SensAI+Expanse Prediction of Emotional Valence Changes on Humans in Context by an Artificial Agent Towards Empathy

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PhD defence, 16 September 2020

Emotions and Human-Agent Interaction

*"[...] if we want **computers** to be genuinely intelligent*
*and to **interact naturally with us**, we must give computers*
*the ability to **recognize**, understand,*
*even to have and express **emotions** [...]"*[1]

[1] Picard, R. W. (1997). *Affective Computing*. MIT Press.

Now

Apple Siri and others Assistants with limited tasks and context. Search and recommend.

Google Duplex Voice-enabled assistant able to mimic human voice. Goes scheduling on ones behalf.

Microsoft Xiaoice Social and conversational, uses text and voice, learns and acts empathetic.

Cleverbot, Meena, Mitsuku, ... Attempting to mimic human conversation but still low success. Open-domain claims without evidence.

Inferring Emotion

"[...] ***constructions*** *of the world, not reactions to it."*

"[...] created from ***concepts*** *which are the* ***predictions*** *that give meaning to your* ***affect*** *in your environment."*

Lisa Feldman Barrett
Professor of Psychology at Northeastern University
https://cos.northeastern.edu/people/lisa-barrett/

Current research issues

- Debate regarding cross-cultural bias.
- Brain-body phenomena in context.
- Vary in dynamic ways over time.

1 **Development**
- Thesis
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2 **Study**
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3 **Discussion**

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Problem

Behaviour Is modified by affective states.

Interaction May be subject to change or bias.

Prediction When, where, and more context may improve the bonding.

Research Questions

How to build a predictive model?

- Emotional valence changes.
- Human context (sensors, text, self-report).
- Artificial agent in mobile device.

How to leverage such a model?

- Adapt interaction.
- Foster empathy.
- Non-anthropomorphic agent.

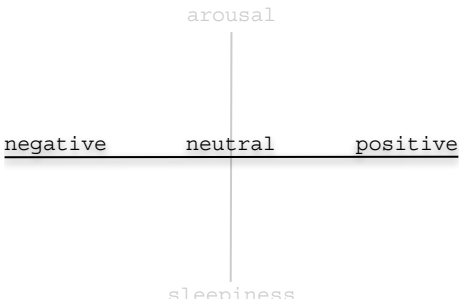
Hypotheses

Hypothesis 1 The human-agent bonding provides enough data to predict emotional valence in context.

Hypothesis 2 The agent prediction ability is gender and age neutral.

Hypothesis 3 Artificial agent leverages smartphone sensors and data to predict idiosyncrasies.

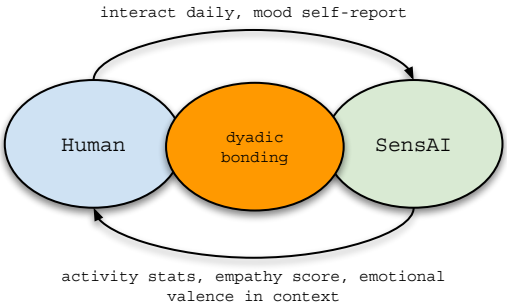
Emotion Sensor



A sensible approach

- Valence dimension (Circumplex model).
- Discrete 3-class scale (ground truth).
- Continuous scale (sentiment analysis).
- Spatial and temporal context add-ons.

Human-Agent Interaction

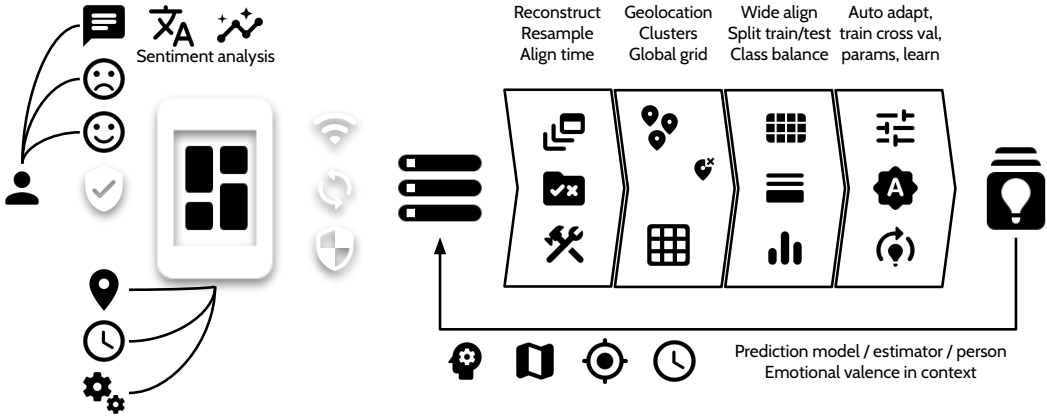


Interaction Non-invasive; non-animal-like; non-anthropomorphic.

Data Mobile sensors; diary sentiment analysis; valence self-report.

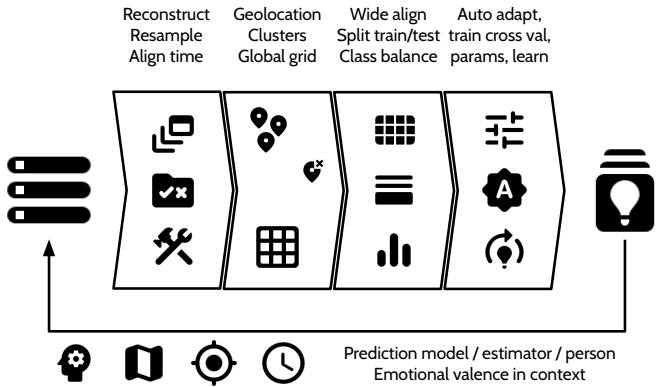
Context Activity dashboard; geolocation; moment.

Architecture, Data, Flow

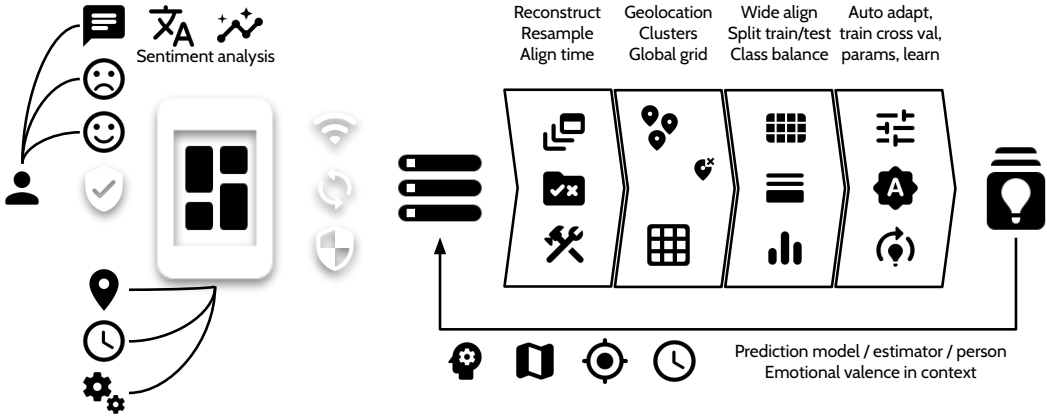


Architecture, Data, Flow: SensAI

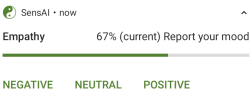
Architecture, Data, Flow: Expanse



Architecture, Data, Flow: SensAI+Expanse

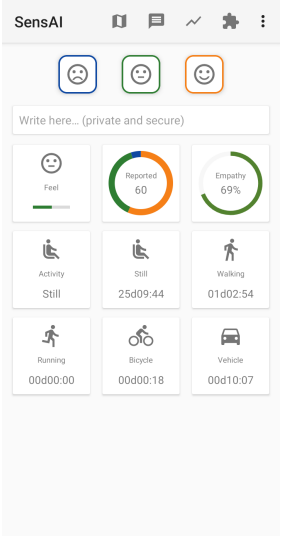


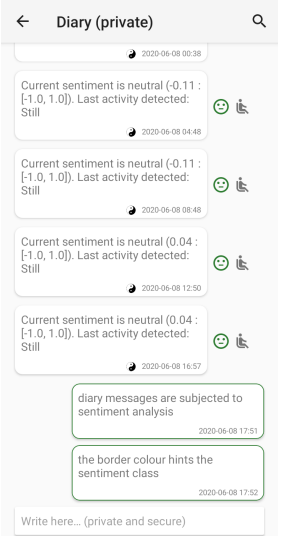
Interaction



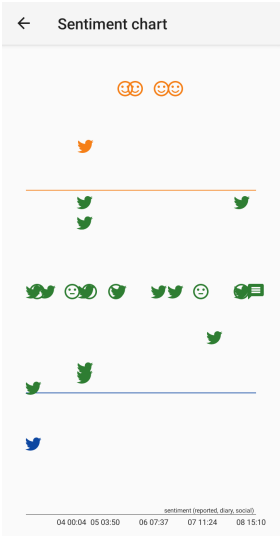
Empathy score

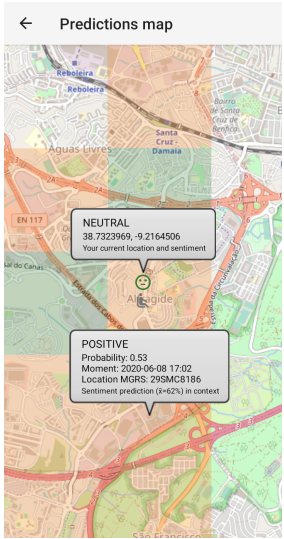
- Decays over time.
- Increases with self-reports.





Insights





- Sentiment self-reported.
- SensAI sentiment analysis (diary and Twitter texts).
- Expanse learning.
- Predictions in context.

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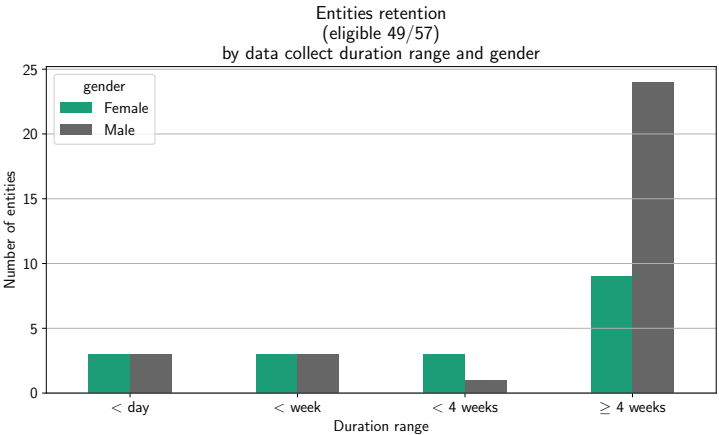
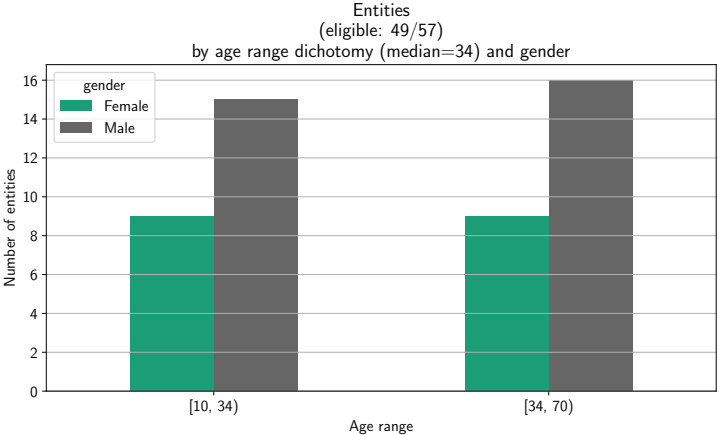
Participants



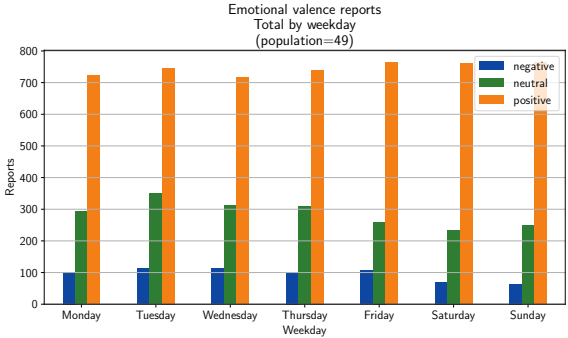
- Age [10, 70), median 34.
- Females and males.
- 33 retained ($\geq$ 4 weeks).
- Africa, America, Asia, Europe.

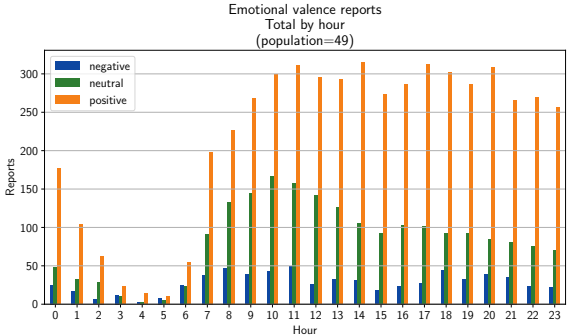
Design, Procedure, and Demographics



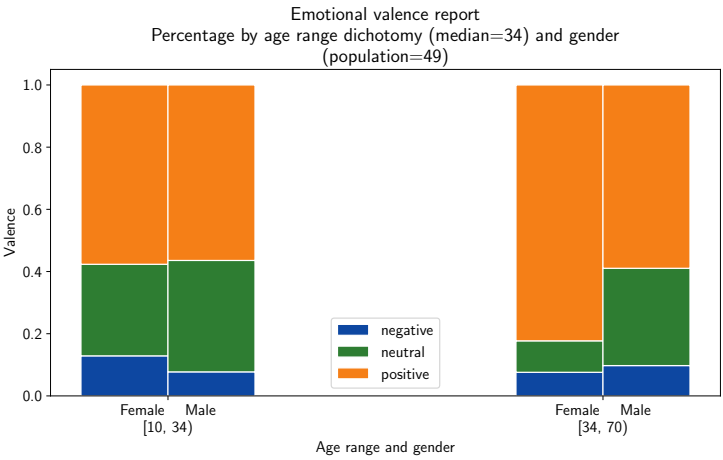
- Worldwide access using a free Android app.
- Neutral messages (age, gender).
- Chromatically consistent. Negative | Neutral | Positive
- Sensorial and non-invasive artificial agent.

Behaviour Aggregated





Behaviour Differences



$[10, 34)$ **vs.** $[34, 70)$
Evidence of differences.
$p = 1.161 \times 10^{-30}$

$[10, 34)$ **F. vs.** $[34, 70)$ **F.**
Older group less negative.
$p = 5.539 \times 10^{-14}$

$[34, 70)$ **F. vs.** $[34, 70)$ **M.**
Female more positive.
$p = 7.027 \times 10^{-67}$

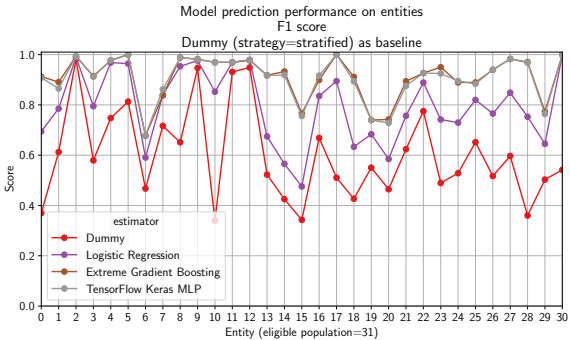
Mann-Whitney U, $\alpha = 0.05$

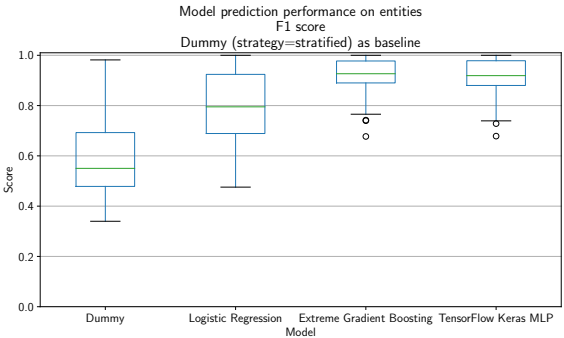
Published in COGNITIVE 2020

Learning Task Requirements

Features	Geolocation (clusters and grid); hour of the day; quarter of the day; day of the week.
Estimators	3 model classes + 1 baseline per person.
Models	Adapted and fine-tuned to each person.
Predictions	Past data predicts future emotional valence in context.

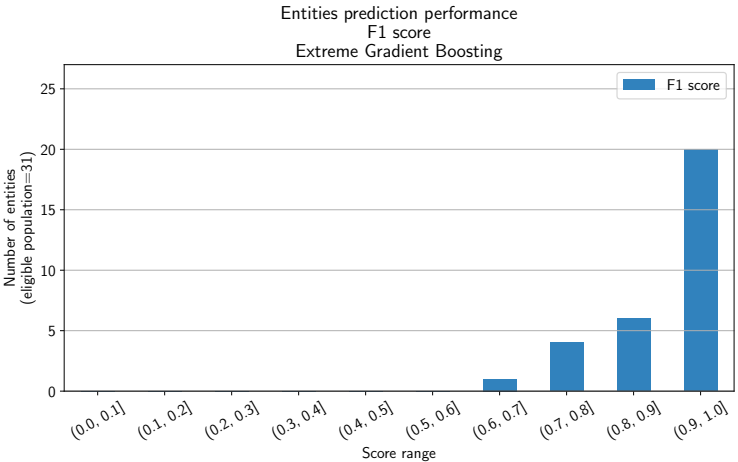
Learning





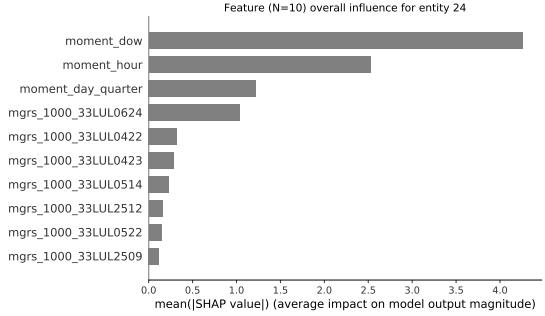
Published in ADAPTIVE 2020

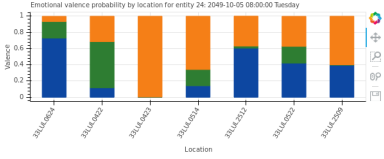
Prediction

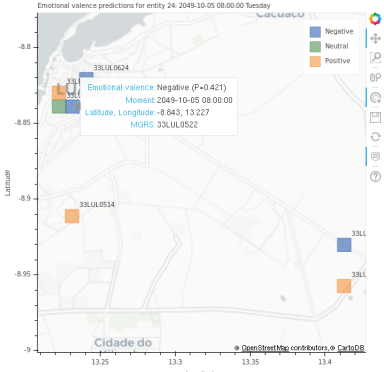


- Good prediction performance in most cases.
- Efficient energy use
  - $^1/_{10}$ duration vs. MLP.
  - Best $\overline{F1} = 0.91$.
- Per class probability.
- Explainable.

3-Class Probabilistic Prediction: Example for Entity 24



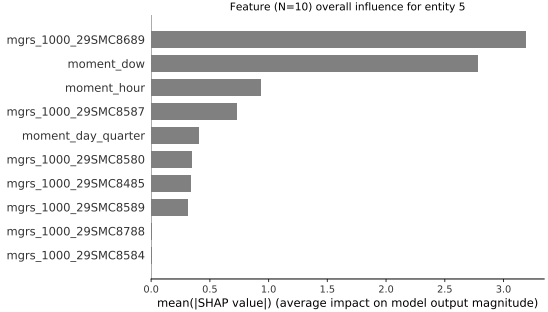




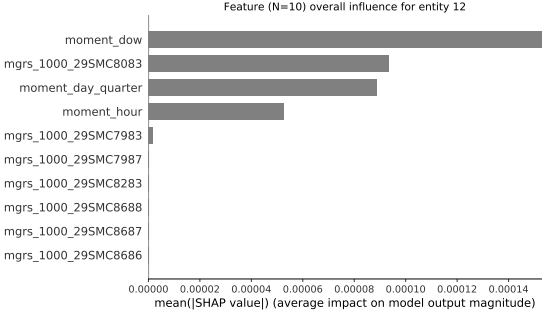
- Evidence of time-related feature impact.
- Location competing with time in some cases.

Time and Space Competing Features: High vs. Low Impact

Entity 5 (High)



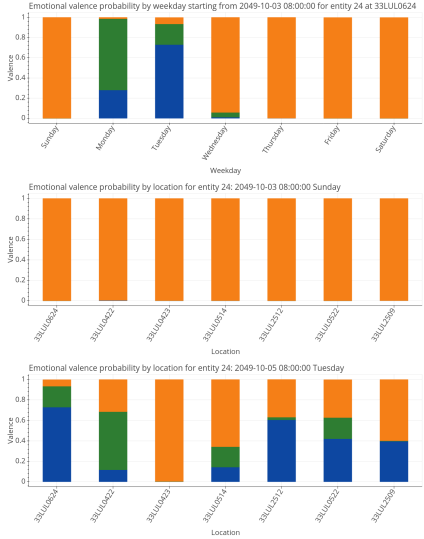
Entity 12 (Low)



Time and Space Competing Features: Results

- Overall temporal dimension sensitivity.
- Most influential (prediction model):
  - Weekday: 64.5%
  - Hour: 25.8%
  - Location: 9.7%
- Prediction of idiosyncratic factors.
- Emotional valence changes in context.
- Adding new features may reveal other relevant factors (e.g., sports).

Hand-picked sample: Entity 24



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Contributions

- A novel system for studies regarding emotional valence changes in context.
- Potentially free of known bias[2].
- Open source code and open science.
- Mobile sensing agent with adaptation and learning capabilities towards emotional valence predictions in context. (H1)
- Age range and gender neutral. (H2)
- Robust to idiosyncratic factors. (H3)

[2] Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences*, *33*(2-3), 61–83. https://doi.org/10.1017/S0140525X0999152X

Contributions

- CogA | Cognitive and affective library.

  `https://gitlab.com/nunoachenriques/coga`

- SensAI | Mobile device sensing agent.

  `https://gitlab.com/nunoachenriques/sensei`

- SensAI Expanse | Learning, prediction.

  `https://gitlab.com/nunoachenriques/sensei-expanse`

- VADER Sentiment Analysis in Java

  `https://github.com/nunoachenriques/vader-sentiment-analysis`

- 2 Conference papers. Open science:

  1. `https://arxiv.org/abs/1912.10084`
     Accepted as a regular paper (ADAPTIVE 2020)
  2. `https://arxiv.org/abs/2001.09746`
     Accepted as a regular paper (COGNITIVE 2020)

Current Limitations and Future Work

- Prior health information and socio-economic status is missing.
- Affective regulation gender differences not considered.
- People matter. Non-anthropomorphic versus human-like interaction.
- Moral agency is missing.
- Feedback regarding privacy perception, expectations, and user experience is missing.
- Smartphone as a wearable device only to some extent.

Future

Unforeseen possibilities arise with further developments in Cognitive Science.

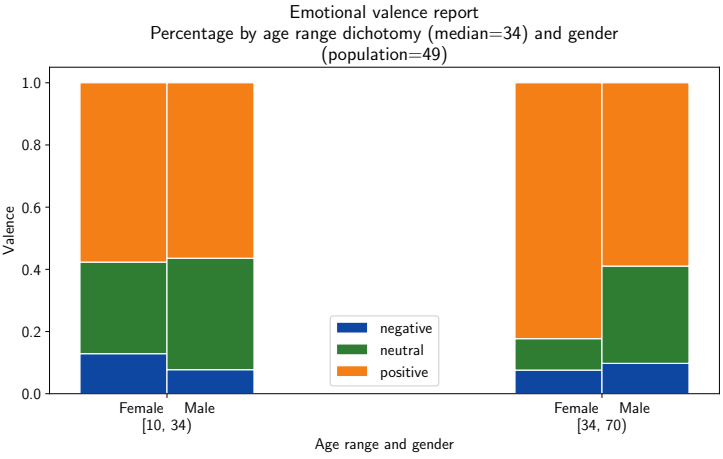
A **hybrid**, **knowledge-driven**, **reasoning-based**[3] cognitive architecture comprising **moral** and **identity**-related capabilities, **integrated in artificial agents**.

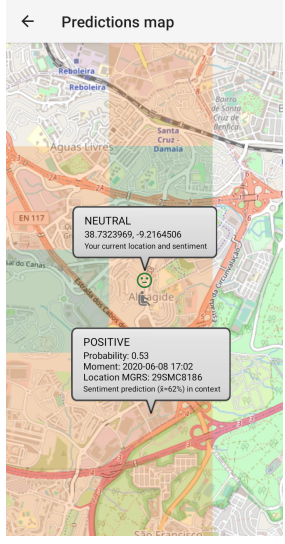
"Computers aren't the thing. They're the thing that gets us to the thing."[4]

[3] Marcus, G. (2020). The Next Decade in AI: Four Steps Towards Robust Artificial Intelligence. (February).

[4] "Halt and Catch Fire", `https://www.amc.com/shows/halt-and-catch-fire`

Summary


Emotional valence report
Percentage by age range dichotomy (median=34) and gender
(population=49)
Valence
1.0
0.8
0.6
0.4
0.2
0.0
negative
neutral
positive
Female
Male
[10, 34)
Female
Male
[34, 70)
Age range and gender


Predictions map
Reboleira
Reboleira
Aguas Livres
Santa Cruz - Damaia
EN 117
NEUTRAL
38.7323969, -9.2164506
Your current location and sentiment
POSITIVE
Probability: 0.53
Moment: 2020-06-08 17:02
Location MGRS: 29SMC8186
Sentiment prediction (k=62%) in context

Thanks

Humans Incognito participants. Advisors. Family and friends. Lab mates.

Funding Universidade de Lisboa [PhD support grant between May 2016 and April 2019]. Fundação para a Ciência e Tecnologia [UID/MULTI/04046/2019 Research Unit grant from FCT, Portugal (to BioISI)].

Logistics MAS/BioISI laboratory. European Grid Infrastructure (EGI) and NCG-INGRID-PT (Portugal).