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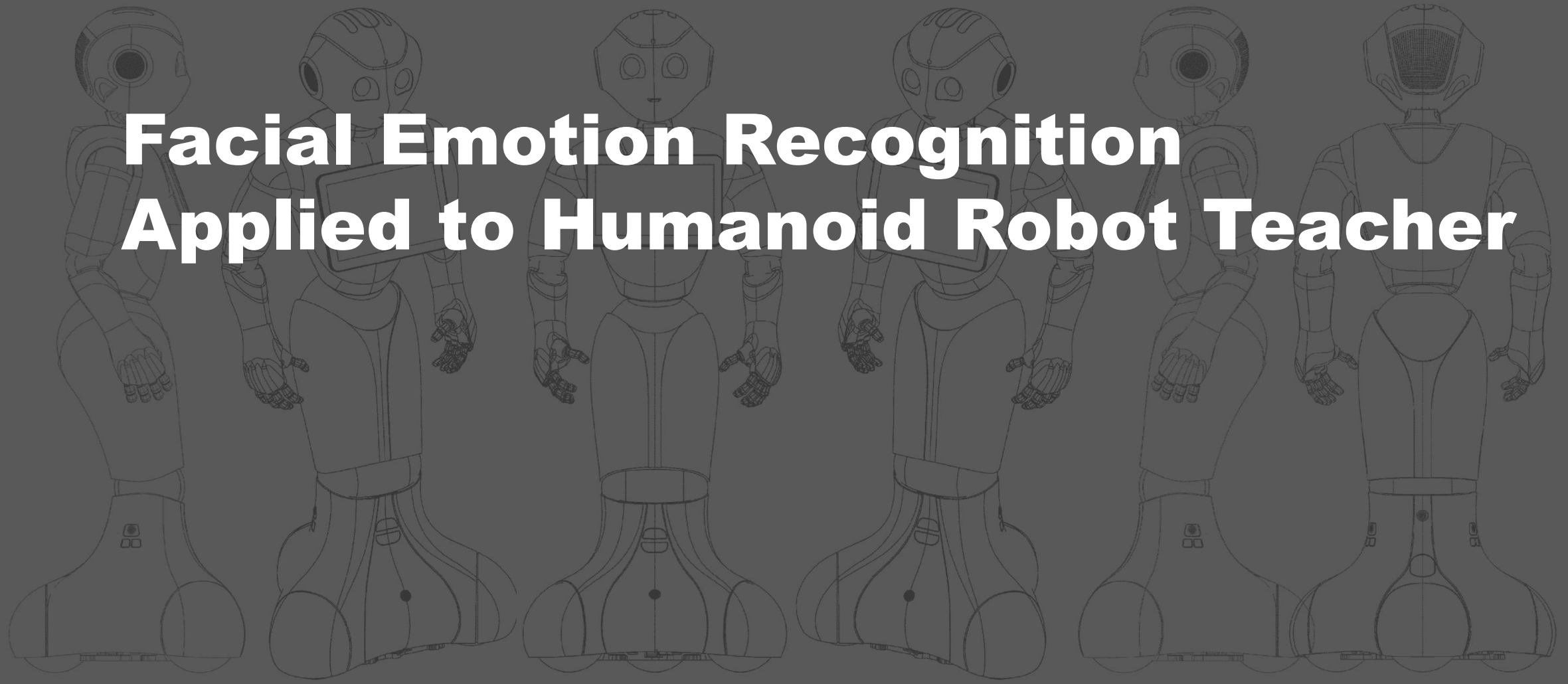


Facial Emotion Recognition Applied to Humanoid Robot Teacher

PROBLEM STATEMENT

Nowadays, more and more robots are introduced to the classroom.

(Softbank, 2019)

Students' engagement and concentration are not being observed.

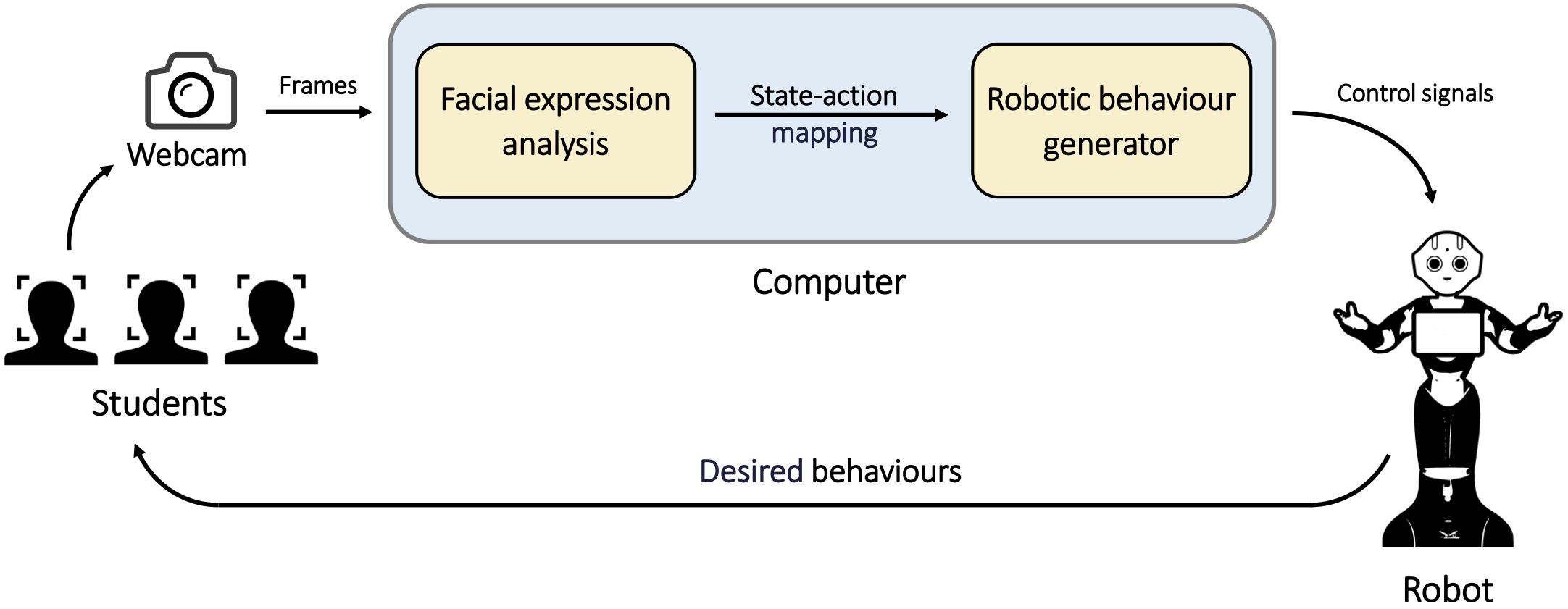
↓

Effective learning may not be guaranteed.

↓

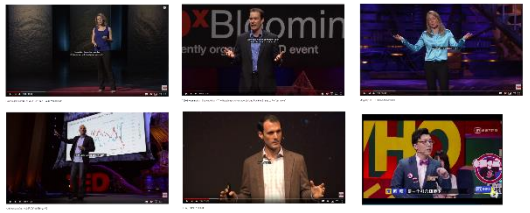
An emotional and sociable humanoid robot is needed.

SYSTEM ARCHITECTURE



DATA COLLECTION

Image dataset	CK+ dataset	Posed behaviour
		

Video dataset		Real class	Simulated scene
	students		
	lecturer		

EXPRESSION ANALYSIS

Face API – Cloud computing service provided by Microsoft

- Face detection: return 1 Face ID + 8 emotion intensities + 27 feature points

Image Input:

(Lucey, P., 2010)

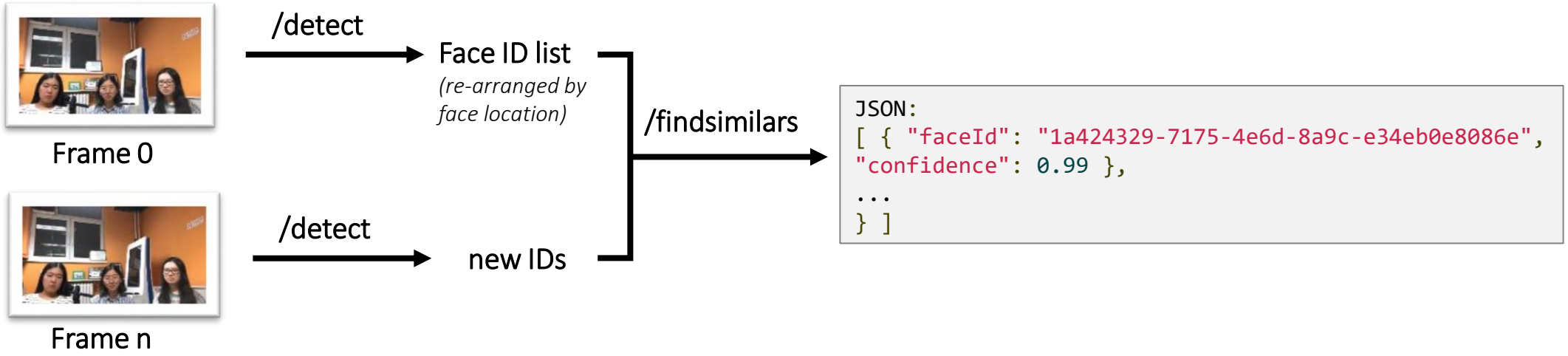
Detection result:


```
JSON:
[ { "faceId": "1a424329-7175-4e6d-8a9c-e34eb0e8086e",
"faceRectangle": { "top": 146, "left": 266, "width": 259, "height": 259 },
"faceAttributes": {
"emotion": { "anger": 0.0, "contempt": 0.0, "disgust": 0.0, "fear": 0.0,
"happiness": 0.975, "neutral": 0.025, "sadness": 0.0, "surprise": 0.0 },
"faceLandmarks": { "pupilLeft": { "x": 334.5, "y": 222.9 }, "pupilRight":
{ "x": 452.5, "y": 218.7 }, "eyeLeftOuter": { "x": 318.2, "y": 234.2 },
"eyeLeftInner": { "x": 353.6, "y": 225.9 }, "eyeRightInner": { "x": 433.9,
"y": 223.1 }, "eyeRightOuter": { "x": 472.5, "y": 220.6 },
...
} ]
```

EXPRESSION ANALYSIS

Group emotion recognition—tracking each face

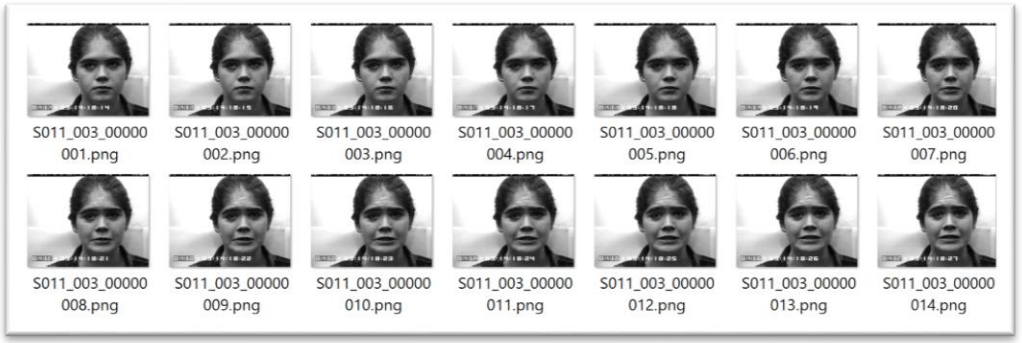
- Face verification: return a candidate Face ID



EXPERIMENT I

On CK+ dataset: 593 sequences across 123 subjects. All sequences are from the neutral face to the peak expression.

"disgust"



"fear"

The results has shown the drawbacks of current system:

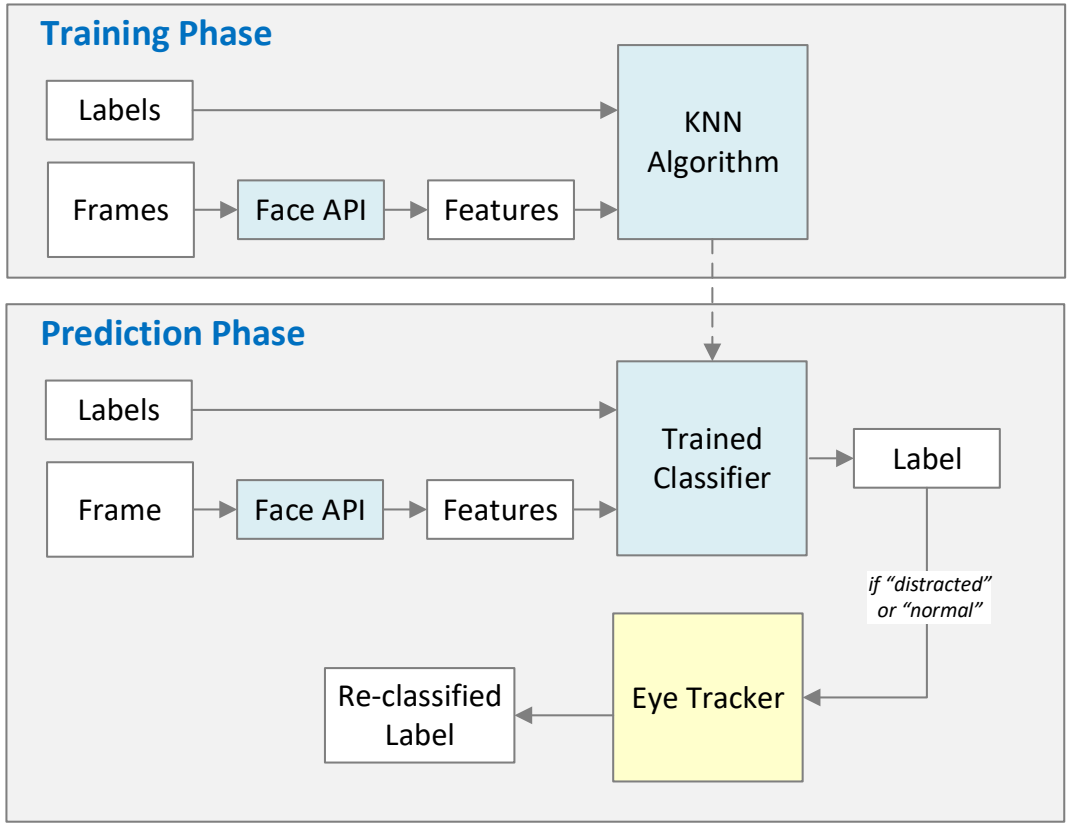
	anger	contempt	disgust	fear	happiness	neutral	sadness	surprise
1	0.004	0.003	**0**	0	0	**0.962**	0.03	0
2	0.006	0.005	**0**	0	0	**0.965**	0.024	0
3	0.014	0.011	**0.001**	0	0	**0.955**	0.018	0
4	0.037	0.01	**0.002**	0	0	**0.947**	0.004	0
5	0.345	0.004	**0.512**	0	0	**0.139**	0.001	0
6	0.28	0.001	**0.716**	0	0	**0.004**	0	0
7	0.271	0	**0.728**	0	0	**0**	0	0
8	0.107	0	**0.893**	0	0	**0**	0	0
9	0.129	0	**0.87**	0	0	**0.001**	0	0
10	0.129	0	**0.871**	0	0	**0**	0	0
11	0.084	0	**0.915**	0	0	**0**	0	0

	anger	contempt	disgust	fear	happiness	neutral	sadness	surprise
1	0	0	0	**0**	0	0.999	**0.001**	0
2	0	0	0	**0**	0	0.999	**0.001**	0
3	0	0	0	**0**	0	0.999	**0.001**	0
4	0	0	0	**0**	0	0.998	**0.002**	0
5	0	0	0	**0**	0	0.998	**0.002**	0
6	0	0	0	**0**	0	0.994	**0.006**	0
7	0	0	0	**0**	0	0.974	**0.026**	0
8	0	0.001	0	**0.001**	0	0.647	**0.351**	0
9	0	0	0	**0.007**	0	0.289	**0.701**	0.002
10	0	0	0	**0.03**	0	0.074	**0.894**	0.001
11	0	0	0	**0.042**	0	0.085	**0.869**	0.003
12	0	0	0	**0.008**	0	0.016	**0.976**	0
13	0	0	0	**0.015**	0	0.017	**0.967**	0
14	0	0	0	**0.009**	0	0.012	**0.978**	0

REFINEMENT

Convert basic emotion into “state”: confused, interested, distracted, and normal

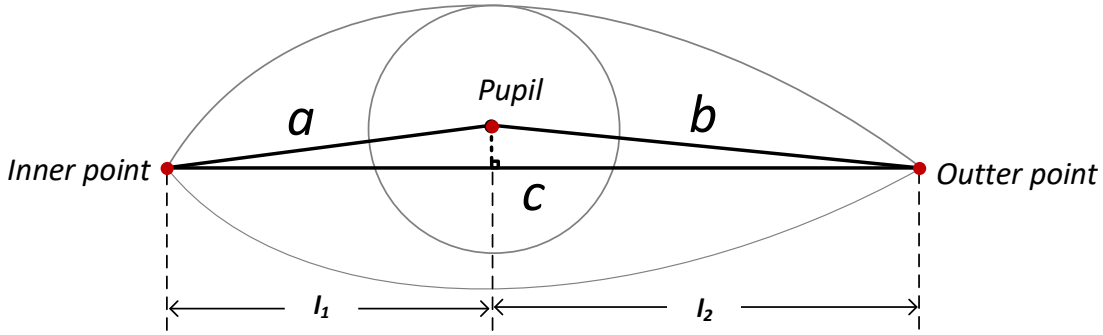
Classification: K-nearest neighbours algorithm + eye movement (by face feature points)



Calculation of the eye movement:

$$ratio = \frac{l_1}{l_2} = \frac{a^2 + c^2 - b^2}{b^2 + c^2 - a^2}$$

ranges in[0.4, 1.5] when looking straight at camera.



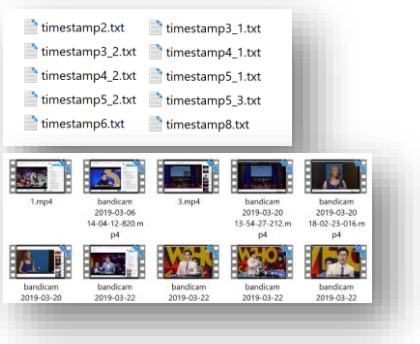
EXPERIMENT II

Relating the students' emotion to the lecturer's behaviour – to mark the time stamps when students are showing interest.

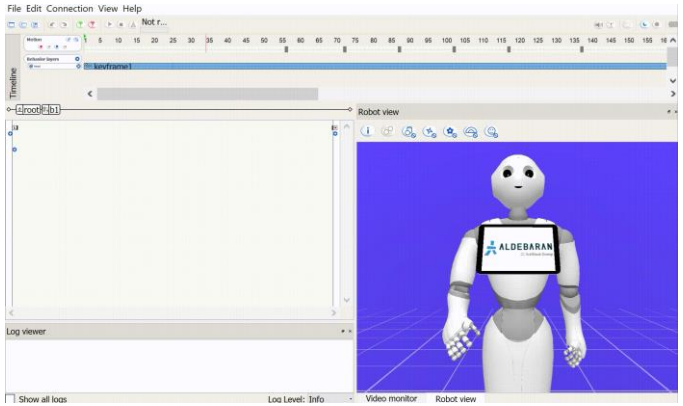
Desired behaviours are summarized as 15 different types.

time	anger	contempt	disgust	fear	happiness	neutral	sadness	surprise	state
0:20	0	0	0	0	0	0.988	0.012	0	3
0:21	0	0	0	0	0	0.994	0.005	0	3
0:22	0	0	0	0	1.0	0	0	0	1
0:23	0	0	0	0	0.992	0.008	0	0	1
0:24	0	0	0	0	0.965	0.035	0	0	1
0:25	0	0	0	0	0.994	0.006	0	0	1
0:26	0	0	0	0	0.998	0.002	0	0	1
0:27	0	0	0	0	0.652	0.348	0	0	1
0:28	0	0	0	0	0.624	0.375	0	0	1
0:29	0	0	0	0	0	0.995	0.004	0	3
0:30	0	0	0	0	0.016	0.982	0.002	0	0
0:31	0	0.001	0	0	0.229	0.749	0.015	0.006	0
0:32	0	0	0	0	0	0.99	0.007	0.003	3
0:33	0	0	0	0	0	0.986	0.002	0.012	3
0:34	0	0	0	0	0	0.984	0.003	0.012	3
0:35	0	0	0	0	0	0.996	0.004	0	3

0: confused
1: interested
2: distracted
3: normal



BEHAVIOUR DESIGN & IMPLEMENTATION



Simulation in Choregraphe

export motions

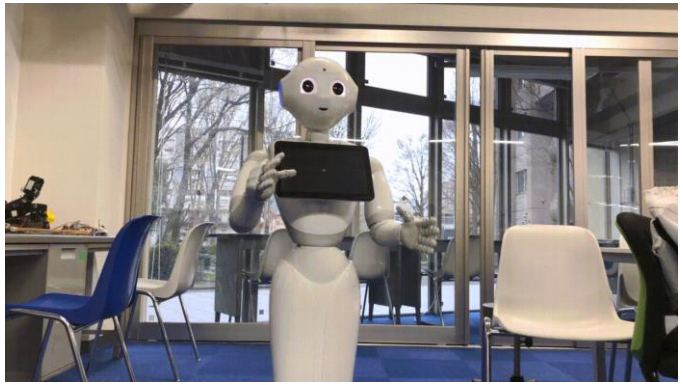
- Name of joint[ ]
- Time[ ]
- Angle[ ]

Control.py

```
from naoqi import ALProxy
ALProxy("ALMotion", ip, port)
motionProxy.post.angleInterpolation()
```

Programming with Naoqi SDK

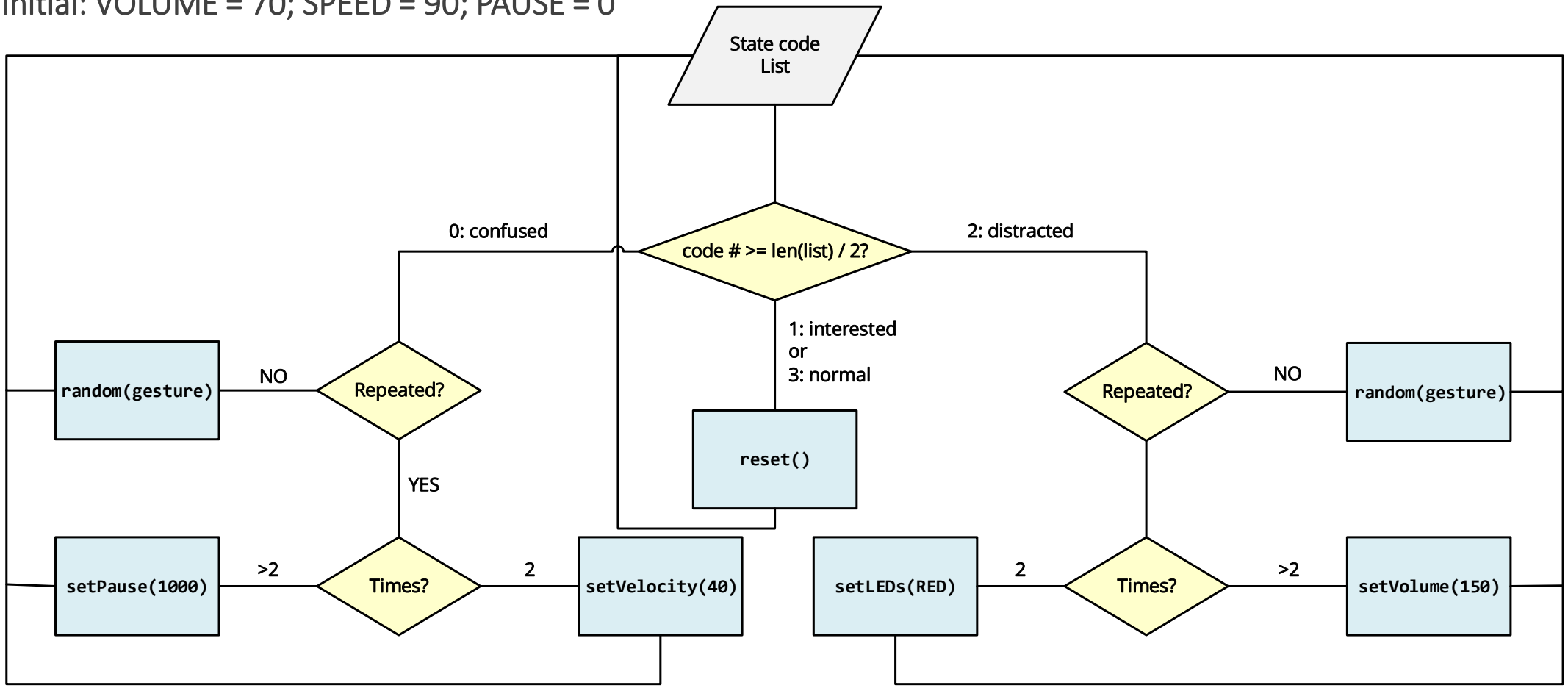
run



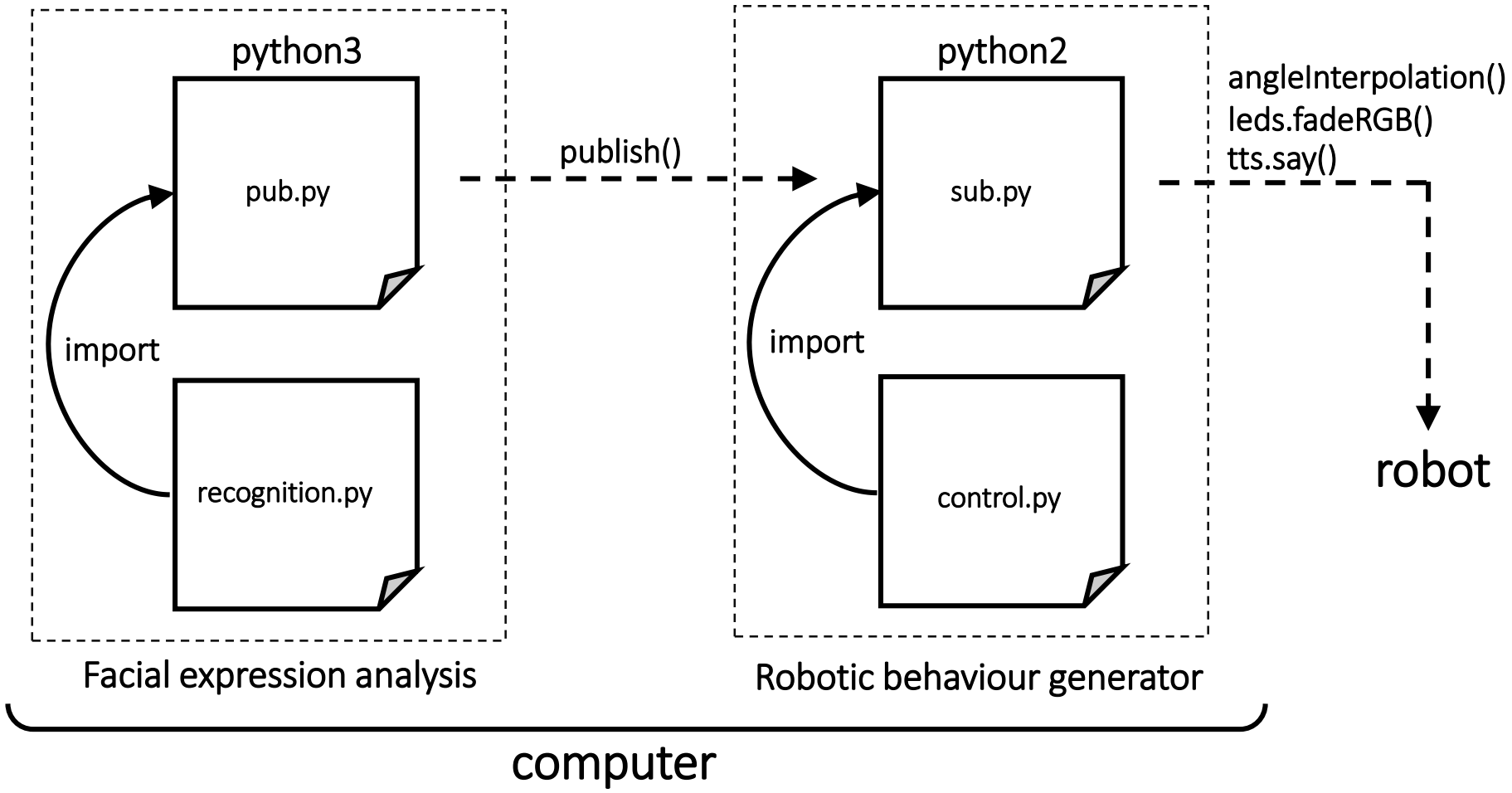
Implementation on the robot

MAPPING STRATEGY

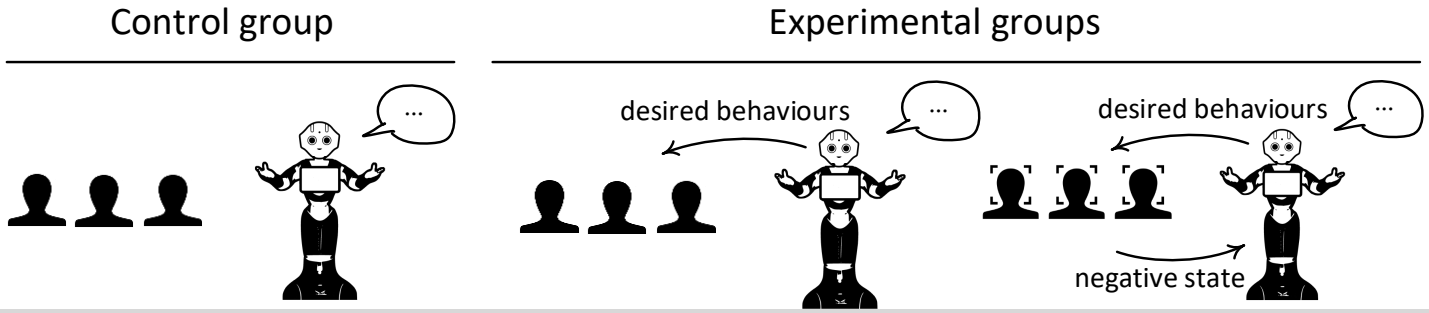
initial: VOLUME = 70; SPEED = 90; PAUSE = 0



SYSTEM INTEGRATION



SYSTEM EVALUATION



Independent variable: Connection with the HRI system	Without the HRI system	Connect to the behaviour generator	Connect to the whole HRI system
Questionnaires: filled up by 16 participants	↓	↓	↓
Dependent variable:			
Understanding of the lecture (%)	55.5%	48.3%	46.3%
Engagement in class (level 0 - 5)	0.188	2.687	3.125
Participants' preference	*2*	*6*	*8*

CONCLUSION & FURTHER WORK

Proposed HRI system

- is an adaptive system
- excels other non-interactive systems in improving students' engagement
- visualises the current "state" with GUI
- is compatible with other robotic devices (e.g. robot arm, the NAO robot)
- is able to run without GPU

Further work: Robot avatar for the online lecture

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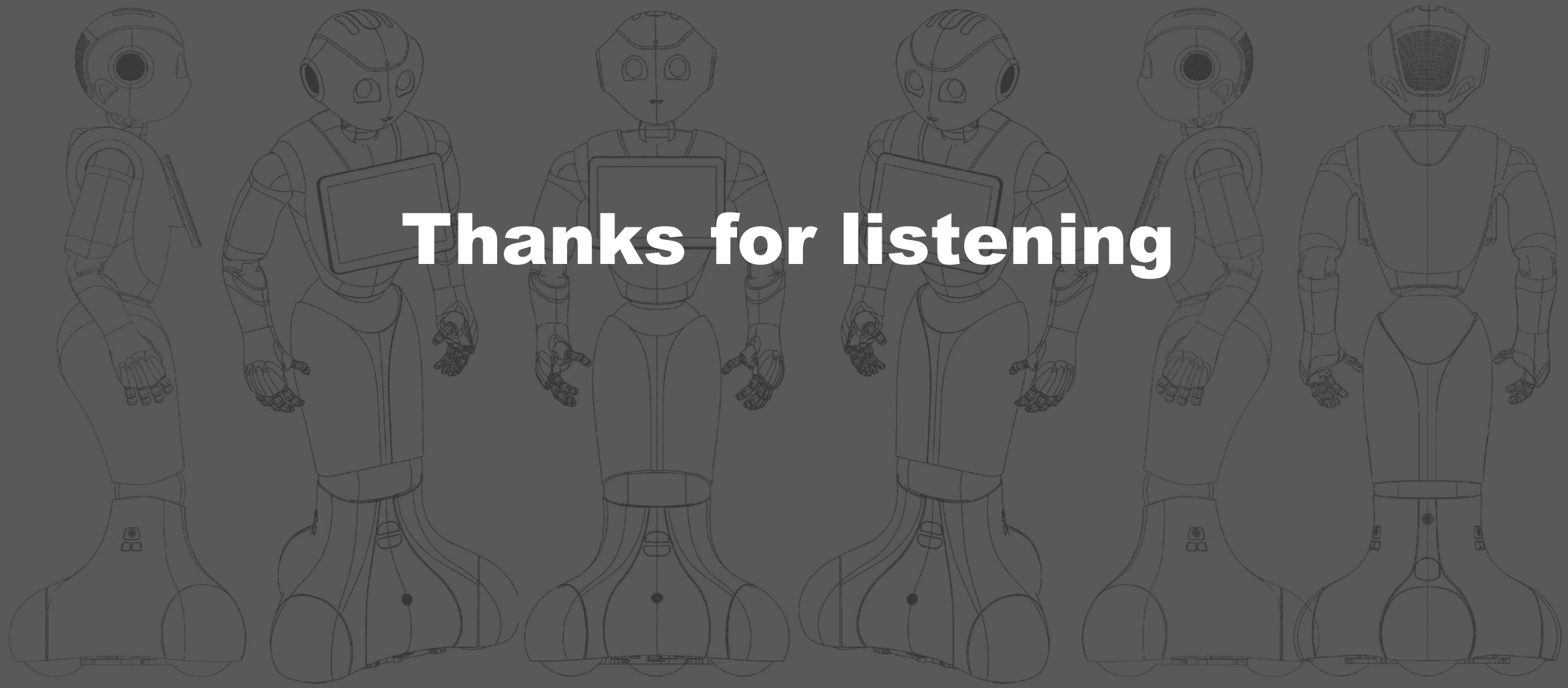

Thanks for listening