

AI @ Uminho **a Path to the Future**

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ISLab/ALGORITMI CENTER/LASI
UNIVERSIDADE DO MINHO

Curriculum Development in Data Science and Artificial Intelligence - DS&AI
ERASMUS+,
Asian Institute of Technology, Pathumthami, Thailand, 3-5 October, 2022

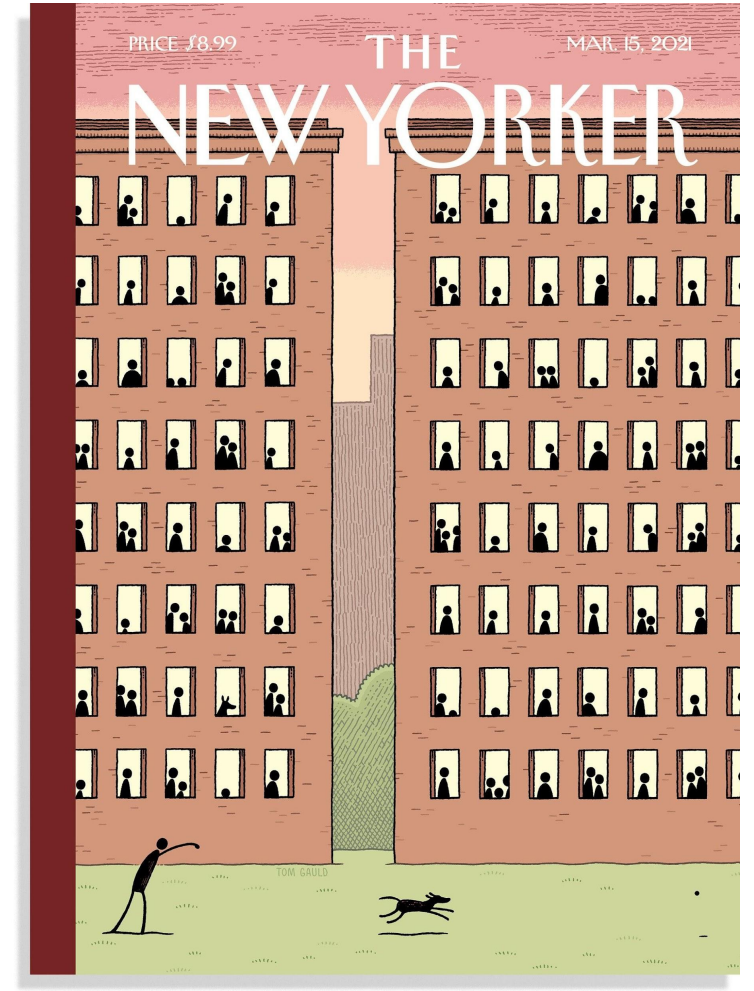
An Age of Transformation



Source: The New Yorker – October 23, 2017
“Rech Support” by R. Kikuo Johnson”

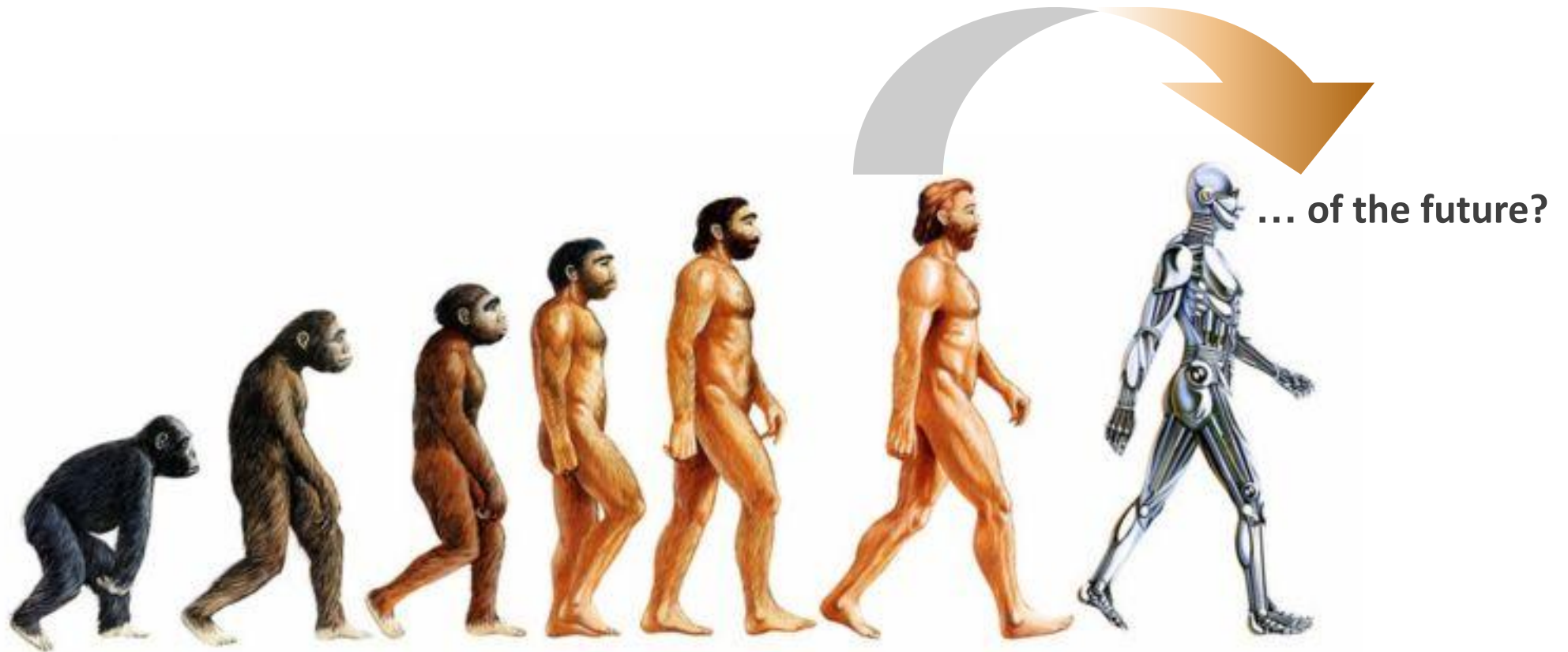


Source: The New Yorker – April 6, 2020
“Bedtime” by Chris Ware.



Source: The New Yorker – March 15, 2021
“Captive Audience” by Tom Gauld.

How far is the present



Our relationships with social networks are restricted by an algorithm;

Google search results change from person to person because the program “thinks and learns” on its own;

AlphaZero (DeepMind) behaves like human beings, who play chess because it is also capable of learning from the game;

AI-controlled U-2fighter planes (US Air Force) behave better than human pilots. They have superior performances when using radar systems and without any assistance;

The “complex intelligence” of GPT-3 (“Generative Pre-trained Transformer”), an Open AI language model that builds new texts (essays), answers to new questions, and complex sentences;

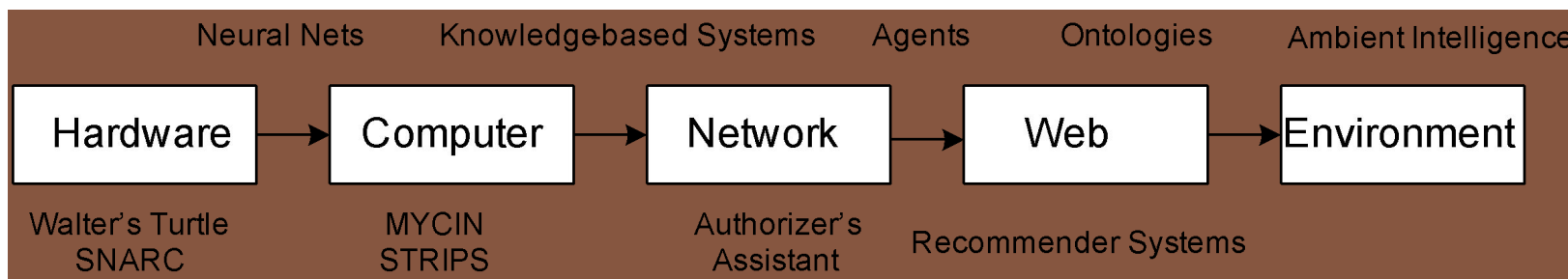
AI systems can generate photos and videos from text descriptions (Meta-FAIR).

Technology is around



R. Karlsson (1996), Printed in Helsingin Sanomat, October 18.

Environment the step!

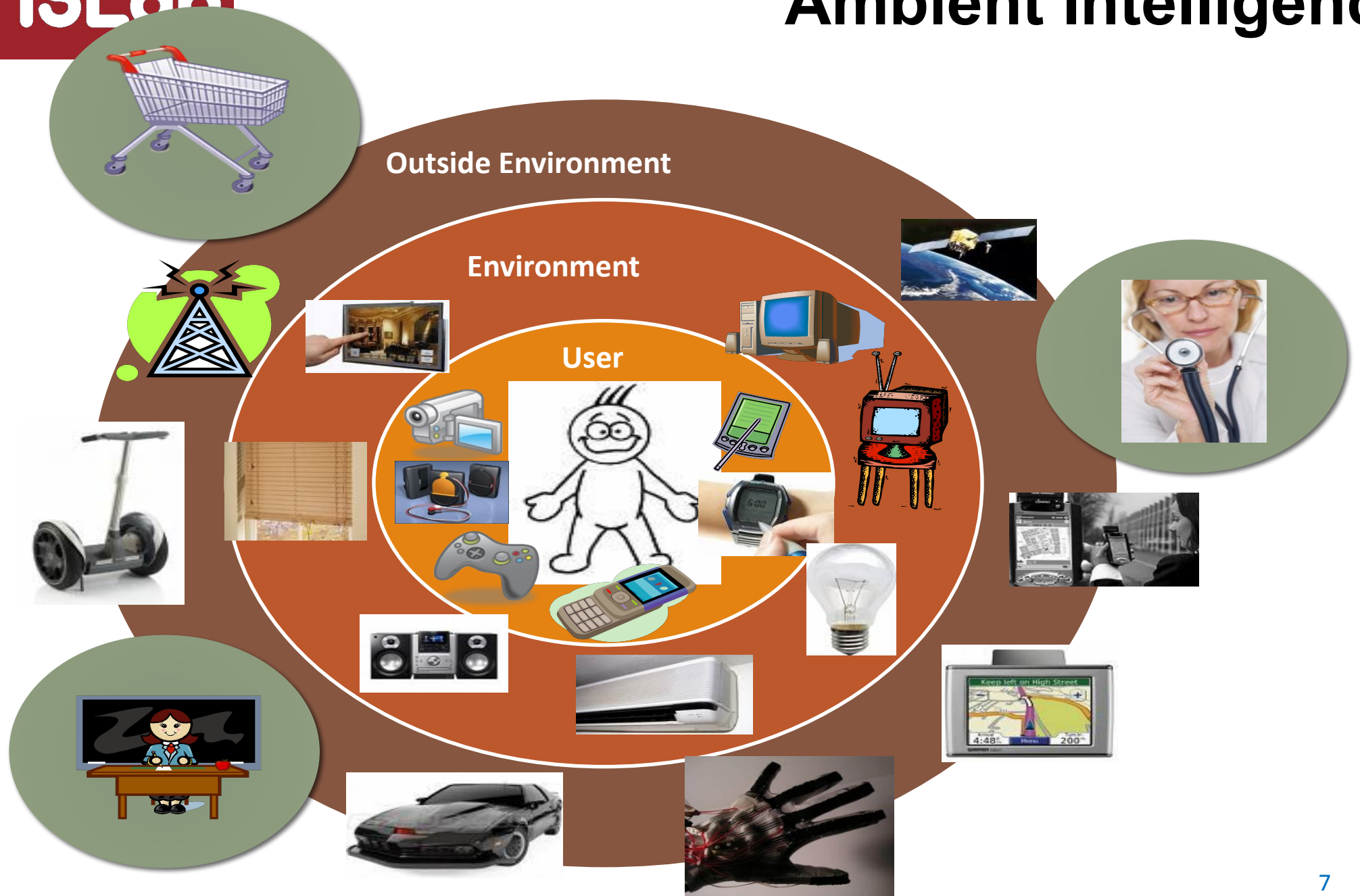


Beginning of AI:

Neural models McCulloch & Pitts, 40's
SNARC, Minsky & Edmonds, 50's

AI in real problems:

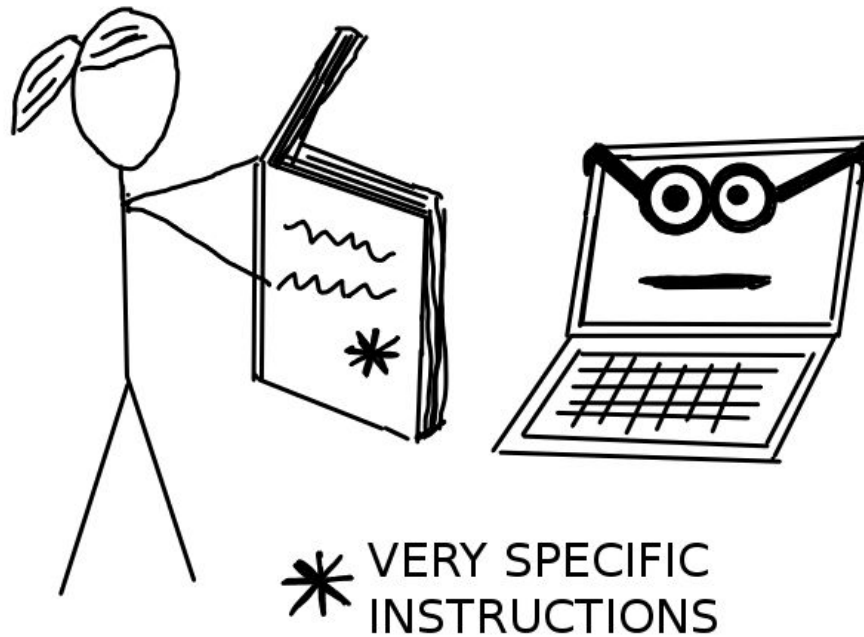
MYCIN on a computer, 70's
AUTHORIZER'S ASSISTANT, American Express, 80's
Agents and Recommendation Systems on the Web, 90's
Semantic Web, emerges in the 21st century



“Computing is not about computers anymore.
It is about living.

Nicholas Negroponte

Without Machine Learning

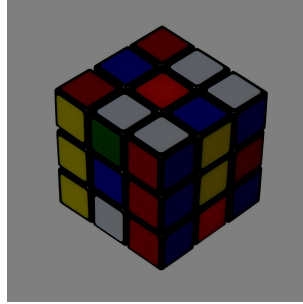


With Machine Learning

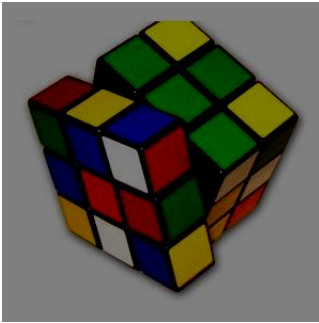


Symbolic

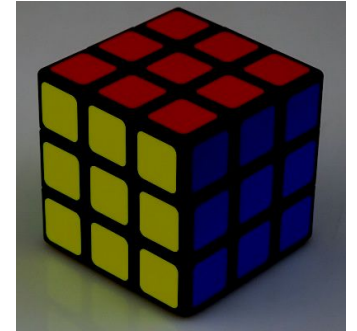
- Initial state



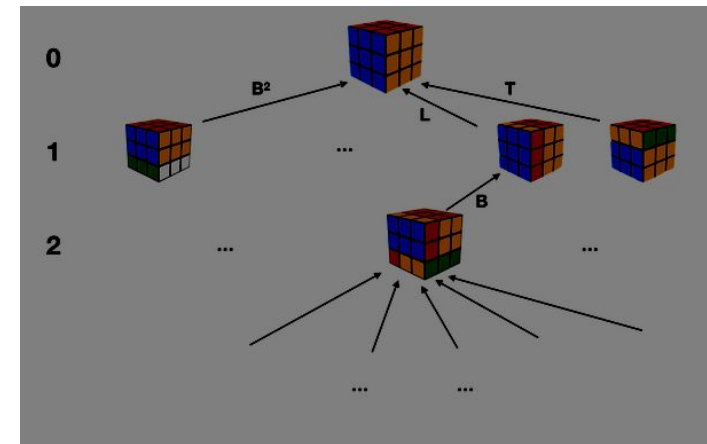
- change state with an action



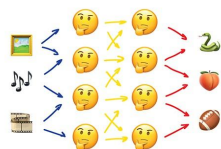
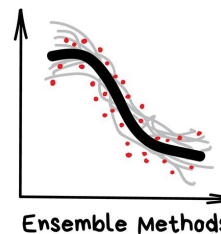
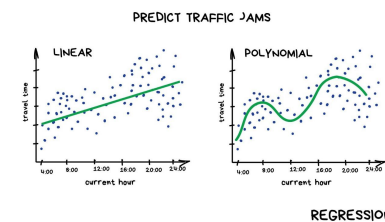
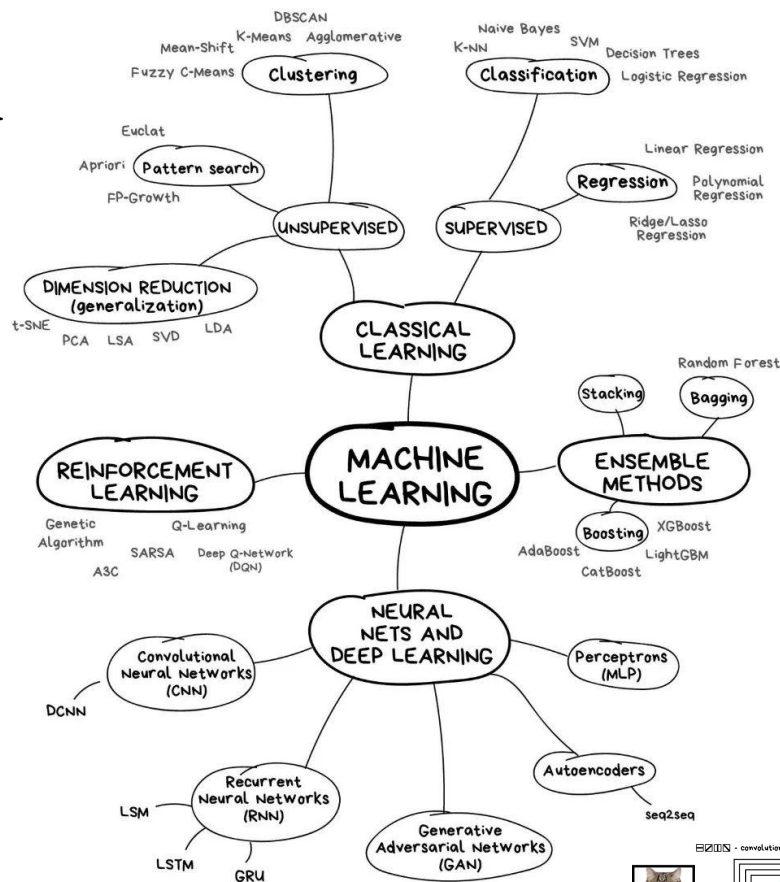
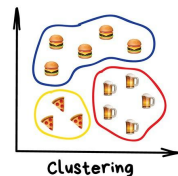
- goal (Final state)



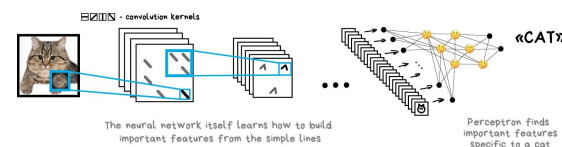
- state space



Machine Learning



Source: The map of the machine learning world
Vasily Zubarev (vas3k.com)





“Our Intelligence is what makes us human, and AI is an extension of that quality”.

Yann LeCun (A.M. Turing Award 2018)



“I know it when I see it”

How to make systems a little more smart, reliable and sensitive to human presence and interaction?

- Everything is learned;
- Self-supervised learning;
- Prediction is the essence of Intelligence...

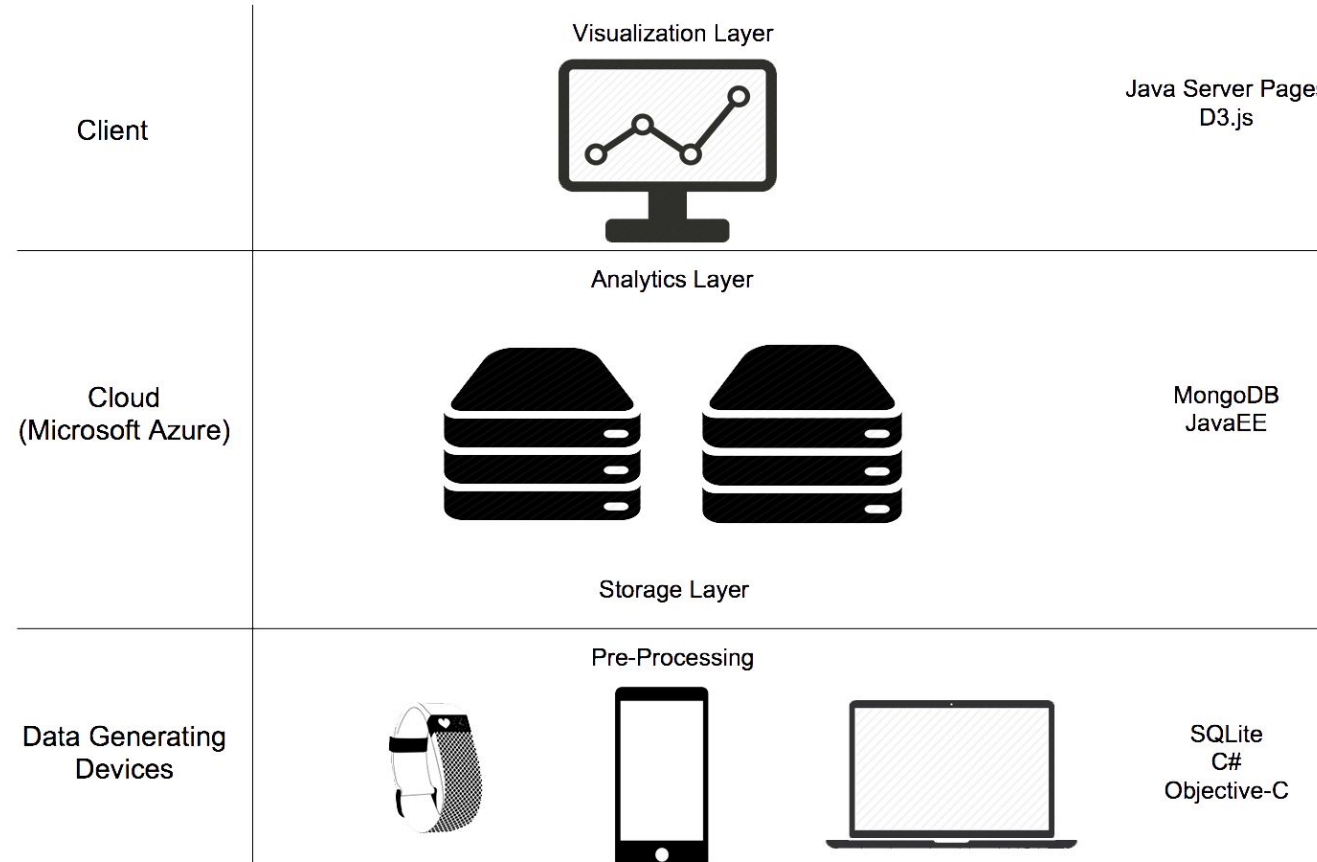
Yann LeCunn

“Behaviour is the mirror in which everyone shows their image.”

Johann Wolfgang von Goethe



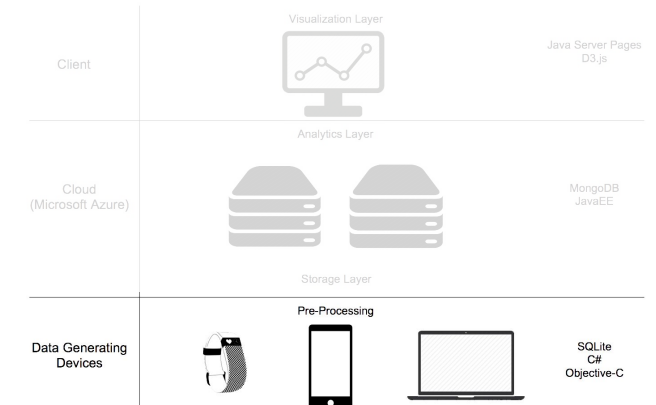
CENTROALGORITMI



Data Generating Devices

Soft Sensors - use information available from other measurements and process parameters to calculate an estimate of the quantity of interest

Logger applications that run in the background, collecting the necessary events



Data Generating Devices

MOV, timestamp, posX, posY

MD[L|R], timestamp, posX, posY

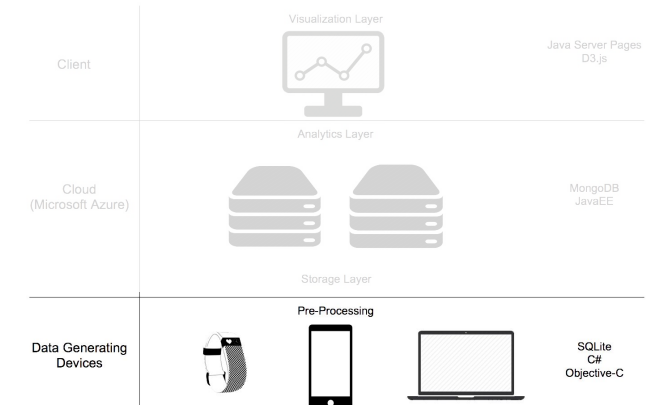
MU[L|R], timestamp, posX, posY

MW, timestamp, dif

KD, timestamp, key

KU, timestamp, key

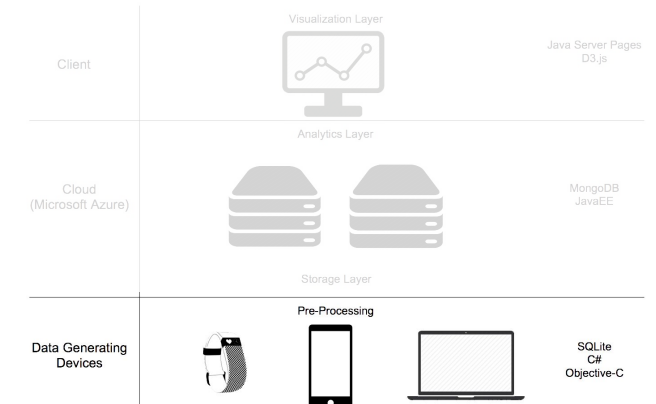
APP, timestamp, app_name



Data Generating Devices

```

MOV,635806021653378954,461,211
MOV,635806021653458962,461,210
MOV,635806021653538970,461,210
MOV,635806021653698986,461,209
MOV,635806021654339050,461,209
MOV,635806021654819098,461,208
MDL,635806021655699186,461,208
MUL,635806021657139330,461,208
APP,635806021659875765, Microsoft Access - M2_TESTE02_Alunos (1)
MOV,635806021662219838,461,207
MOV,635806021662319848,461,207
MOV,635806021662919908,461,206
MOV,635806021663219938,461,204
MOV,635806021663369953,460,204
MOV,635806021663379954,460,203
MOV,635806021663622278,460,203
  
```



Lab

Keyboard

- Key Down
- Key Up

Mouse

- Mouse Down
- Mouse Up
- Movement
- Scroll

- Smartphone
 - Acceleration
 - Touch Down
 - Touch Up
 - Touch Intensity
 - Touch Area
 - Other Sensors...

- Chair
 - Accelerometers placed on different points on the chair
- Video Camera
 - Amount of Movement

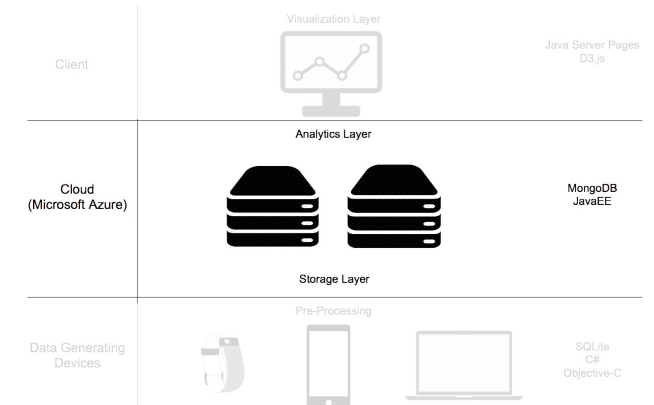
Data Generating Devices

Database: MongoDB

- Cross-platform, document oriented database that provides, high performance, high availability, and easy scalability
- Works on concepts of collection and document

Data aggregation tasks

- Generate interaction features at 5 minute intervals
- Mean, median, variance, etc.
- Classify data if necessary



Click Duration (CD)

Time Between Clicks (TBC)

Time Double Click (TDC)

Mouse Velocity (MV)

Mouse Acceleration (MA)

Distance Between Clicks (DBC)

Excess of Distance (ED)

Average Excess of Distance (AED)

Distance of the Mouse to the Straight Line (DMSL)

Average Distance of the Mouse to the Straight Line (ADMSL)

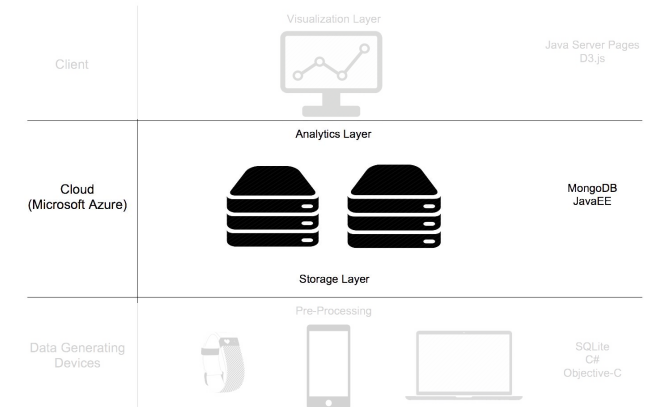
Absolute Sum of Angles (ASA)

Signed Sum of Angles (SSA)

Time Between Keys (TBK)

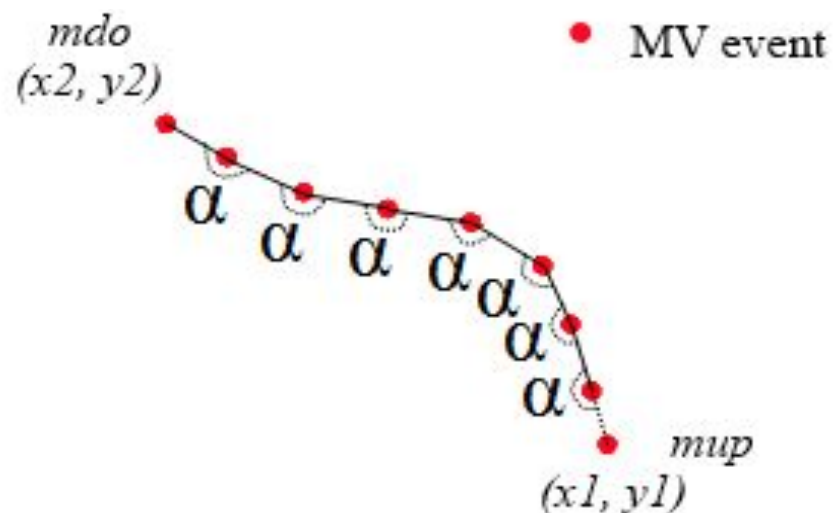
Key Down Time (KDT)

Writing Velocity (WV)



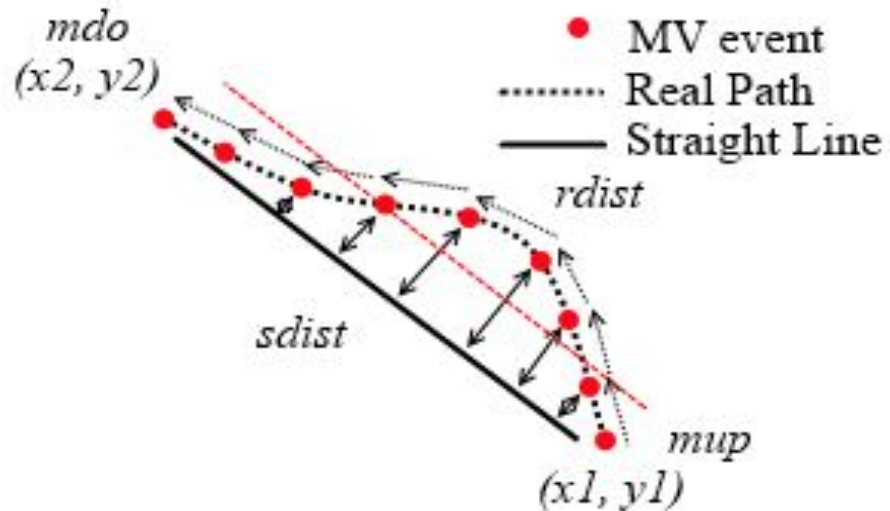
- Absolute Sum of Angles

$$rCls_angle = \sum_{i=0}^{n-2} | degree(posx_i, posy_i, posx_{i+1}, posy_{i+1}, posx_{i+2}, posy_{i+2}) |$$



- Average Distance of the Mouse to the Straight Line

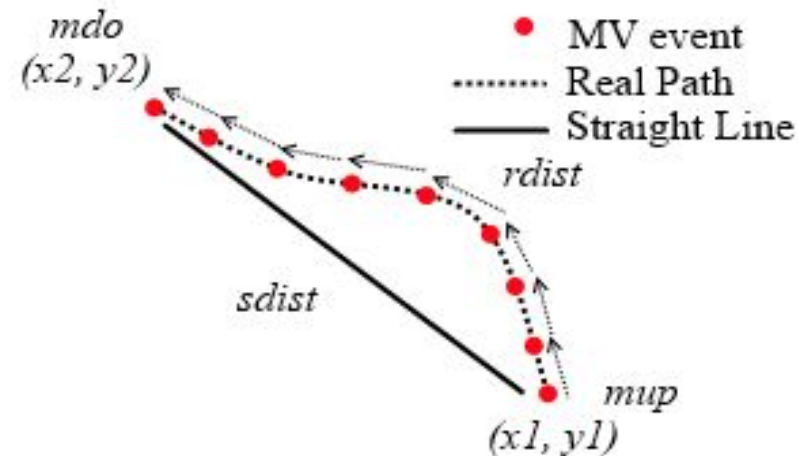
$$s_dists = \sum_{i=0}^{n-1} ptLineDist(posx_i, posy_i)$$

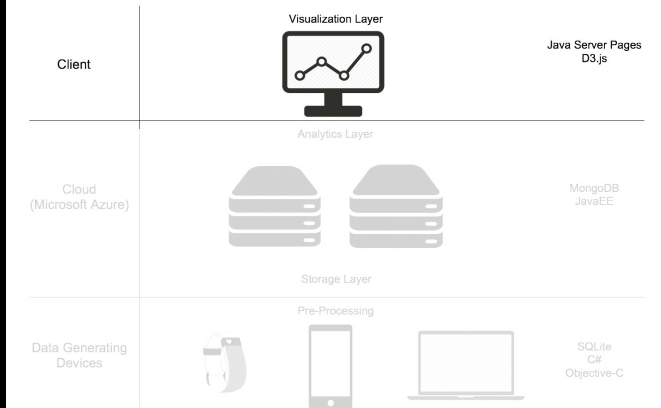


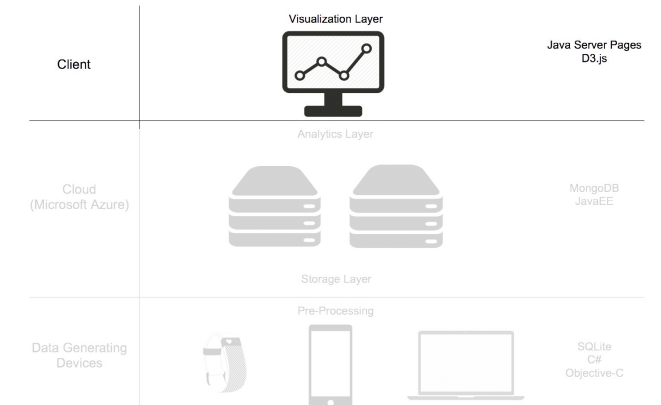
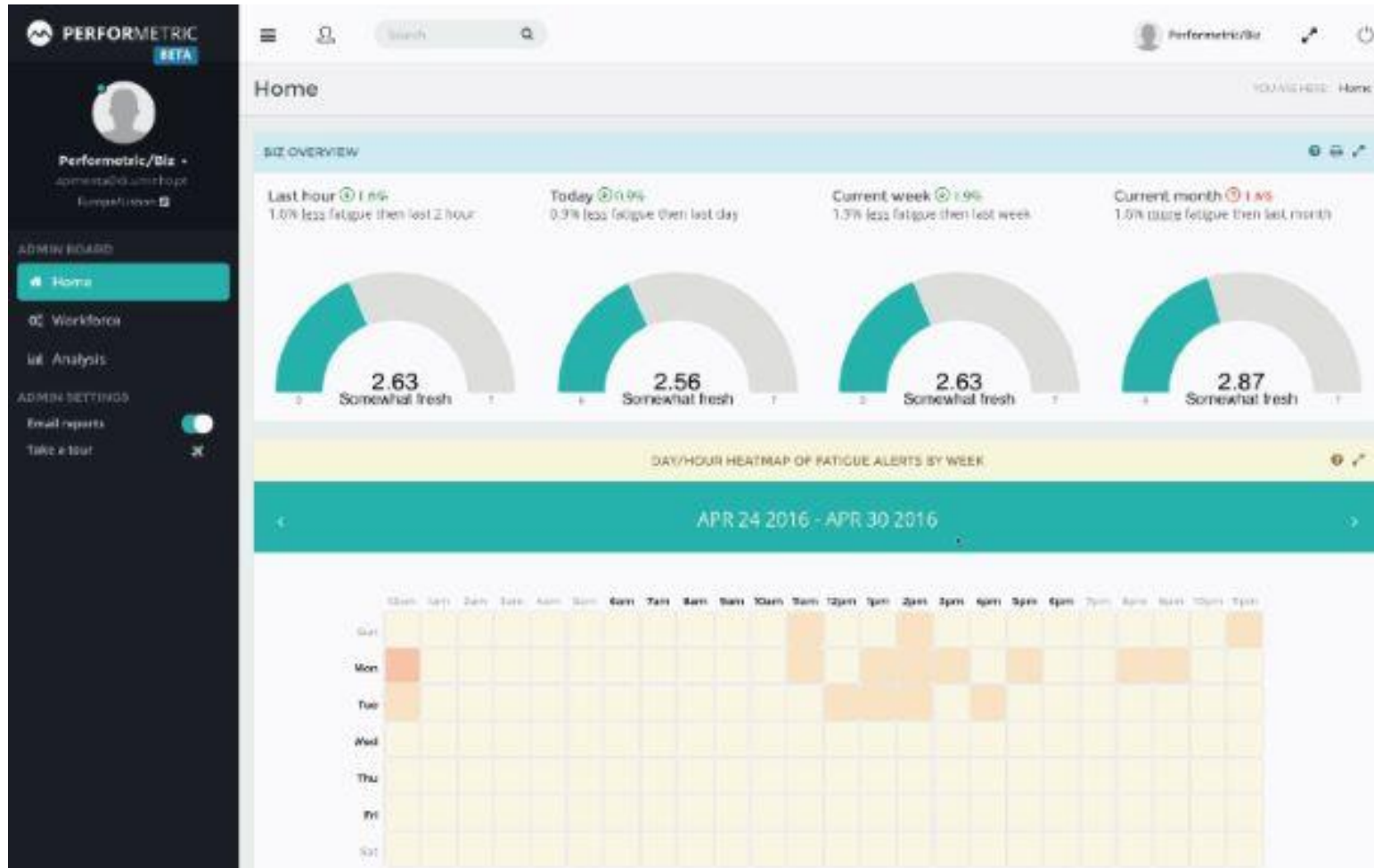
- Average Excess of Distance^{Lab}
- Distance Between Clicks

$$s_dist = \sqrt{(x2 - x1)^2 + (y2 - y1)^2}$$

$$r_dist = \sum_{i=0}^{n-1} \sqrt{(posx_{i+1} - posx_i)^2 + (posy_{i+1} - posy_i)^2}$$







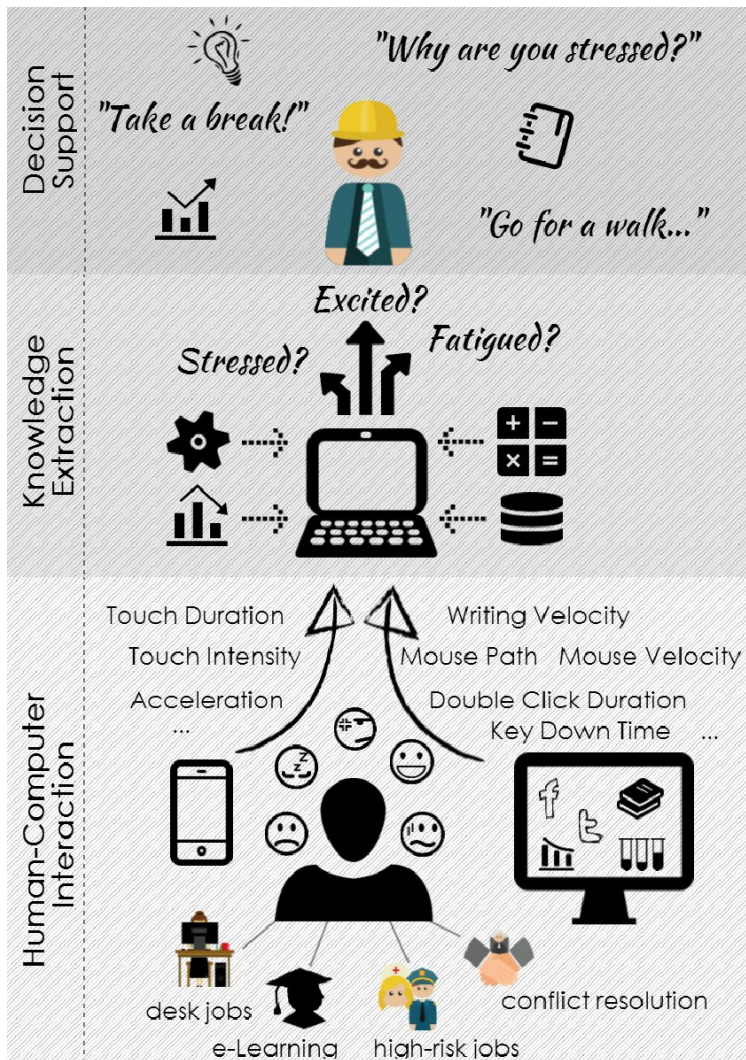
Challenge

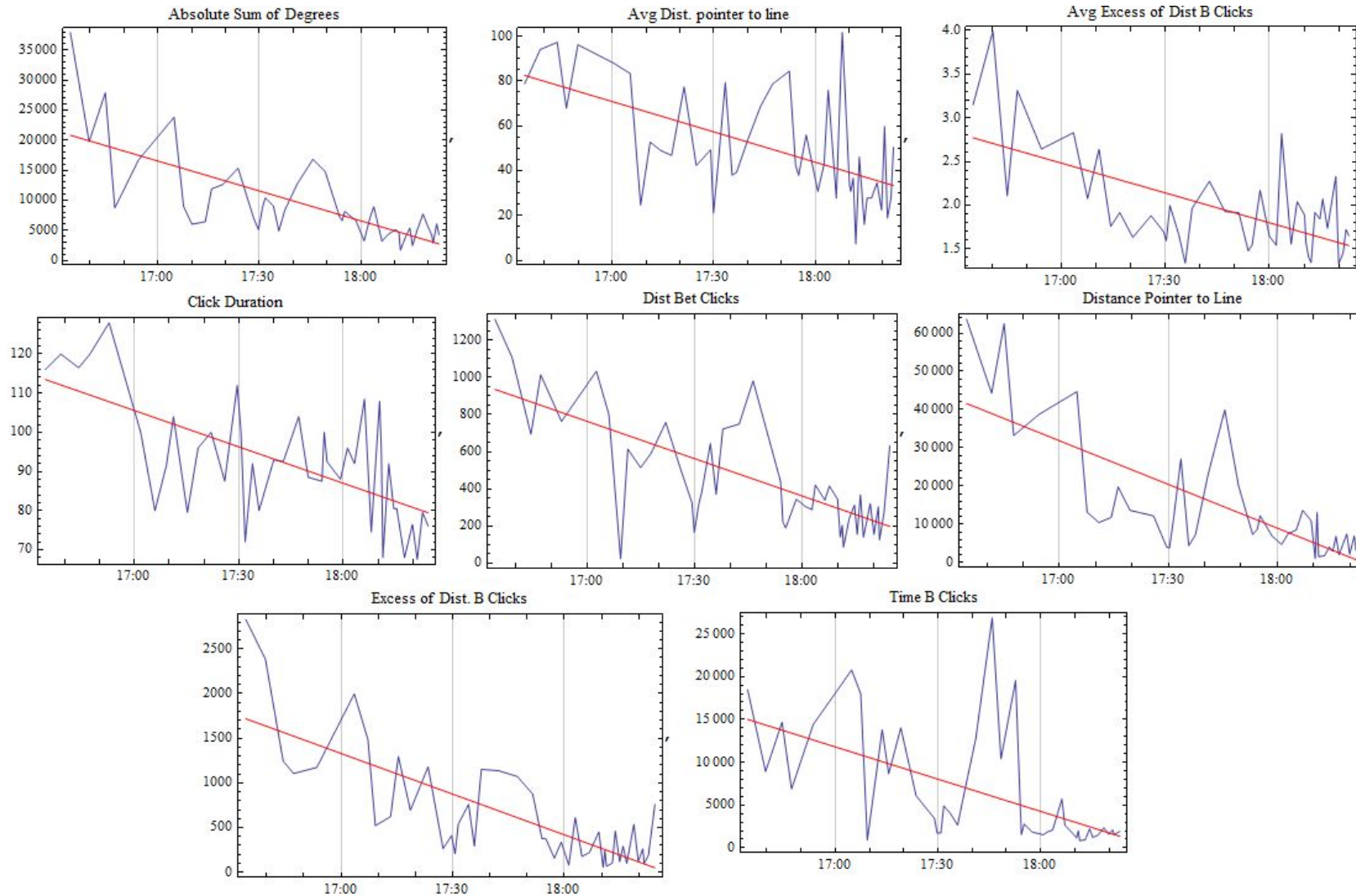
Estimate behaviours in a non-invasive way



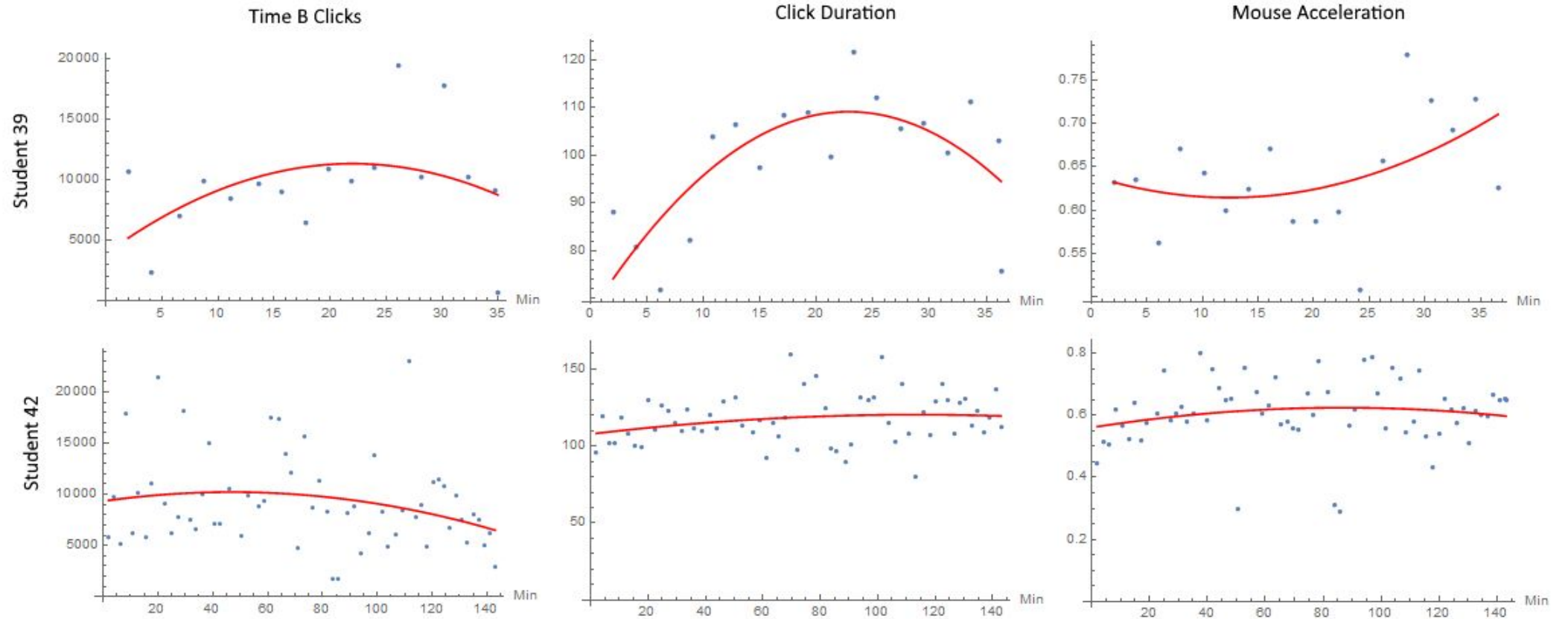
Behavioural Analysis

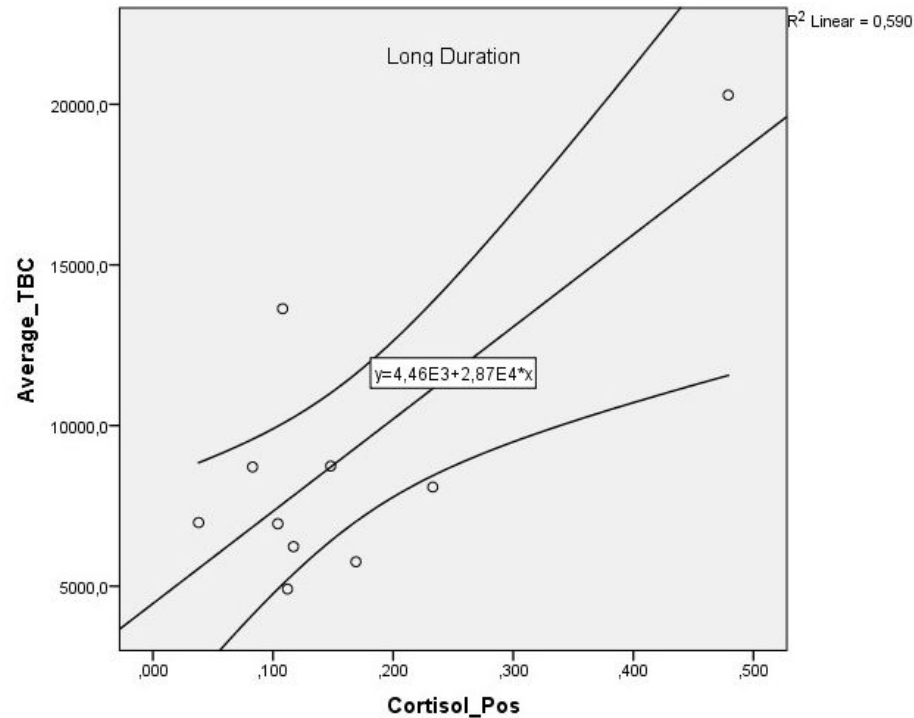
Stress, Fatigue and Attention Detection





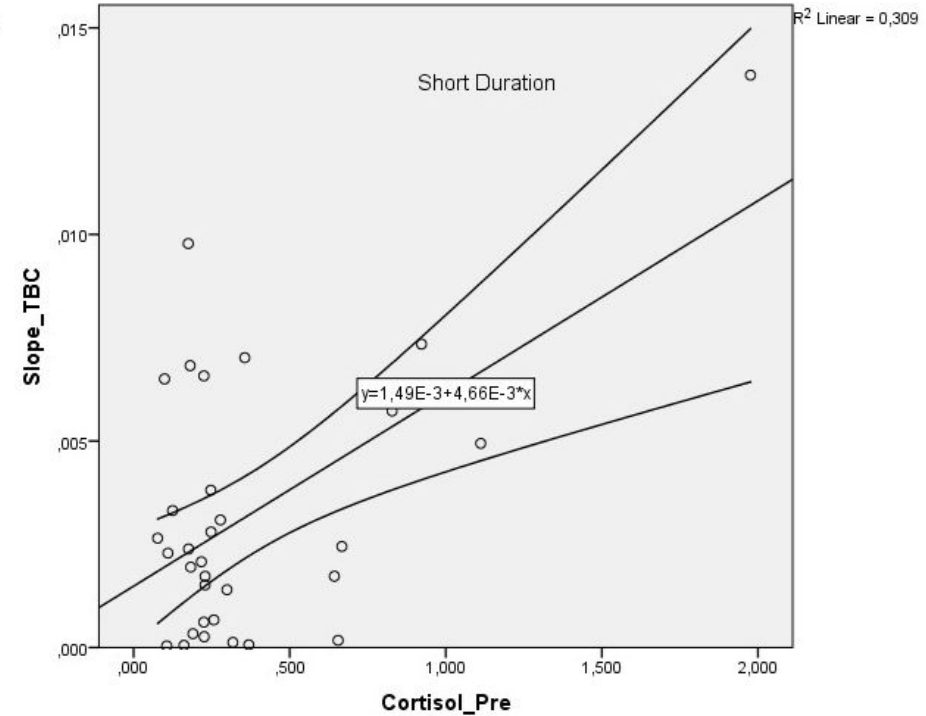
This system is being used to study people's interaction with technological devices in different contexts. This example shows data from a student during one high-stake exam (School of Medicine, University of Minho).





N= 24

R = 0.768; p= 0.009

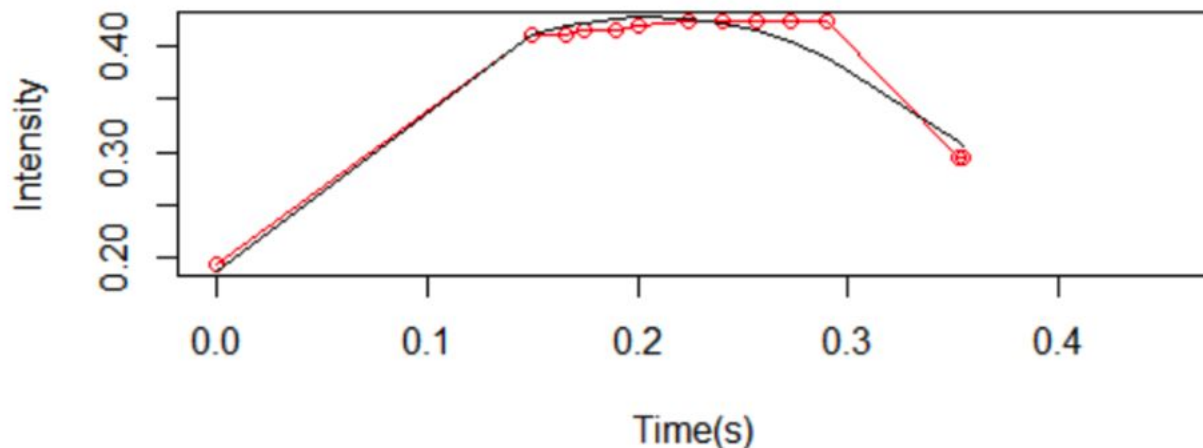


N= 38

R = 0.556; p= 0.001

A strong positive correlation was also found between this feature and Cortisol, both before and after the exam. Cortisol is one of the most reliable stress indicators.

A touch is a sequence of touch events over time, each with a timestamp, intensity and area.



An Interaction Model

The model includes the following features:

- Touch duration
- Touch intensity (avg, min, max)
- Touch area (avg, min, max)
- Intensity values
- Area values
- Type of action
- Touch pattern (coefficients of the quadratic fit)

Differences between individuals

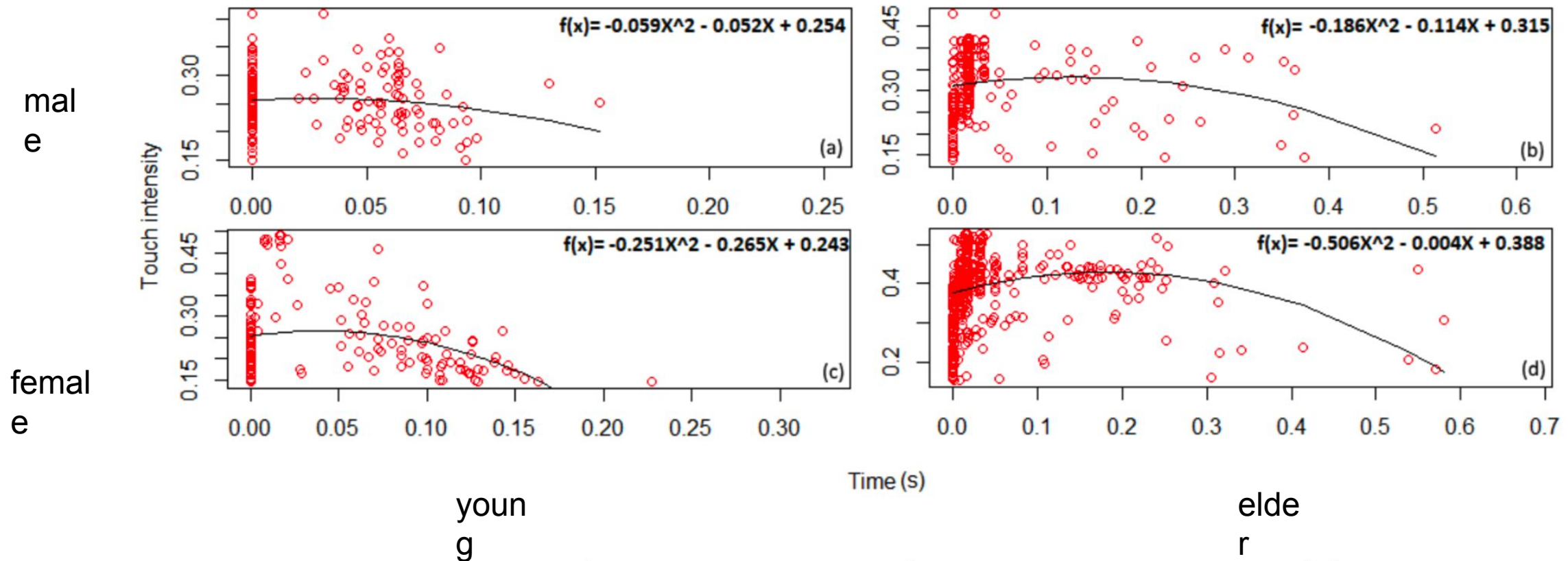


Fig. 2. Interaction models (intensity over time) of four sample users: (a) young male, (b) elder male, (c) young female and (d) elder female.

It shows that older users appear to have longer and more intense touches

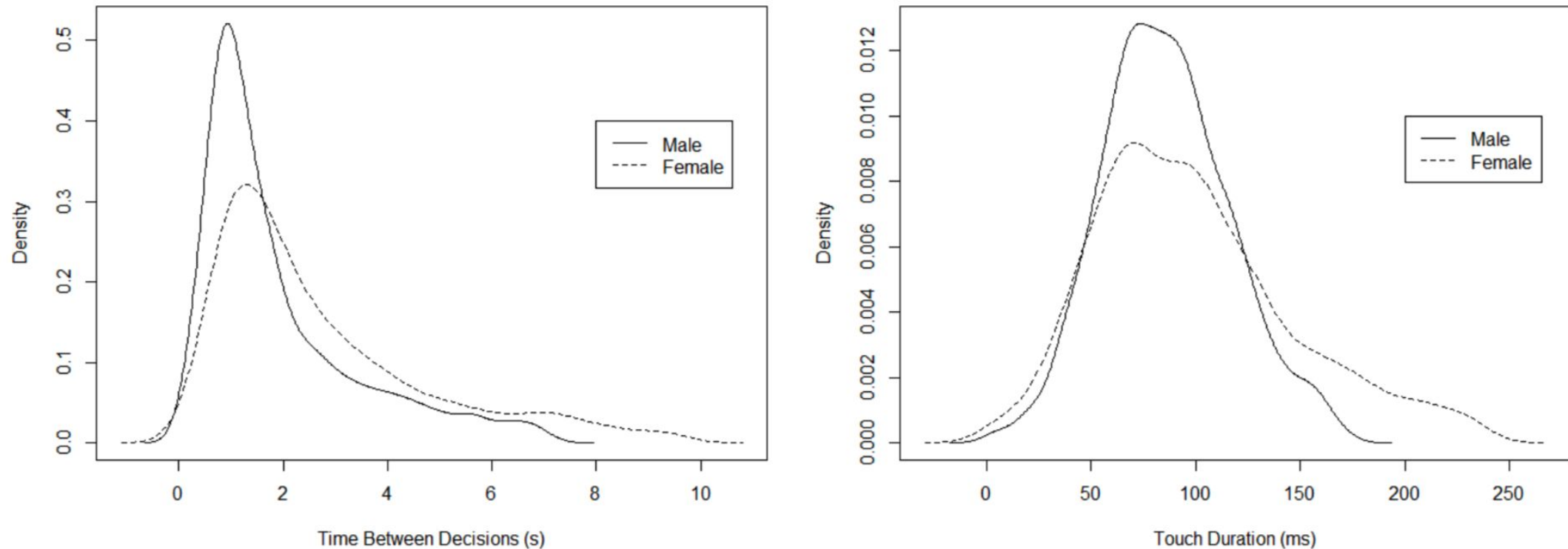


Fig. 3. Gender differences in time between decisions ($p\text{-value} < 2.2^{-16}$) (left) and in touch duration ($p\text{-value} = 1.933^{-9}$) (right) due to gender.

In both cases, female participants tend to exhibit higher values

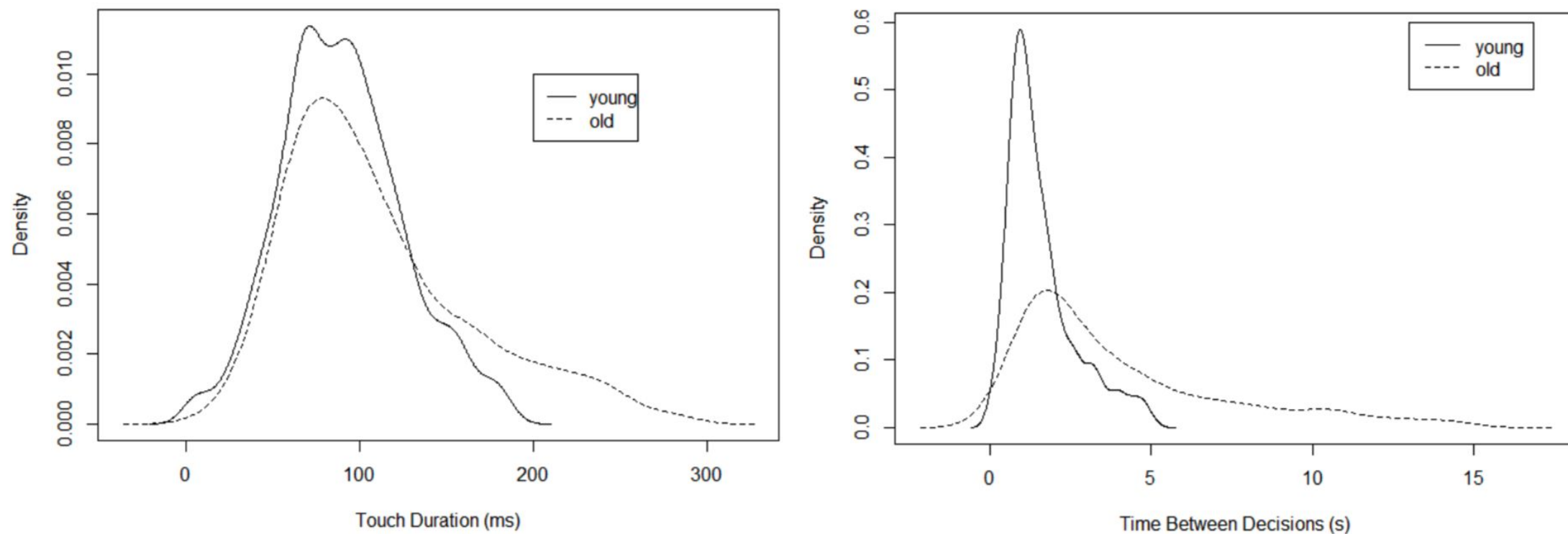


Fig. 4. Differences in touch duration ($p\text{-value} = 2.909^{-08}$) (left) and in the time between decisions ($p\text{-value} = 0.025$) (right) due to age.

In general, and as expected, **older participants tend to have an overall slower interaction**

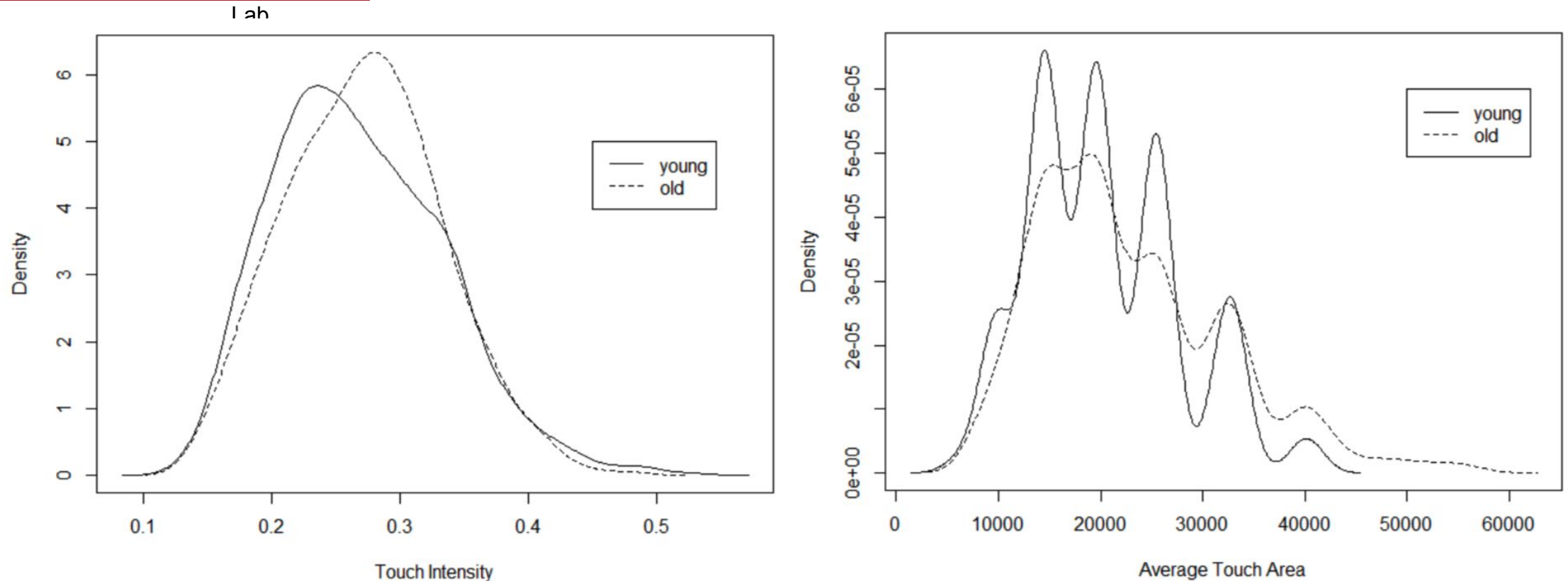


Fig. 5. Differences in the average value of touch intensity ($p\text{-value} = 2.909^{-08}$) (left) and in the average value of touch area ($p\text{-value} = 2.643^{-05}$) (right) due to age.

In general, **older people tend to have more intense touches and also tend to use a larger area of the finger**

Binomial classification model for predicting age group

- Young ≤ 35 years old (17 individuals)
- Old > 35 years old (15 individuals)

Ensemble of trees with gradient boosting

Non relevant features were discarded

Features used:

- Max, min and avg touch area
- Max, min and avg touch intensity
- Time between decisions
- Touch duration
- Age bin

30 trees, each using 80% of the data and 70% of the features, 5-fold cross validation

The resulting model correctly classifies 82.03% of **young users** and 66.37% of **old users**, with an overall **76.08%** of correctly classified instances

- precision = 0.6936
- recall = 0.6637
- F1 Score = 0.6783
- AUC = 0.82

Table 2. Confusion Matrix of the trained model.

Actual/Predicted	Young	Old	Error
Young	744	163	0.1797
Old	187	369	0.3363
Total	931	352	0.2392

Limitation:

- Relatively small number of users in each case studies;

Results:

- Approach does not depend on application-specific data and can be easily implemented;
- Allows to collect data from large numbers of users in a non intrusive way;
- May prove relevant for studying other aspects (e.g. emotion, personality traits);
- May be used to develop mobile applications that are more user-aware and person-centric.

Chapter
Hybrid Artificial Intelligence
Volume 9121 of the series Lecture Notes in Computer Science pp 345-356

Date: 29 May 2015

Using Mouse Dynamics to Assess Stress During Online Exams

Davide Carneiro , Paulo Novais, José Miguel Pêgo, Nuno Sousa, José Neves



[Journal of Ambient Intelligence and Humanized Computing](#)
April 2017, Volume 8, [Issue 2](#), pp 191–203

Context acquisition in auditory emotional recognition studies

Authors [Authors and affiliations](#)

Davide Carneiro , Ana P. Pinheiro, Paulo Novais

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New Methods for Stress Assessment and Monitoring at the Workplace

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Text Views

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Author(s)

> Davide Carneiro , Paulo Novais; Juan Carlos Augusto; Nicola Payne

 SpringerLink

Published: 14 October 2021

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José Pedro Pinto , André Pimenta & Paulo Novais

[Machine Learning](#) **110**, 3037–3057 (2021) | [Cite this article](#)

779 Accesses | 1 Altmetric | [Metrics](#)



Neurocomputing
Volume 172, 8 January 2016, Pages 413–426



A neural network to classify fatigue from human–computer interaction

André Pimenta , Davide Carneiro , José Neves , Paulo Novais 

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Future Generation Computer Systems
Volume 92, March 2019, Pages 549–559



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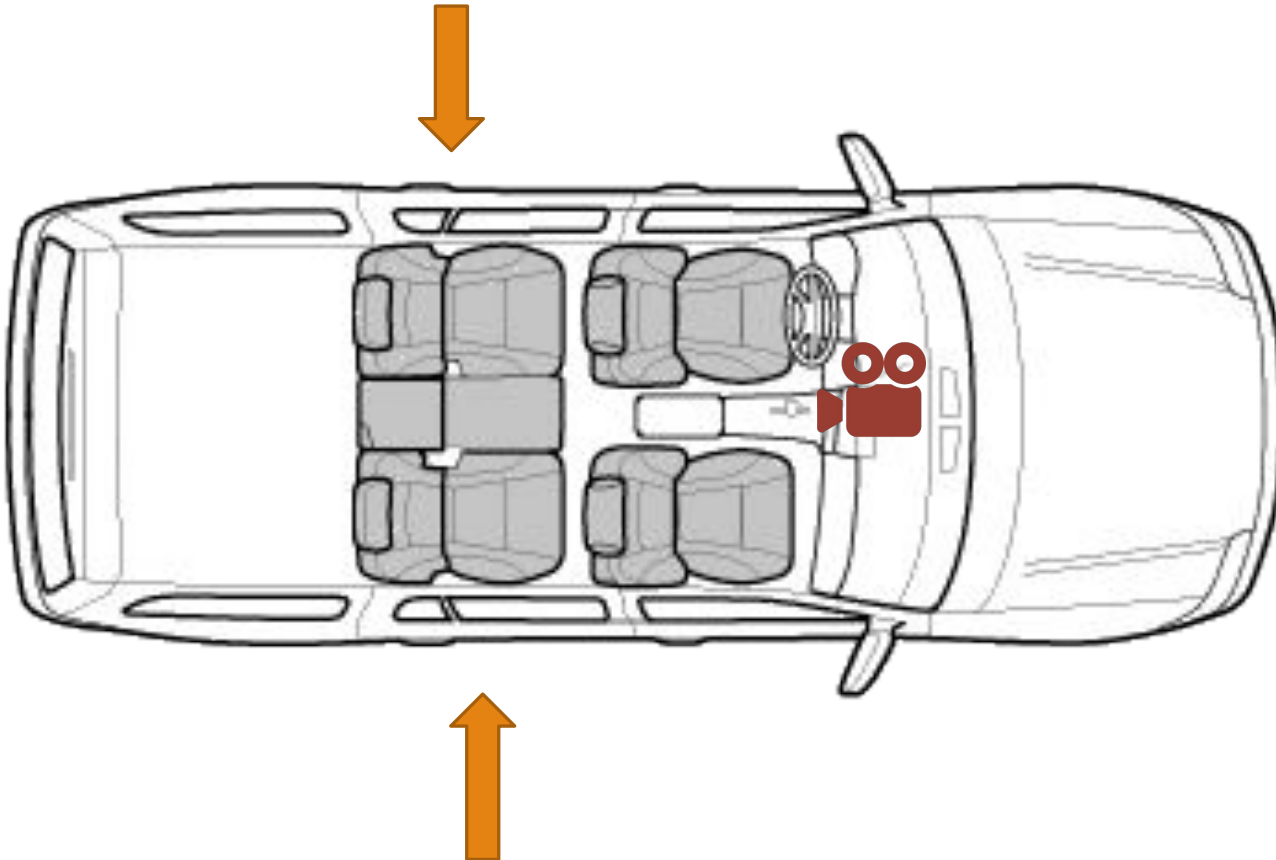
Non-intrusive quantification of performance and its relationship to mood

Authors

[Authors and affiliations](#)

Davide Carneiro , André Pimenta, José Neves, Paulo Novais

RECORDING PARAMETERIZATION



Violence Detection

Camera position:

- under the rearview mirror

Scenes:

- violence
- non violence
- non violence with “violent” music

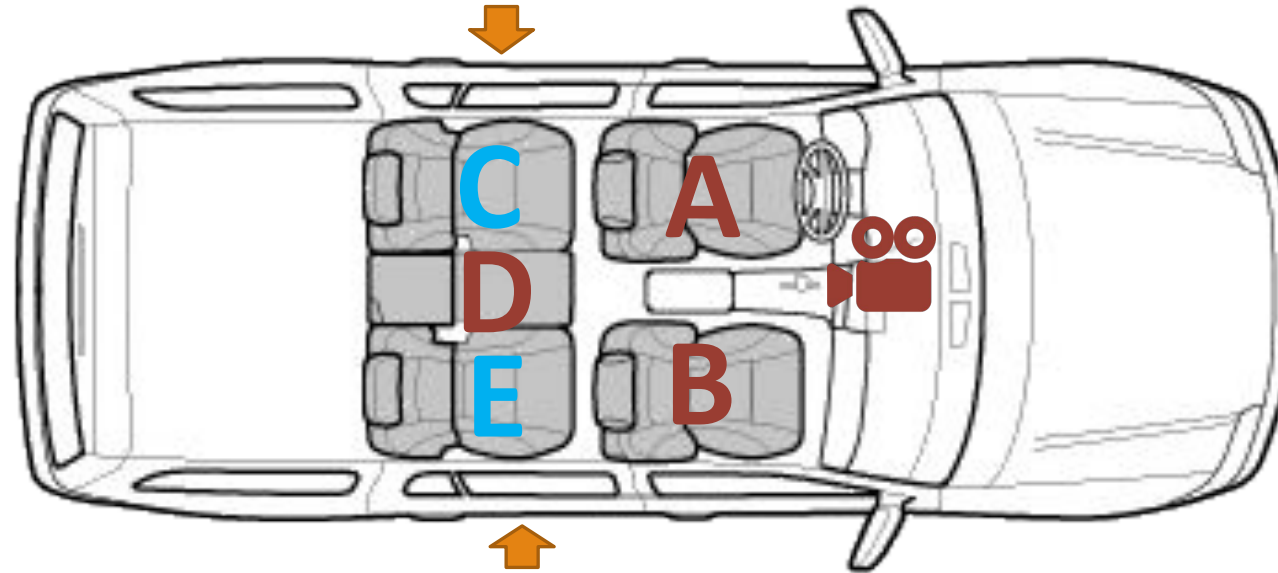
Video format:

- mp4

Number of persons:

- 2 back seats

Violence Detection



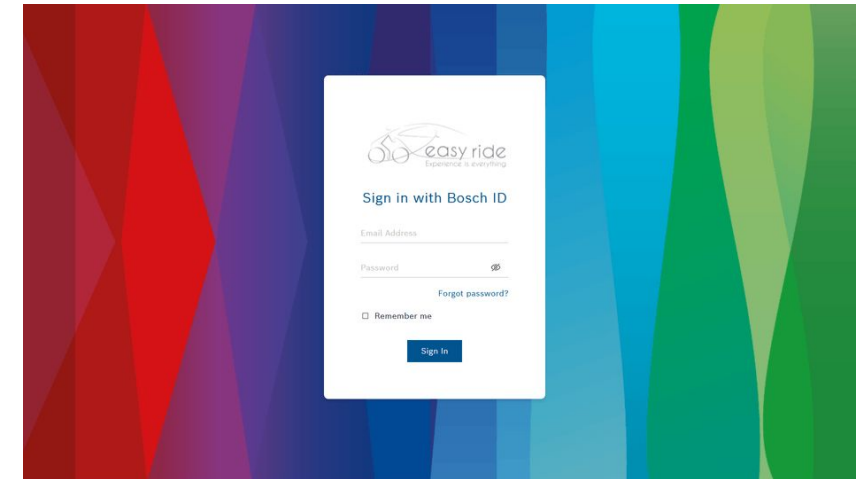
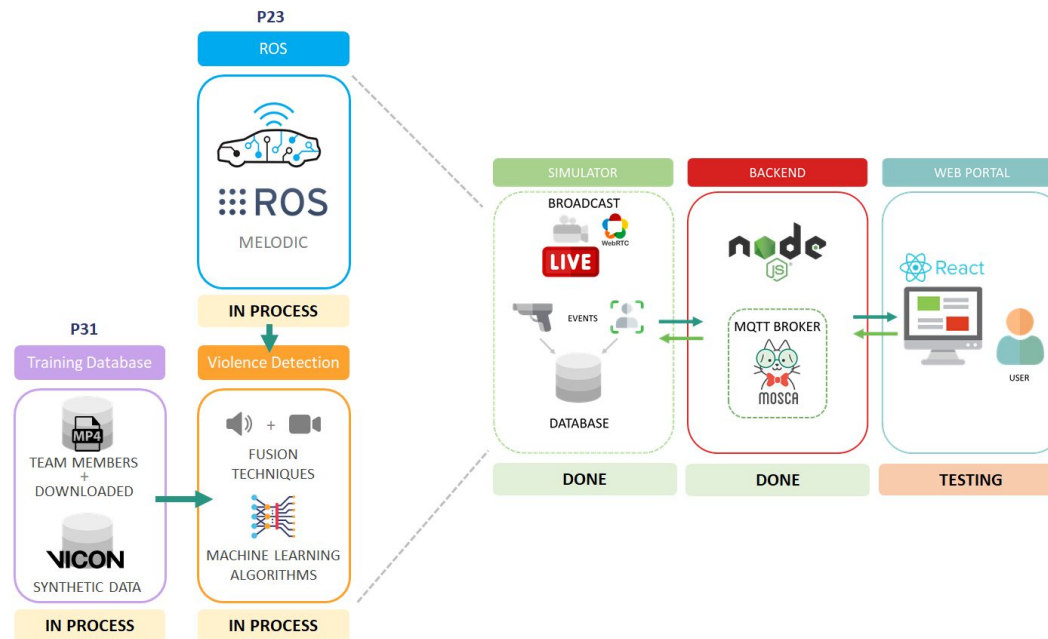
Violence/Non Violence	Start action	End action	Start sound	End sound	Day / Night	Language	Occupation seat	Type of action
0 - Non Violence 1 - Violence	00:00	00:00			0 - Day 1 - Night	Ex: Portuguese; English	ABCDE 1- occupied 0- free Ex: 10100 (2 persons)	Ex: singing; Violence with gun

Source: ER.InCo.P30

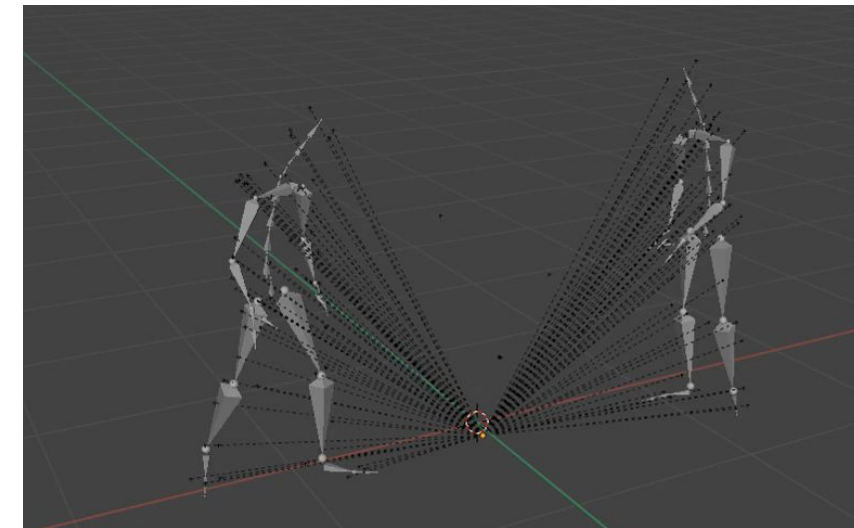
Sistema de fusão multissensorial em cockpit

Sensor fusion & Action recognition, BOSCH-UMinho Project

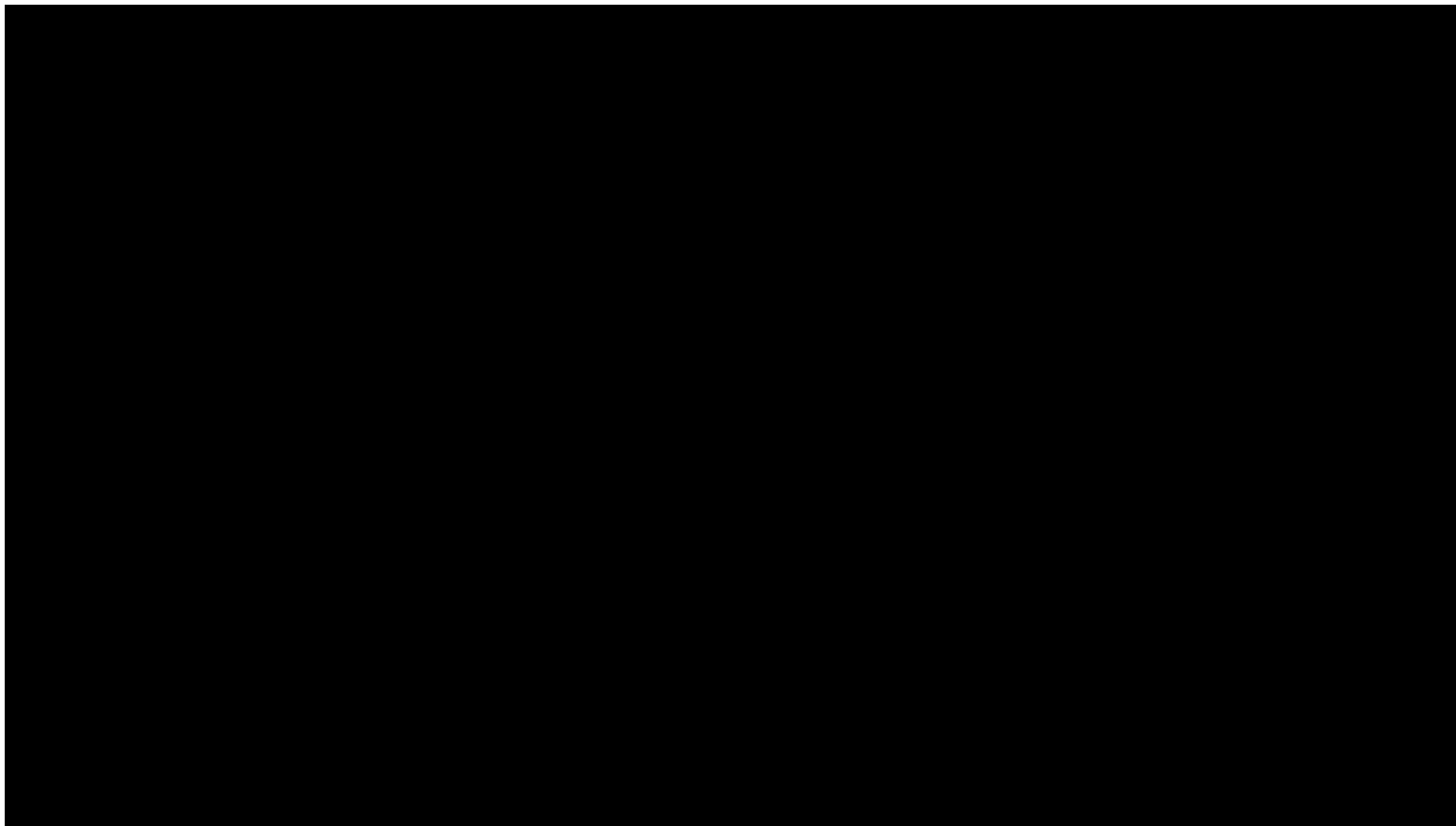
Aml Cockpit



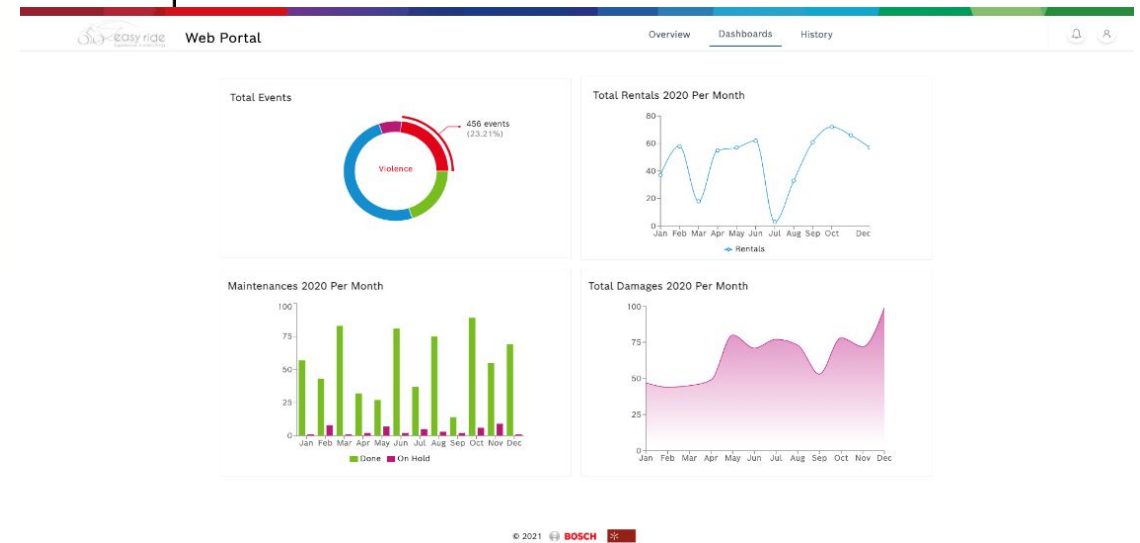
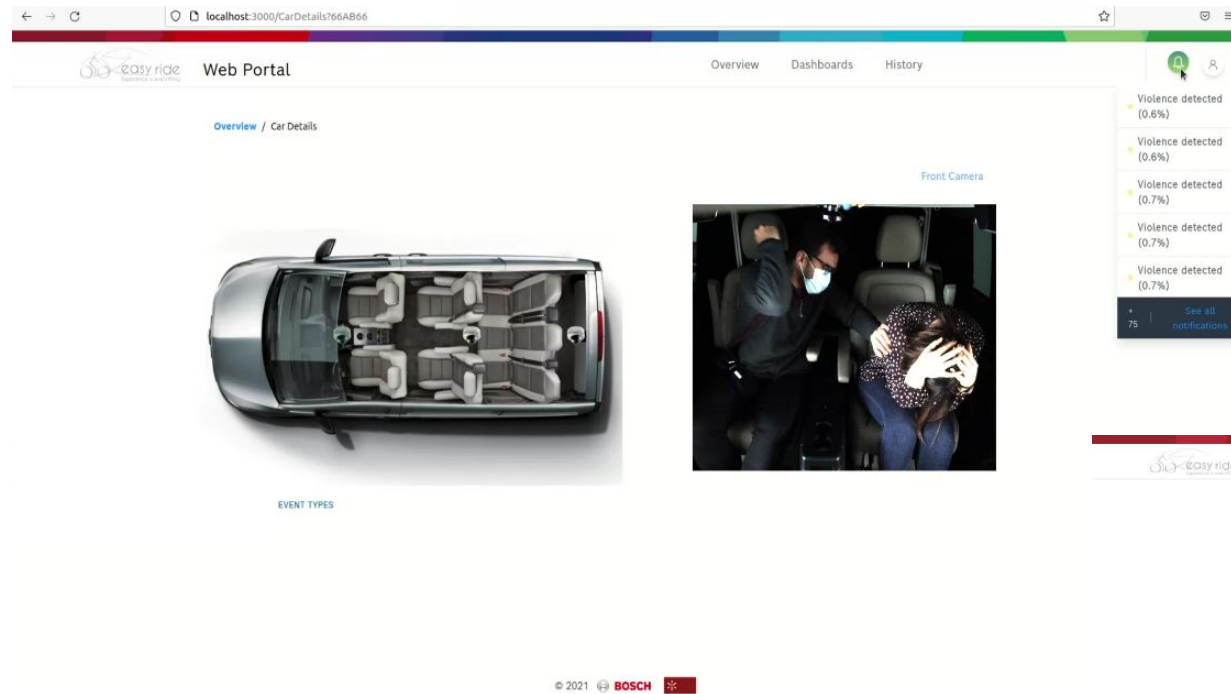
Web Portal
Interface



Skeleton mesh to
generate
synthetic data



Source: ER.InCo.P30
Sistema de fusão multissensorial em cockpit
Sensor fusion & Action recognition, BOSCH-UMinho Project





International Symposium on Ambient Intelligence
 ↳ ISAmI 2020: **Ambient Intelligence – Software and Applications** pp 106–116 | [Cite as](#)

Detection Violent Behaviors: A Survey

[Dalila Durães](#) ✉, [Francisco S. Marcondes](#), [Filipe Gonçalves](#), [Joaquim Fonseca](#), [José Machado](#) & [Paulo Novais](#)

Conference paper | [First Online: 10 September 2020](#)



International Symposium on Distributed Computing and Artificial Intelligence
 ↳ DCAI 2020: **Distributed Computing and Artificial Intelligence, 17th International Conference**

In-Vehicle Violence Detection in Carpooling: A Brief Survey Towards a General Surveillance System

[Francisco S. Marcondes](#) ✉, [Dalila Durães](#), [Filipe Gonçalves](#), [Joaquim Fonseca](#), [José Machado](#) & [Paulo Novais](#)

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Weakness Evaluation on In-Vehicle Violence Detection: An Assessment of X3D, C2D and I3D against FGSM and PGD

by [Flávio Santos](#) ^{1,2,*} ✉, [Dalila Durães](#) ^{1,*} ✉, [Francisco S. Marcondes](#) ¹ ✉, [Niklas Hammerschmidt](#) ³ ✉, [José Machado](#) ^{1,4} ✉ and [Paulo Novais](#) ^{1,4} ✉

- 1 ALGORITMI Centre, University of Minho, 4710-057 Braga, Portugal
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 - 3 Bosch Car Multimedia, 4705-820 Braga, Portugal
 - 4 LASI—Intelligent Systems Associate Laboratory, 4800-058 Guimarães, Portugal
- * Authors to whom correspondence should be addressed.

Academic Editor: George A. Tsihrintzis

Received: 2020-11-10; Accepted: 2020-11-10; Published: 2020-11-10



International Conference on Practical Applications of Agents and Multi-Agent Systems
 ↳ PAAMS 2021: **Highlights in Practical Applications of Agents, Multi-Agent Systems**

Efficient Violence Detection Using Transfer Learning

[Flávio Santos](#), [Dalila Durães](#) ✉, [Francisco S. Marcondes](#), [Sascha Lange](#), [José Machado](#) & [Paulo Novais](#)



International Conference on Intelligent Data Engineering and Automated Learning
 ↳ IDEAL 2020: **Intelligent Data Engineering and Automated Learning – IDEAL 2020** pp 549–560

Review of Trends in Automatic Human Activity Recognition Using Synthetic Audio-Visual Data

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Personal Assistants

Pharos - a personal trainer
ISLab.UMinho





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ME³CA: A Cognitive Assistant for Physical Exercises that Monitors Emotions and the Environment

by Jaime A. Rincon¹, Angelo Costa², Paulo Novais², Vicente Julian¹ and Carlos Carrascosa¹

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A new emotional robot assistant that facilitates human interaction and persuasion

[Jaime A. Rincon](#), [Angelo Costa](#), [Paulo Novais](#), [Vicente Julian](#) & [Carlos Carrascosa](#)

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Future Generation Computer Systems

Volume 92, March 2019, Pages 479–489



Emotions detection on an ambient intelligent system using wearable devices

[Angelo Costa](#)^a, [Jaime A. Rincon](#)^b, [Carlos Carrascosa](#)^b, [Vicente Julian](#)^b, [Paulo Novais](#)^a



Volume 26, Issue 6

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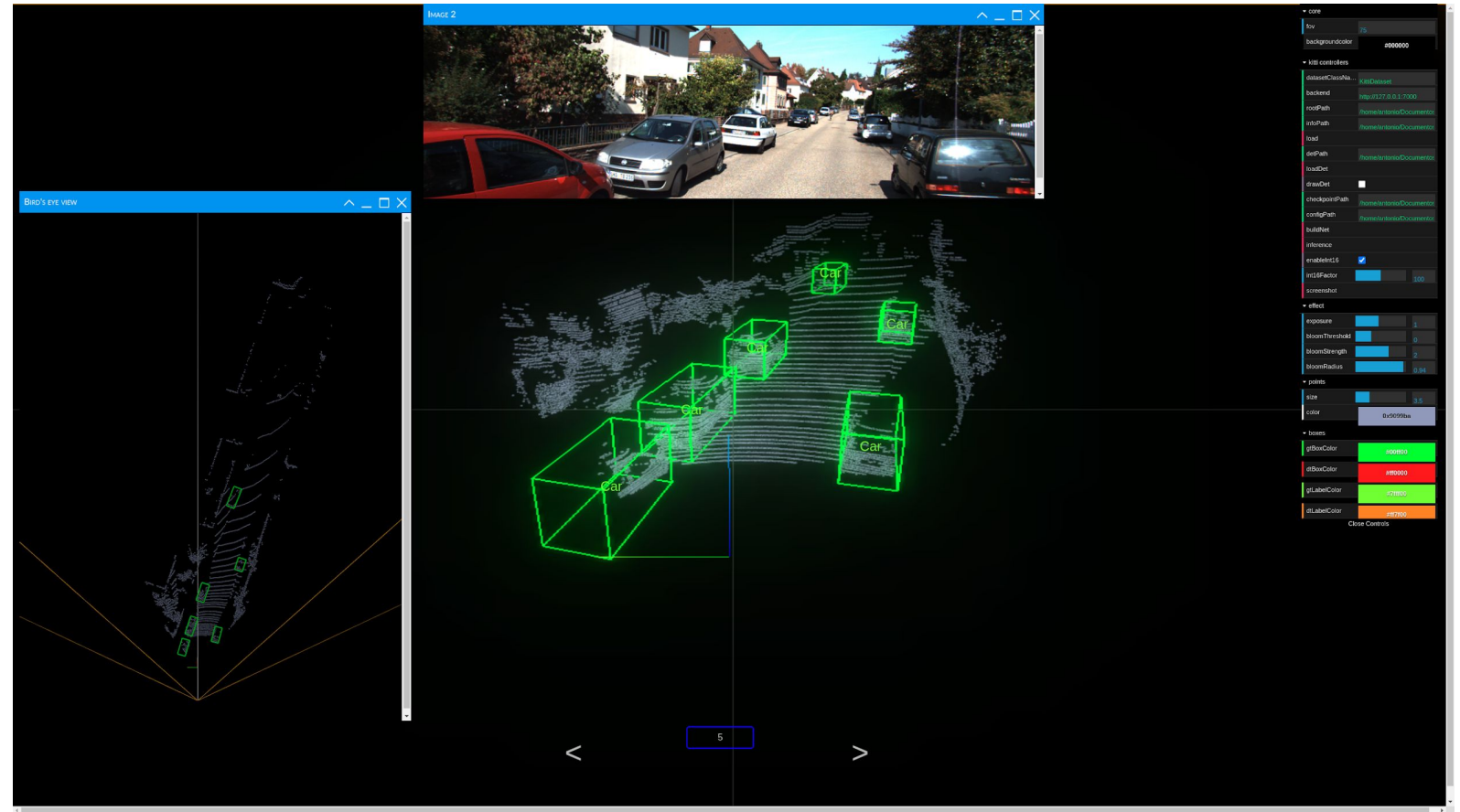
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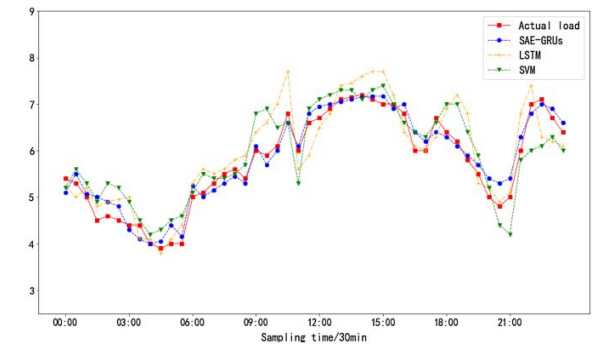
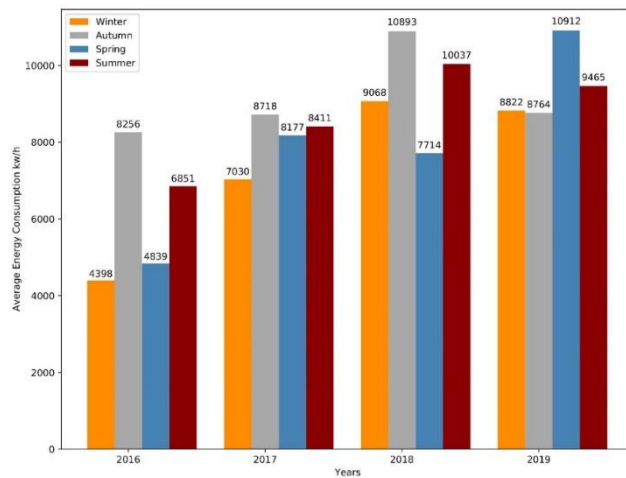
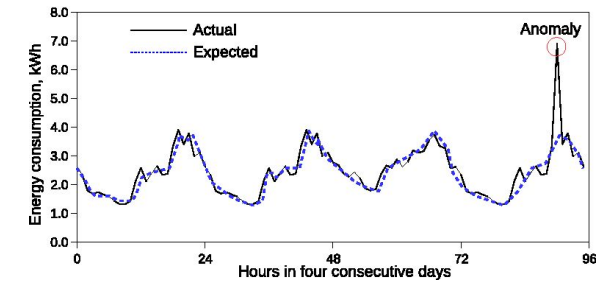
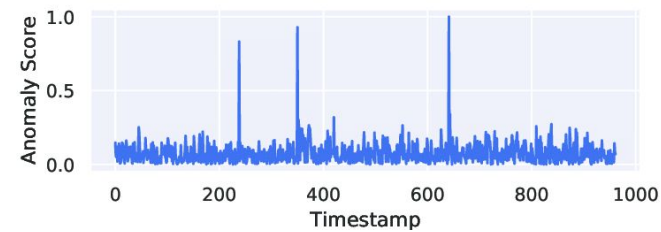
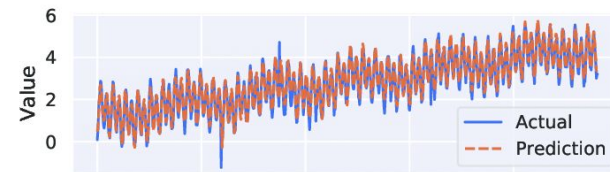
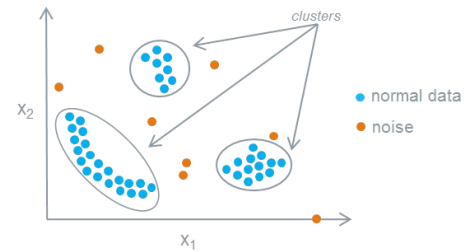
Mobility

Cars of the Future (Present)

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Predictive and Analytic Models for the Optimization of Multi-Municipal Water Systems



INTEROPERABILITY

SYNTACTIC

Reference
Model

STRUCTURAL

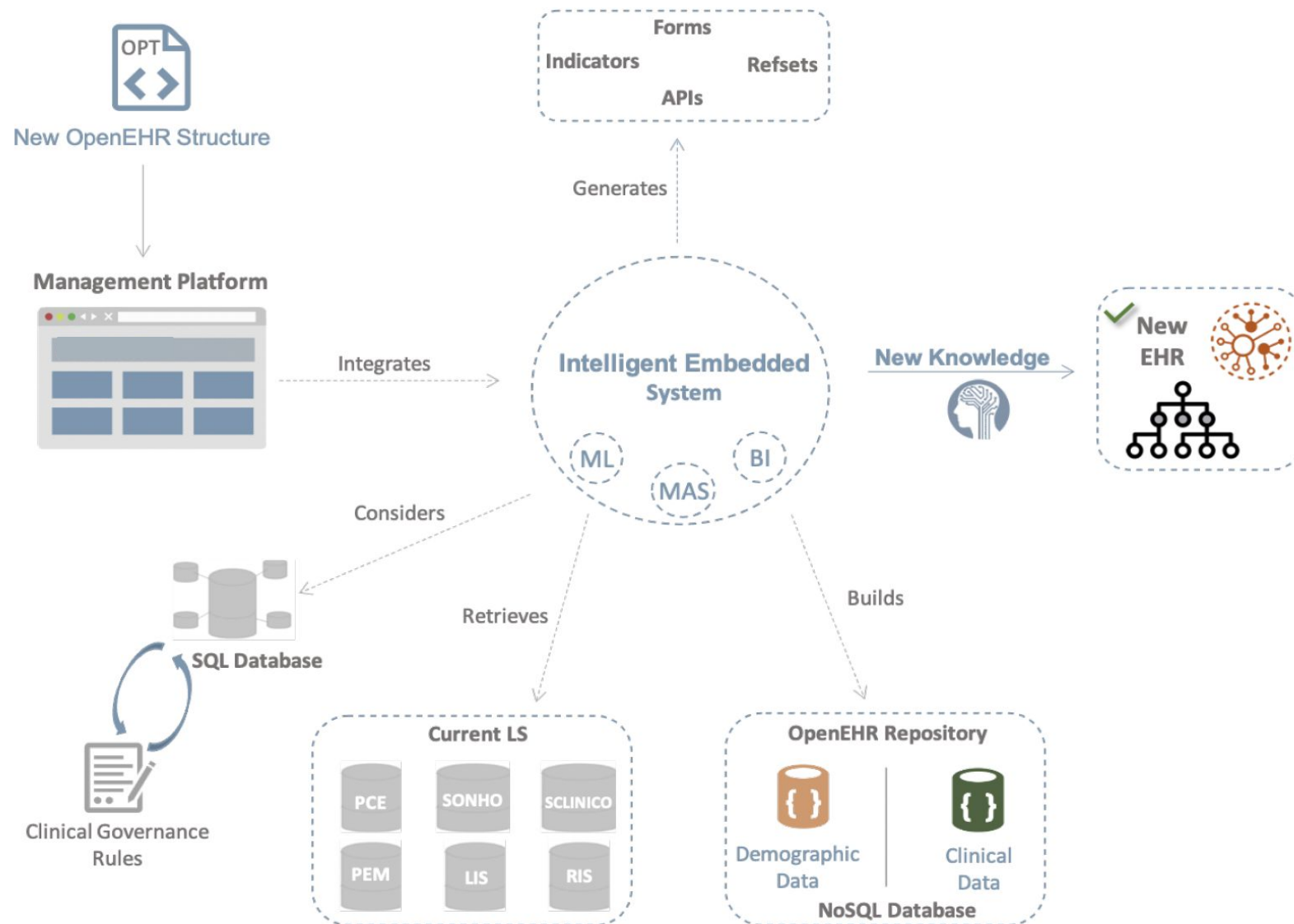
Archetypes

SEMANTIC

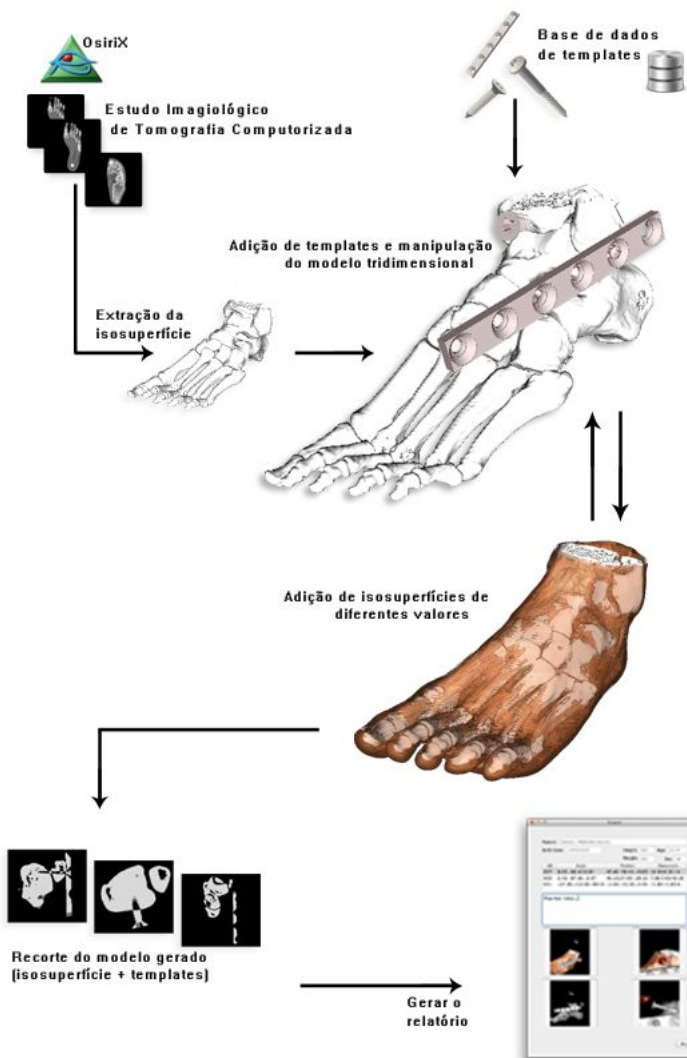
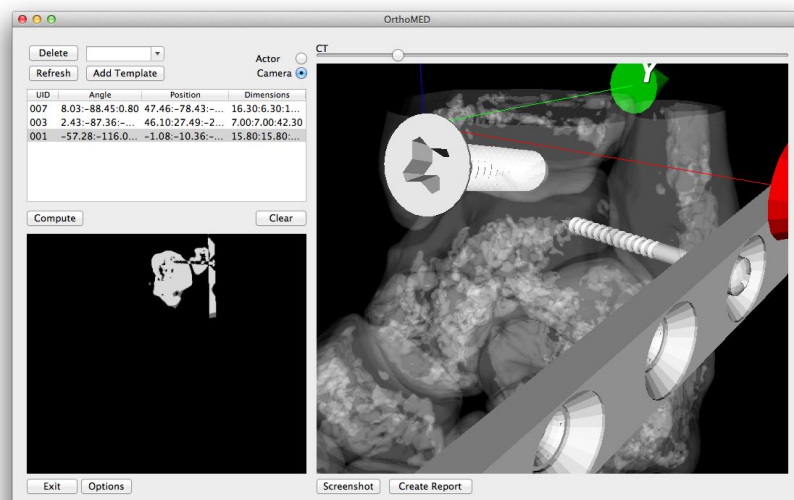
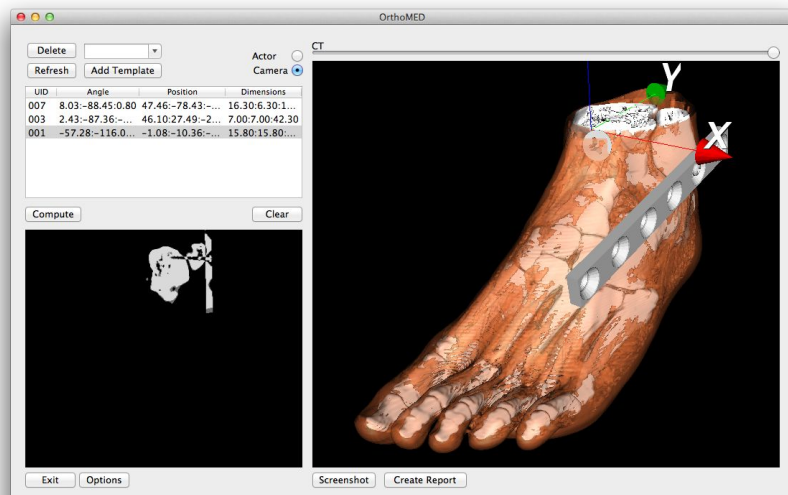
Terminologies

open
EHR

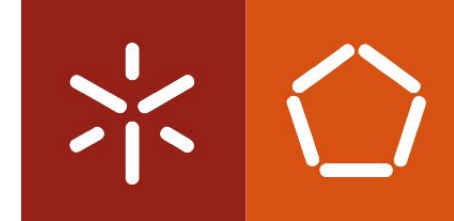
DANIELA
OLIVEIRA



Computed Tomography Based Orthopedic Surgery Planning solution



- Just like Human-Human interaction, Human-computer Interaction is richer in information than what we can see at first sight
- This information can be used to develop more intelligent and sensitive interfaces
- This is in-line with one of the main objectives of Human-computer Interaction
 - To put the user in the middle



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