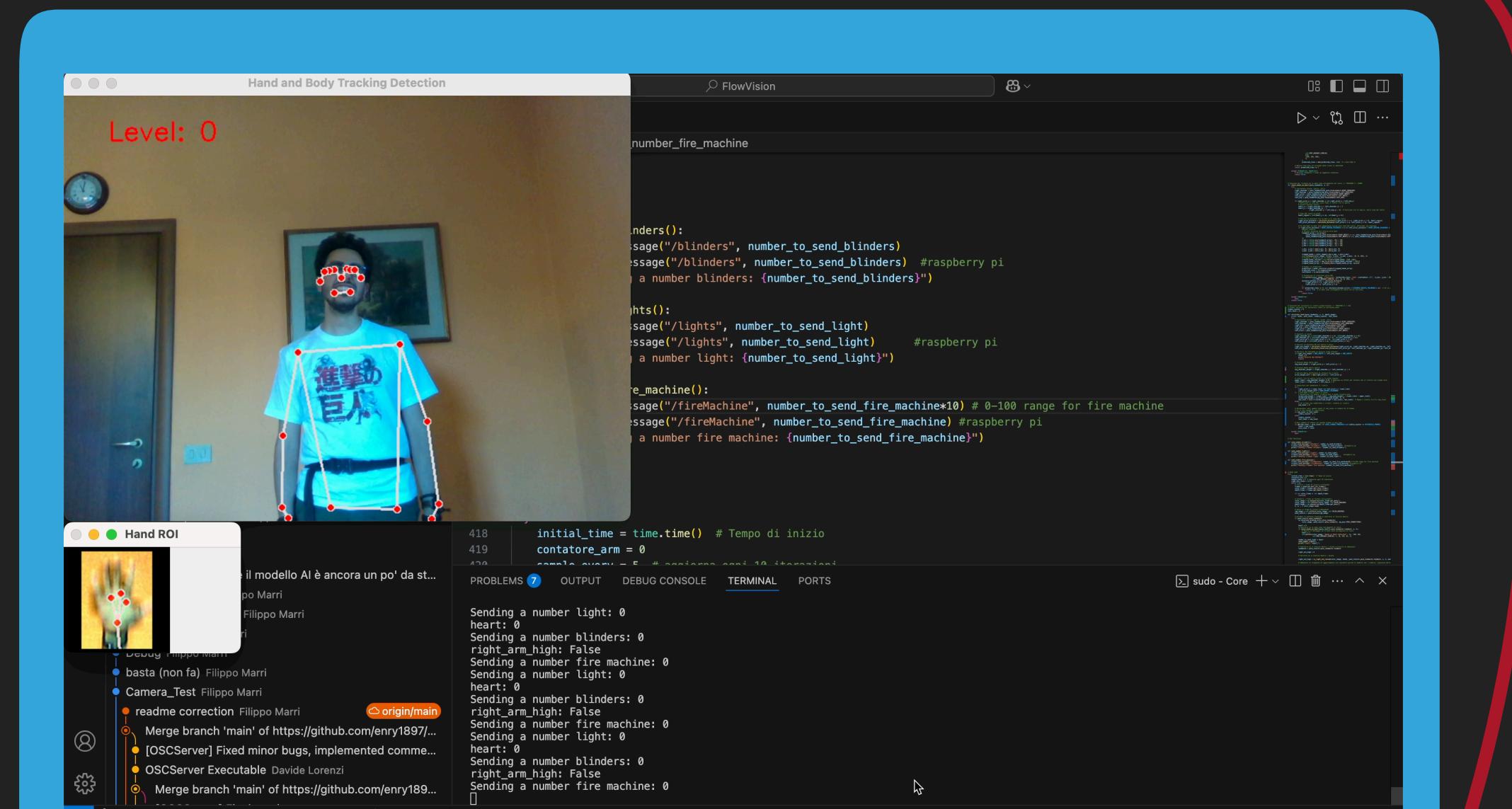


- ▶ MediaPipe module that allows the system to target the position and posture of the user
  - ▶ Triggering system
    - ▶ Bigger movements -> Thresholds
    - ▶ Details -> AI models fed with cropped images



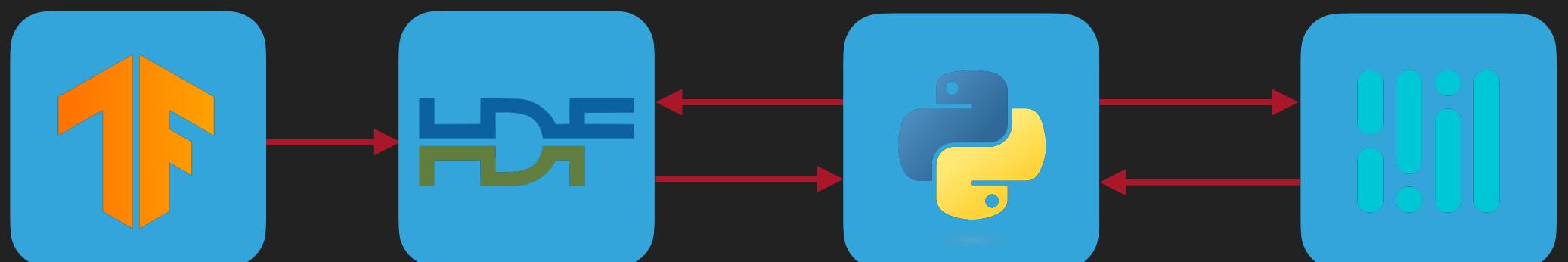
# FLOWVISION

## CORE



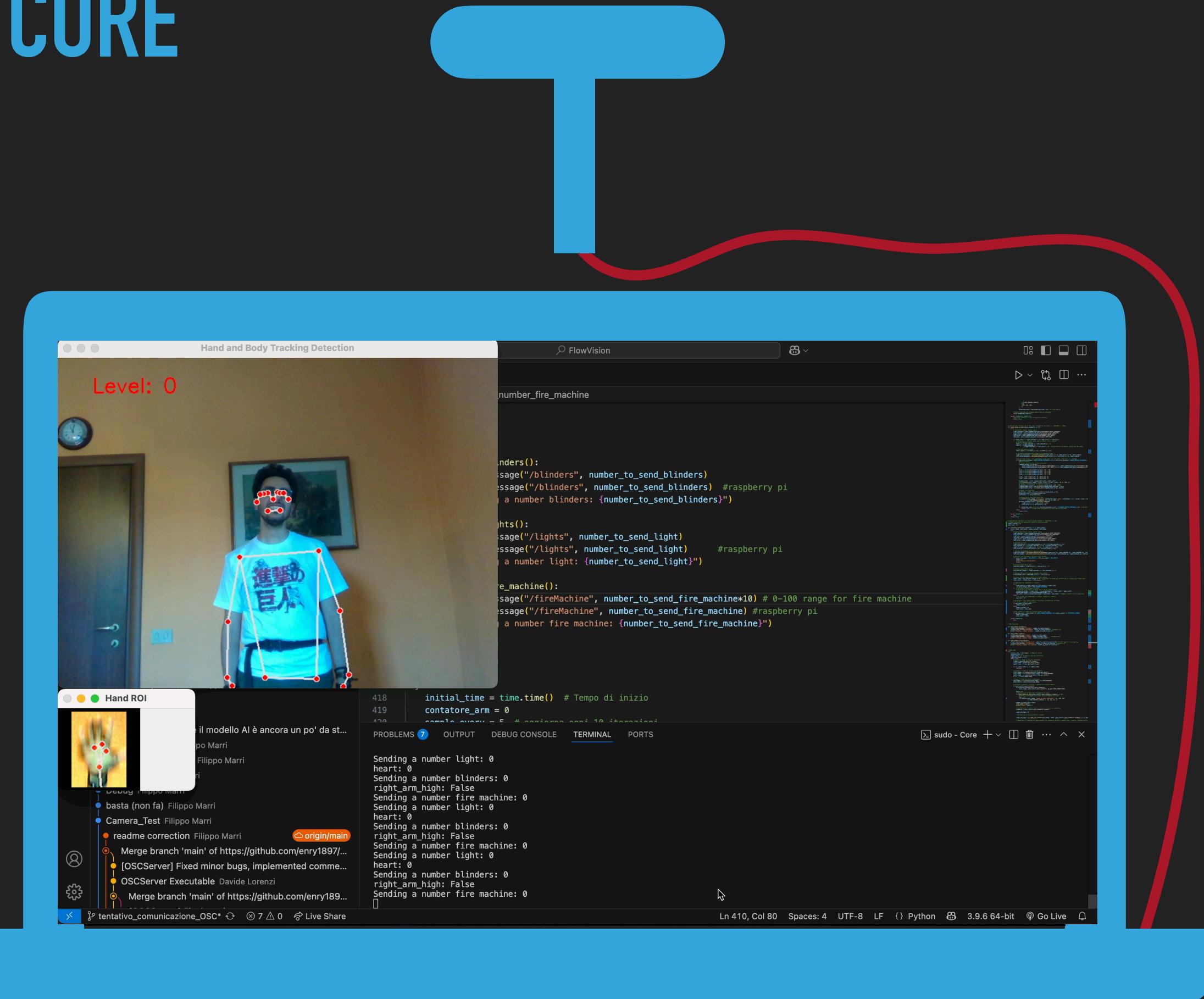
- ▶ MediaPipe module that allows the system to target the position and posture of the user
- ▶ Triggering system
  - ▶ Bigger movements -> Thresholds
  - ▶ Details -> AI models fed with cropped images

**CHALLENGE:**  
BLINKING DUE TO THE HIGH FPS



# FLOWVISION

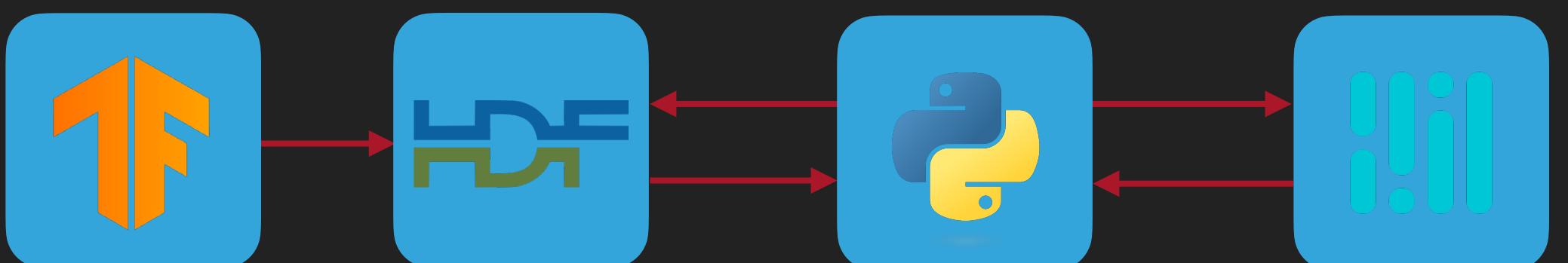
# CORE



- ▶ MediaPipe module that allows the system to target the position and posture of the user
  - ▶ Triggering system
    - ▶ Bigger movements -> Thresholds
    - ▶ Details -> AI models fed with cropped images

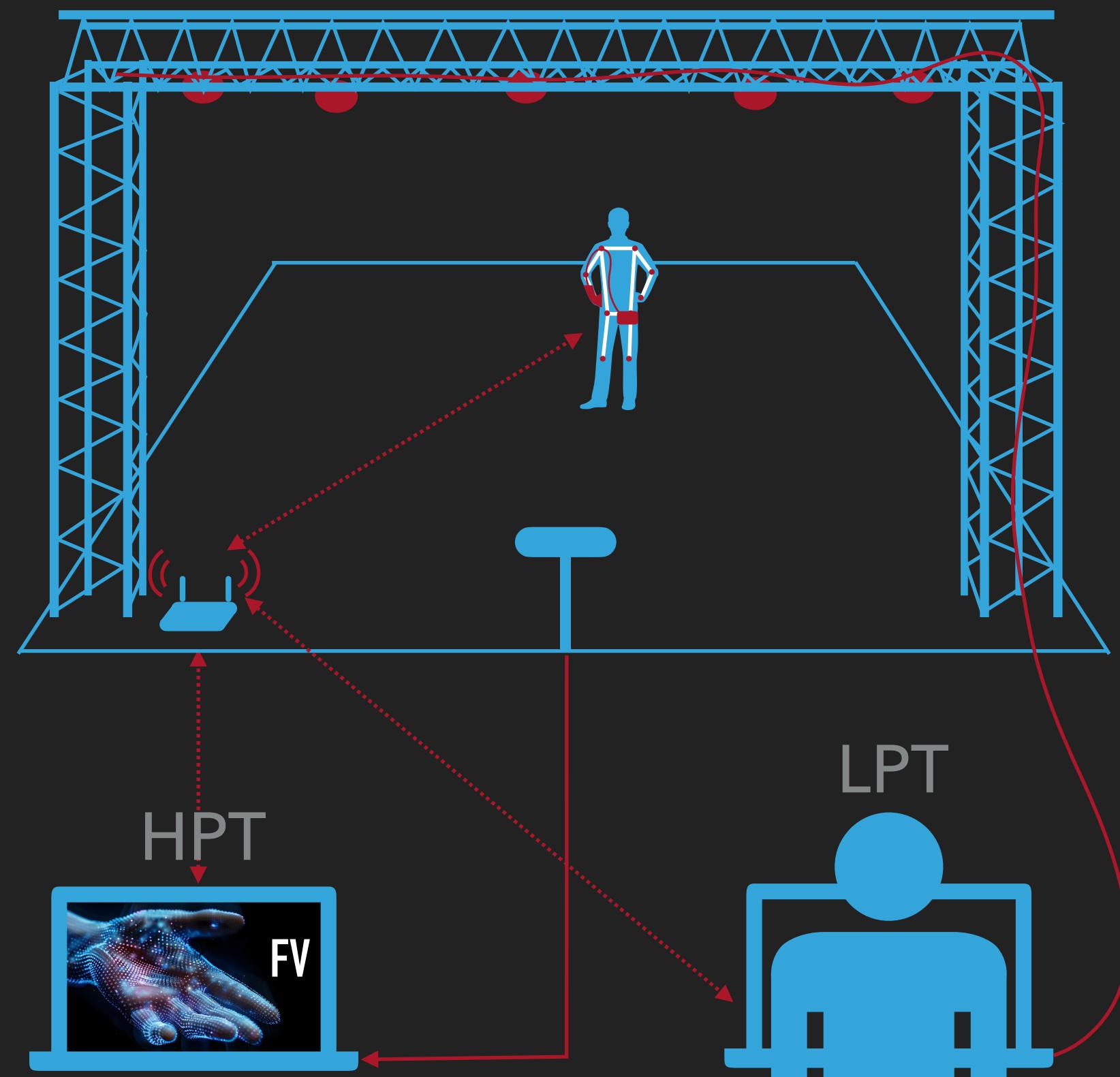
# SOLUTION:

# IMPLEMENTATION OF A HYSTERESIS CODE THAT ACTS AS A SAMPLE-AND-HOLD BLOCK TO REDUCE THE SPEED OF THE UPDATE



# ARCHITECTURE

ON STAGE

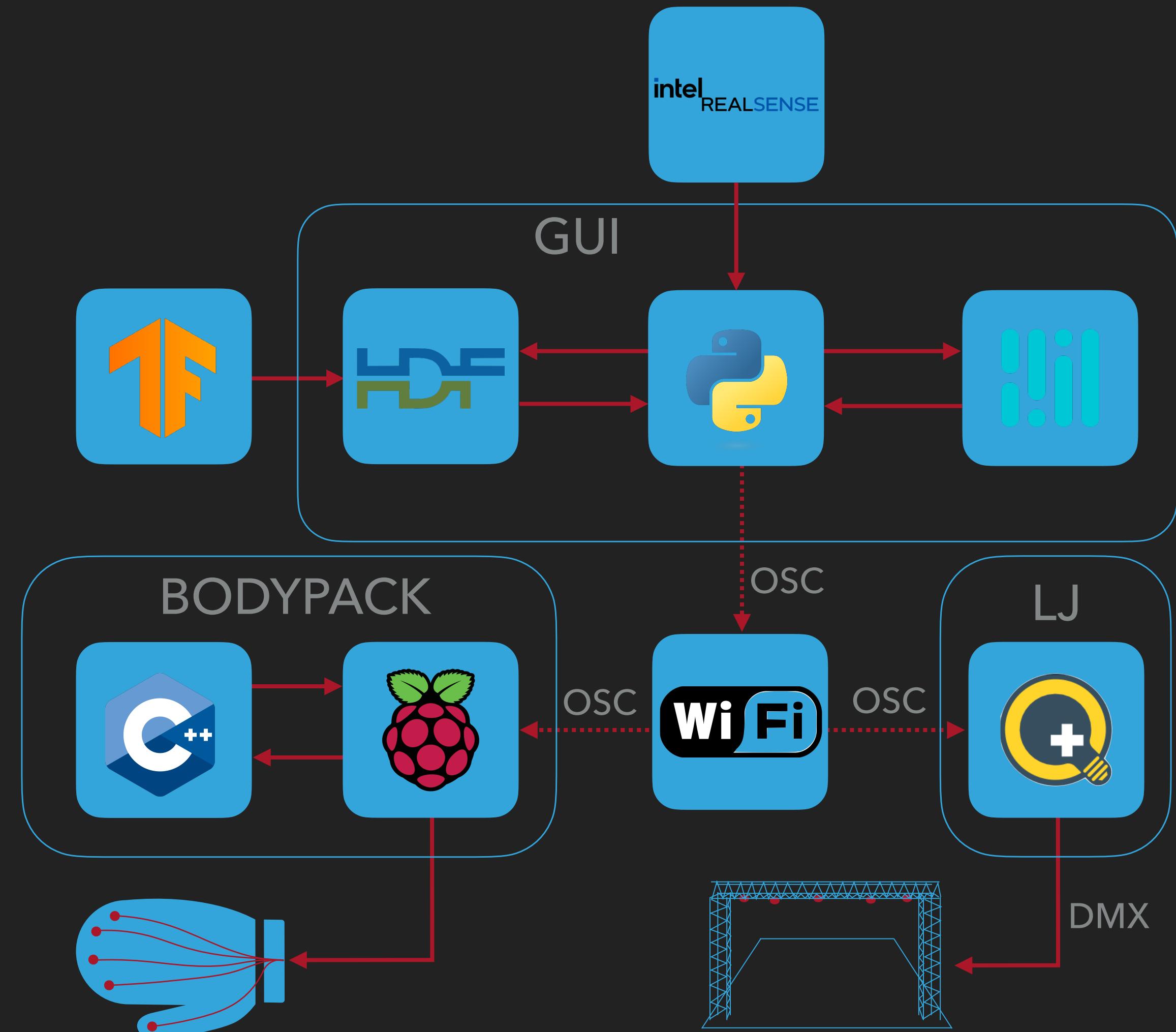


INPUT

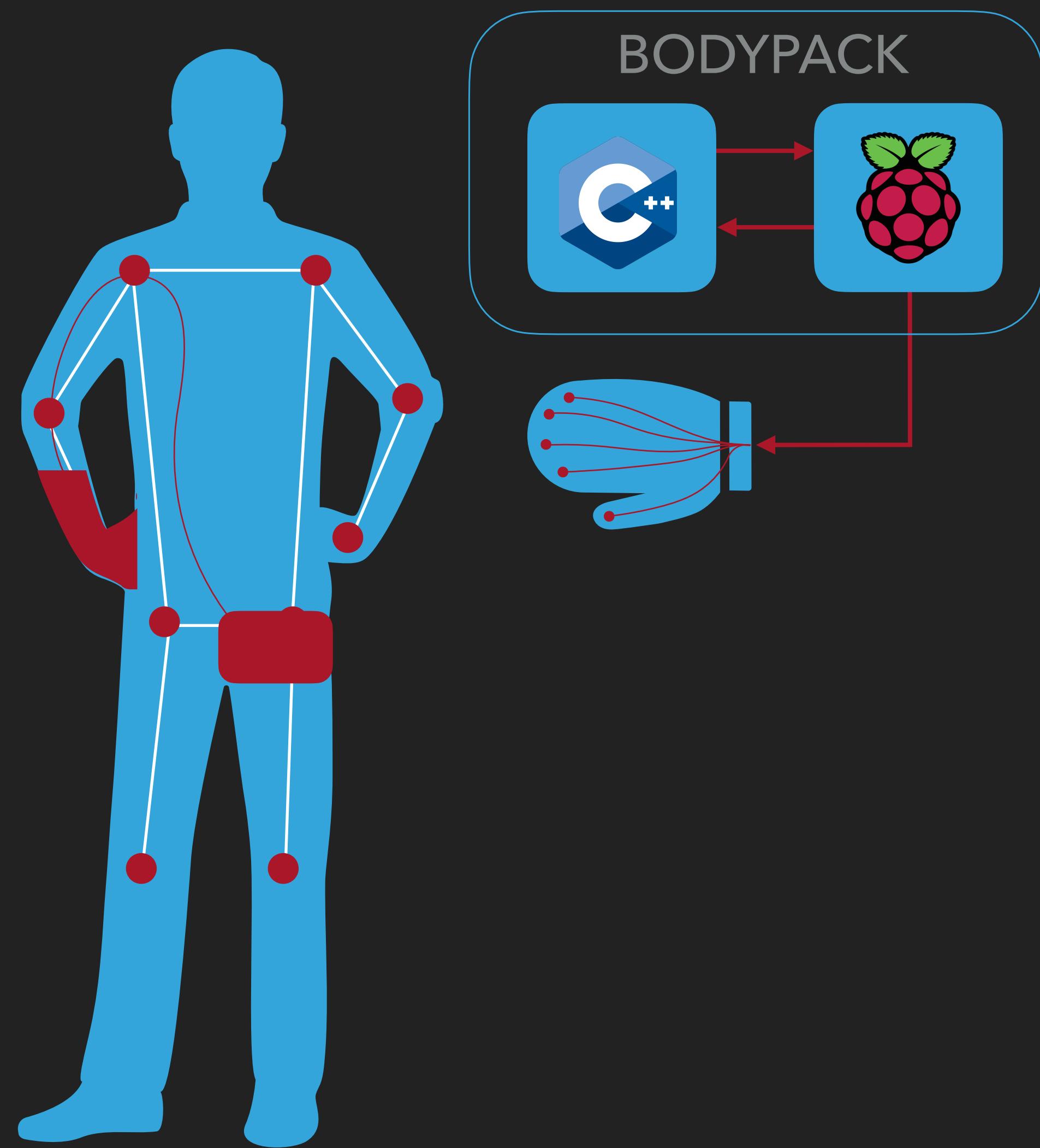
CORE

OUTPUT

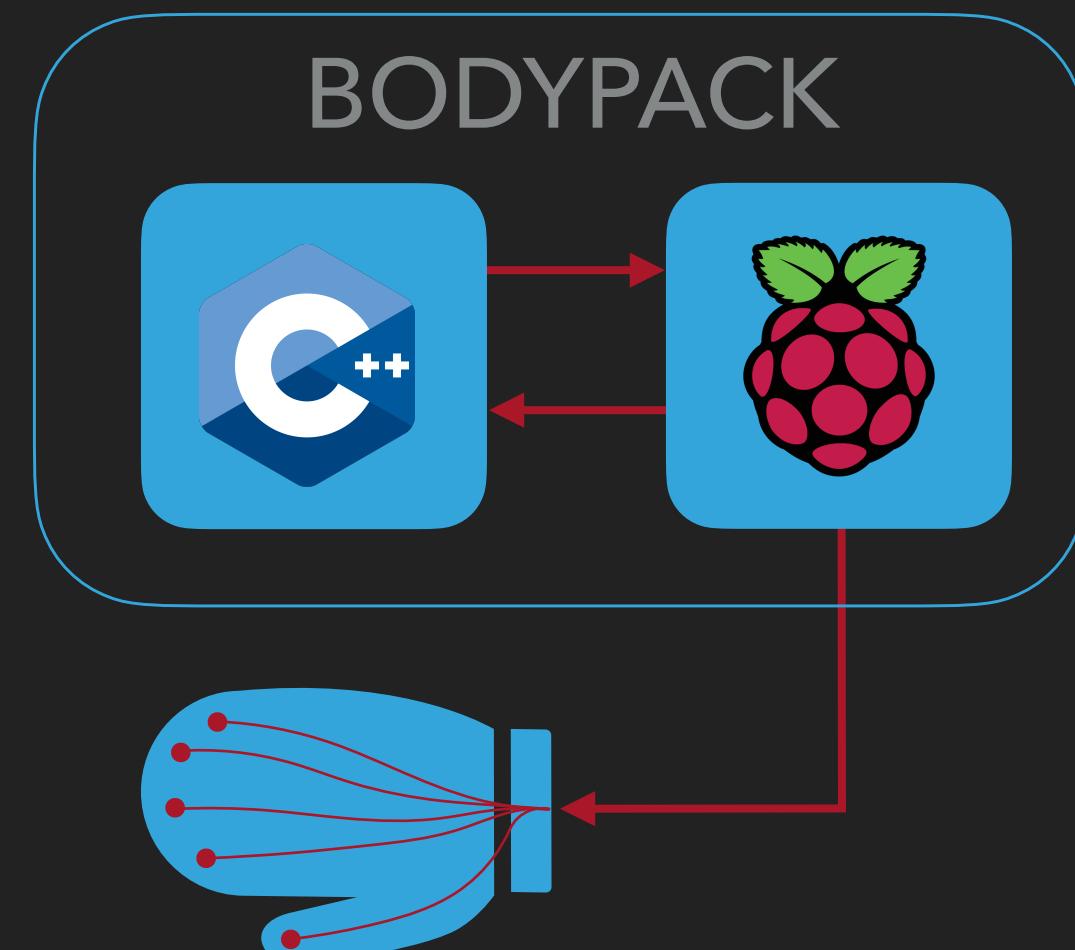
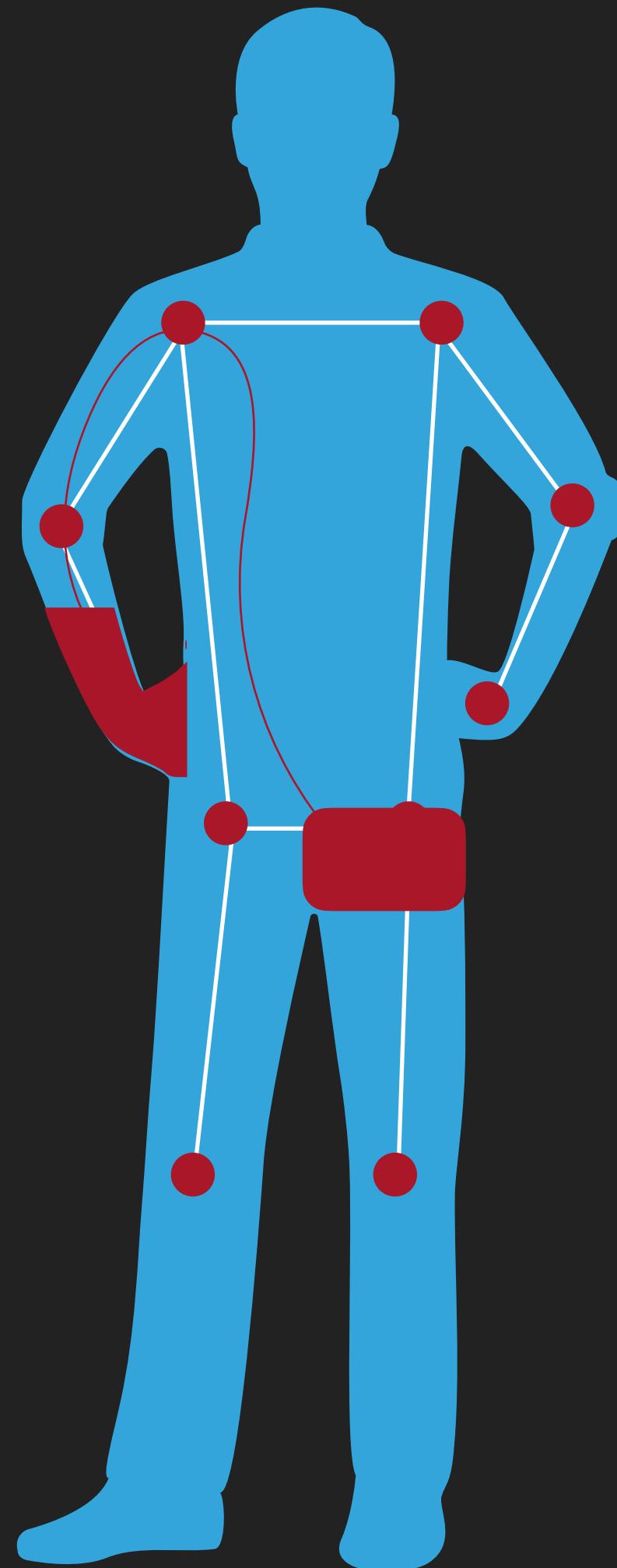
BEHIND THE SCENE



# OUTPUT - BODYPACK

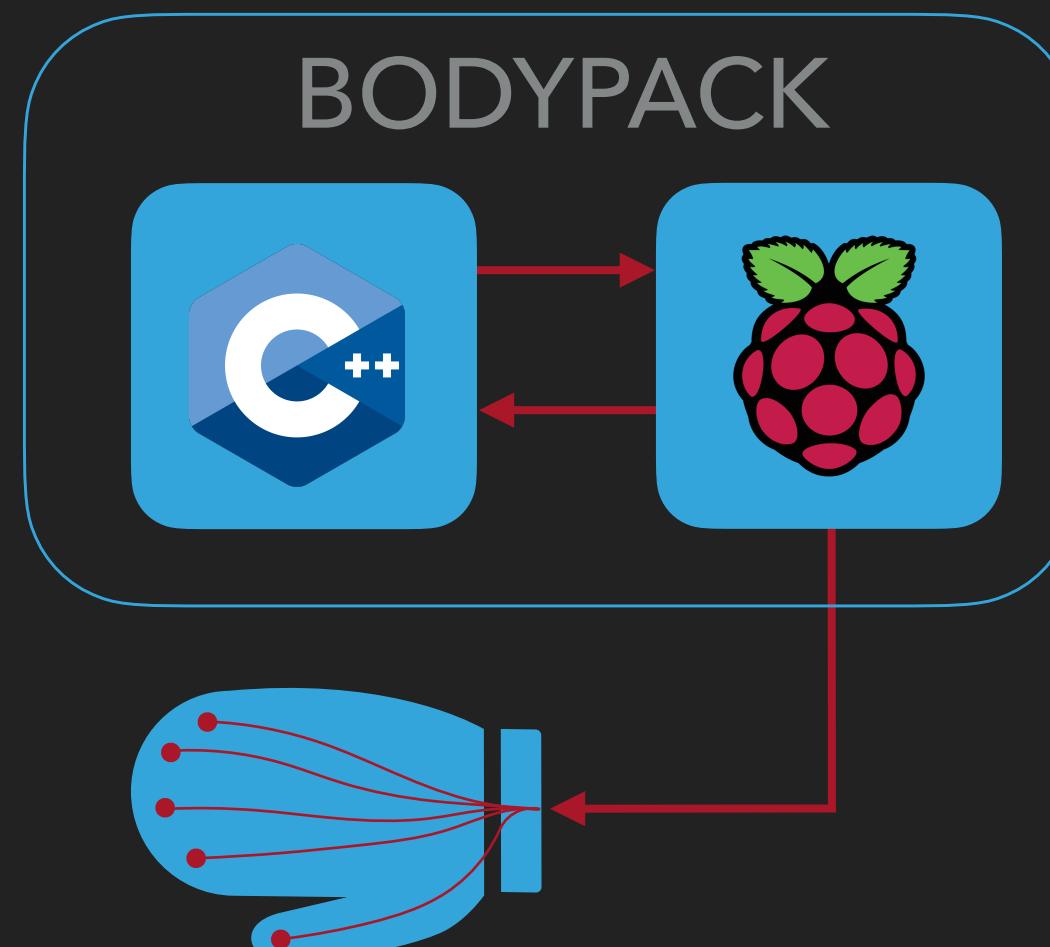
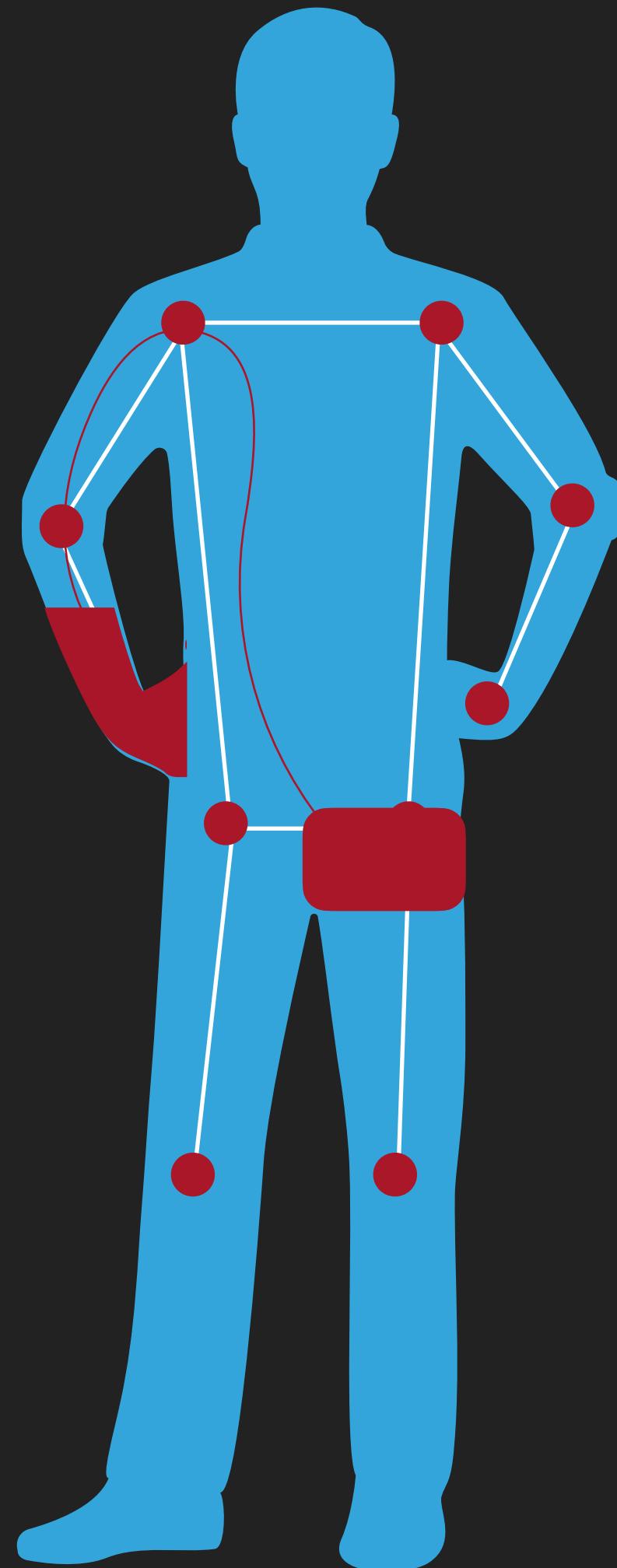


# OUTPUT - BODYPACK



- ▶ RaspberryPi5 wi-fi that works as interface between the software and the actuator circuit driven directly by a module of the main function

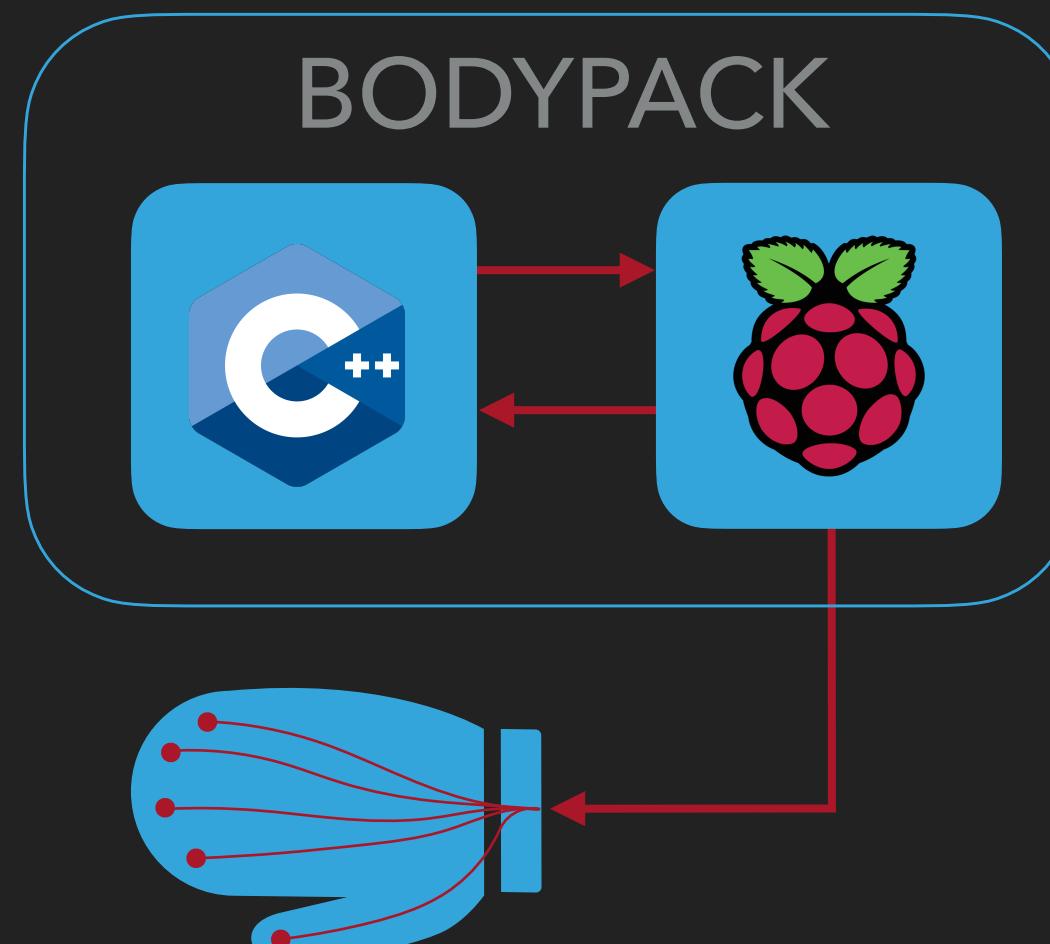
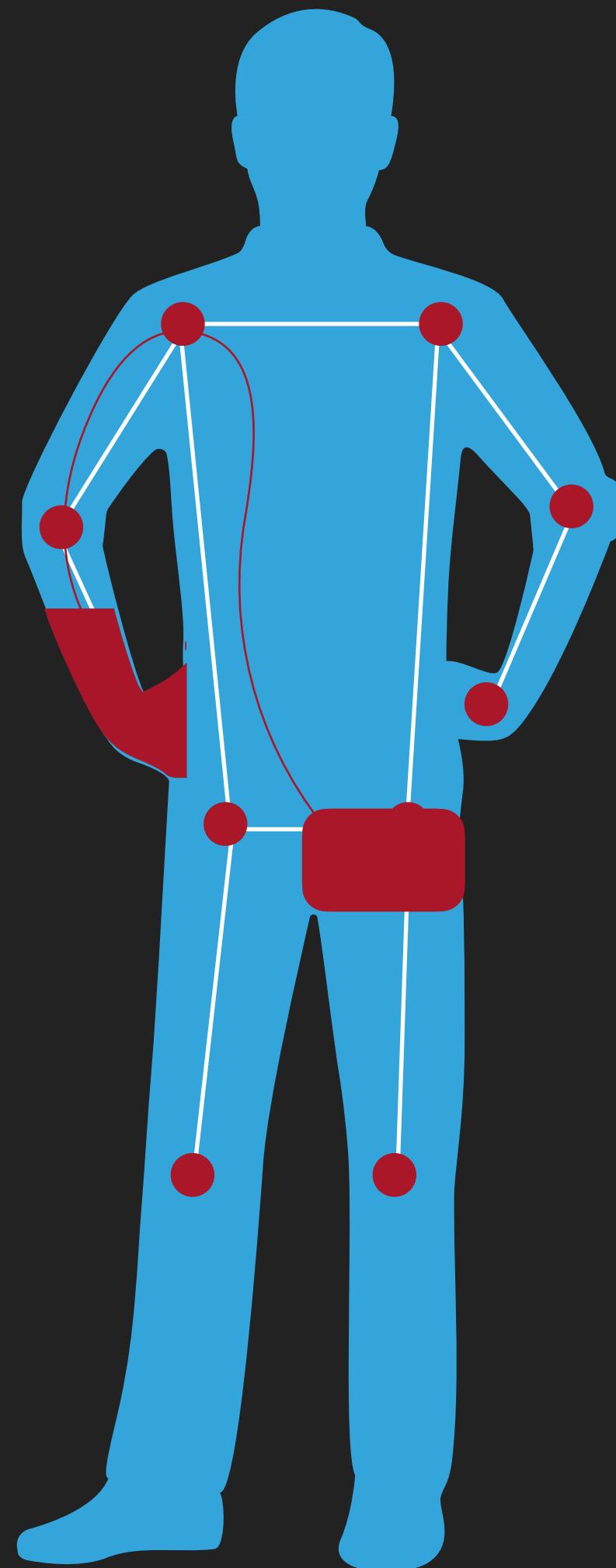
## OUTPUT - BODYPACK



- ▶ RaspberryPi5 wi-fi that works as interface between C++ driver and Python function.

**CHALLENGE:**  
COMPATIBILITY PROBLEM BETWEEN PYTHON AND RASPBERRY PI 5

## OUTPUT - BODYPACK

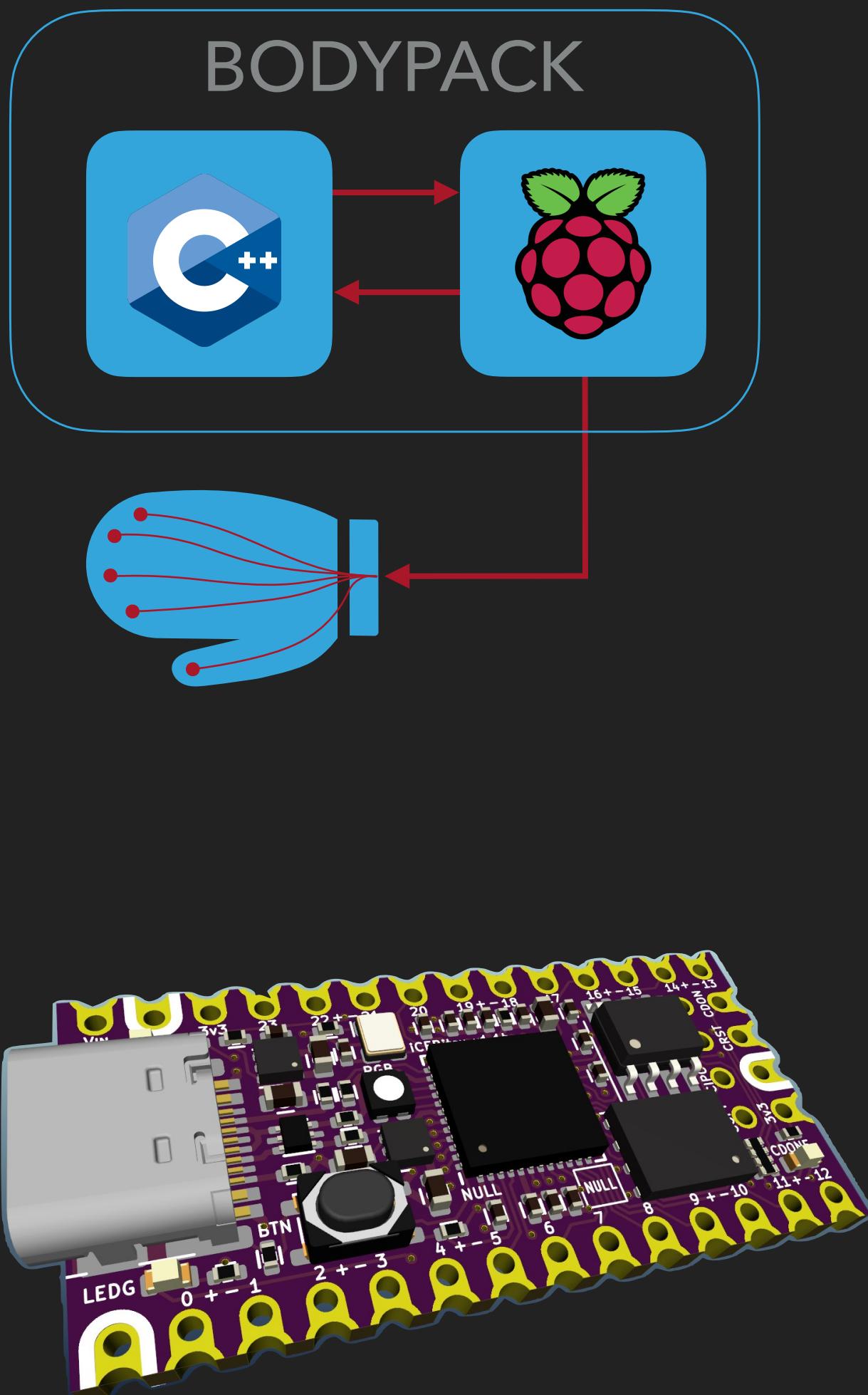
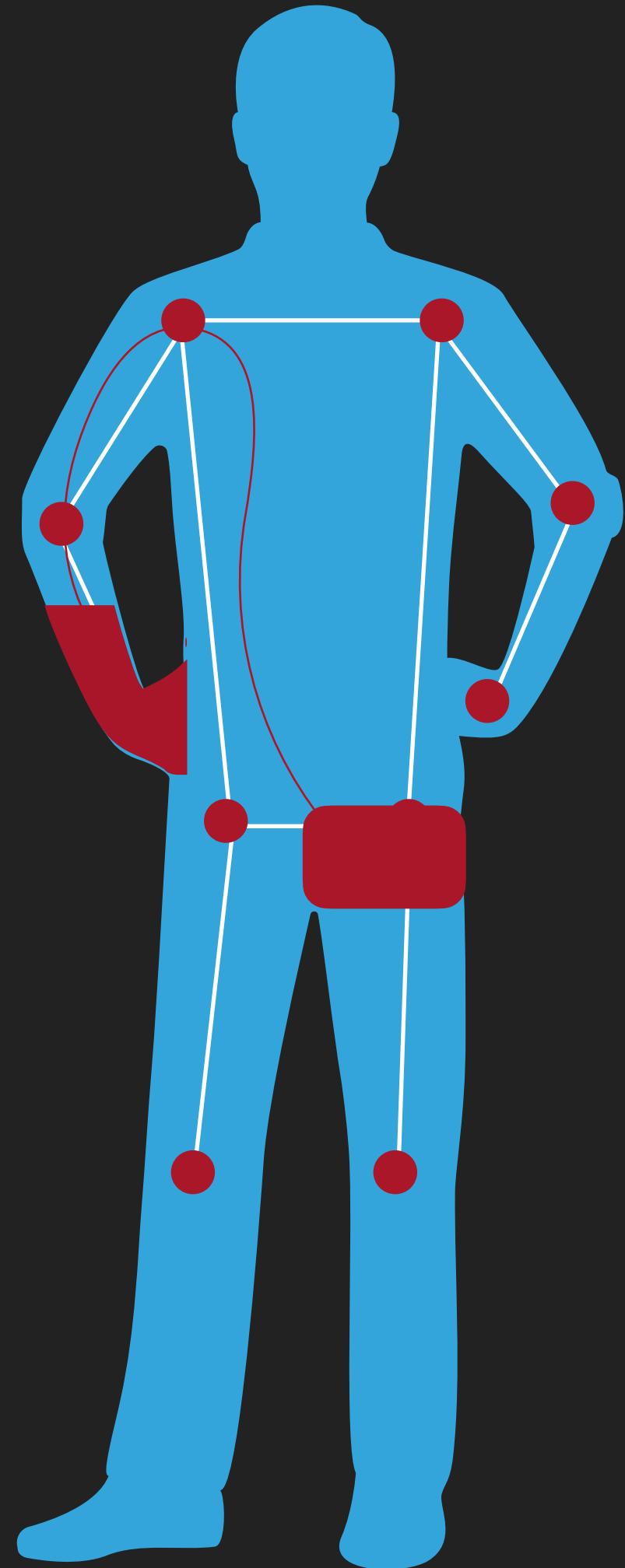


- ▶ RaspberryPi5 wi-fi that works as interface between driver functions

**SOLUTION:**

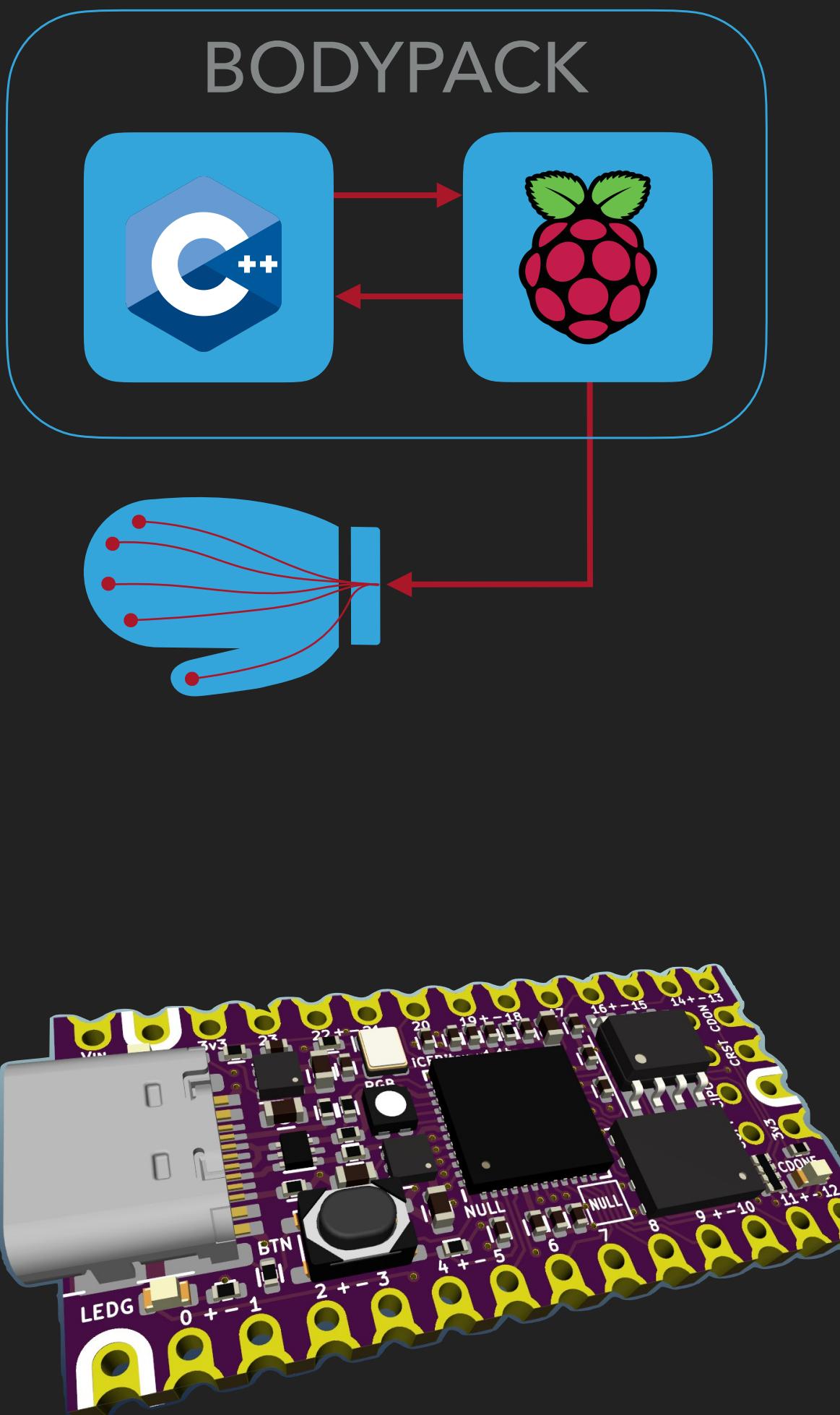
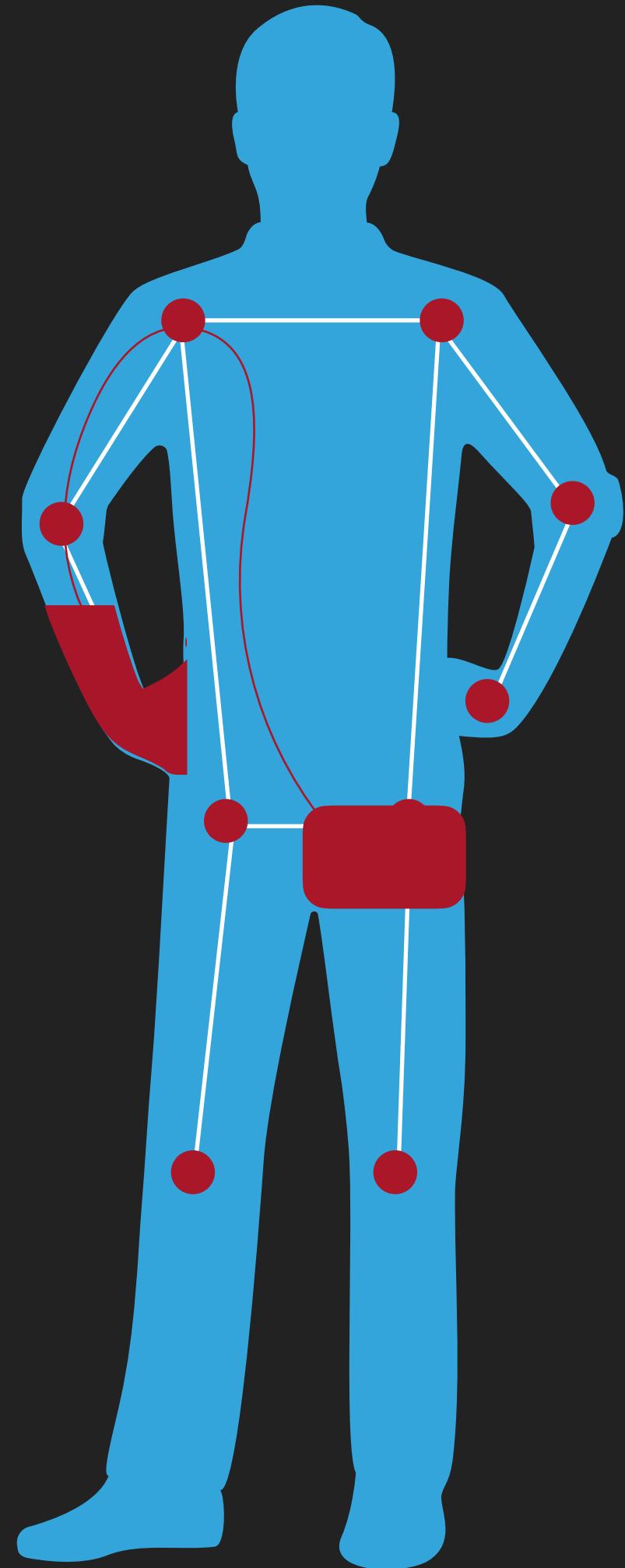
**RE-IMPLEMENTATION OF THE FIRMWARE IN C++  
INSTEAD OF PYTHON**

# OUTPUT - BODYPACK



- ▶ RaspberryPi5 wi-fi that works as interface between the software and the actuator circuit driven by a specific firmware written in C++ due to compatibility reasons
- ▶ Actuator integrated circuit designed in KiCad powered by a power bank able to give two types of feedback:
  - ▶ ON/OFF feedback -> On/Off MOS
  - ▶ Continuous feedback -> PWM + Low pass filter

# OUTPUT - BODYPACK



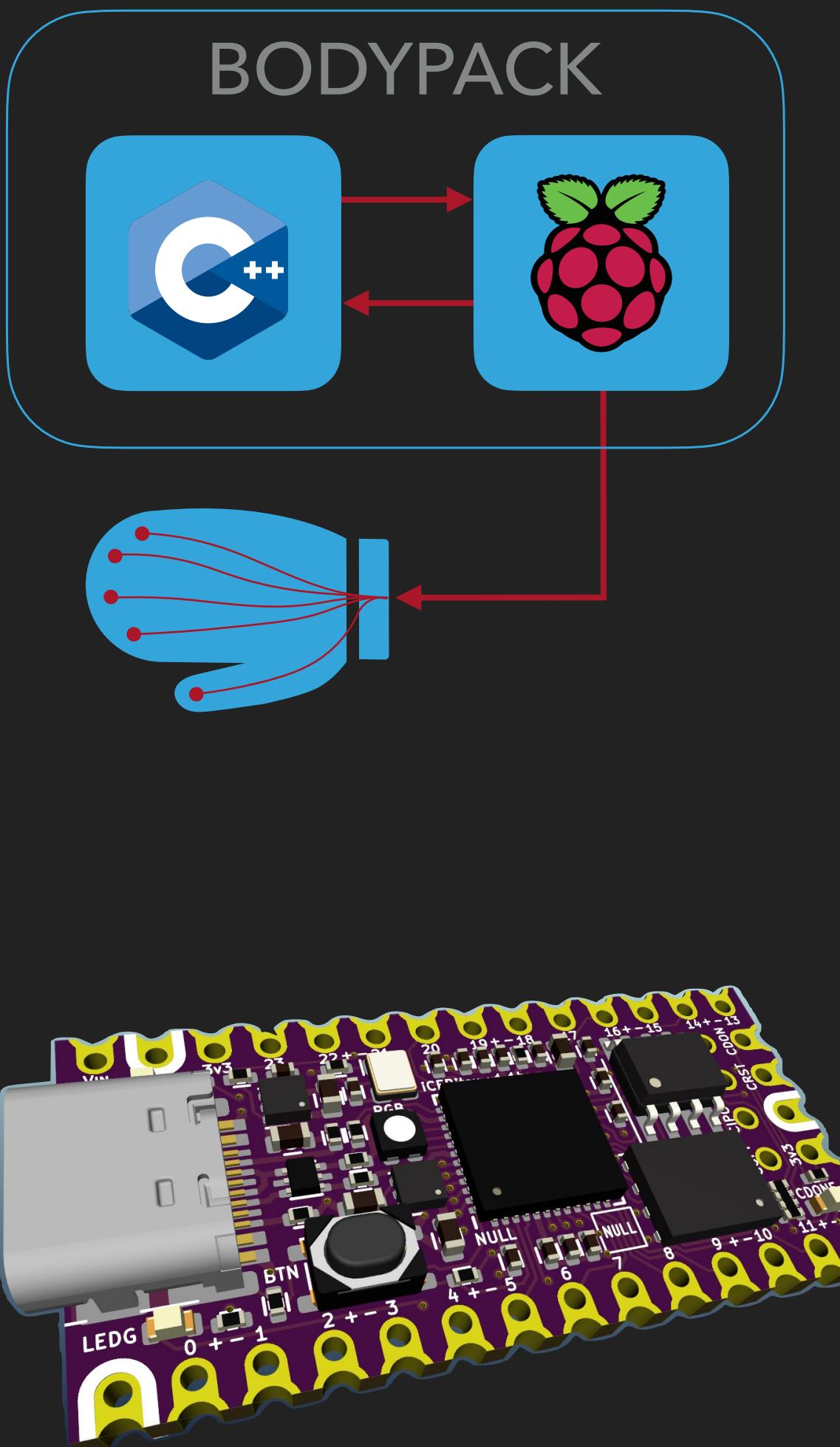
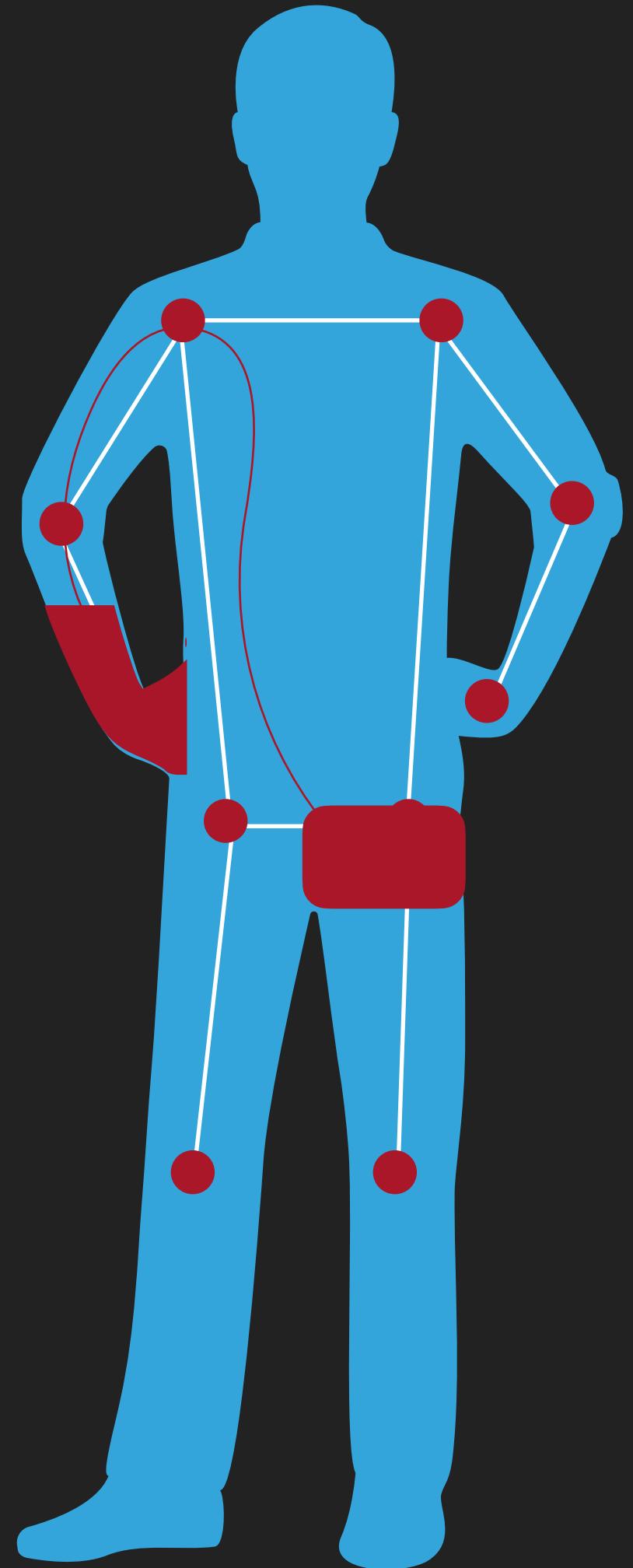
- ▶ RaspberryPi5 wi-fi that works as interface between the software and the actuator circuit driven by a specific firmware written in C++ due to compatibility reasons

- ▶ Actuator interface: interface between the RaspberryPi5 and the actuators. It is composed of two types of readbacks:

**CHALLENGE:**  
**TOO LONG SHIPPING TIME FROM CHINA TO MILAN**

- ▶ ON/OFF feedback -> On/Off MOS
- ▶ Continuous feedback -> PWM + Low pass filter

# OUTPUT - BODYPACK



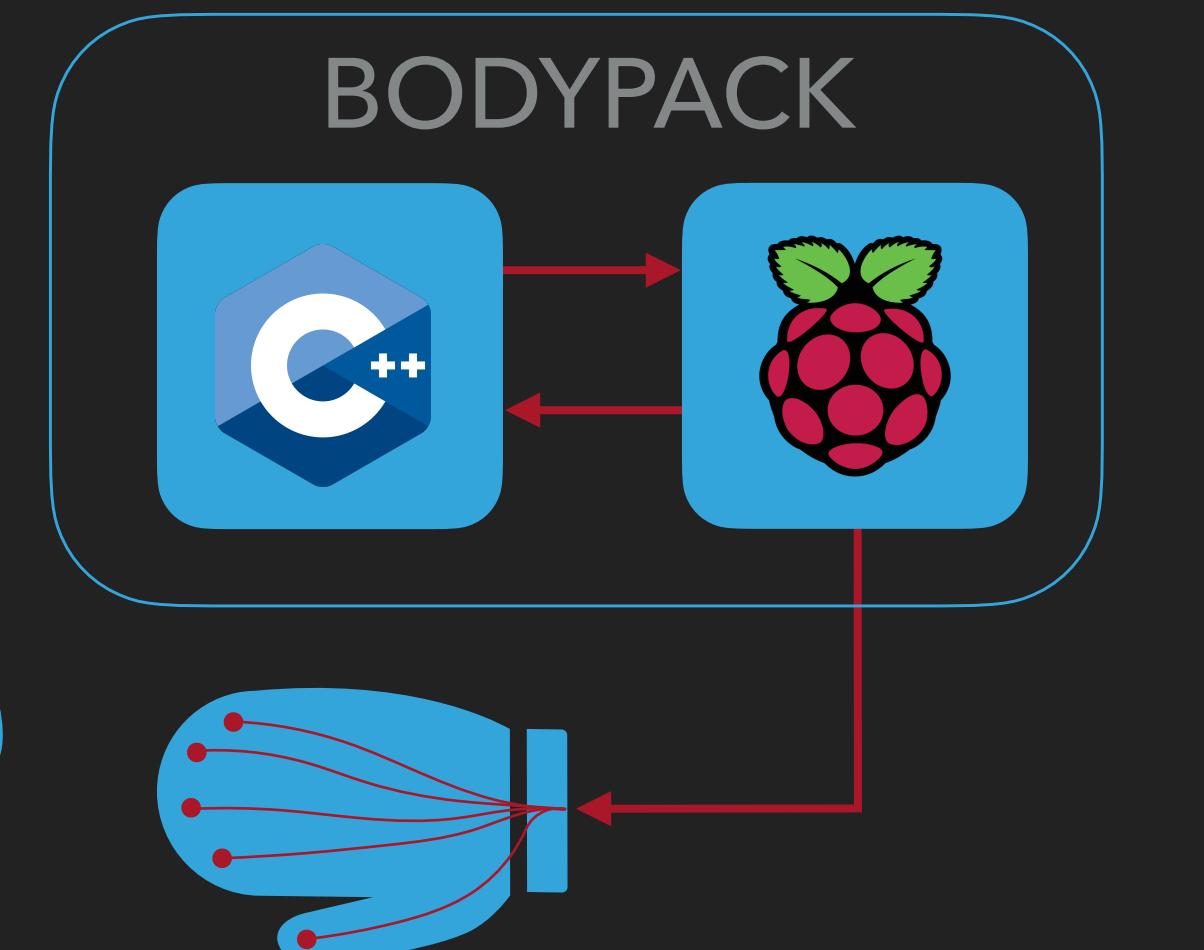
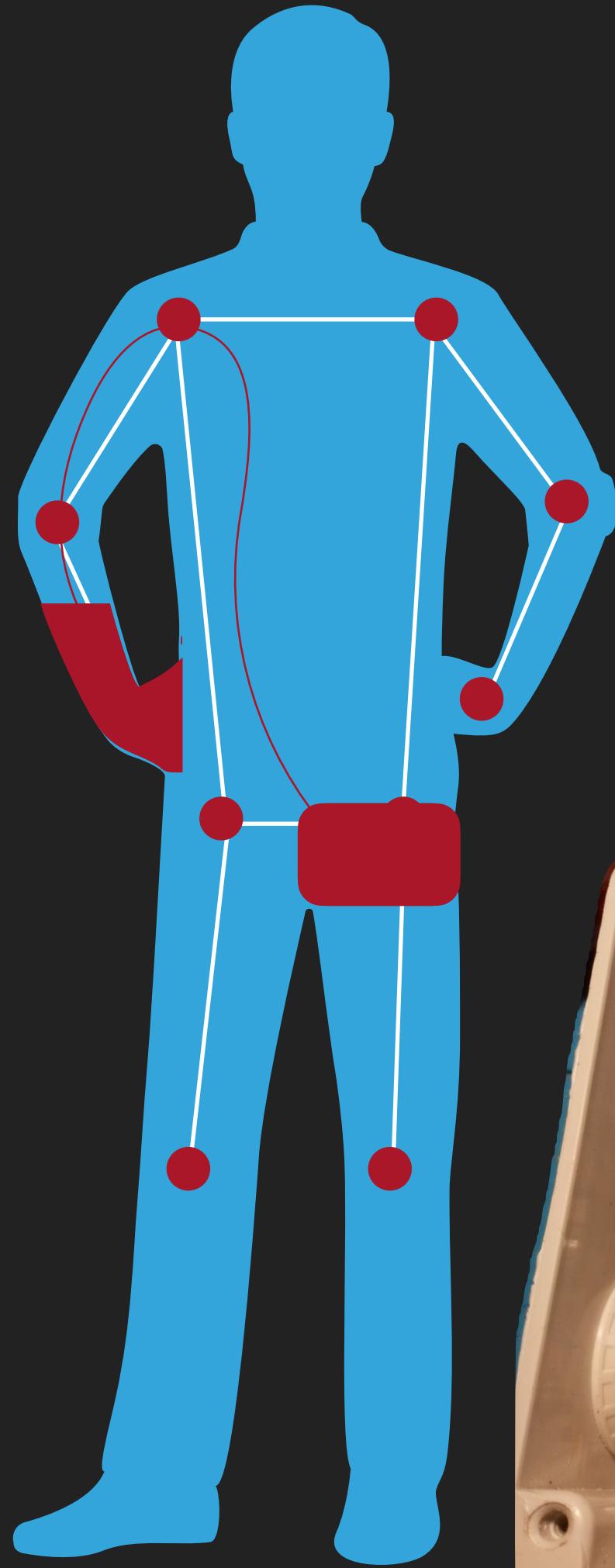
- ▶ RaspberryPi5 wi-fi that works as interface between the software and the actuator circuit driven by a specific firmware written in C++ due to compatibility reasons

- ▶ Actuator

**SOLUTION:**  
SIMPLER CIRCUIT BASED ON RELAYS INSTEAD OF TRANSISTORS

- ▶ ON/OFF feedback -> On/Off MOS
- ▶ Continuous feedback -> PWM + Low pass filter

# OUTPUT - BODYPACK



- ▶ RaspberryPi5 wi-fi that works as interface between the software and the actuator circuit driven by a specific firmware written in C++ due to compatibility reasons
- ▶ Relays-based actuator circuit powered by a power bank able to give two types of feedback:
  - ▶ ON/OFF feedback -> On/Off MOS
  - ▶ Continuous feedback -> PWM + Low pass filter

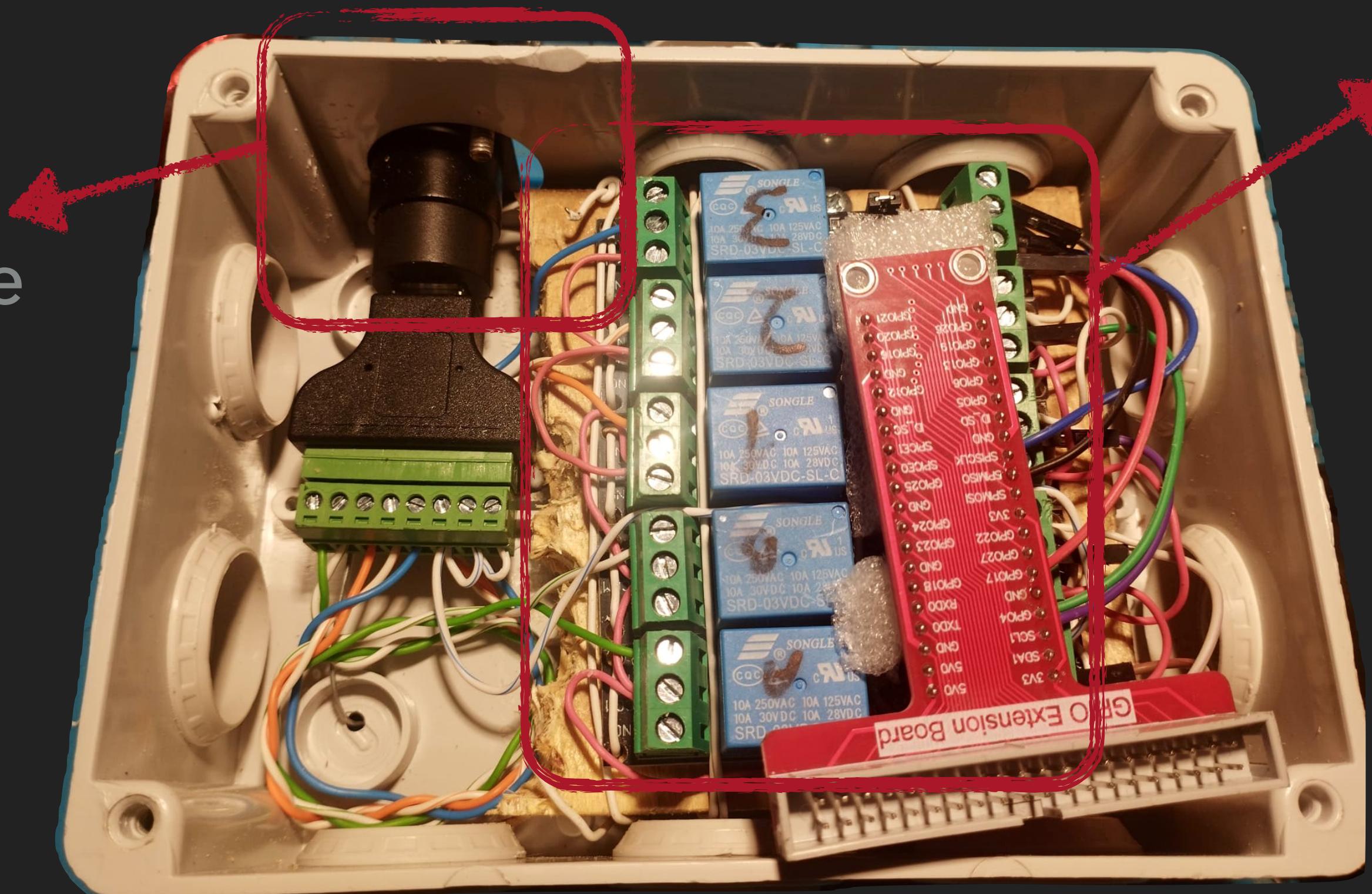
FLOWVISION

# OUTPUT - CIRCUIT

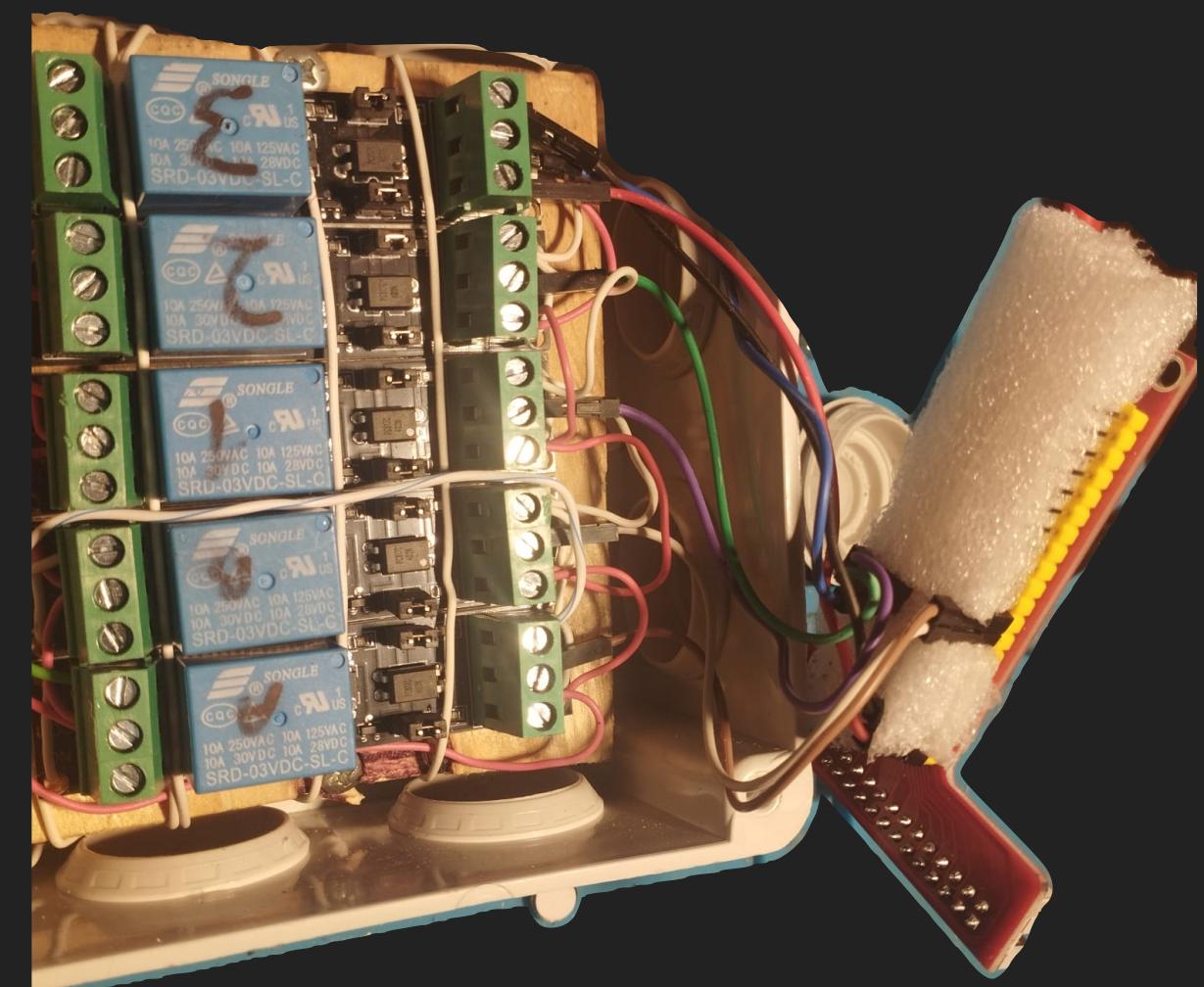


# OUTPUT - CIRCUIT

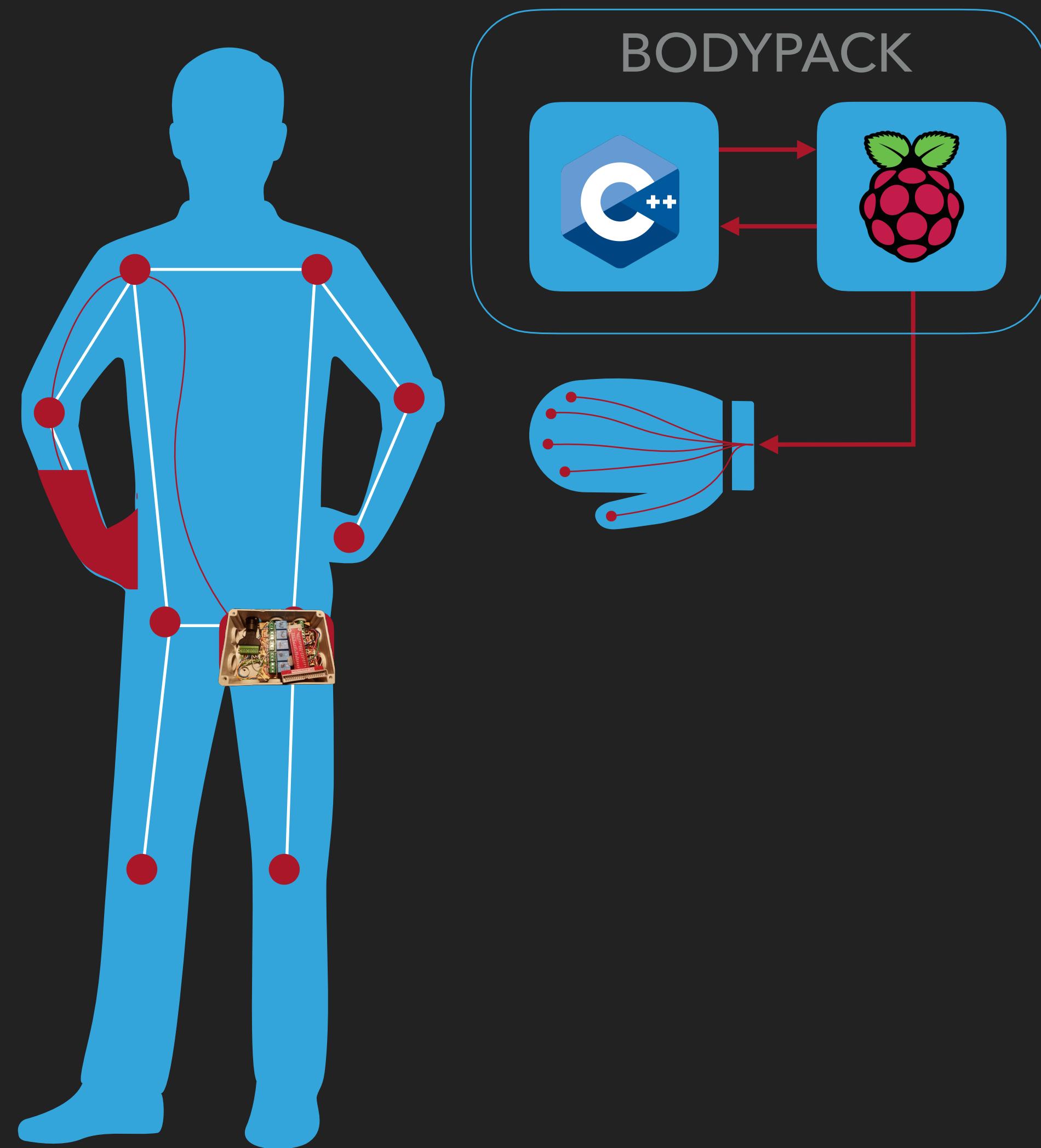
Ethernet socket to have a quick and comfortable plug for the glove



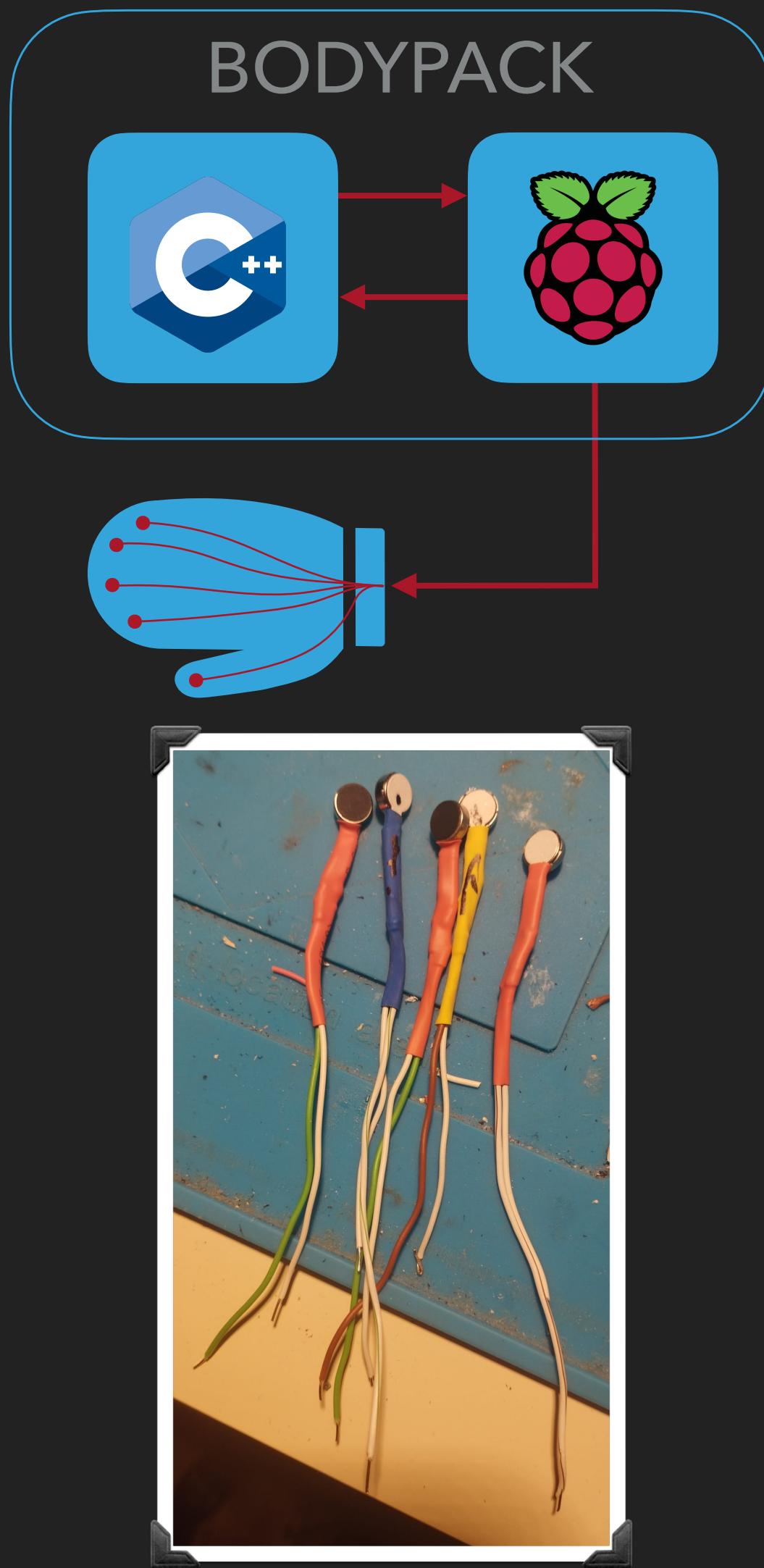
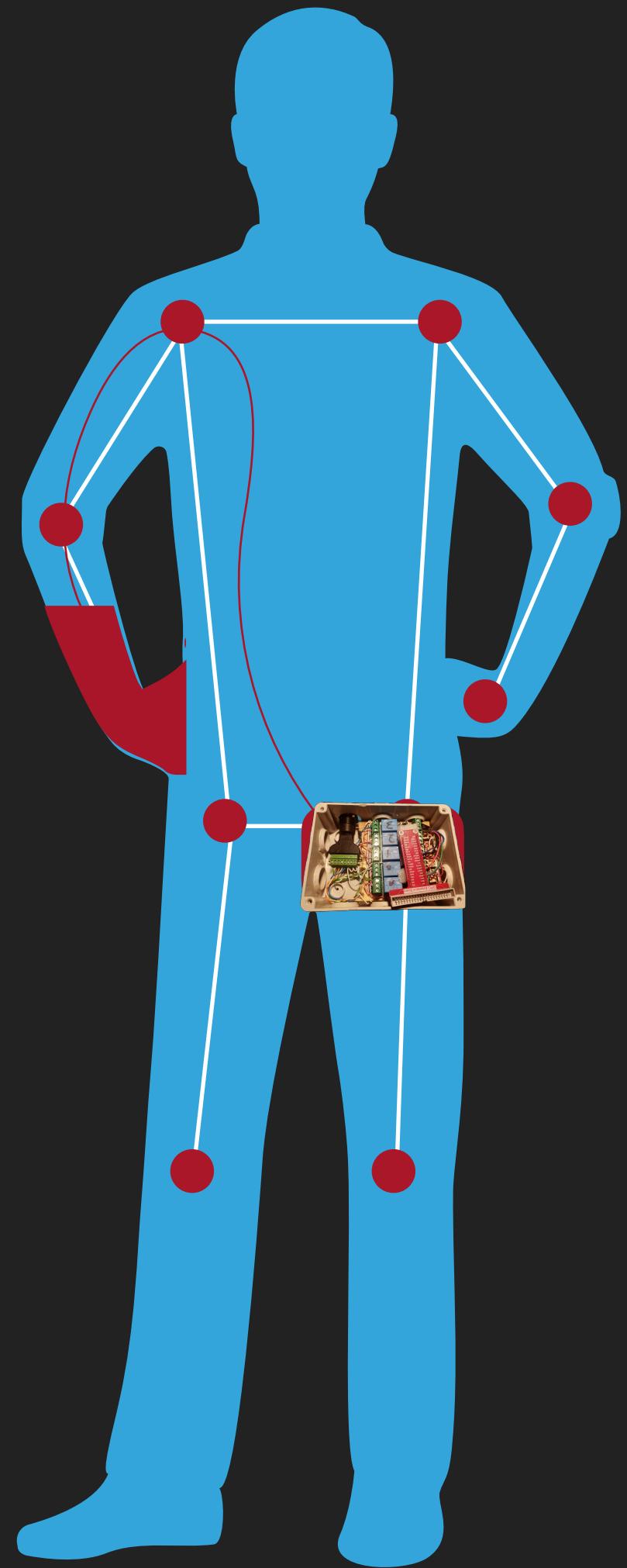
Five relays  
connected to the  
GPIO interface of  
the Raspberry Pi to  
control the actuators  
of the glove



# OUTPUT - GLOVE



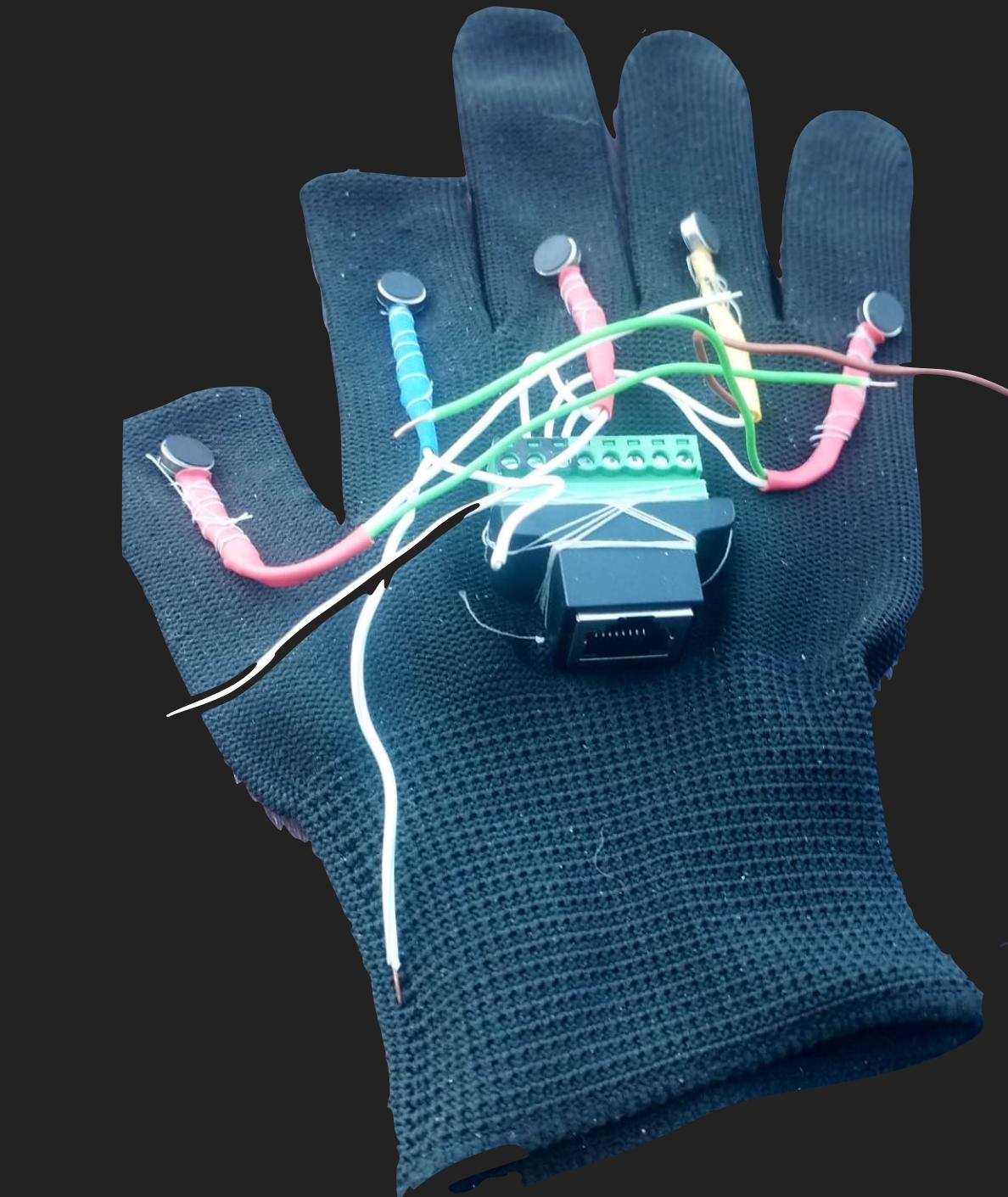
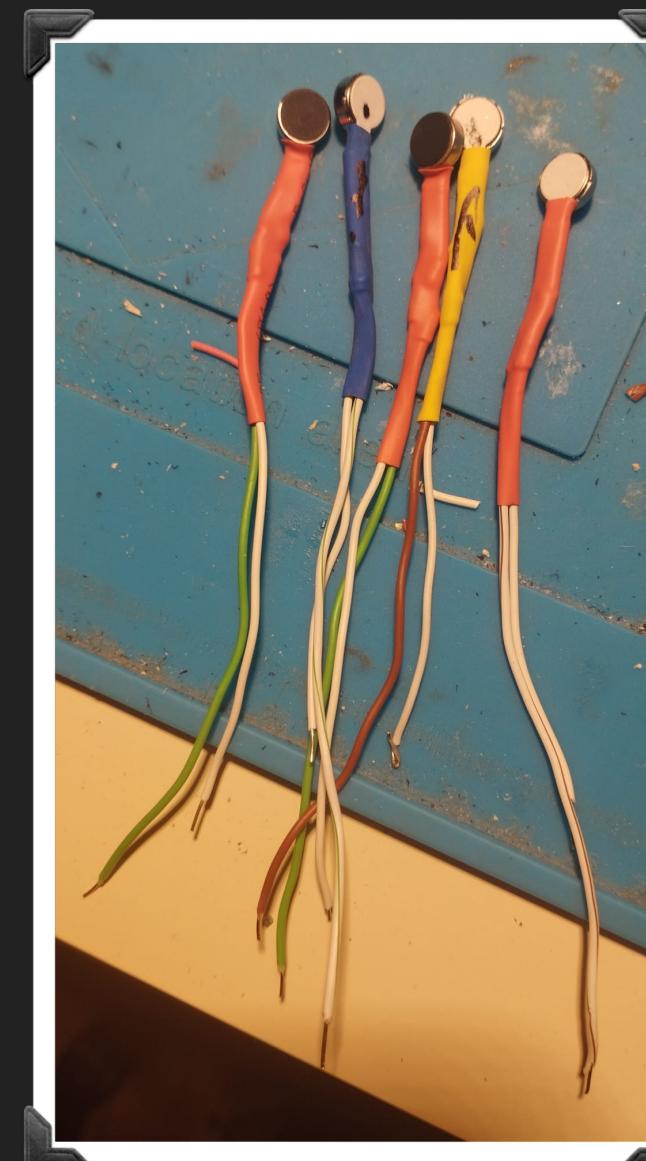
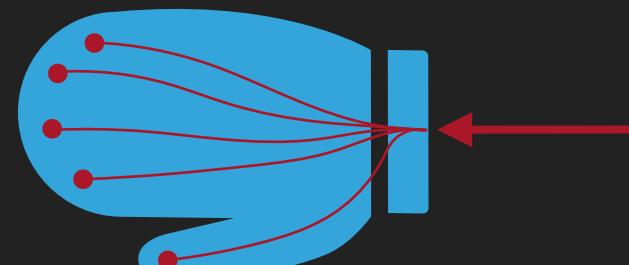
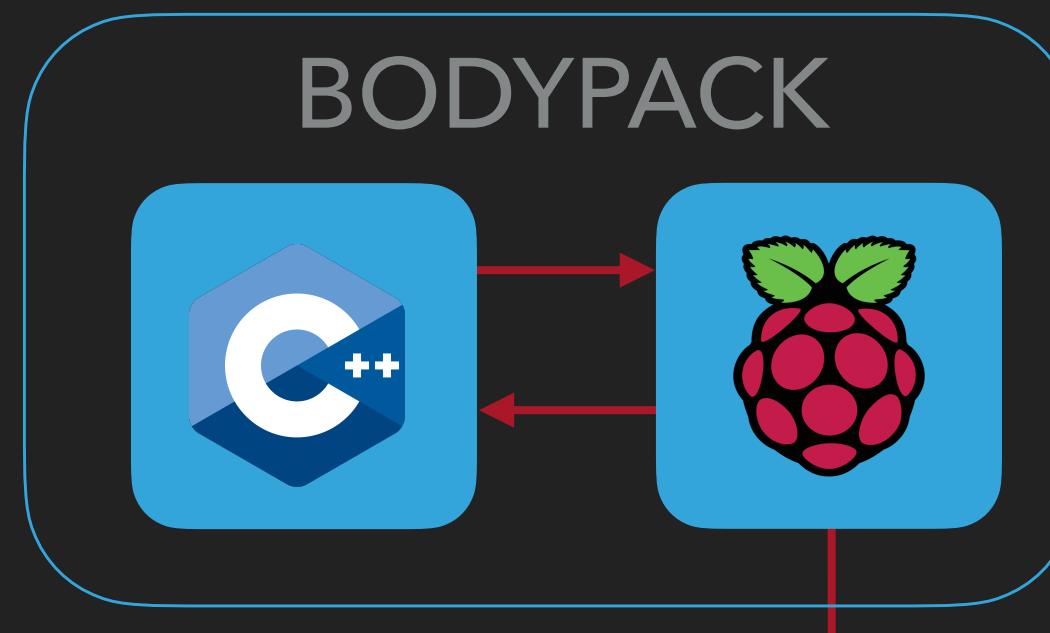
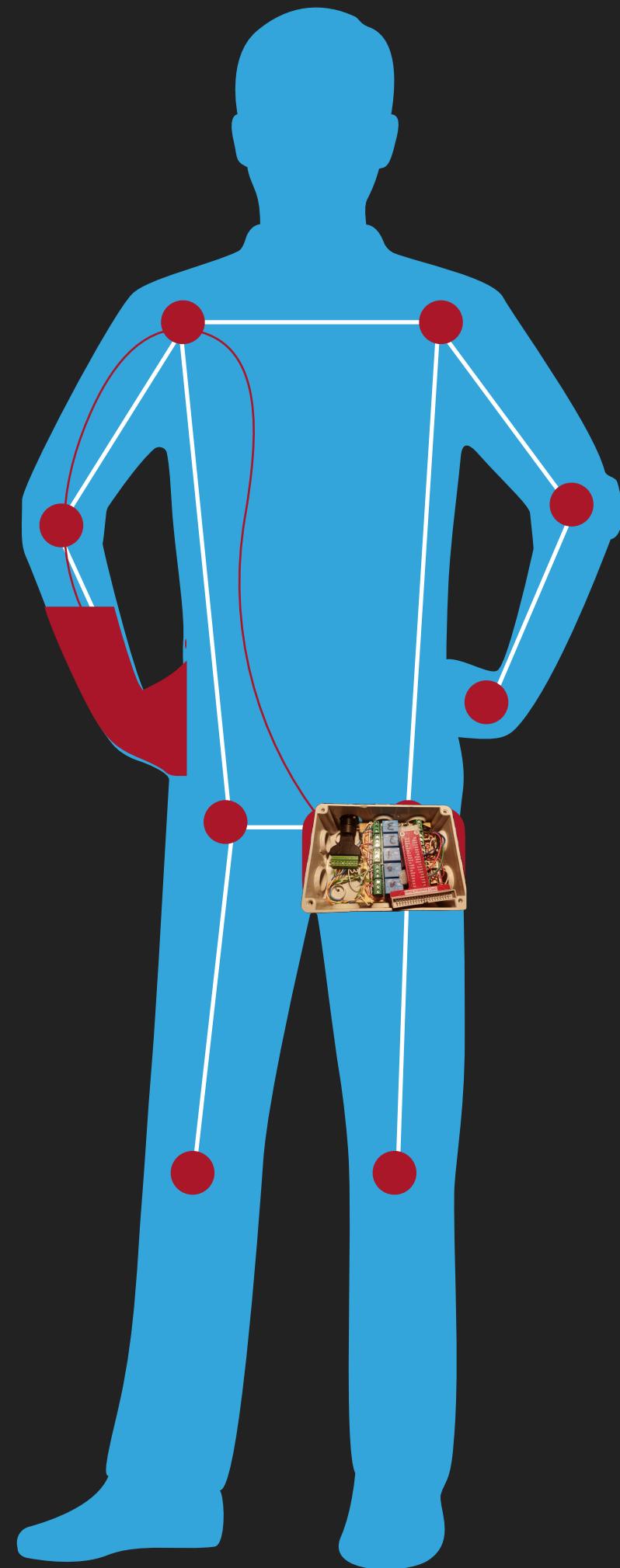
## OUTPUT - GLOVE



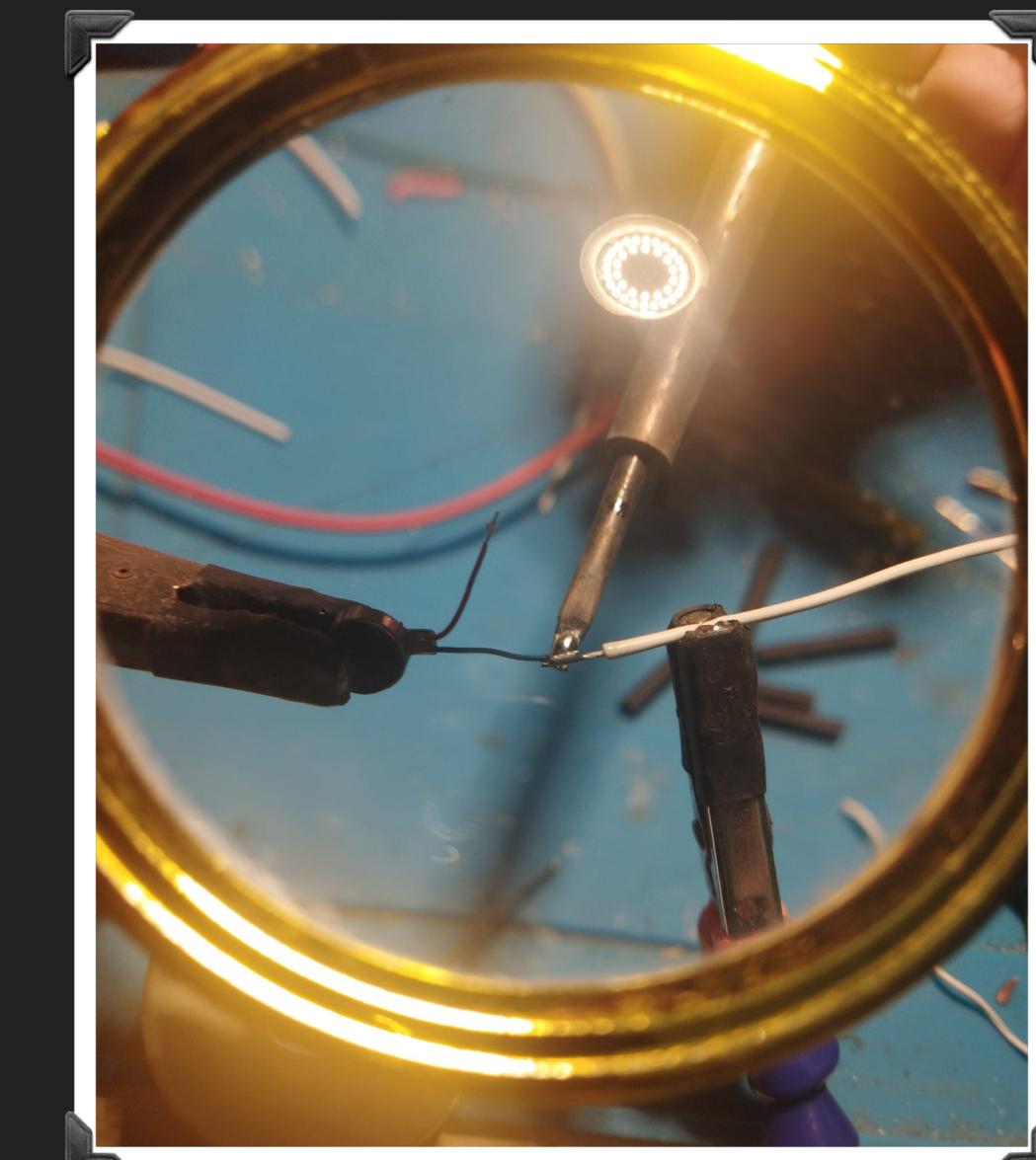
- ▶ Haptic feedback given by vibrating actuators placed on the fingers of a glove working at 3.3V



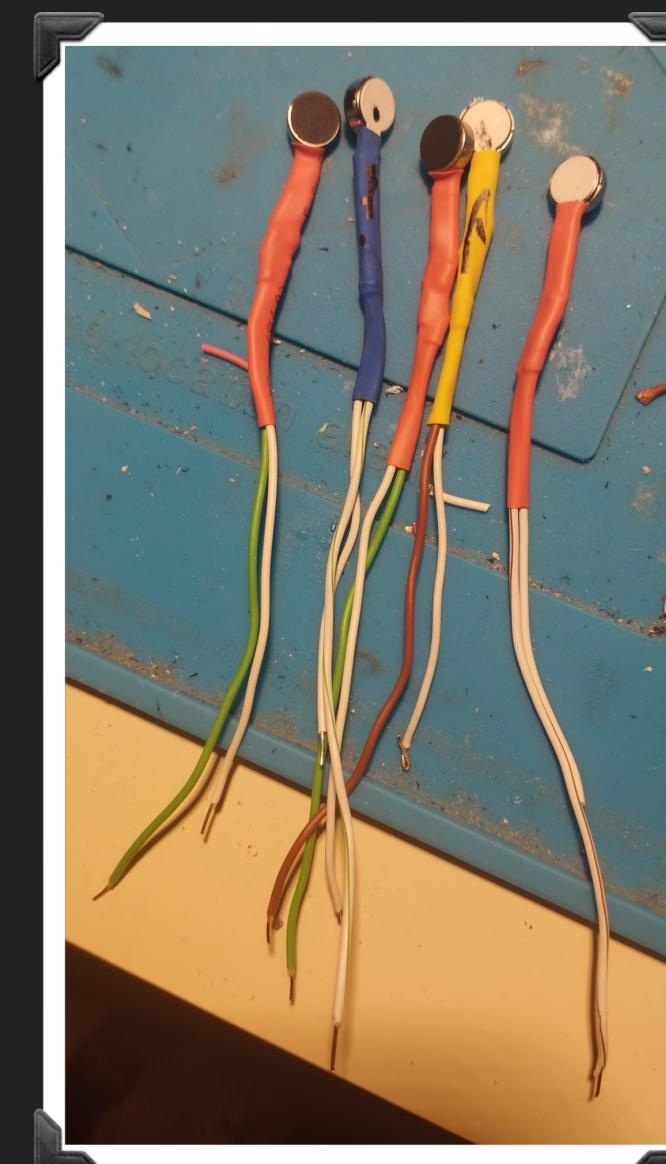
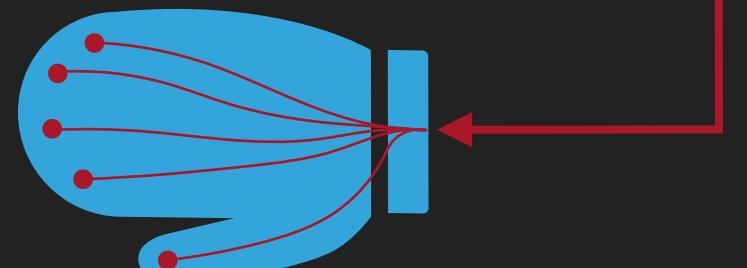
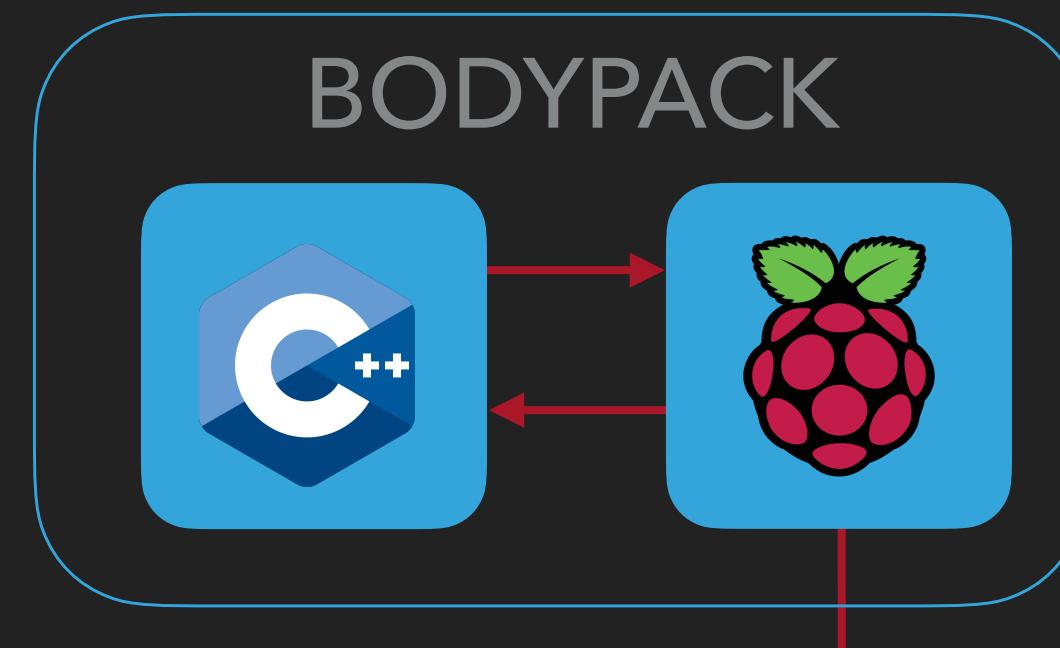
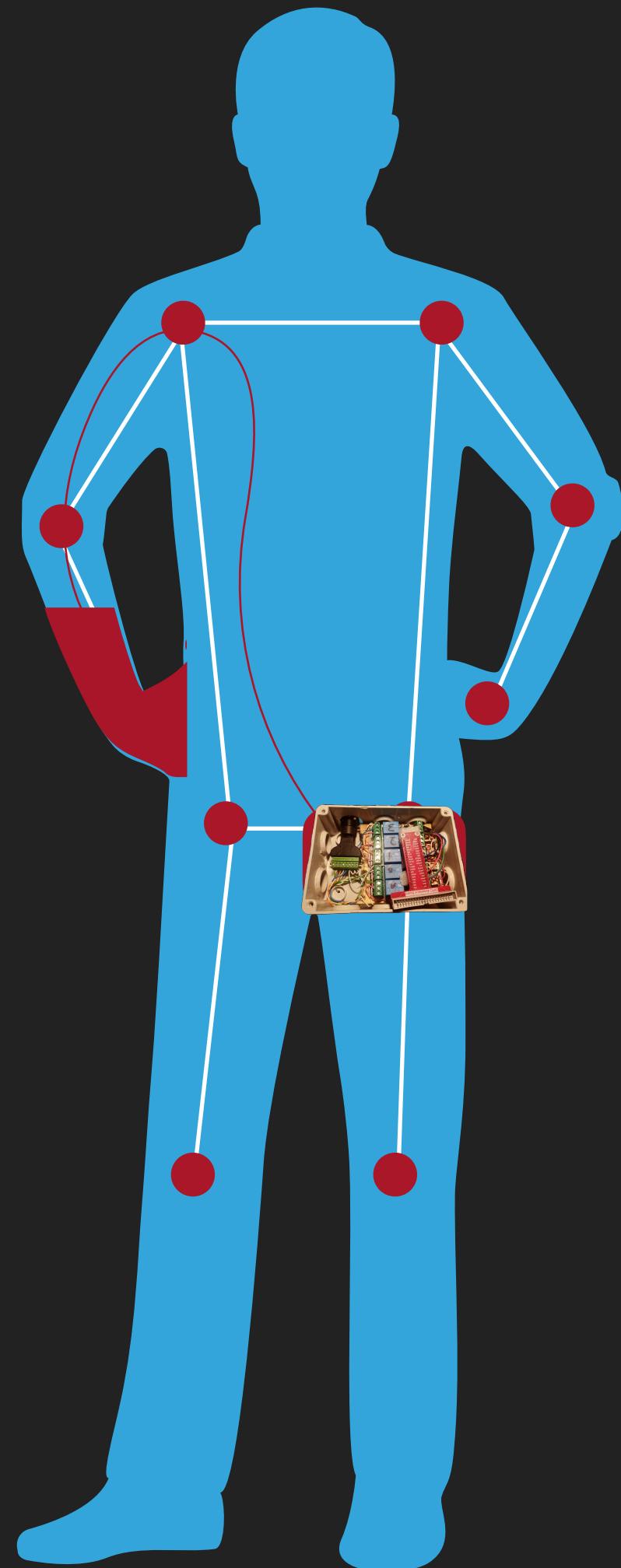
# OUTPUT - GLOVE



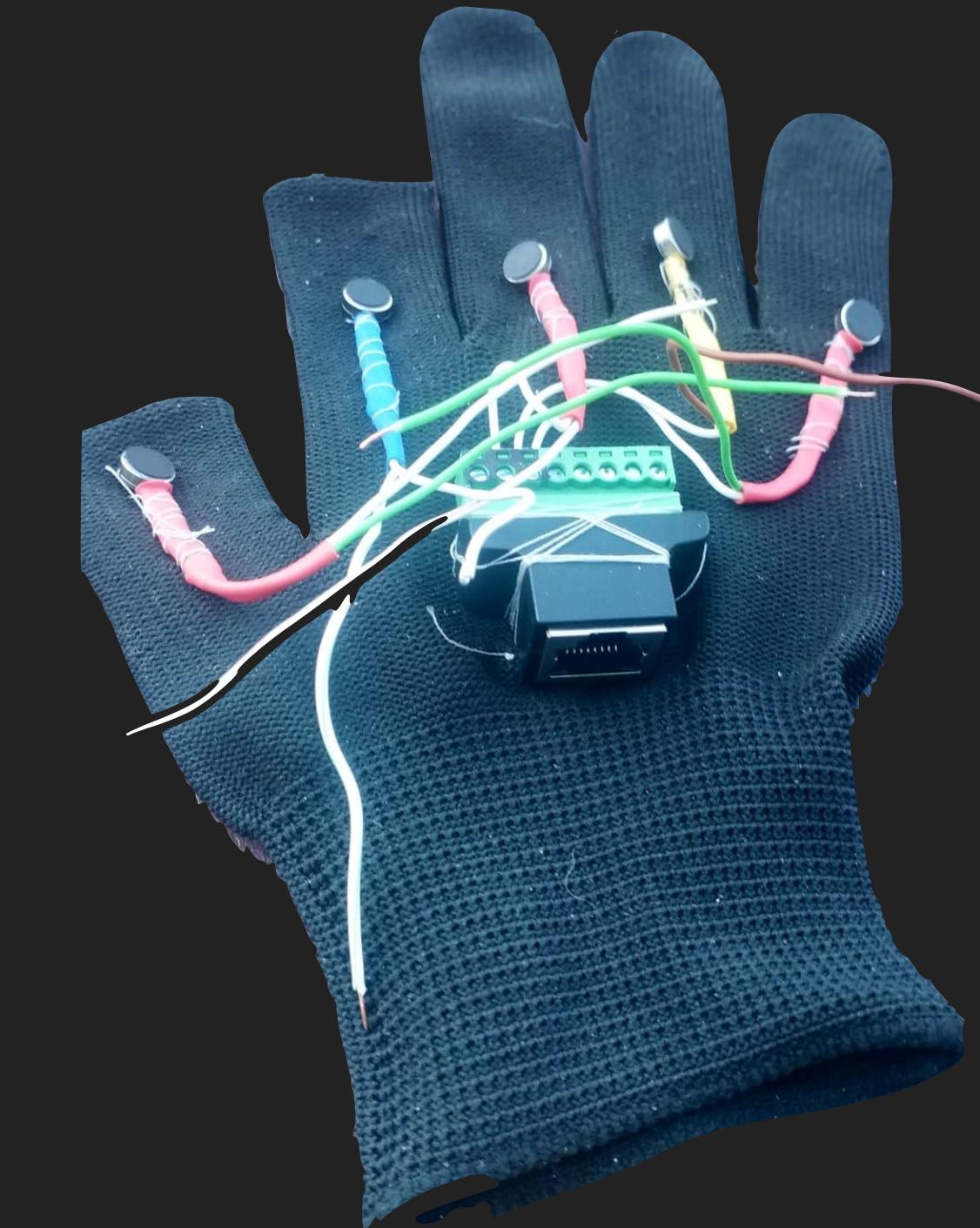
- ▶ Haptic feedback given by vibrating actuators placed on the fingers of a glove working at 3.3V
- ▶ Installation of an ethernet socket to have a quick and comfort plug



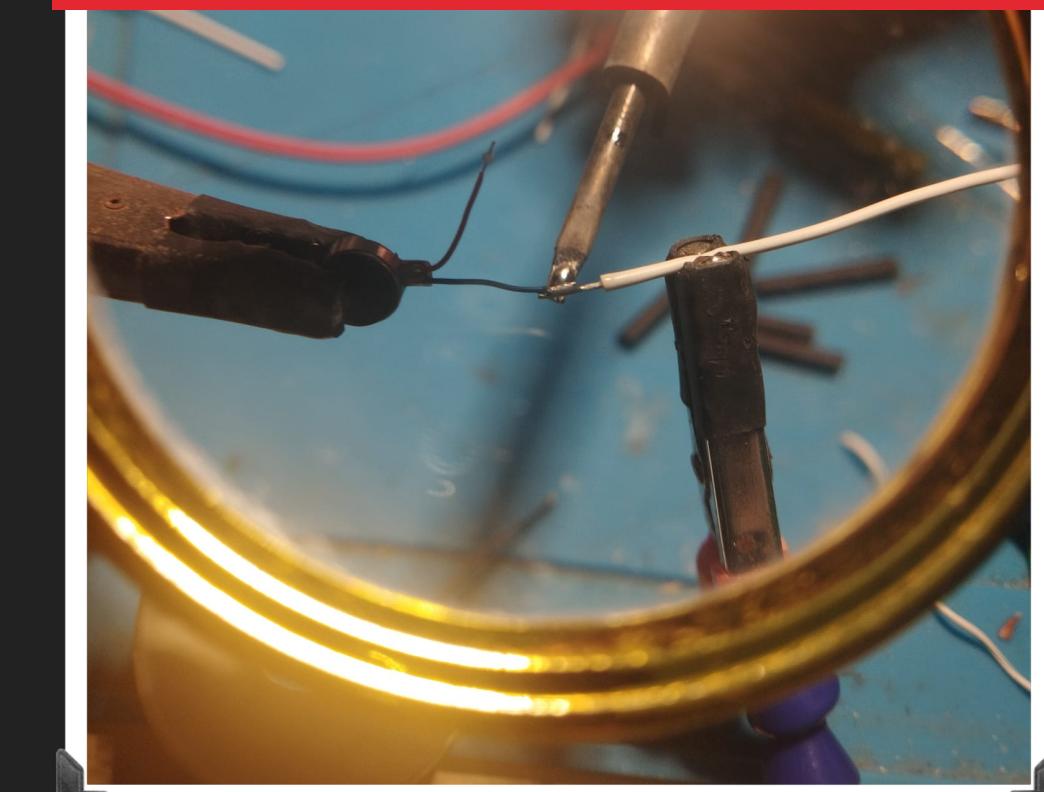
## OUTPUT - GLOVE



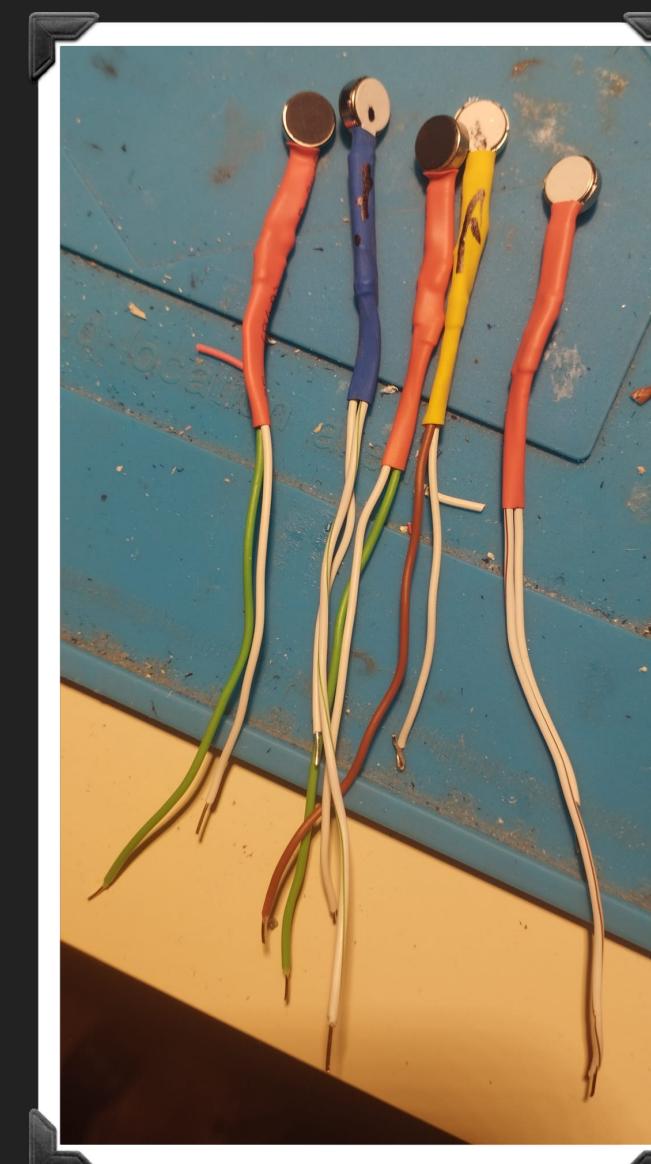
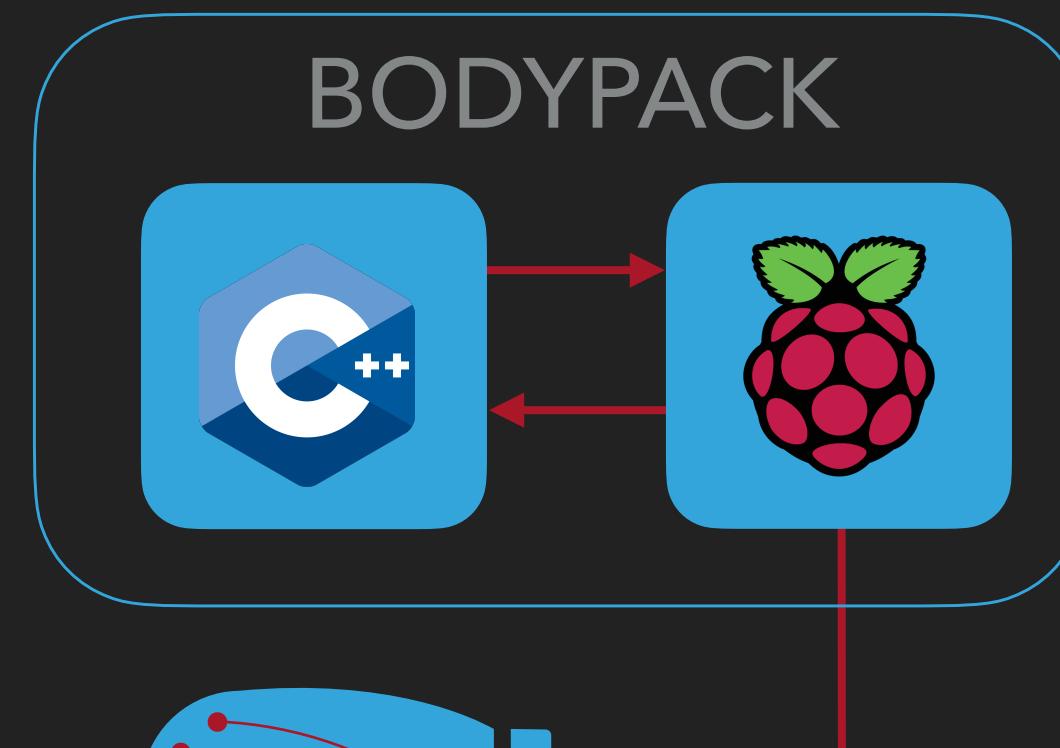
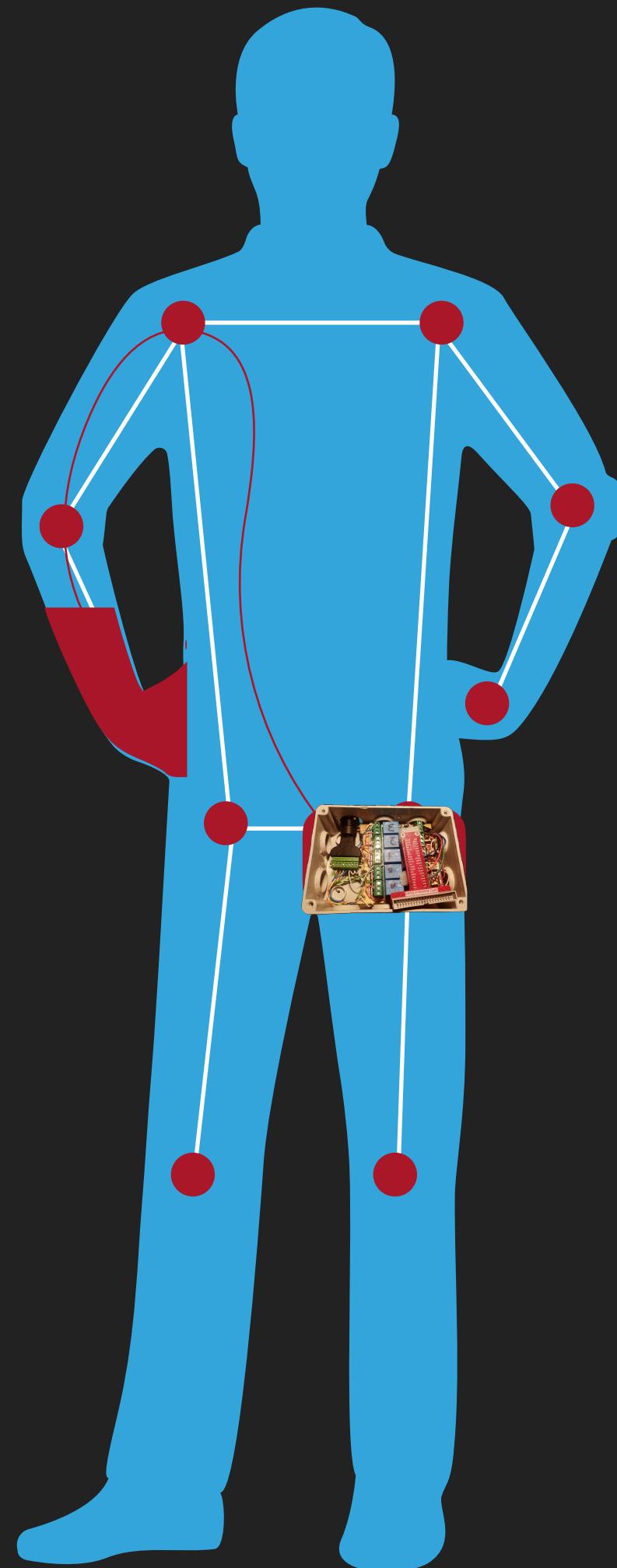
- ▶ Haptic feedback given by vibrating actuators placed on the fingers of a glove working at 3.3V
- ▶ Installation of an ethernet socket to have a quick and comfort plug



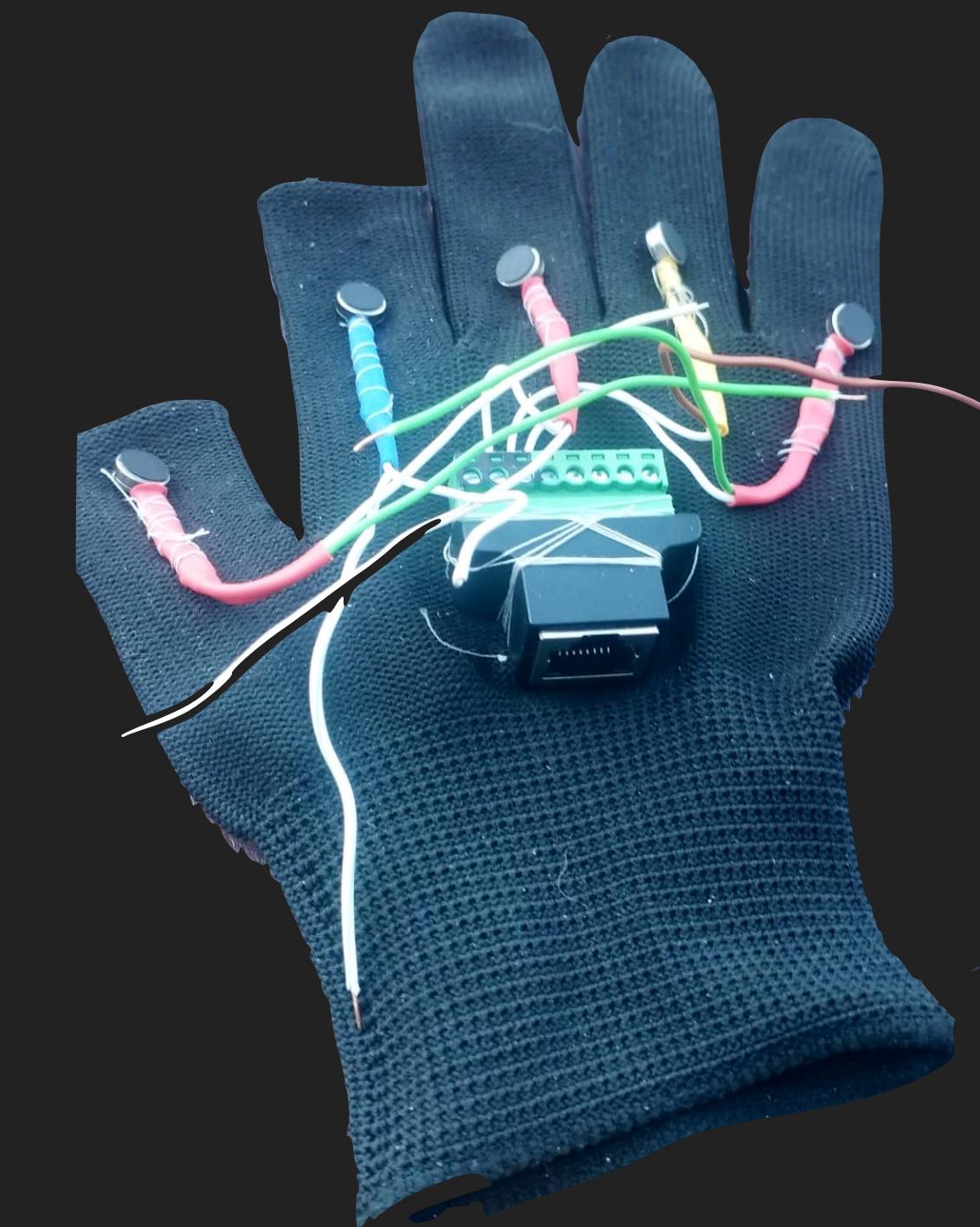
**CHALLENGE:**  
EXTREMELY THIN AND DELICATE WIRES FOR THE ACTUATORS



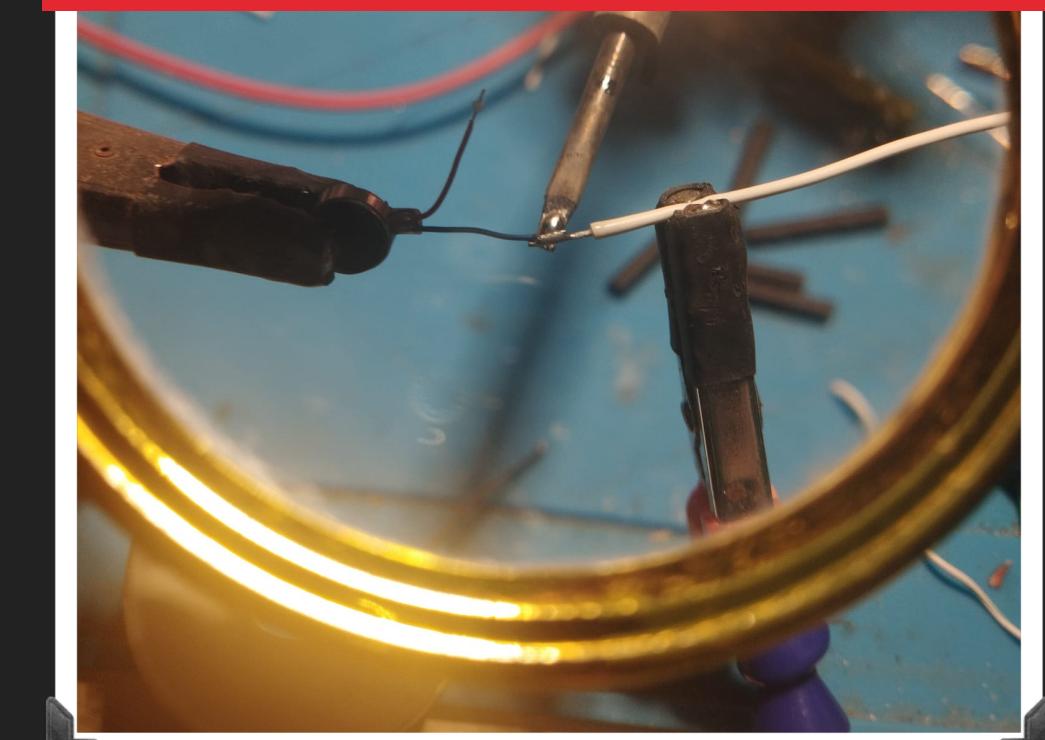
## OUTPUT - GLOVE



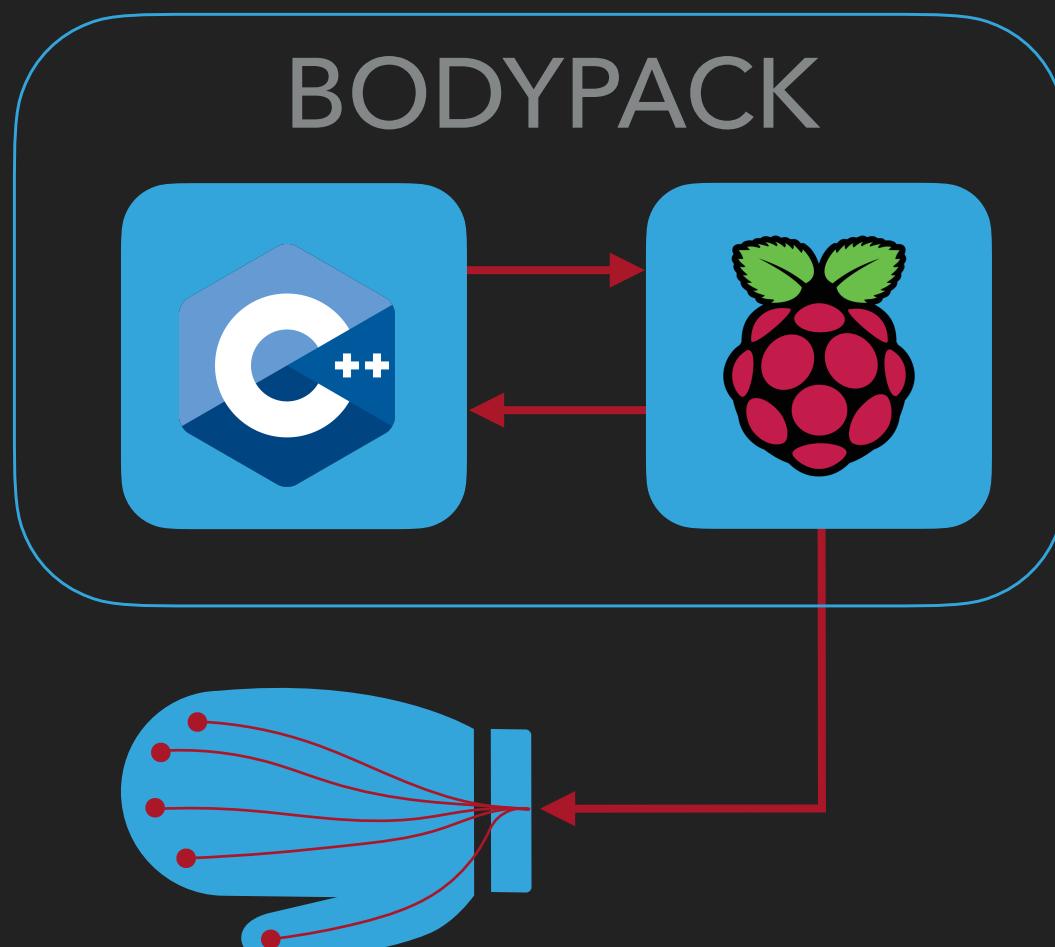
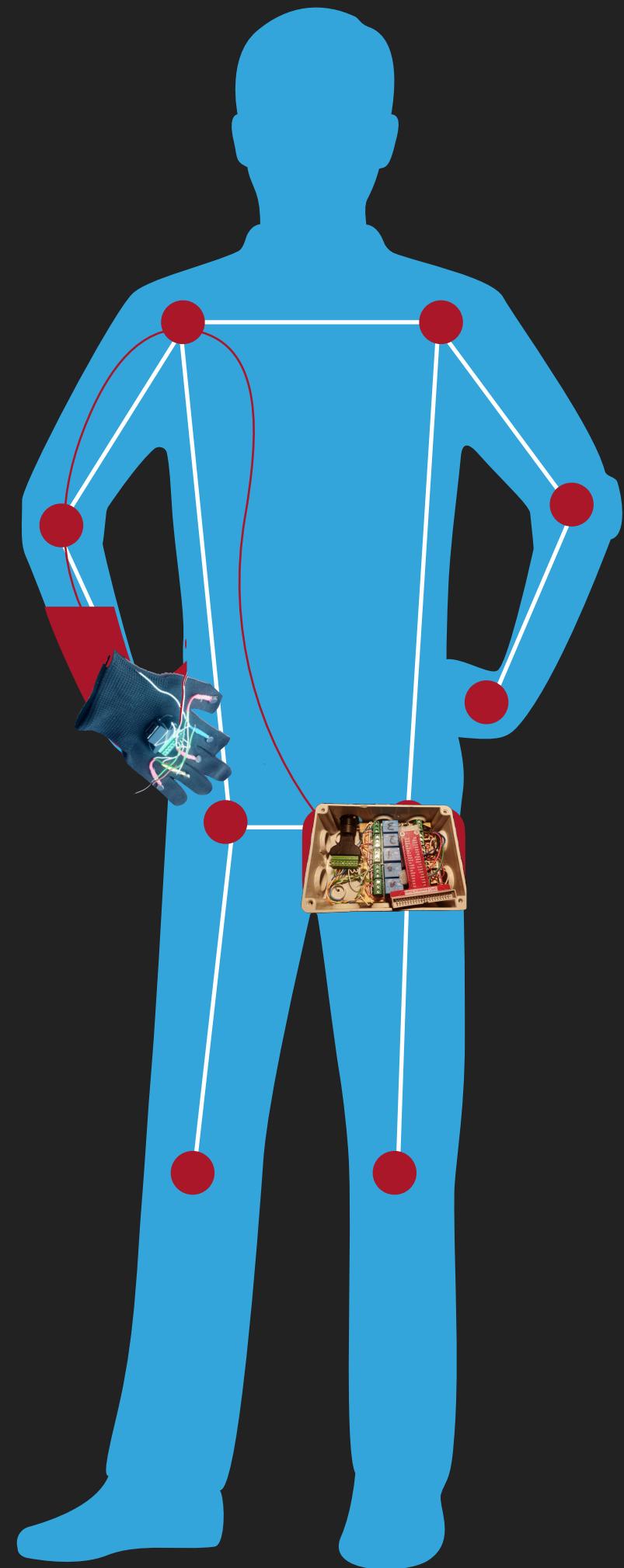
- ▶ Haptic feedback given by vibrating actuators placed on the fingers of a glove working at 3.3V
- ▶ Installation of an ethernet socket to have a quick and comfort plug



**NO SOLUTION:**  
ONE WIRE BROKE LAST WEEK AND  
THE MID FINGER ACTUATOR DOES  
NOT WORK ANYMORE :(



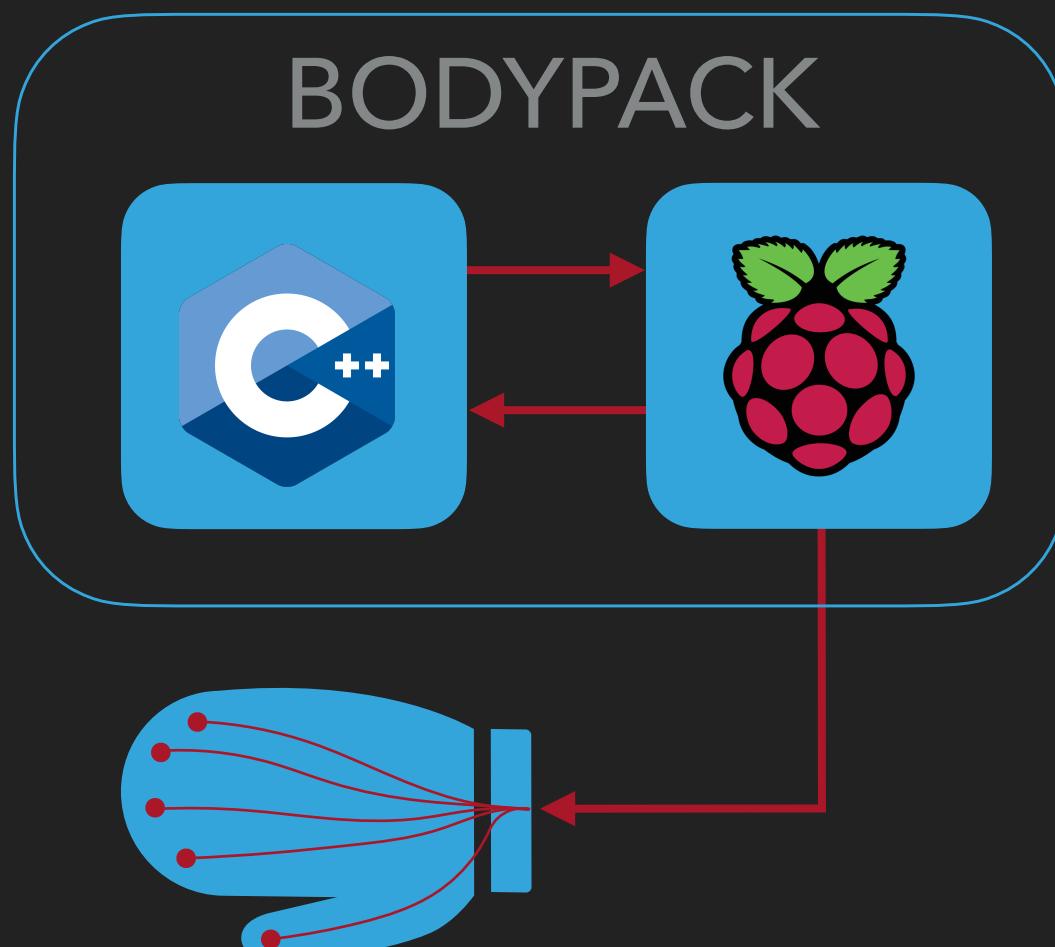
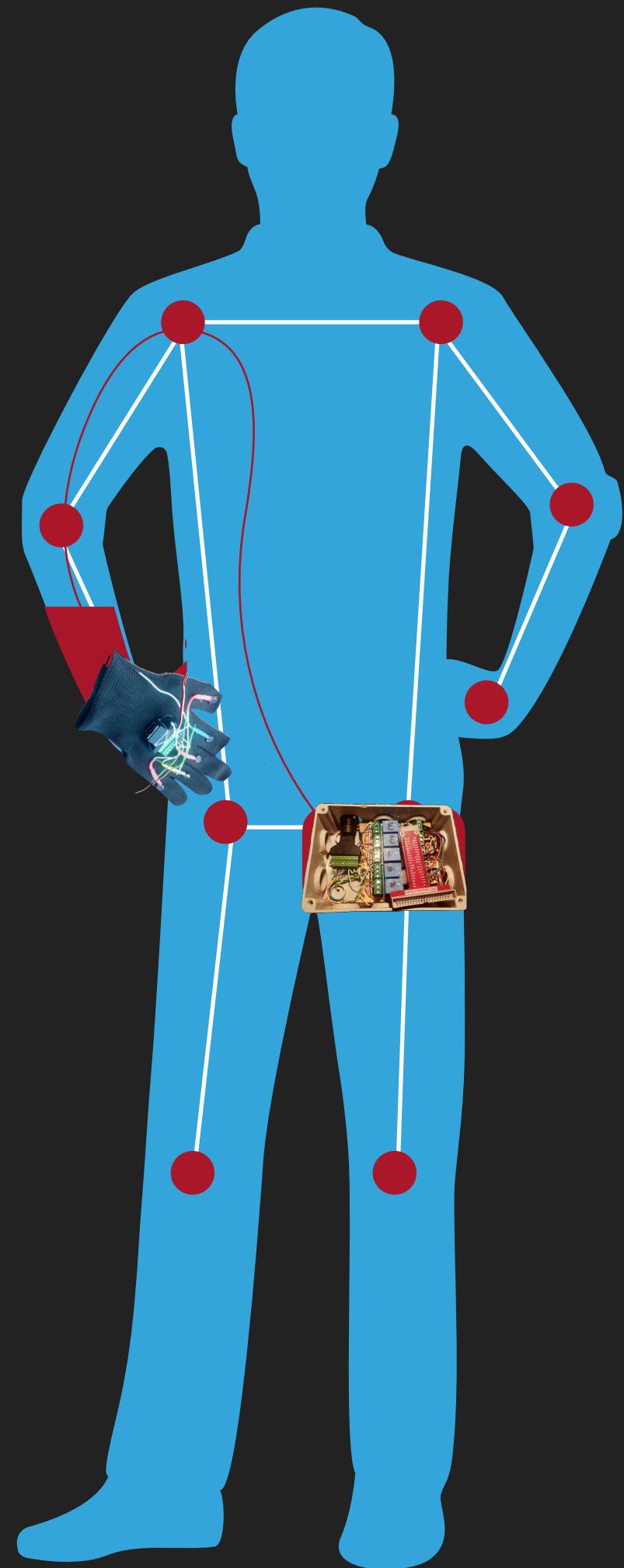
## OUTPUT - GLOVE



- ▶ Haptic feedback given by vibrating actuators placed on the finger of a glove working at 3.3 V



## OUTPUT - GLOVE

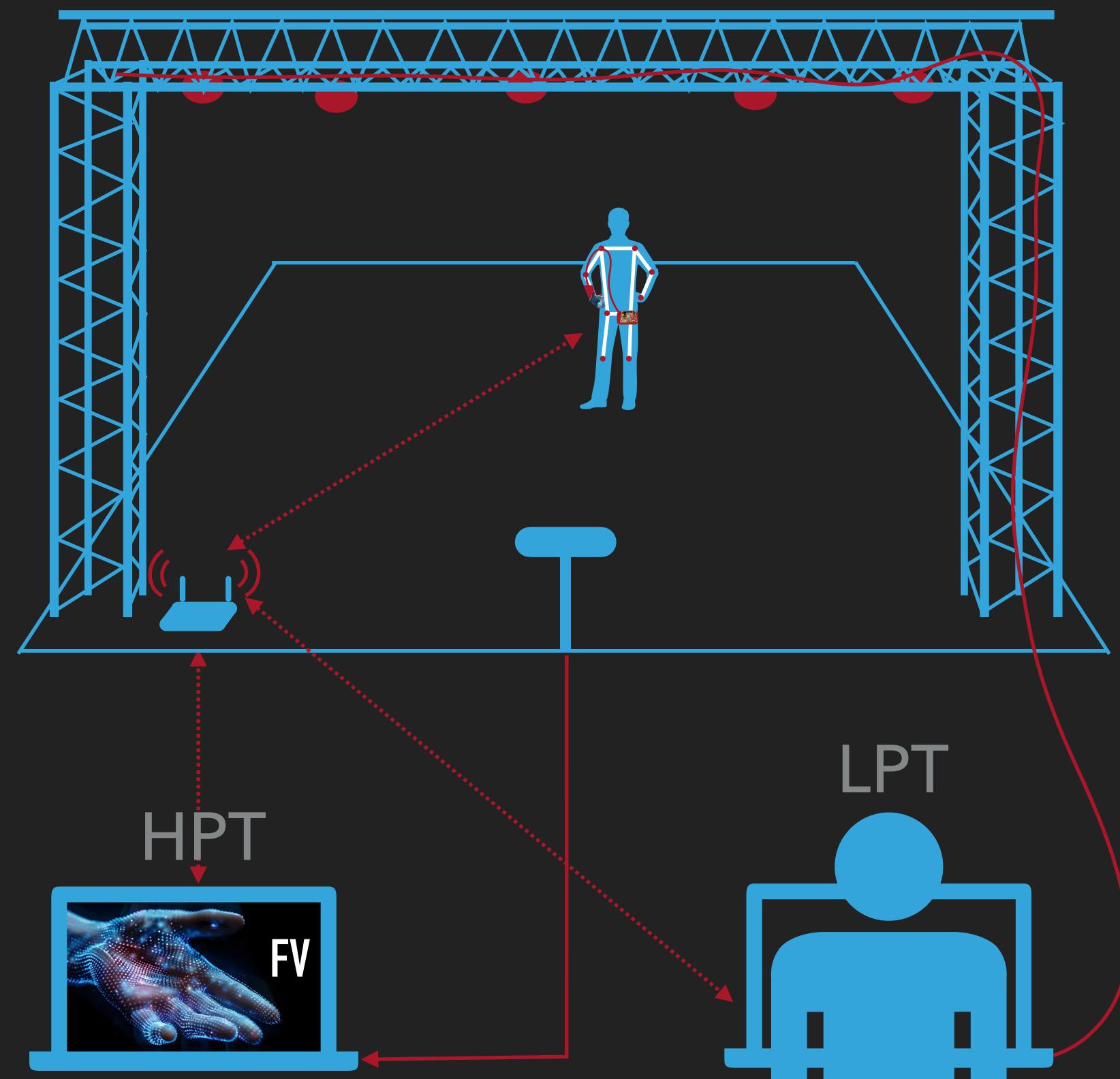


- ▶ Haptic feedback given by vibrating actuators placed on the finger of a glove working at 3.3 V



# ARCHITECTURE

ON STAGE

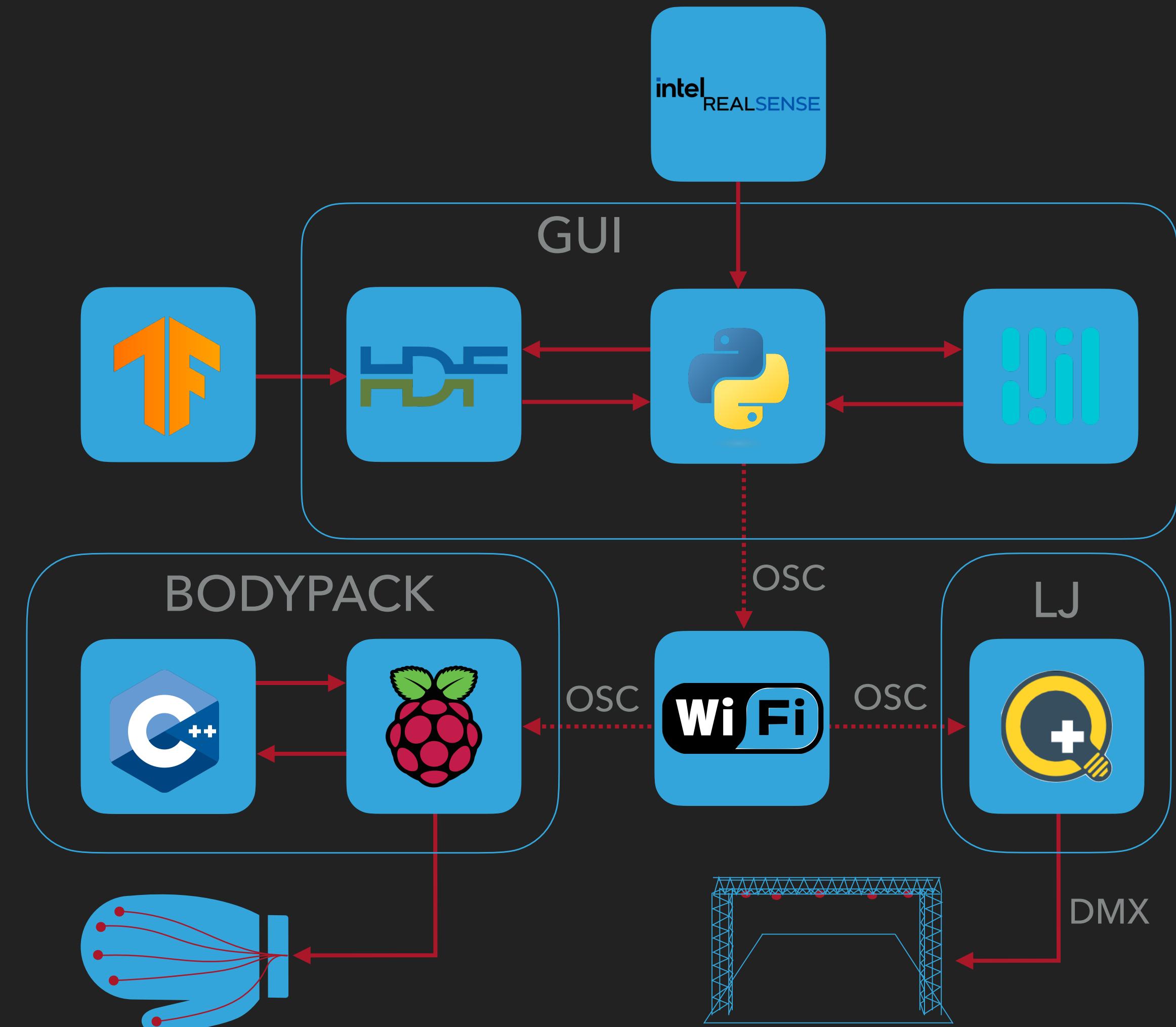


INPUT

CORE

OUTPUT

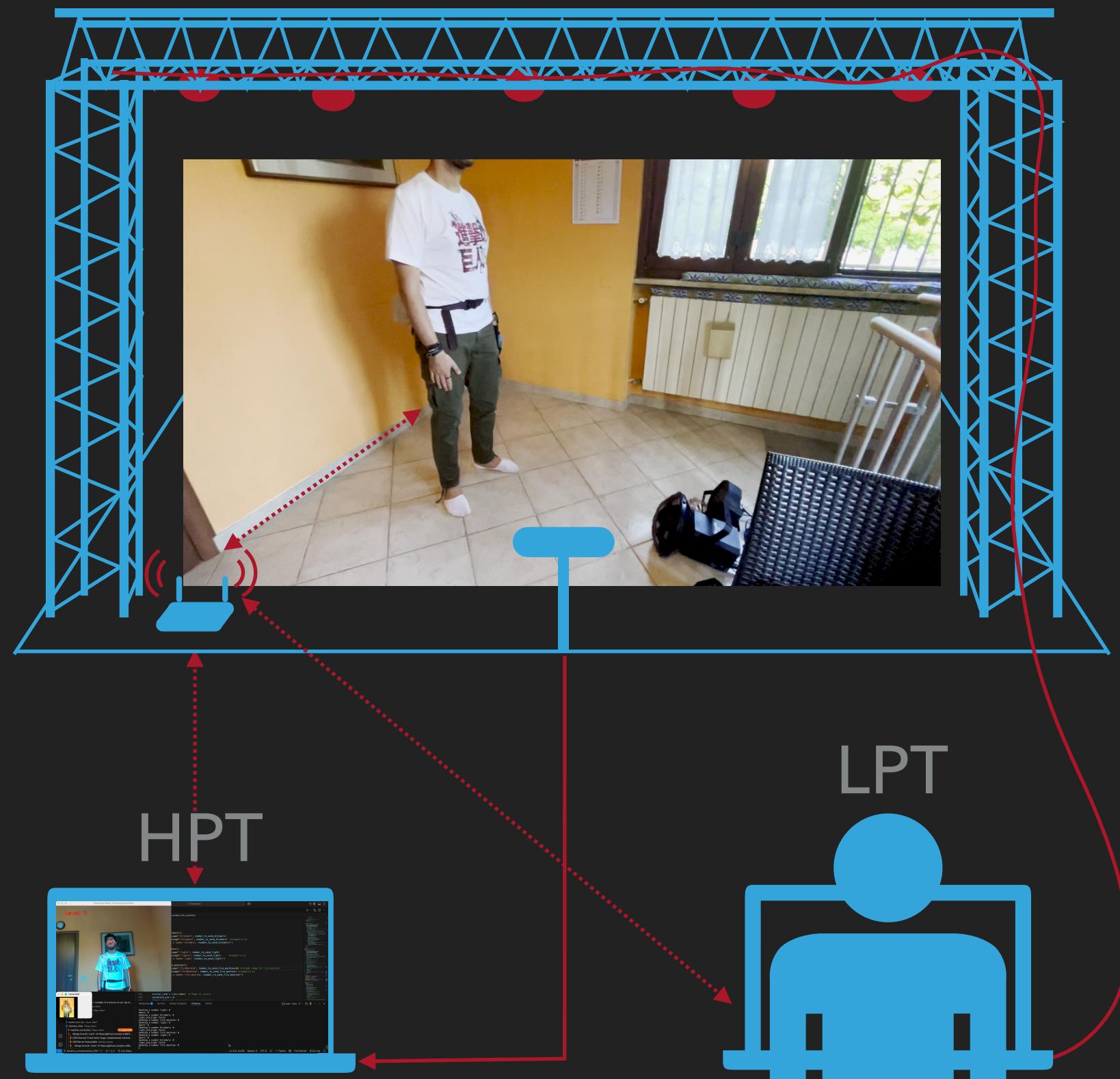
BEHIND THE SCENE



# FINAL VERSION

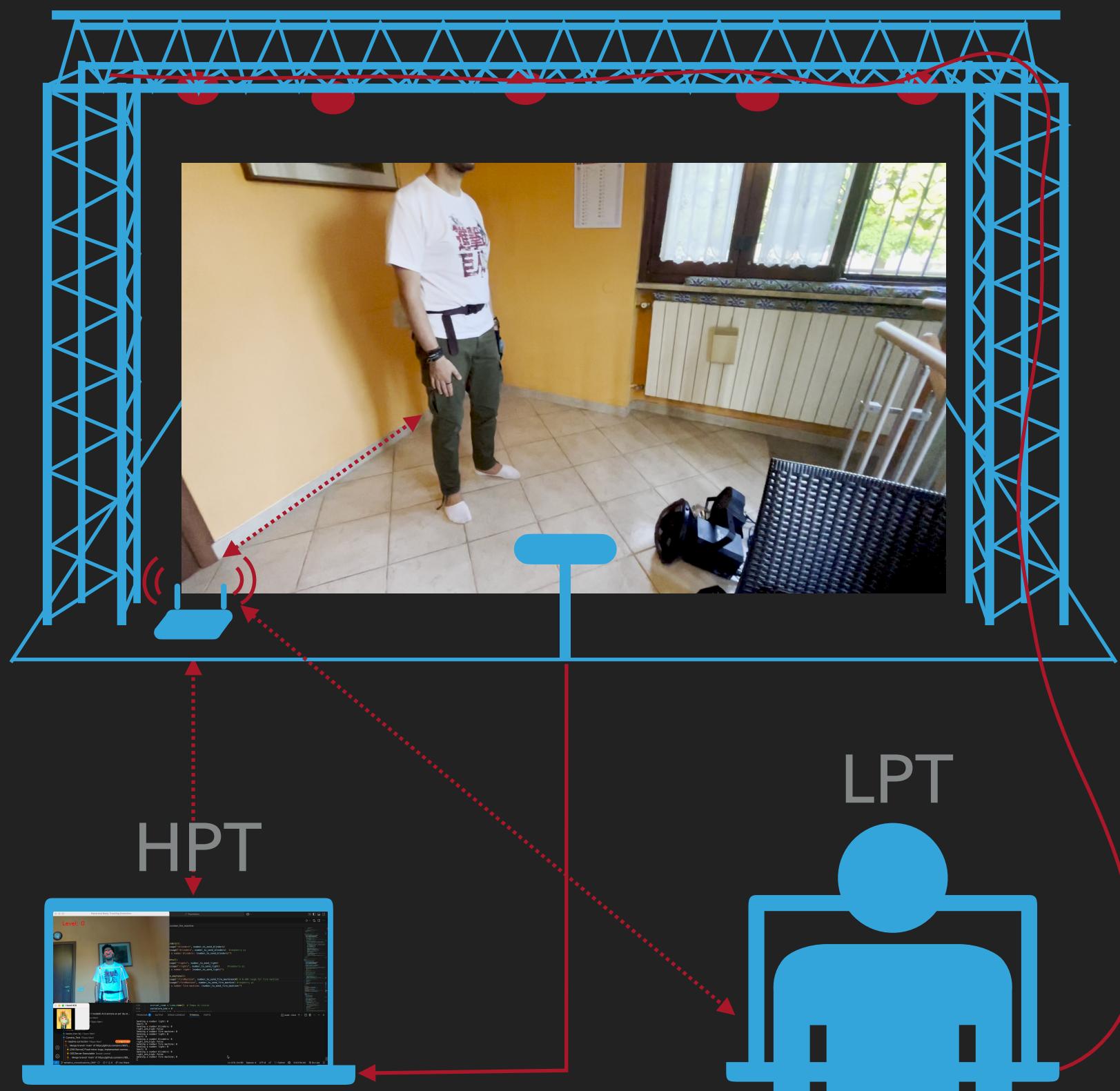
ON STAGE

## POSSIBLE IMPROVEMENTS



# FINAL VERSION

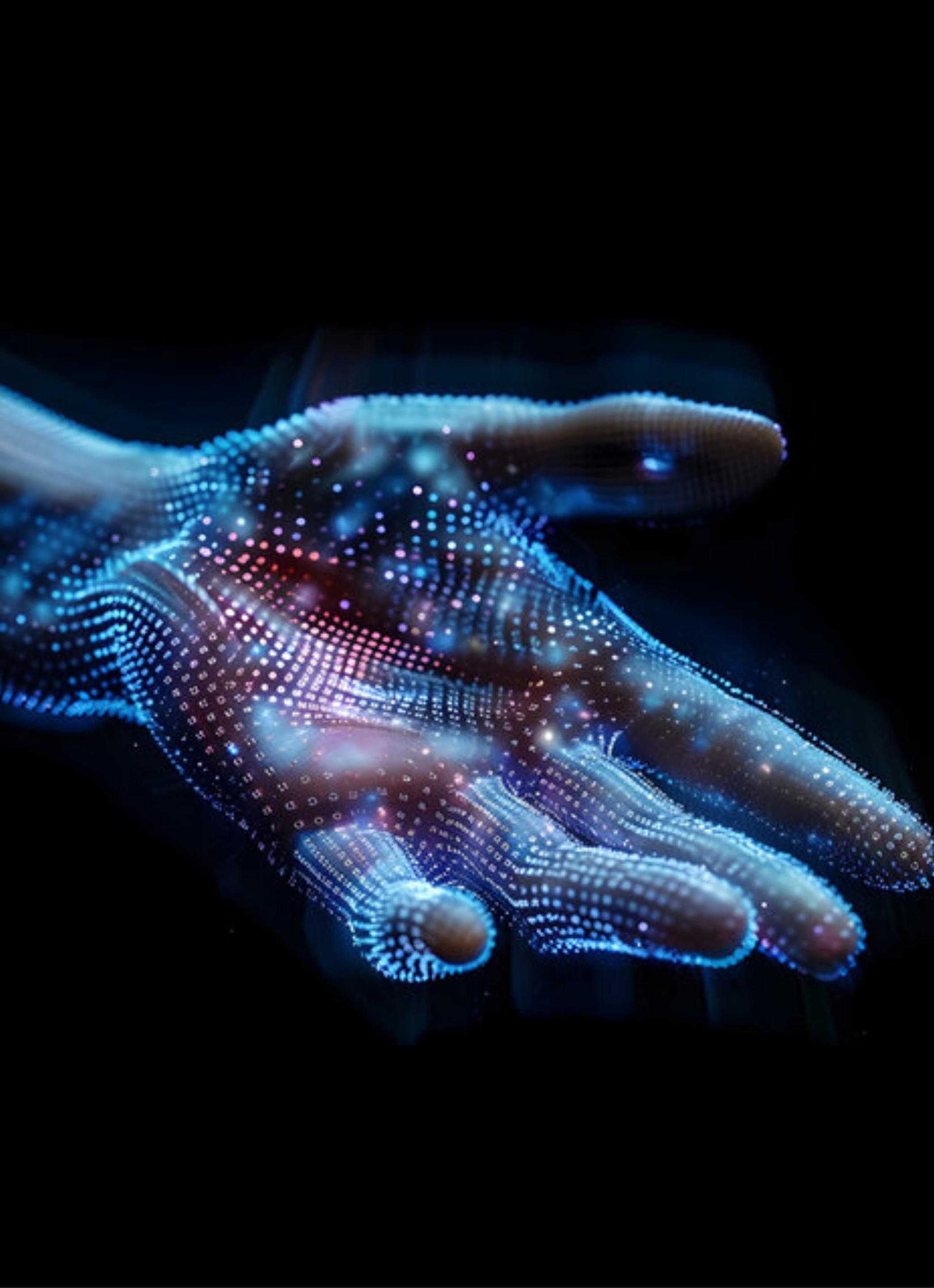
## ON STAGE



## POSSIBLE IMPROVEMENTS

- ▶ Creating a set of movements that can be recognized and making the model customizable
- ▶ Print the integrated circuit
- ▶ Optimize the computational effort in order to increase the definition and, therefore, the performance of the overall system





THANKS FOR YOUR  
ATTENTION

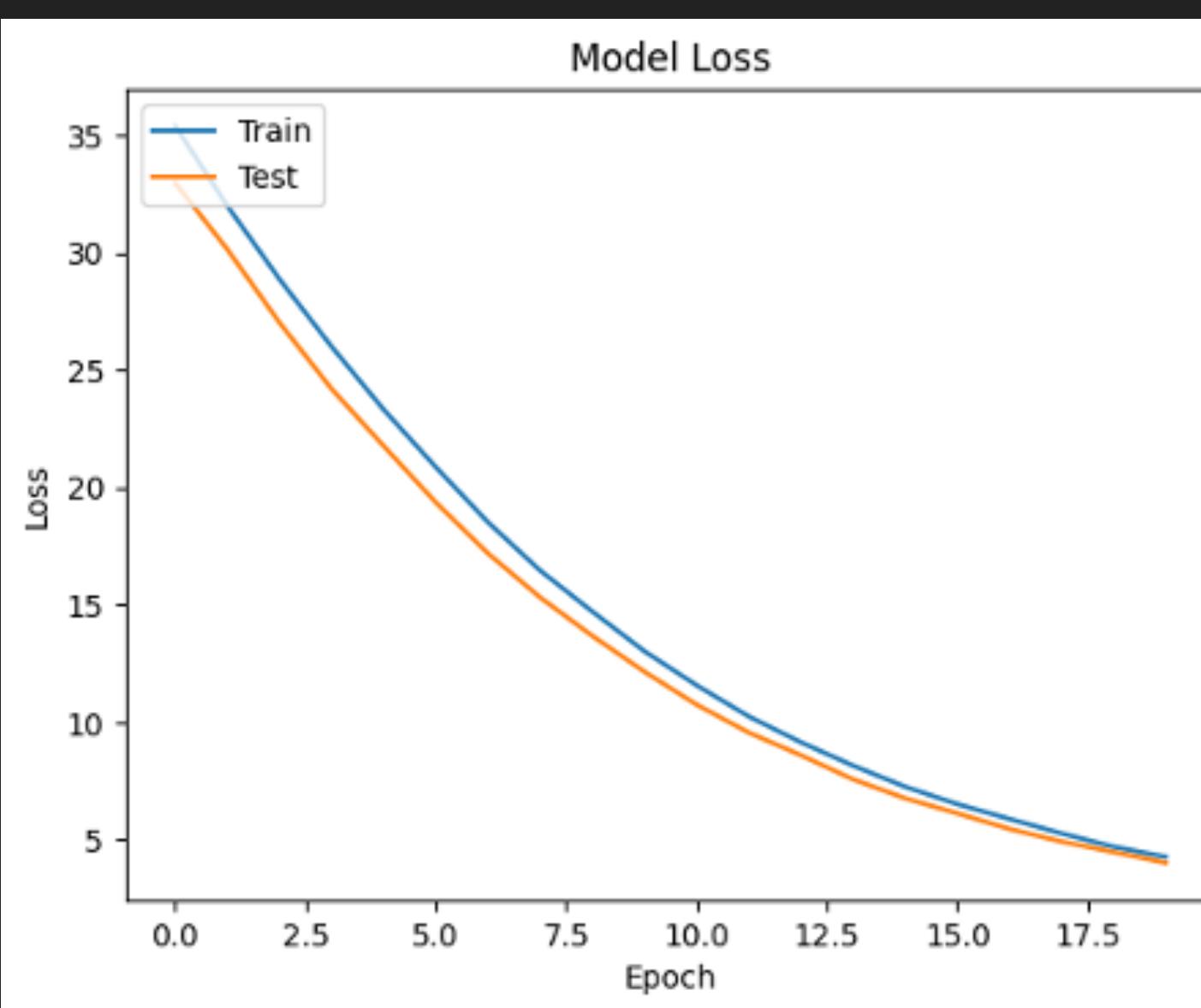
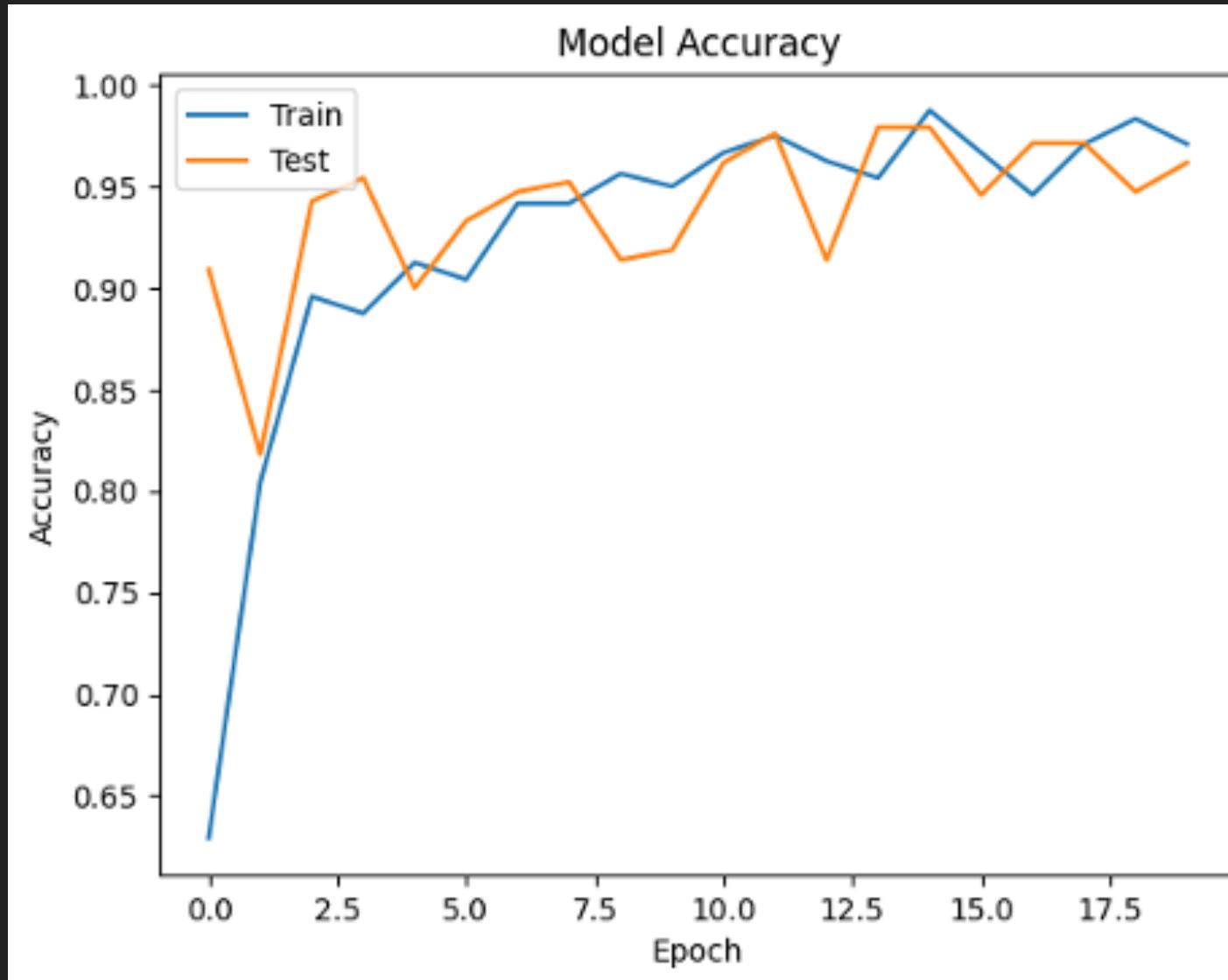
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**FLOWVISION**

# APPENDEX

## APPENDEX

# AI MODEL: HAND



Layer (type)	Output Shape	Param #
mobilenet_1.00_224 (Functional)	(None, 3, 3, 1024)	3,228,864
global_average_pooling2d_6 (GlobalAveragePooling2D)	(None, 1024)	0
dense_31 (Dense)	(None, 128)	131,200
dropout_16 (Dropout)	(None, 128)	0
dense_32 (Dense)	(None, 128)	16,512
dropout_17 (Dropout)	(None, 128)	0
dense_33 (Dense)	(None, 2)	258

Total params: 3,376,834 (12.88 MB)

Epoch: 40

Train Accuracy: 0.9667

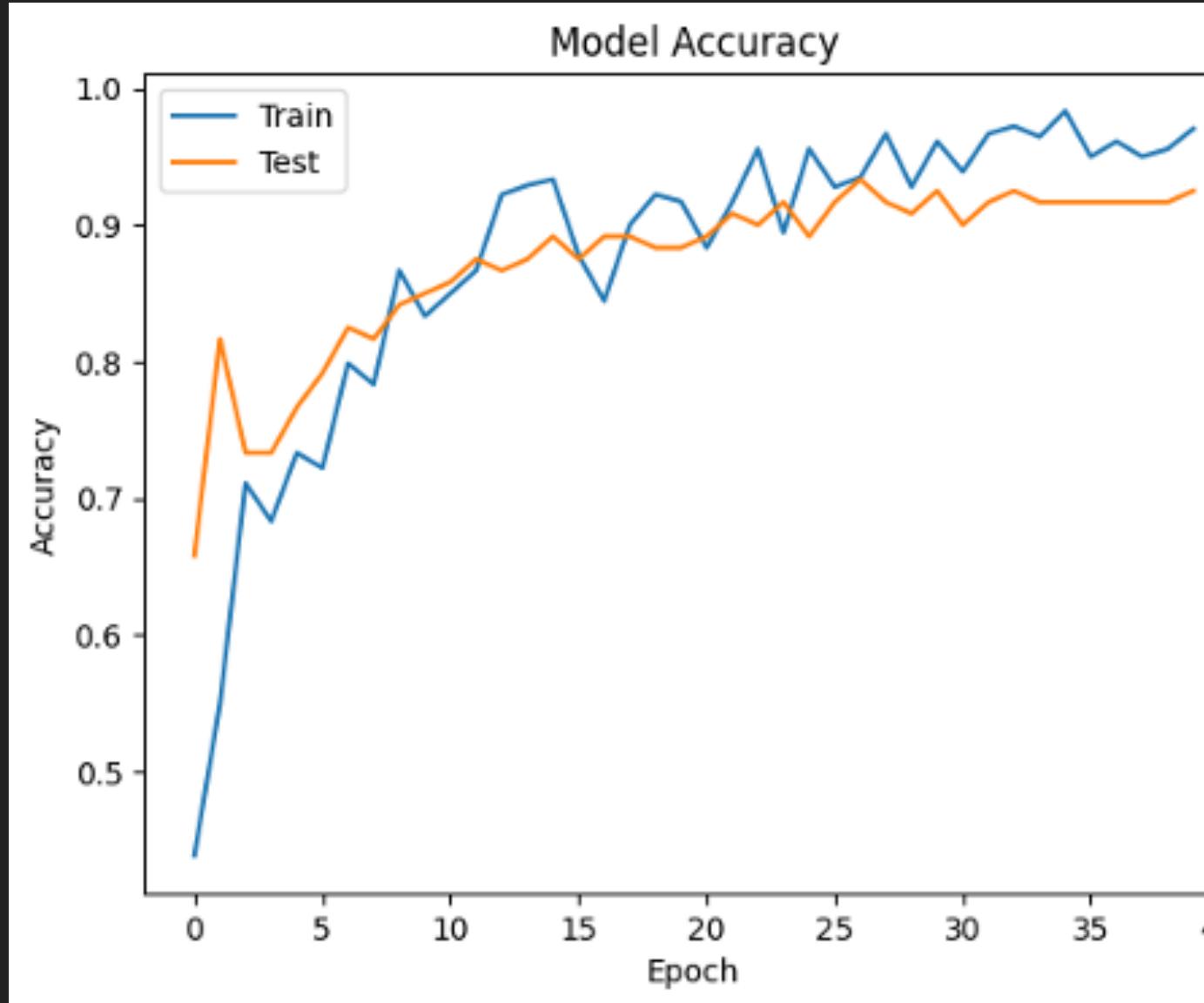
Val Accuracy: 0.9617

Train Loss: 4.3496

Val Loss: 4.0218

## APPENDIX

# AI MODEL: HEART



Epoch: 40

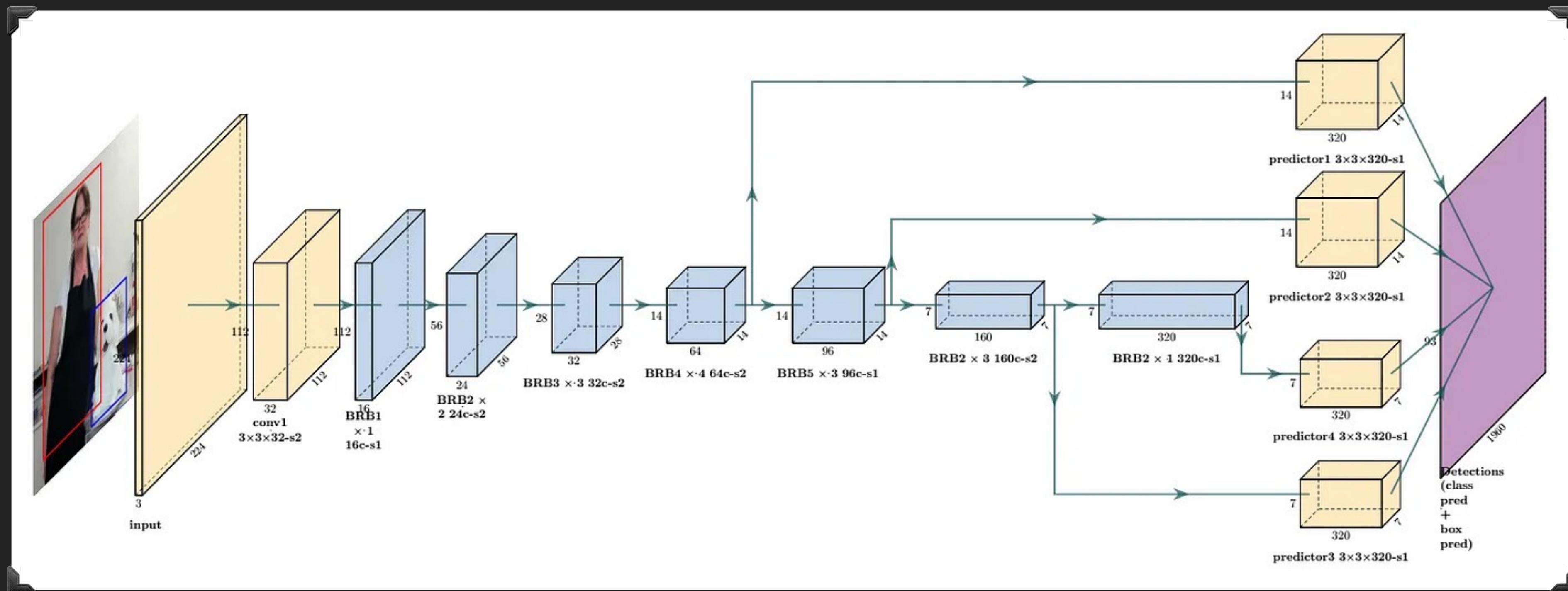
Train Accuracy:  
0.9602

Val Accuracy:  
0.9250

Train Loss:  
0.0794

Val Loss:  
0.1886

# MOBILE-NET - VERSION 1



► Convolutional Neural Network (CNN) architecture designed for image classification, object detection, and other computer vision tasks

► Developed in 2013 by Laurent Sifre as an architectural variation on AlexNet

► Based on **depthwise separable convolution**, process that decomposes a single standard convolution into two convolutions: a **depthwise convolution** that filters each input channel independently and a **pointwise convolution** (1x1 convolution) that combines the output of the depthwise convolution.

# CHALLENGE REPORT

Context	Challenge	Solution
Docker	MacOS restrictions on external devices on docker	Trade-off: we decided not to use docker and to implement a simple gui from which to run
Fist Gesture recognition NN	When the hand is closed, its coordinates are not available	Implementation of a fallback code in which the reference point is the wrist when the coordinate
Heart Gesture Recognition NN	No dataset available for the heart gesture	Creation of a dataset by merging two others
Heart Gesture Recognition NN	When the hands are placed on the chest, we get a mistake: they are classified as heart gesture	Implementation of a script that impose the condition that the wrist are not overlapped during
Neural Network	No available dataset to implement a rnn network	Hybrid models (threshold + CNN)
Neural Network	The model does not work well if there is no proper illumination	A higher resolution is not supported with our computational power so we decided to work as
Neural Network	Blinking due to instability of the images	Hysteresis code
RaspberryPi5	Compatibility problems between Python and Raspberry	Implementation of the firmware in C++
Actuator Circuit	Too long shipping time from China to Milan	Implementation of a simpler relais-based circuit
Glove	One wire of the vibrating actuators broke the week before the presentation	NO SOLUTION FOUND :(