Andrea Arosio, Davide Lorenzi
Enrico Torres, Filippo Marri

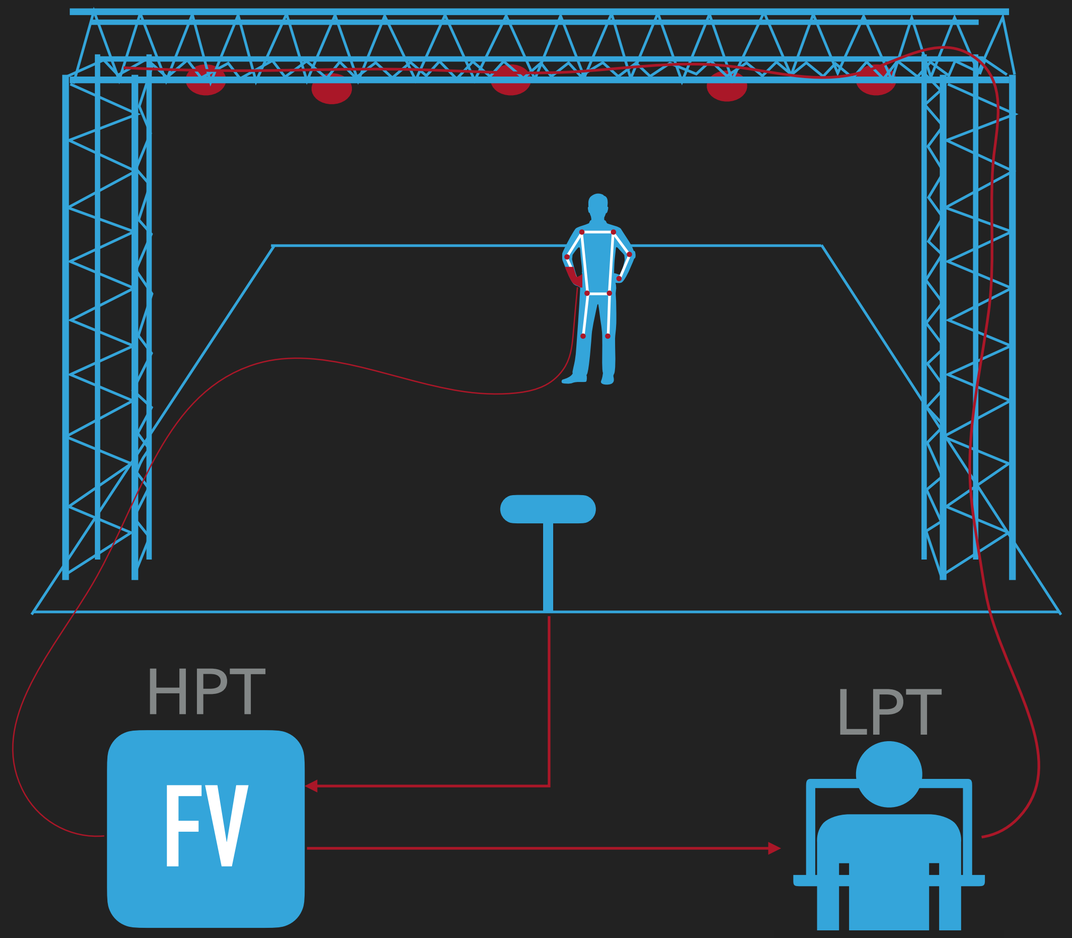
AN INCLUSIVE SOLUTION FOR LIGHT CONTROL

FLOWVISION

CONCEPT

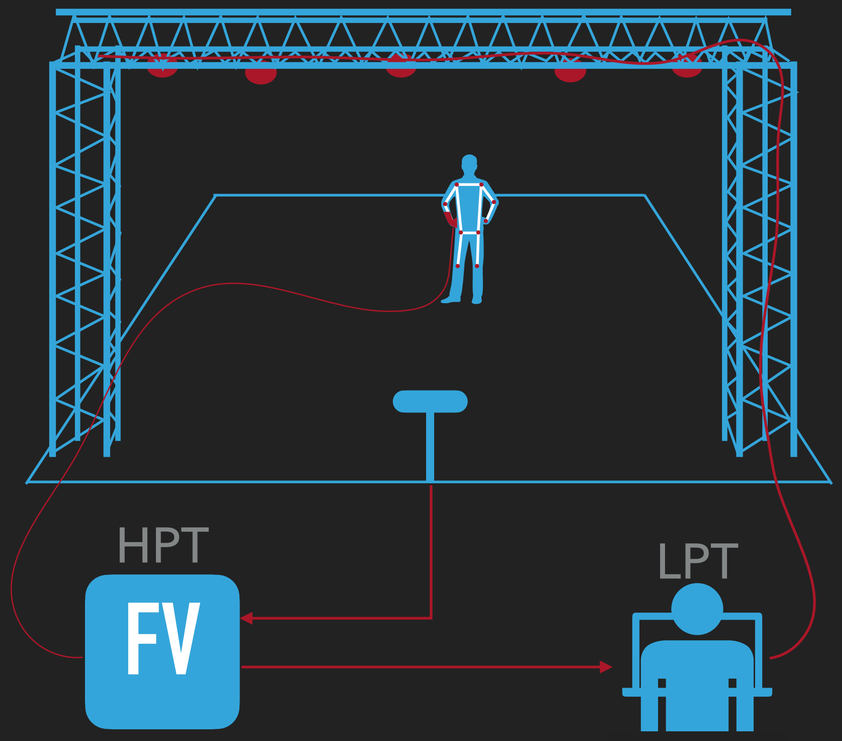
CONCEPT

- 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

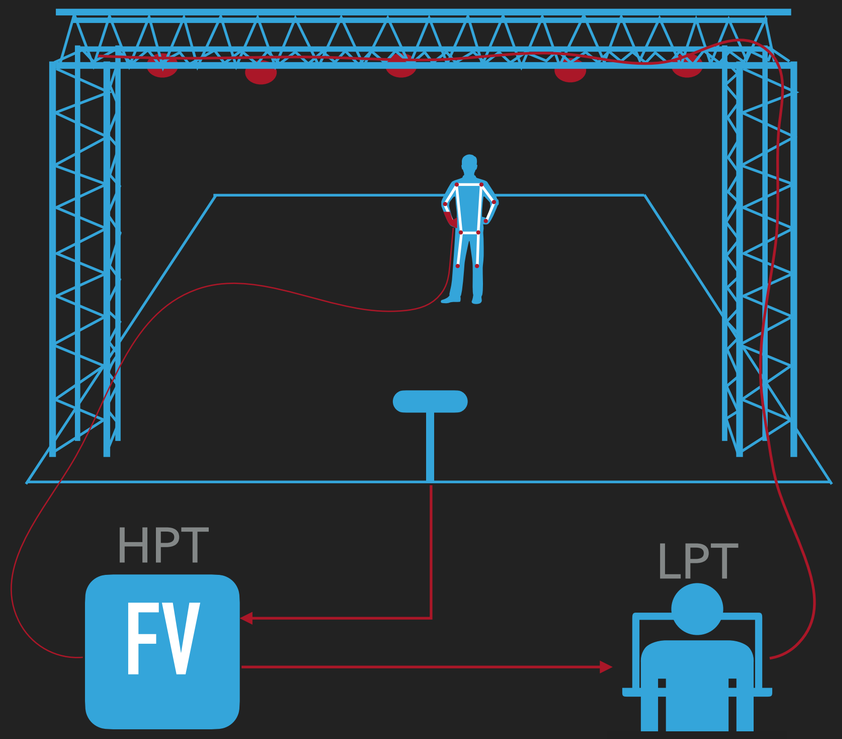
ON STAGE



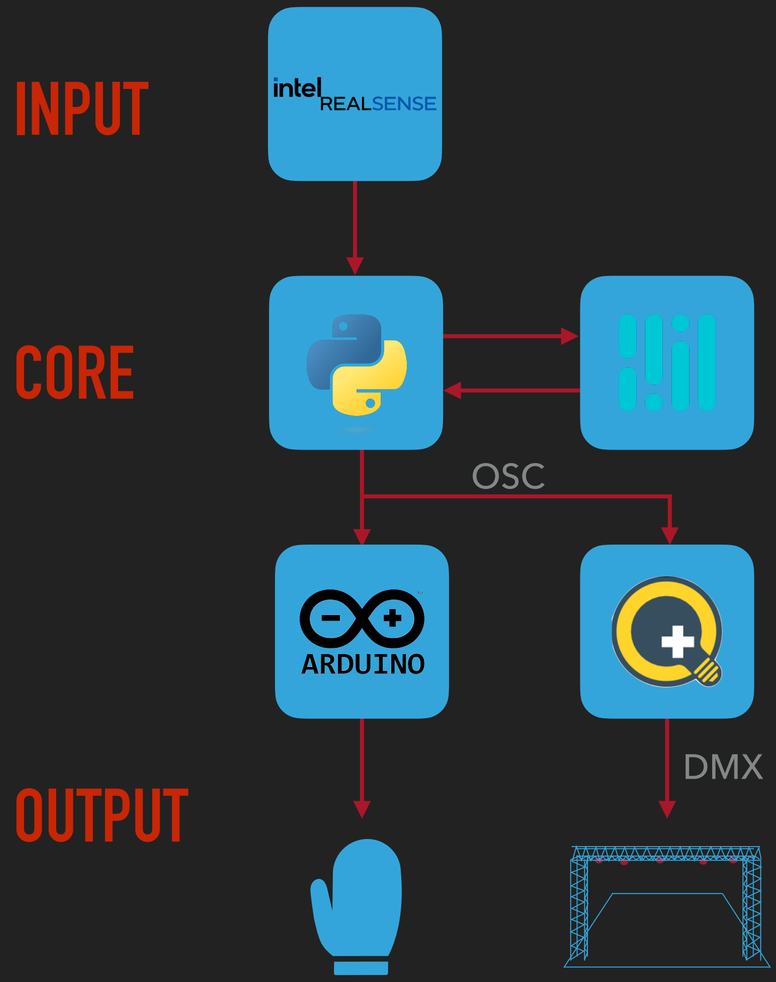
BEHIND THE SCENE

FROM THE HACKATHON TO THE FINAL VERSION

ON STAGE

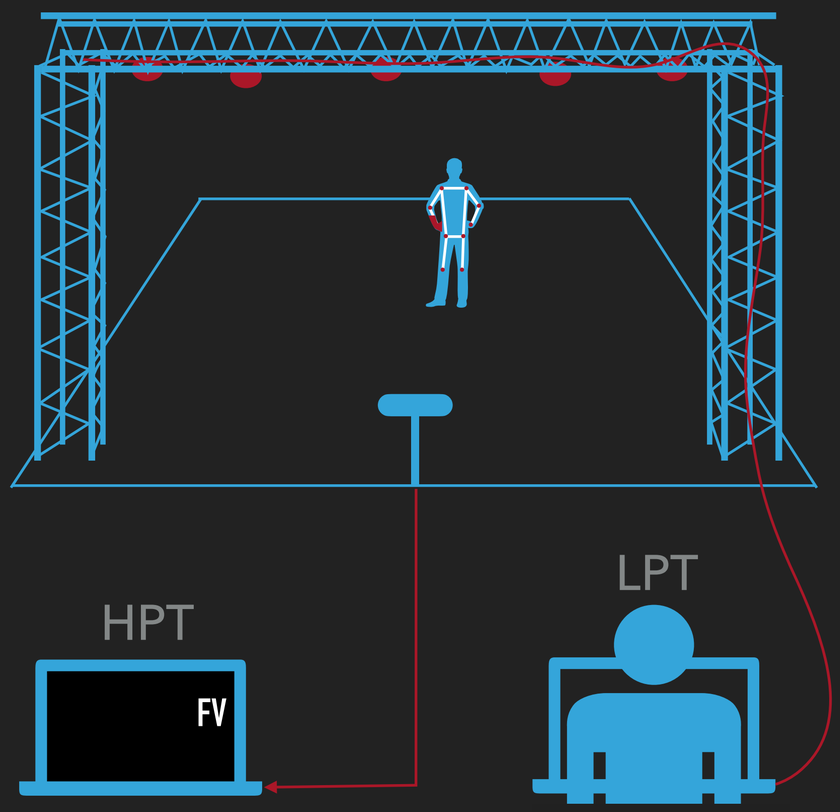


BEHIND THE SCENE



FROM THE HACKATHON TO THE FINAL VERSION

ON STAGE

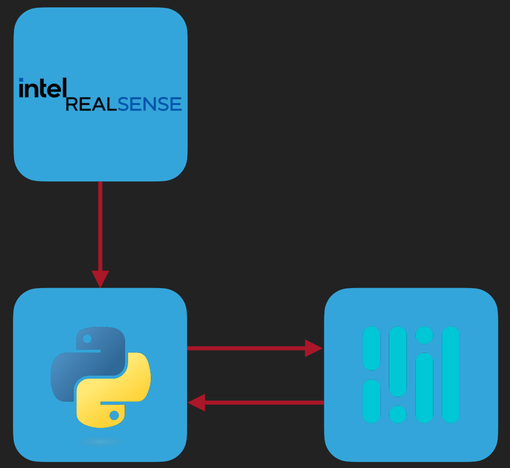


INPUT

CORE

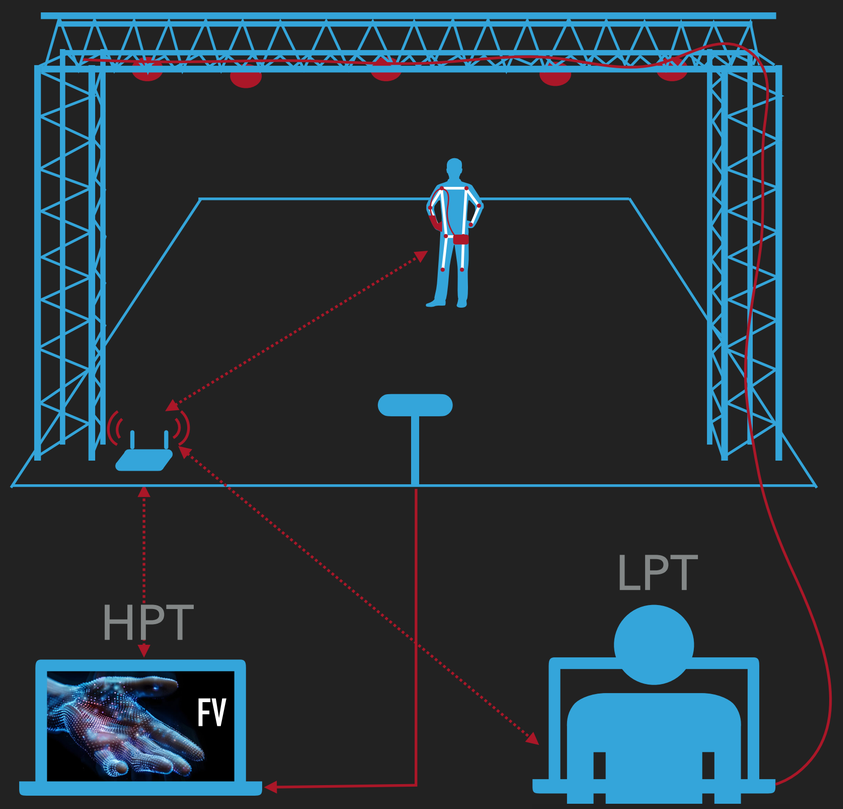
OUTPUT

BEHIND THE SCENE

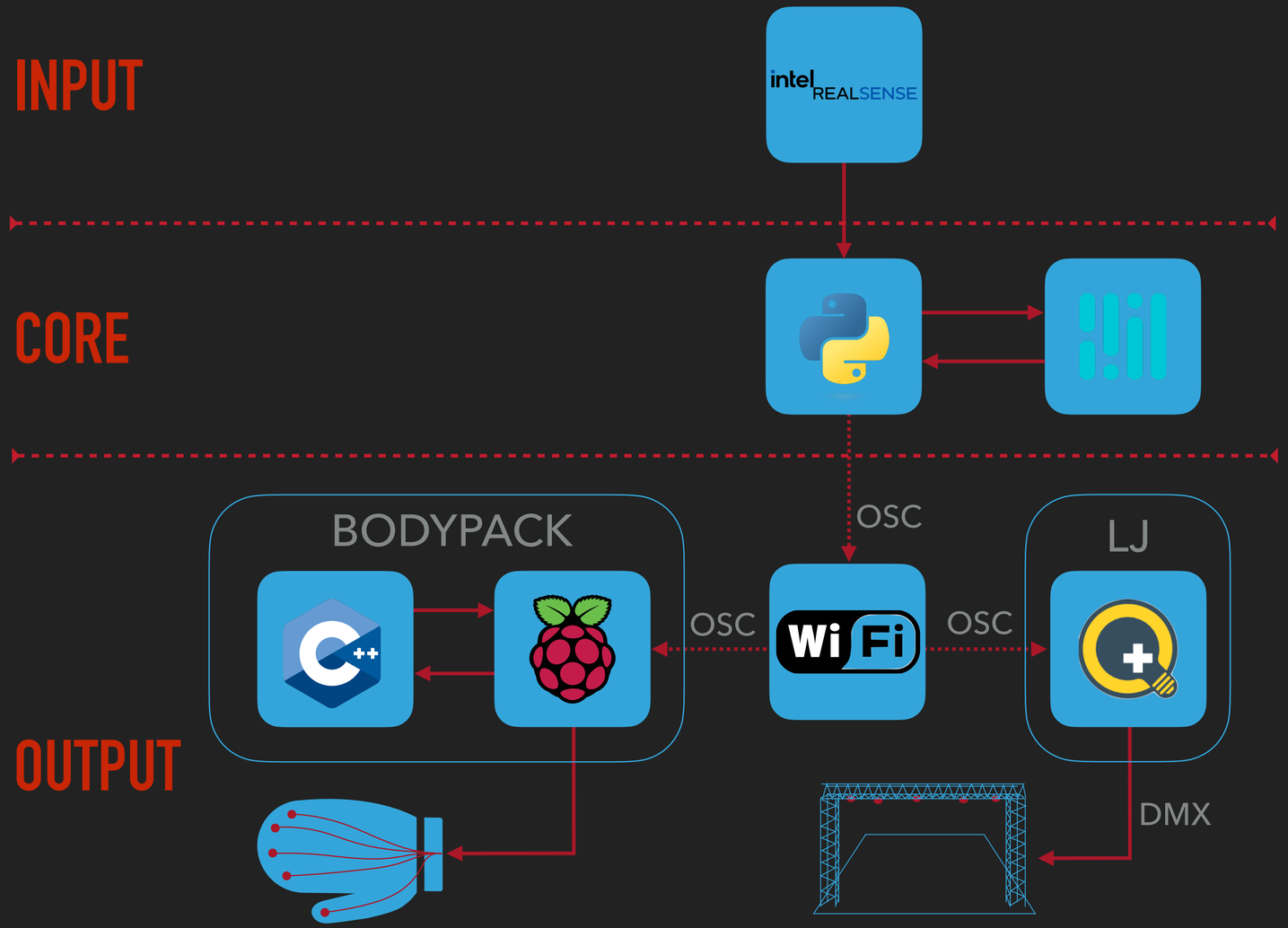


FROM THE HACKATHON TO THE FINAL VERSION

ON STAGE



BEHIND THE SCENE



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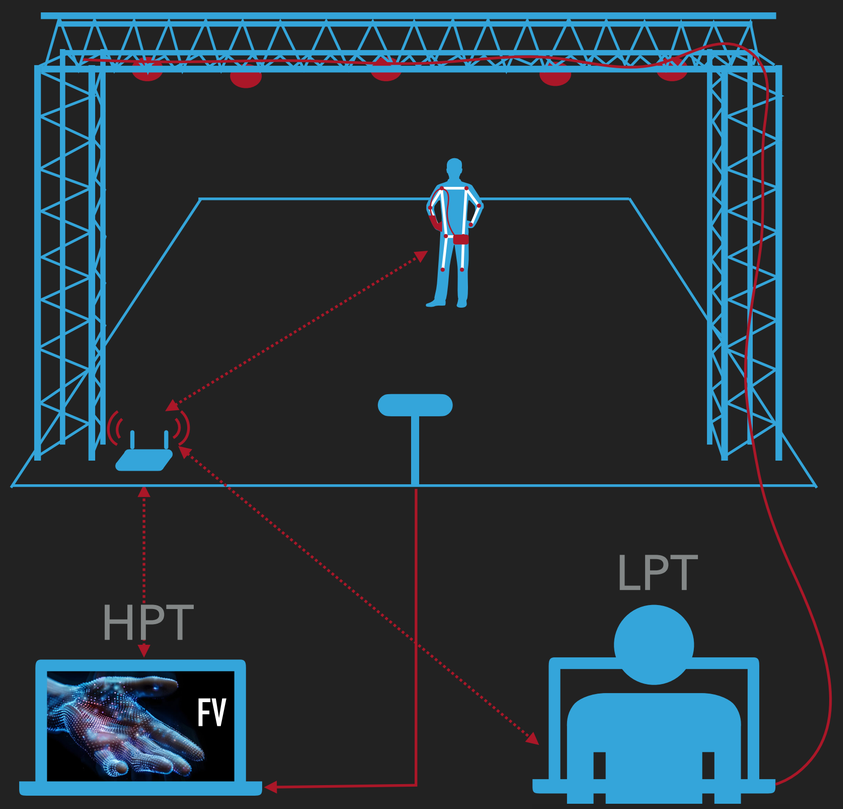
ON STAGE



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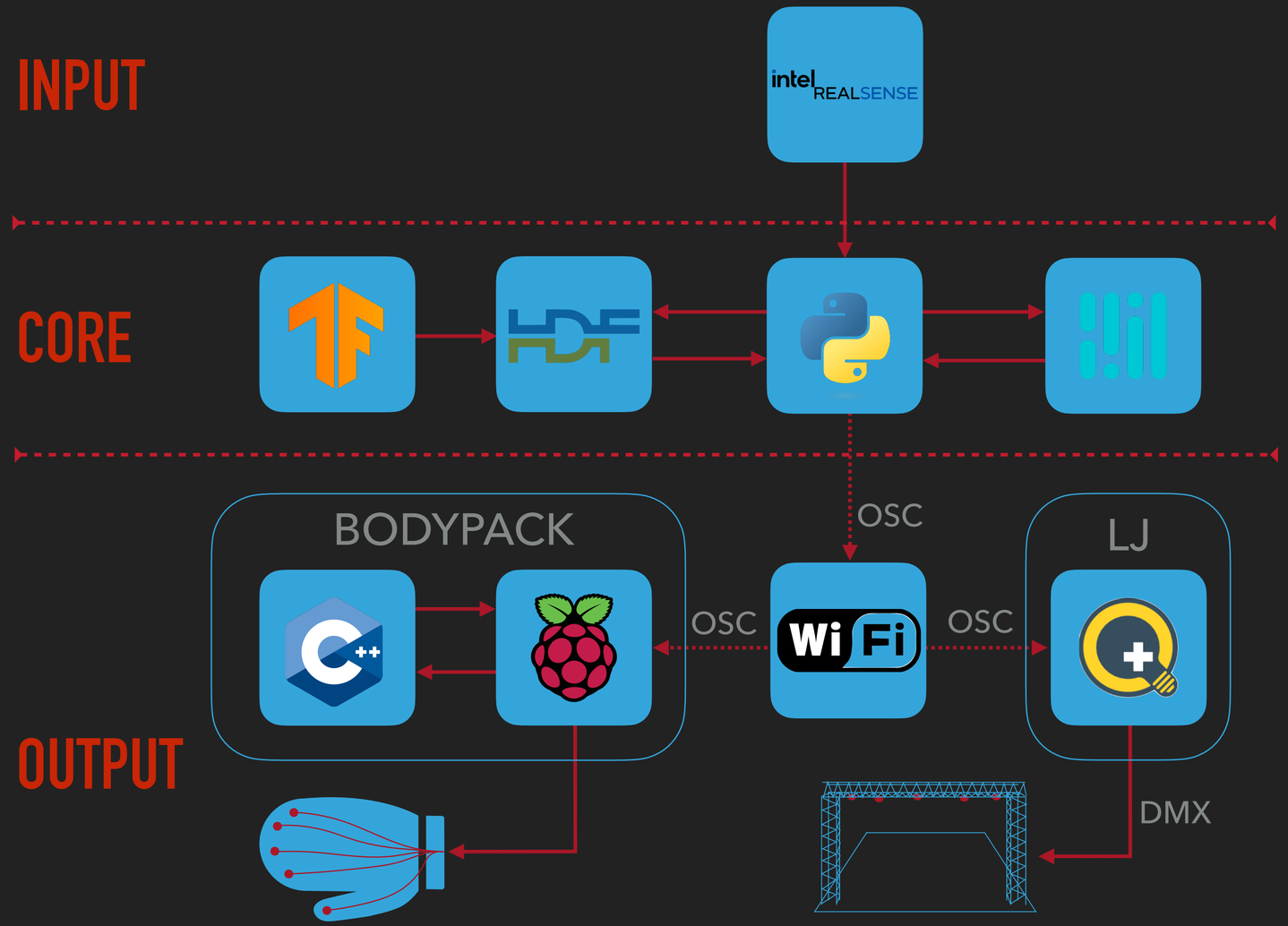

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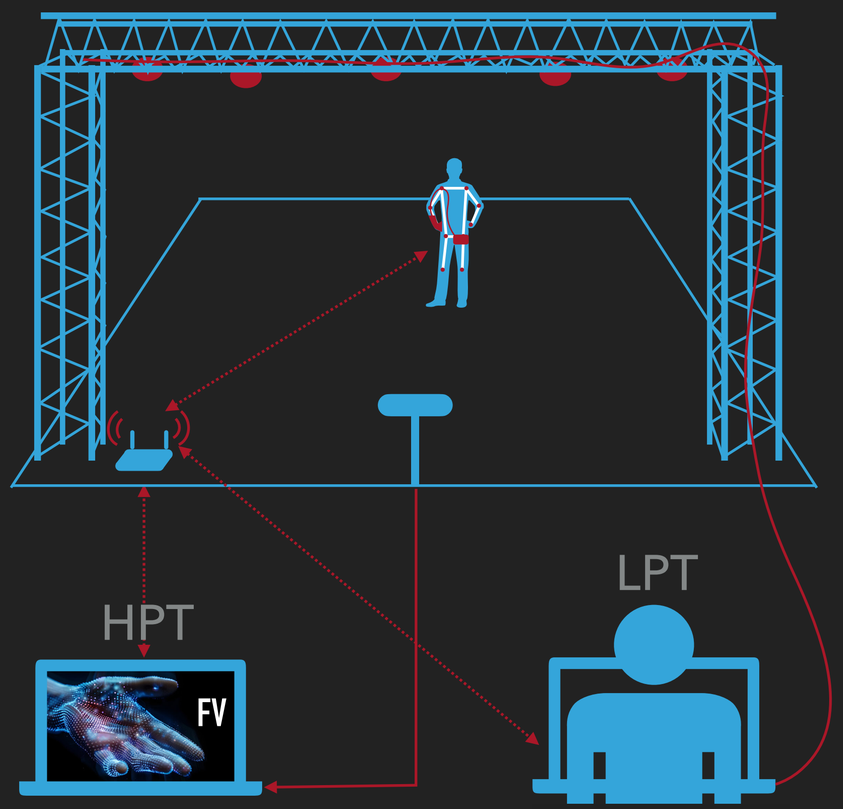
ON STAGE



BEHIND THE SCENE

GRAPHIC USER INTERFACE

GRAPHIC USER INTERFACE

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

GRAPHIC USER INTERFACE

CHALLENGE:

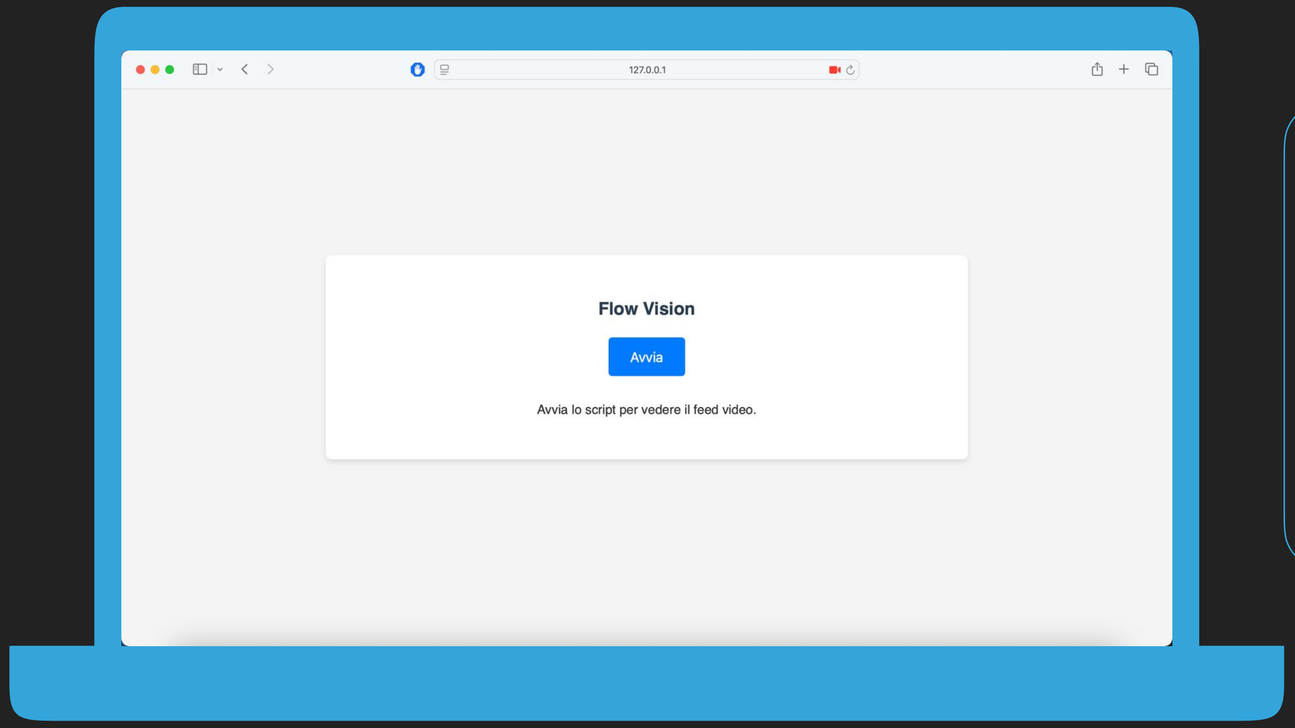
MACOS RESTRICTIONS ON EXTERNAL DEVICES ON DOCKER

GRAPHIC USER INTERFACE

TRADE-OFF:

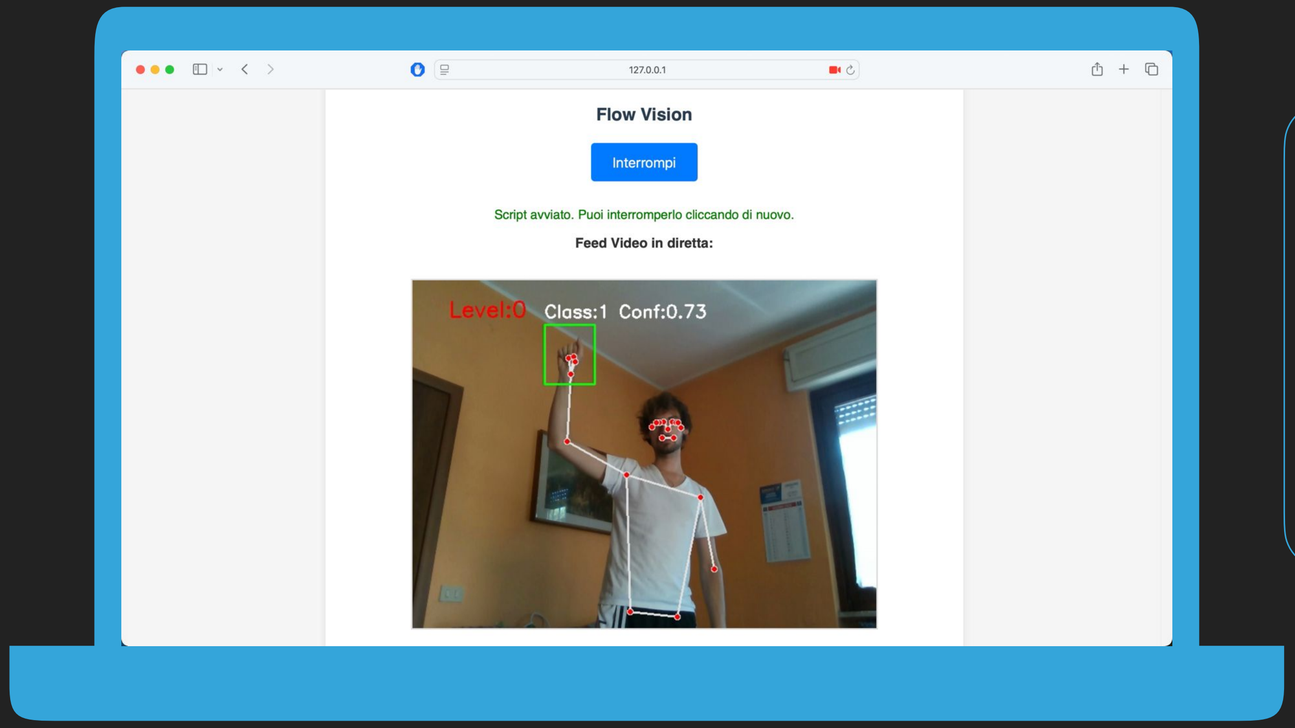
WE DECIDED NOT TO USE DOCKER AND TO IMPLEMENT A SIMPLE GUI FROM WHICH TO RUN EVERYTHING

GRAPHIC USER INTERFACE



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

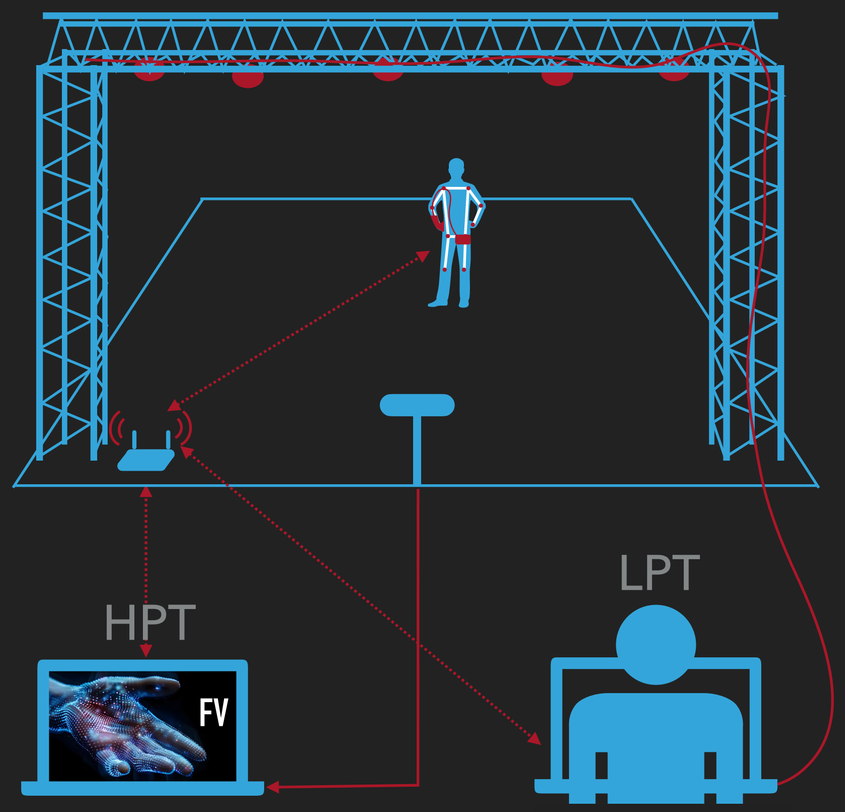
GRAPHIC USER INTERFACE



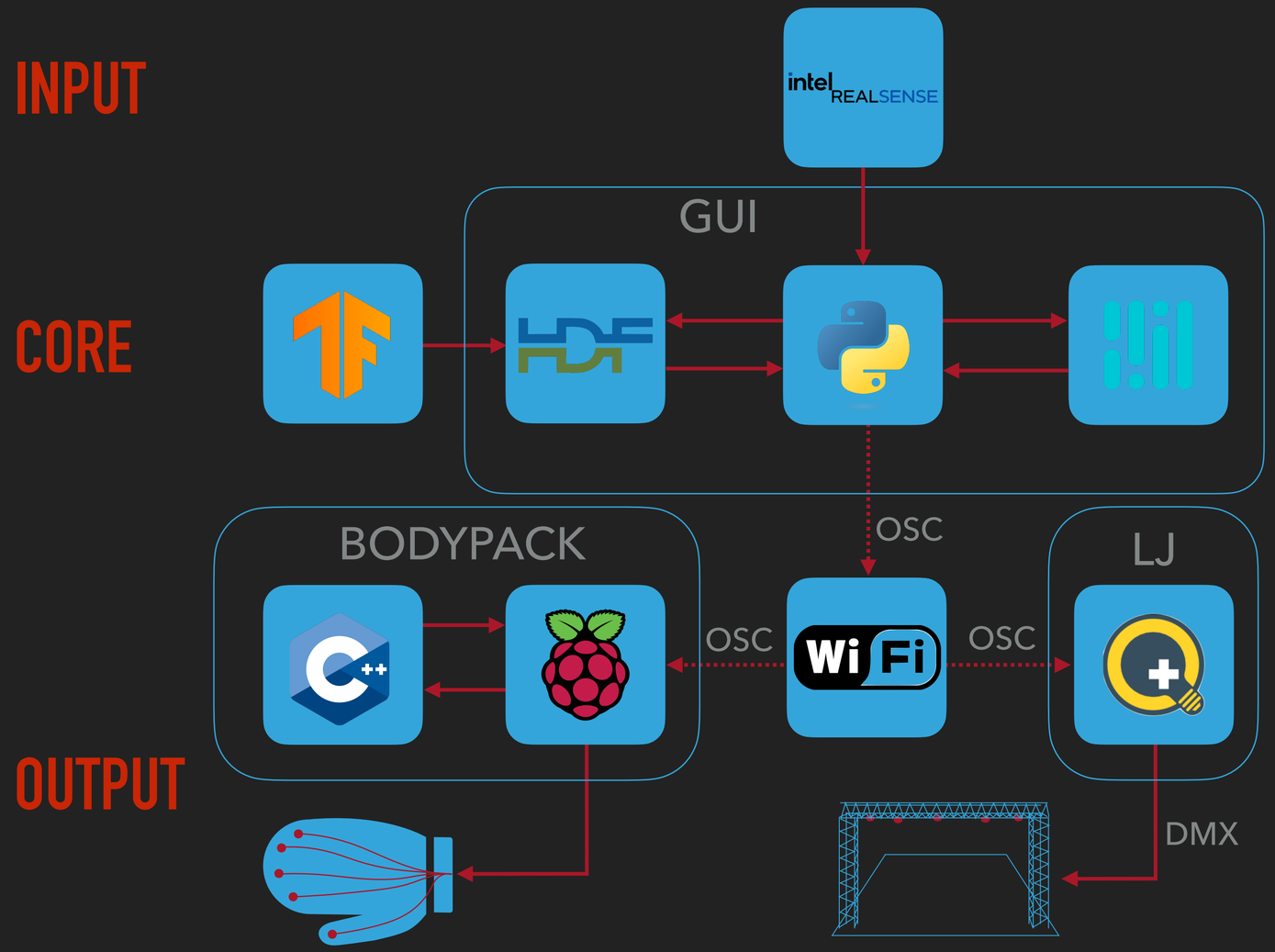
- Implementation of just a simple GUI from which to run the entire application smartly
- Once the code is started, it is possible to control the execution with a video stream

ARCHITECTURE

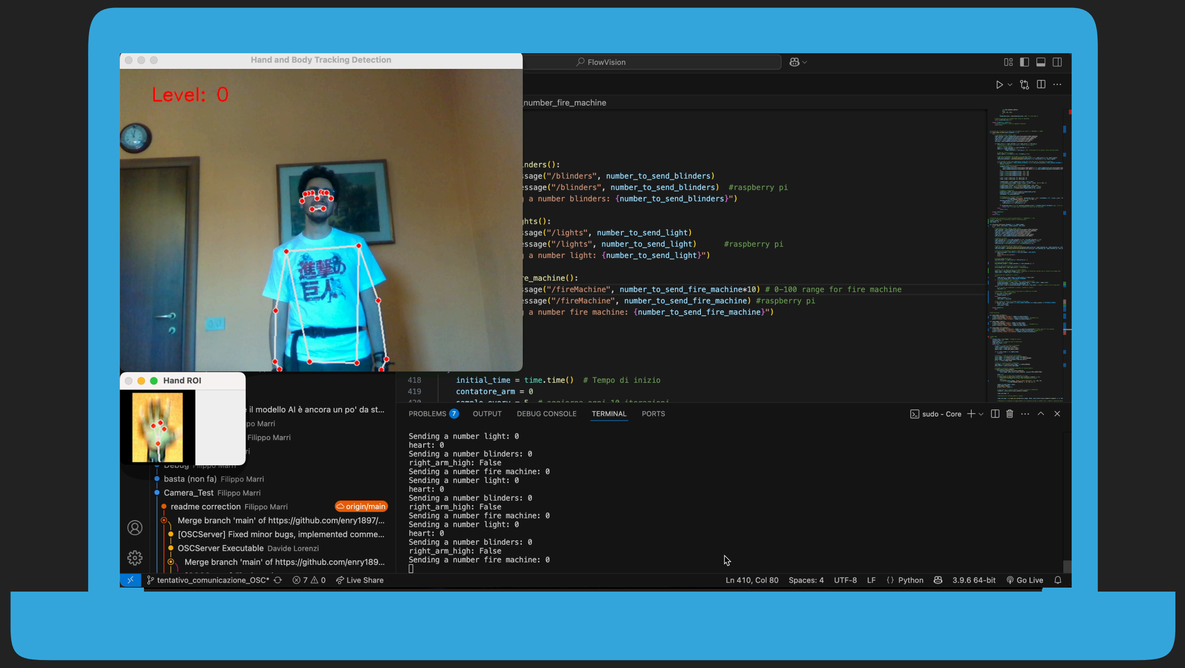
ON STAGE

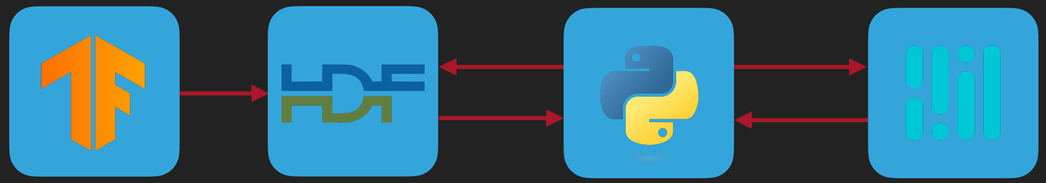


BEHIND THE SCENE

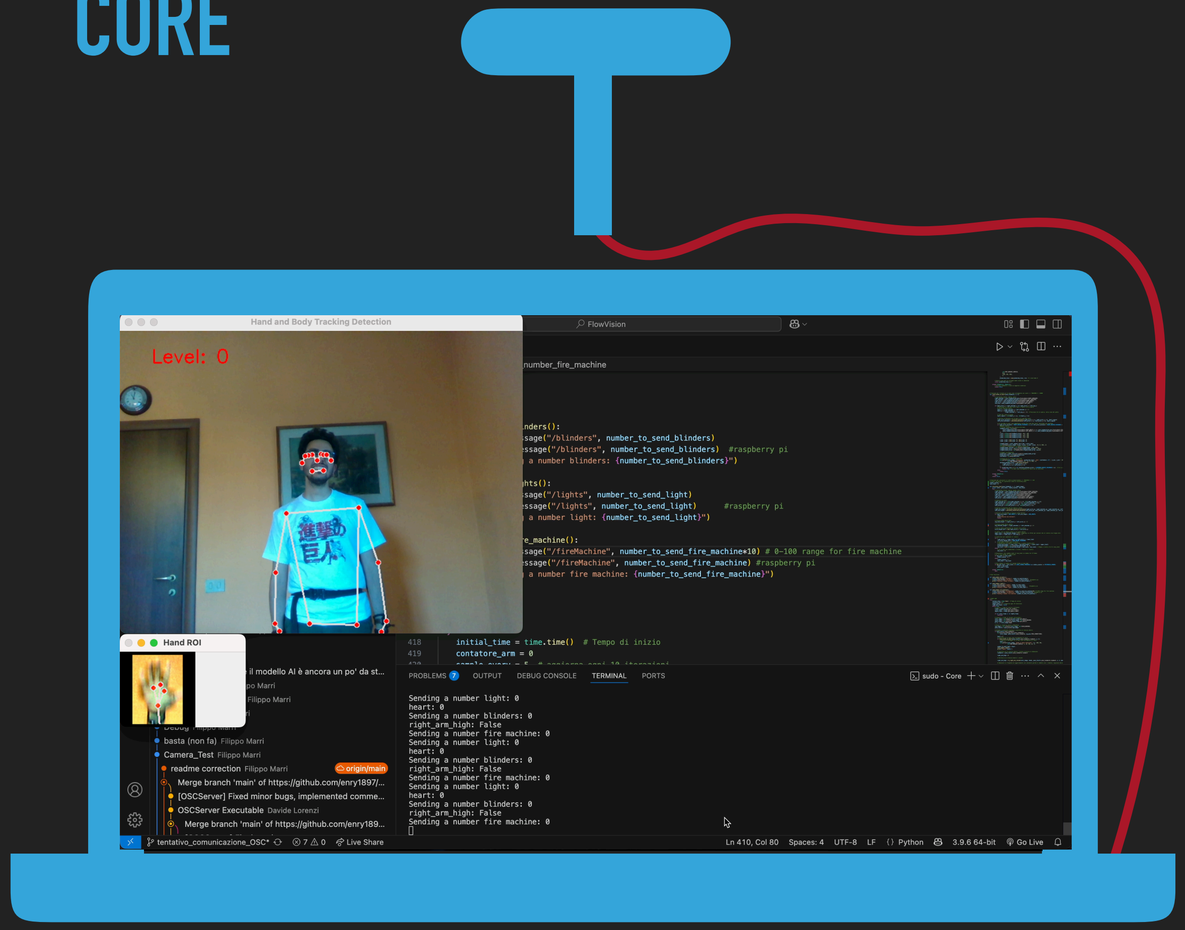


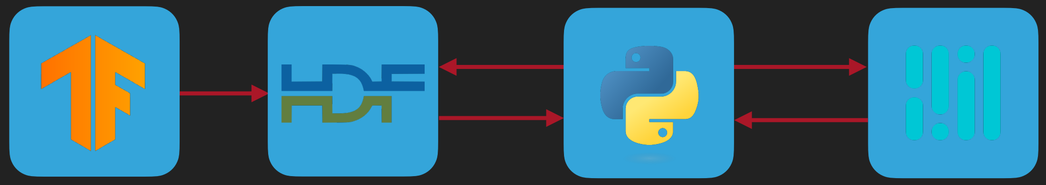
CORE


Hand and Body Tracking Detection
Level: 0
Hand ROI
FlowVision
number_fire_machine
initial_time = time.time() # Tempo di inizio
contatore_arm = 0
PROBLEMS 7
OUTPUT
DEBUG CONSOLE
TERMINAL
PORTS
sudo - Core
Sending a number light: 0
heart: 0
Sending a number blinders: 0
right_arm_high: False
Sending a number fire machine: 0
Sending a number light: 0
heart: 0
Sending a number blinders: 0
right_arm_high: False
Sending a number fire machine: 0
Sending a number light: 0
heart: 0
Sending a number blinders: 0
right_arm_high: False
Sending a number fire machine: 0
basta (non fa) Filippo Marri
Camera_Test Filippo Marri
readme correction Filippo Marri
origin/main
Merge branch 'main' of https://github.com/enry1897/...
[OSCServer] Fixed minor bugs, implemented comme...
OSCServer Executable Davide Lorenzi
Merge branch 'main' of https://github.com/enry189...
tentativo_comunicazione_OSC*
Live Share
Ln 410, Col 80
Spaces: 4
UTF-8
LF
Python
3.9.6 64-bit
Go Live



CORE

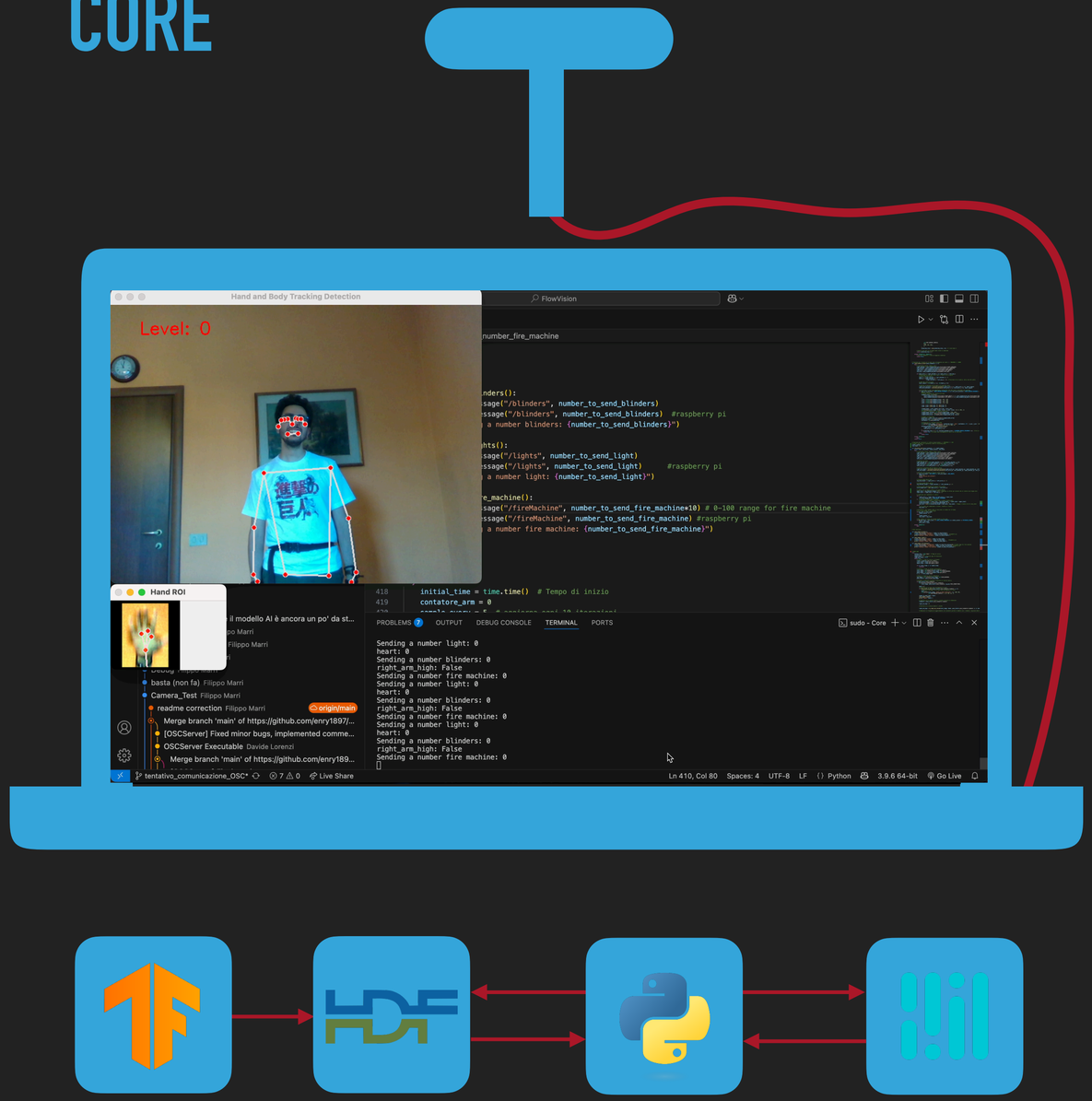




- MediaPipe module that allows the system to target the position and posture of the user
- Triggering system
  - Bigger movements -> Thresholds
  - Details -> AI models fed with cropped images

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

CORE

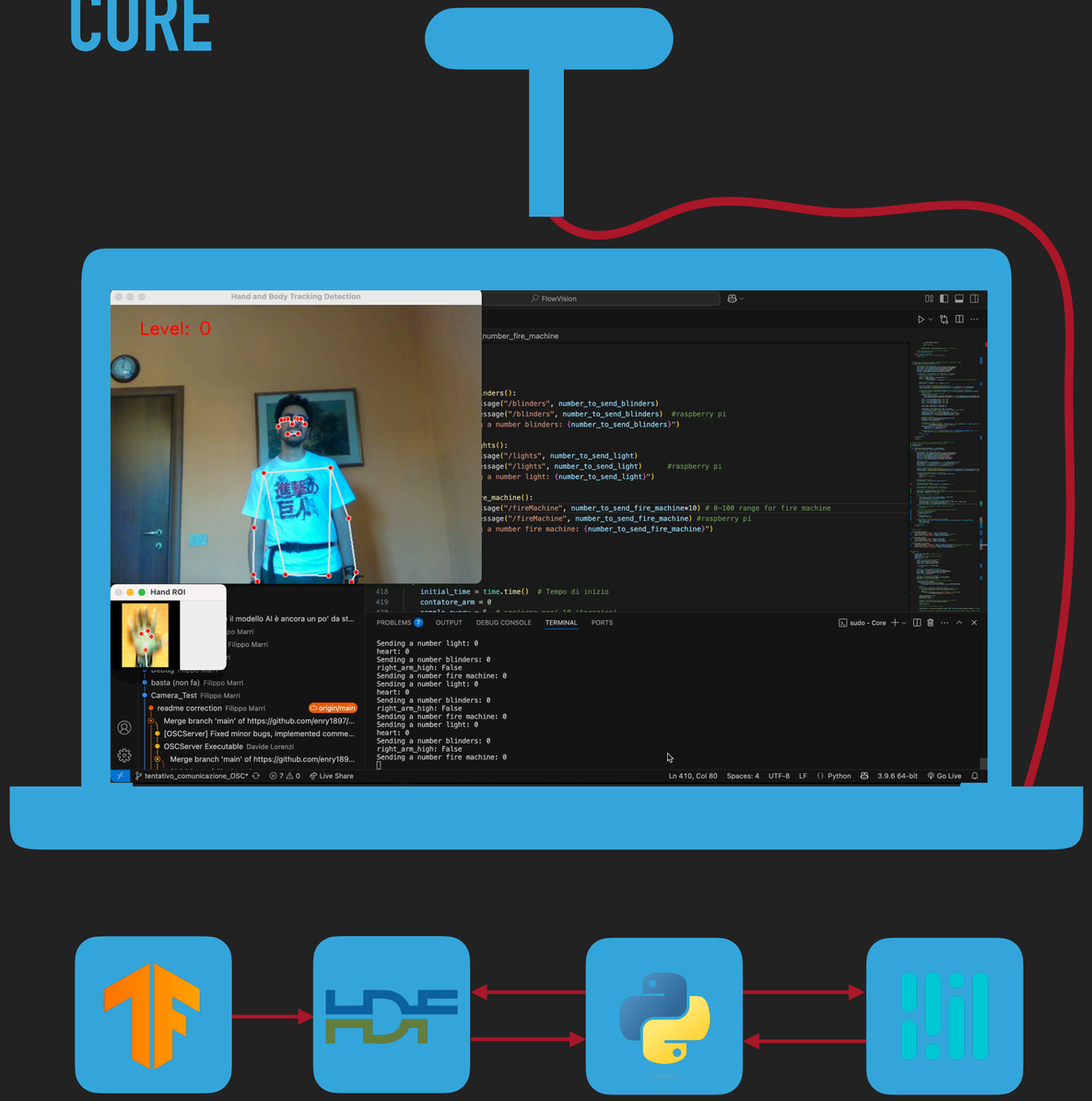


- Med
  targ
- Triggering system
  - Bigger movements -> Thresholds
  - Details -> AI models fed with cropped images

CHALLENGE:
WHEN THE HAND IS CLOSED, ITS COORDINATES ARE NOT AVAILABLE

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

CORE



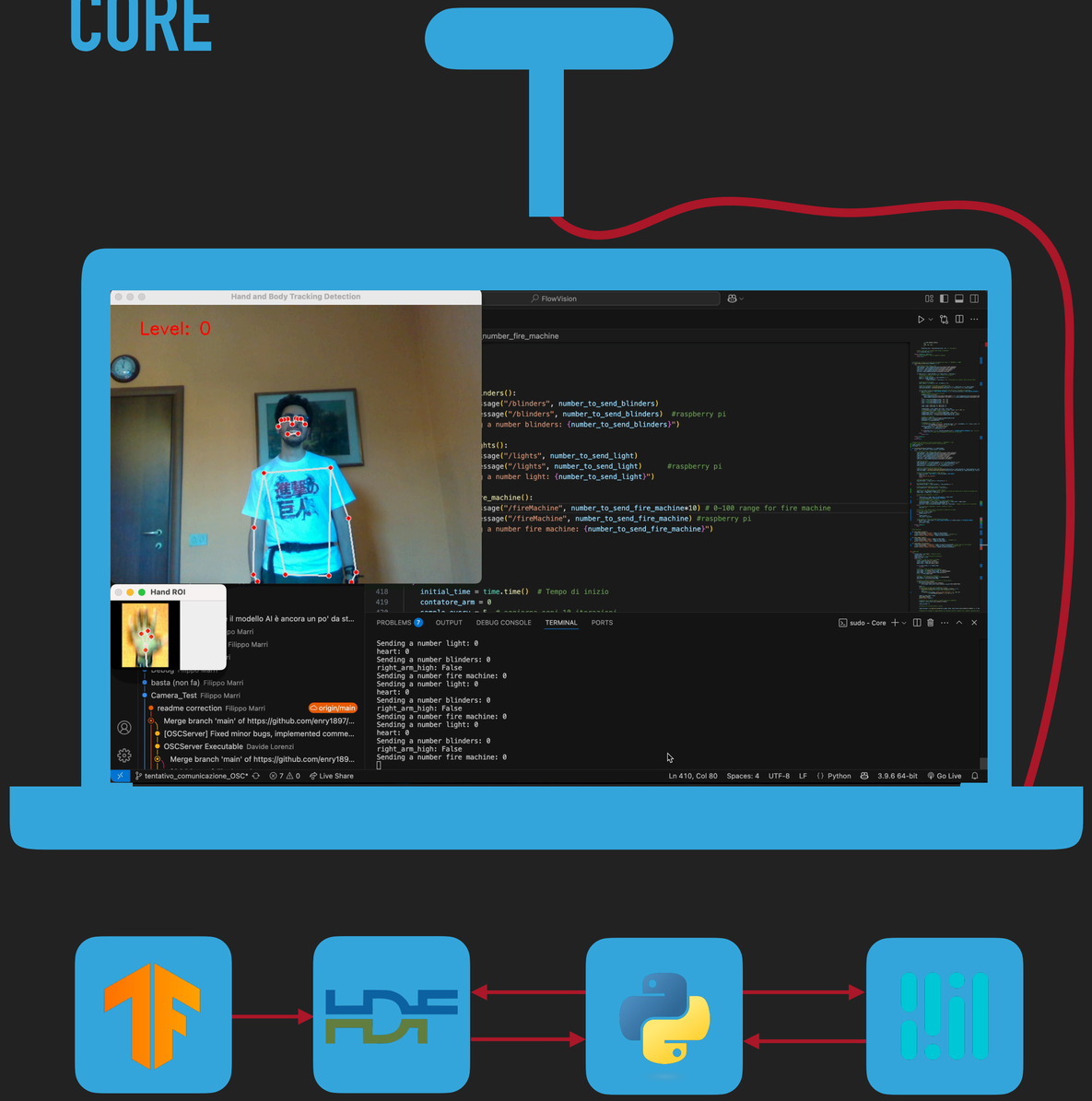
- Med
  targ
- Triggering system
  - Bigger movements -> Thresholds
  - Details -> AI models fed with cropped images

SOLUTION:

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

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

CORE



- Med
  targ
- Triggering system
  - B
  - D ages

SOLUTION:

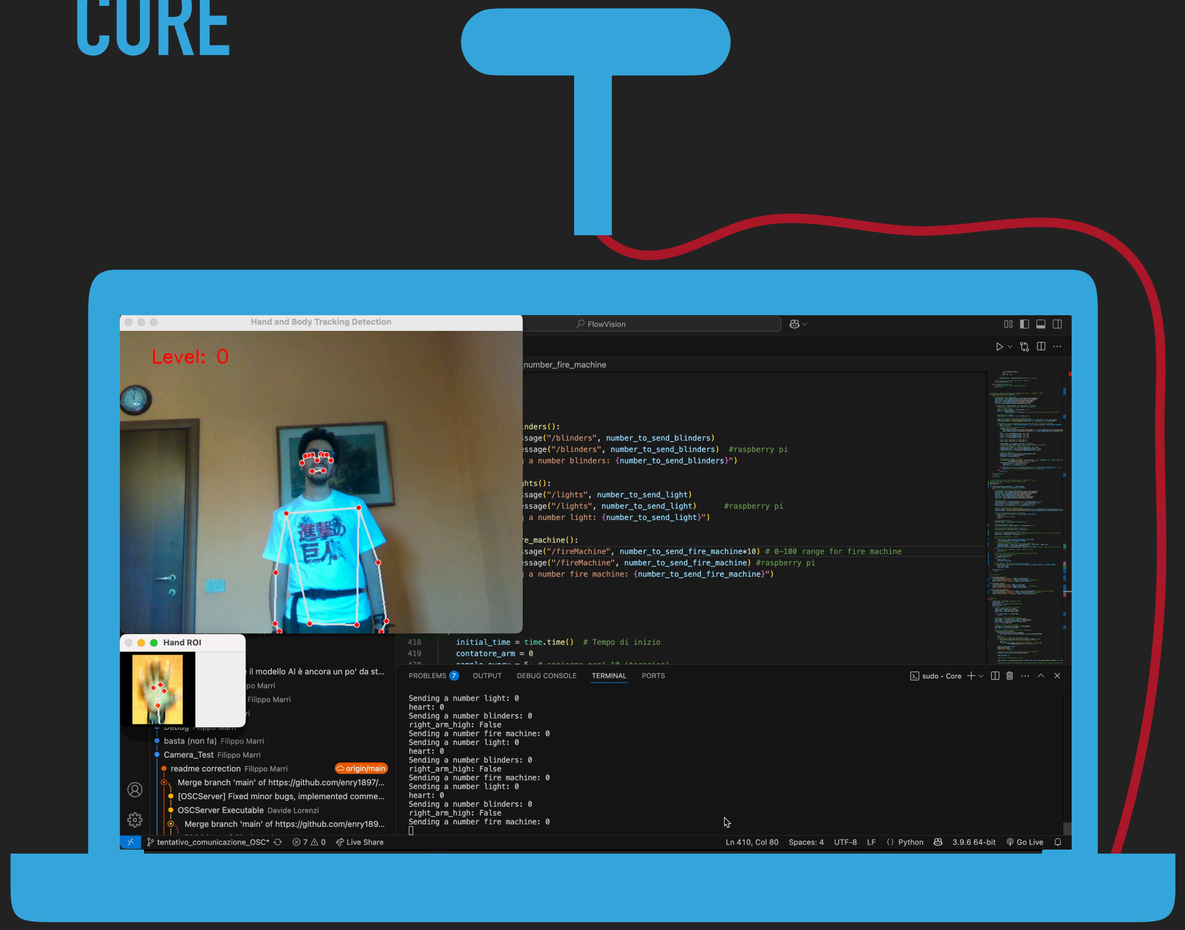
IMPLEMENTATION OF A FALLBACK CODE IN WHICH THE REFERENCE POINT IS THE WRIST WHEN THE COORDINATE OF THE HAND ARE NOT AVAILABLE

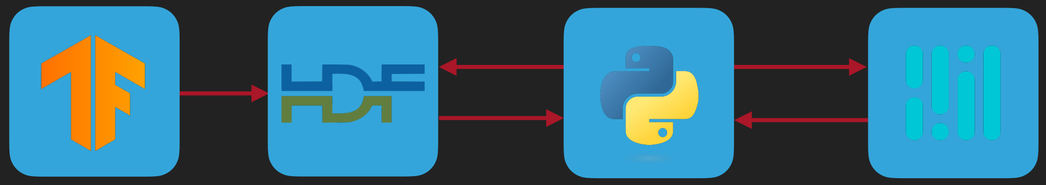
CHALLENGE:

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

CORE





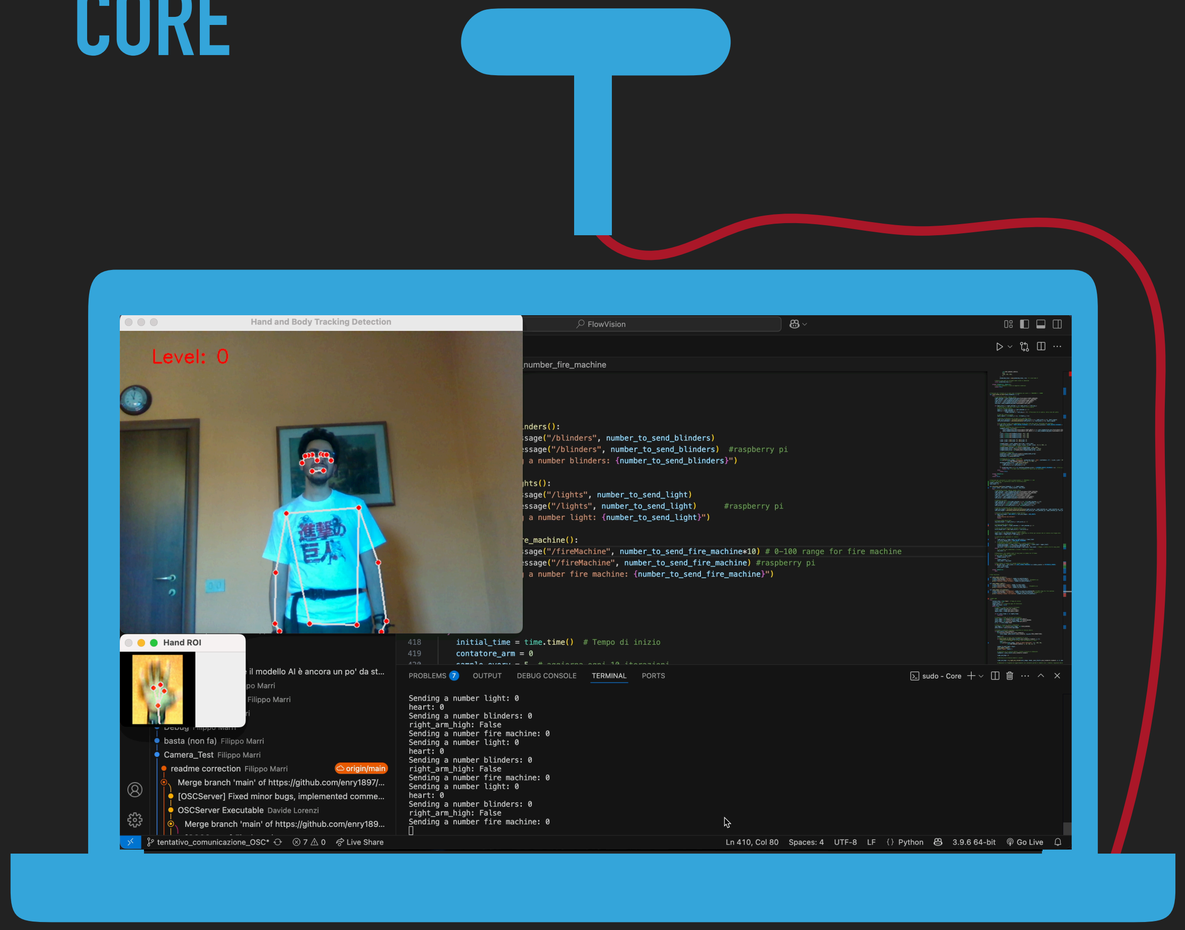
- Med… targ…
- Triggering system
  - B…
  - D… …ages

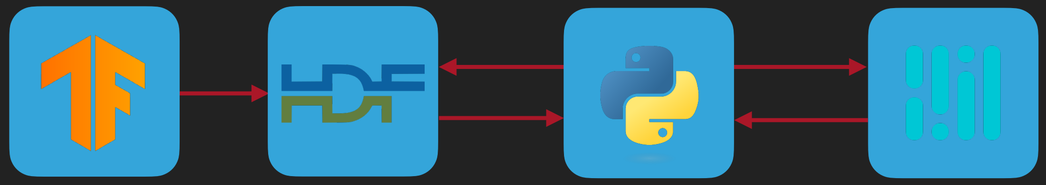
SOLUTION:
IMPLEMENTATION OF A FALLBACK CODE IN WHICH THE REFERENCE POINT IS THE WRIST WHEN THE COORDINATE OF THE HAND ARE NOT AVAILABLE

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

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

CORE





- Med… targ…
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  - B…
  - D… …ages

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

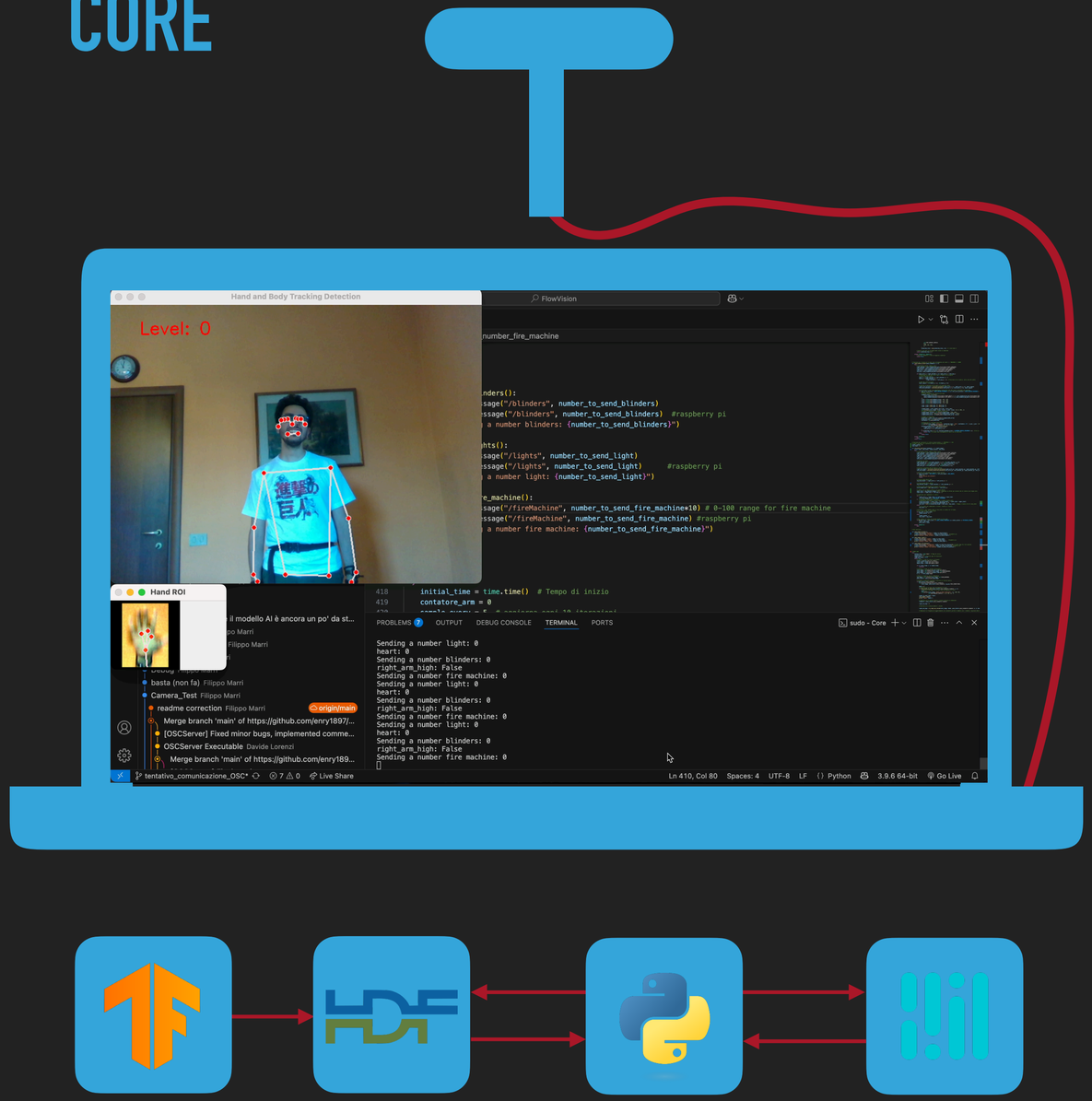
SOLUTION:
IMPLEMENTATION OF A SCRIPT THAT IMPOSE THE CONDITION THAT THE WRIST ARE NOT OVERLAPPED DURING THE HEART GESTURE

CHALLENGE:
NO AVAILABLE DATASET TO IMPLEMENT A RNN NETWORK

Mo…

Arm …iting on the side	Threshold	Progressive
Heart Gesture	Threshold + AI	ON/OFF
Fist Gesture	Threshold + AI	ON/OFF

CORE



- Med
  targ
- Triggering system
  - B
  - D
- Mo

ages

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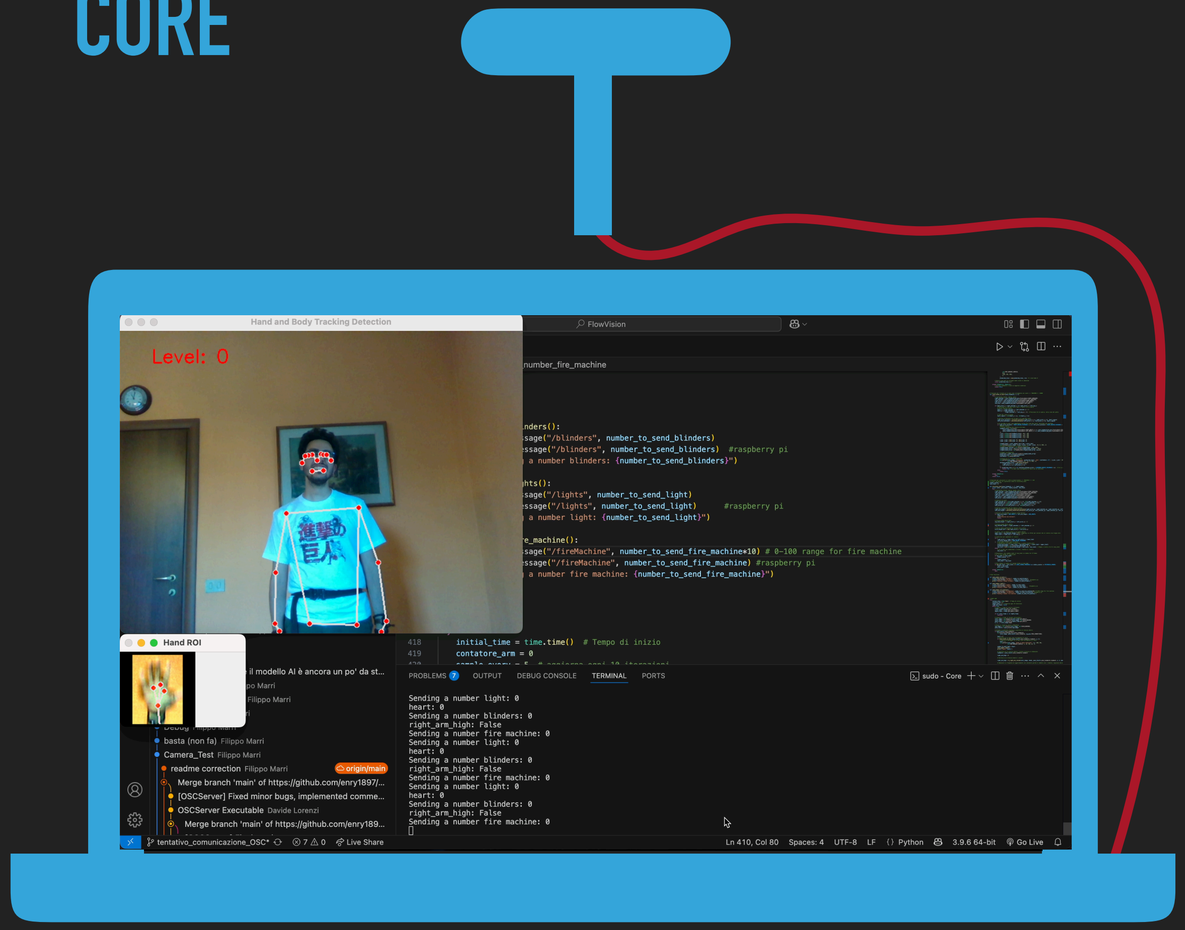
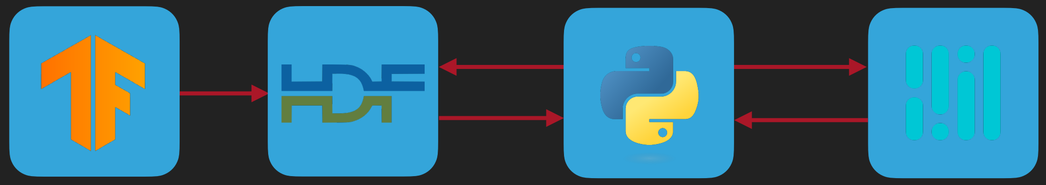
SOLUTION:
IMPLEMENTATION OF A SCRIPT THAT IMPOSE THE CONDITION THAT THE WRIST ARE NOT OVERLAPPED DURING THE HEART GESTURE

SOLUTION:
HYBRID MODELS (THRESHOLD + CNN)

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

CORE





- Med… targ…
- Trigg… system
  - B…
  - D… …ages

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

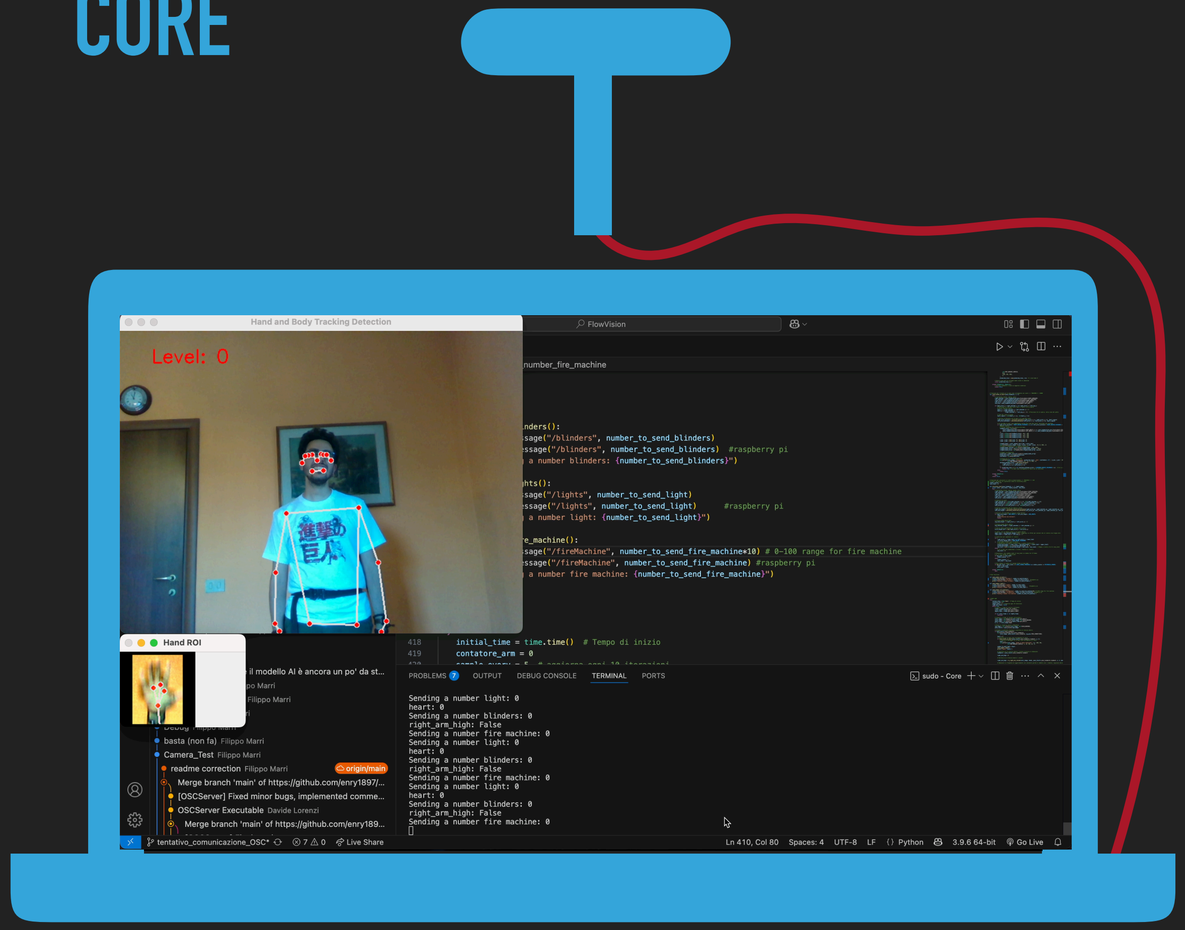
SOLUTION:
IMPLEMENTATION OF A SCRIPT THAT IMPOSE THE CONDITION THAT THE WRIST ARE NOT OVERLAPPED DURING THE HEART GESTURE

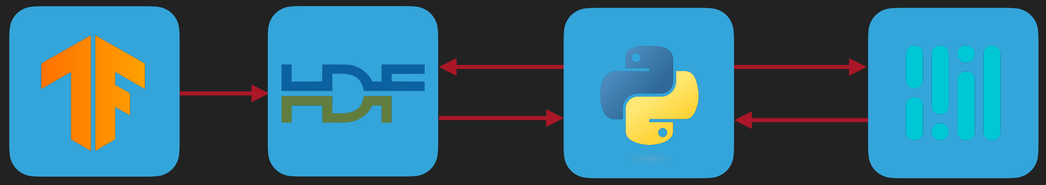
SOLUTION:
HYBRID MODELS (THRESHOLD + CNN)

Mo…		
Arm lifting on the side	Threshold	Progressive
Hear…		
Fist Gesture	Threshold + AI	ON/OFF

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

CORE





- Med… targ…
- Triggering system
  - B…
  - D…

…ages

Mo…		
Arm lifting on the side	Threshold	Progressive
Hear…		
Fist Gesture	Threshold + AI	ON/OFF

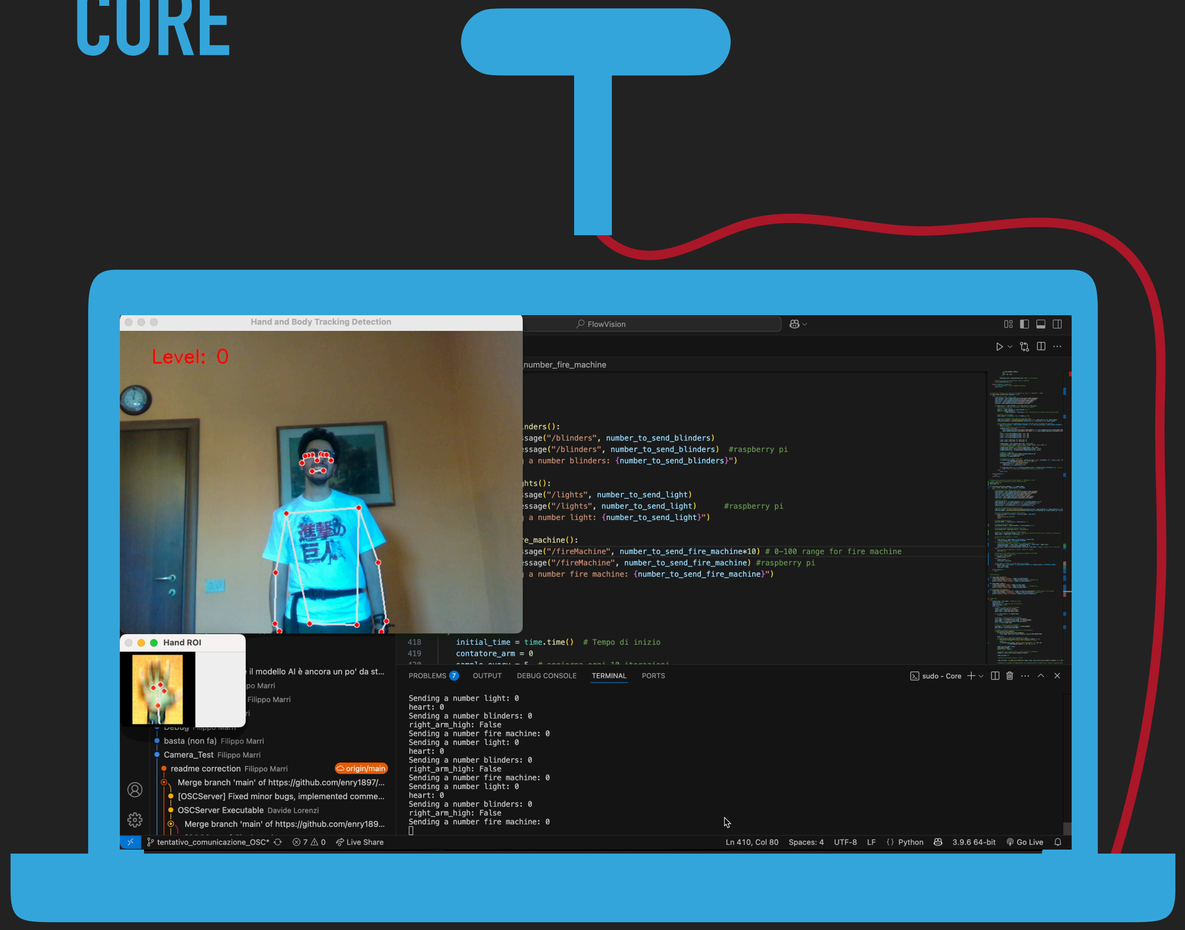
SOLUTION:
IMPLEMENTATION OF A FALLBACK CODE IN WHICH THE REFERENCE POINT IS THE WRIST WHEN THE COORDINATE OF THE HAND ARE NOT AVAILABLE

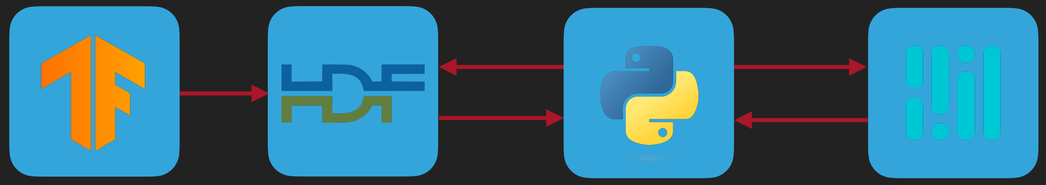
SOLUTION:
IMPLEMENTATION OF A SCRIPT THAT IMPOSE THE CONDITION THAT THE WRIST ARE NOT OVERLAPPED DURING THE HEART GESTURE

SOLUTION:
HYBRID MODELS (THRESHOLD + CNN)

SOLUTION:
INCREASING THE RESOLUTION OF THE IMAGE, WE GET BETTER PERFORMANCE

CORE





- Med
  targ
- Triggering system
  - B
  - D

ages

Mo

Arm lifting on Threshold Progressive
th

Hear

Fist Gesture ON/OFF
AI

SOLUTION:

IMPLEMENTATION OF A FALLBACK 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:

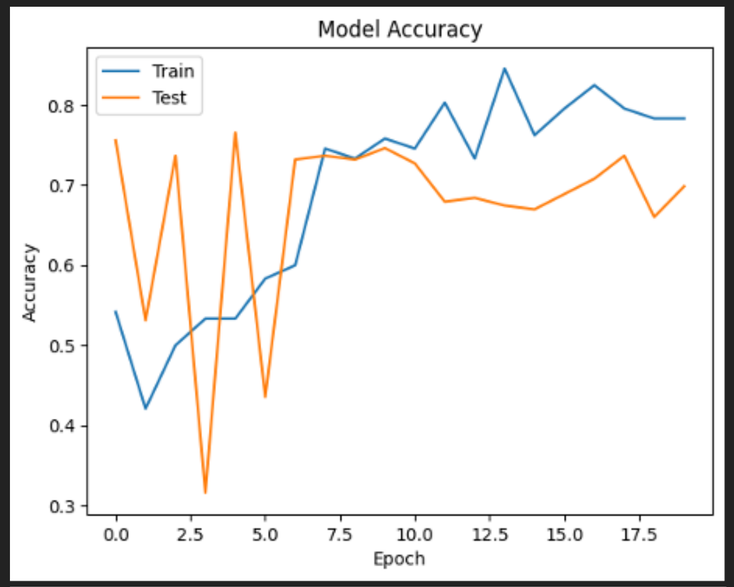
HYBRID MODELS (THRESHOLD + CNN)

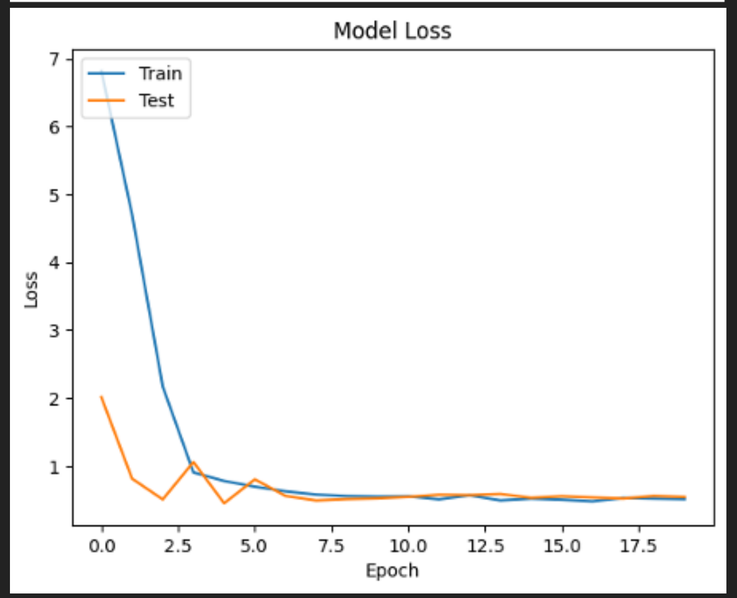
TRADE-OFF:

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





MOBILENET

GLOBAL AV POOLING 2D

DENSE (128)

DROPOUT

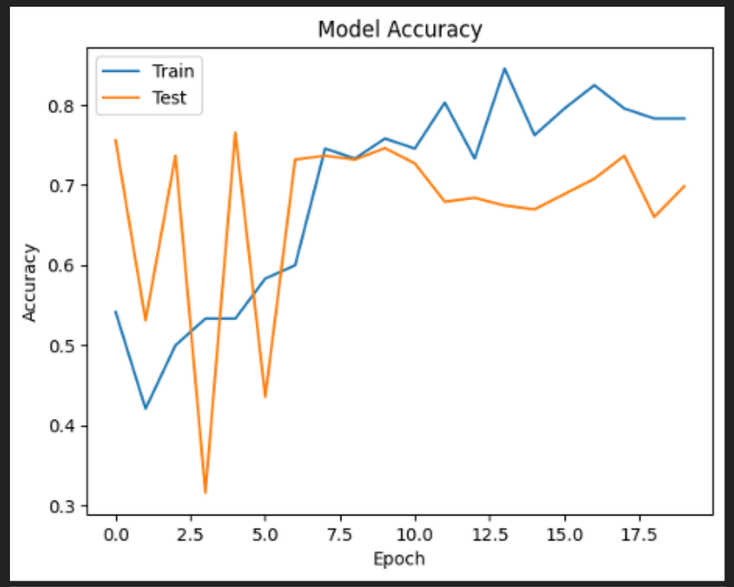
DENSE (128)

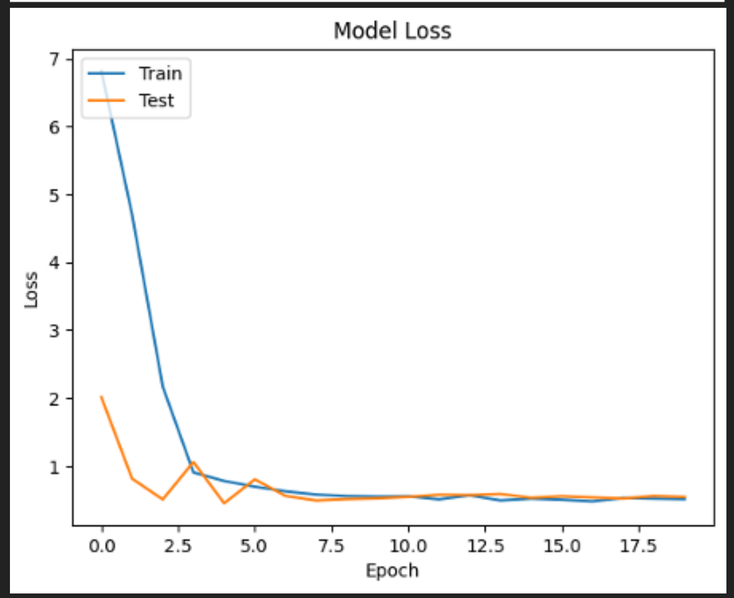
DROPOUT

DENSE (2)

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

CORE – AI MODELS: FIST GESTURE





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DENSE (128)

DROPOUT

DENSE (128)

DROPOUT

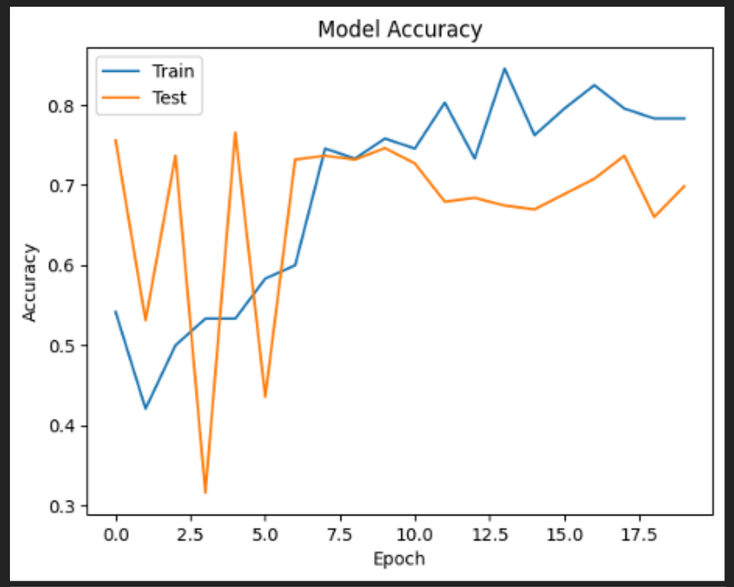
DENSE (2)

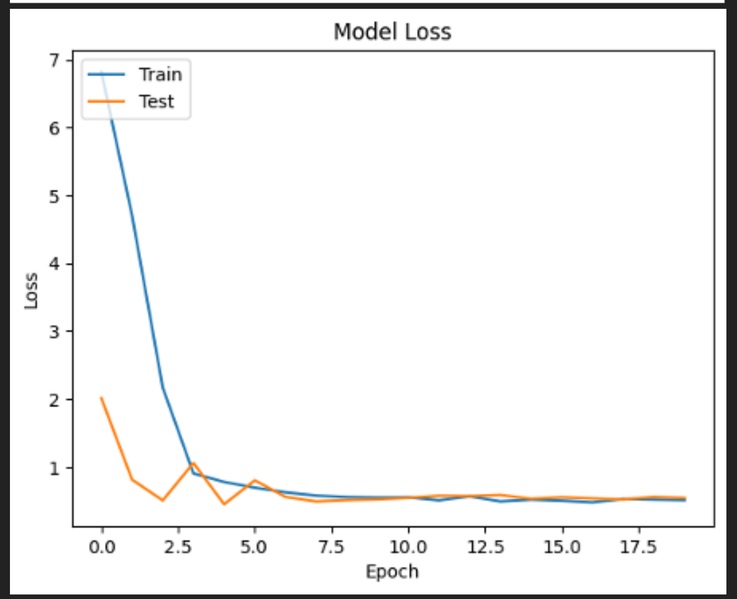
- Complex model
- More than 3 million of parameters
- Strong-pre processing on the image that feeds the Neural Network

CHALLENGE:

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

CORE – AI MODELS: FIST GESTURE





MOBILENET

GLOBAL AV POOLING 2D

DENSE (128)

DROPOUT

DENSE (128)

DROPOUT

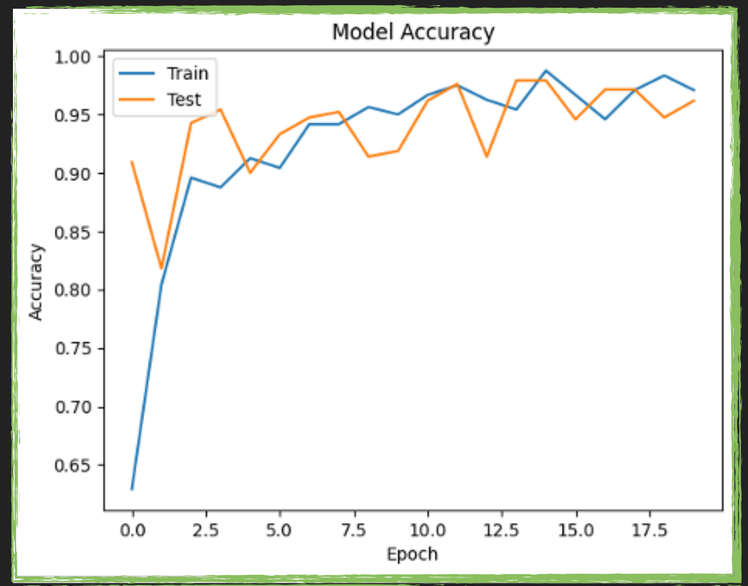
DENSE (2)

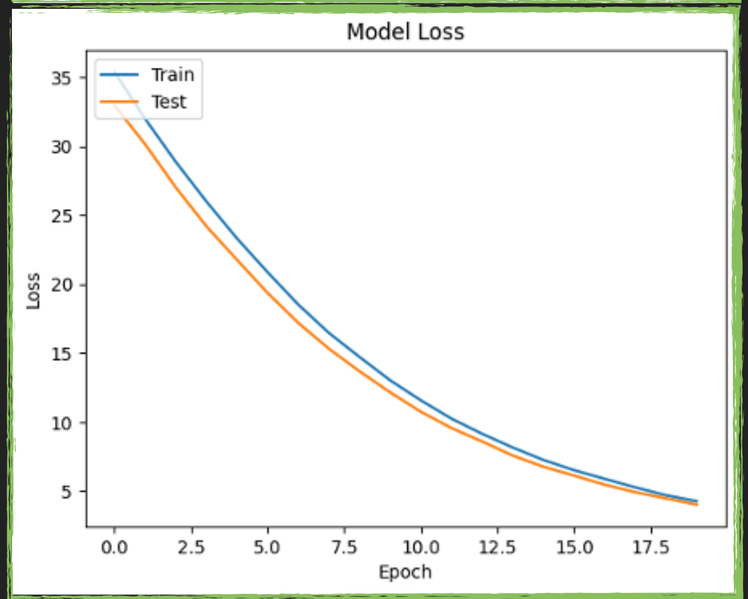
- Complex model
- More than 3 million of parameters
- Strong-pre processing on the image that feeds the Neural Network

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)

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

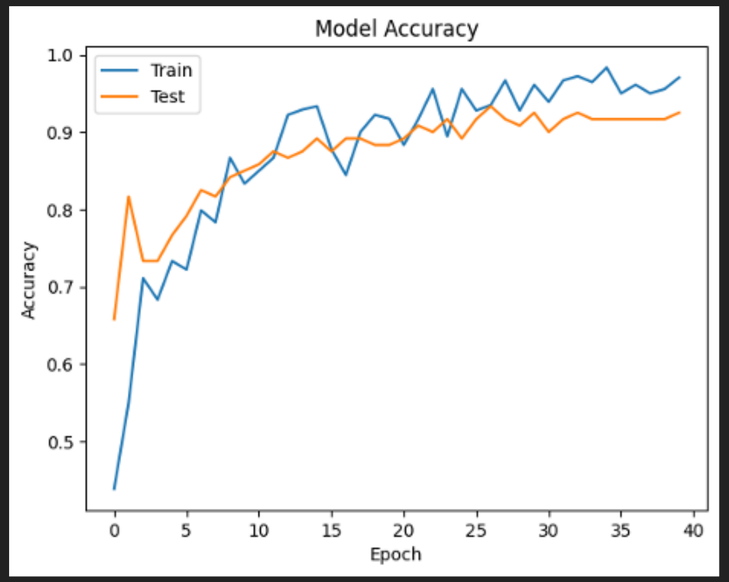
CORE – AI MODELS: HEART GESTURE

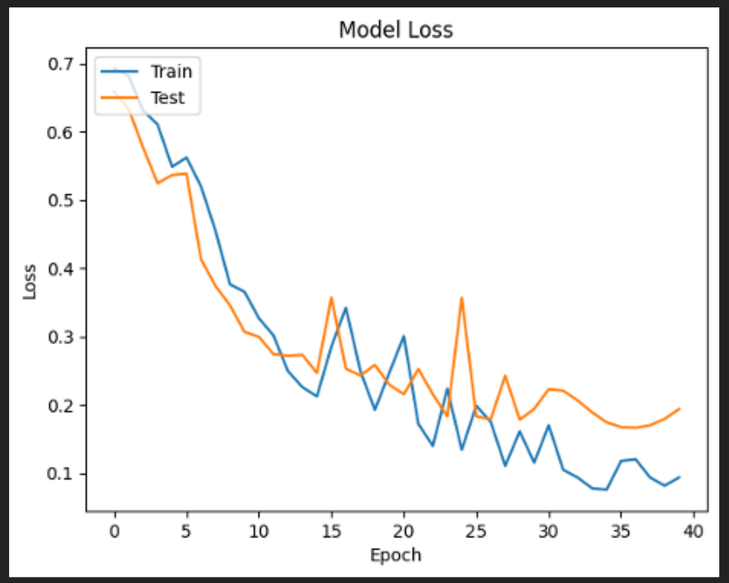
SOLUTION:

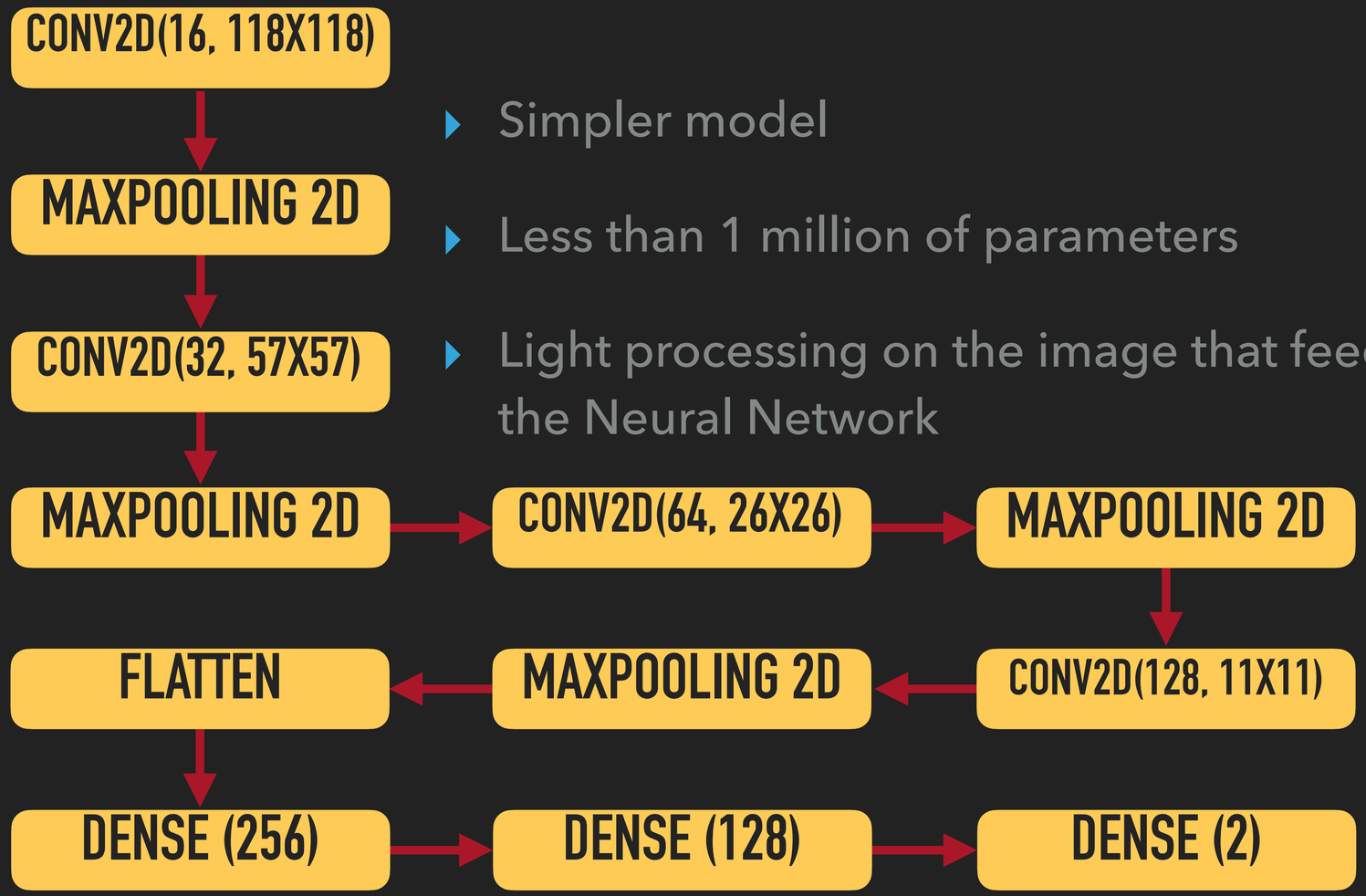
WE CREATED A DATASET MERGING SOME RANDOM IMAGES OF HANDS AND A SET OF PICTURE OF HANDS GESTURE

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

CORE – AI MODELS: HEART GESTURE

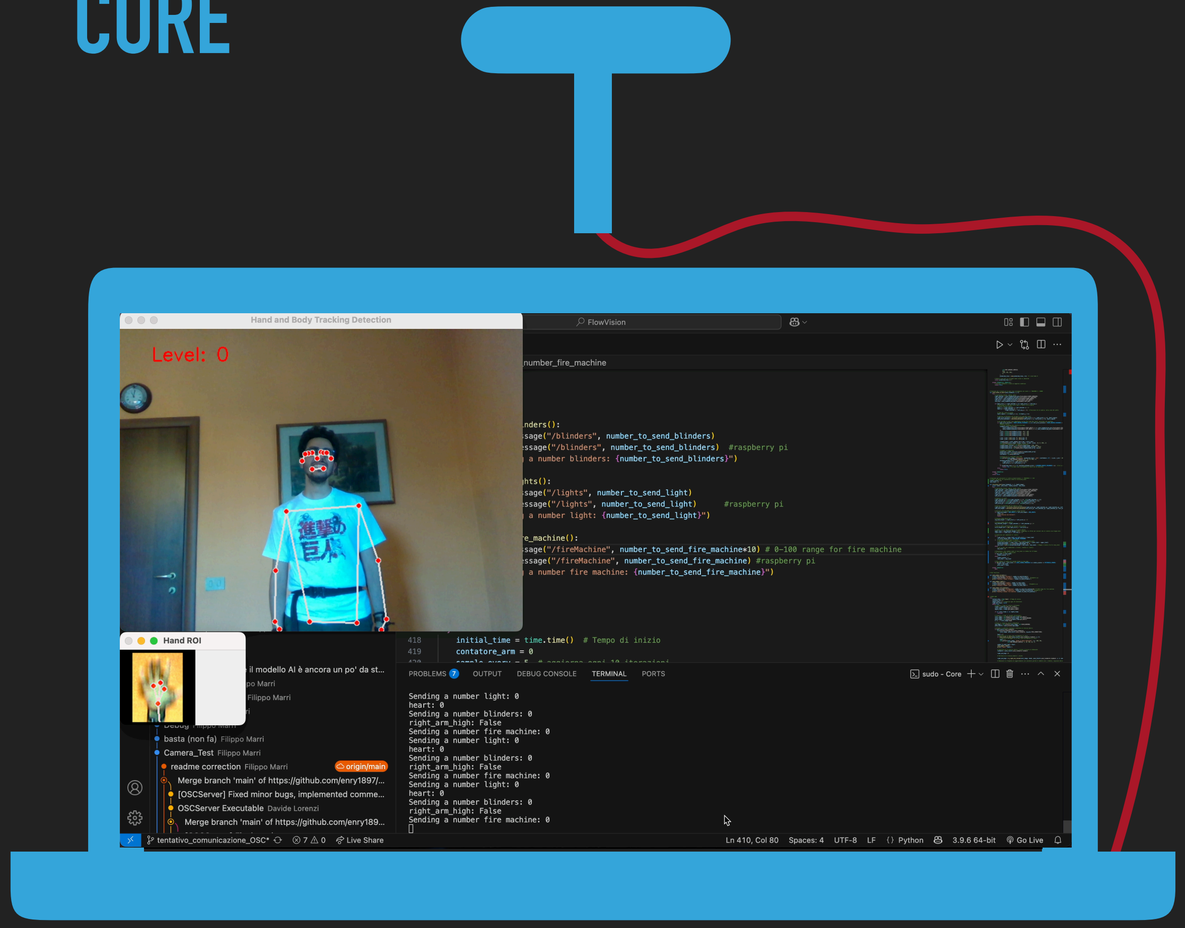






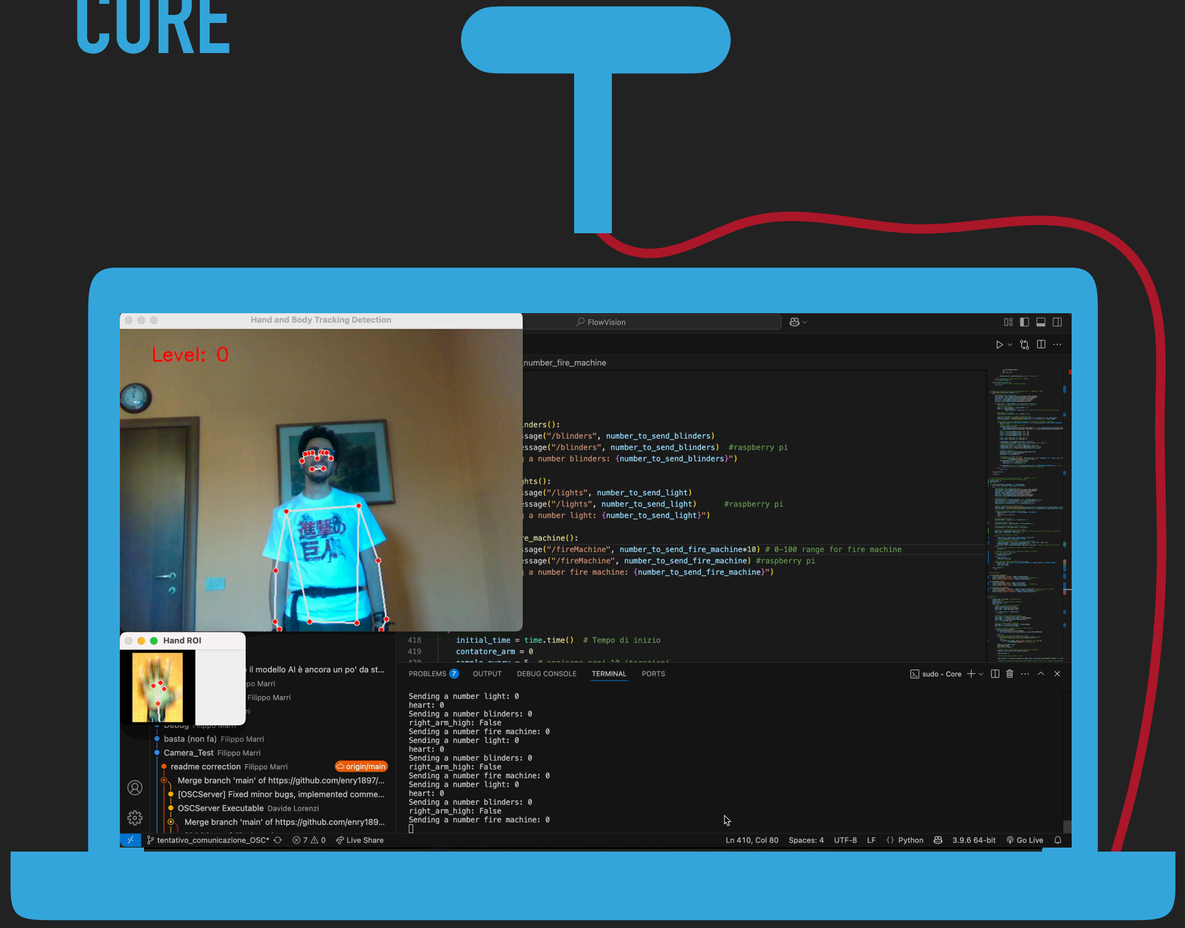
- Simpler model
- Less than 1 million of parameters
- Light processing on the image that feeds the Neural Network

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

CORE



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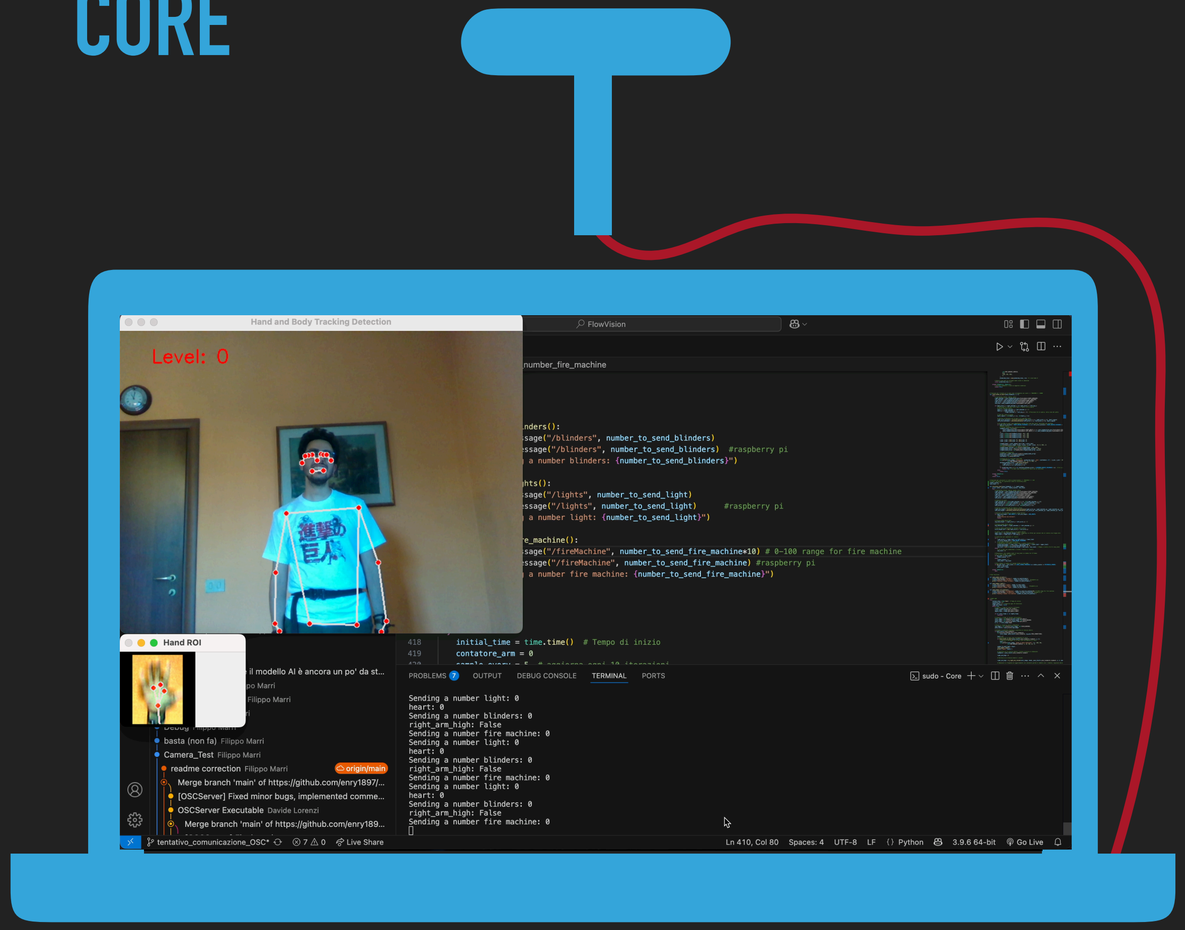
  - Bigger movements -> Thresholds
  - Details -> AI models fed with cropped images

CORE

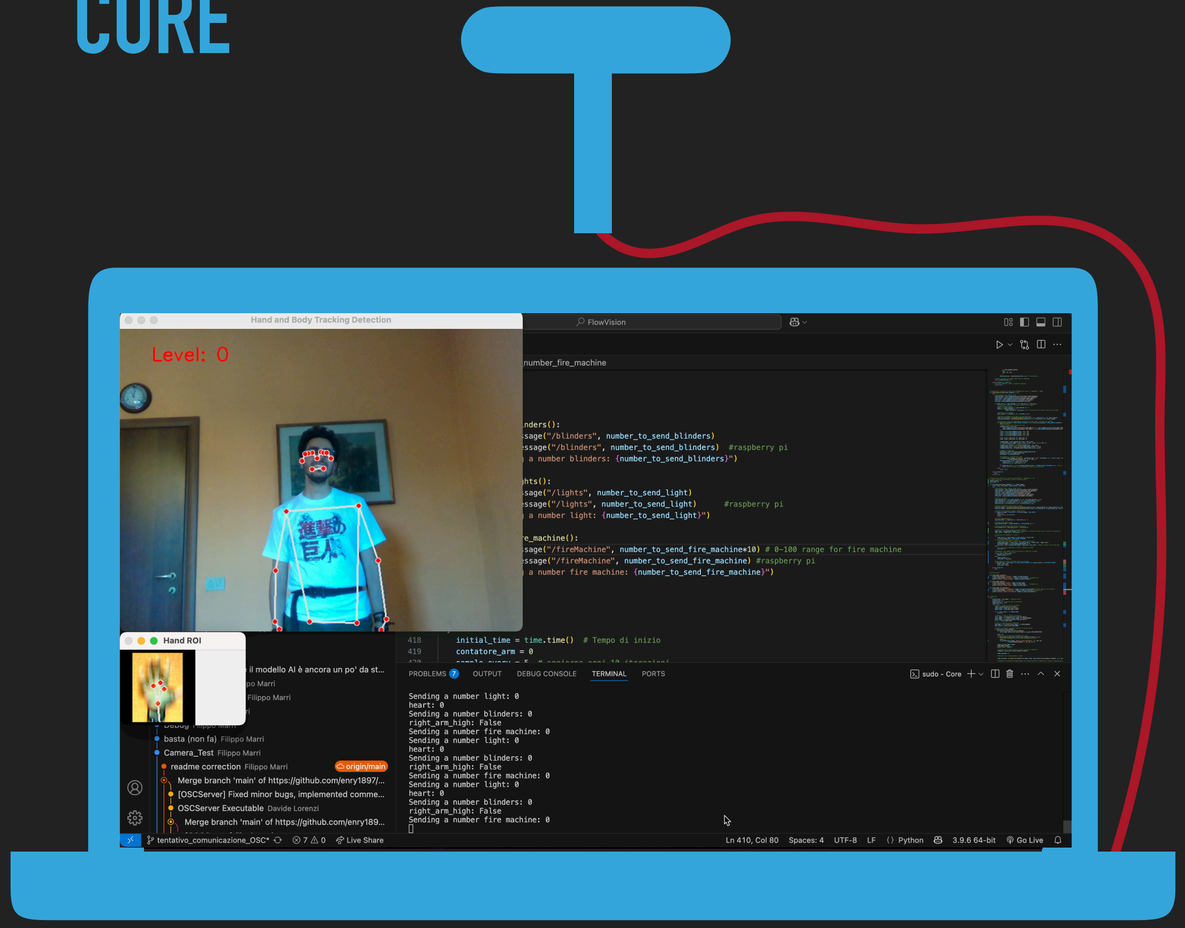


- MediaPipe module that allows the system to target the position and posture of the user
- Triggering system
  - Bigger movements -> Thresholds
  - Details -> AI models fed with cropped images

CHALLENGE:

BLINKING DUE TO THE HIGH FPS

CORE



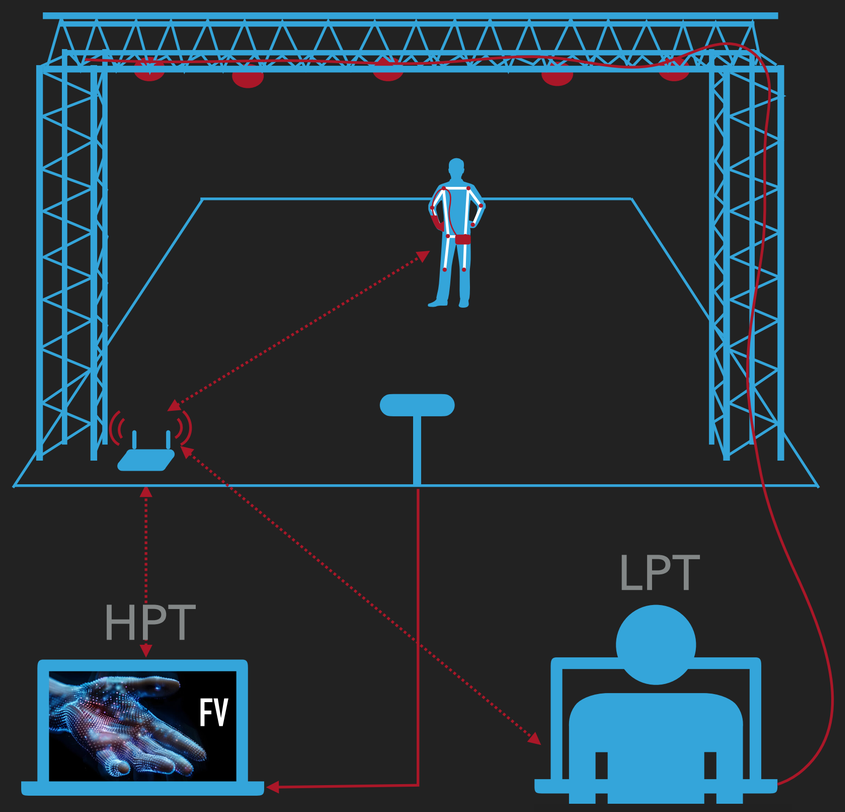
- MediaPipe module that allows the system to target the position and posture of the user
- Triggering system
  - Bigger movements -> Thresholds
  - Details -> AI models fed with cropped images

SOLUTION:

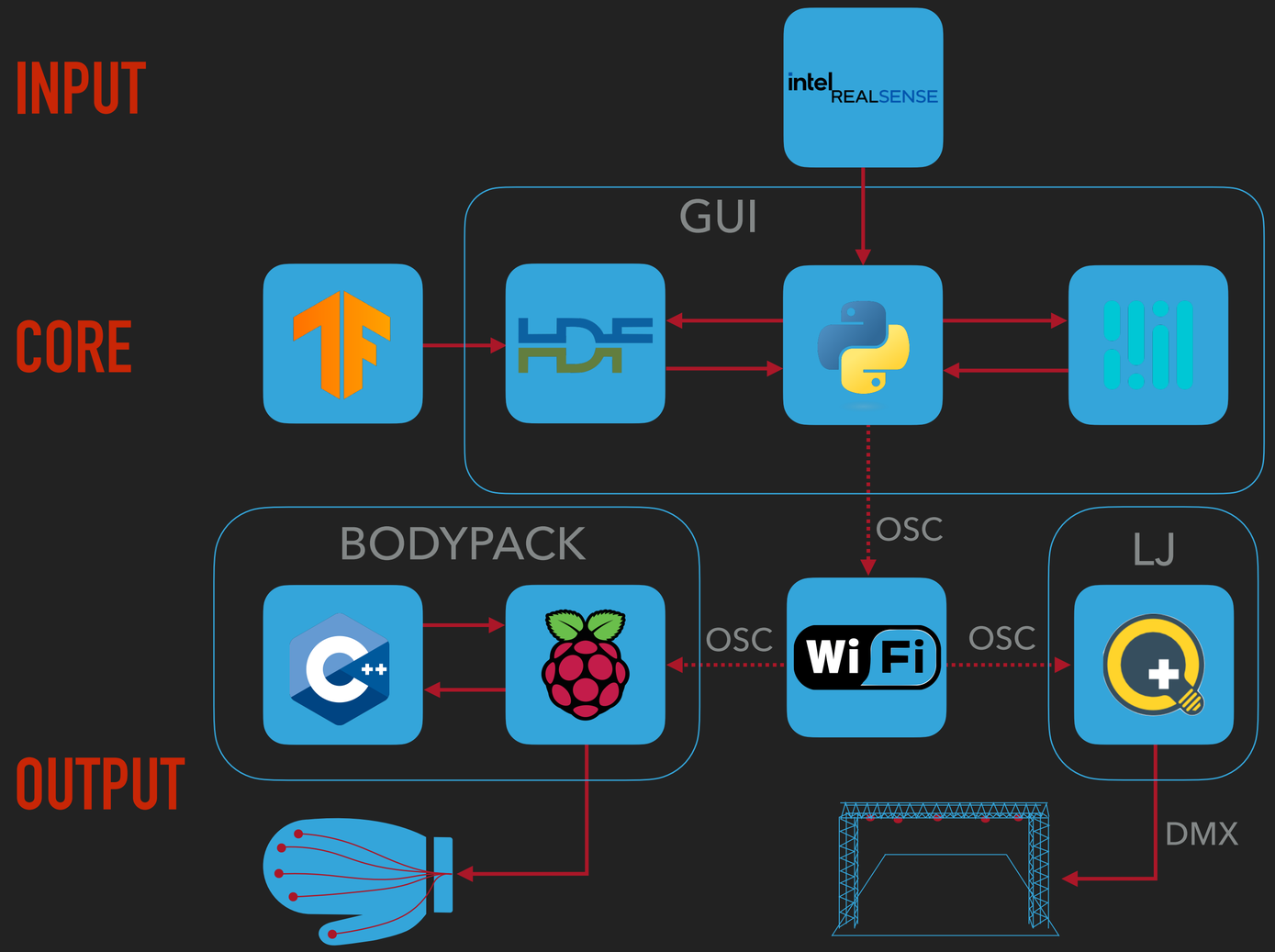
IMPLEMENTATION OF A HYSTERESIS CODE THAT ACTS AS A SAMPLE-AND-HOLD BLOCK TO REDUCE THE SPEED OF THE UPDATE

ARCHITECTURE

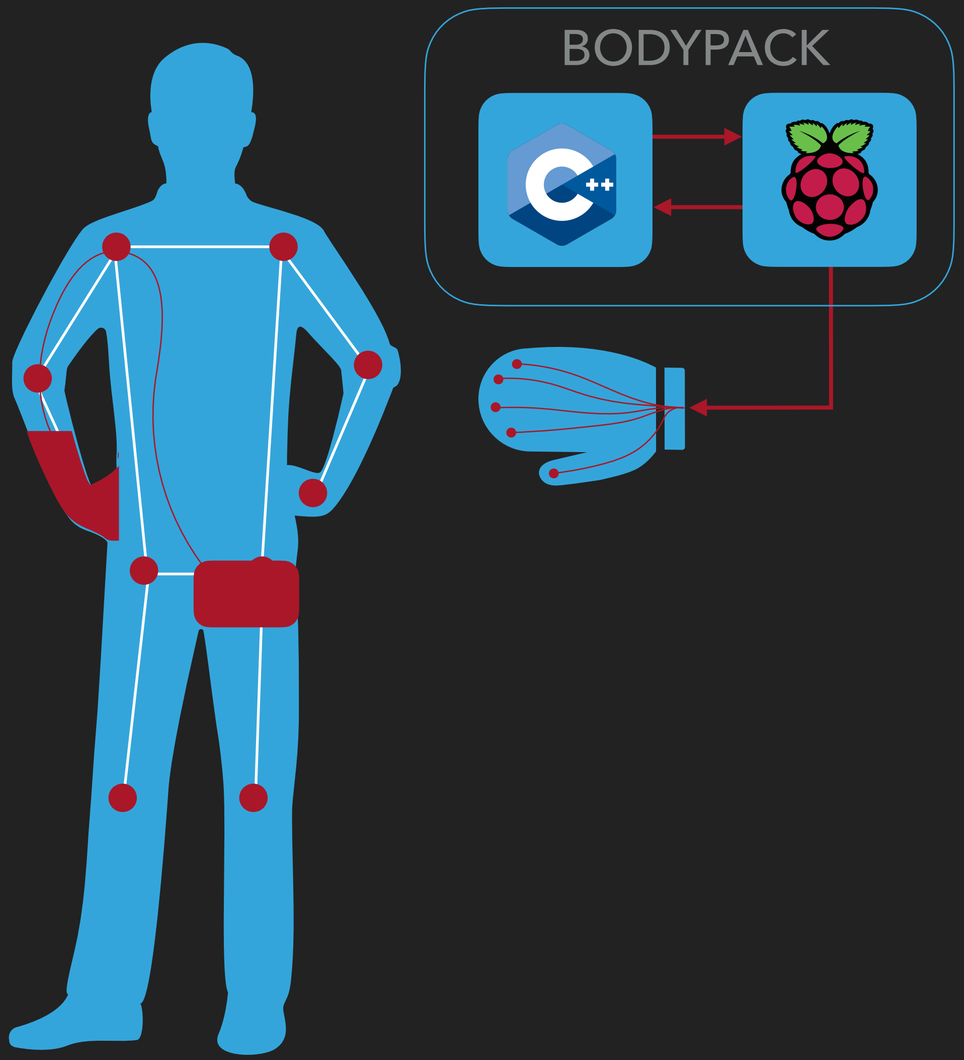
ON STAGE



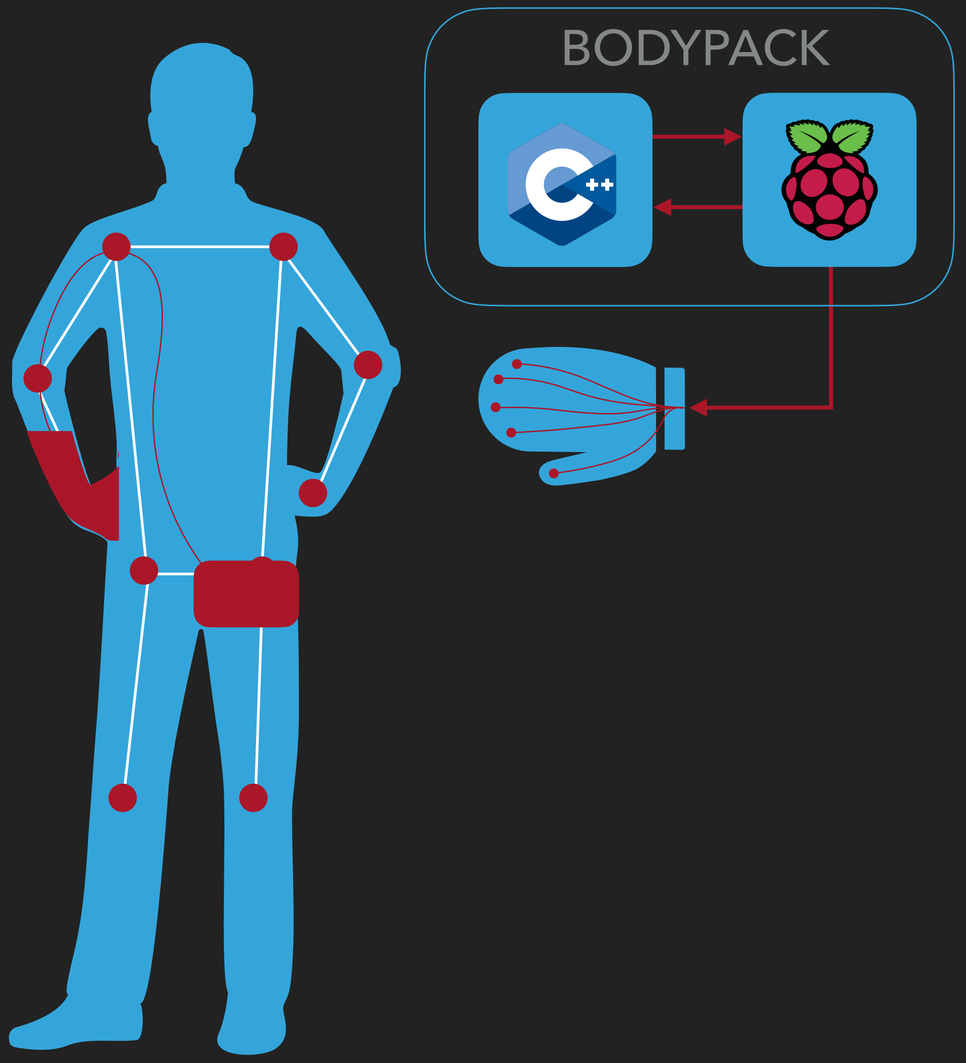
BEHIND THE SCENE



OUTPUT – BODYPACK

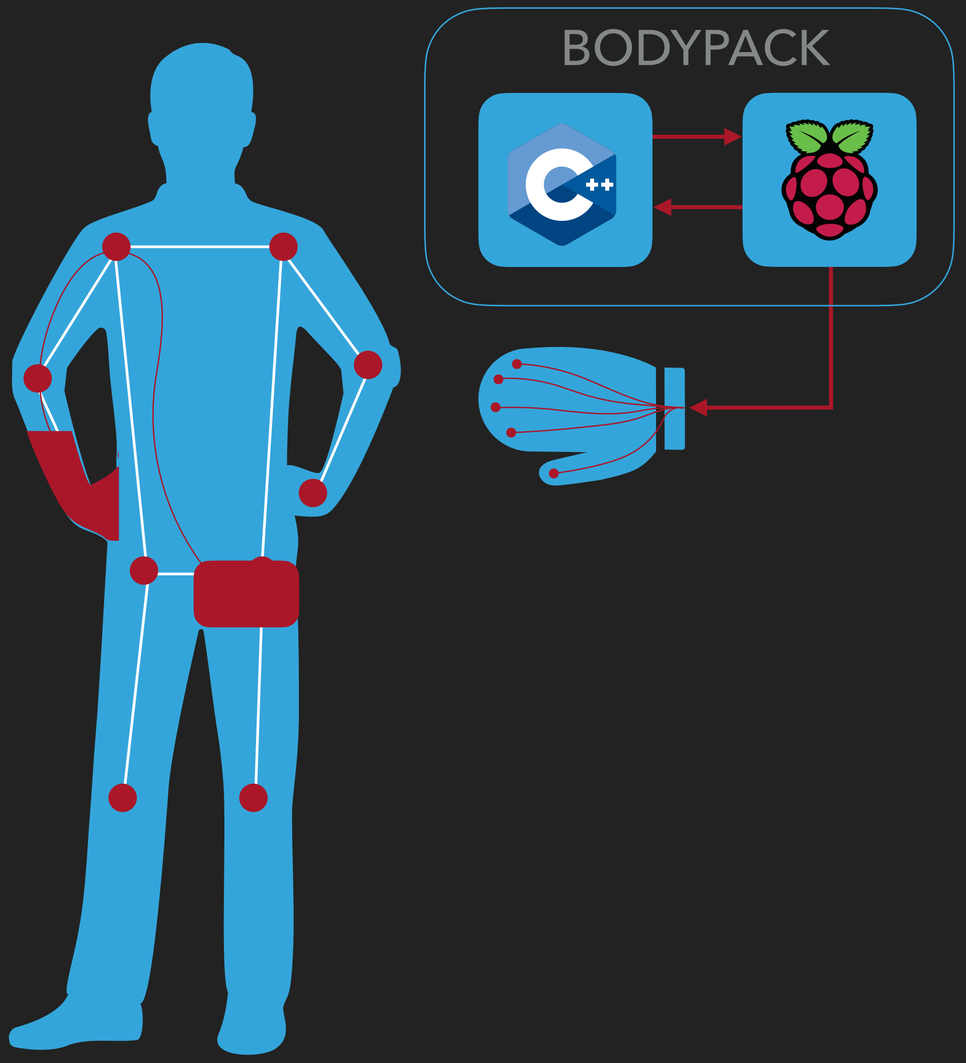


OUTPUT – BODYPACK



- 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

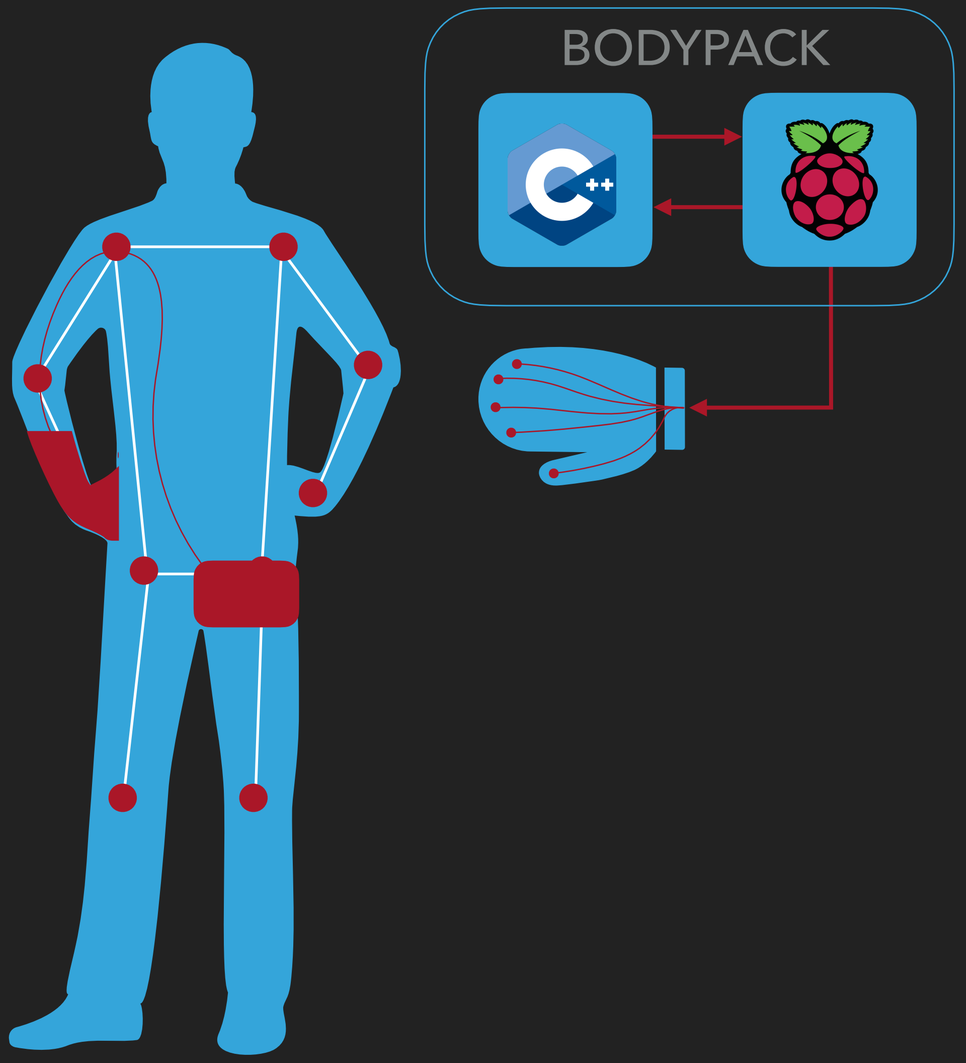


- RaspberryPi5 wi-fi that works as interface bet cuit driv function

CHALLENGE:

COMPATIBILITY PROBLEM BETWEEN PYTHON AND RASPBERRY PI 5

OUTPUT – BODYPACK

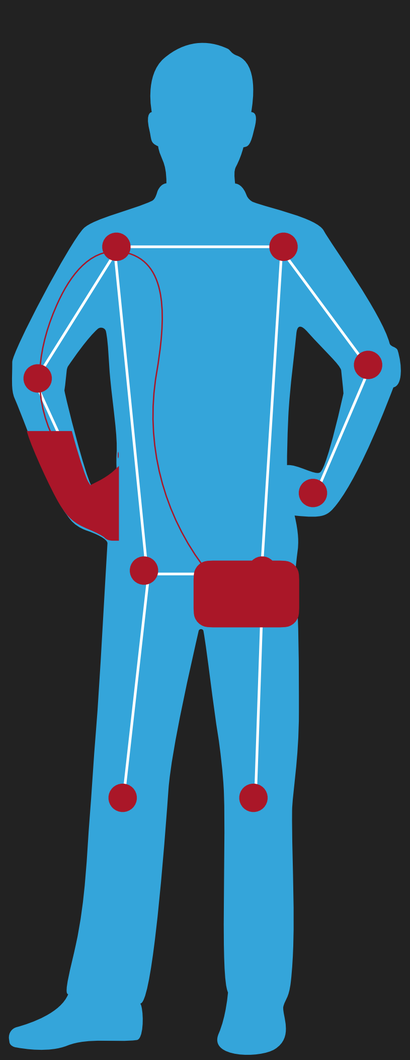


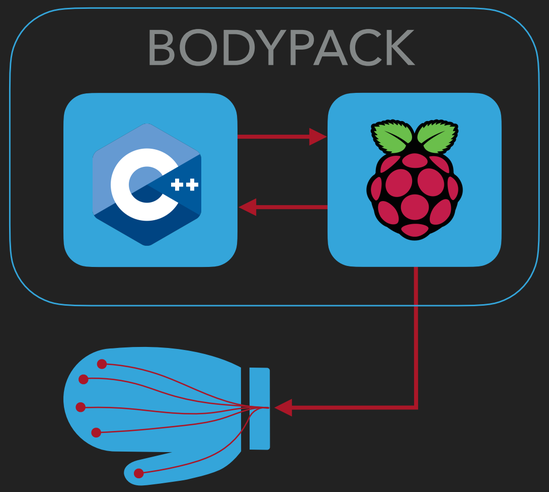
- RaspberryPi5 wi-fi that works as interface
  bet cuit
  driv
  function

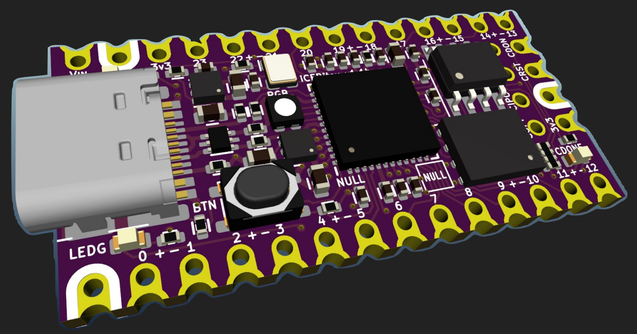
SOLUTION:

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

OUTPUT – BODYPACK

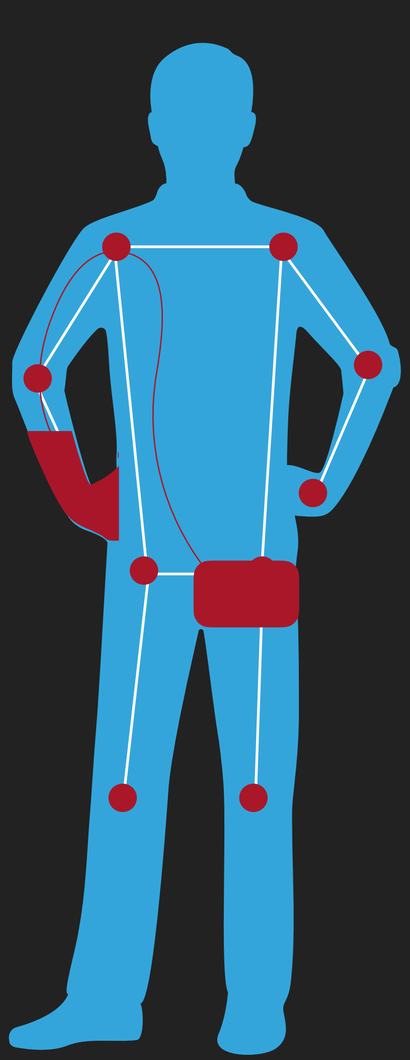


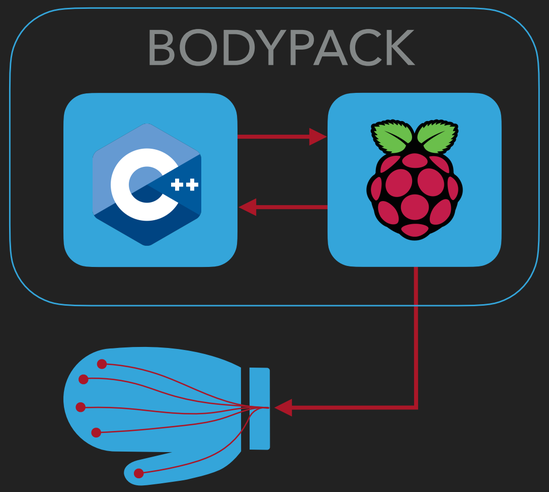


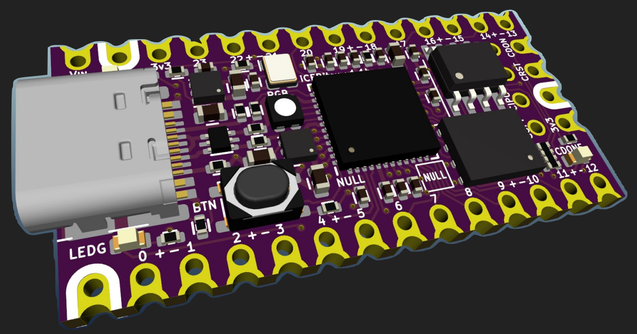


- RaspberryPi5 wi-fi that works as interface between the software and the actuator circuit driven by a specific firmware written in C++ due to compatibility reasons
- Actuator integrated circuit designed in KiCad powered by a power bank able to give two types of feedbacks:
  - ON/OFF feedback -> On/Off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

OUTPUT – BODYPACK



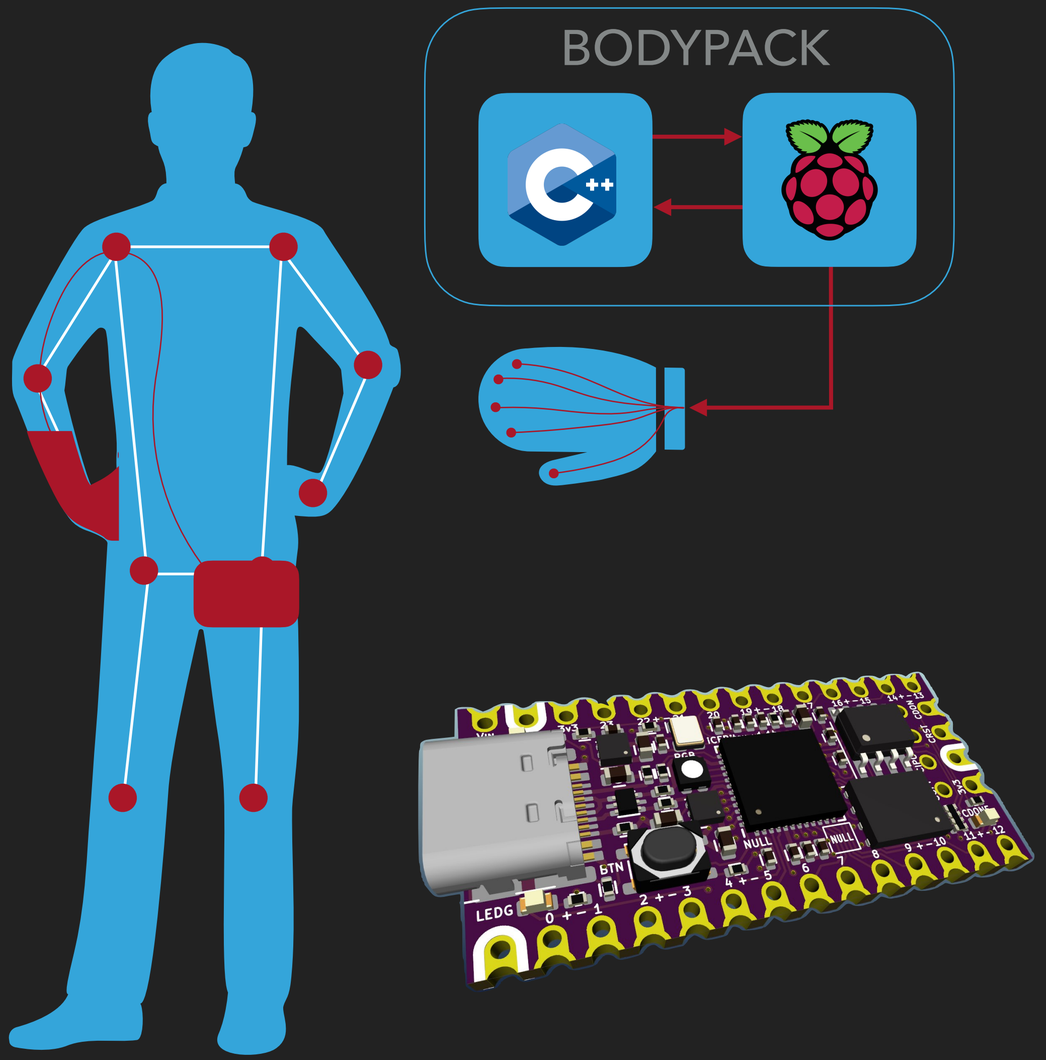




- RaspberryPi5 wi-fi that works as interface between the software and the actuator circuit driven by a specific firmware written in C++ due to compatibility reasons
- A… …KiCad po… …wo types of feedbacks:
  - ON/OFF feedback -> On/Off MOS
  - Continous feedback -> PWM + Low pass filter

CHALLENGE:
TOO LONG SHIPPING TIME FROM CHINA TO MILAN

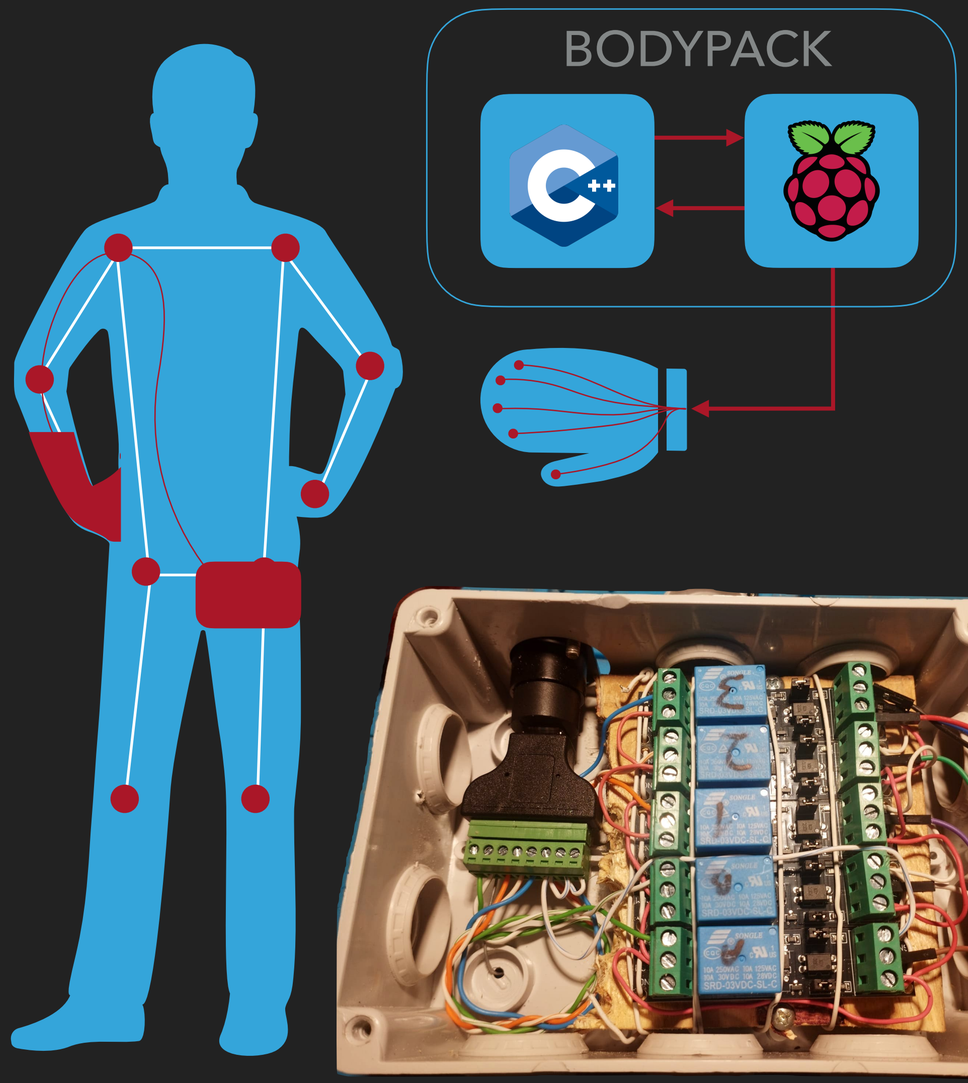
OUTPUT – BODYPACK



- 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
- Ac… KiCad po… wo types of feedbacks:
  - ON/OFF feedback -> On/Off MOS
  - Continous feedback -> PWM + Low pass filter

SOLUTION:
SIMPLER CIRCUIT BASED ON RELAYS INSTEAD OF TRANSISTORS

OUTPUT – BODYPACK

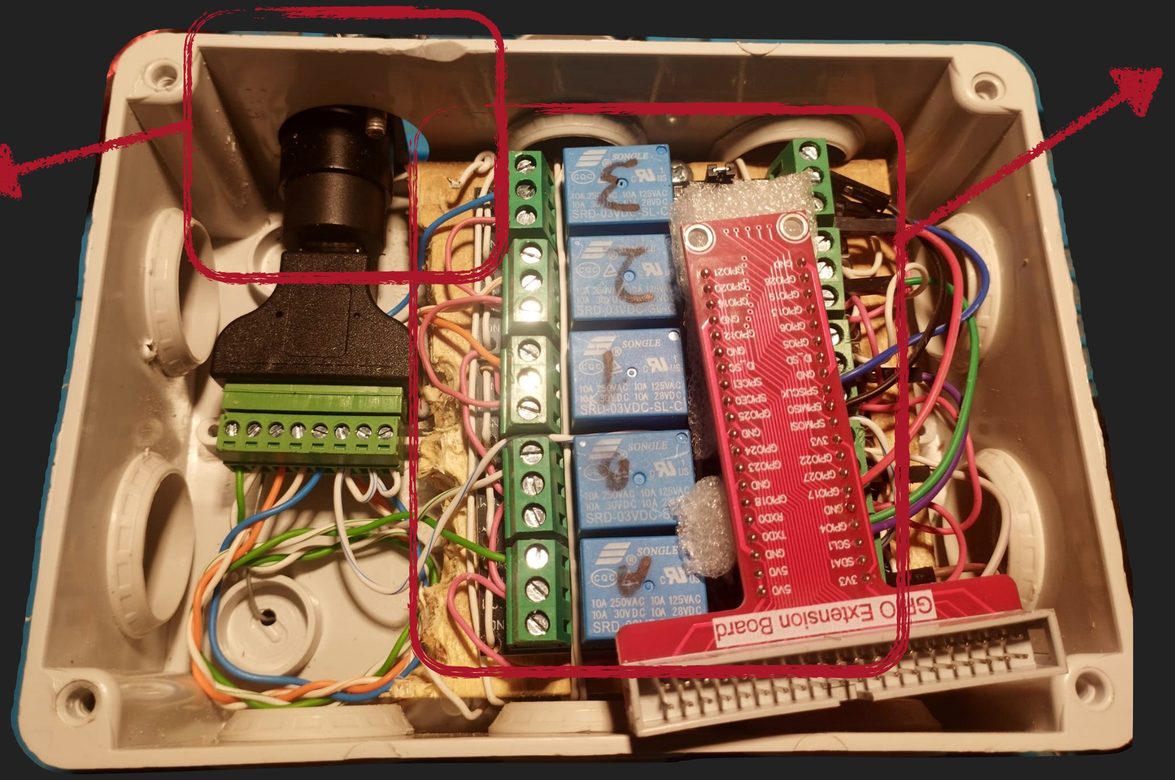


- RaspberryPi5 wi-fi that works as interface between the software and the actuator circuit driven by a specific firmware written in C++ due to compatibility reasons
- Relays-based actuator circuit powered by a power bank able to give two types of feedbacks:
  - ON/OFF feedback -> On/Off MOS
  - Continous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

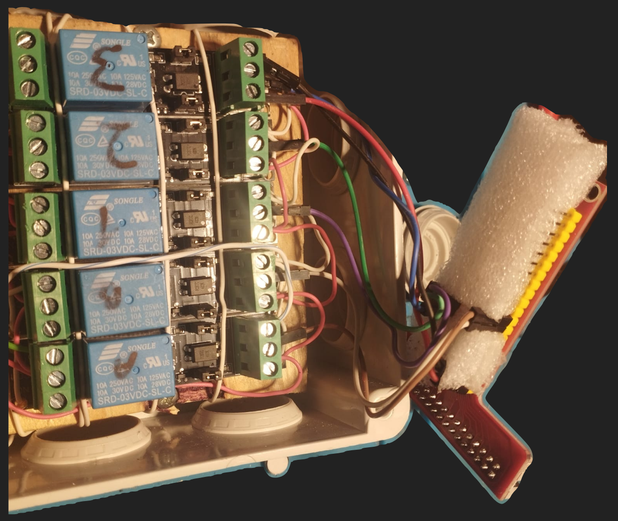
OUTPUT - CIRCUIT

OUTPUT – CIRCUIT

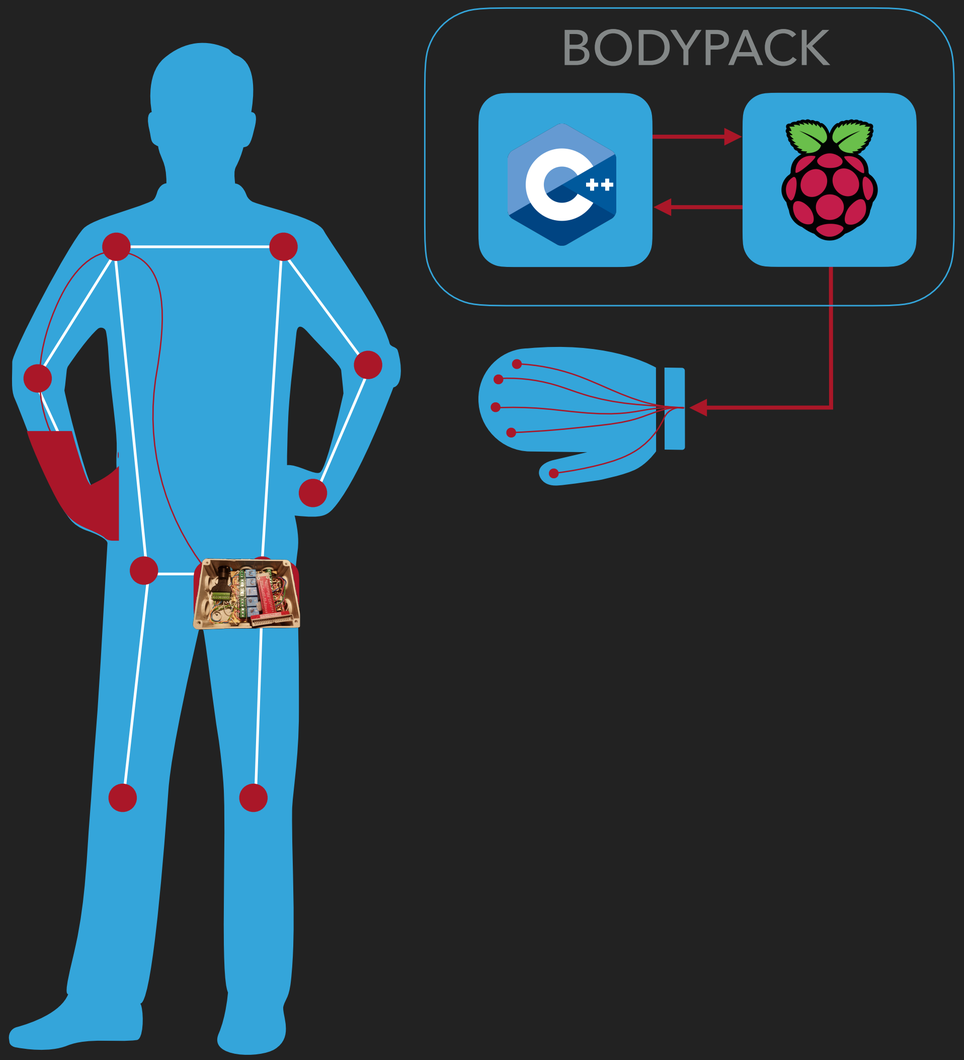
Ethernet socket to have a quick and comfort plug for the glove



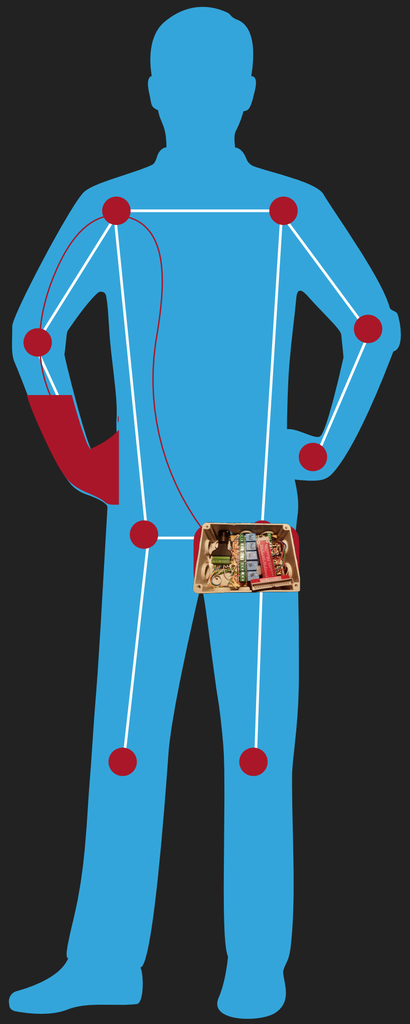
Five relays connected to the GPIO interface of the Raspberry Pi to control the actuators of the glove

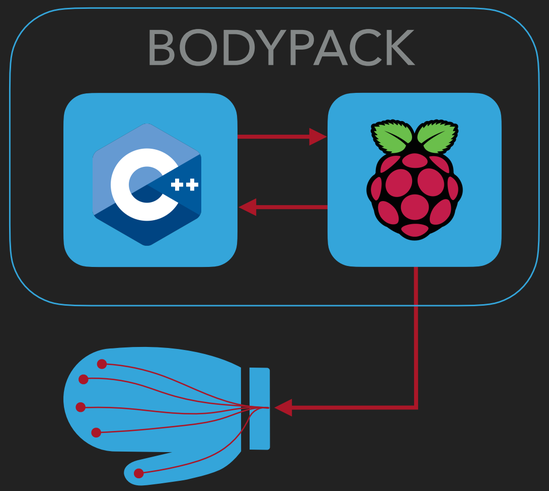


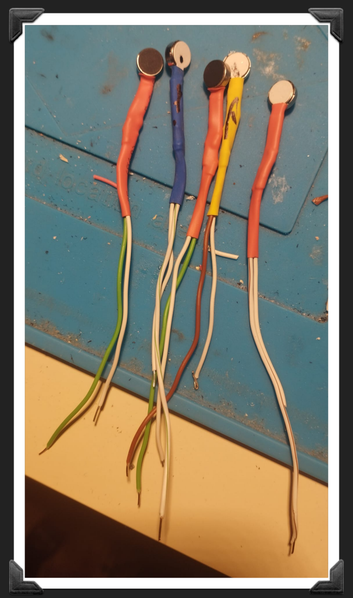
OUTPUT – GLOVE



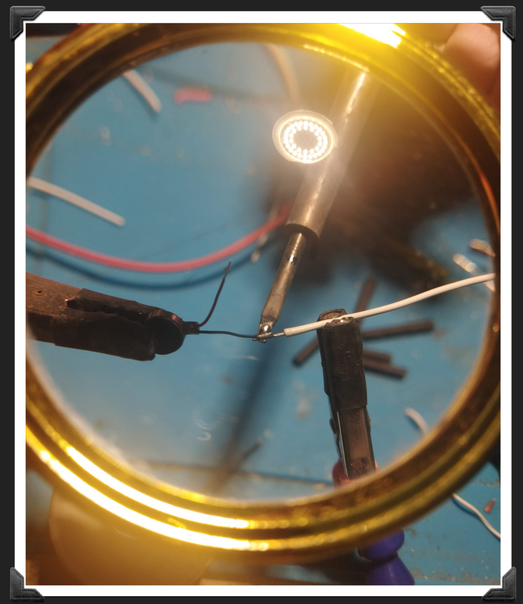
OUTPUT – GLOVE



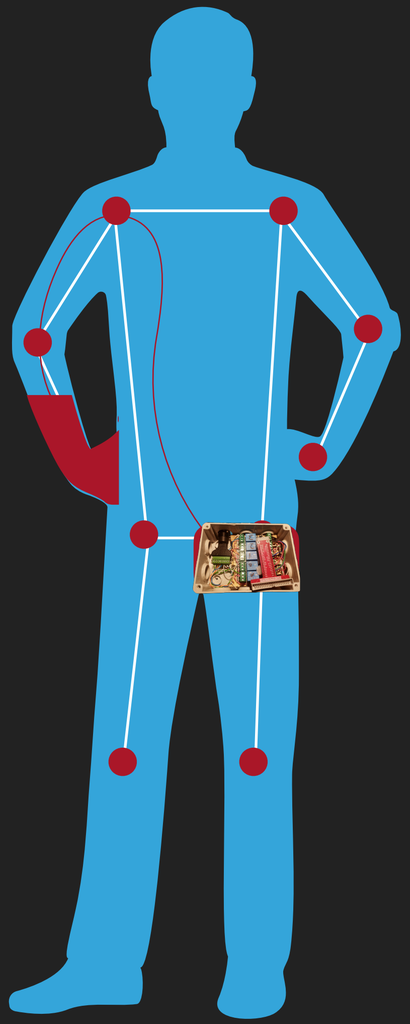


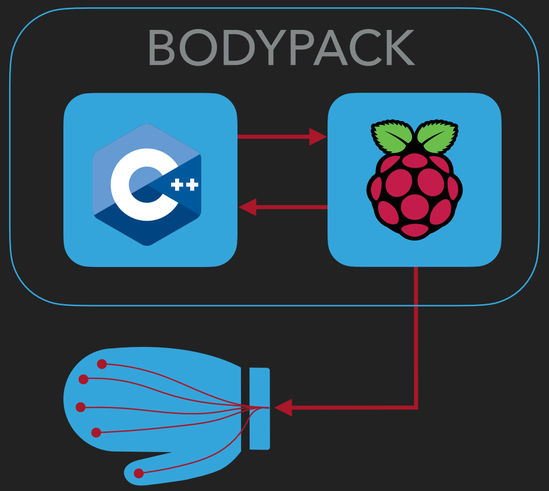


- Haptic feedback given by vibrating actuators placed on the fingers of a glove working at 3.3V

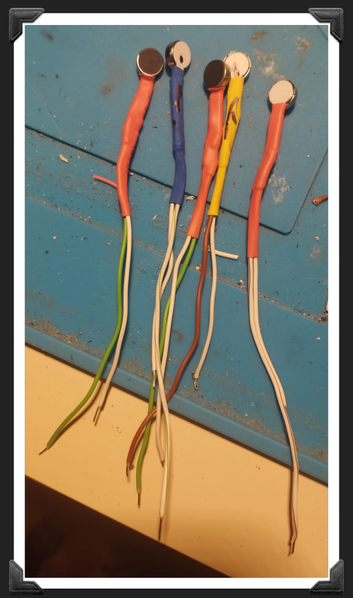


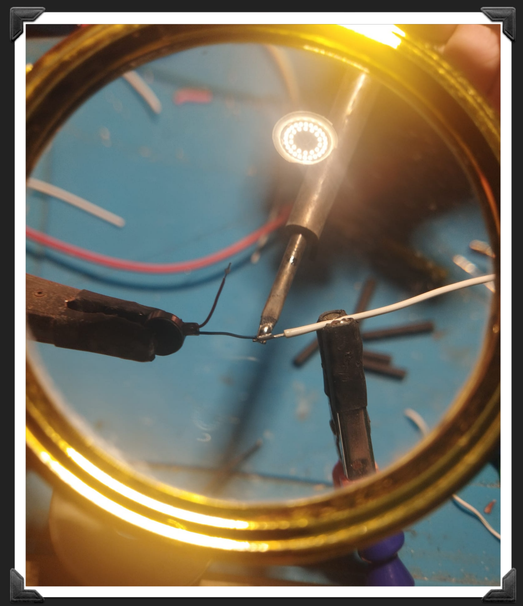
OUTPUT – GLOVE



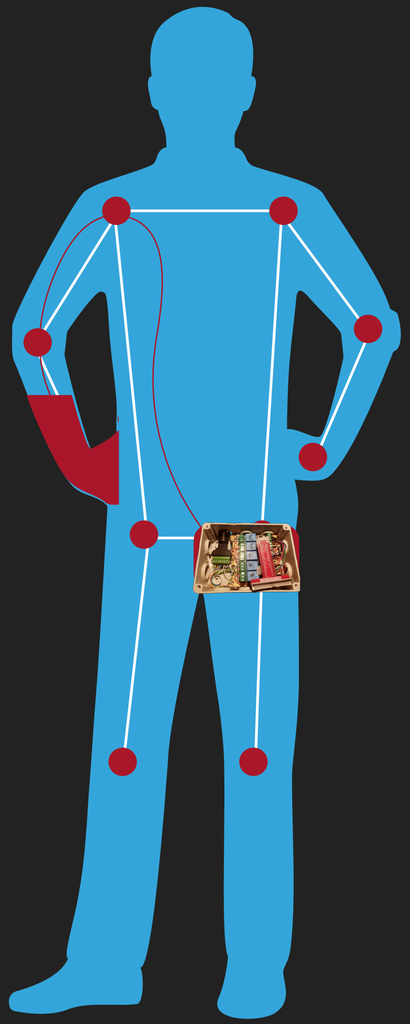


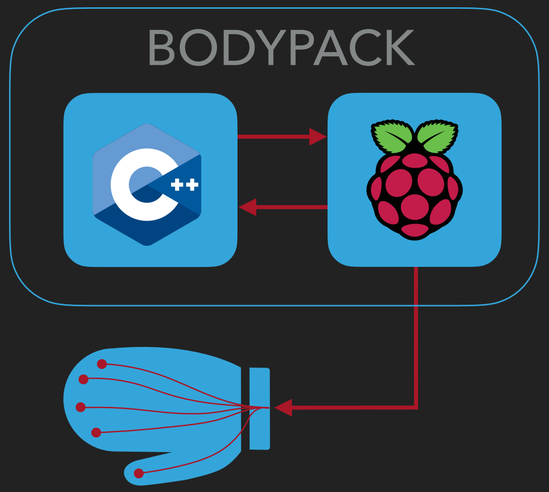
- Haptic feedback given by vibrating actuators placed on the fingers of a glove working at 3.3V
- Installation of an ethernet socket to have a quick and comfort plug

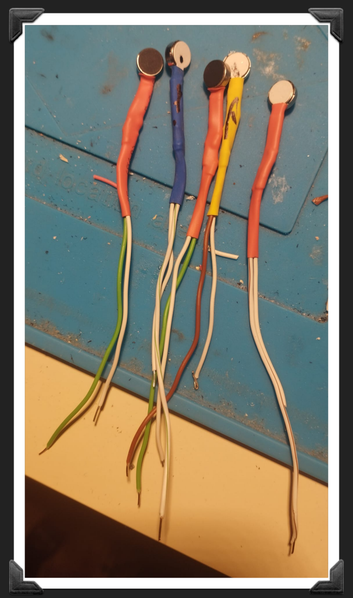




OUTPUT – GLOVE



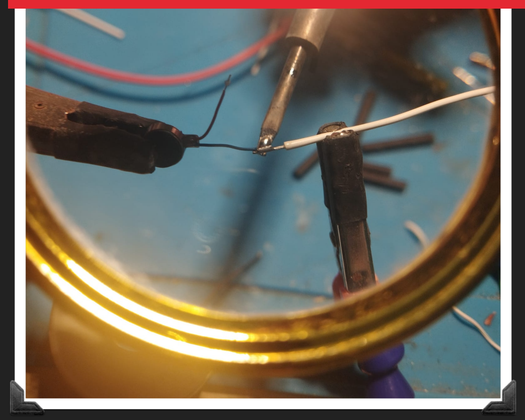




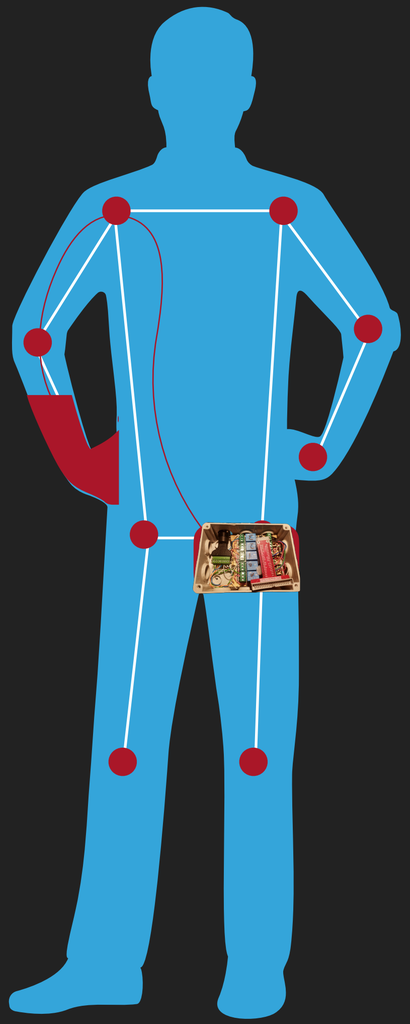
- Haptic feedback given by vibrating actuators placed on the fingers of a glove working at 3.3V
- Installation of an ethernet socket to have a quick and comfort plug

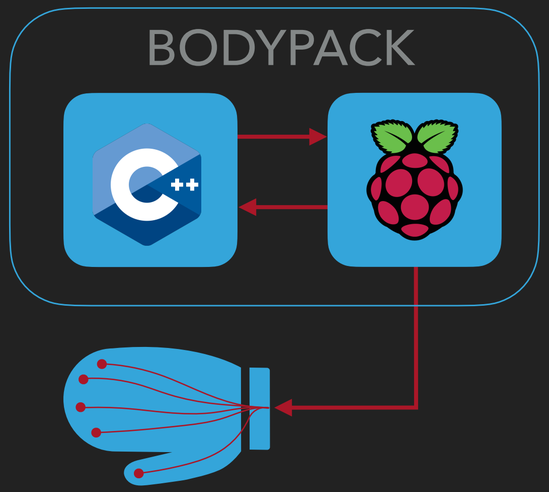
CHALLENGE:

EXTREMELY THIN AND DELICATE WIRES FOR THE ACTUATORS

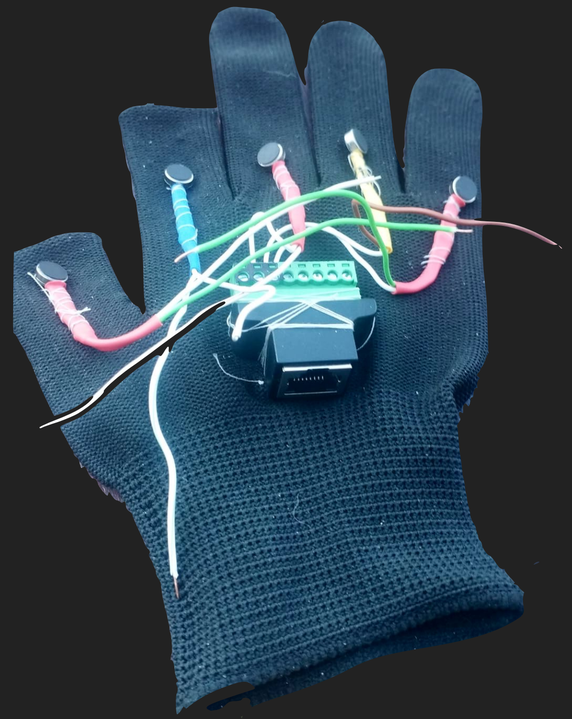


OUTPUT – GLOVE



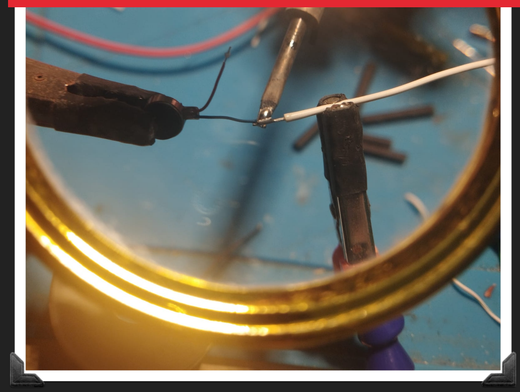


- Haptic feedback given by vibrating actuators placed on the fingers of a glove working at 3.3V
- Installation of an ethernet socket to have a quick and comfort plug

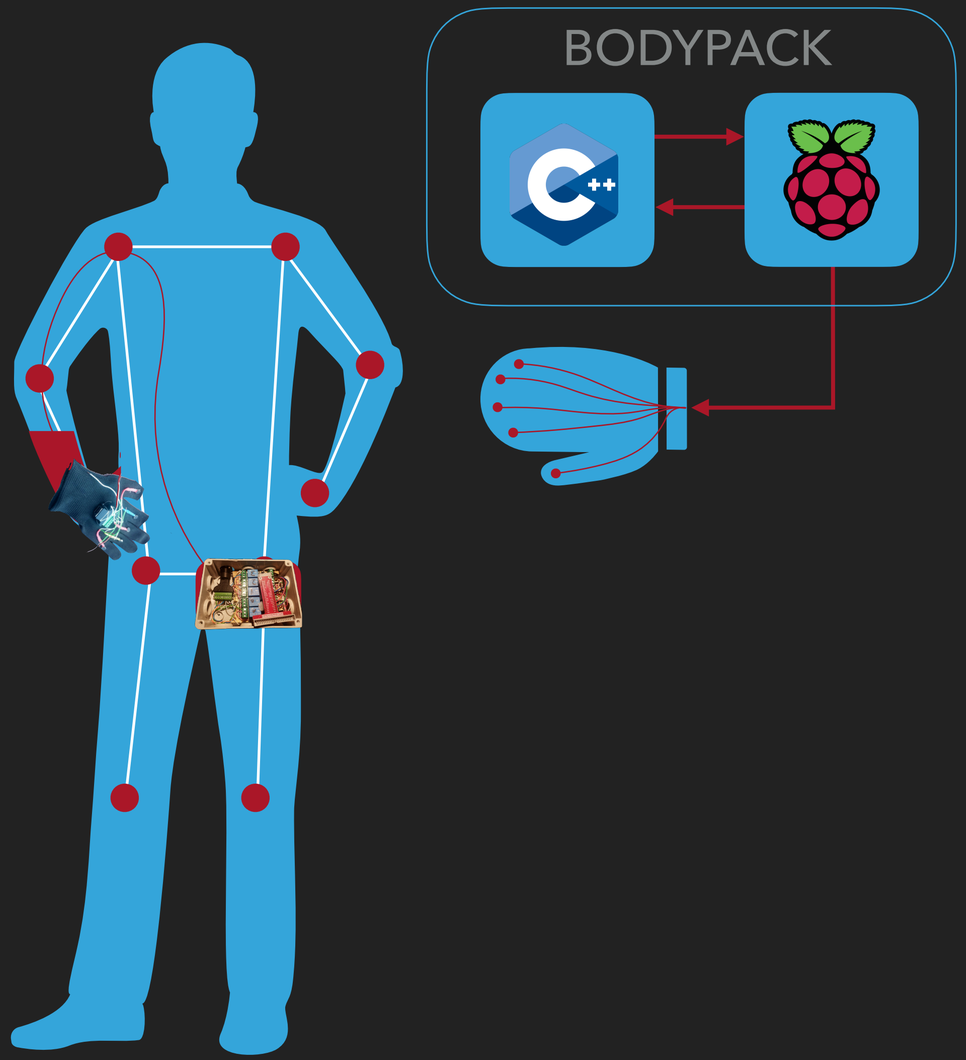


NO SOLUTION:

ONE WIRE BROKE LAST WEEK AND THE MID FINGER ACTUATOR DOES NOT WORK ANYMORE :(

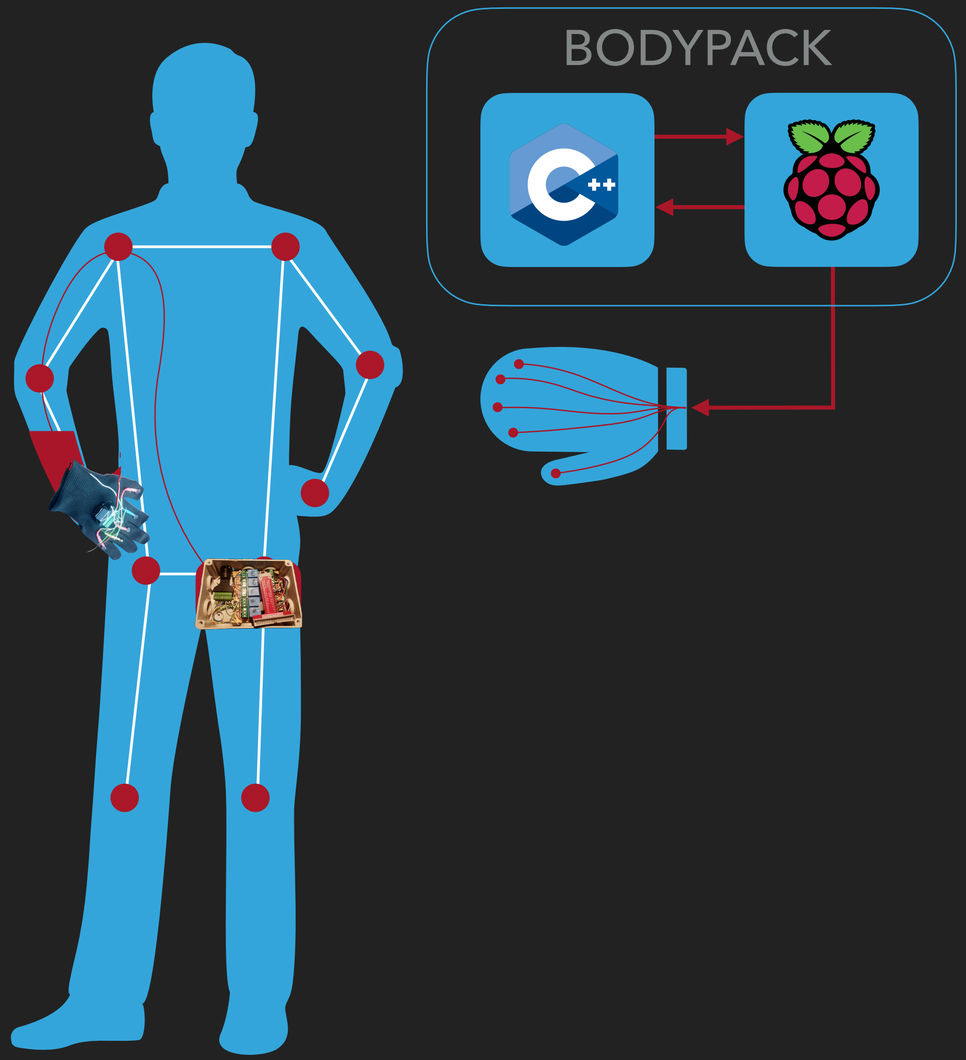


OUTPUT – GLOVE



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

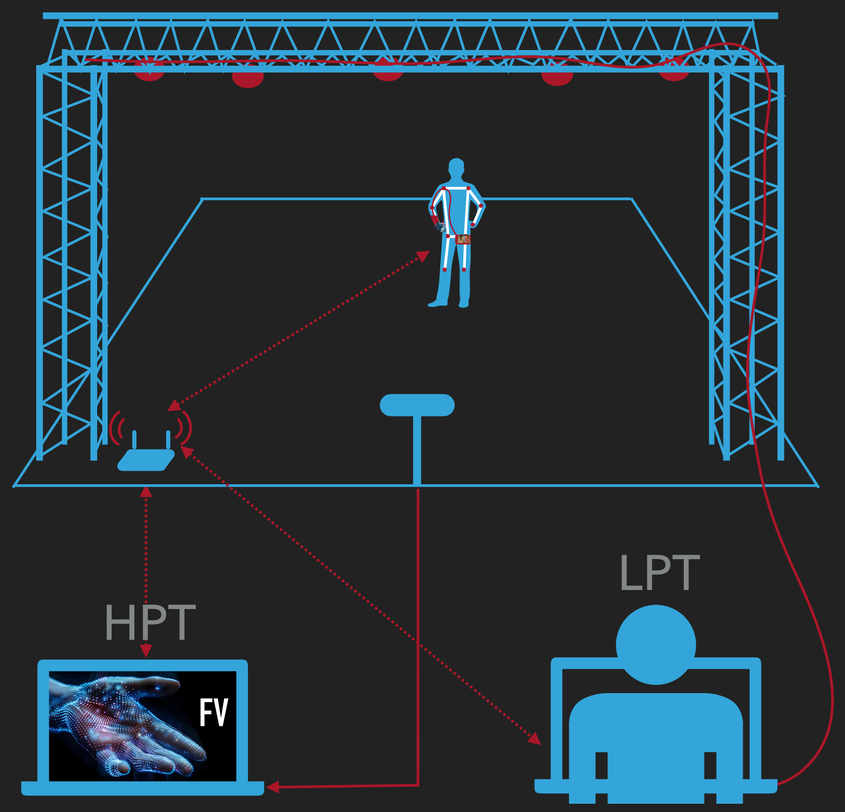
OUTPUT – GLOVE



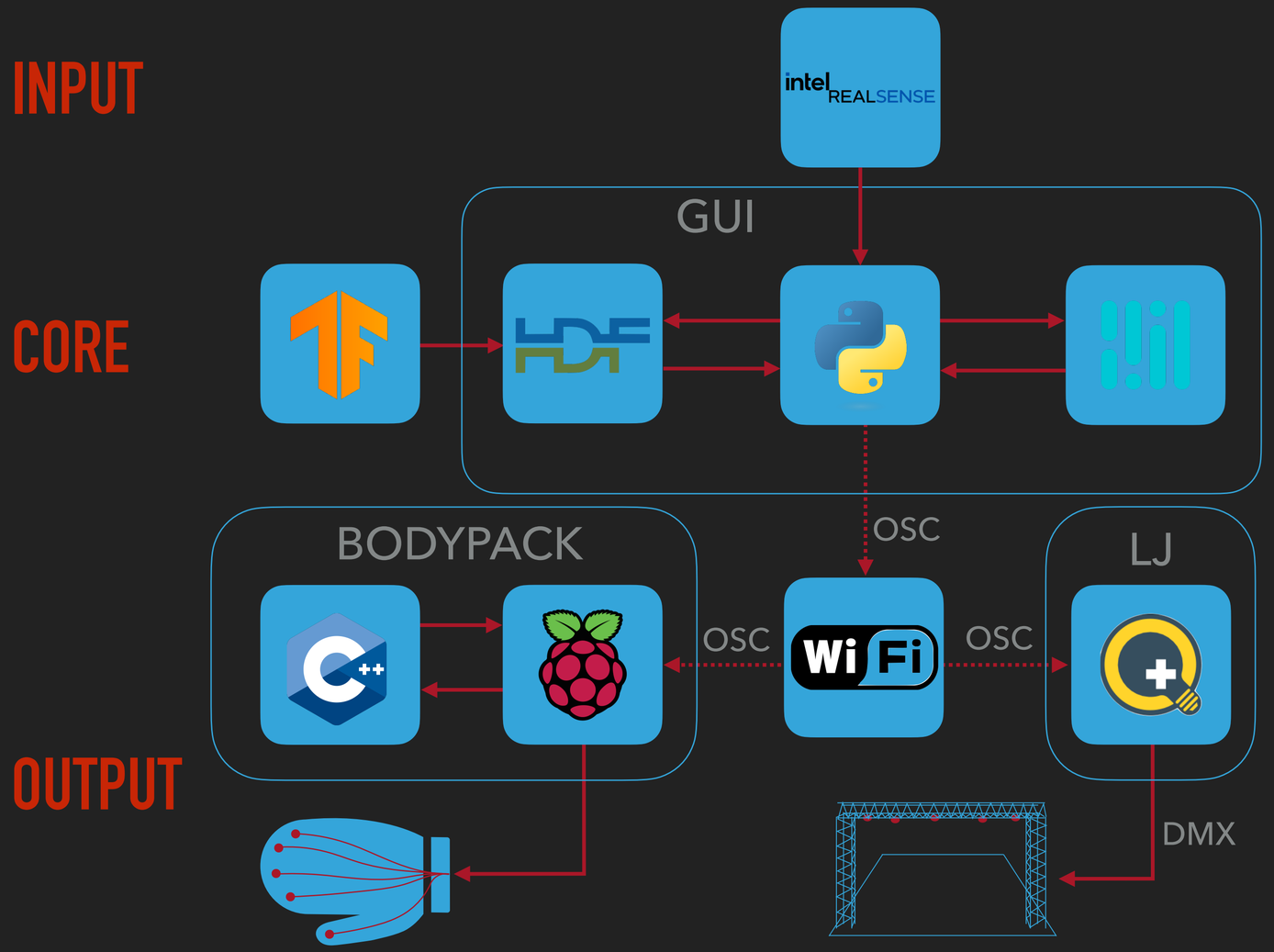
- Haptic feedback given by vibrating actuators placed on the finger of a glove working at 3.3 V

ARCHITECTURE

ON STAGE

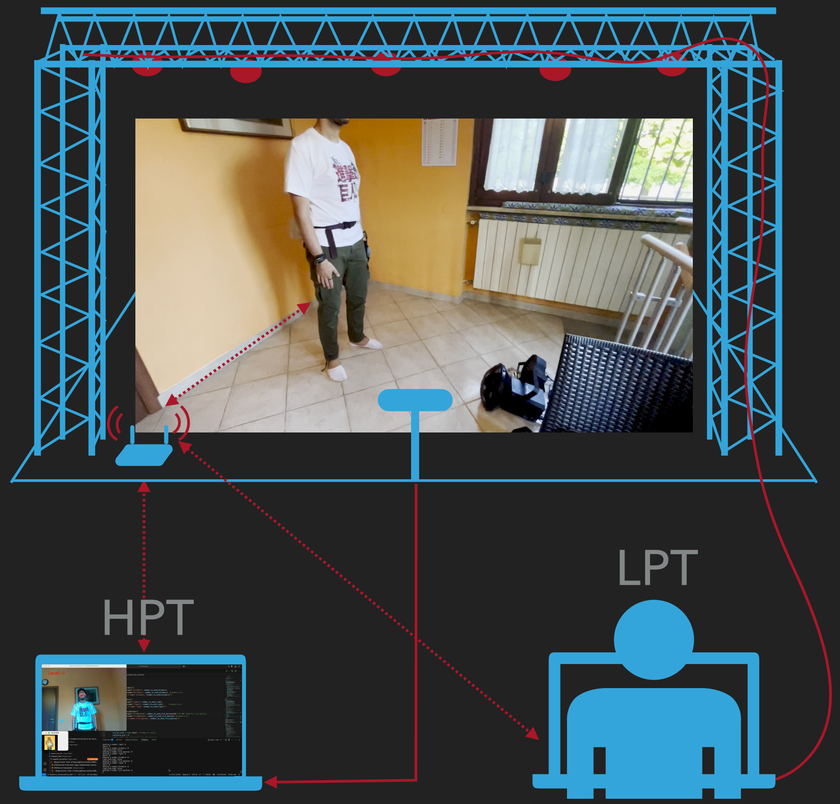


BEHIND THE SCENE



FINAL VERSION

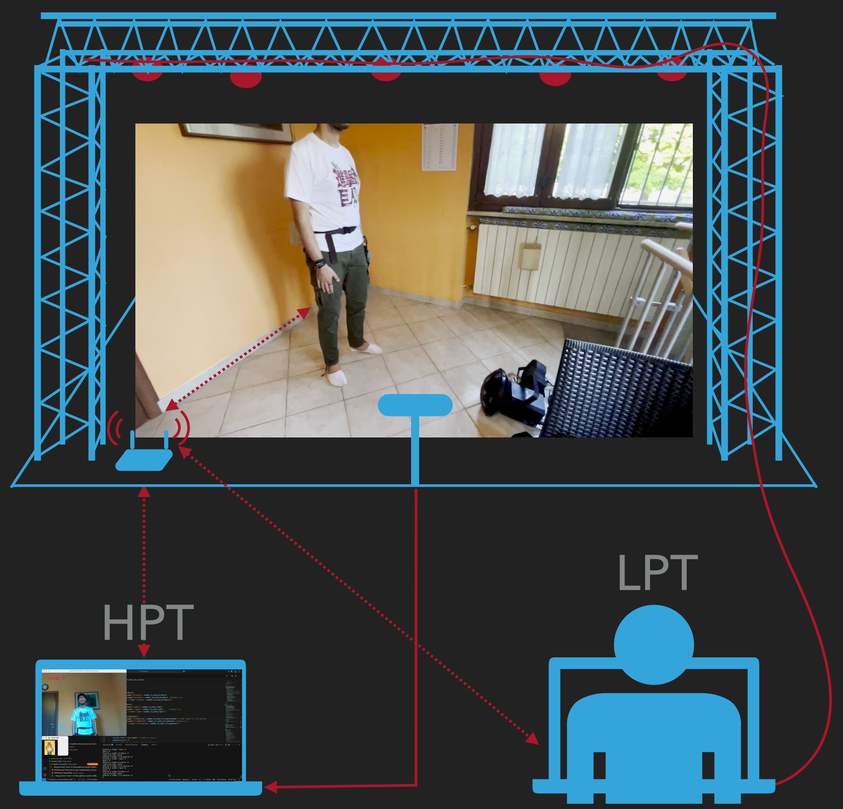
ON STAGE



POSSIBLE IMPROVEMENTS

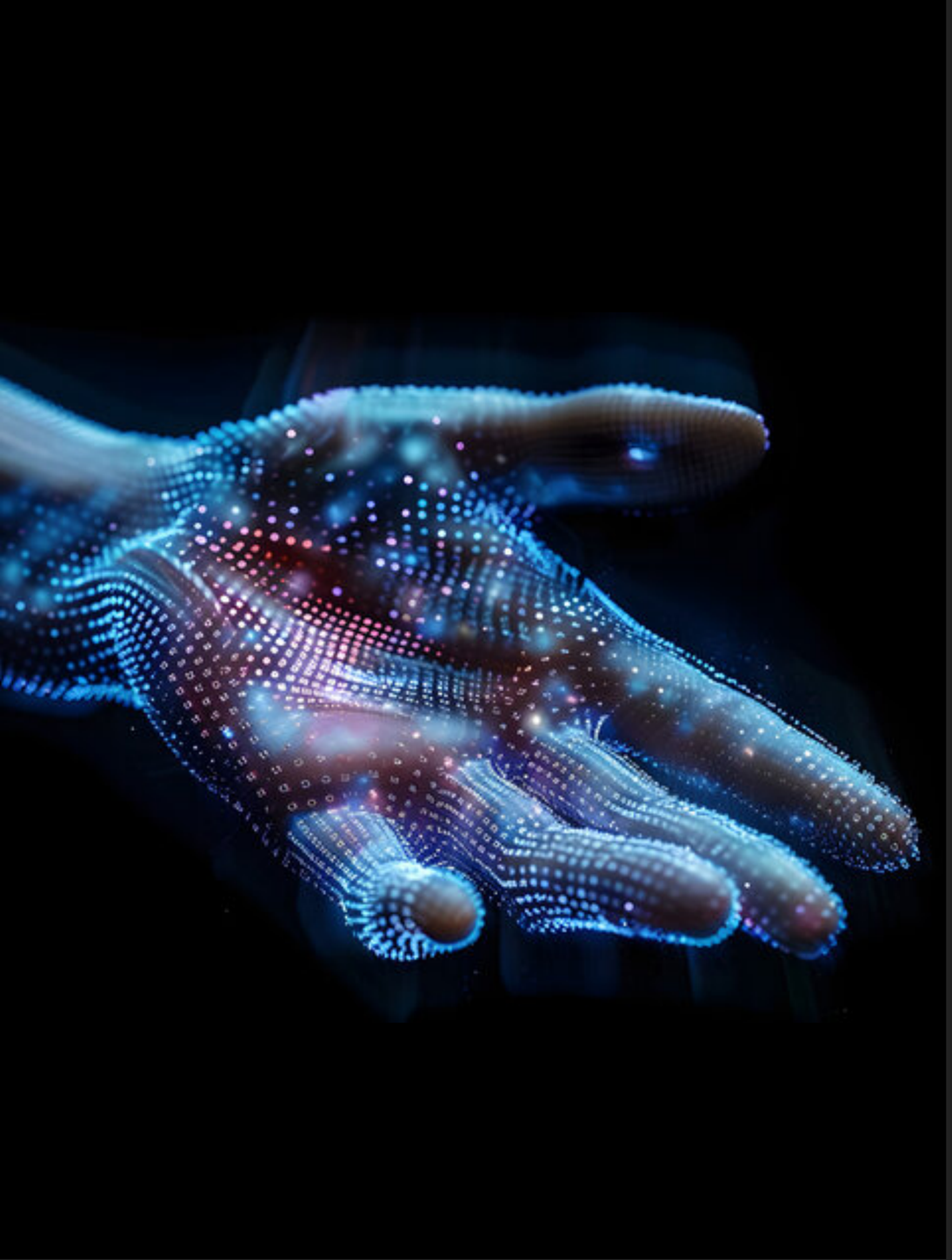
FINAL VERSION

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

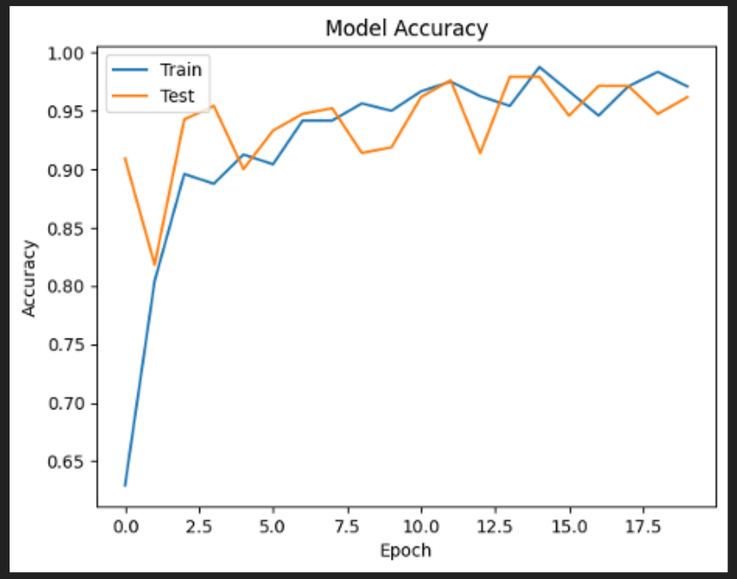


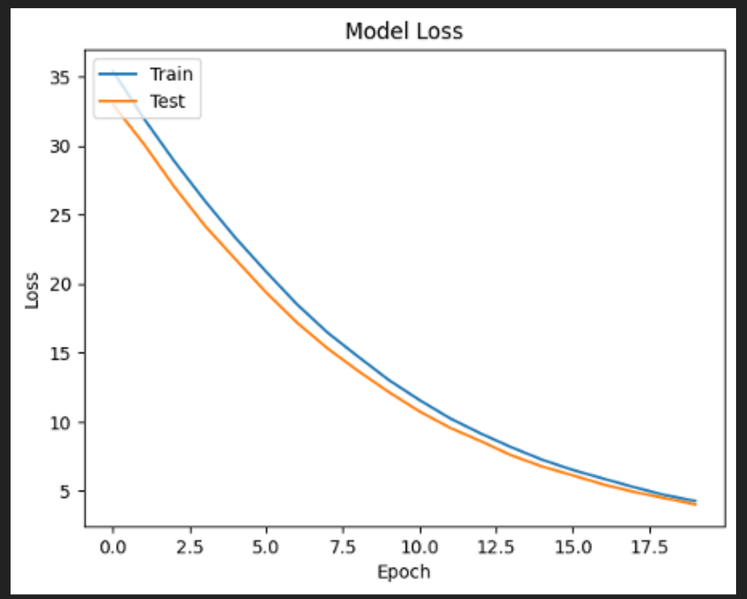
THANKS FOR YOUR ATTENTION

FLOWVISION

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

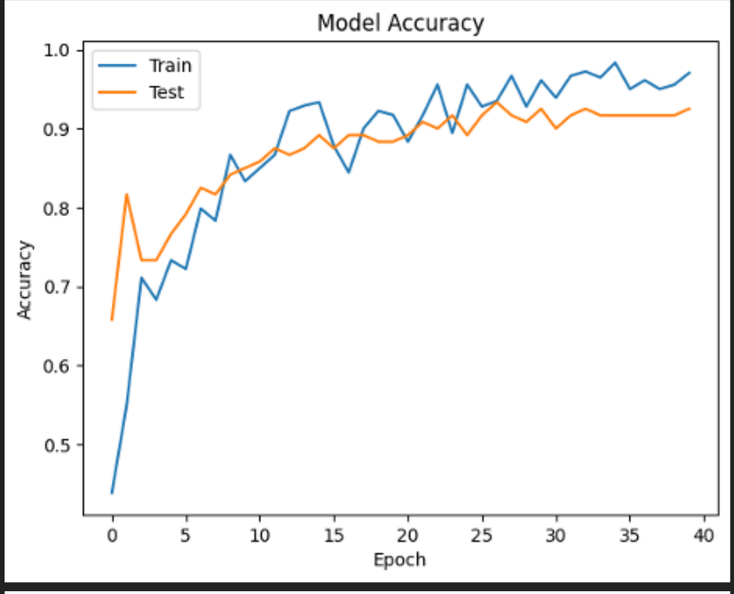
Train Accuracy: 0.9667

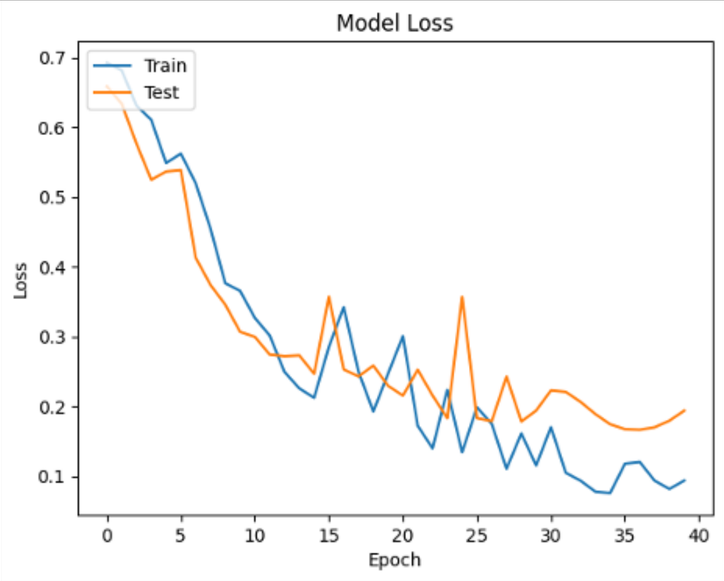
Val Accuracy: 0.9617

Train Loss: 4.3496

Val Loss: 4.0218

AI MODEL: HEART





Epoch: 40

Train Accuracy: 0.9602

Val Accuracy: 0.9250

Train Loss: 0.0794

Val Loss: 0.1886

Layer (type)	Output Shape	Param #
conv2d_1 (Conv2D)	(None, 118, 118, 16)	448
max_pooling2d_1 (MaxPooling2D)	(None, 59, 59, 16)	0
conv2d_2 (Conv2D)	(None, 57, 57, 32)	4,640
max_pooling2d_2 (MaxPooling2D)	(None, 28, 28, 32)	0
conv2d_3 (Conv2D)	(None, 26, 26, 64)	18,496
max_pooling2d_3 (MaxPooling2D)	(None, 13, 13, 64)	0
conv2d_4 (Conv2D)	(None, 11, 11, 128)	73,856
max_pooling2d_4 (MaxPooling2D)	(None, 5, 5, 128)	0
flatten_2 (Flatten)	(None, 3200)	0
dense_5 (Dense)	(None, 256)	819,456
dense_6 (Dense)	(None, 128)	32,896
dense_7 (Dense)	(None, 2)	258

Total params: 950,050 (3.62 MB)

Trainable params: 950,050 (3.62 MB)

Non-trainable params: 0 (0.00 B)

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 :(