I see you, do you see me?

Socially aware robots

Koen Hindriks

Social Intelligence

A social signal processing perspective:

The ability to
recognize & **express**
social signals and social behaviors

Understanding Social Signals

"The ability to understand and manage social signals of a person we are communicating with is the core of social intelligence."

Social Psychology → Signal Processing → Social Information

Facial expressions tell us something about emotion

Facial recognition

Emotion classification based on extracted face

Source: Vinciarelli, A., Pantic, M., & Bourlard, H. (2009). Social signal processing: Survey of an emerging domain. *Image and vision computing*, *27*(12).

Social Cognition & Intelligence

Yesterday's lecture:

- Social cognition: "Mental processes involved in perceiving, attending to, remembering, thinking about, and making sense of the people in our social world."

Today's lecture:

- Social intelligence: "The ability to recognize & express social signals and social behaviors"

Social Cues and Signals

- **Social cues** are the **observable features** of an agent that are biologically and physically determined, and these are transmitted as a short, discrete set of physical/physiological activity.

- **Social signals** are **meaningful interpretations of cues** in the form of attributions of an agent's mental state or attitudes. They depend on the situational **context** and which **combinations of cues** are used

- *Example:* signal empathy towards a friend by smiling at them

Social Cues

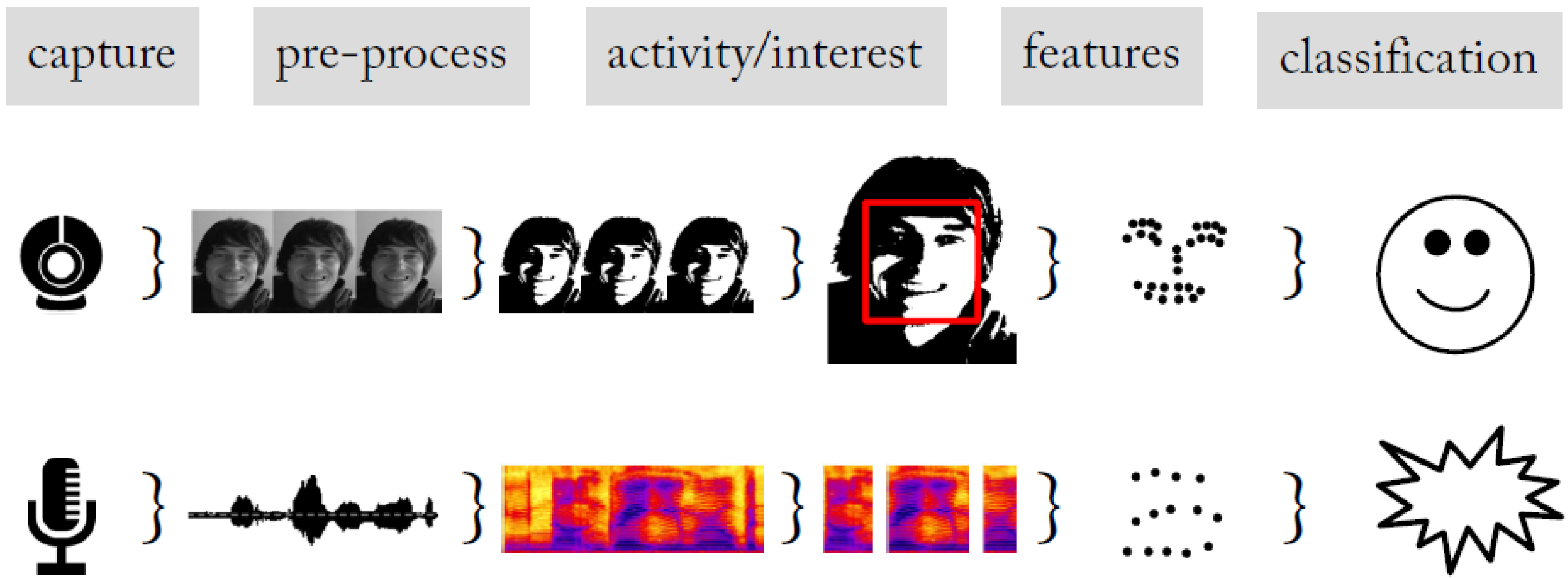
- Space and environment (proxemics)
- Physical appearance – height, body shape, skin and hair color, dress
- Facial expressions
- Gaze & head pose
- Postures and body movement
- Gestures (hand and arm)
- Vocal cues
- …

Signals: what information is conveyed?

Cues often accompany speech:

- **Attitudes**: emotion, cognitive attitudes, e.g. disbelief.
- **Manipulators**: towards the environment or oneself.
- **Cultural emblems**: specific to cultural circle, e.g. “high five”.
- **Illustrators**: underlining information transmitted in other channels of communication.
- **Regulators**: affirm other communication partners or indicate turn-taking.

Processing Pipeline



Visual and Audio Channels

Source: Wagner, 2015, Social Signal Processing (dissertation, p27)

Proxemics & People Detection

Thomas van Orden
joint work with the robot programming team in the Social AI lab.

Physical Appearance – Clothing

- Most studies about the effects of clothing has used pictures. It has been hard to demonstrate effects of clothing in social interactions between humans.

- Is clothing only relevant for first impressions, but not for judgements over extended periods of interaction?

Clothing on Humans versus Robots

- Are the effects of clothing similar for humans and robots?
- How can we find out, i.e. establish that clothing for a particular aspect has a different effect for a human than a robot?

Differences?

Attributing sexual intent:

a lot of research on dress and sexual intent; dress on a robot such as Pepper perhaps will not lead to attributing sexual intent to it?

Clothing vs no clothing:

It is not clear how robots with and without clothing are perceived, which for robots is an interesting question to explore.

Facial Expressions

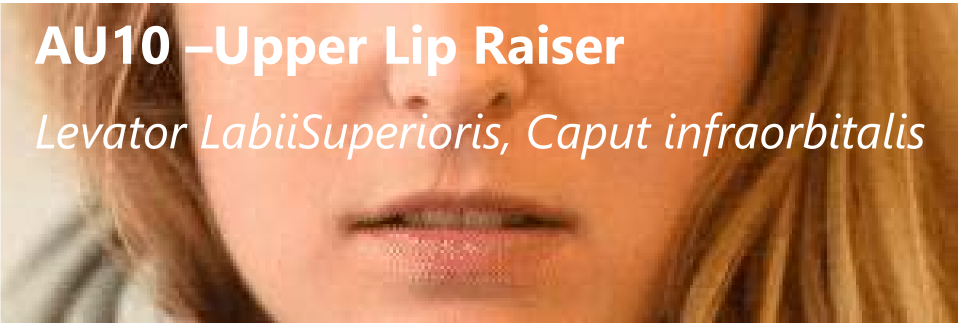
Communicates:

- Affective state
- Intentions
- Personality
- Attractiveness
- Age
- Gender

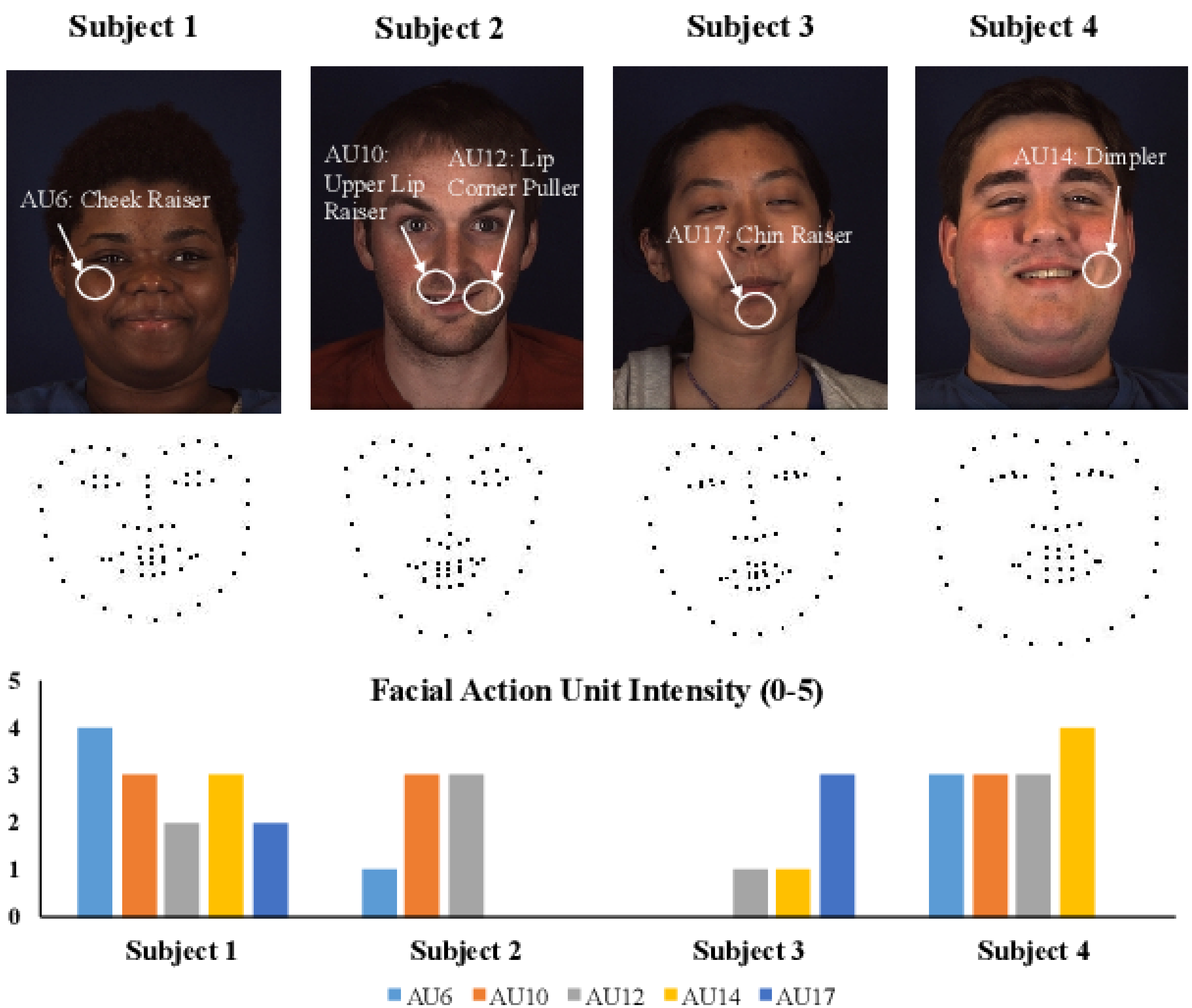
Facial Expressions – FACS

- FACS provides an objective and comprehensive language for describing facial expressions
- FACS associates facial-expression changes with actions of the muscles that produce them.
- It defines:
  - nine different action units (AUs) in the upper face,
  - 18 in the lower face,
  - 11 for head position,
  - 9 for eye position, and
  - 14 additional descriptors for miscellaneous actions

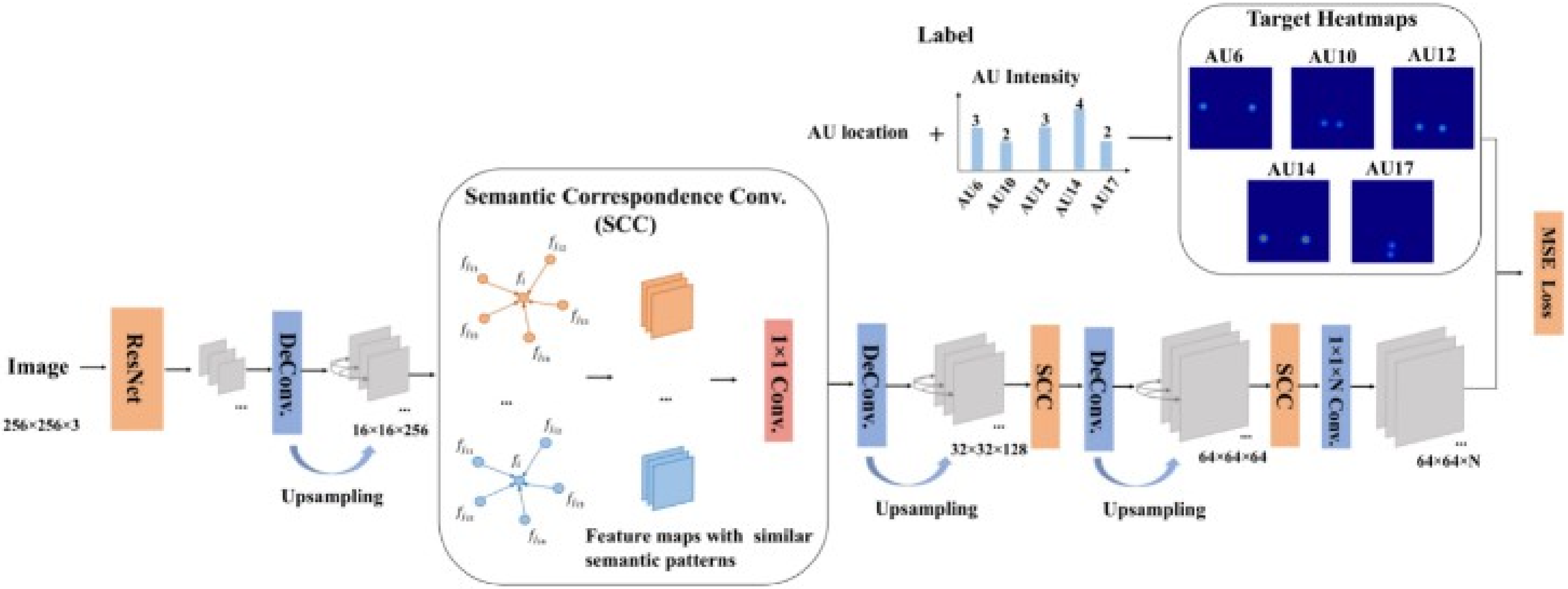
FACS – Exampe AUs



Facial Action Unit Intensity Estimation



Facial Action Unit Intensity Estimation via Semantic Correspondence Learning with Dynamic Graph Convolution. Yingruo Fan, Jacqueline C.K. Lam and Victor O.K. Li. *AAAI 2020*



Exercise Feedback for People with Facial Paralysis

1. Raise eyebrows, holding for 5 seconds, repeating 10x.

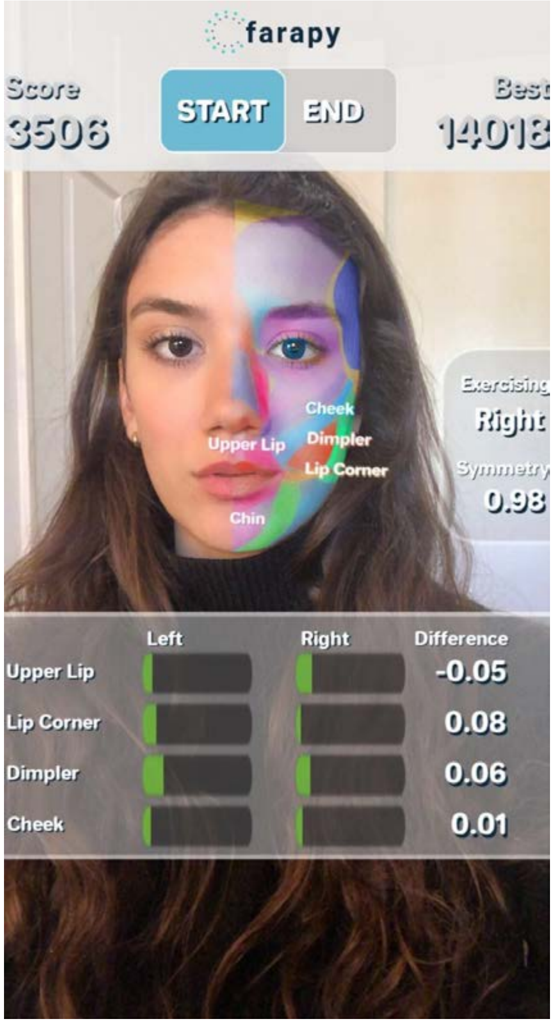
2. Wrinkle nose, holding for 5 seconds, repeating 10x.

6. Show lower teeth, holding for 5 seconds, repeating 10x.

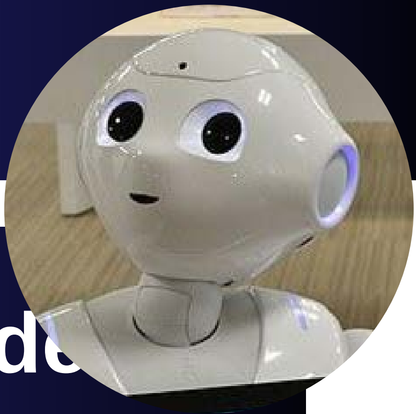
3. Snarl, holding for 5 seconds, repeating 10x.

4. Smile, holding for 5 seconds, repeating 10x.

5. Pucker lips, holding for 5 seconds, repeating 10x.



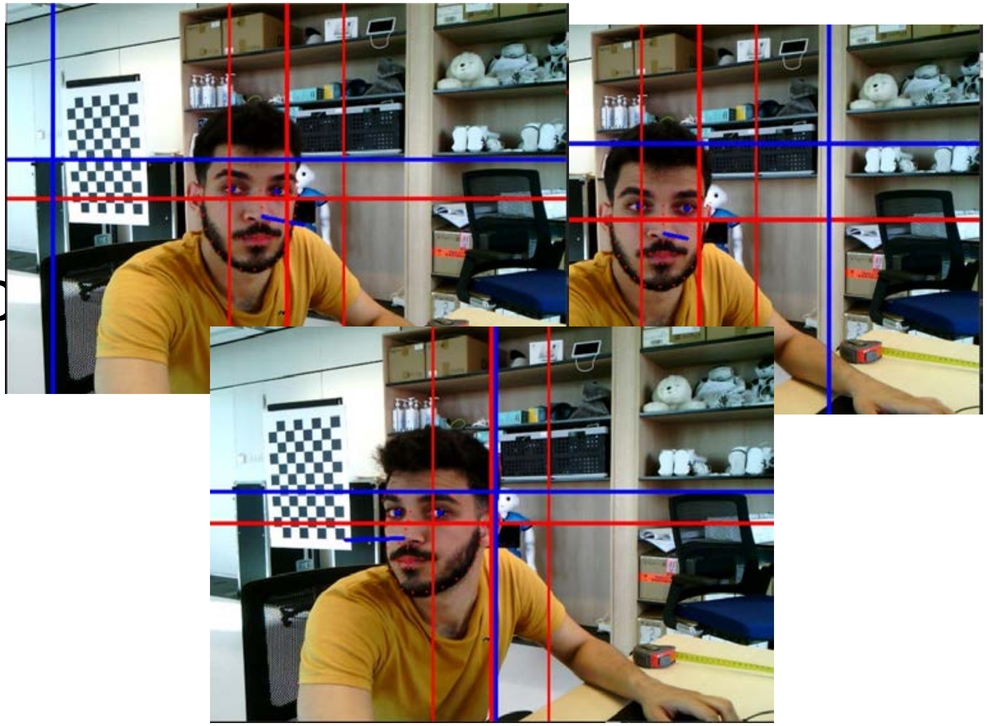
Gaze & Head Pose



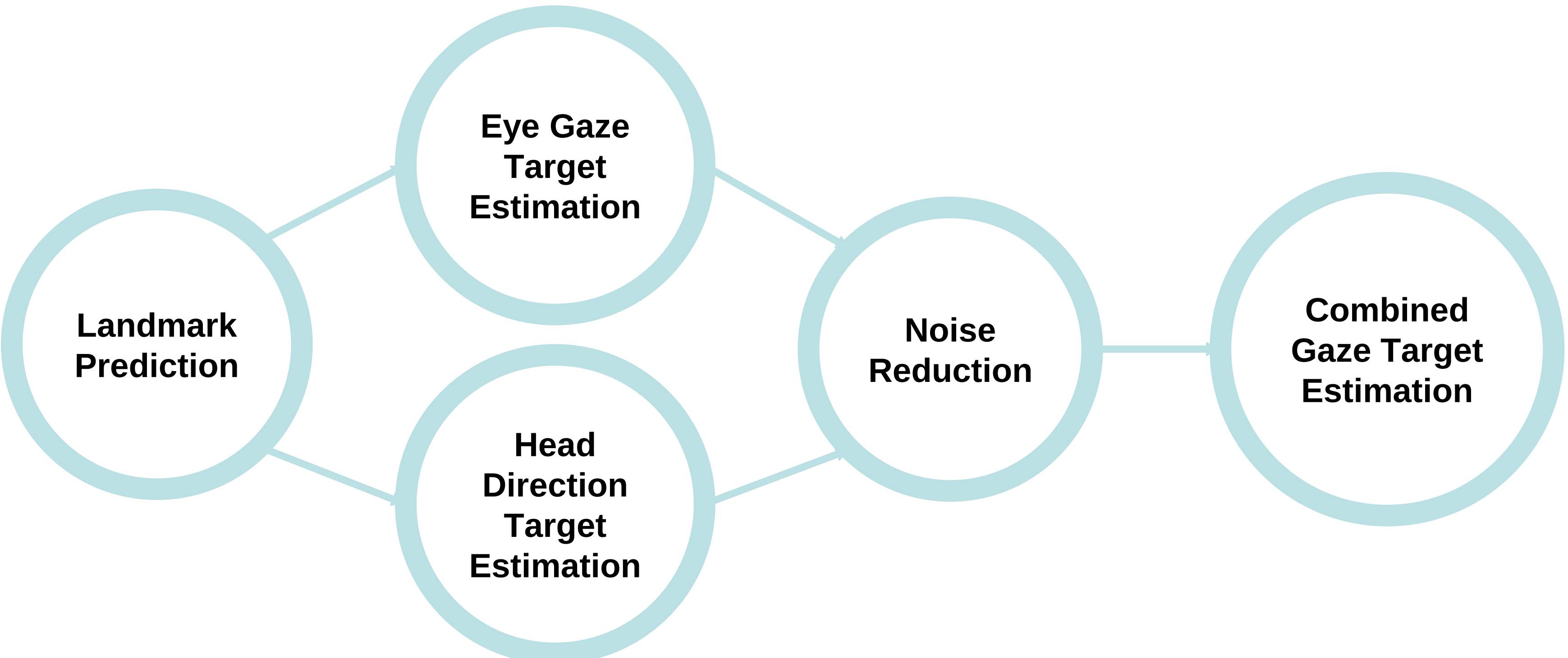
Gaze Direction Estimation unde
Varying Head Positions using a Pepper Robot's In-Built Camera

Thesis of Marinos Savva

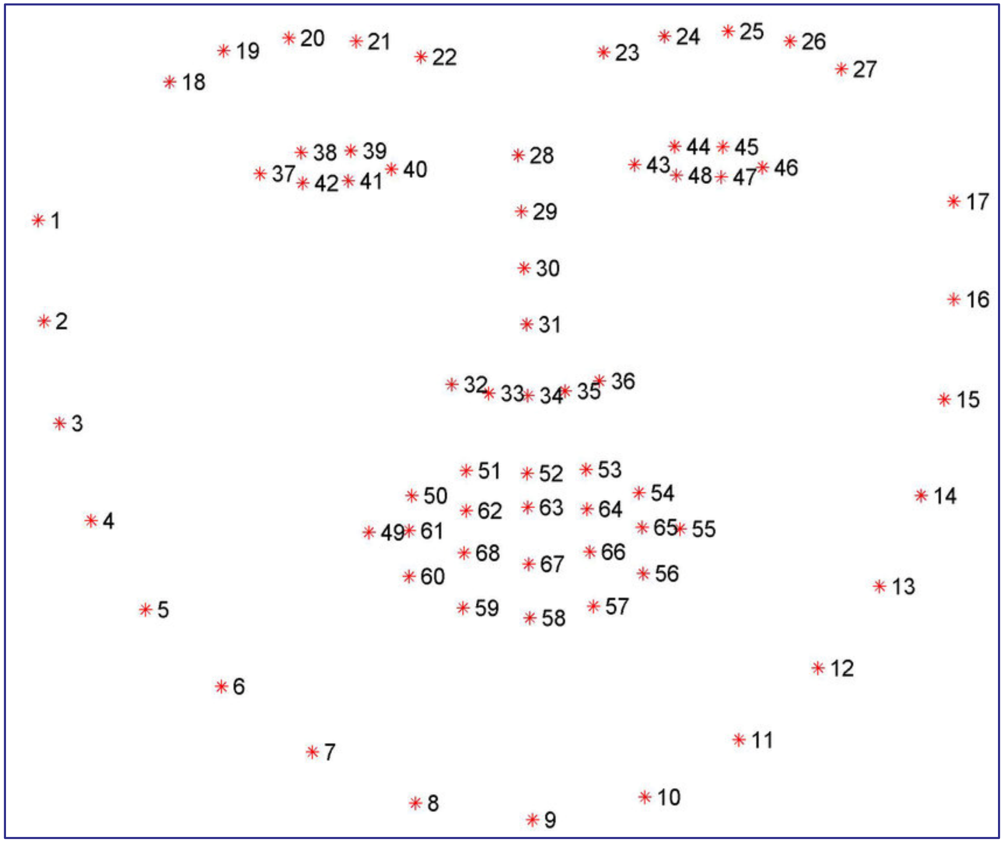
How can we estimate human eye gaze directio from camera input?

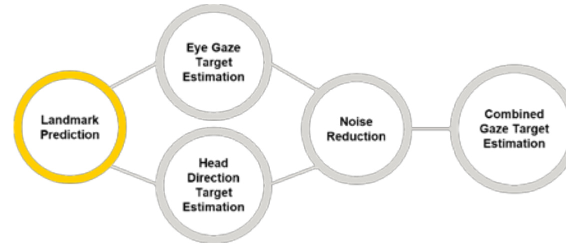


A First Principles Approach



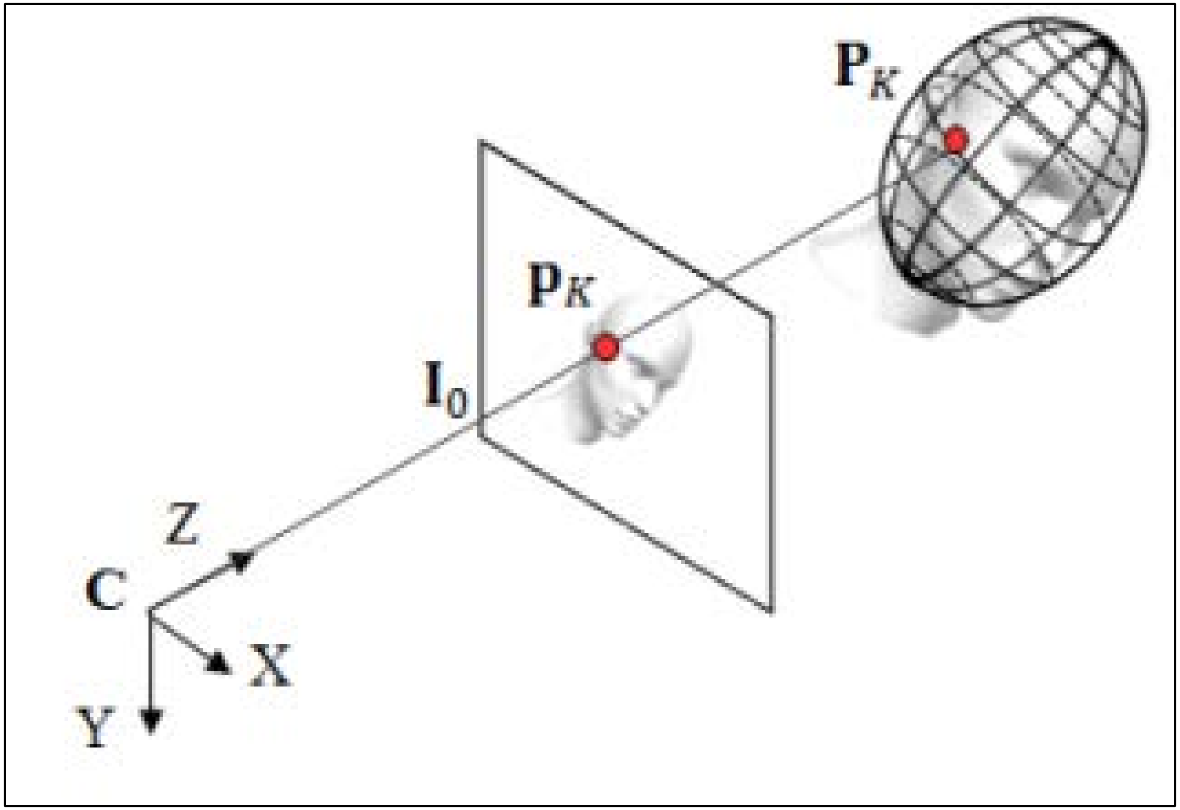
Step 1: Landmark Prediction

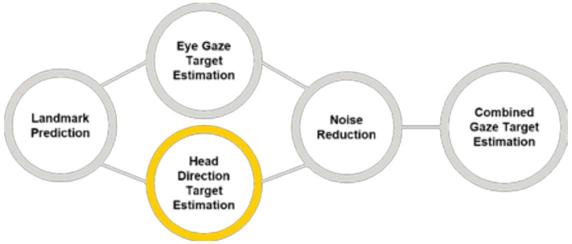




Source: V. Kazemi and J. Sullivan, “One millisecond face alignment with an ensemble of regression trees," in 2014 IEEE Conference on Computer Vision and Pattern Recognition, 2014, pp. 1867-1874

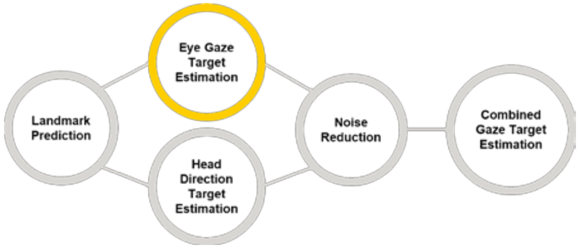
Head Pose Estimation





Source: J. M. D. Barros, B. Mirbach, F. Garcia, K. Varanasi, and D. Stricker, “Real-time head pose estimation by tracking and detection of keypoints and facial landmarks," in VISIGRAPP, 2018.

Eye Gaze Target Estimation



Region of Interest Extraction

The landmarks acquired are utilized to create a cut-out of the eye while omitting the area around the eyeball

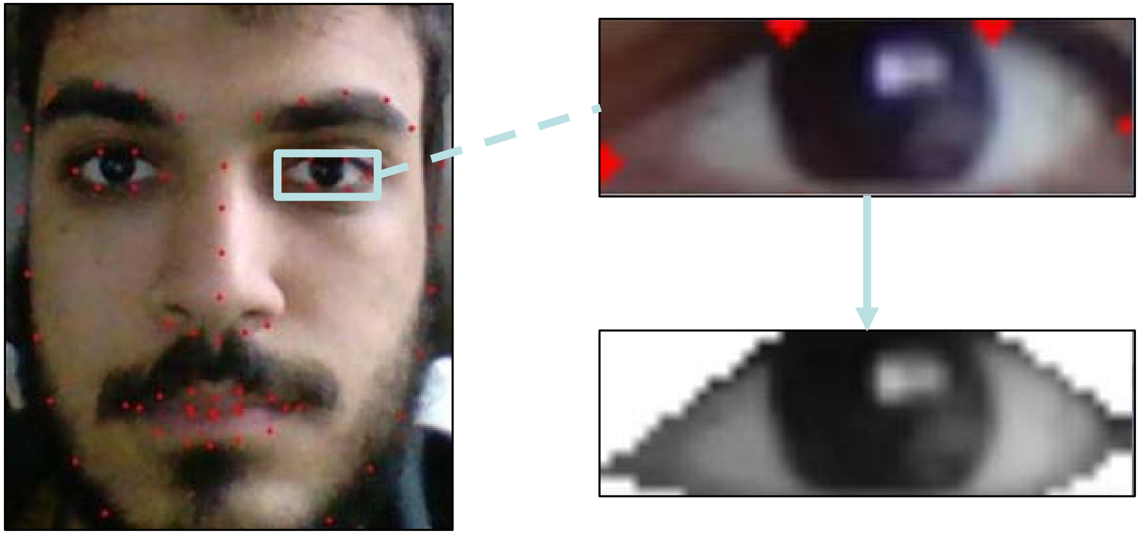
Image Processing

The extracted image is processed to remove the effects of surface light reflections and to localize the pupil

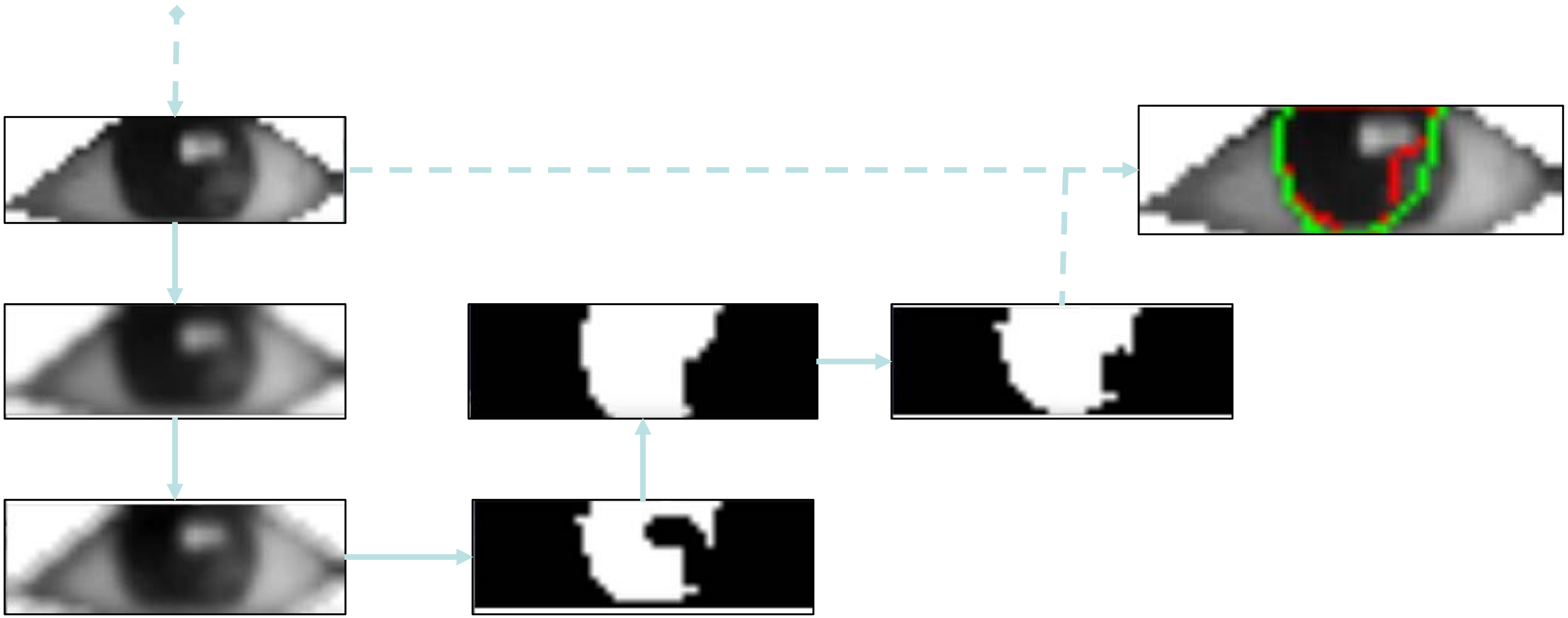
Gaze Angle Calculation

The angle of gaze is calculated using a simplified eyeball model

Region of Interest Extraction



Localizing the Pupil

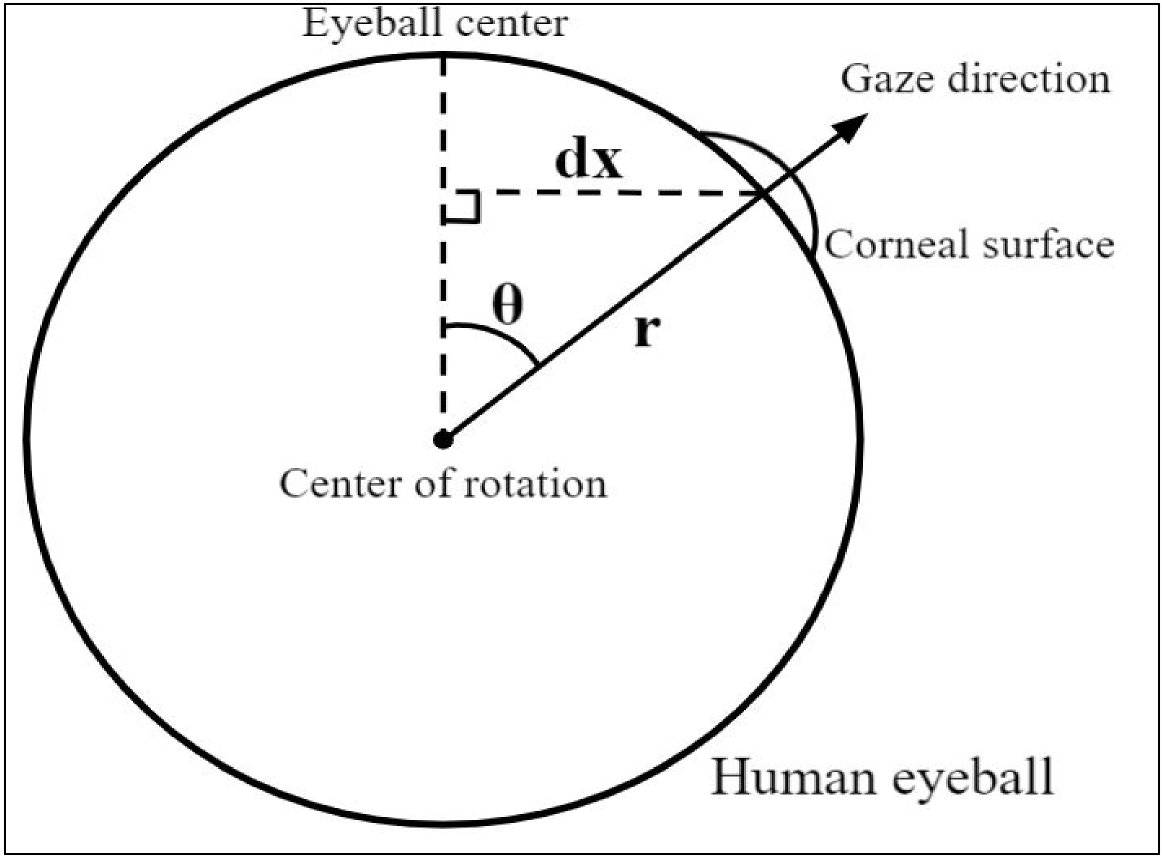


Gaze Angle Calculation

A simplified model of the eyeball is used, where some assumptions are made

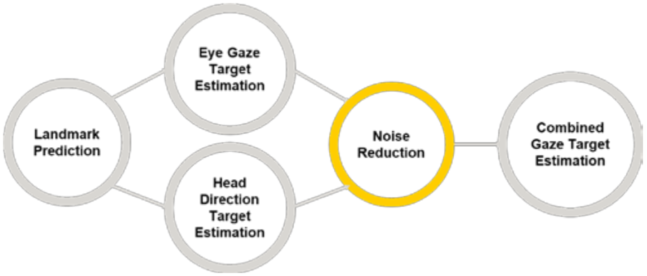
- Eyeball shape approximated to that of a sphere of constant radius
- Eyeball radius approximated to human average of 10.94mm
- Assumed no difference between pupillary and visual axes

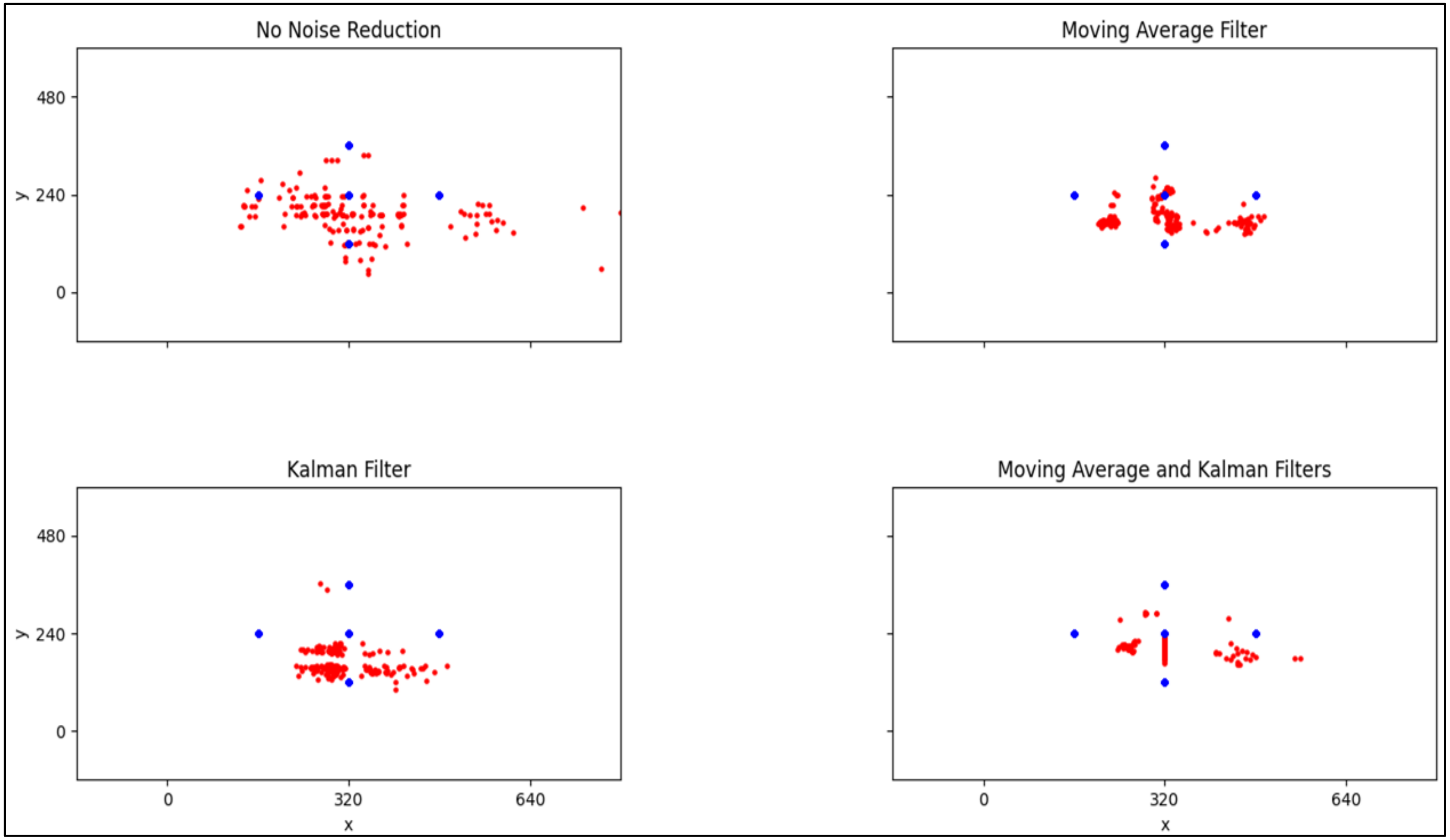
Gaze Angle Calculation



Source: N. M. Scoville, R. Y. Lu, and H. Jung, “Optical axes and angle kappa," url: https://eyewiki .aao.org/Optical_Axes_and_Angle_Kappa.

Noise reduction





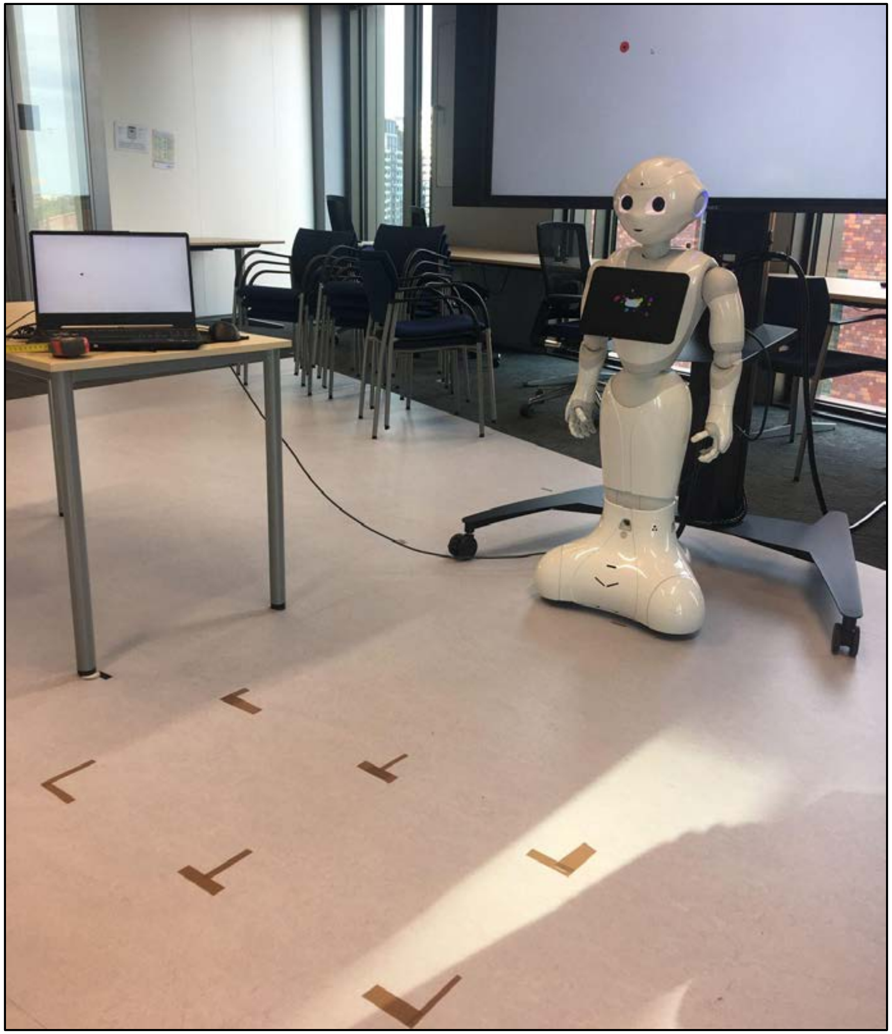
Evaluation: Setup

Small experiment:

- 12 participants

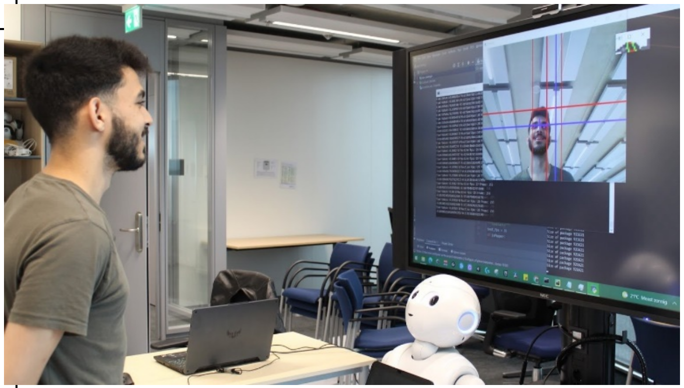
- 6 standing positions
  - 2 distances
  - 3 offset positions

- 5 projected points per position



Evaluation: Results

Participant	80cm		120cm	
	Error(px)	Accuracy	Error(px)	Accuracy
1	122.41	61%	159.95	55%
2	151.41	54%	225.54	43%
3	159.29	53%	266.36	33%
4	167.66	50%	298.63	23%
5	165.25	50%	268.66	30%
6	170.58	49%	295.40	20%
7	164.10	51%	288.00	23%
8	162.35	51%	270.35	28%
9	162.59	51%	258.83	30%
10	159.3	52%	247.76	33%
Mean	158.49	52%	257.65	32%



Participant	80cm		120cm	
	Accuracy X-Coordinate	Accuracy Y-Coordinate	Accuracy X-Coordinate	Accuracy Y-Coordinate
1	78%	44%	74%	37%
2	69%	40%	63%	24%
3	66%	41%	65%	1%
4	65%	34%	47%	0%
5	65%	36%	51%	9%
6	62%	38%	38%	3%
7	65%	39%	38%	8%
8	67%	36%	42%	14%
9	68%	35%	45%	16%
10	69%	36%	48%	19%
Mean	67%	38%	51%	12%

MIT’s Gaze 360

https://youtu.be/w_tkaqfqlsM

wearable eye tracker glasses

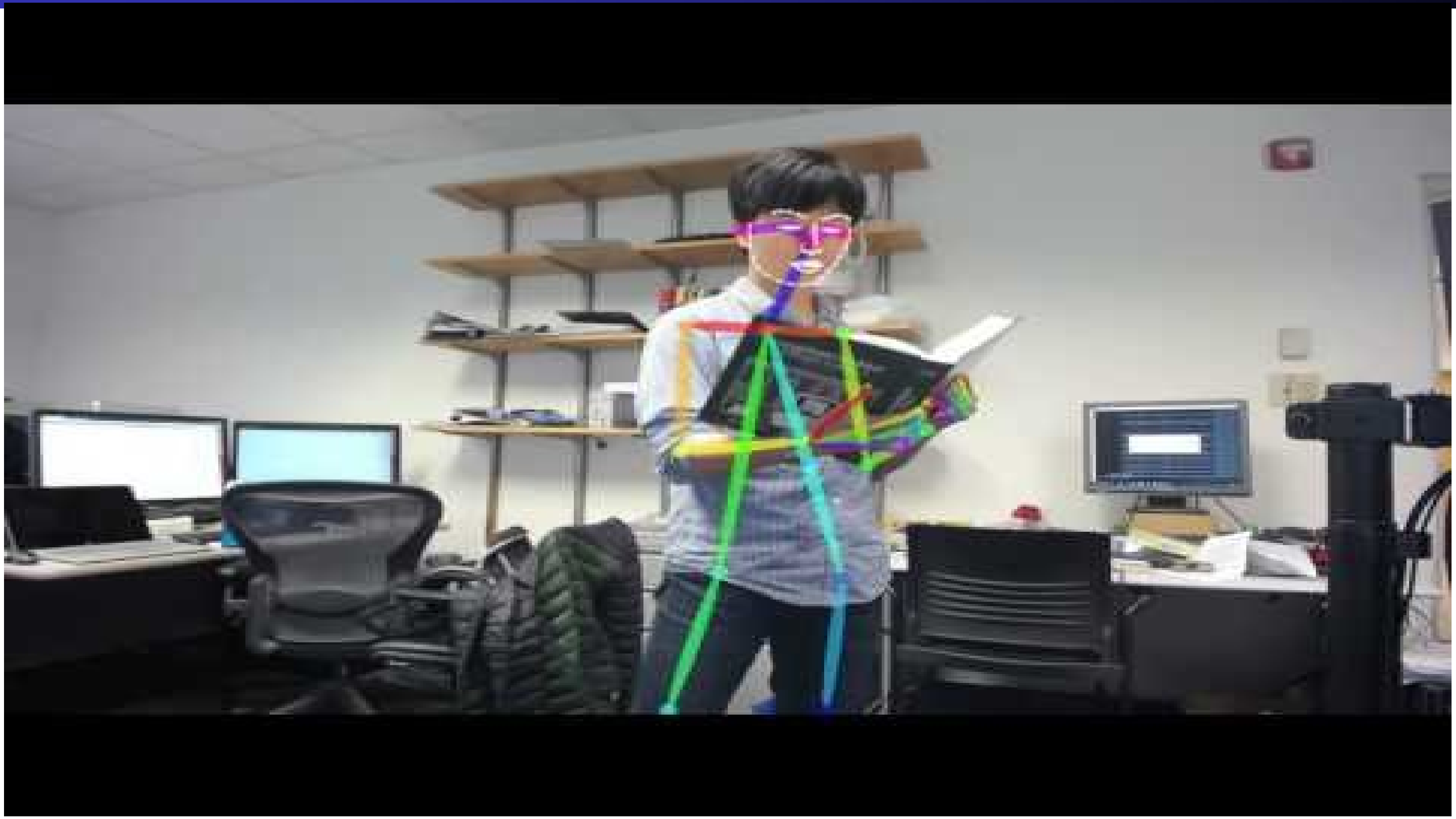
Vocal cues

- **Prosody** (how something is said): pitch, tempo, and energy
- **Back-channeling** (express attention, agreement, wonder, etc.) and **disfluencies** (non-words, or fillers): ehm, ah-ah, uhm, etc.
- **Non-linguistic vocalizations**, e.g., coughing, laughing, sobbing, crying, whispering, groaning, etc.
- **Silences**: hesitation & psycholinguistic (difficulty), and interactive (convey messages about the interactions taking place)

Postures and body movement

- Inclusive vs non-inclusive: looking at vs looking away
- F2f or parallel: more active (monitoring) vs less attentive
- Congruence vs incongruence: mirroring in interactive setting

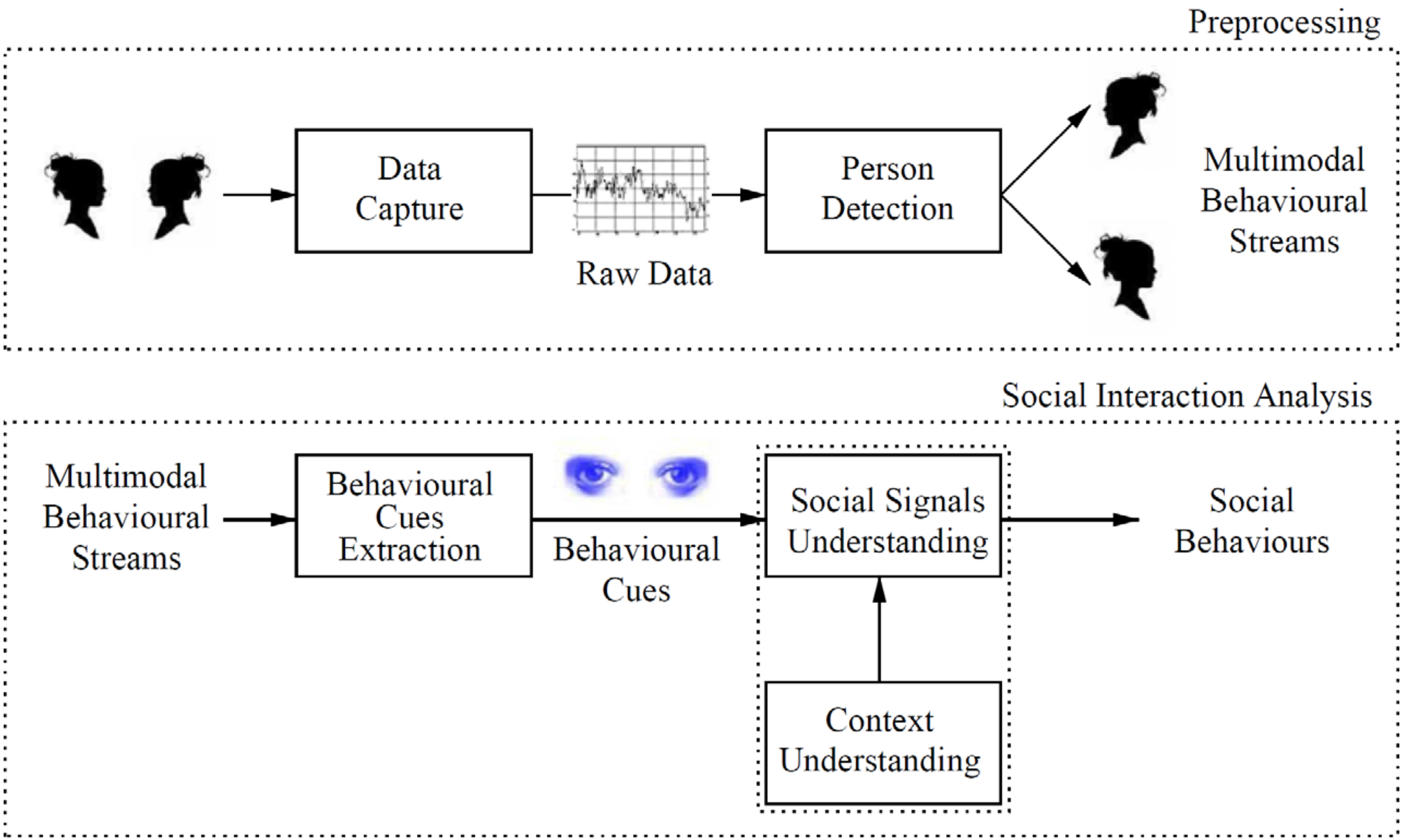
Openpose & Gestures



Two challenges:

- detecting the body parts in the gesture (e.g., hands)
- modeling the temporal dynamic of the gesture

Is Social-Aware also Context-aware?



Source: Figure 6 in Vinciarelli, A., Pantic, M., & Bourlard, H. (2009). Social signal processing: Survey of an emerging domain. *Image and vision computing*, *27*(12), 1743-1759.

How to interpret a smile?

A smile can be a display of:

- politeness,
- contentedness,
- joy,
- irony,
- empathy,
- greeting,
- …

How to interpret a smile?

To identify a smile **as a social signal** we need to know:

- Where: the location of the subject is (outside, at a reception, etc.),
- What: current task
- When: timing of the signal
- Who: the expresser is (identity, age, …)

This is the **W4 model** (where, what, when, who)

How to interpret a smile?

But comprehensive human behavior understanding requires the W5+ model (where, what, when, who, why, how):

- Why and how: identify the stimulus that caused the social signal (e.g., funny video) as well as how the information is passed on (e.g, by means of facial expression intensity).

Addressing W5+ is key challenge of data-driven SSP.

Future work

Important but not discussed today:

- context-dependent multimodal fusion
- multimodal temporal fusion
- multiparty
- are social signals natural or cultural?