R&D&I IN DIAGNOSIS AND THERAPY: LESSONS FROM THREE CASES

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The three cases

1. Intelligent assistant for ***physical rehabilitation***
2. Machine help for ***autism diagnosis and therapy***
3. Machine assistant in cognitive behavioral therapy ***for PTSD***

First, I will talk about the needs of these tasks

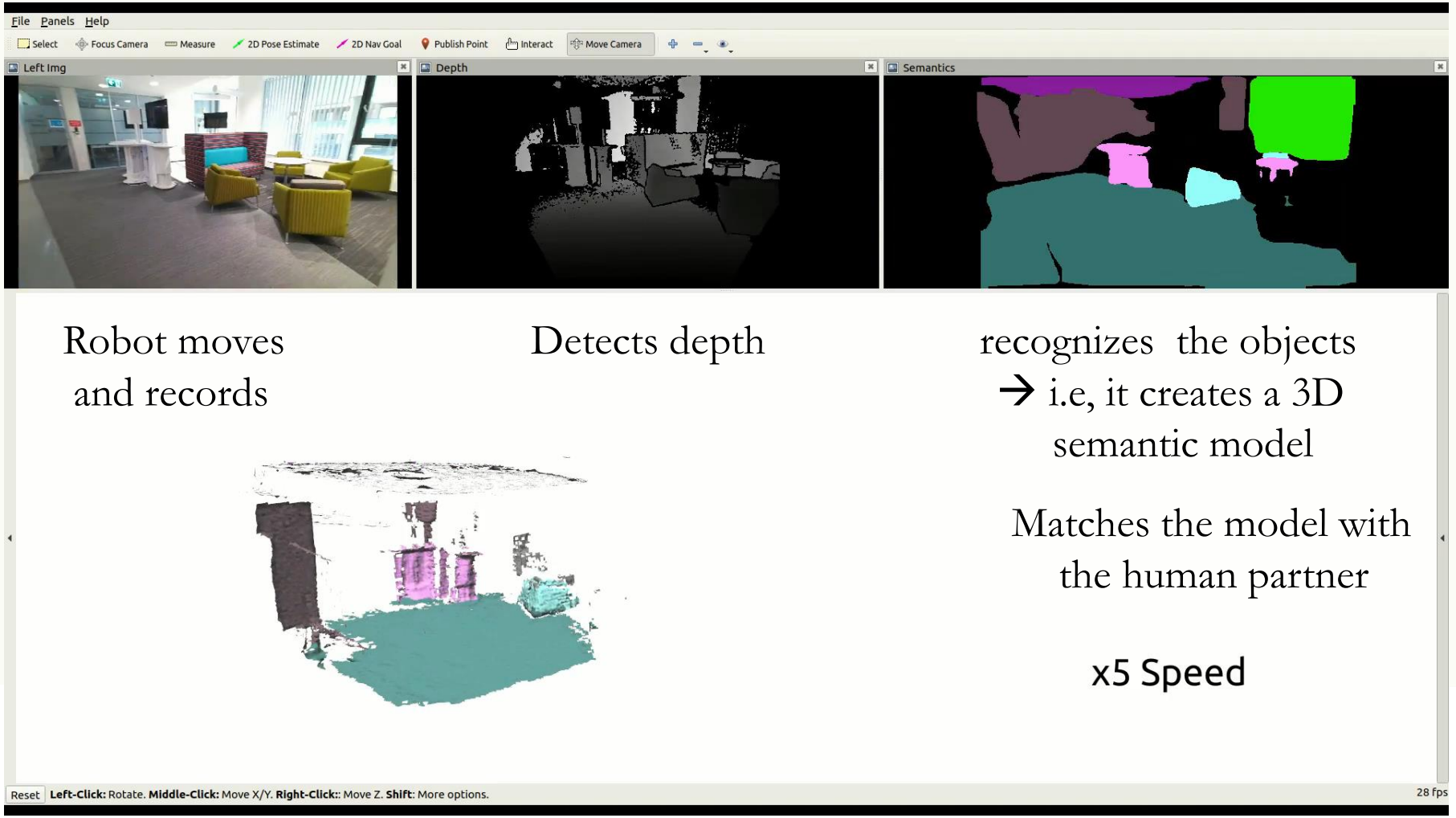
and then the three cases

General needs

The machine

- should know about the environment and
- follow and help the execution of the task,
- detect manipulation and patient's movement,
- should know about the mood, emotions, and personality, and
- should optimize the collaboration,
- and thus, ***verbal communication*** *during task execution* ***is a must***

Environment ⇒ Semantic Map ⇒ Verbal Interaction

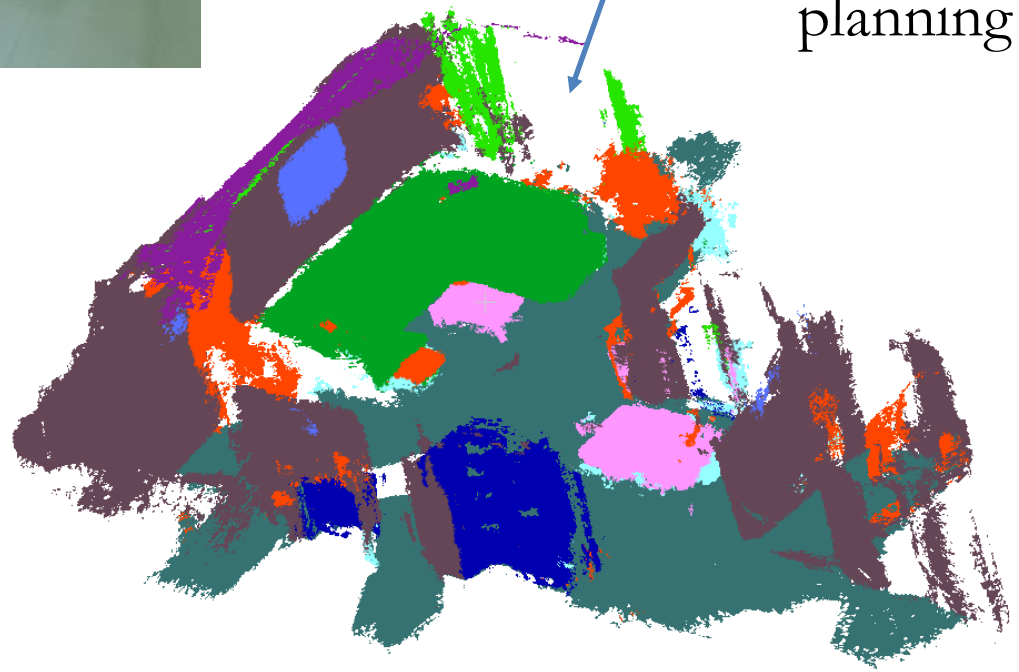


3D Semantic Label Transfer in Human-Robot Collaboration. In *Proceedings of the IEEE/CVF International Conference on Computer Vision*, pp. 2602-2611. 2021.

3D Semantic Label Transfer and ***Matching*** in Human-Robot Collaboration – submitted

Semantic Map can be used in different ways

- Robot can talk about partner's body relative to the objects, and directions in:
  a. the patient's ego-centric coordinate system – e.g., for guidance and motion error correction
  b. top-down view – for path planning



Components for characterizing patient's state

We are combining the following tools

- Body part detection and motion estimation
  - *full body*, *head*, *hand*,
  - *object in hand* ←→ *detecting manipulation*,
  - *eyes*, *blinking*
  - *gaze* ←→ *estimating intention*
- Behavior estimation
  - *emotion*
- Software tools
  - *tracking*
  - *information fusion using deep transformer networks*
  - *deep neural networks and* ***Composite AI***

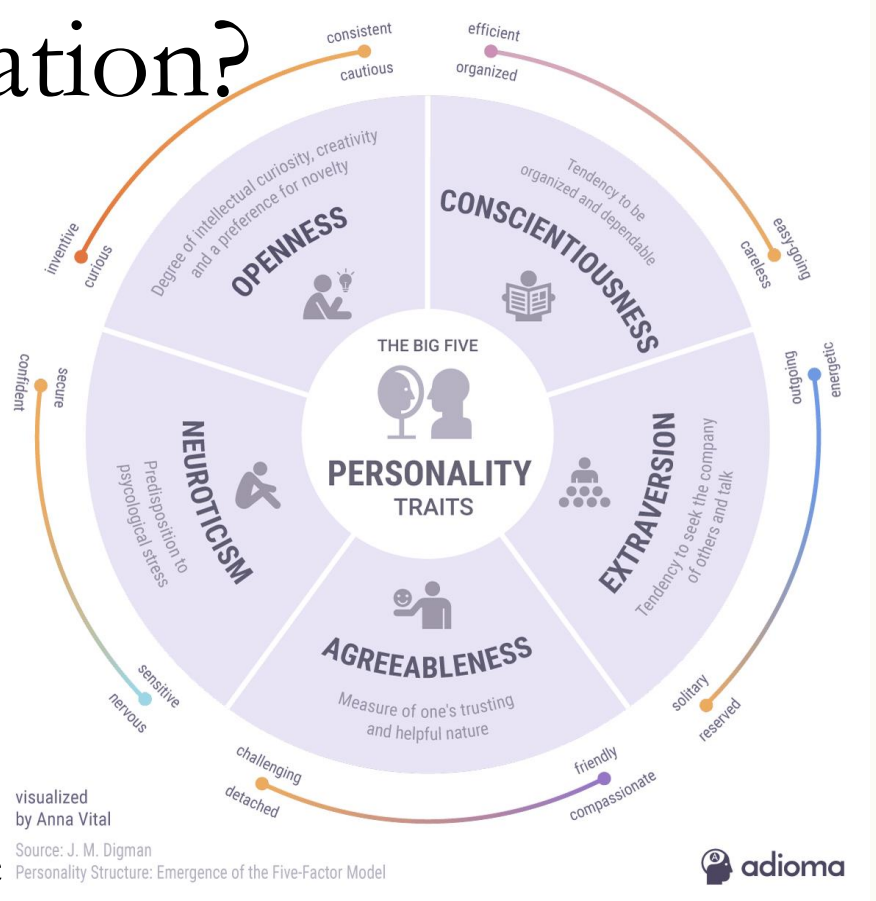
Personality for optimizing collaboration?

Many different measures

- ***Big-five*** is the most popular:
  - Openness
  - Conscientiousness
  - Extraversion
  - Agreeableness
  - Neuroticism (opposite of Emotional Stability)

  OCEAN

Method: Self-assessment. For example: BFI-10 – 10-item questionnaire



- Self-assessment may change but it is a slow process.
- ***But during interactions:***
  - ***OCEAN parameters may change by quickly***
  - ***Actual personality influences the interaction***

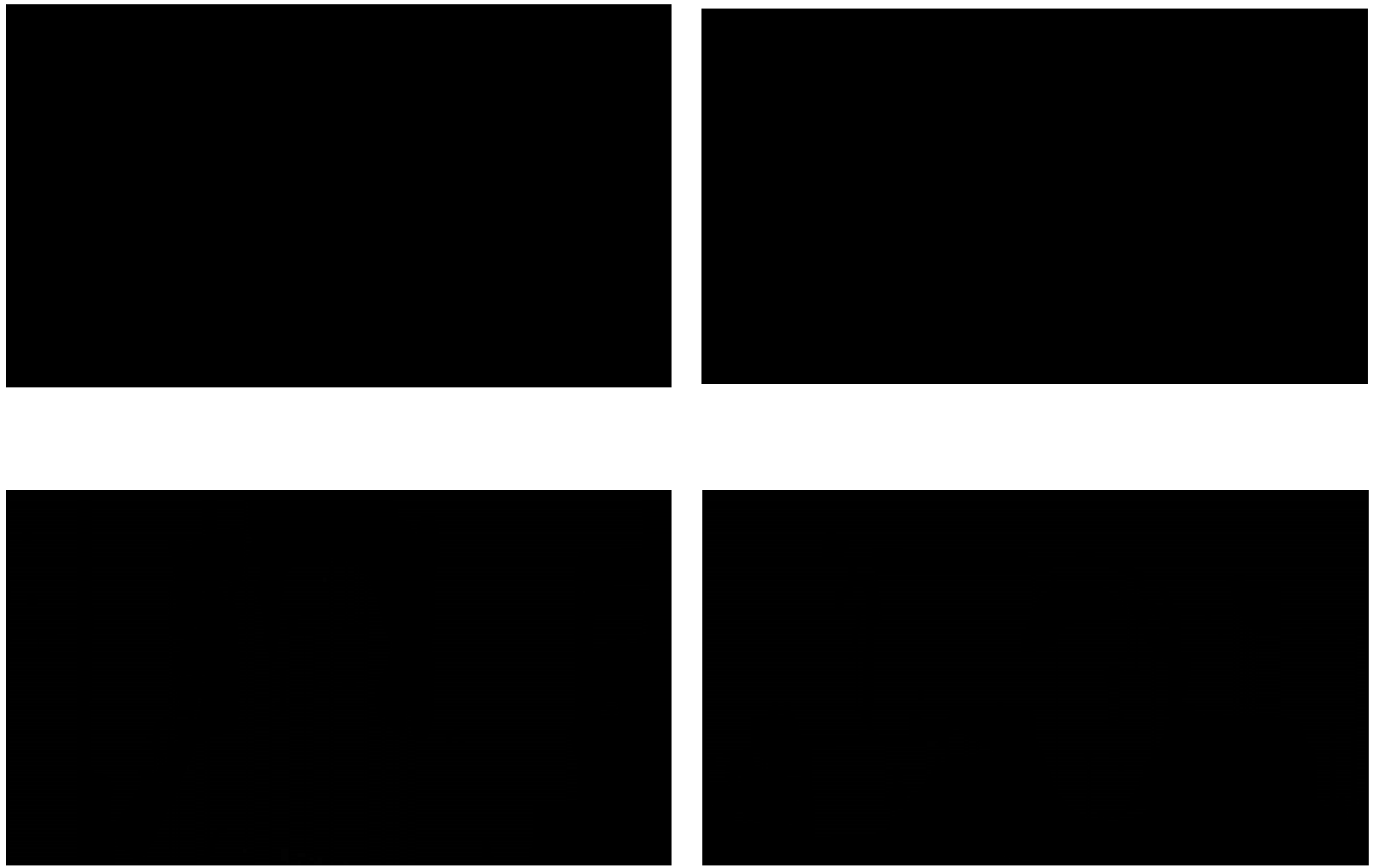
The ChaLearn Database

Barcelona group:
Escalante, H. J.; Kaya, H.; Salah, A. A.; Escalera, S.; Gucluturk, Y.; Guclu, U.; Baró, X.; Guyon, I.; Jacques Junior, J. C. S.; Madadi, M.; Ayache, S.; Viegas, E.; Gurpinar, F.; Wicaksana, A.S.; Liem, C.C.S.; van Gerven, M. A. J.; van Lier, R. "Modeling, Recognizing, and Explaining Apparent Personality from Videos," IEEE Transactions on Affective Computing (TAC), 2020.

15s vlogs
more than 10,000 with relative OCEAN scores using Amazon Turk

We trained a deep transformer-based fusion architecture with 10,000 vlogs.

We have 15s estimations



"Multimodal Sentiment and Personality Perception Under Speech: A Comparison of Transformer-based Architectures." In *Understanding Social Behavior in Dyadic and Small Group Interactions*, pp. 218-241. PMLR, 2022.

Perceived personalities

Perceived personality may differ

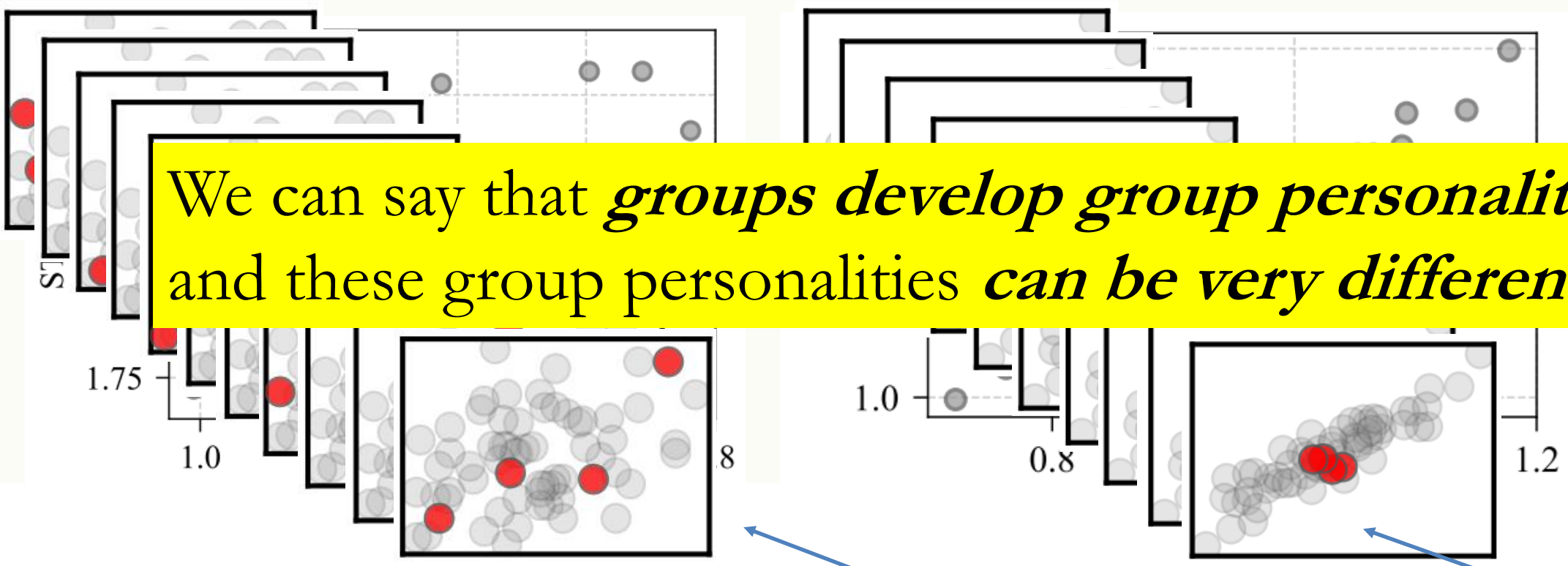
- in different groups
- as a function of the task performed
- We worked with different databases (ELEA, UDIVA, AMI, Multisimo)
- I show results on two ***meta traits***
  - ***Stability*** (Agreeableness + Conscientiousness + (Emotional Stability))
  - ***Plasticity*** (Extraversion + Openness)

ELEA =: Emergent LEader Anal-ysis

Example: the ELEA database

(a) Self-assessment

(b) During task execution (narrower distribution)



We can say that ***groups develop group personalities*** and these group personalities ***can be very different***

17 groups, 63 participants

Red blobs: group members

groups are as if they ***were „sampled”*** from the full distribution

groups are as if they ***were not „sampled”*** from the distribution

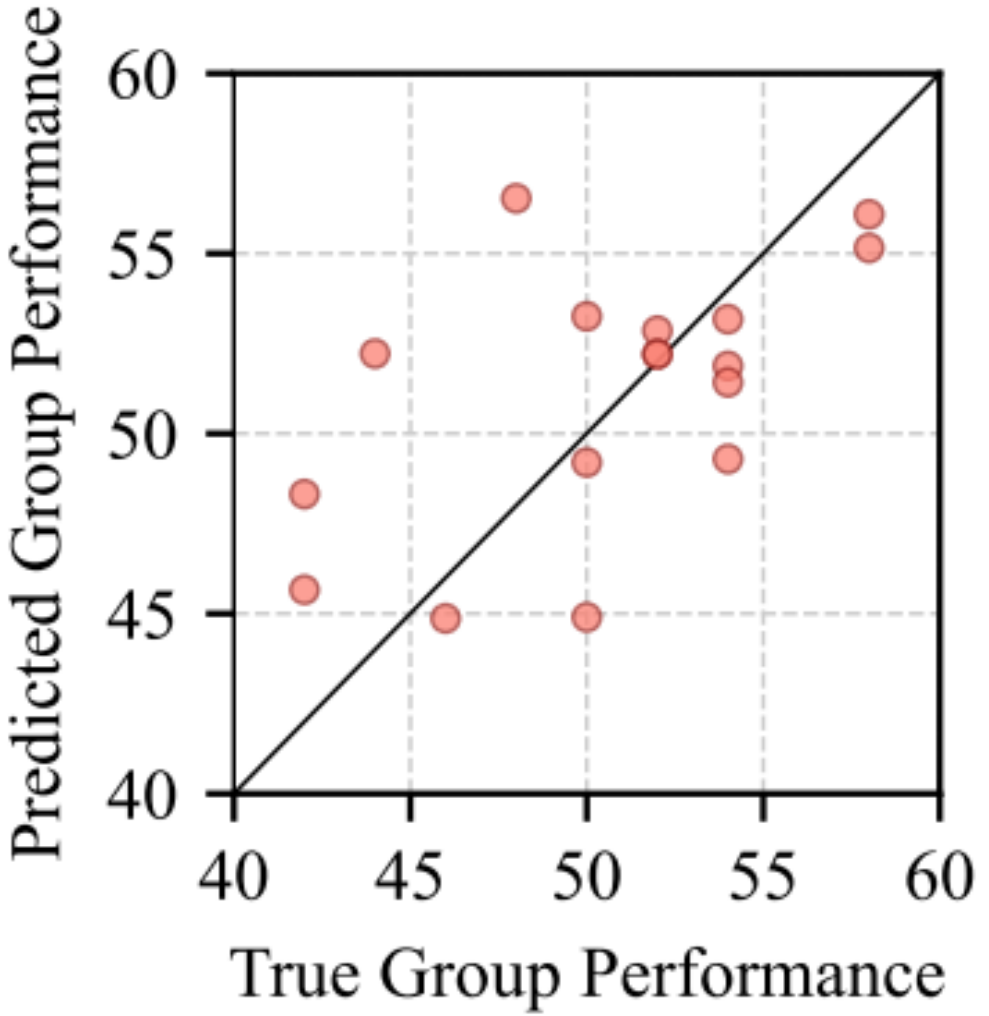
Performance

Prediction of group performance is possible

- The same prediction does not work for group affect estimations

OUTLOOK

- Personality estimation may help improve performance during patient-avatar dyadic interaction by *modulating the* personality of the avatar partner



APPLICATIONS

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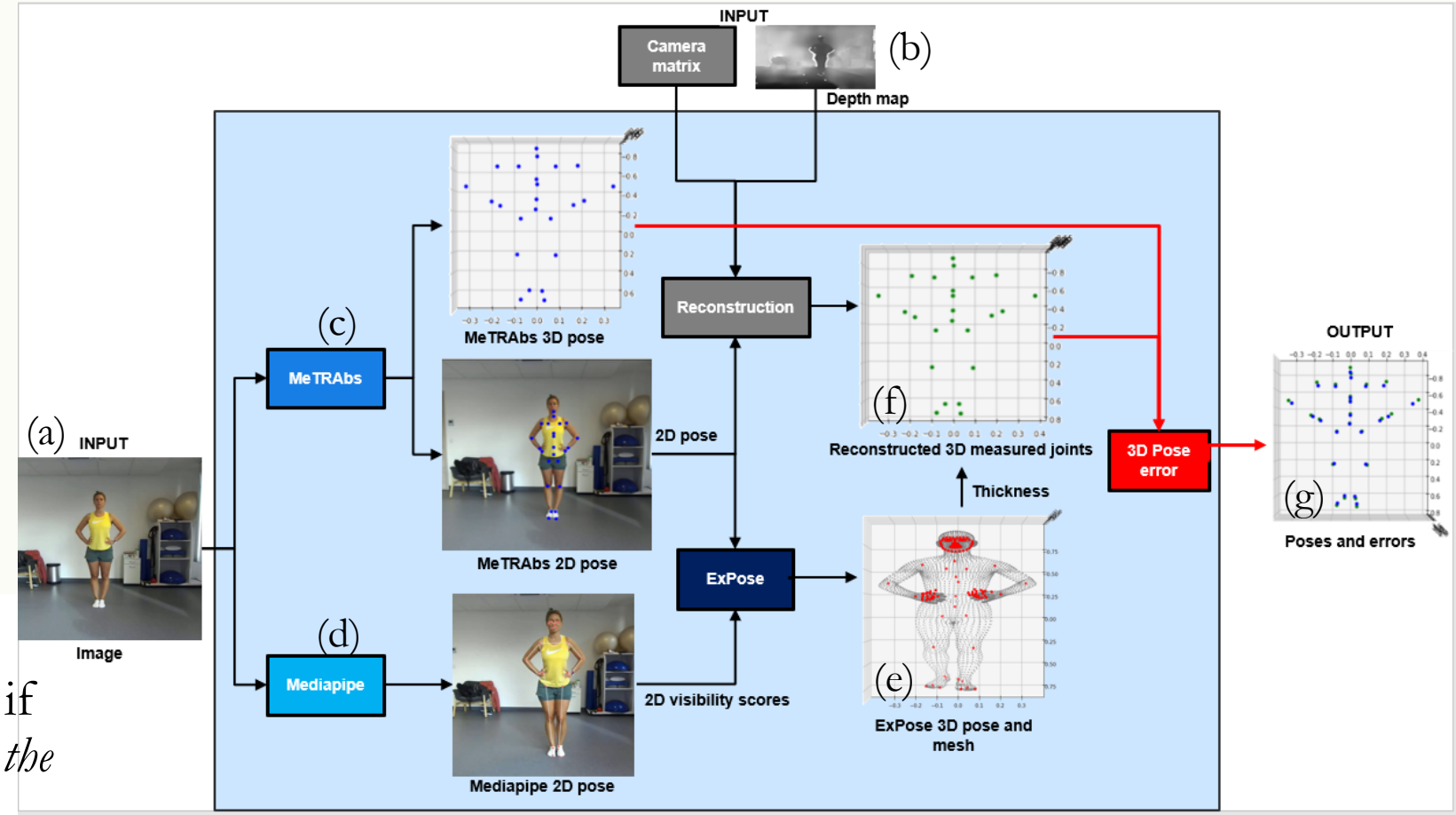
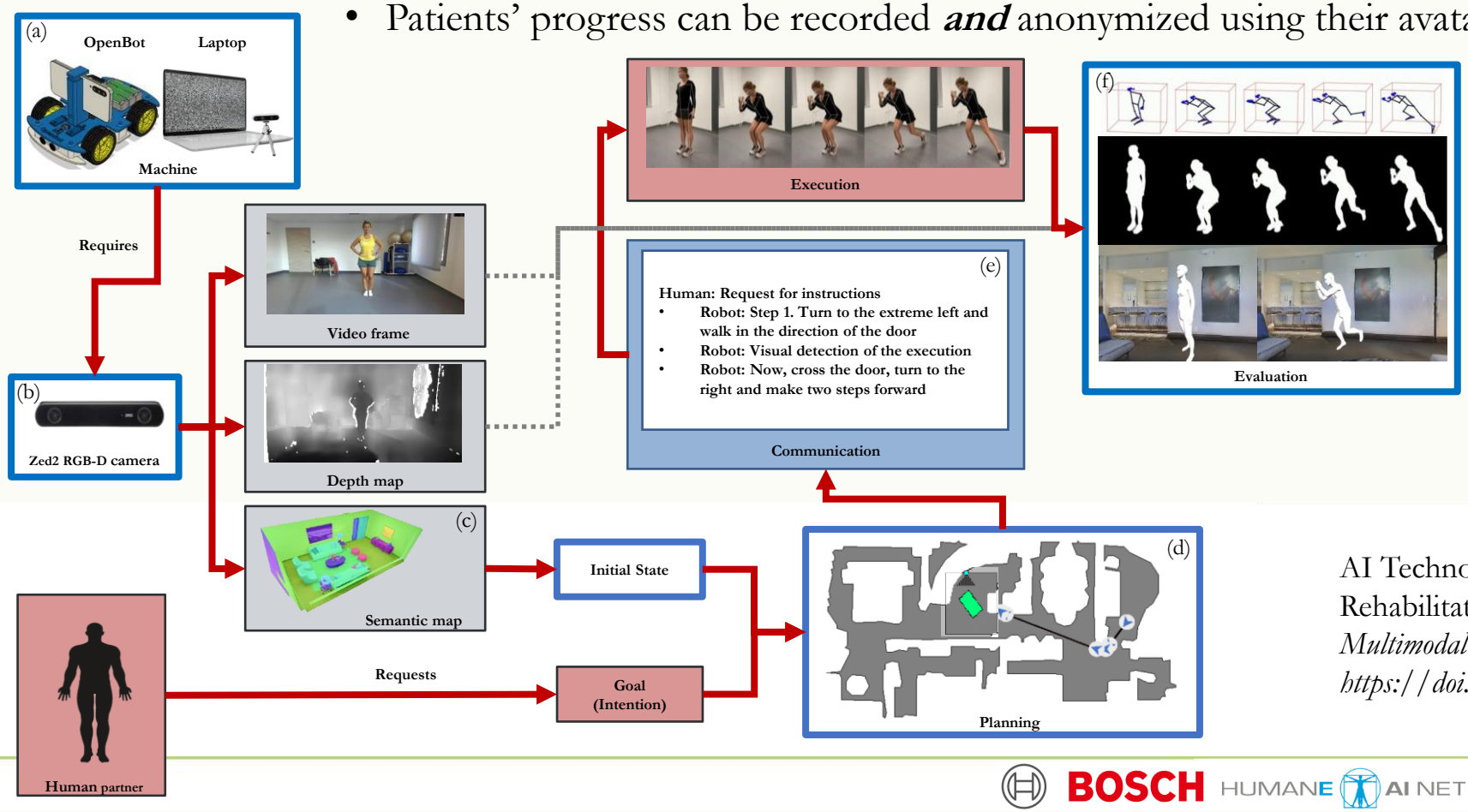
Physical rehabilitation
⇒ Human body pose estimation

- Precise pose estimation and error minimization
  - with 2D cameras
- Software tools
  - MeTRAbs software
  - MediaPipe software
  - ExPose for avatar model
  - New transformer models
- Result:
  - Precise (2-4 cm) pose estimation if *patient is guided to the right place and the direction is right*



Physical rehabilitation:
⇒ Full architecture (only the components are ready)

- Video recording of the expert results in avatar-based demonstration that can be viewed from different angles
- Patient's avatar model for the optimization of positions and directions (camera and patient) within the map
- Dialogue for guiding navigation, explaining errors, and offering pre-recorded suggestions for error correction
- Patients' progress can be recorded ***and*** anonymized using their avatars and virtual environments.



AI Technologies for Machine Supervision and Help in a Rehabilitation Scenario.
Multimodal Technol. Interact. 2022, 6(7), 48;
https://doi.org/10.3390/mti6070048

Manipulation/activities

What is s/he doing?

What is her/his mood?

What is s/he up to?

Is help needed?

How could the machine help?

Composite AI combines deep networks

1. 3D upper body (including wrist and hand) estimation from 2D camera using MediaPipe
2. Hand detector trained with tracked samples
3. Hands detected by MediaPipe and hand detector must "agree"
4. Tracking based improvements if they don't
5. 3D hand configuration estimation

Manipulation and interaction – healthy children

I can't show movies with autistic children, unfortunately

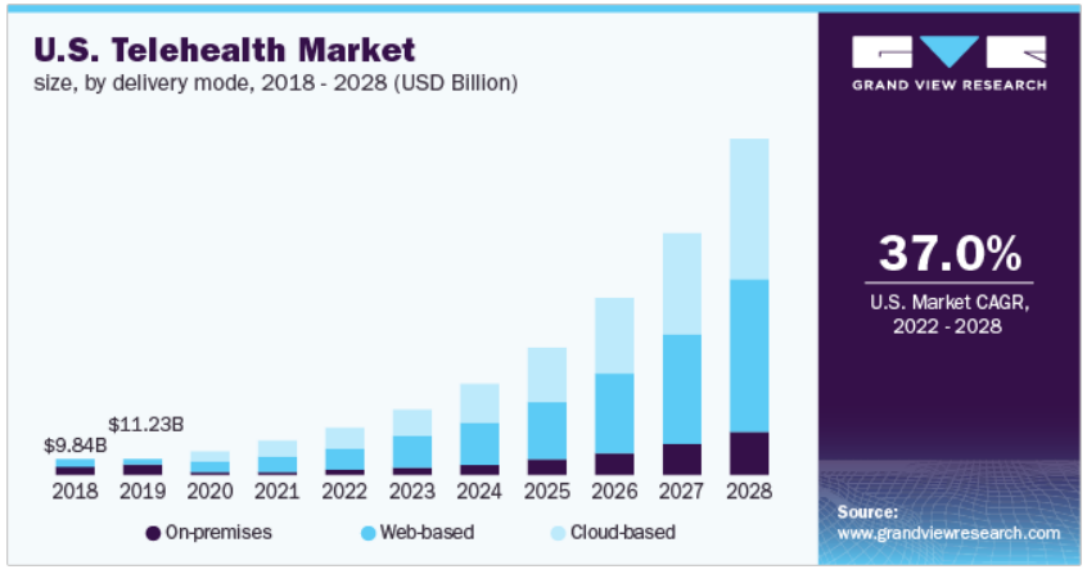
PTSD, depression, anxiety – under construction

- ***Cognitive behavioral therapy uses homeworks, like***
  - writing a diary,
  - doing *thought recording* with Socratic-Questioning Technique
- However, ***adherence*** to the homeworks is
  - critical as they are useful
    - for the documentation of the success of the therapy and
    - enable high-quality cross-border follow ups.
- We are about to use techniques ***known to improve adherence*** to homeworks
  - dialogues with ***paraphrasing*** and ***clarifying questions***
  - modulating ***avatar*** reactions according to content
- ***Under construction***

TRL and Market for the three cases

- Autism: startup is entering Series A financing stage
- Physical Rehabilitation: ready for launching a startup – no plan yet
- PTSD, depression, anxiety – R&D&I project is under construction

Global Home Rehabilitation Market $225 Billion by 2027
October 20, 2021 by [iHealthcareAnalyst, Inc.]



Demand for Global Mental Health Software Market Size Will
- hit USD 5,7 Billion by 2028,
- Exhibit a CAGR (Compound annual growth rate) of 18.50%

Our partners:

Autism

- **USA:** Autism Center, Rush Medical School, Chicago
- **USA**: Argus Cognitive, Inc.

Phyical rehabilitation

- **Hungary:** Emineo Clinic, Budapest – Therapy after total knee/hip replacements
- **Czechia:** Charles University, Prague – NLP

Personality estimation

- **Spain:** Barcelona University
- **The Netherlands:** Delft Technical University – Covid-19 study

Avatar animation/design and smart environment

- **Germany:** DFKI (German Research Center for Artificial Intelligence)

PTSD - under construction

- **Ukraine:** National Technical University, Kharkiv
- **USA:** Veteran Center, Rush Medical School, Chicago – Zoom recordings

National Laboratory of Artificial Intelligence, Hungary

- Main Hungarian universities, research centers, and governmental units

EU project: HumanE-AI

- 53 partners on Human-Centered AI from basic science to prototypes

Lessons

These are complex tasks that require:

- AI experts → Composite AI methodology
  - including speech processing, video processing, rule-constrained chatbots, and avatar animation designers
- ***psychologists, psychiatrists***
- ***physiotherapists***
- ***experts on the fields of***
  - ***medical psychology***
  - ***medical sociology***
- legal partners, including experts on privacy, human rights, GDPR, and ethical issues
- ***high-tech naturalistic environments for testing***

among others

Photos are ***from our partner***:
Interactive Machine Learning Lab
DFKI – Saarbrücken and Oldenburg

https://nipg.inf.elte.hu/
https://iai.inf.elte.hu/
https://www.elte.hu

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ADDITIONAL SLIDES

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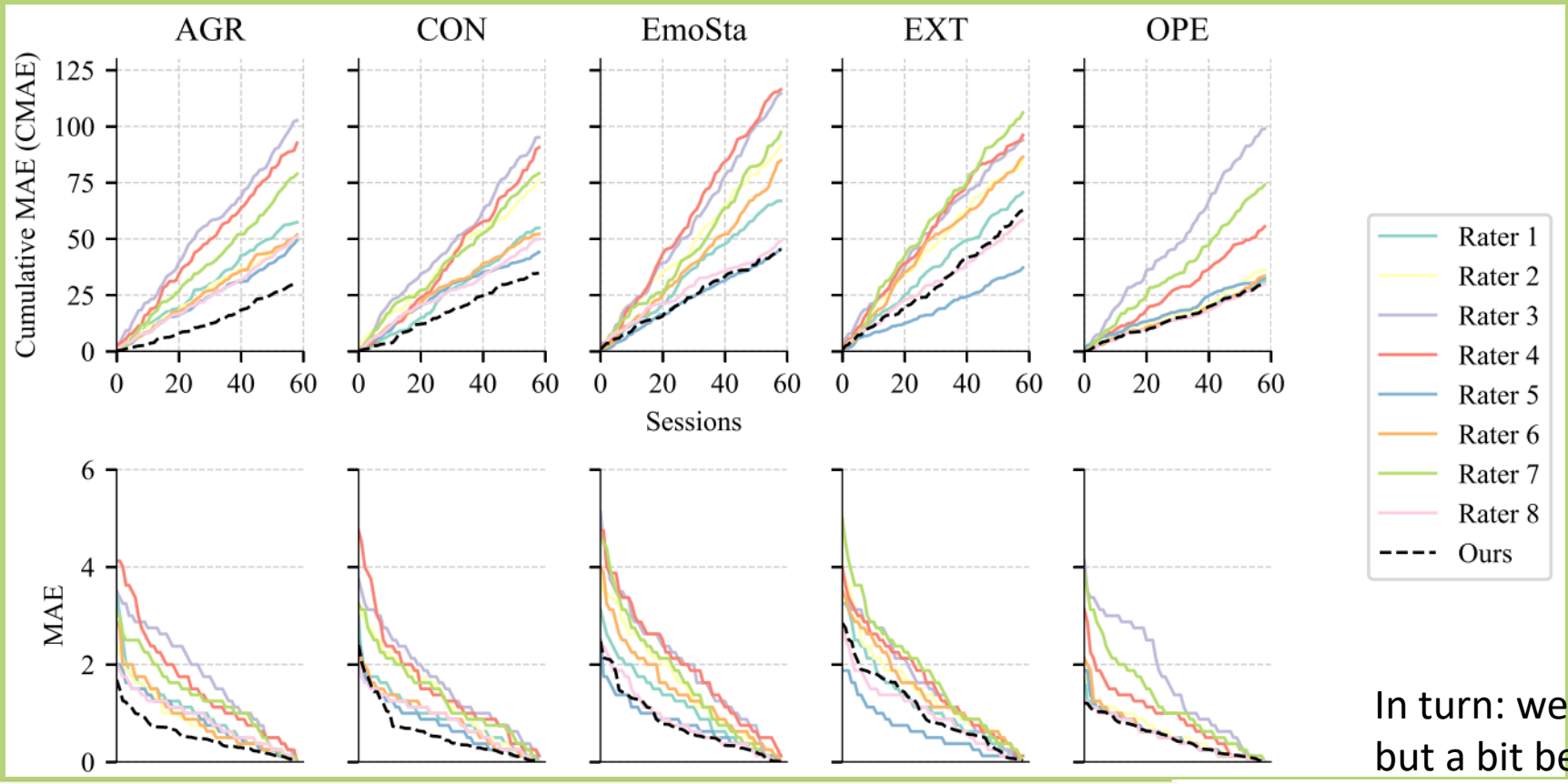
What we measure (submitted – don not quote it yet..)

- Fortunate situation: Database Multisimo
- It has: 8 raters estimate perceived personalities over 15s videos on 59 time segments



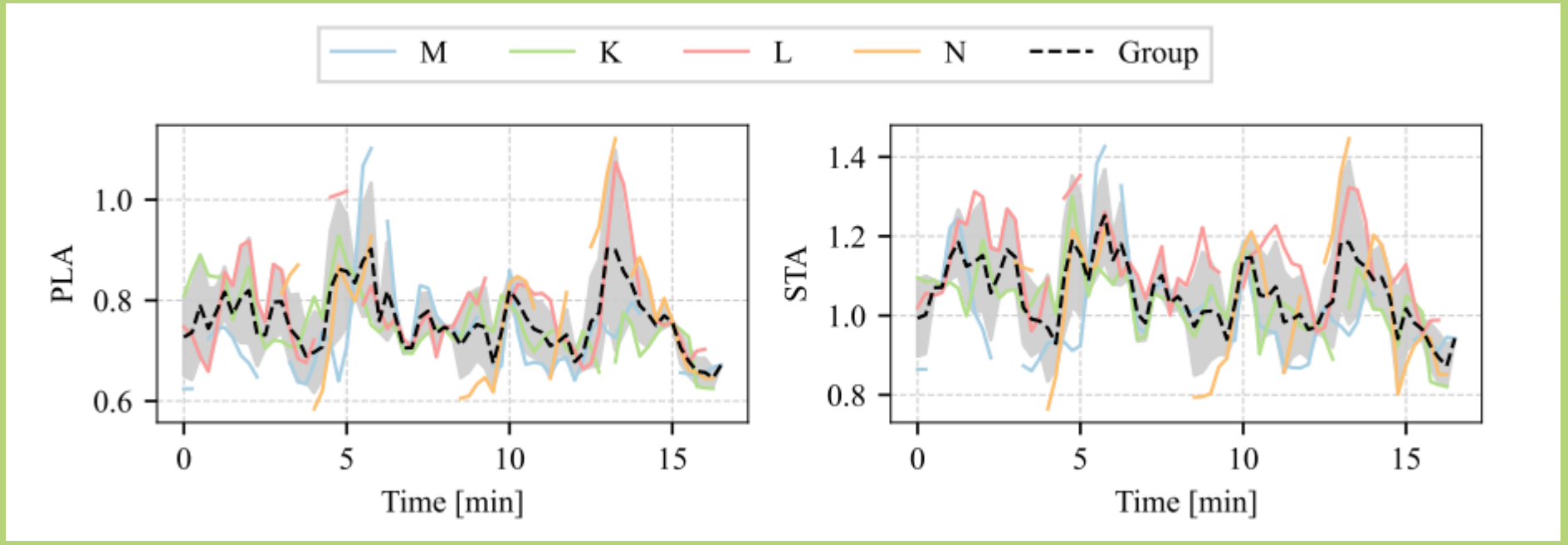
Rater error from the average first impression score for the raw big-five traits.

- Top row: Cumulative mean absolute error (CMAE) of the human raters and the mapped transformer rating.
- Bottom row: Mean absolute error for human raters and the mapped transformer rating. MAE shown in descending order

In turn: we are measuring what human raters do, but a bit better than the majority of the human

Can we predict performance?

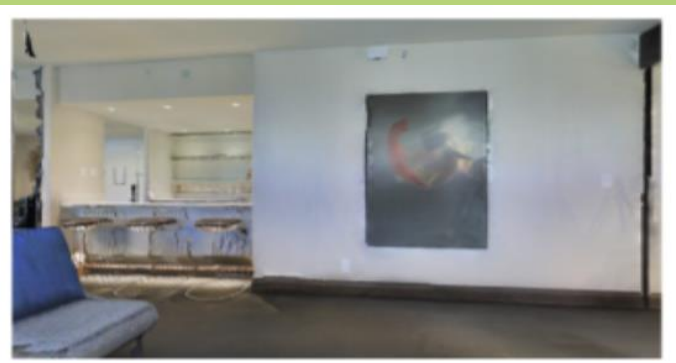
- There is a temporal dependence
  - Groups change over time
  - They tend to move together, or come together from time-to-time



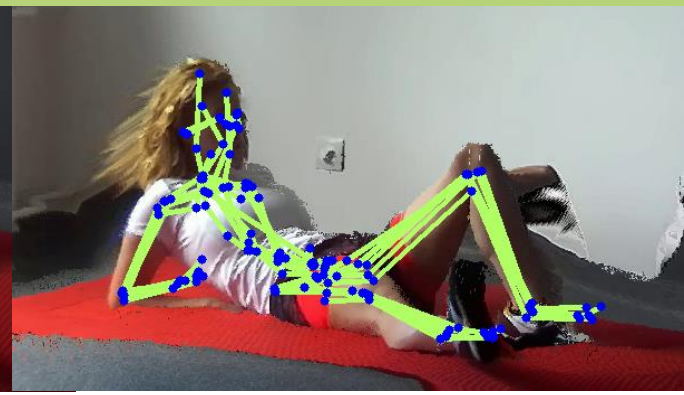
Rehabilitation scenario

- Deep deep network's outputs
  - *Should be non-foolable*
  - *Should provide explanations*
    - Networks that develop dictionaries (sparse coding networks) are promising
- Real time solutions
- Verbal interaction – environmental intelligence can help, controls and may provide instructions
  - joint cognitive space – „semantic map"

Complexity of the full software is large



Where to?
What trajectory?
Where to put the camera?
What to execute?
What was the error?
How to correct the error?
Problems with 2D cameras



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Department of Artificial Intelligence
Eötvös Loránd University (ELTE)
Budapest, Hungary

ELTE's Department of Artificial Intelligence

Founded on May 9th 2022

MESTERSÉGES INTELLIGENCIA TANSZÉK

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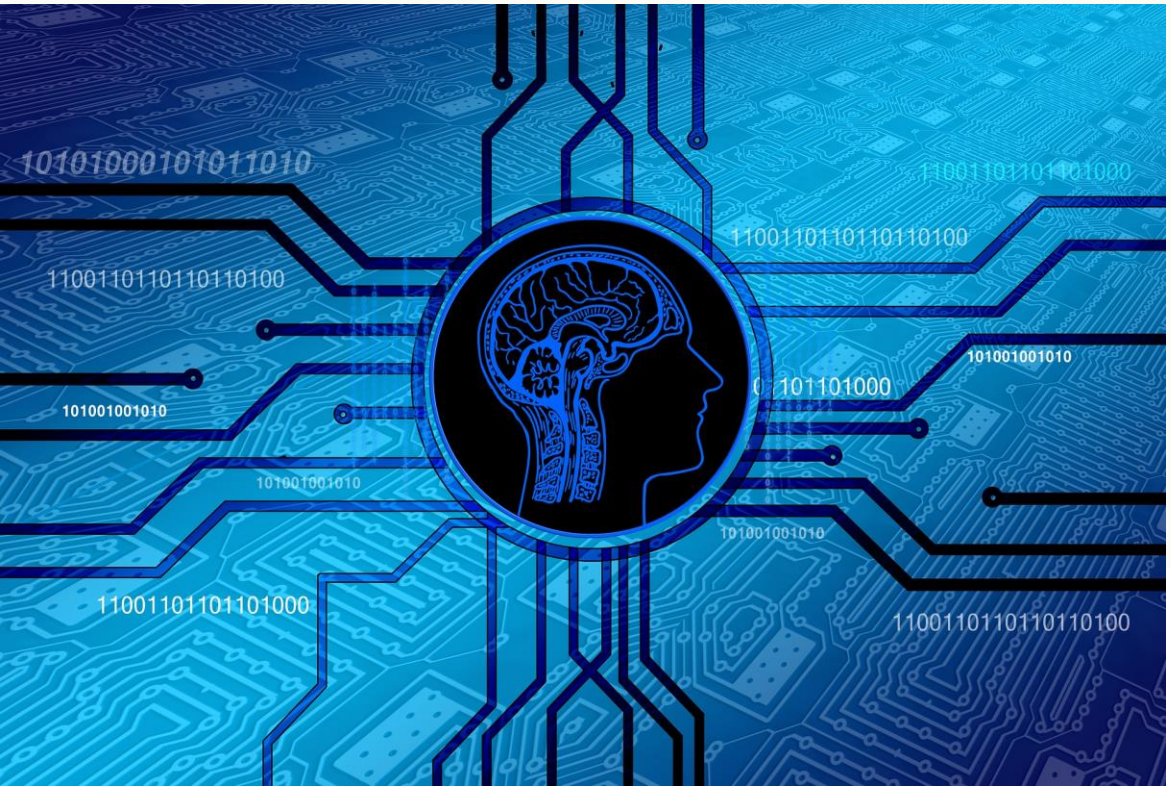


Our department has been founded in cooperation with Bosch. We proudly believe that industry-academy collaboration is a most fruitful driver of research and technology education that combines scientific rigor with practical relevance. This creates synergies that result in excellence not only in research and education, but in innovation as well.

BOSCH

AI research found for industrial collaboration
155 000 EUR / year
2020 - 2022

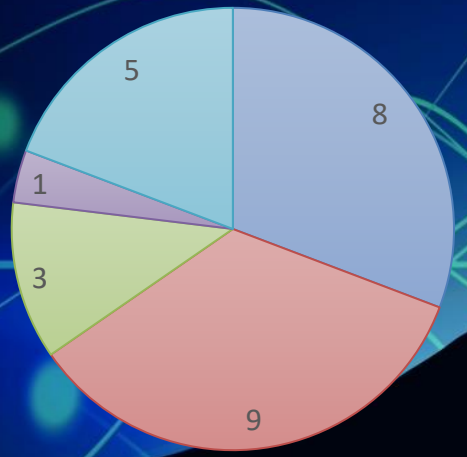
ELTE's Department of Artificial Intelligence

We work on human-centered Artificial Intelligence (AI). On a trustworthy, ethical technology that enhances human capabilities. Our mission is to empower citizens and society to benefit from the AI revolution we are undergoing and to avoid the challenges of our age.

Our aim is to build a Department that is listed among the bests in Europe and is the number one in Hungary in Computational Intelligence and Composite AI. To this end, we work with a diverse set of technologies, like Deep Learning, Evolutionary Technologies, Embodied and Societal Intelligence.

ELTE's Department of Artificial Intelligence

AI Department Staff, 2022



- PhD student
- Assistant Research Fellow
- Senior Research Fellow
- Dept. Administrator
- Research Fellow

Total number of involved students in 2022 to the R&D activities of the AI Department

- BSc
- MSc DS
- MSc AI
- MSc AUS
- MScHUN
- PhD

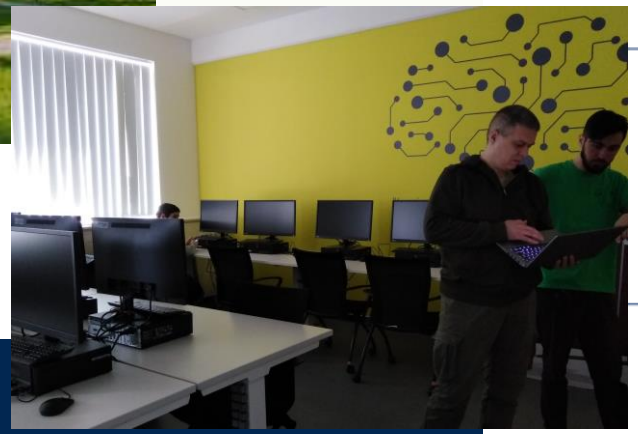
Introducing University Eötvös Loránd Budapest (ELTE)

University Eötvös Loránd Budapest (ELTE) is **Hungary's most prestigious university with the richest traditions and the highest international and national rankings** in the country, where **tradition and innovation** go hand-in-hand. Throughout the course of its history, which stretches back almost four centuries, ELTE's excellence has been based on the strong ties between education and research. Its mission includes preserving and enriching culture at national and universal levels, cultivating science and passing on academic knowledge, and shaping and satisfying the long-term needs of society. ELTE became a **Research University in 2010** and received the distinguished title of **University of National Excellence in 2013.**

ELTE Faculty of Informatics

ELTE Faculty of Informatics plays a leading role in Hungarian computer science education offering degree programs in computer science, cartography and geoinformatics, mechanical engineering, and teaching informatics. Our study program focuses on Software architectures, Artificial intelligence, Autonomous systems, Cyber-security, Software, Data science, and Fintech. The Faculty's research activities cover computer science and mathematics in the fields of reliable complex software systems, large-scale data analysis, application-specific programming languages, data security and software security, cyber-physical systems, autonomous vehicle control, artificial intelligence, cartography, and educational methodology.

Brief history of ELTE



BRIEF HISTORY OF ELTE

1635 Cardinal Péter Pázmány signs the founding documents of the University in Nagyszombat *(today: Trnava, Slovakia)*. The first two faculties are the Faculty of Humanities and the Faculty of Theology *(becomes an independent institution in 1950)*.

1667 The Faculty of Law is founded.

1769 The Medical Faculty is founded *(becomes an independent institution in 1951)*.

1777 The University moves to Buda.

1860 Authorization of Hungarian as a language of instruction at the University.

1869 The State Teacher Training Institution *(predecessor of the Faculty of Primary and Pre-School Education)* is founded.

1872 Europe's first teacher-training school, *(predecessor of ELTE Trefort Ágoston Teacher-Training School)* is founded.

1898 The Budapest University Athletics Club *(BEAC)* is founded.

1900 The first Special Education Teacher Training Course in the world *(predecessor of the Bárczi Gusztáv Faculty of Special Needs Education)* is founded.

1948 The ELTE Bartók Béla Choir is founded.

1950 The University adopts the name of the world-renowned physicist Loránd Eötvös.

2000 The Faculty of Primary and Pre-School Education and the Bárczi Gusztáv Faculty of Special Needs Education are integrated into the University.

2003 The Faculty of Informatics, the Faculty of Education and Psychology, and the Faculty of Social Sciences are founded.

2006 ELTE is awarded the Erasmus E-Quality Label.

2010 ELTE is awarded the title *"research university"*.

2012 ELTE receives the Quality Award for International Cooperation.

2013 The University is declared a University of Excellence.

2017 Savaria University Centre is integrated into the University.

2018 The Institute of Business Economics and the Berzsenyi Dániel Teacher Training Center are founded.