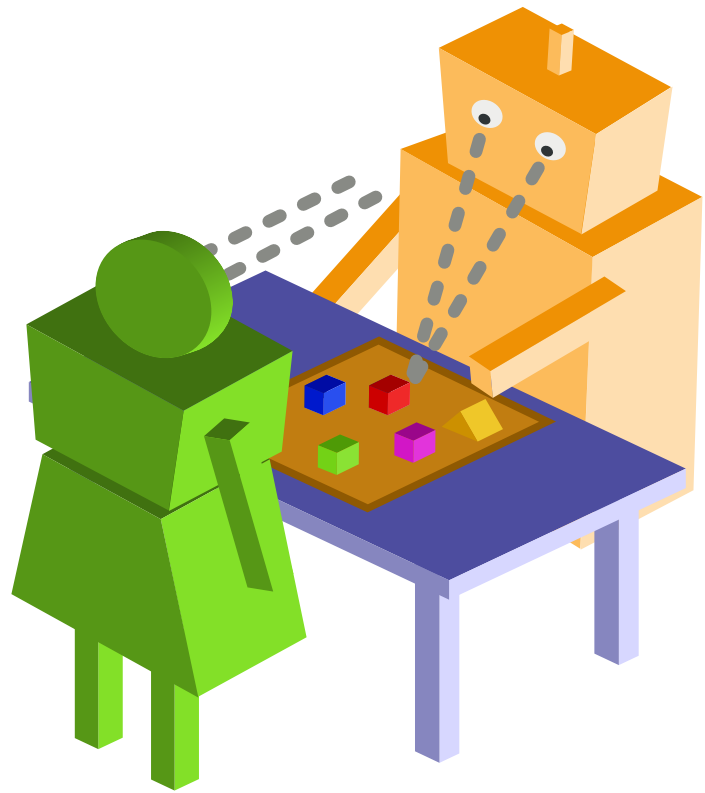
cognition, HRI & data

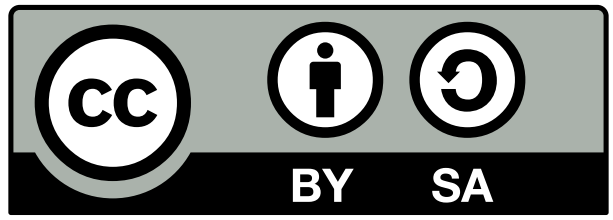
how to *do* together?

UKRAS19 – 24th Jan. 2019



Séverin Lemaignan

Bristol Robotics Lab University of the West of England



You can download the sources of this presentation here:

github.com/severin-lemaignan/2019-ukras-talk

JOINT ACTION WITH A ROBOT?

MODEL-BASED JOINT ACTION

1. establish a joint goal
2. plan for the robot
3. plan for the human in order to build a set of priors
4. execute the robot plan
5. monitor progress of the partner towards the goal
6. (loop back)

[Lemaignan et al. **Artificial Cognition for Social Human-Robot Interaction: An Implementation** Artificial Intelligence 2017]

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⇒ **explicit cognitive steps**

...hard (and brittle) ones, though:

- *how to communicate/agree on goals & plans?*
- *what about the human's own plans?*
- *what to do when we're going off track?*
- *monitoring/recognising error situations*
- *...*

[Lemaignan et al. **Artificial Cognition for Social Human-Robot Interaction: An Implementation** Artificial Intelligence 2017]

WE CAN DO A BIT ALREADY

[Lemaignan et al. **Artificial Cognition for Social Human-Robot Interaction: An Implementation** – Artificial Intelligence 2017]

HOW DO HUMANS PERFORM TASKS TOGETHER?

Collaborating is a costly socio-cognitive activity.

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...which is closely related to: **be lazy**

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What does "be lazy" mean for robots?

ONE EXAMPLE: GROUNDING OF SPATIAL LANGUAGE

Ambiguities arise easily when describing spatial scenes.

How do we solve them?

SURFACE ALIGNMENT; GROUNDING CRITERION

Psycholinguistics provides a lot of the foundational work on these questions.

- ***Communication is a dynamic social process***: the partner often to signal missing/misunderstood informations

[Clark and Wilkes-Gibbs, ***Referring as a collaborative process***, Cognition 1986
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- You only ever need to reach the ***grounding criterion***, ie ***enough*** mutual understanding for the task
- $\Rightarrow$ we typically only reach ***partial (or surface) alignment*** – full alignment is usually not required

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IN SOCIAL HUMAN-ROBOT INTERACTION

Well studied in communication (cf back-channeling)

Can we expand this line of thought to sHRI in general?

Most of our social and behavioural alignment comes from sub-conscious social mechanisms:

- entrainment (coupling),
- mimicry,
- implicit turn-taking,
- joint attention
- ...and others

IN SOCIAL HUMAN-ROBOT INTERACTION

- These mechanisms are unfortunately often ill-defined, and particularly difficult to turn into equations (or controllers, in our case)
- no close-form equation of social interactions $\Rightarrow$ data-driven approaches?

TOWARDS THE DATA-DRIVEN STUDY OF SOCIAL DYNAMICS

DATA!

If we want to use machine learning, we need data.

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...a task that exhibits:

- complex social dynamics
- open, underspecified situations
- natural interactions
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...a task that exhibits:

- complex social dynamics
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while being...

- reproducible/replicable experimental procedure
- clear quantitative metrics
- practical

FREE PLAY

"Just play! Enjoy yourselves!"

- **rich set of cognitive and social dynamics**; importance of motivation/drive; **uncertain and unexpected situations**
- what is the right action policy? Focus instead on the **social policy**

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- focus on children
- with a little bit of scaffolding & framing

SOCIAL DYNAMICS TO BE OBSERVED

- the **task engagement**

  are the participants 'on task' or not?

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→ **paradigm for socio-cognitive investigation**

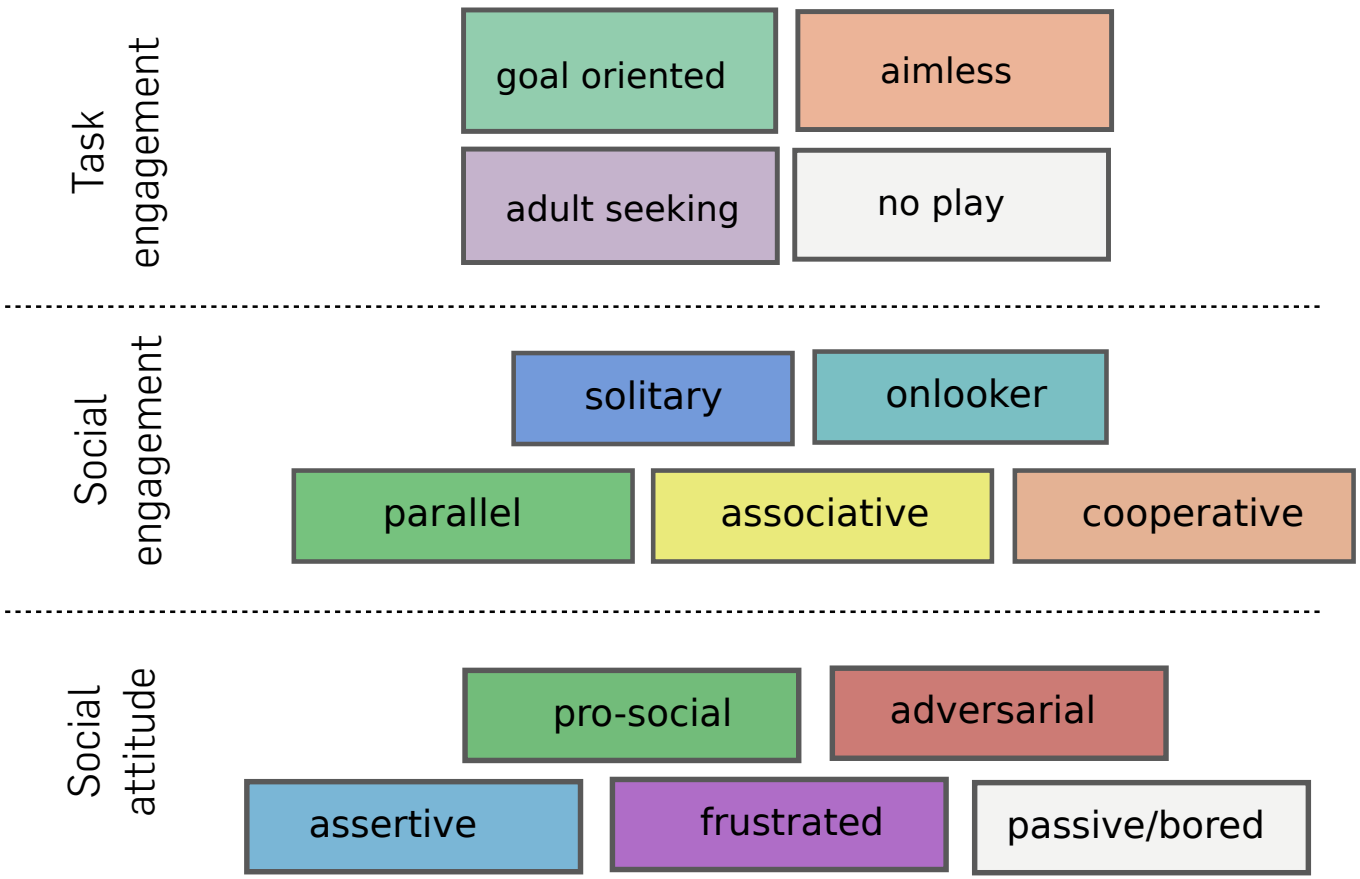
THE PINSORO DATASET

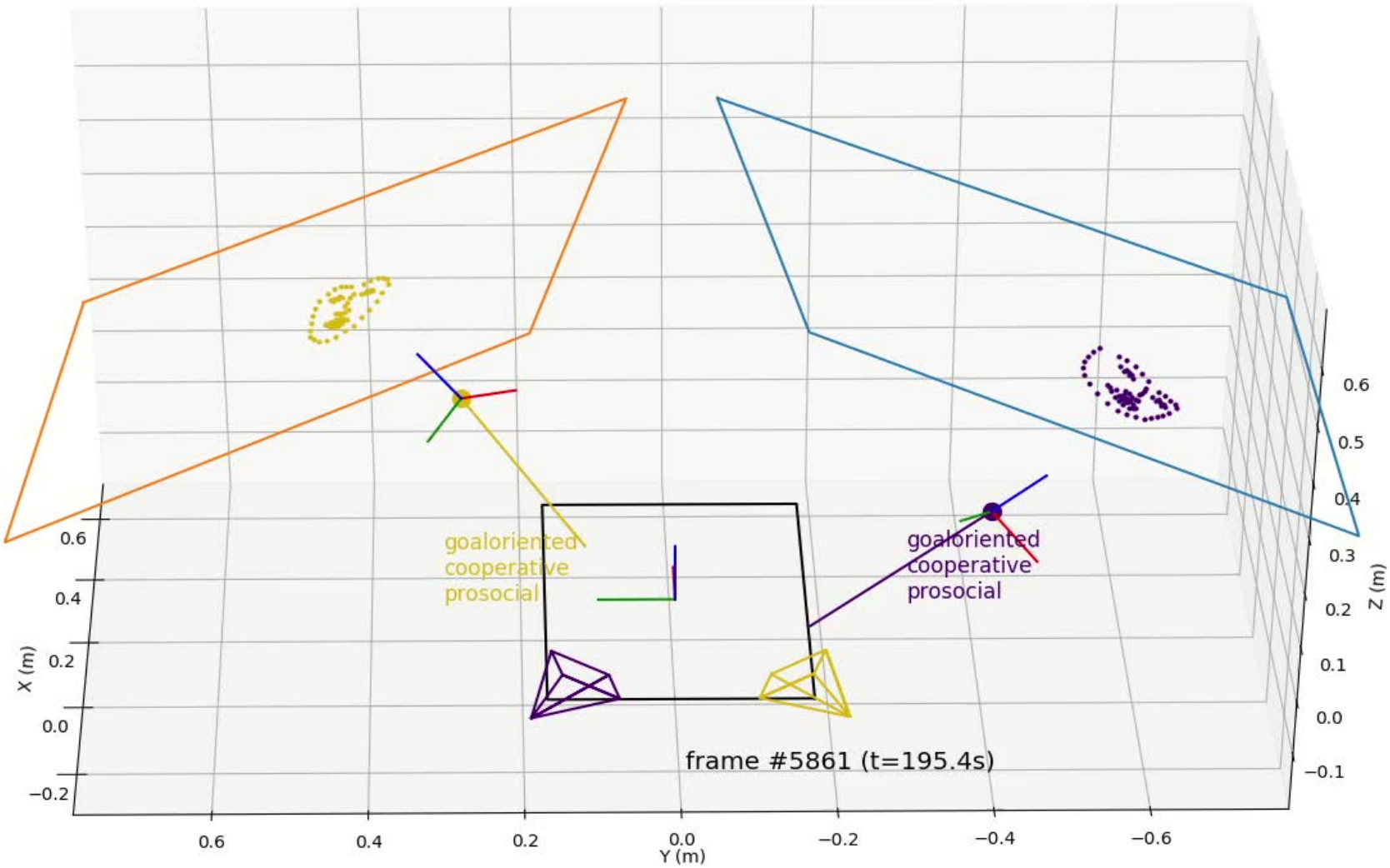
- 120 children, 4 to 8 years old
- 75 interactions

  90 children playing with another child,
  30 playing with a robot
- About 45h+ of recordings; 2M+ frames; ≈ 2TB
- average duration of freeplay interactions: 24min in child-child condition; 19min in child-robot condition

[Lemaignan et al. **The PInSoRo dataset: Supporting the data-driven study of [...]** PLOS One 2018]

13000+ ANNOTATIONS




goaloriented
cooperative
prosocial
goaloriented
cooperative
prosocial
frame #5861 (t=195.4s)
X (m)
Y (m)
Z (m)
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
0.5
0.3
0.1
−0.1

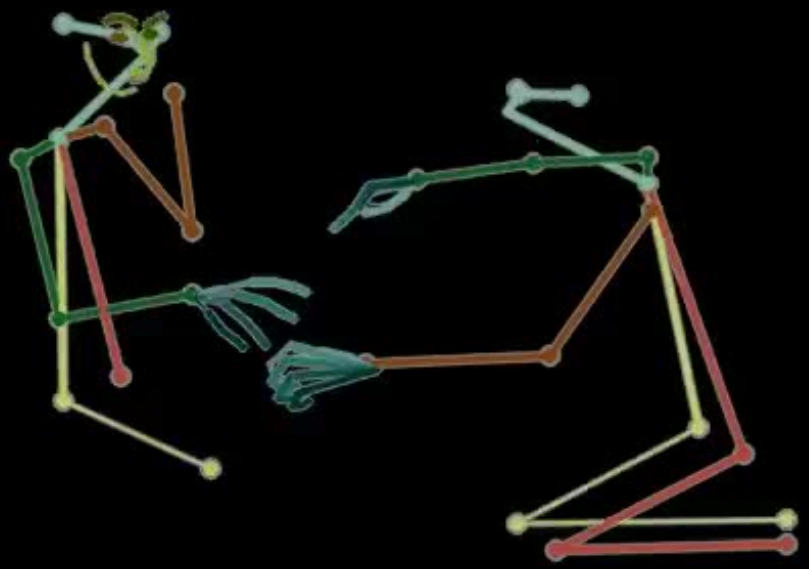
LARGEST OPEN DATASET OF NATURAL SOCIAL INTERACTIONS

Anonymised version (7.2GB) available on-line.
Grab it now!

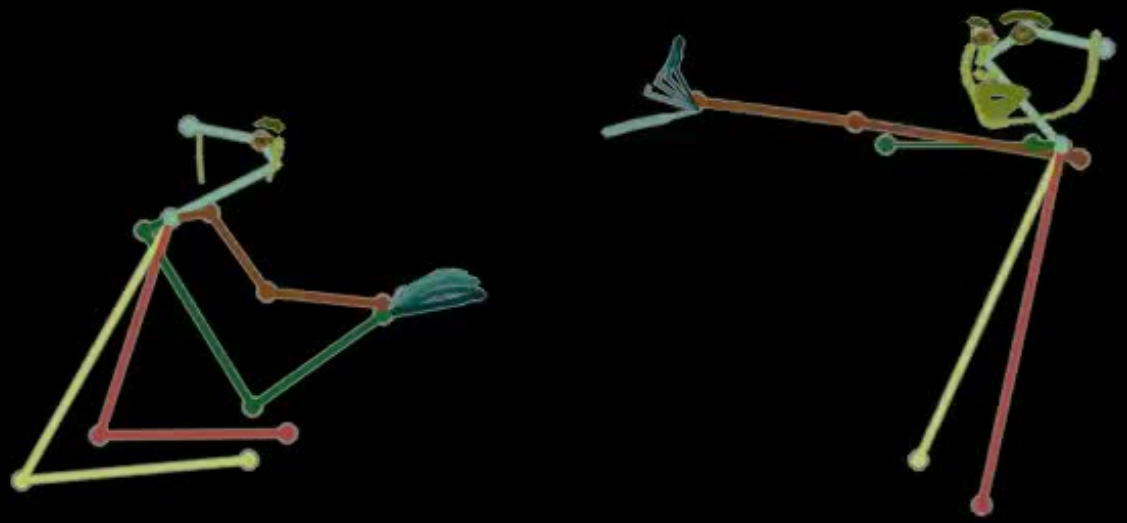
freeplay-sandbox.github.io

Open data! Hosted on EU's zenodo

CASE STUDY: UNDERSTANDING SOCIAL KINEMATICS




Focused!
ILLUMINATED POLITICAL
& PHYSICAL




open me

200 participants, 4 clips each, on MTurk

For each construct, calculate Δ and Σ

EFA: EXPLORATORY FACTOR ANALYSIS

	Factor 1 *full-scene*	**Factor 2** *full-scene*	**Factor 3** *full-scene*
Δ Sad	0.41		
Σ Sad		0.72	
Δ Happy	0.49		
Σ Happy			-0.55
Δ Angry	0.40		
Σ Angry		0.81	
Δ Excited	0.53		
Σ Excited			-0.71
Δ Calm	0.45		
Σ Calm			
Δ Friendly	0.69		
Σ Friendly			-0.43
Δ Aggressive	0.78		
Σ Aggressive		0.80	-0.36
Δ Engaged			0.65
Σ Engaged			-0.64
Δ Distracted			0.65
Σ Distracted		0.63	
Δ Bored			0.61
Σ Bored		0.58	0.48
Δ Frustrated	0.53		
Σ Frustrated		0.70	
Δ Dominant	0.75		
Σ Dominant		0.53	
Δ Submissive	0.68		
Σ Submissive		0.54	

EFA: EXPLORATORY FACTOR ANALYSIS

	Factor 1: imbalance *full-scene*	**Factor 2: (negative) valence** *full-scene*	**Factor 3: engagement** *full-scene*
Δ Sad	0.41		
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	Factor 1: imbalance		Factor 2: (negative) valence		Factor 3: engagement	
	full-scene	*mov.-alone*	*full-scene*	*mov.-alone*	*full-scene*	*mov.-alone*
Δ Sad	0.41	0.52				
Σ Sad			0.72	0.53		0.49
Δ Happy	0.49	0.53				
Σ Happy				-0.51	-0.55	
Δ Angry	0.40	0.62				
Σ Angry			0.81	0.85		
Δ Excited	0.53	0.63				
Σ Excited					-0.71	
Δ Calm	0.45	0.63				
Σ Calm				-0.45		
Δ Friendly	0.69	0.56				
Σ Friendly				-0.60	-0.43	
Δ Aggressive	0.78	0.79				
Σ Aggressive			0.80	0.72	-0.36	
Δ Engaged		0.39			0.65	0.52
Σ Engaged					-0.64	-0.64
Δ Distracted					0.65	0.63
Σ Distracted			0.63			0.82
Δ Bored		0.44			0.61	0.54
Σ Bored			0.58		0.48	0.83
Δ Frustrated	0.53	0.61				
Σ Frustrated			0.70	0.69		
Δ Dominant	0.75	0.81				
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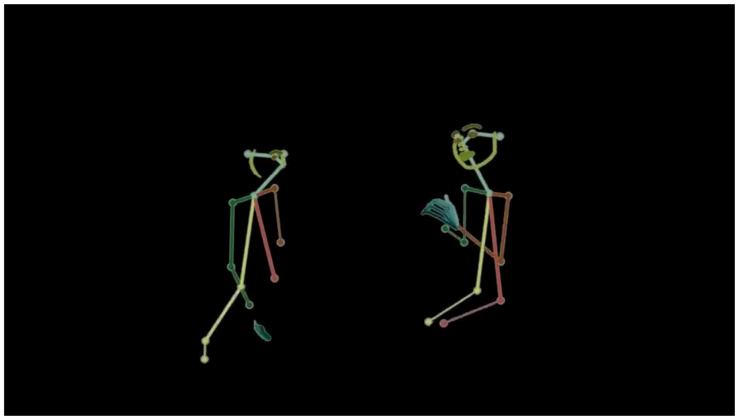
THREE CONSTRUCTS TO RULE THEM ALL



Interaction imbalance

Interaction valence

Engagement

MEAN EFA PROJECTION OF CLIPS PER SOCIAL SITUATION

The 20 clips were labelled after their salient social features (*aggressive*, *excited*, *aimless*, *fun*, *cooperative*, *bored*, *dominant*).

What happen if we project the ratings for 'aggressive' clips, 'excited' clips, etc. onto the 3 EFA factors?

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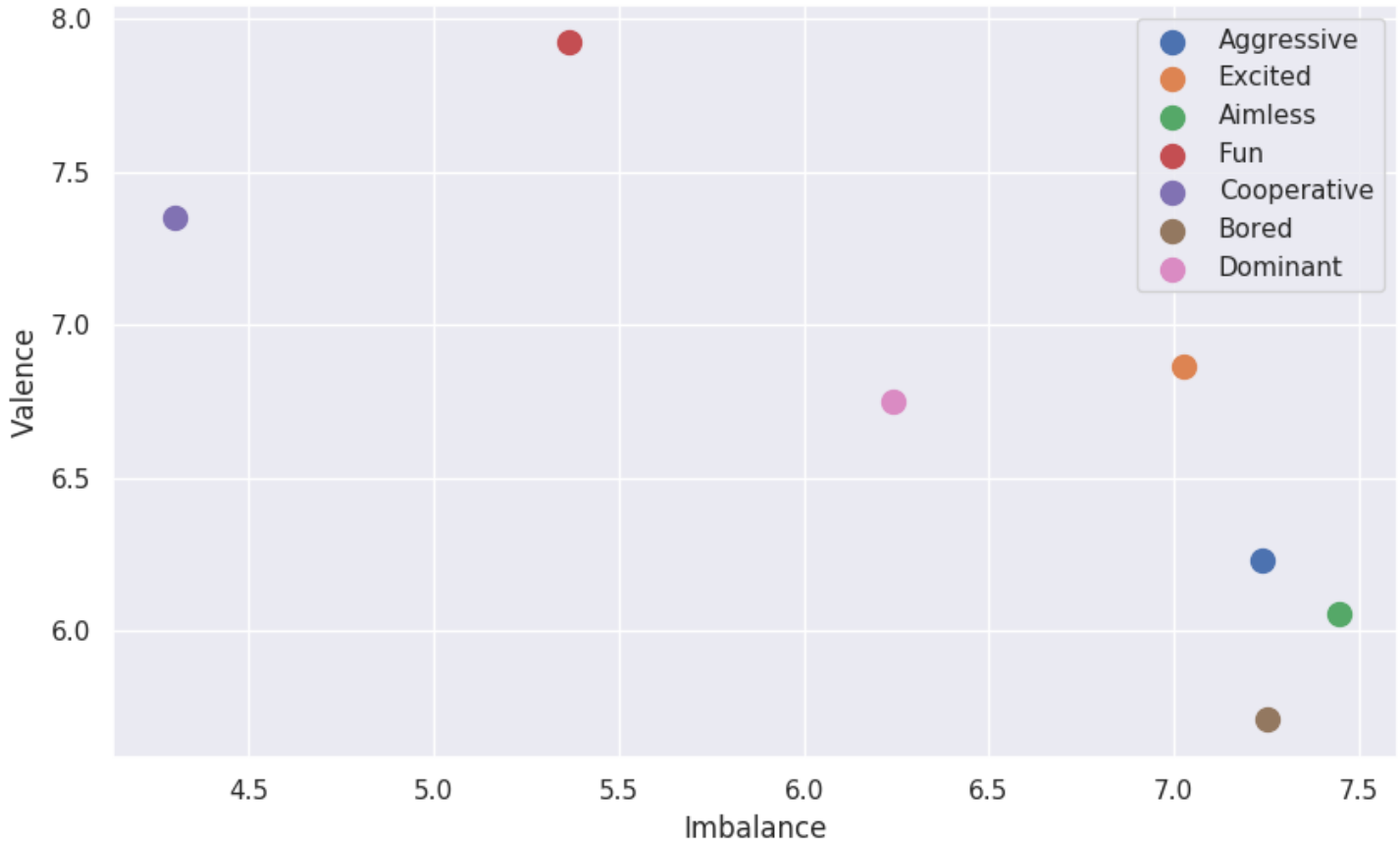

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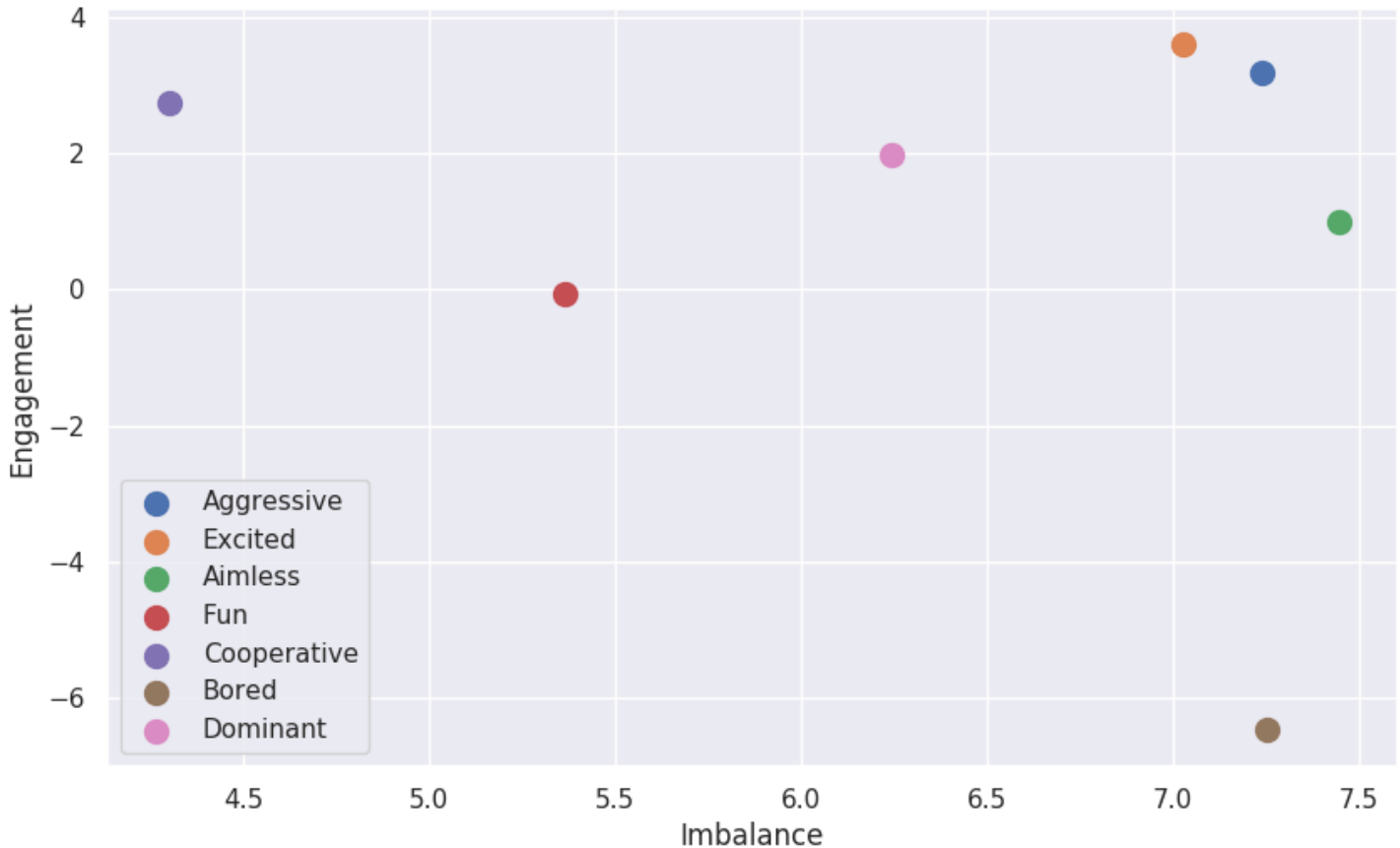

WHAT NEXT?


Attitude: passive
Social engag.: onlooker
Task engag.: no play
Attitude: passive
Social engag.: solitary
Task engag.: goal oriented

ULTIMATELY...

Real-time identification by the robot of...

- the **task engagement**

  is my partner 'on task' or not?

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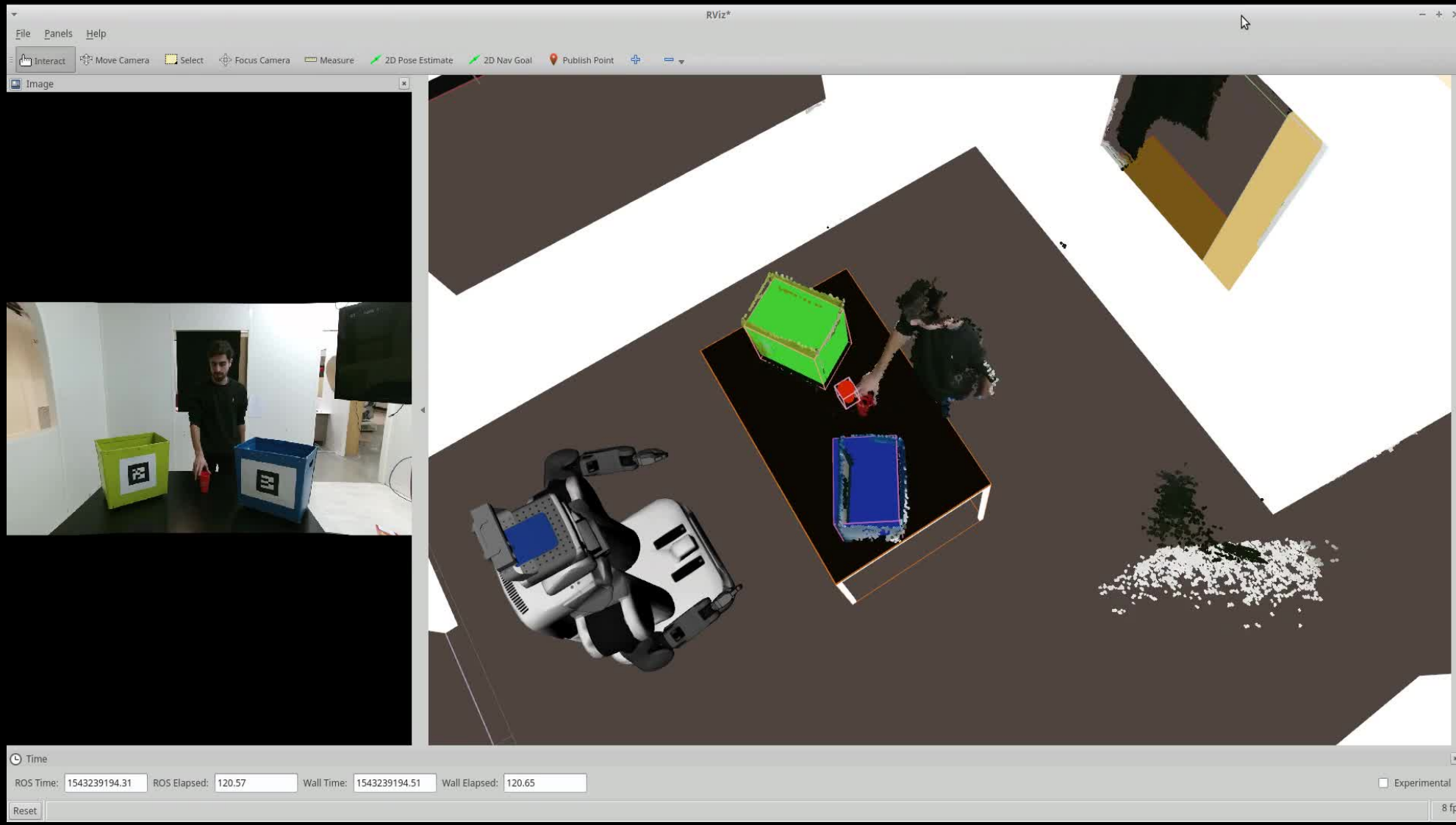
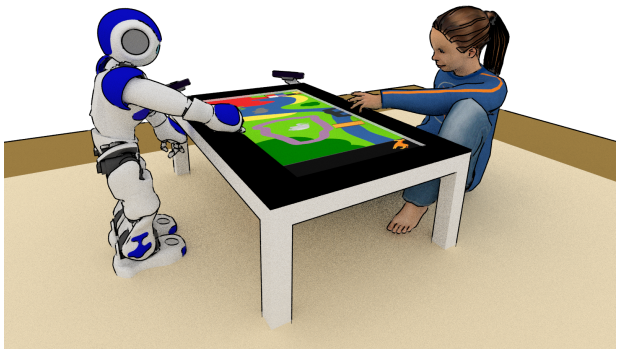
Social behaviours; Social dynamics: **generation as well!**

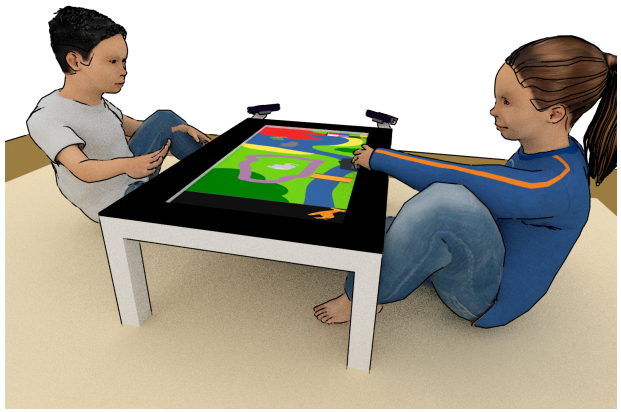
Thank you!

SOME MORE STUFF


RViz*
File
Panels
Help
Interact
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
2D Nav Goal
Publish Point
Image
Time
ROS Time: 1543239194.31
ROS Elapsed: 120.57
Wall Time: 1543239194.51
Wall Elapsed: 120.65
Experimental
Reset

TWO BASELINES





child - non-social robot

child - child

richness of social interactions

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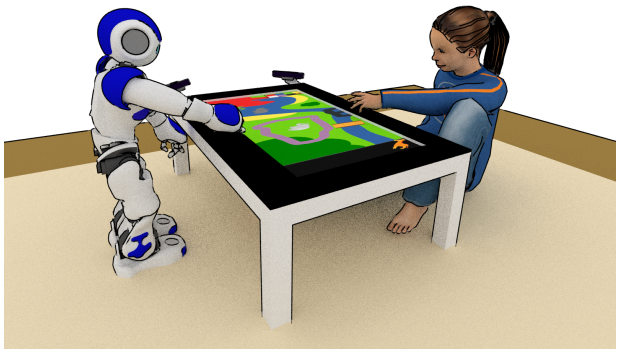

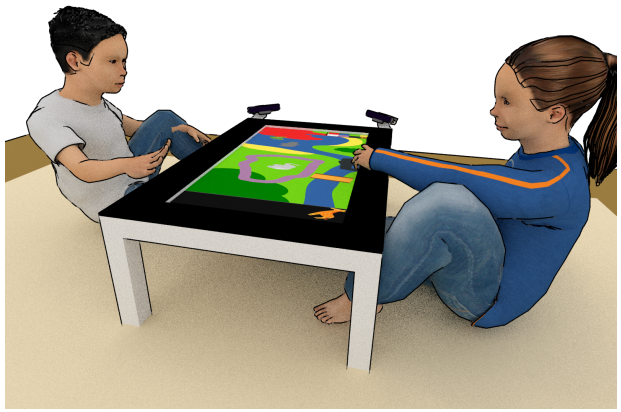

child - non-social robot

your next socio-cognitive model

child - child

richness of social interactions

SOME BUILDING BLOCKS EXISTS

- **Multi-modal fusion**

  e.g. Noda et al. **Multimodal integration learning of robot behavior using DNN**, Robotics and Autonomous Systems 2014

- **Behavioural sequences recognition**

  How et al. **Behavior recognition for humanoid robots using long short-term memory**, IJARS 2016 → *LSTM to recognise Nao behaviours*

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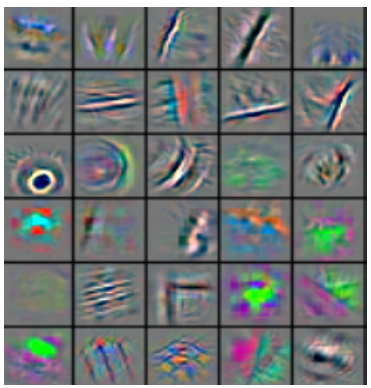
DBSoC: Deep Behavioural Social Cloning – LfD + CNNs + LSTM

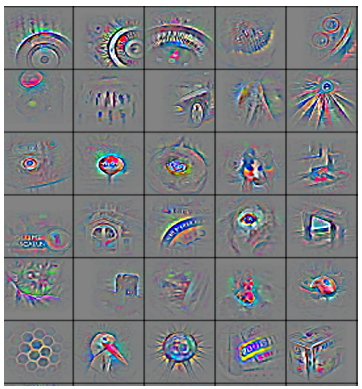
Two tasks for a telepresence robot:

1. position itself in a (dynamic) group of persons
2. follow 2 persons

DEEP NETWORKS ≡ BLACK BOXES?

→ Low-Level features → Mid-Level features → High-Level features → Trainable classifier





[taken from a NIPS2015 tutorial by Geoff Hinton, Yoshua Bengio & Yann LeCun]

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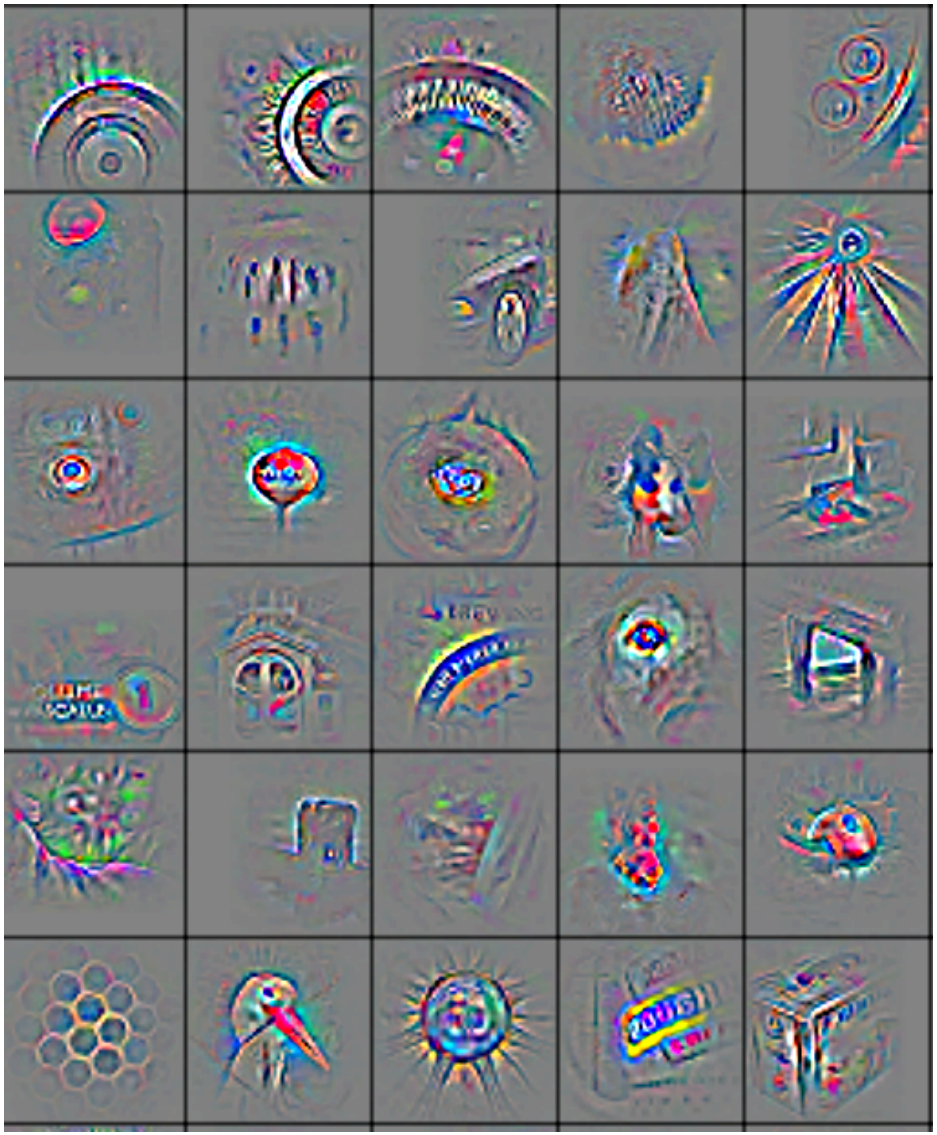

[taken from a NIPS2015 tutorial by Geoff Hinton, Yoshua Bengio & Yann LeCun]

WHAT DID WE RECORD?

Domain	Type	Details
child × 2	audio	16kHz, mono, semi-direction
	face (RGB)	qHD (960x540), 30Hz
	face (depth)	VGA (640x480), 30Hz
	facial features	70 2D points, 30Hz
	skeleton	15 2D points, 30Hz
	hands	20 x 2 2D points, 30Hz
environment	RGB	qHD (960x540), 29.7Hz
touchscreen	background drawing (RGB)	4Hz
	touches	6 points multi-touch, 10Hz
	items position and orientation	(x,y,theta), 10Hz
annotations	timestamped annotations of social behaviours	
+ post-process	optical flow, audio features	
	facial action units...	