ML4IoT Implementation of different projects

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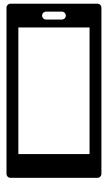
Introduction

Use Deep Learning to:

- Recognize sounds 
- Classify images 

Connect Devices as:

- Cloud Servers 
- Sensors  
- Smartphones 

THE SENSORS ALLOW TO COOK MORE EFFICIENTLY

WE CAN KEEP TRACK OF OUR NUTRITIONAL HABITS AND TAILOR THEM IN CASE OF NEEDS

WE CAN BE HELPED BY THE SENSORS TO COOK BETTER

WE CAN KEEP TRACK OF OUR WORKING ACTIVITY

WE UNDERSTAND WHEN WE NEED A BREAKE TO PLAY SOMETHING FUN

THE SENSORS WILL KEEP OUR HOME SAFE WHEN WE ARE OUT

Nutritional help

Activity tracking

Alarm systems

Sound Recognition

Train and tailor DL architecture. Then push them on the edge applying state of the art techniques as post training quantization and structured/sparse pruning

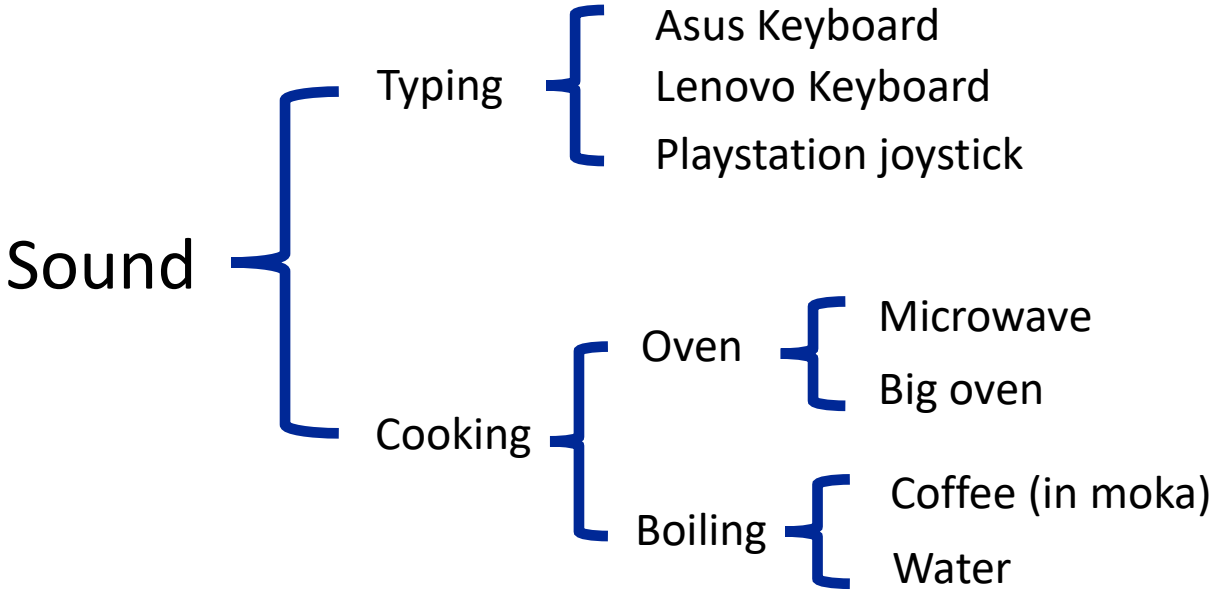
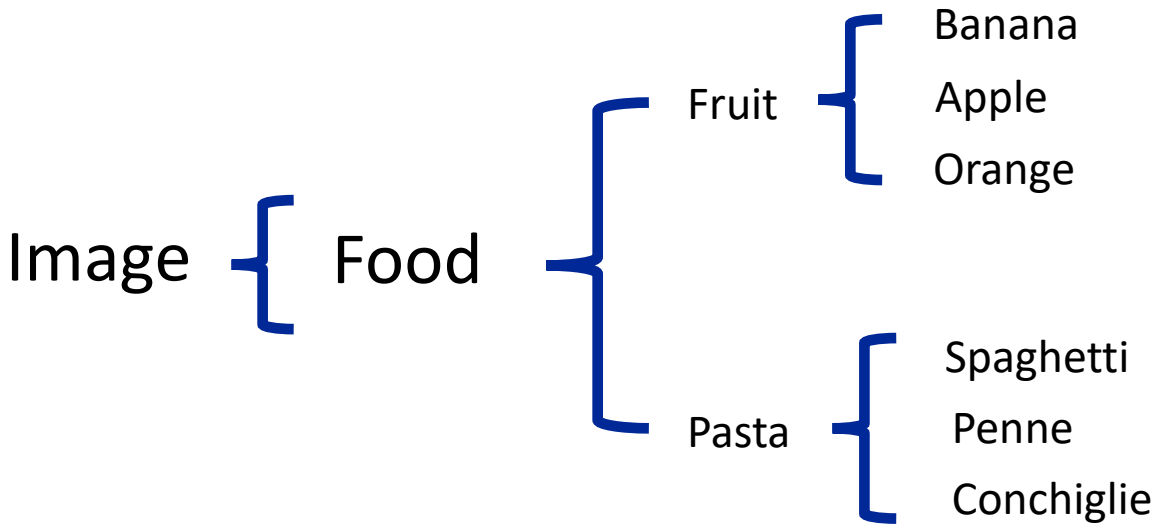
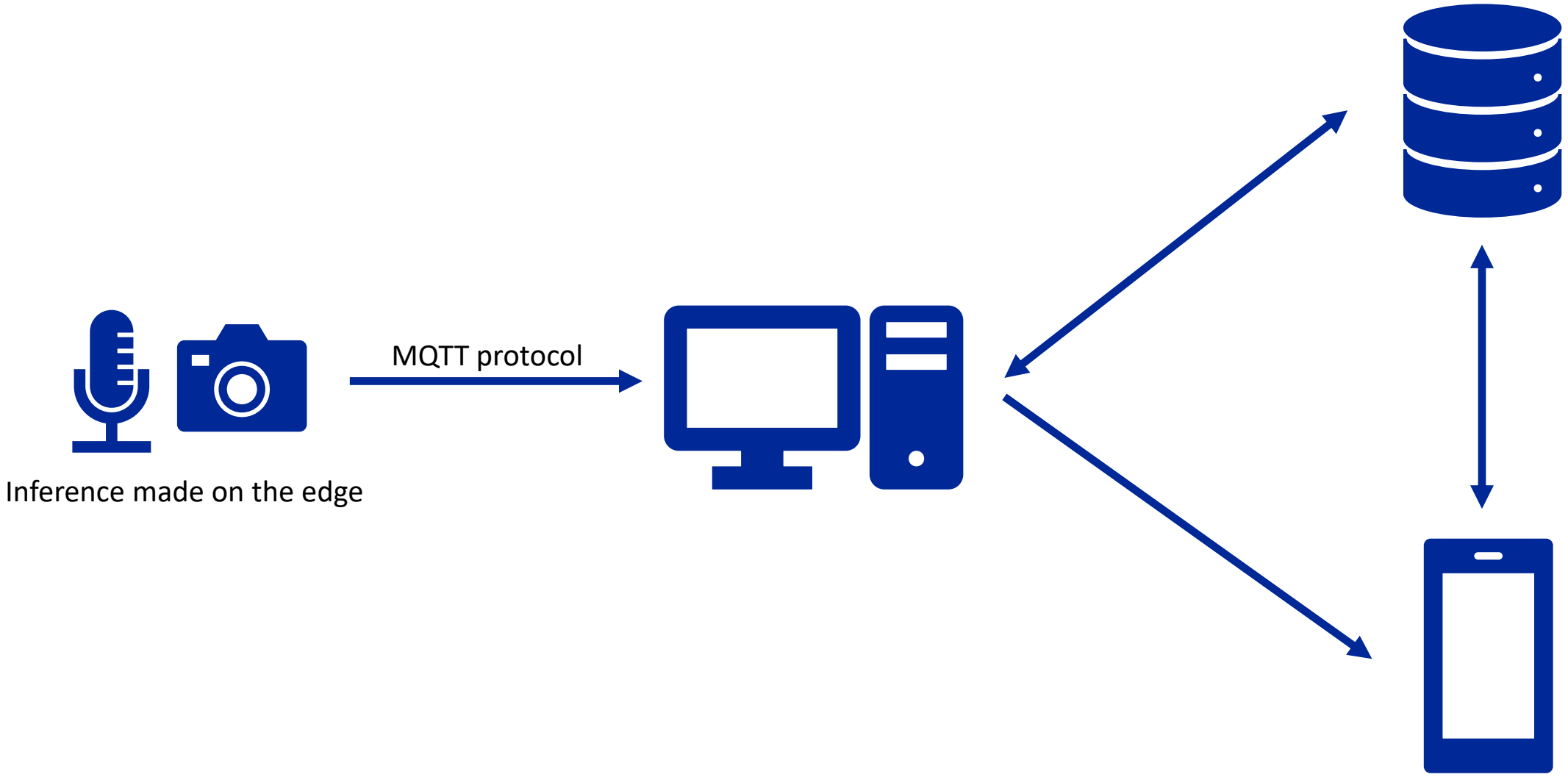


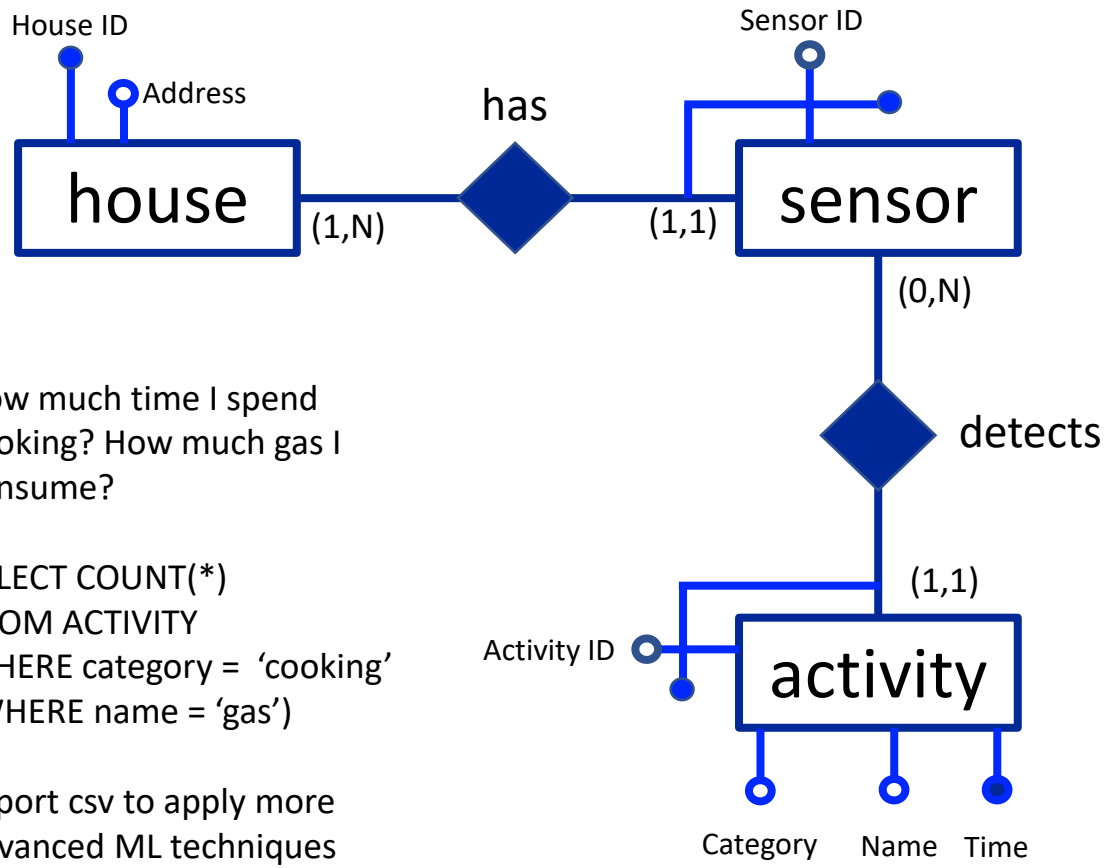
Image Classification



System interaction between sensors, servers and smartphone



To store data and perform analysis a DBMS is created

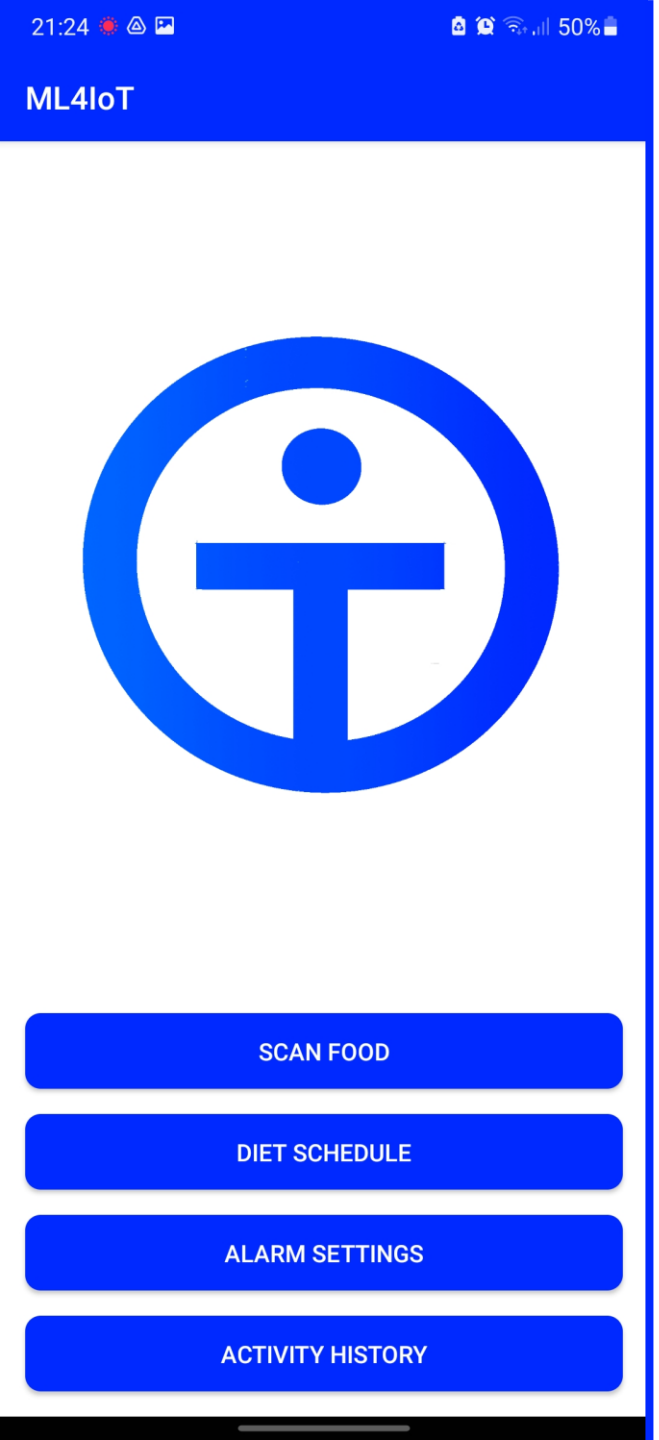


How much time I spend cooking? How much gas I consume?

SELECT COUNT(*)
FROM ACTIVITY
WHERE category = ‘cooking’
(WHERE name = ‘gas’)

Export csv to apply more advanced ML techniques

aid	name	category	time	sid	hid
2111	microwave_oven	cooking	1640877987	1	1
2112	microwave_oven	cooking	1640877990	1	1
2113	microwave_oven	cooking	1640877992	1	1
2114	microwave_oven	cooking	1640877996	1	1
2115	silence_kitchen	NULL	1640877998	1	1
2116	silence_kitchen	NULL	1640878001	1	1
2117	silence_kitchen	NULL	1640878004	1	1
2118	silence_kitchen	NULL	1640878006	1	1



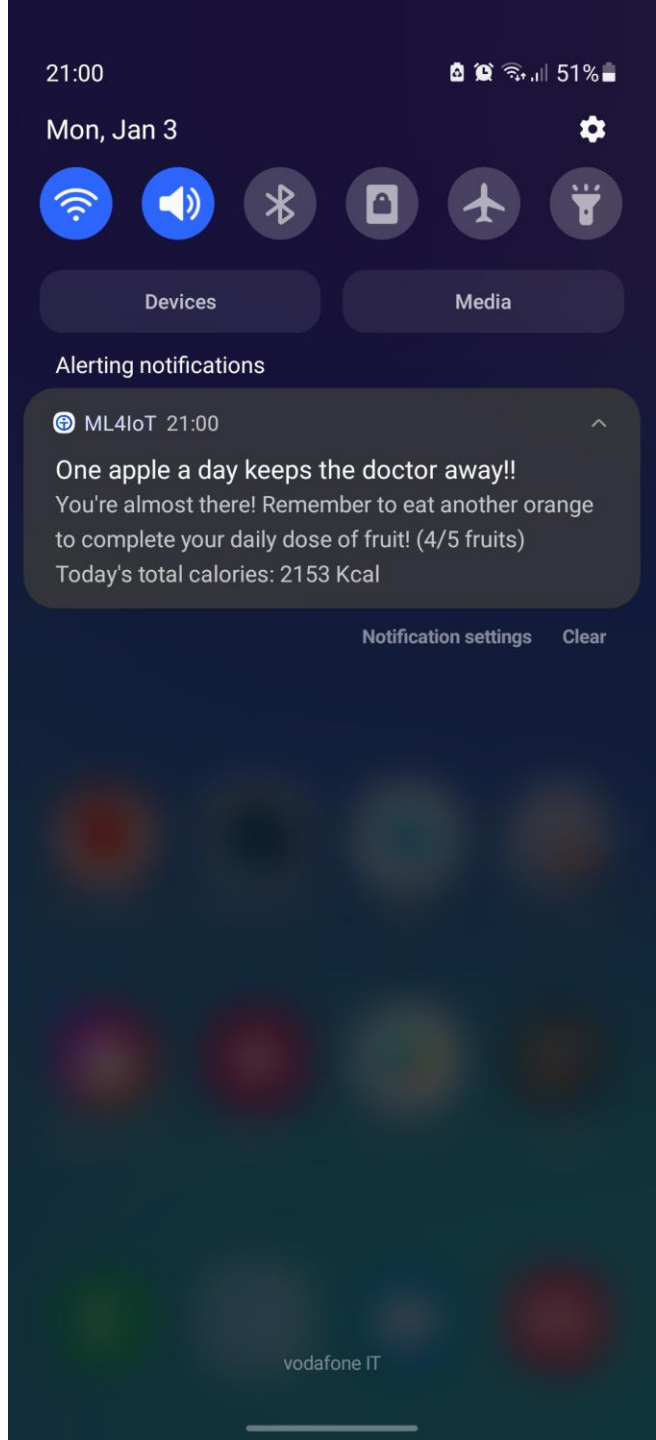
User experience is the core of our business

Mobile Application

The app makes the system user friendly. The customers can easily keep track of their activity

Notification System

The notification alerting feature makes the application quickly interact with the user in case of need



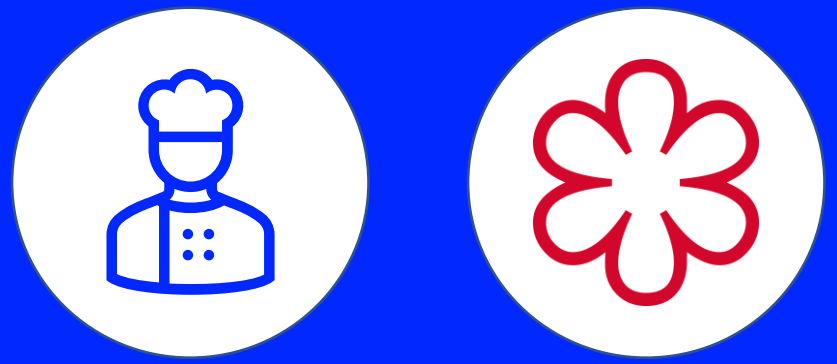
Most Important rules I retained from Business School

- Never think about short term profits but always medium-long perspective
- If you estimate a budget for a project and if you want to be almost certain to achieve the goal, then:

"Final Budget = 3 x Estimated Budget"

(misfortune is around the corner, ready to hit)

Translation: A safe economic and financial margin is obviously always better



Enhanced Cooking

Premises on development approach

- Agile and greedy strategy
- Local optimum is the way

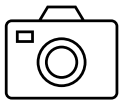
Following this technique allowed me to start the project, but I had to pay something back during the handling of some unexpected issues

Store the progresses every 2 days on the cloud and on an external hardisk

- ✓ Scripts for notebook and rpi
- ✓ Best DL models
- ✓ Mobile application code
- ✗ Databases (totally forgot)

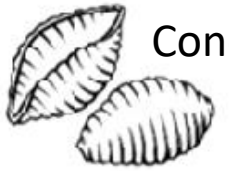
Process of enhanced pasta cooking

The microphone monitors the state of the water and as soon as the water is boiling a notification is sent to the user.

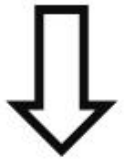


The camera sees the type of pasta and consequently how much time it should cook. After the correct cooking time is ended, a notification is sent to the user.

Penne 9 min.



Conchiglie 8 min.



silence

gas

boiling water

boiling water

READY TO EAT! *

* = a notification is sent to the user

HOMEMADE DATASETS

- 250 1-second records of boiling water (fridge engine on)
- 250 1-second records of boiling water (fridge engine off)

- 250 1-second records of gas (fridge engine on)
- 250 1-second records of gas (fridge engine off)

- 250 1-second records of silence (fridge engine on)
- 250 1-second records of silence (fridge engine off)

Total samples = 1500 sounds.

The samples differ in terms of background noise like traffic noise, move chairs, open/close doors etc..

- 250 samples of rice

- 250 samples of farfalle

- 250 samples of background

Total samples = 750 images.

The samples differ in terms of lighting conditions, shape position, dish position, dish distance from camera etc..

Example of the first part of the semi-automated process

edoardo@edoardo-Lenovo-G505: ~/final_project

```
(py38) edoardo@edoardo-Lenovo-G505:~/final_project$ python project_cli
ent.py
2022-01-19 12:21:20.059304: W tensorflow/stream_executor/platform/defa
ult/dso_loader.cc:59] Could not load dynamic library 'libcudart.so.10.
1'; dlerror: libcudart.so.10.1: cannot open shared object file: No suc
h file or directory
2022-01-19 12:21:20.059793: I tensorflow/stream_executor/cuda/cudart_s
tub.cc:29] Ignore above cudart dlerror if you do not have a GPU set up
 on your machine.
19-01-22 11:21:31 silence [0.195 0.019 0.786]
```

VIDEO DEMONSTRATION

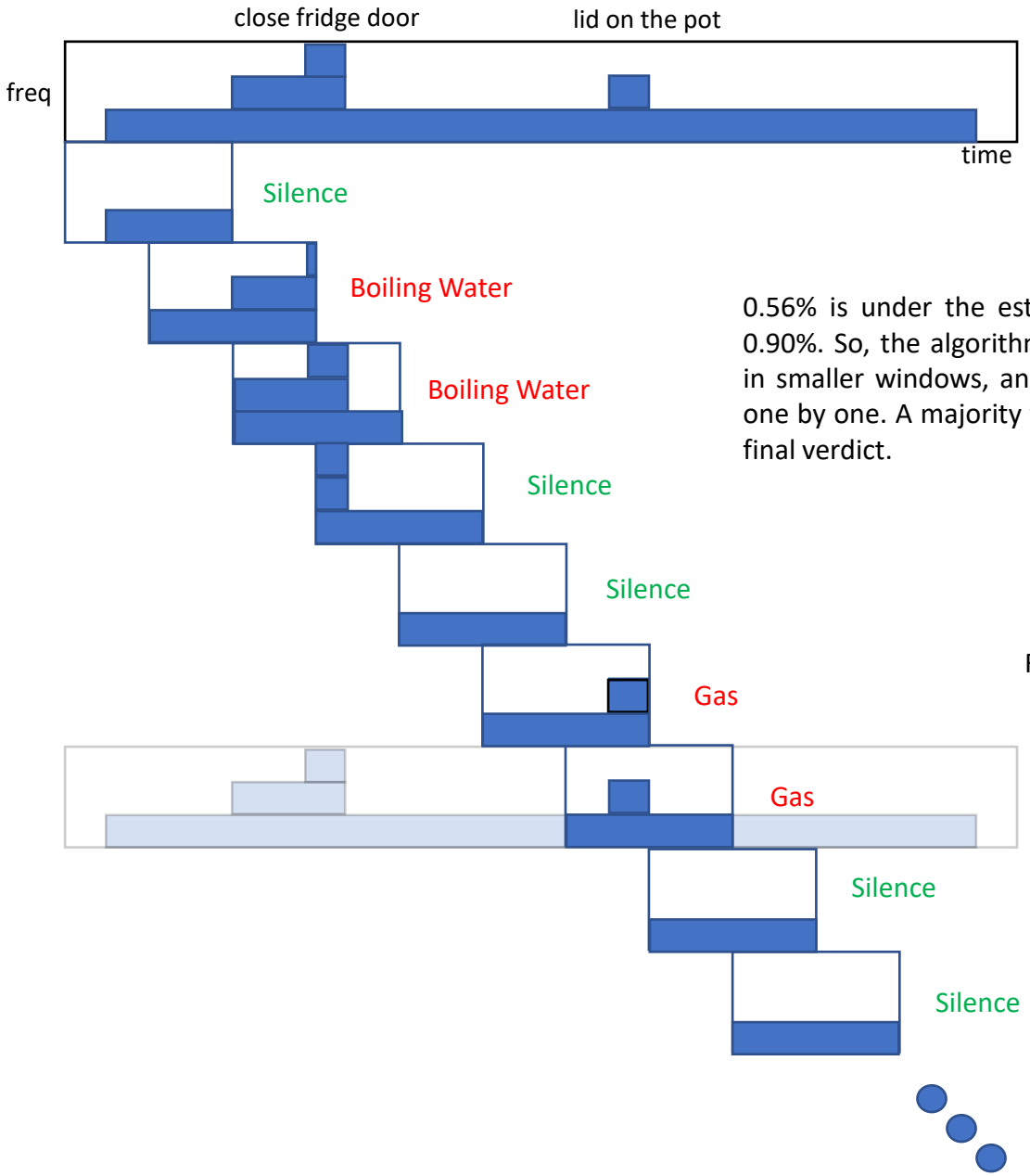
The P-Technique

Some issues could arise when the microphone detects noises that are “anomalous” like:

- Open and close drawer
- Put the pot on the stoven
- Put the lid on the pot
- Move a chair

These noises could make the algorithm not sure about its prediction.

So, when the algorithm is not sure, the prediction is found splitting the signal in multiple and overlapped smaller windows.



On the complete signal the model (pretty confused) predicts Boiling Water 0.56% instead of Silence/Background

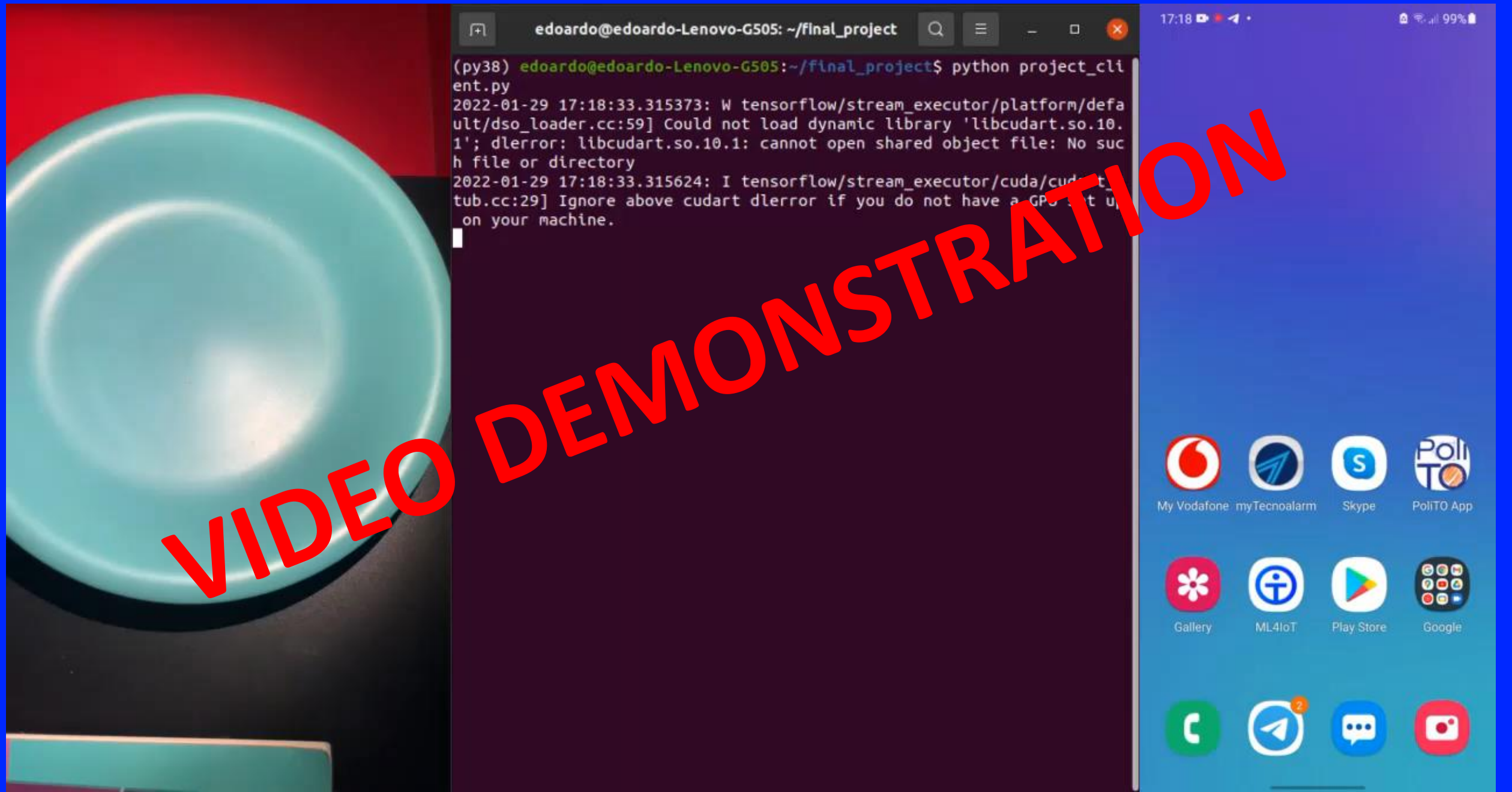
0.56% is under the established threshold of 0.90%. So, the algorithm will split the signals in smaller windows, and it will analyze them one by one. A majority vote will return us the final verdict.

Boiling Water = 2
Gas = 2
Silence = 7

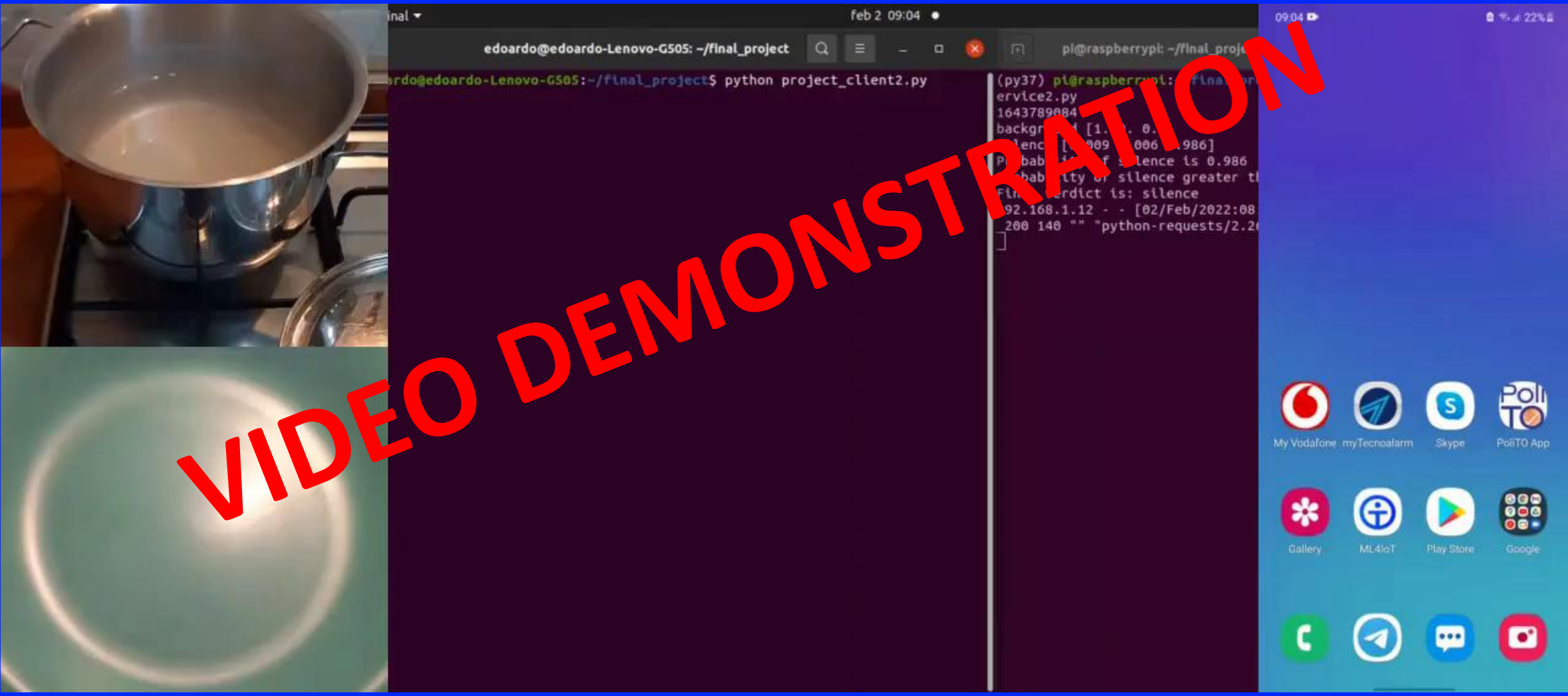
Final Verdict = SILENCE

New technique to isolate «anomalous» noise

Example Food Shape



Demonstration of the overall process



pi@raspberrypi: ~/final_project

```
(py37) pi@raspberrypi:~/final_project $ python test_model.py
27-01-22 10:13:35
silence [0.001 0.004 0.002 0.993]
Probability of silence is 0.993
Probability of silence grater than threshold 0.9
Final verdict is: silence
27-01-22 10:13:38
```

VIDEO DEMONSTRATION

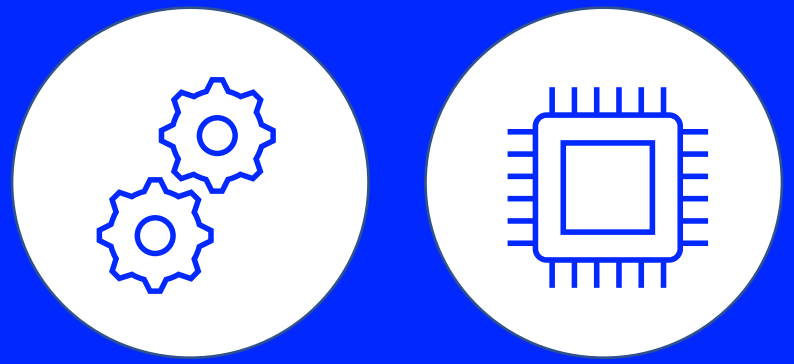
Example of Future Timer Trigger

Notes on future trigger

- Difficulties in creating the dataset (≈ 2 hours for 75 samples + farfalle devastated, maybe try with other materials that make similar sounds)
- Could vanish the potential of the P-Technique. Threshold extremely important.

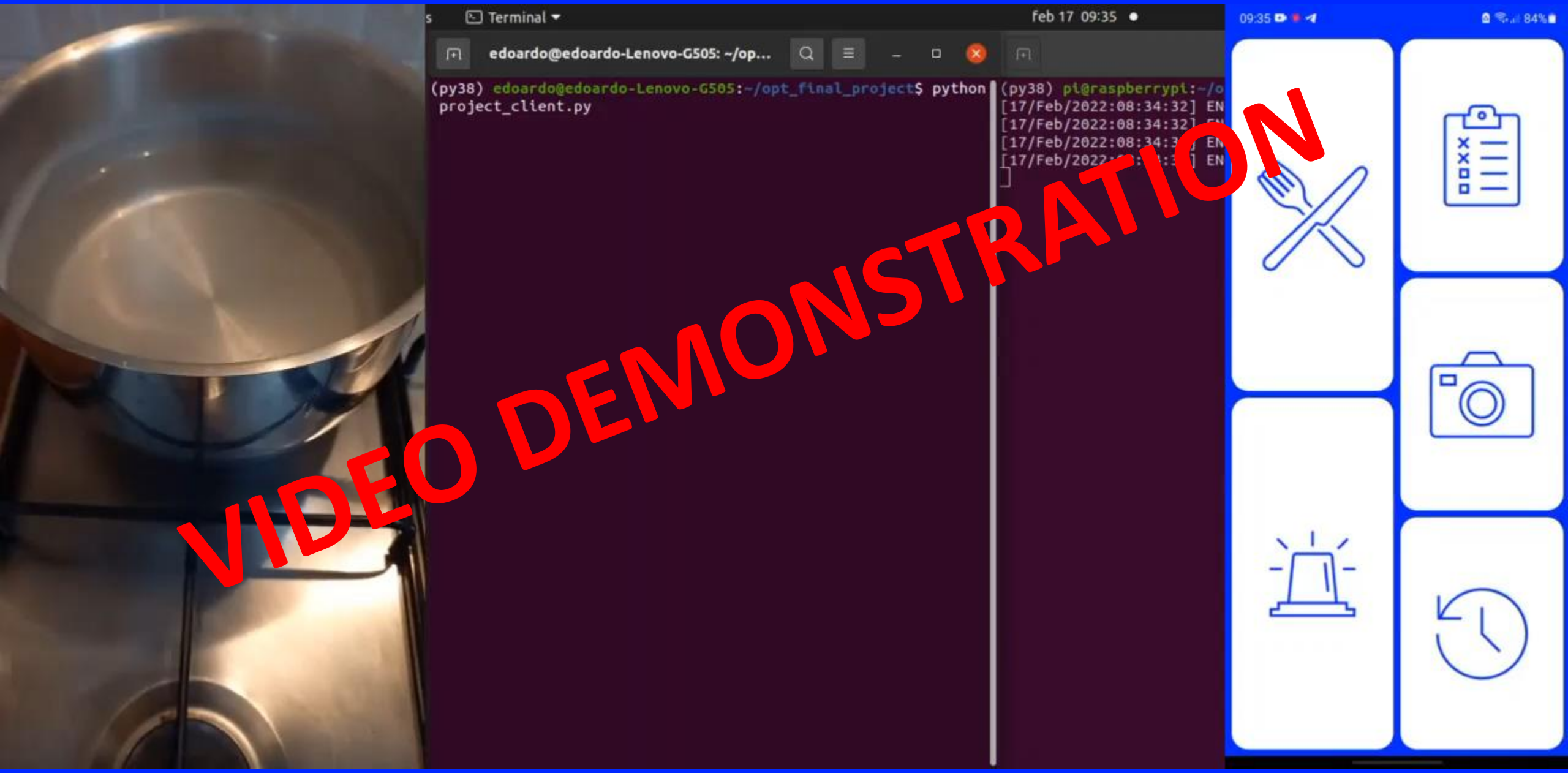
(Tested on cold water)

Not necessary for full automated process (but a plus and a safe parachute)

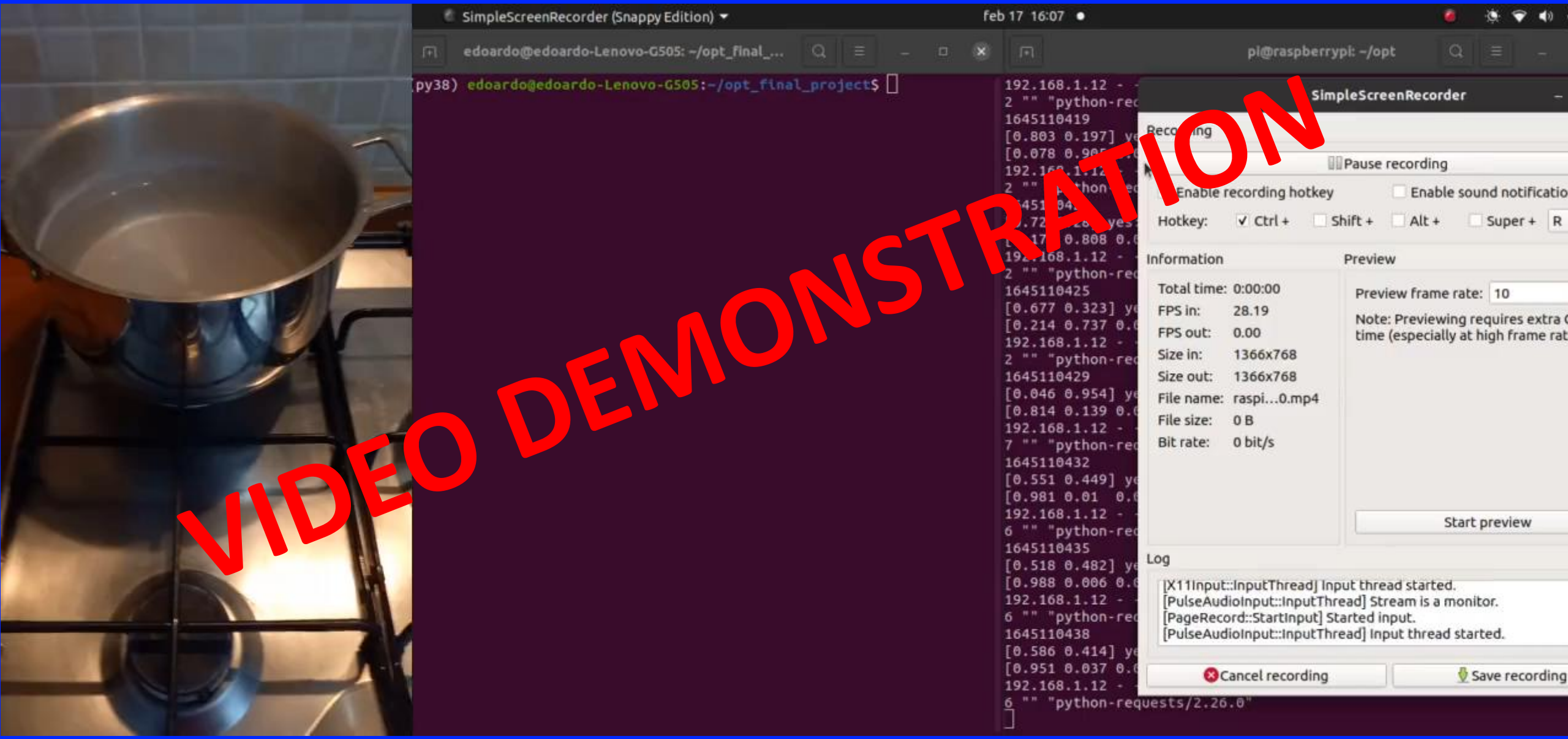


Models Architectures Optimization in terms of Memory Requirements

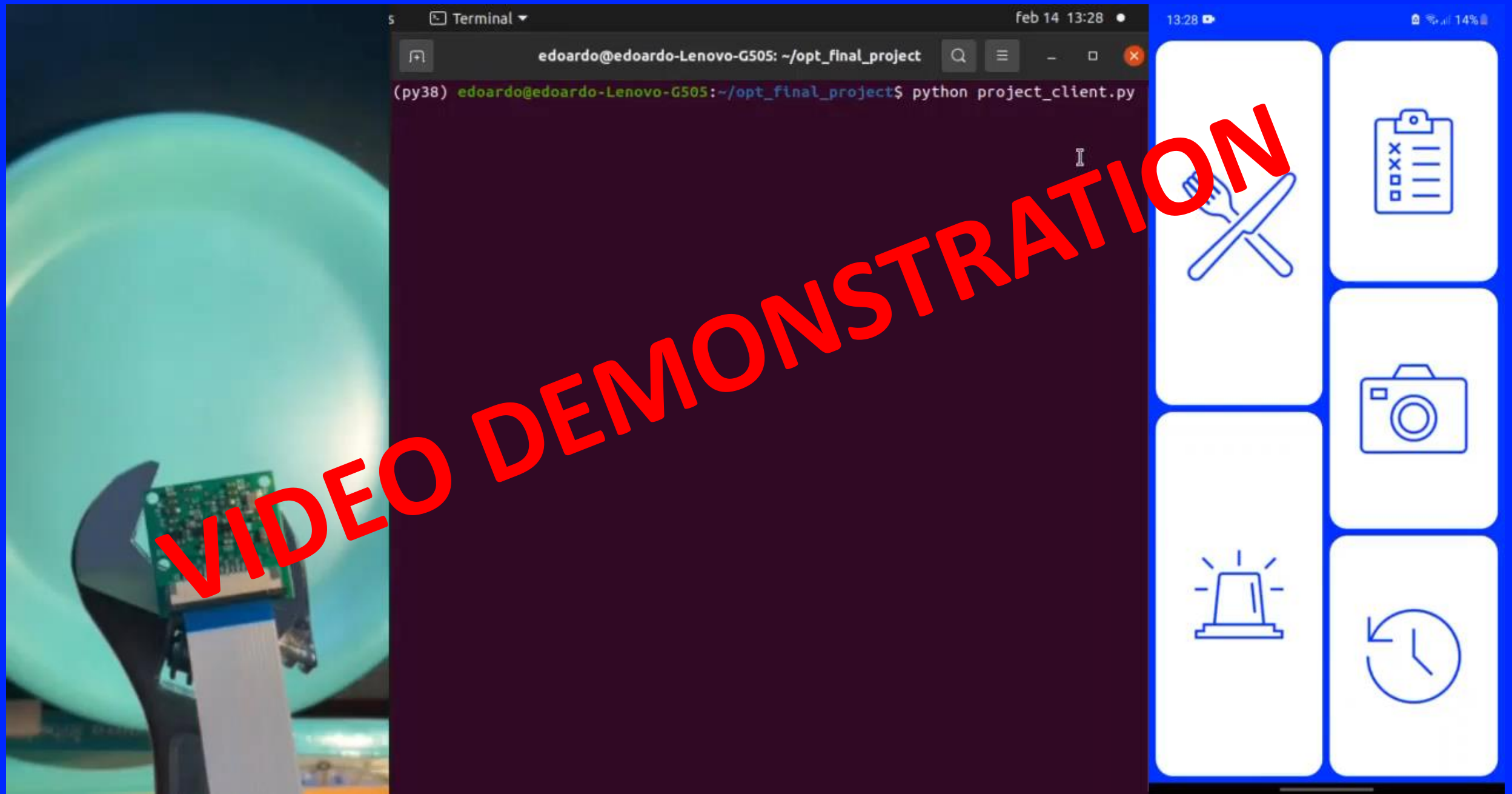
Maximum size reduction on kitchen-state dedicated architecture



Maximum size reduction on pouring dedicated architecture



Maximum size reduction on food classification architecture



Food classifier

3 classes

empty, penne, rice

16932 B ≈ 17 KB

Conv2D(), BatchNormalization(), ReLU() x 10

GlobalAveragePooling2D(),

Dense()

*Different downsamples of the feature maps

Kitchen state classifier

3 classes

silence, gas, boiling

15004 B ≈ 15 KB

Conv2D(), BatchNormalization(), ReLU(),

DepthwiseConv2D(), Conv2D(), BatchNormalization(), ReLU() x 3

GlobalAveragePooling2D(),

Dense()

Pouring pasta recognizer

2 classes

pouring, no pouring

43084 B ≈ 43 KB

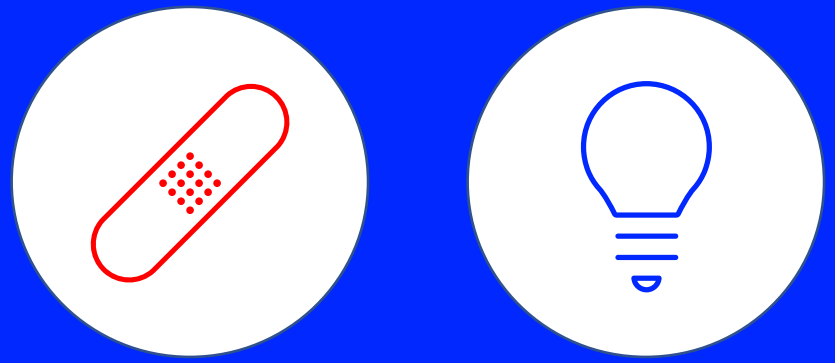
Conv2D(), BatchNormalization(), ReLU(),

DepthwiseConv2D(), Conv2D(), BatchNormalization(), ReLU() x 3

GlobalAveragePooling2D(),

Dense()

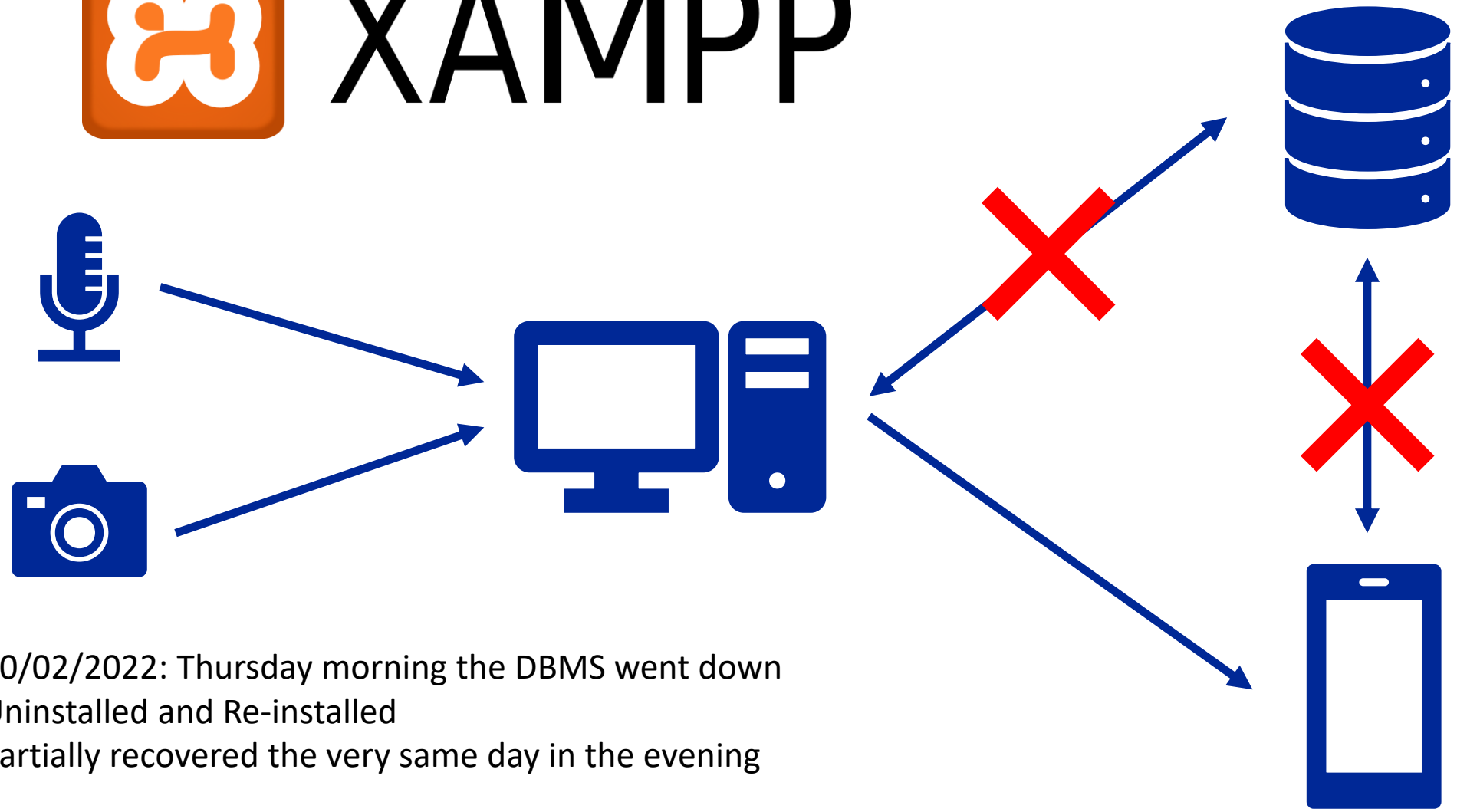
*Adapted Output



From problems to opportunities

1st problem

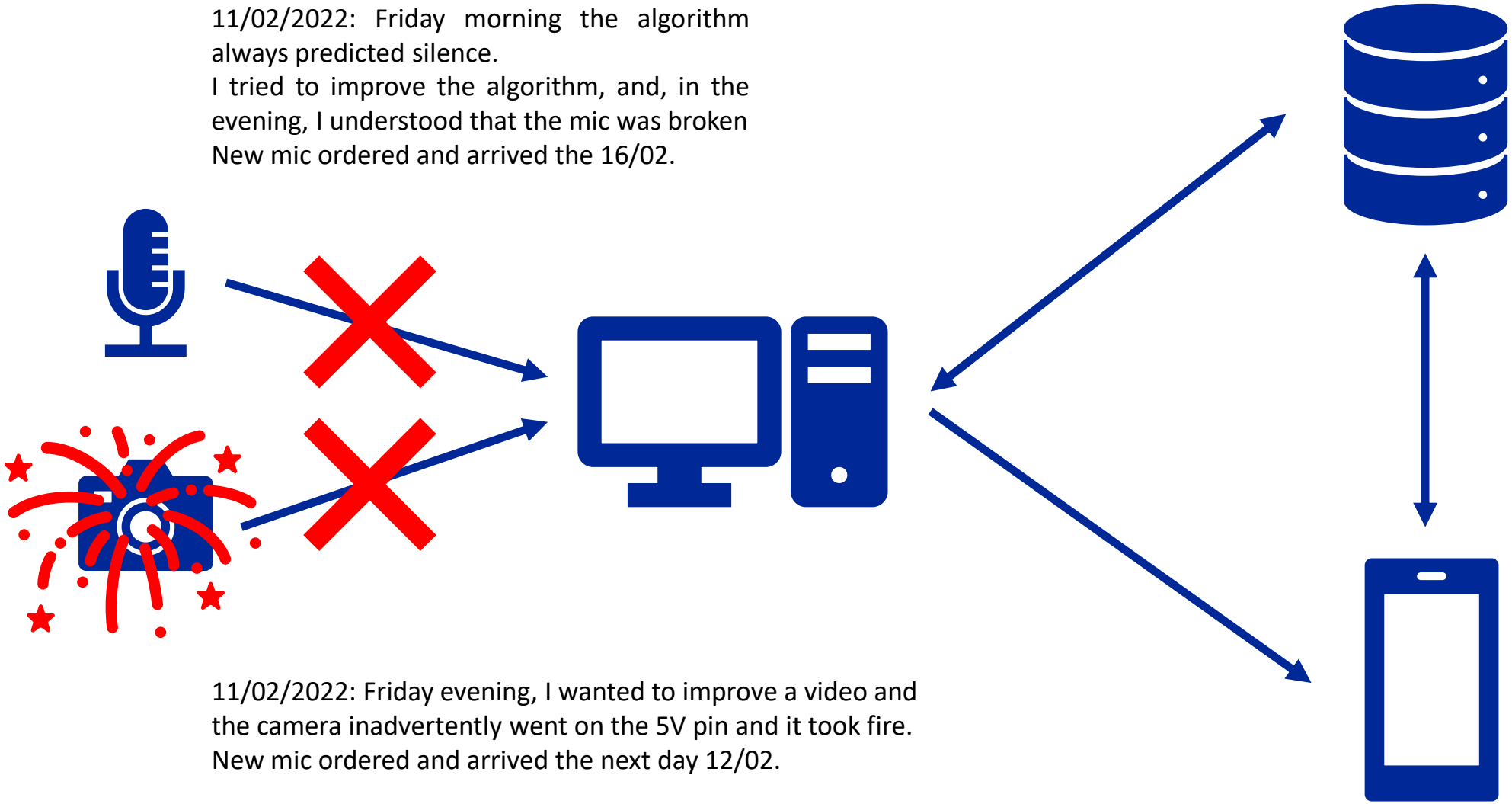
XAMPP



10/02/2022: Thursday morning the DBMS went down
Uninstalled and Re-installed
Partially recovered the very same day in the evening

2nd and 3rd problem

11/02/2022: Friday morning the algorithm always predicted silence.
I tried to improve the algorithm, and, in the evening, I understood that the mic was broken
New mic ordered and arrived the 16/02.



11/02/2022: Friday evening, I wanted to improve a video and the camera inadvertently went on the 5V pin and it took fire.
New mic ordered and arrived the next day 12/02.

18:13 65%

Cerca su Amazon.it

KEYESTUDIO Raspberry Pi...

Condividi questo articolo

Compralo di nuovo

Consegnato 12 febbraio

Il pacco è stato consegnato presso il domicilio selezionato

Traccia il mio pacco

18:13 65%

Cerca su Amazon.it

GeekerChip USB Microfono,Mini...

Condividi questo articolo

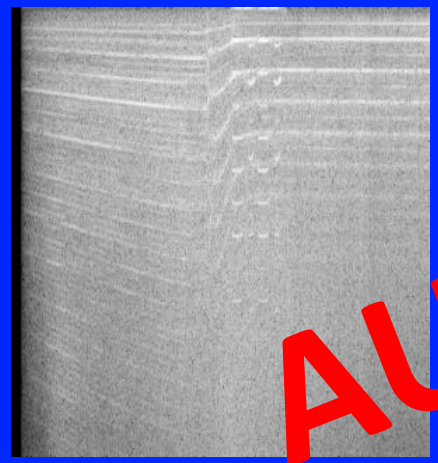
Compralo di nuovo

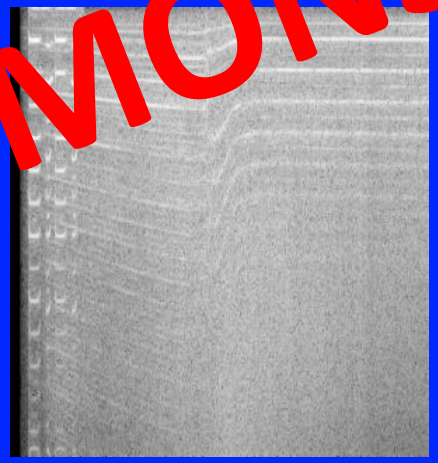
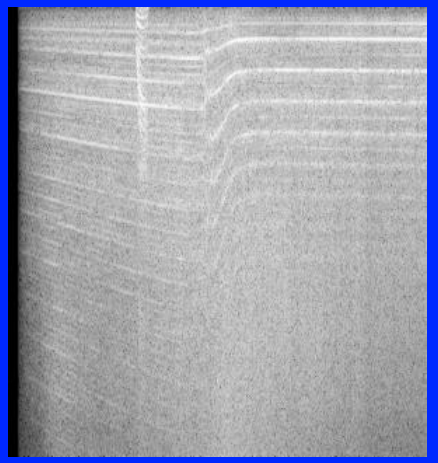
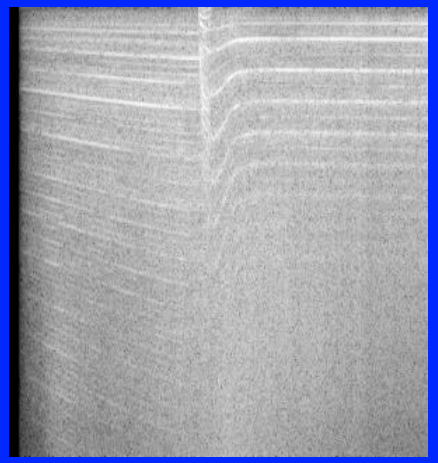
Consegnato 16 febbraio

Waiting for the orders means “Massive” Data Augmentation for pouring pasta recognition

Some experiments that I made to improve my data augmentation skills

AUDIO DEMONSTRATION



New pouring pasta augmented data

pouring pasta in cold water
(silence in the background)

+

audio of boiling water

=

pouring pasta in boiling water

Homemade image-dataset version 2

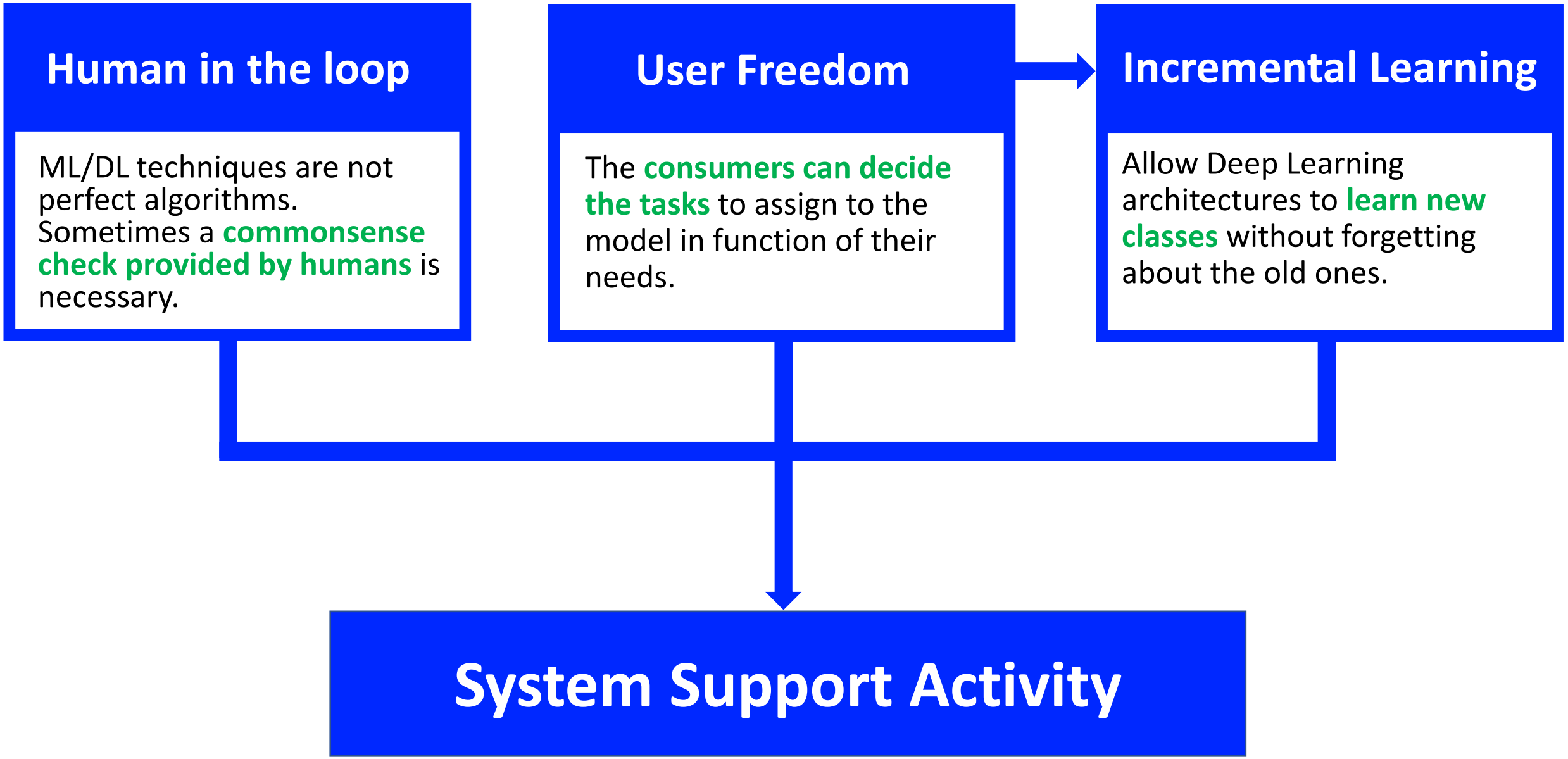
14 different plates
25 image each x 3 classes (empty, farfalle and rice).
Total of 1050 images

Difference in shapes:

- Rectangular
- Circular big
- Circular small

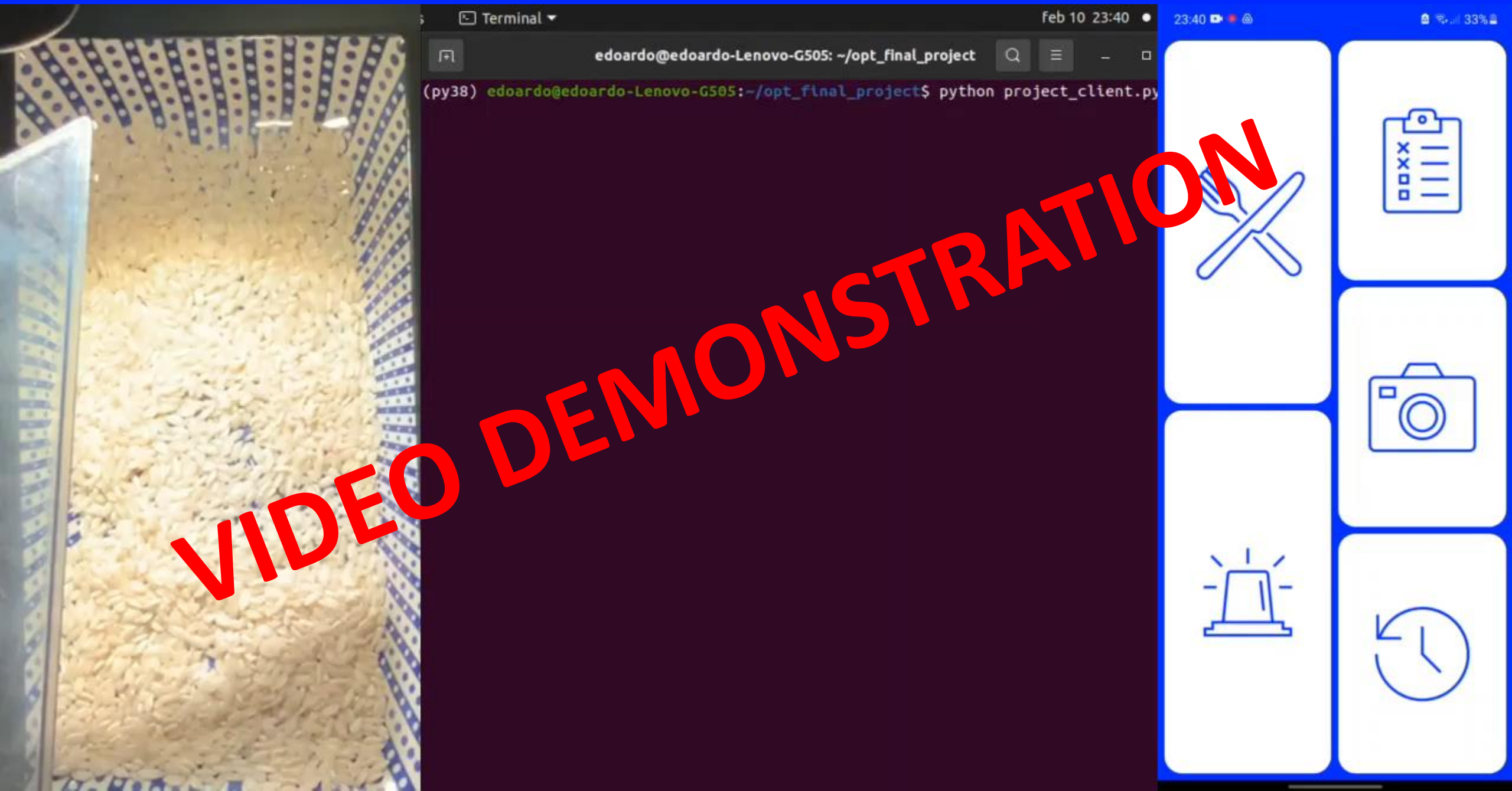
Difference in colors:

- Blue
- Green
- Pink
- Red
- Gray
- Fantasy blue 1
- Fantasy blue 2
- Fantasy blue 3
- Christmas theme


Human in the loop
ML/DL techniques are not perfect algorithms. Sometimes a commonsense check provided by humans is necessary.
User Freedom
The consumers can decide the tasks to assign to the model in function of their needs.
Incremental Learning
Allow Deep Learning architectures to learn new classes without forgetting about the old ones.
System Support Activity

Experiment with medium size reduction of the architecture

Model: 48364 B ≈ 48 KB



The “Brunello di Montalcino’s” history

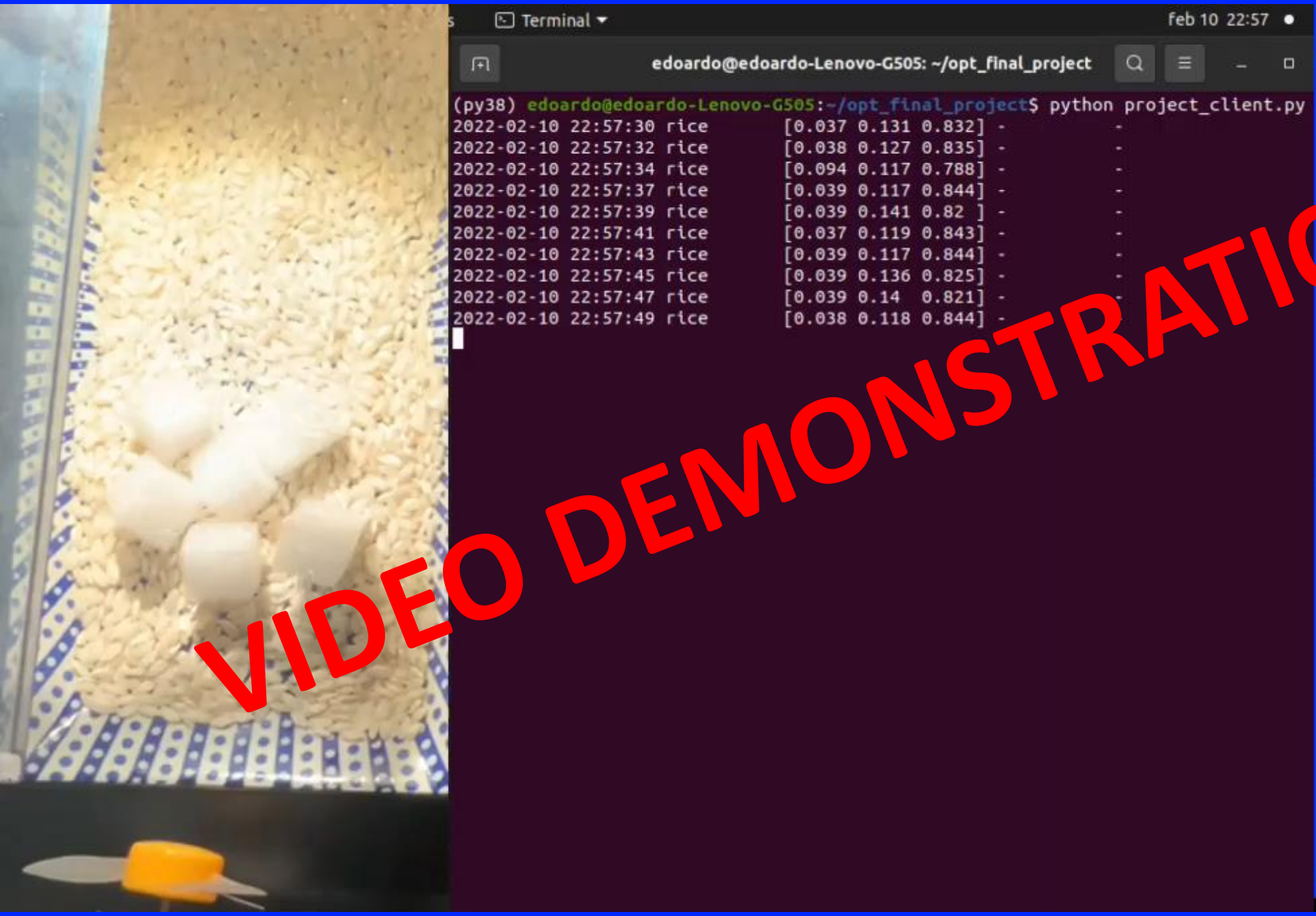
To protect the precious vineyard from animals like birds, in the famous Tuscany region, the farmers emit a **noisy sound at regular intervals** in order to frighten the animals.

1) It is annoying for the tourists.
2) No causal-effect relationship between birds' action and noisy sound. The fear of the animal could fade away.

A better solution would be to **emit the sound only if an anomaly is detected**.

And this is how the auto-cleaner was born.

Model: 48364 B ≈ 48 KB

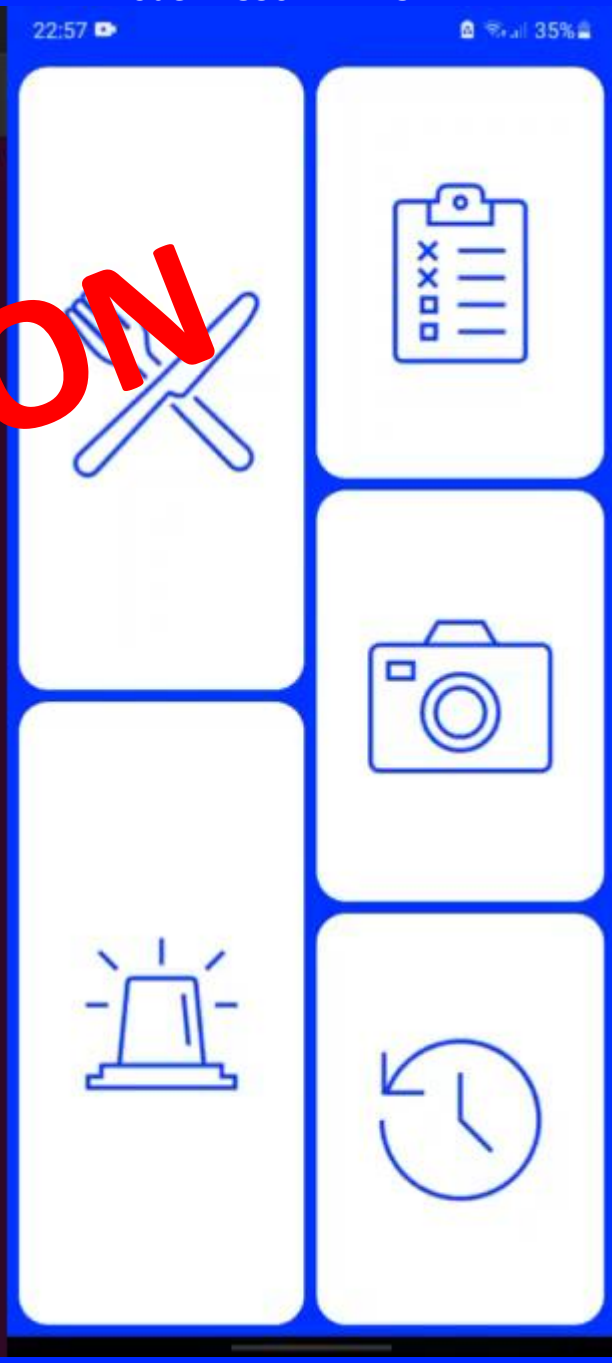


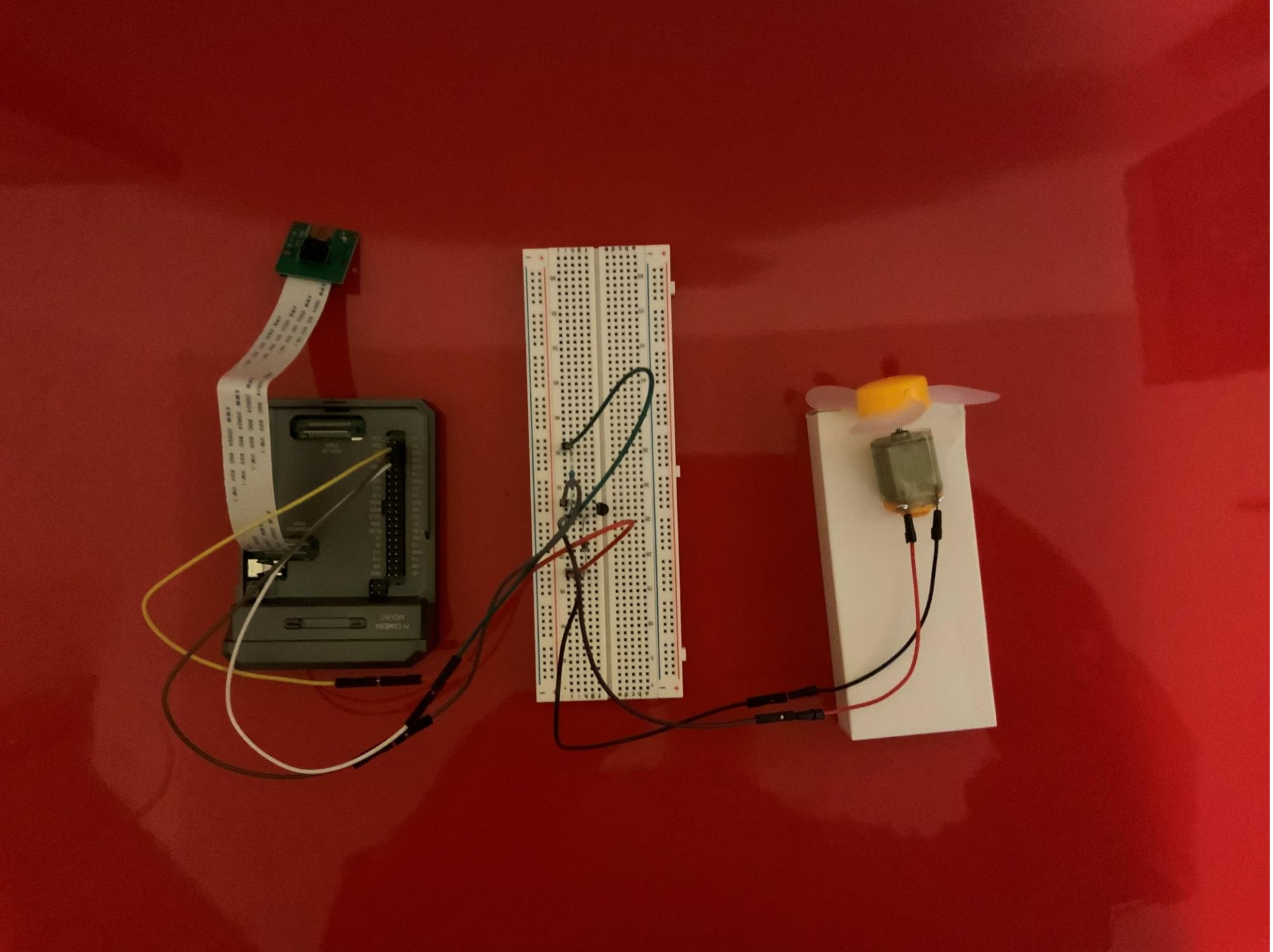
Terminal Feb 10 22:57

edoardo@edoardo-Lenovo-G505: ~/opt_final_project

```
(py38) edoardo@edoardo-Lenovo-G505:~/opt_final_project$ python project_client.py
2022-02-10 22:57:30 rice        [0.037 0.131 0.832] -           -
2022-02-10 22:57:32 rice        [0.038 0.127 0.835] -           -
2022-02-10 22:57:34 rice        [0.094 0.117 0.788] -           -
2022-02-10 22:57:37 rice        [0.039 0.117 0.844] -           -
2022-02-10 22:57:39 rice        [0.039 0.141 0.82 ] -           -
2022-02-10 22:57:41 rice        [0.037 0.119 0.843] -           -
2022-02-10 22:57:43 rice        [0.039 0.117 0.844] -           -
2022-02-10 22:57:45 rice        [0.039 0.136 0.825] -           -
2022-02-10 22:57:47 rice        [0.039 0.14  0.821] -           -
2022-02-10 22:57:49 rice        [0.038 0.118 0.844] -           -
```

VIDEO DEMONSTRATION





Code for Fan Blade

```
import time
import RPi.GPIO as GPIO

GPIO.setmode(GPIO.BCM)
GPIO.setup(14, GPIO.OUT)
pwmOut = GPIO.PWM(14, 200)
pwmOut.start(0)

dutyCycle = 0
cnt = 0
while cnt<20:
  time.sleep(0.2)
  dutyCycle = dutyCycle + 1
  if(dutyCycle > 100):
     dutyCycle = 0
  pwmOut.ChangeDutyCycle(100 - dutyCycle)
  cnt += 1
```

The auto-cleaner is activated only if the prediction over the image is uncertain.

Train the model on harder tasks then deploy it on easier ones

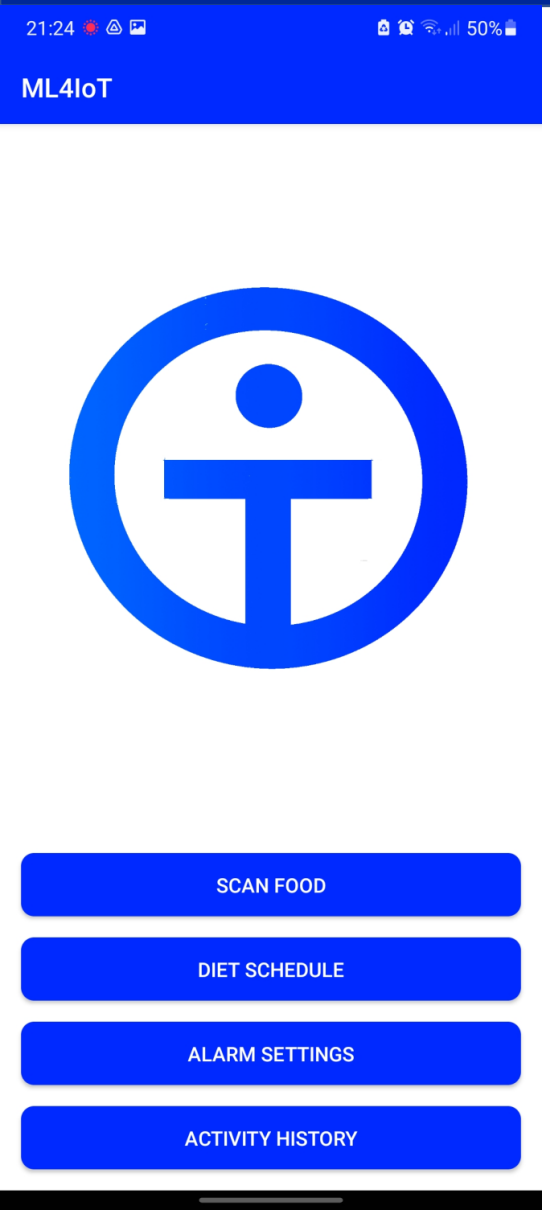
Train pouring pasta model to discriminate between: pouring_silence, pouring_gas, pouring_boiling. Then, during inference, ask to discriminate only on dropping non-dropping

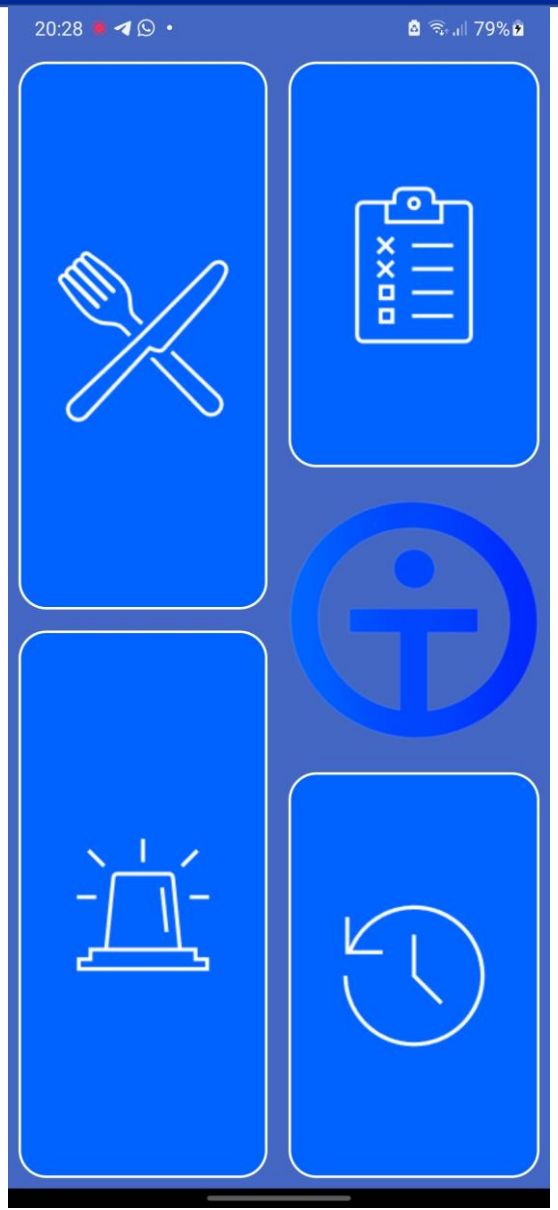
Attempt to derive new sound categories from native classes

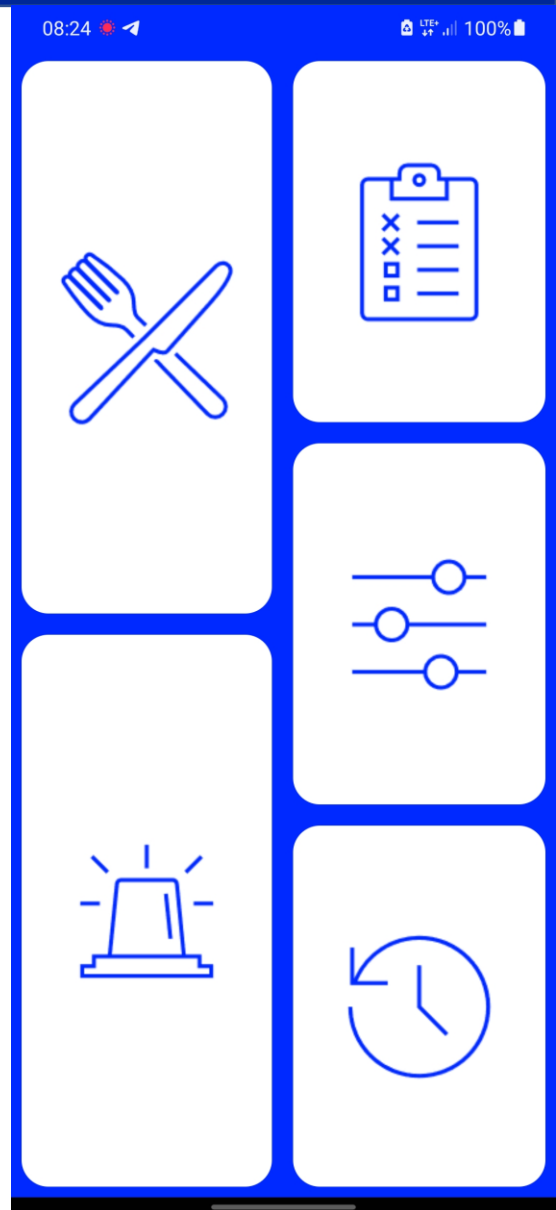
	boiling	gas	silence	
After P-Technique:	[0.231	0.567	0.202]	→ model still confused P(gas) > P(boiling) label = START GAS

	boiling	gas	silence	
After P-Technique:	[0.567	0.231	0.202]	→ model still confused P(boiling) > P(gas) label = TRANSITION PHASE

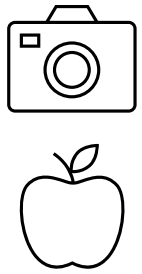
Restyle of HomeActivity



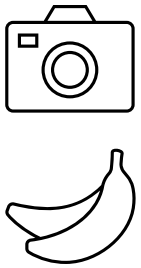




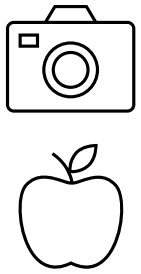
Example of food schedule and alerting



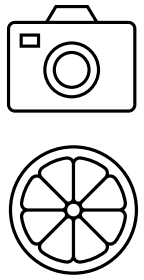
Apple, 08:30



Banana, 10:30



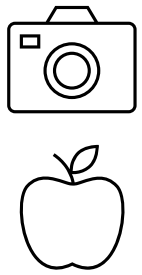
Apple, 13:30



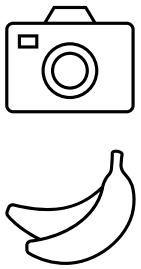
Orange, 17:30

H 21:00 and 4/5 fruits.

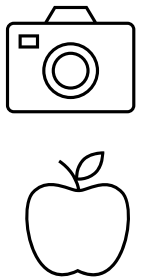
Notification:
You are almost there! Eat just another orange to reach the optimal daily dose of fruit.



Apple, 09:05



Banana, 09:10



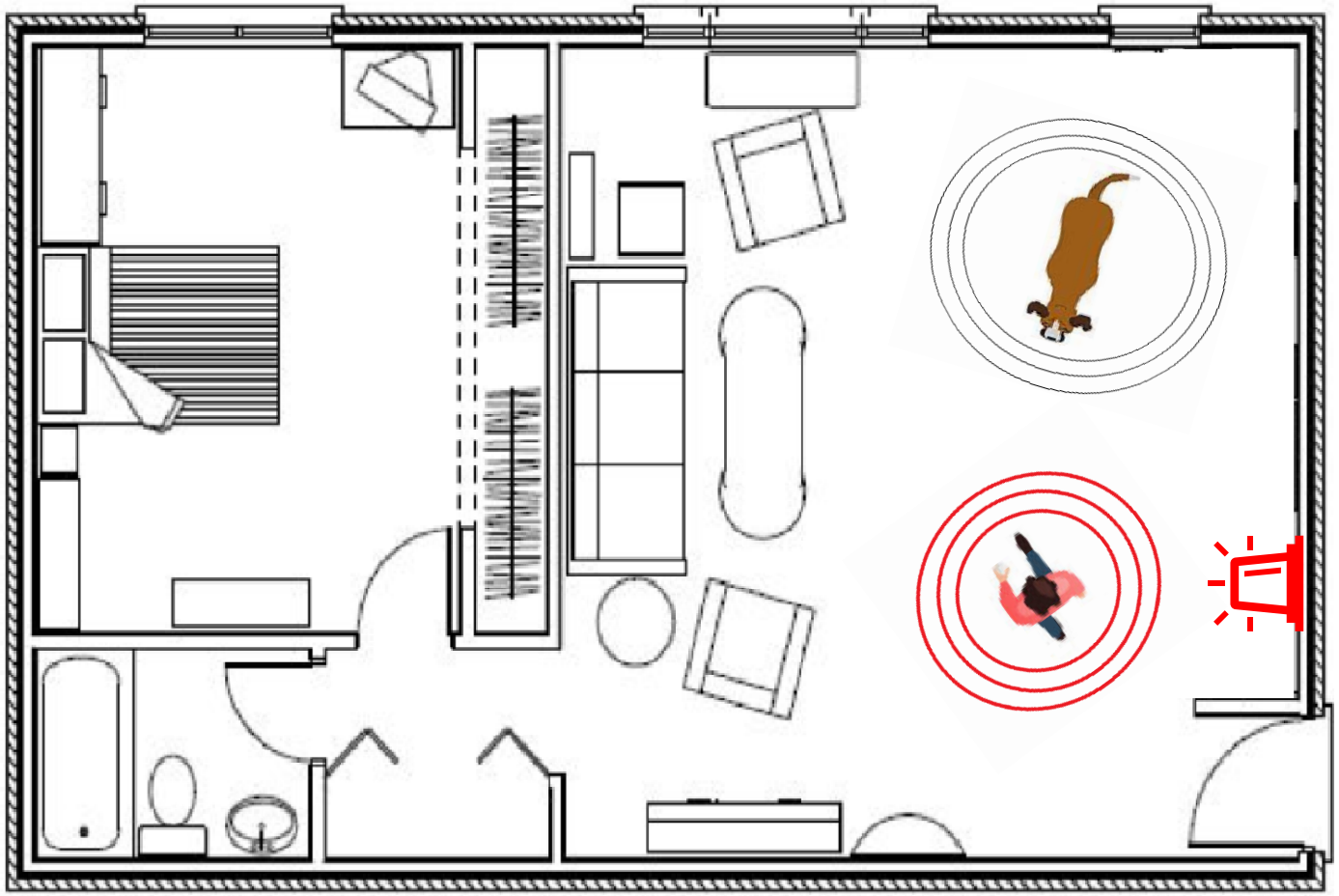
Apple, 09:15

Apple, 09:20

H 09:15:01.

Notification Warning.
Do not eat other fruits, your level of glucose could exceed the safe threshold.
Or: need another dose of insulin.

Example of future application on Safety and Alarms



During a working day, you can turn on the alarm and the microphone will detect the sounds of the dogs as normal.

Instead, the walking noise of a thief/intruder and sounds like closing and opening doors will be identified as anomalies and the system will immediately send a notification to the user or directly to the competent authority.

Thank you for your attention