Artificial Intelligence and Emotion Recognition: saving pain.

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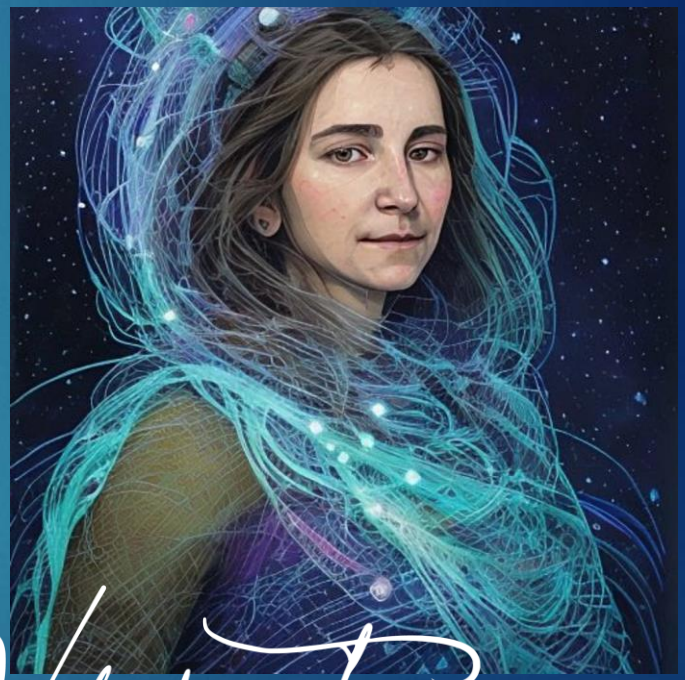
V Workshop of the *Department of Mathematics and Computer Science University of Perugia*

8 February 2023



DMI DIPARTIMENTO DI MATEMATICA E INFORMATICA

A.D. 1308 unipg UNIVERSITÀ DEGLI STUDI DI PERUGIA

Research questions

- *What* is an emotion, and how it can be defined in Artificial Intelligence
- *How* emotions can be measured
- *How* emotions and pain are similar
- *Which* applications we can have in health management
  - methods and techniques used to recognize emotions
  - real-world applications and recent advances
  - limitations and challenges

What is an emotion?

What is an «emotion»

Cognitive system *input*
+
emotional system *input*
(limbic/Cranial Nerves)
=
decision *output*

BRAIN

situations

Cognitive system
Emotional system

Cognitive system
Emotional system

If there is a lion…

Cognitive system says: baby lion, maybe mother around.

Emotional system says: AAAWW! CUTE!! I would like to touch!

Decision system says: better to watch from far.

And what if…

Cognitive system says: lions running at me!

Emotional system says: **FEAR** of death! **RUN AWAY**!

Decision system says: **EMERGENCY**!

What emotions are

Emotions are something that get us to act in a particular way.

We don't need to *feel* or *understand* emotions to act, but to teach and plan for the future.

Emotions are universal; a feeling is instead the internal subjective component of the sense of perception, arising from the stimulation of the senses by phenomena.

Emotions in an AI perspective

- Primitives (**modular**)
- Fast (**approximate**)
- Executed automatically (**reactive**)
- Based on environment (**adaptive**)
- Temporary with learning (**evolutionary**)
- Can be **collective** and **contagious**

Affective Computing studies emotions and:

- feelings and physiological sensations
- sentiments (positive/negative/neutral)
- moods and mind states
- thoughts and beliefs

Emotions in Collaborative Collective Networks

Relational

Emotions in Network Science and Social Network Analysis

Communication channel

Emotions in Multitasking and Process Management

Bidirectional flux

Emotions in Trauma

- Executed automatically *(**reactive**)*
- Based on environment *(**adaptive**)*
- Temporary with learning *(**evolutionary**)*

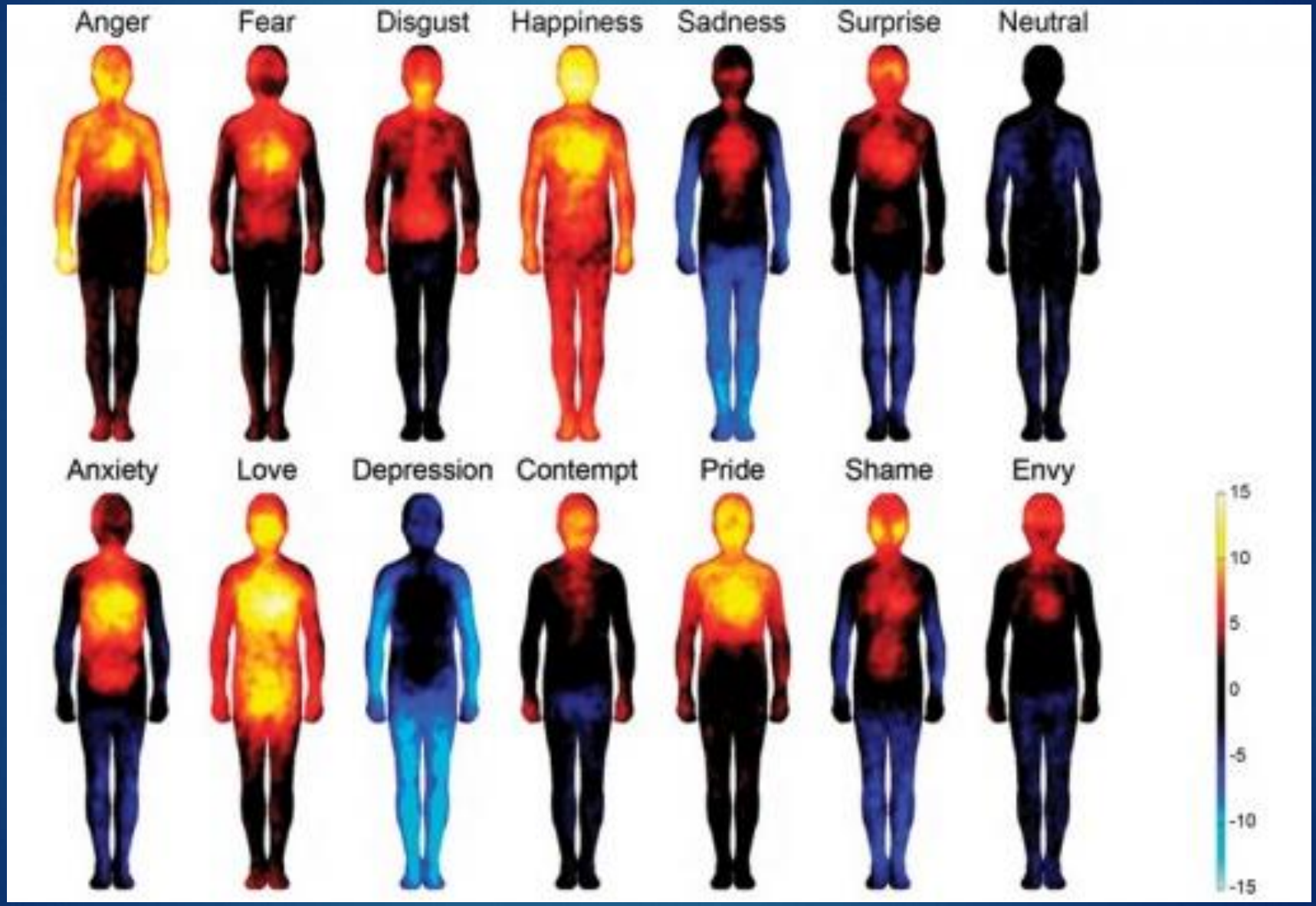
Emotions in Trauma

- Executed automatically *(**reactive**)*
- Based on environment *(~~**adaptive**~~ ***maladaptive**)*
- Temporary with learning *(**evolutionary**)*

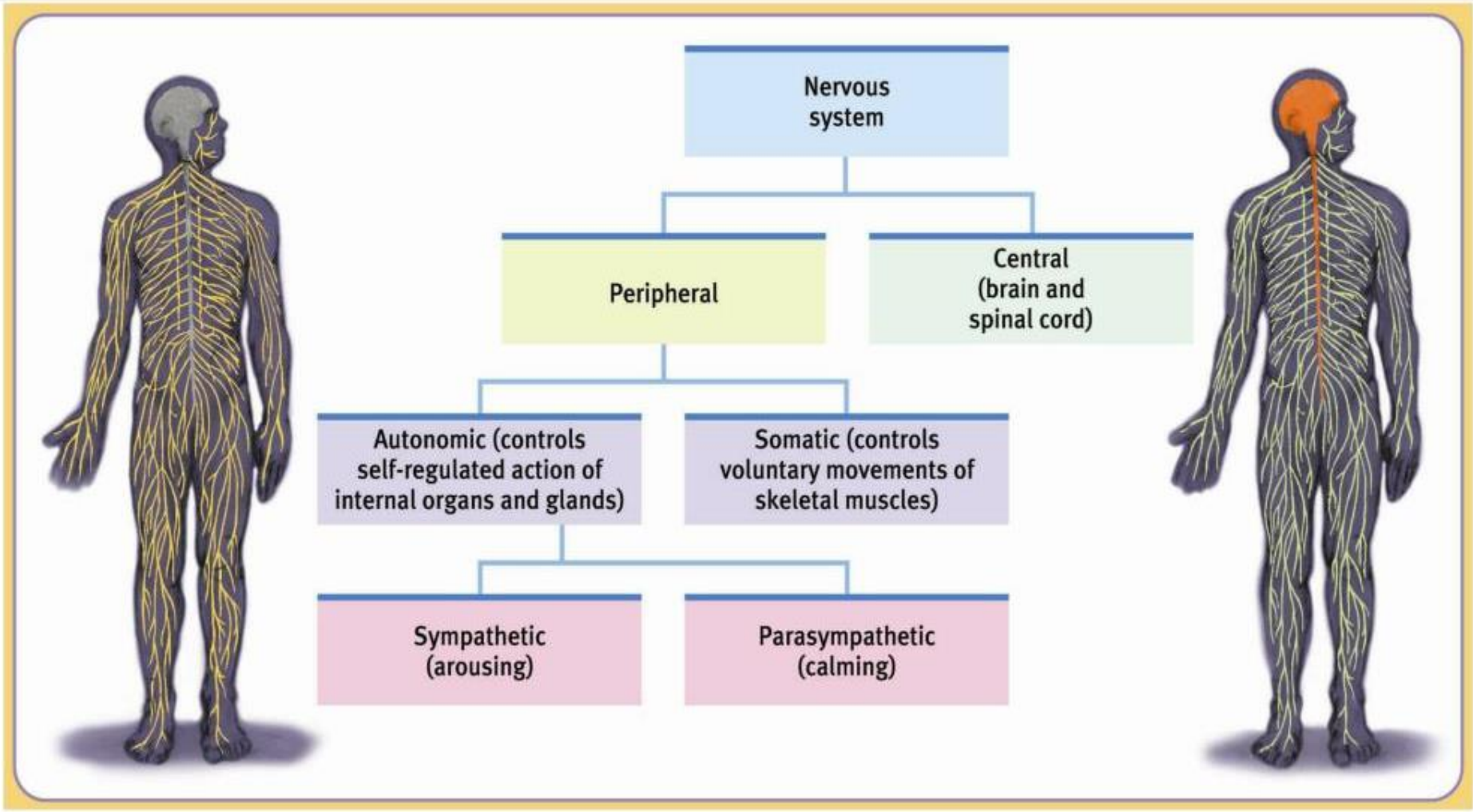
Traumatic emotional memories are safe during the traumatic event but can be later triggered again in non-dangerous contexts, becoming maladaptive.

How to measure emotions?

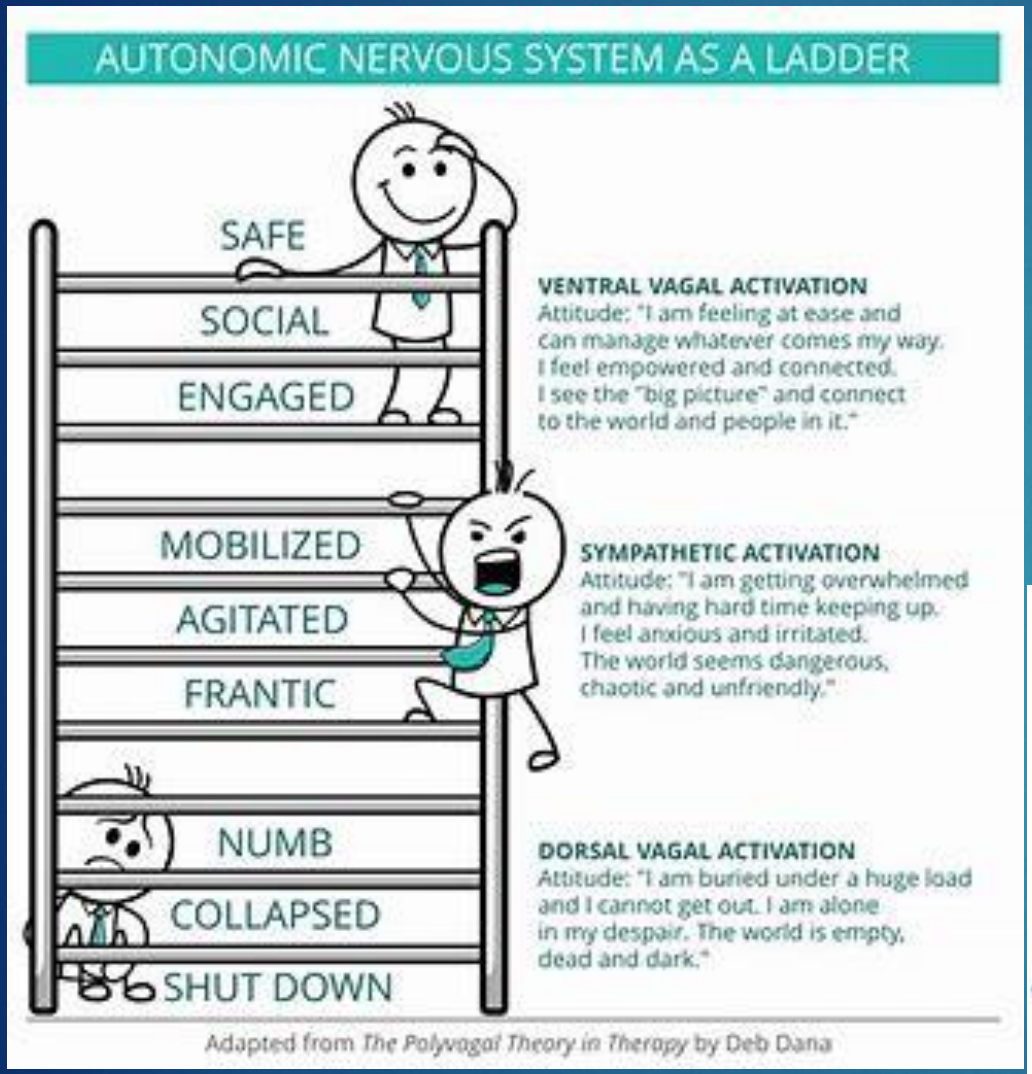
Physiology of emotional sensations



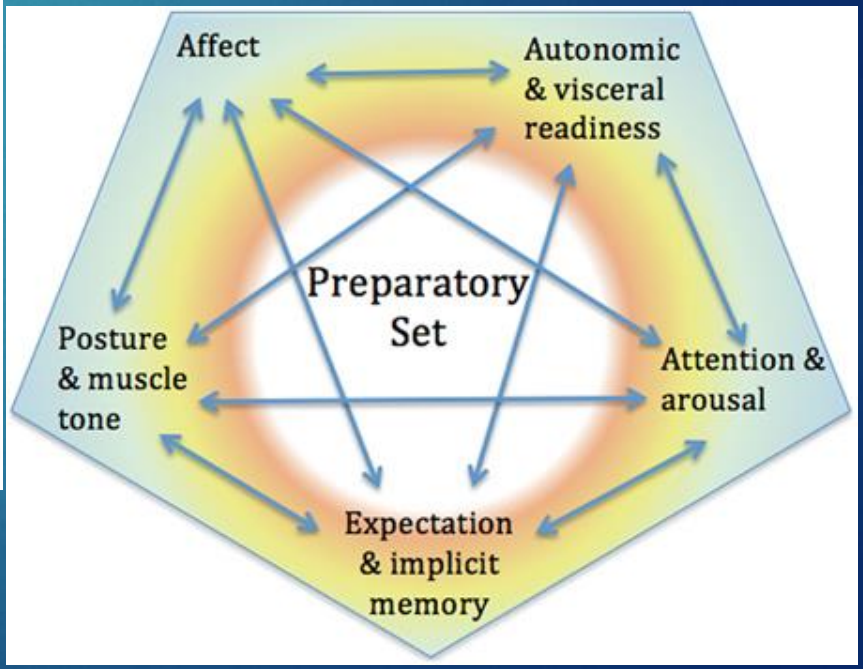
Neurophysiology of emotions



Polyvagal Theory



Sensitive (input) and Active (output) nerve bidirectional fibers from the Cranial Nerves to internal organs, skin, and head.



How are emotions and pain similar?

Emotions and pain

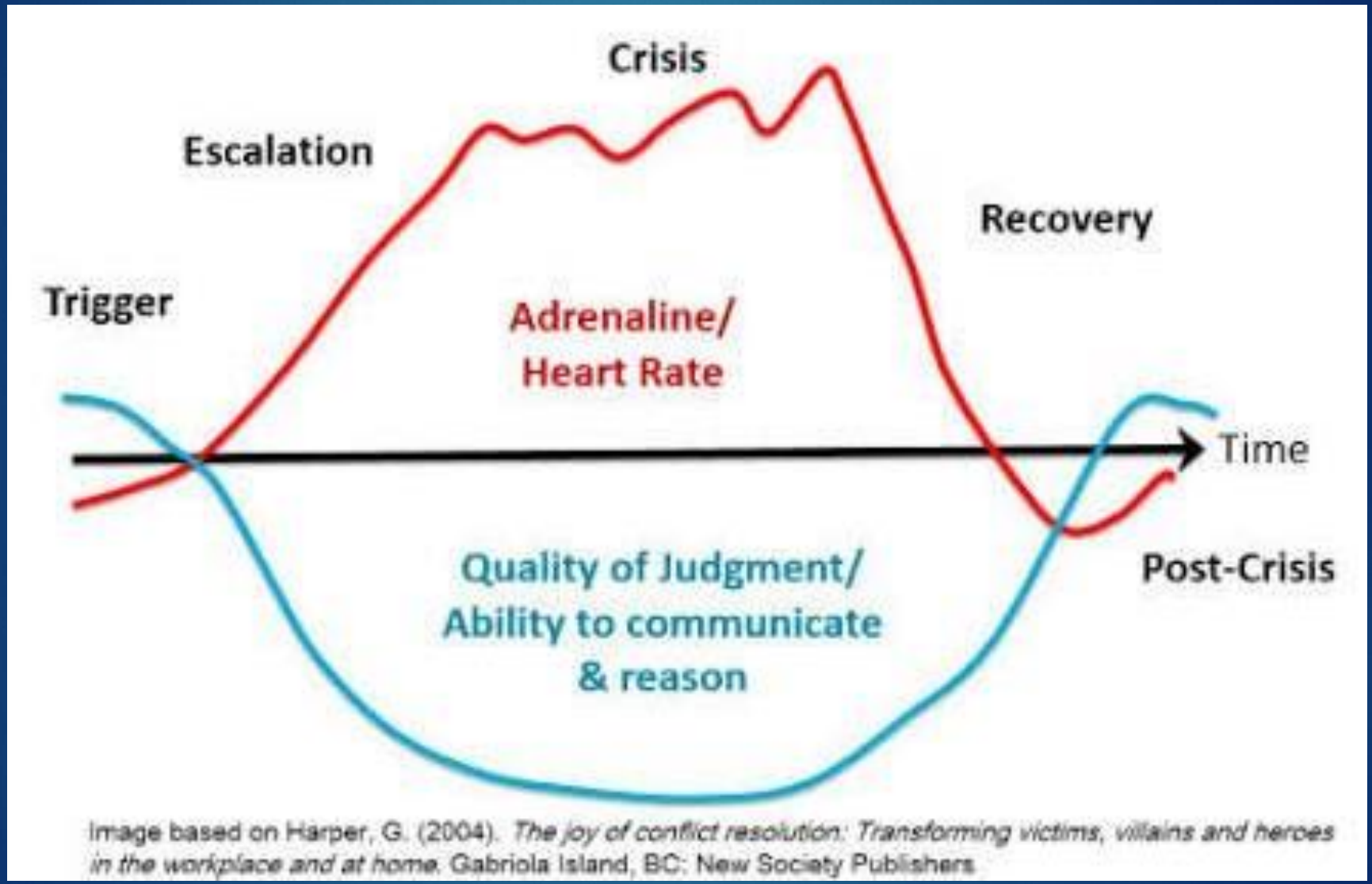
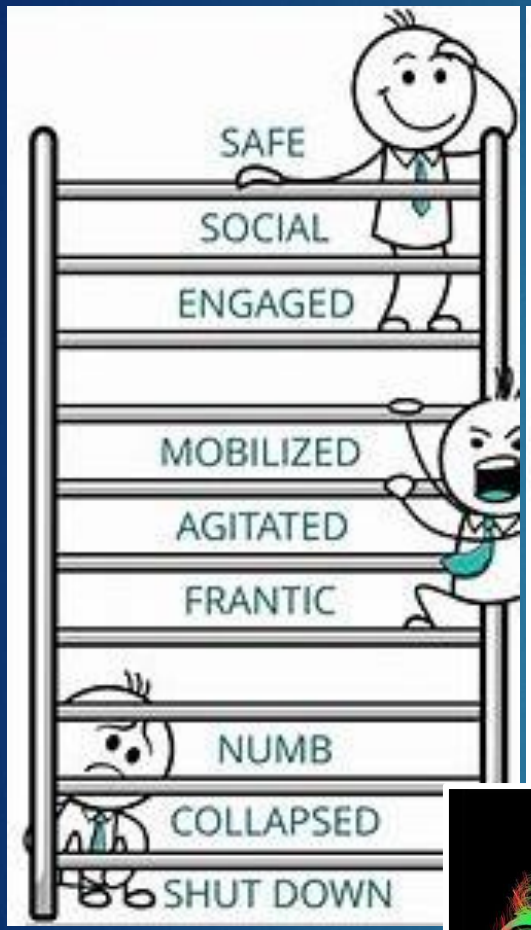
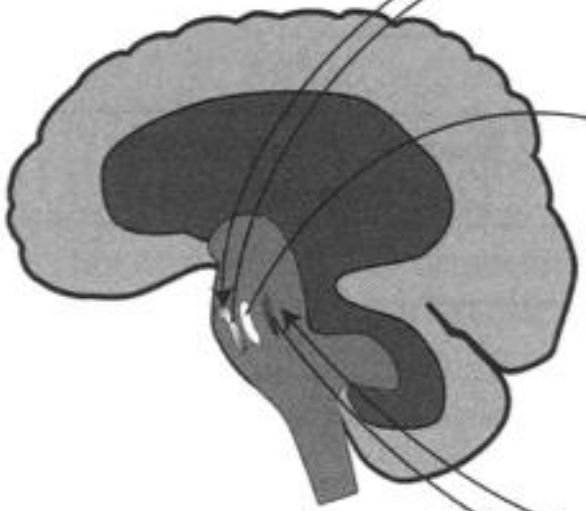


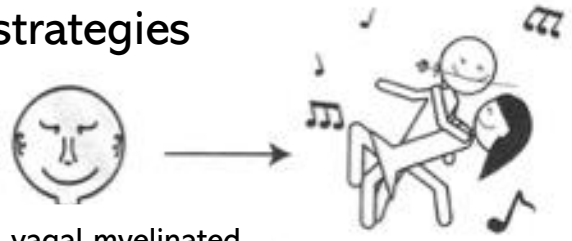
Image based on Harper, G. (2004). *The joy of conflict resolution: Transforming victims, villains and heroes in the workplace and at home.* Gabriola Island, BC: New Society Publishers

Polyvagal Theory



Phylogenetic hierarchy of response strategies





the ventral vagal myelinated system communicates emotional information through the face and pharynx and…

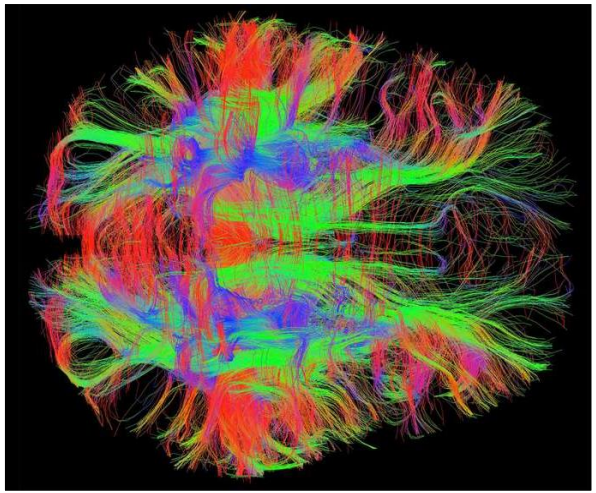
it is also the system of social involvement and communication

the sympathetic nervous system sends information to the limbs, and…

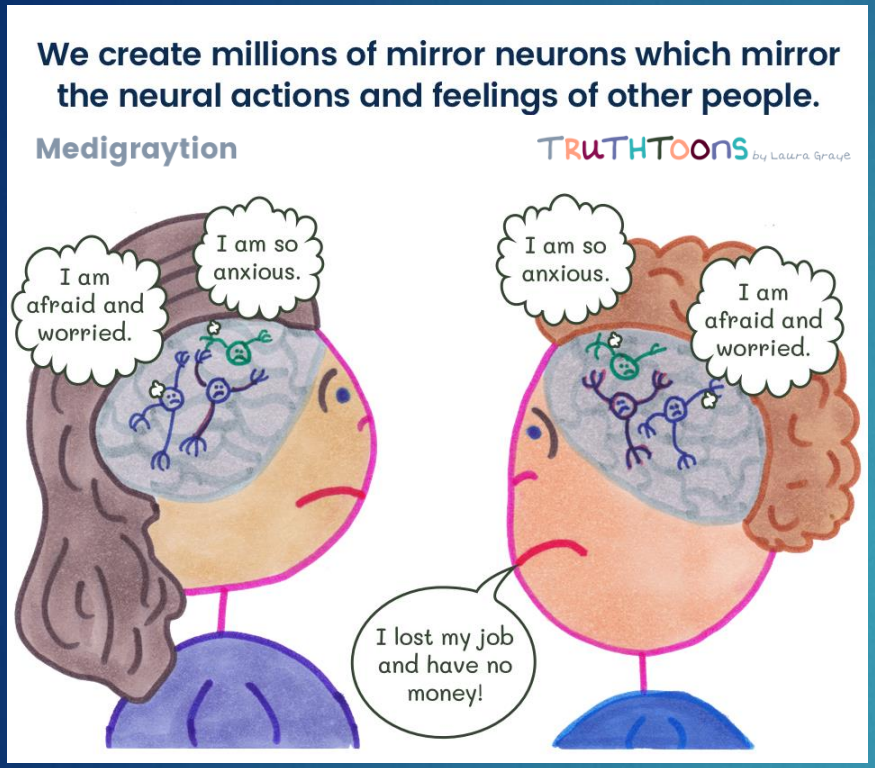
it supports the fight/flight response

the dorsal vagal system receives and transmits information by communicating with the viscera, and…

it is responsible for the immobilization and freezing response



Mirror Neurons



Sensory, cognitive and motor implications

Response is similar for:

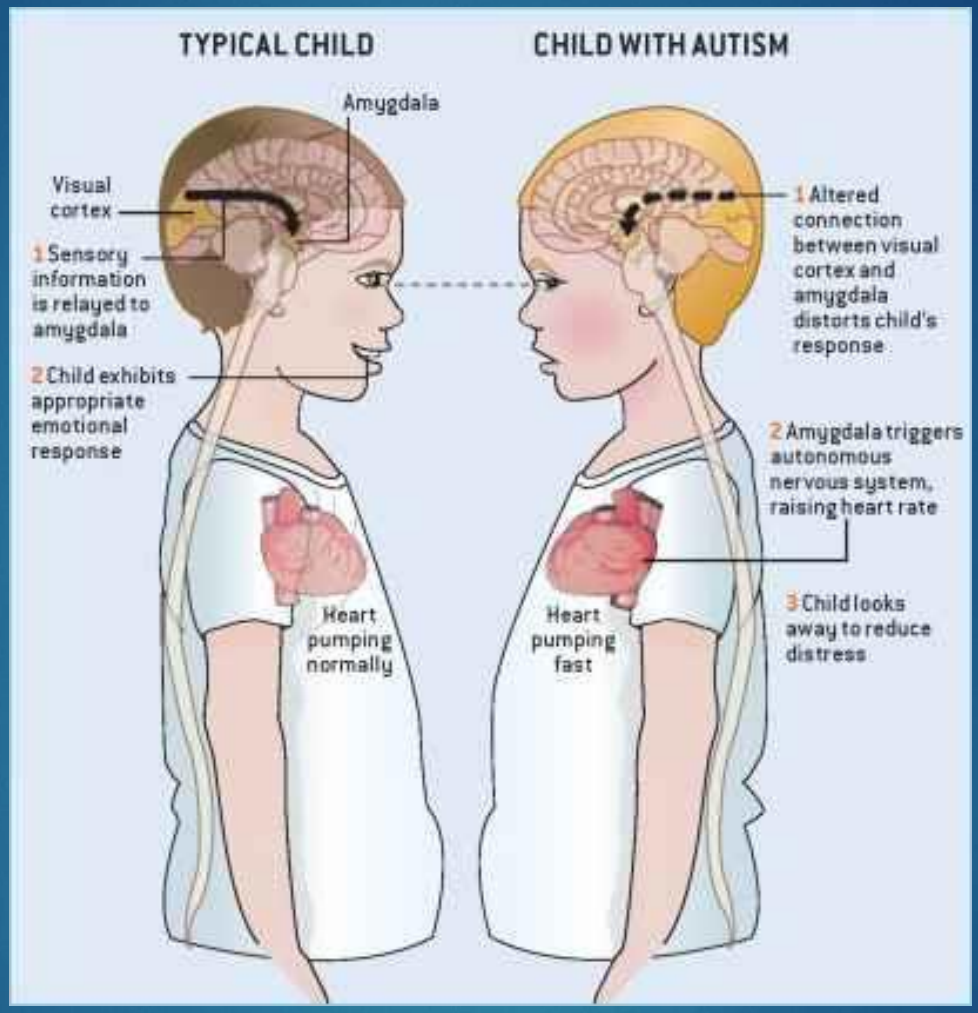
- Performing the action
- Witnessing the action
- Hearing about the action

Mirror Neurons enable:

- Empathy
- Skill building through mimic
- Vicarious experience

Which challenges for health?

Assistive Systems



Assistive Systems for Emotion Recognition

O.Gervasi, V.Franzoni, M.Riganelli, S.Tasso: ***Automating facial emotion recognition****. Web Intell. 17(1): 17-27 (2019)*

Affective Computing in Trauma management

- Key approach to use with patients who are unable to verbalize their trauma.
- Critical ways the head and facial muscles activate to calm a fear response.
- How to activate the part of the nervous system that promotes stronger social engagement.
- How to shift a patient's physiological state to move them out of shutdown.

M. Riganelli, V. Franzoni, O. Gervasi, S.Tasso: ***EmEx, a Tool for Automated Emotive Face Recognition Using Convolutional Neural Networks****. ICCSA (3) 2017: 692-704V.Franzoni, G.Biondi, V.Franzoni, O.Gervasi, D.Perri:* ***An Approach for Improving Automatic Mouth Emotion Recognition****. ICCSA (1) 2019: 649-664*

Franzoni V., Biondi G., Perri D., Gervasi O. (2020). Enhancing mouth-based emotion recognition using transfer learning. SENSORS, vol. 20

MOUTH: critical element of human face recognition, symmetric, visible from any perspective, ideal element to focus for facial Emotion Recognition.

Mouth-based ER gets 95% of the performance compared to full face.

Emotional model:

Neutral
Happy
Surprise
Anger

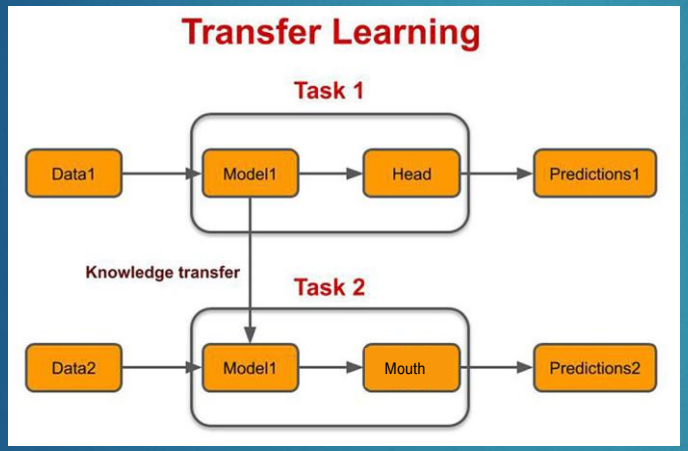


Table 2. Final results related to the considered CNNs.

Network	Accuracy
Vgg-16	71.8%
InceptionResNetV2	79.5%
Inception V3	77.0%
Xception	75.5%

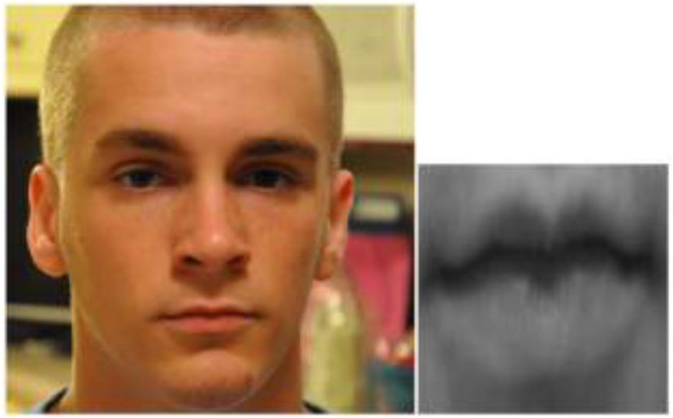


Figure 1. Mouth detection, cropping and resizing (source image from AffectNet database).

Applications (e.g.):

- automated **supervision of bedridden critical patients**,
- portable support for disabled users in seeing or recognizing facial emotions.

Baia, A.E., Biondi, G., Franzoni, V., Milani, A., Poggioni, V., (2022). Lie to me: Shield Your Emotions from Prying Software. SENSORS, vol.22

For an input facial image $x \in X \subset \mathbb{R}^d$ and the related label y, let F be a Neural Network (NN) classifier that correctly predicts the emotional class label for the input image $x : F(x) = y$. An EAA attempts to modify x adding a δ perturbation into an adversarial image $x^* - x + \delta$, such as to induce F to make a *faulty emotion class prediction*, i.e., $F(x^*) \neq F(x)$.

Adversarial attack preserving users' privacy from ER.

The quality of the images from the human perception point of view is maintained.

EASR = 91.25%, 93.75%, and 96.25% when using 3, 4, and 5 filters.
The only classes that maintain some correct classifications are fear and happiness. Other classes show a 100% success rate.

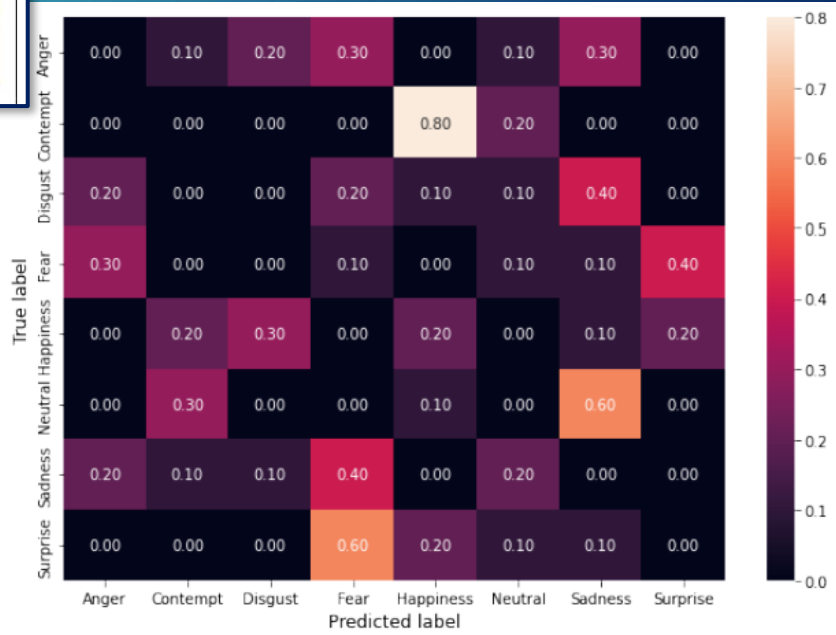
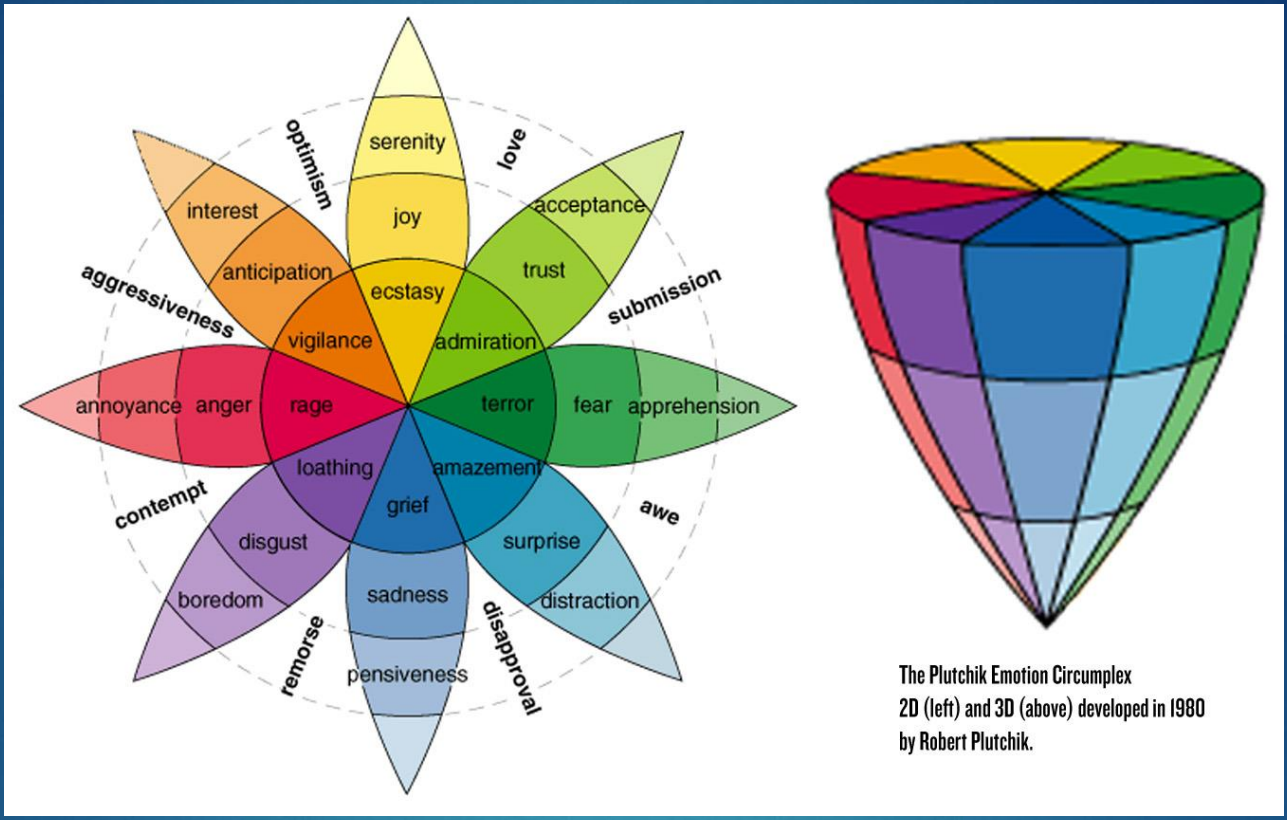


Figure 3. Confusion matrix from the results of the attack with five filters.

Multidimensional models



V.Franzoni, J.Vallverdú, A.Milani: ***Errors, Biases and Overconfidence in Artificial Emotional Modeling****. WI (Companion) 2019: 86-90*

V.Franzoni, V.Poggioni, F.Zollo: ***Automated Classification of Book Blurbs According to the Emotional Tags of the Social Network Zazie****. ESSEM@AI*IA 2013: 83-94*

V.Franzoni, V.Poggioni: ***Emotional book classification from book blurbs****. WI 2017: 931-938*

V.Franzoni, G.Biondi, A.Milani: ***A Web-Based System for Emotion Vector Extraction****. ICCSA (3) 2017: 653-668*

Milani A., Rajdeep N., Mangal N., Mudgal R. K., Franzoni V. (2018). Sentiment extraction and classification for the analysis of users' interest in tweets. INTERNATIONAL JOURNAL OF WEB INFORMATION SYSTEMS, vol. 14, p. 29-40

- **Topic Extraction**: open NLP, WORDNET similarity to categories: *Entertainment, Business/Finance, Technology, Sports, Recreation, Health, Politics, Social Issues*
- **Sentiment Analysis**: Stanford CoreNLP Tweet positivity and negativity based on sentiment score in [0,4]->Positive

231750 tweets 1150 users: behaviour
202578 tweets: comparison of 5 cities in India

Hybrid Methodology for Sentiment and Topic Extraction.

M.Atif, V.Franzoni, A.Milani: **Emojis Pictogram Classification for Semantic Recognition of Emotional Context**. BI 2021: 146-156

M.Atif, V.Franzoni: **Tell Me More: Automating Emojis Classification for Better Accessibility and Emotional Context Recognition**. Future Internet 14(5): 142 (2022)

G. Biondi, V.Franzoni, A.Mancinelli, A.Milani, R.Niyogi:**Hate Speech and Stereotypes with Artificial Neural Networks**. ICCSA (Workshops 3) 2022: 15-32

D. Saetta, V, Franzoni, et al., **Collection and Analysis of Narratives for a Values Charter of the Italian Society for Hospital Pharmacy**. WI 2022 (in press)

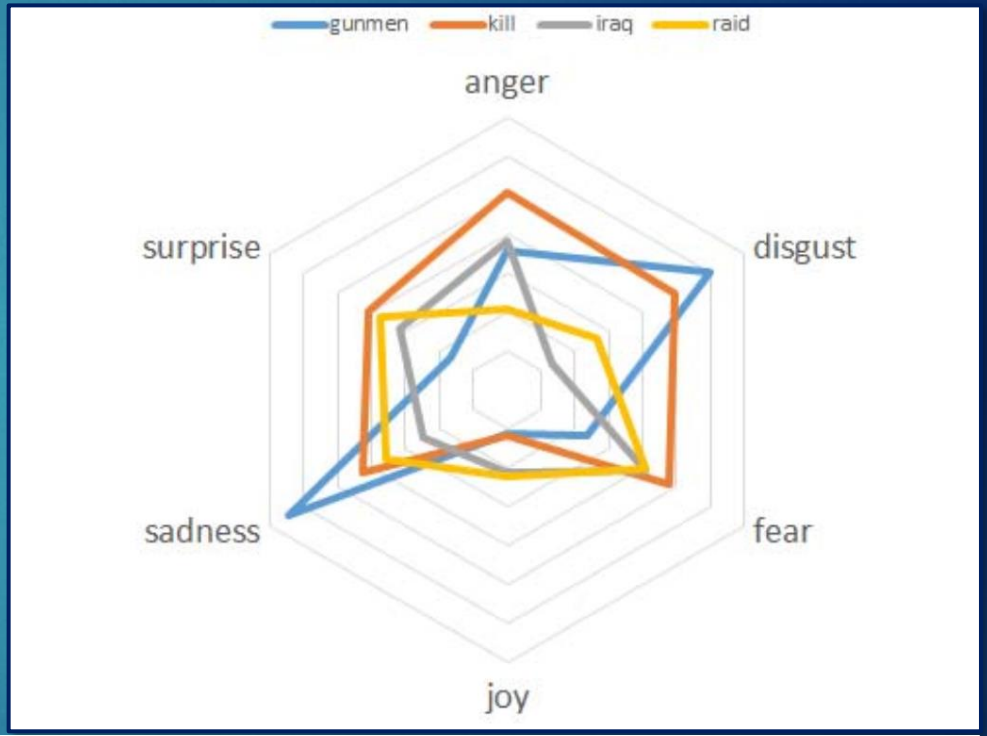
Biondi, Giulio, FRANZONI, VALENTINA, Li, Yuanxi, Milani, Alfredo (2016). Web-based similarity for emotion recognition in web objects. In: 2016 IEEE/ACM UCC. vol. 1, p. 327-332, ACM

Emotion recognition based on distance from emotional poles of state-of-the-art models:

Ekman.=[*anger, disgust, fear, joy, sadness, surprise*]
Plutchik=[*anger, anticipation, disgust, fear, joy, sadness, surprise, trust*]
Lovheim=[*anger, disgust, distress, fear, interest, joy, shame, surprise*]

Web-based proximity correlation based on: *PMI, Confidence, NGD*

Ekman, PMI; Dataset: News titles
«*Gunmen kill 11 in Iraq TV raid*»

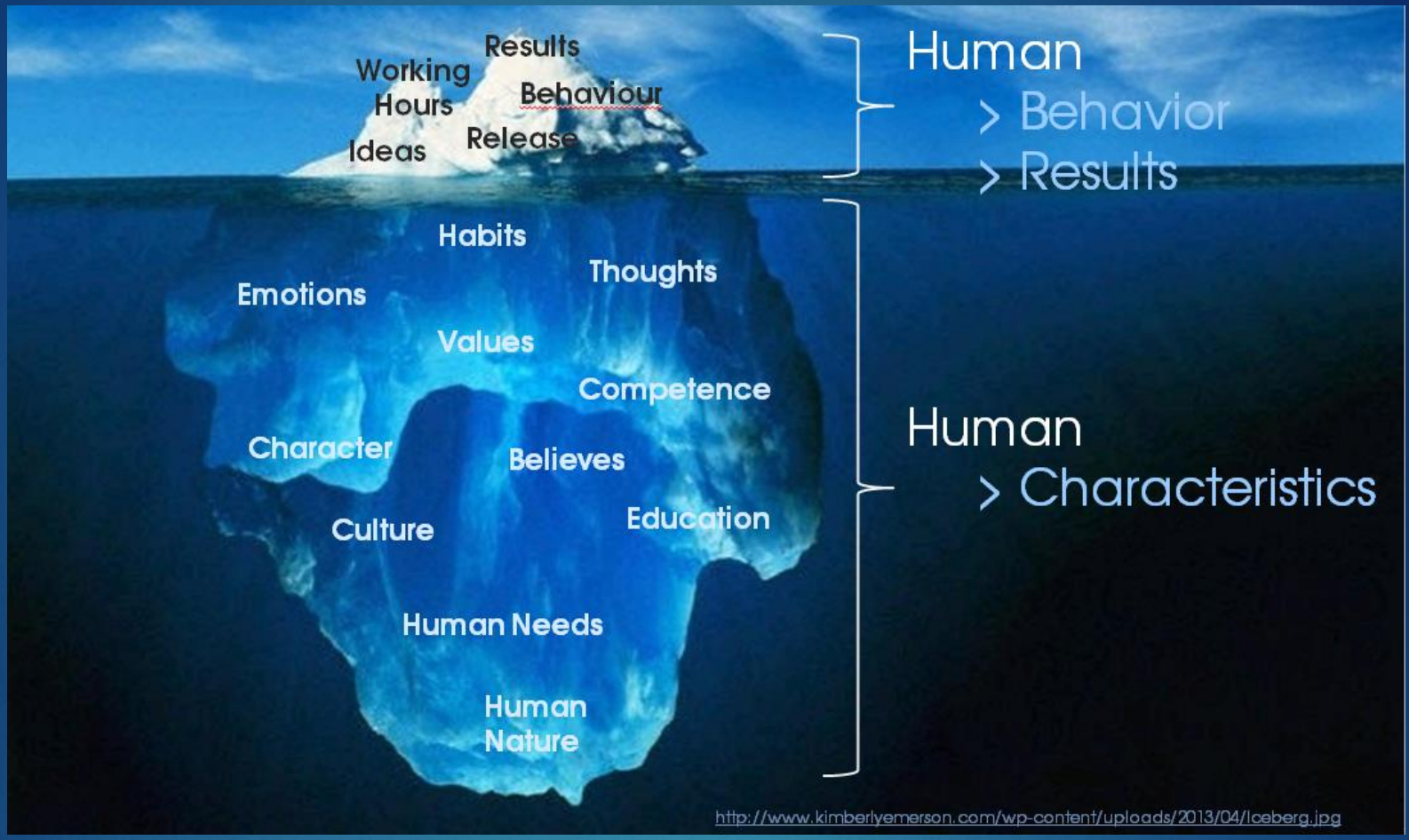


V.Franzoni, A.Milani, G.Biondi: **SEMO: a semantic model for emotion recognition in web objects**. WI 2017

V.Franzoni, Y.Li, P.Mengoni: **A path-based model for emotion abstraction on facebook using sentiment analysis and taxonomy knowledge**. WI 2017: 947-952

Giulio Biondi, Valentina Franzoni, Valentina Poggioni: **A Deep Learning Semantic Approach to Emotion Recognition Using the IBM Watson Bluemix Alchemy Language**. ICCSA (3) 2017: 718-729

Complex models



Emotional Affordances and Complex Models

V.Franzoni, A.Milani, J.Vallverdú: ***Emotional affordances in human-machine interactive planning and negotiation****. WI 2017: 924-930*

V.Franzoni, Y.Li, P.Mengoni, A. Milani: ***Clustering Facebook for Biased Context Extraction****. ICCSA (1) 2017: 717-729*

Anger multidimensional model

Non-Violent Communication

V.Franzoni, A.Milani: ***Emotion Recognition for Self-aid in Addiction Treatment, Psychotherapy, and Nonviolent Communication****. ICCSA (2) 2019: 391-404*

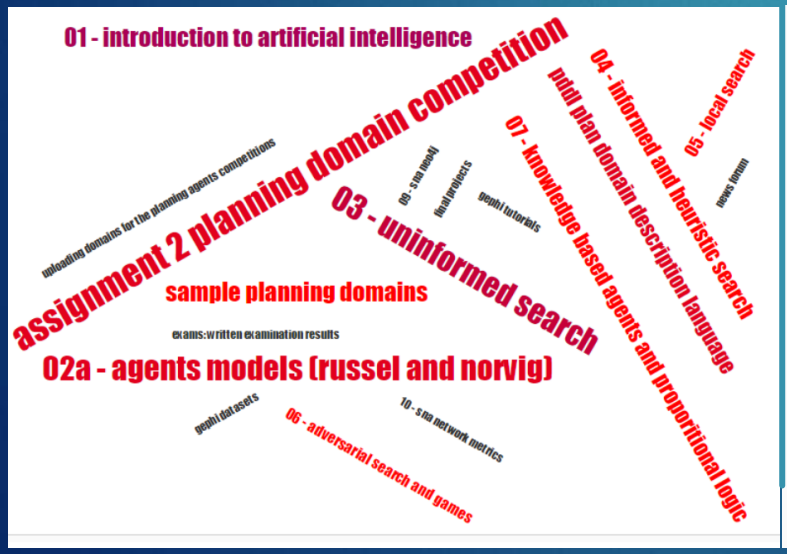
Franzoni V., Milani A., Mengoni P., Piccinato F. (2020). Artificial intelligence visual metaphors in e-learning interfaces for learning analytics. APPLIED SCIENCES, vol. 10, p. 1-25, ISSN: 2076-3417

AI Learning Analytics made understandable through Visual metaphors:

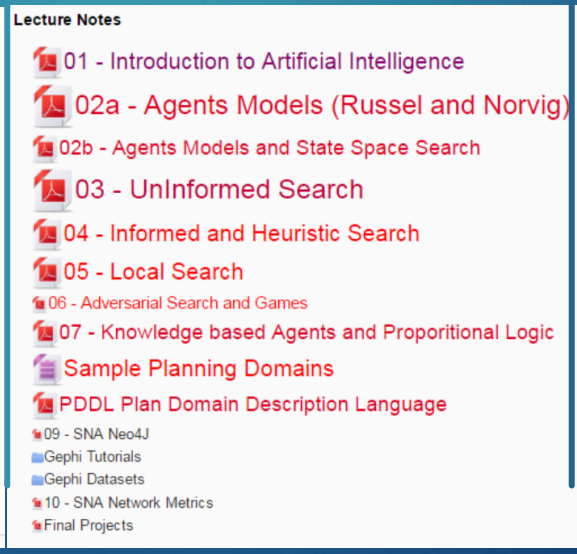
- Temporal Proximity
- Frequency and Distribution
- Users/objects Aggregation

Visual feedback on content engagement.

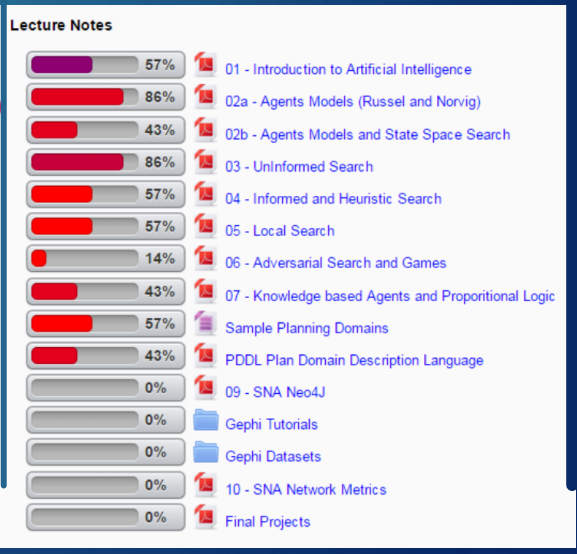
Tag Cloud Morphing



Dimensional Morphing



Thermometer Bar



Boston Dynamics' Spot

V.Franzoni, G.Biondi, A.Milani: ***Exploring Negative Emotions to Preserve Social Distance in a Pandemic Emergency***. ICCSA (2) 2020: 562-573

Gestione della pandemia

Robot sociali

V.Franzoni, A.Milani, D.Nardi, J.Vallverdú: ***Emotional machines: The next revolution***. Web Intell. 17(1): 1-7 (2019)

V.Franzoni, N.Di Marco, G.Biondi, A.Milani:

-***Virtual Reality for Enhancement of Emotional Mindset in the First Lockdown of United Kingdom for the Covid-19 Pandemics***. BI 2021: 189-198;

-***How Virtual Reality Influenced Emotional Well-being Worldwide During the Covid-19 Pandemics***. WI/IAT 2021: 268-272

V.Franzoni, A.E.Baia, G.Biondi, A.Milani:***Producing Artificial Male Voices with Maternal Features for Relaxation***. WI/IAT 2021: 273-277

Franzoni, V., Biondi, G., Milani, A. (2020). Emotional Sounds of Crowds: spectrogram-based analysis using deep learning. MULTIMEDIA TOOLS AND APPLICATIONS

Crowds express emotions as **collective individuals**.

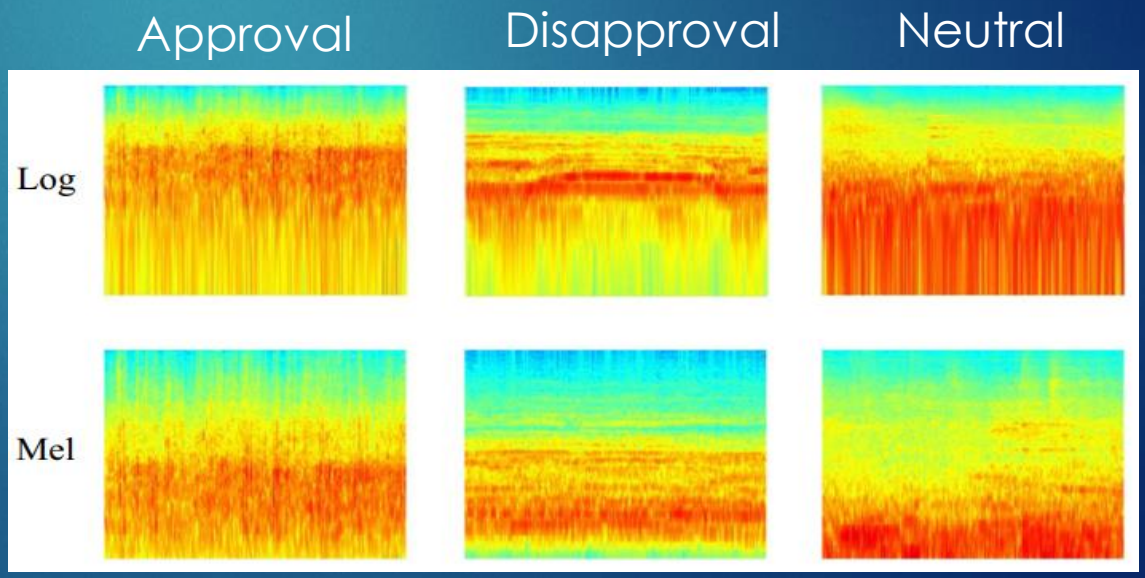
Experiments on crowd sounds in particular events

e.g., *collective booing, laughing or cheering* in sports matches, cinema, theaters, concerts, political demonstrations, riots.

Deep learning based on sound spectrogram of different **scales**:

- *Mel*
- *Log*
- *Bark*
- *Erb*

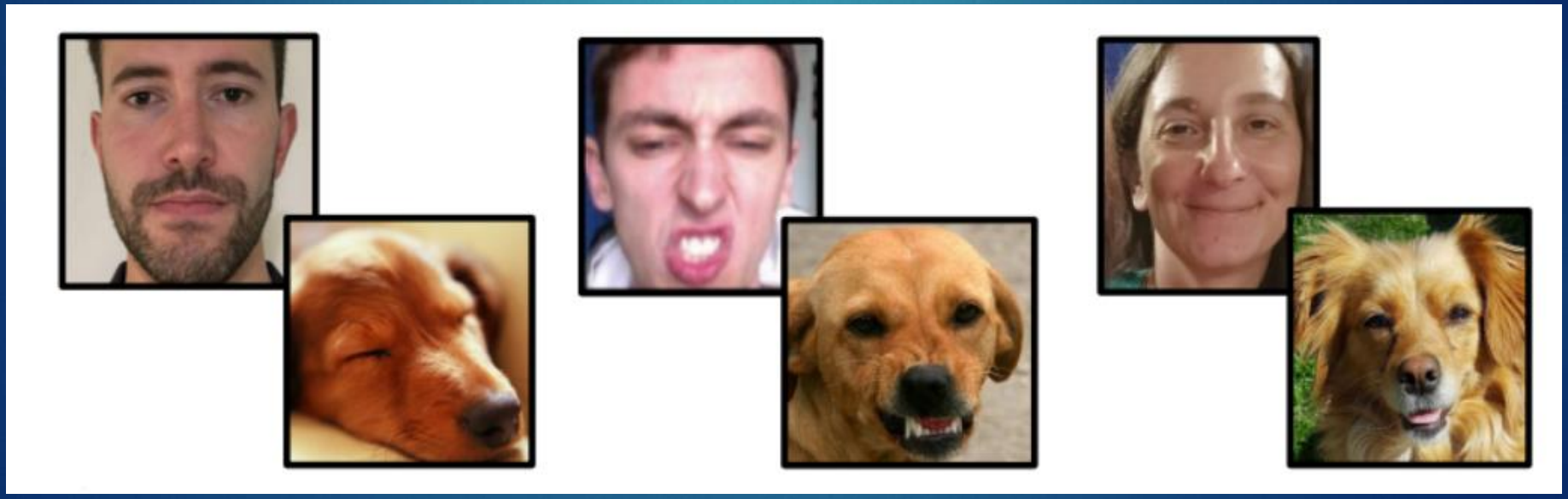
Visual deep learning on sound spectrograms using transfer learning.



Emotion Recognition in animals

V. Franzoni, A. Milani, G. Biondi, F. Micheli: **A Preliminary Work on Dog Emotion Recognition**. WI (Web Intelligence) 2019: 91-96

Classification of *aggressive*, *happy*, and *neutral* dogs' expressions.



Pain Recognition in Preterm Infants

V. Franzoni, D. Mezzetti: **Recognizing and Predicting Neonatal Pain in Preterm Intensive Care Unit: a Study Protocol**.
WI (Web Intelligence) 2022 (in press)

Challenges of pain in preterms

- Underdeveloped nociceptive modulation
- High prevalence of painful procedures
- Assessing and predicting pain intensity and duration is paramount
- More than 40 pain scales, most of them based on facial expressions identified by doctors and nurses.

Challenges of pain in preterms

- Underdeveloped ***nociceptive modulation***
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- Assessing and predicting **pain intensity and duration** is paramount
- More than 40 pain scales, most of them based on facial expressions identified by doctors and nurses.

Proposed study protocol

- facial and body images: neural networks

- professional evaluation and objective data, e.g. patient data, pathology, and vital parameters

Advantages:

- images acquired sequentially
- continuous monitoring
- enabling quantification pain (time,intensity)

Methods

Convolutional Neural Networks for Image Recognition, Knowledge-Transfer Learning, Decision System and Reinforced Learning

Image acquisition setup:

- Smartphone camera on 3D-printed mount
- Body and face close-up
- Collection of data from the monitor of vital parameter
- Written notes by nurses (usual protocol)

Goal of the research

The intended information to be achieved is related to:

- need for intervention
- correlation between pathology or intervention and pain
- prediction of pain level in similar situations

Challenge: high ethical standards.

Conclusions

- Recognition of emotions and pain, especially in premature infants, is a complex and challenging task.
- It requires a multidisciplinary approach.
- Collaboration between computer scientists and physicians can save lives.

Multidisciplinary Resources

M.C. Schumer , E.K. Lindsay, J.D. Creswell, *Brief mindfulness training for negative affectivity: A systematic review and meta-analysis*. J Consult Clin Psychol. 2018 Jul;86(7):569-583. doi: 10.1037/ccp0000324.

D. Siegel, *Past two decades have been filled with a variety of technological advances*. J Drugs Dermatol. 2005 Jan-Feb;4(1):12-3. PMID: 15696978.

B.A. Van Der Kolk, et al., *A Randomized Controlled Study of Neurofeedback for Chronic PTSD*. PLoS One. 2016 Dec 16;11(12):e0166752. doi: 10.1371/journal.pone.0166752.

P. Ogden, C. Pain, J. Fisher, *A sensorimotor approach to the treatment of trauma and dissociation*. Psychiatr Clin North Am. 2006 Mar;29(1):263-79, doi:10.1016/j.psc.2005.10.012.

S.W. Porges, *The polyvagal perspective*. Biol Psychol. 2007 Feb;74(2):116-43. doi: 10.1016/j.biopsycho.2006.06.009. Epub 2006 Oct 16.

D. Mistry, et al., *Meditating in virtual reality: Proof-of-concept intervention for posttraumatic stress*. Psychol Trauma. 2020 Nov;12(8):847-858. doi: 10.1037/tra0000959.

C. Pain, R. Lanius, *Disasters, pandemics and mental health*. CMAJ. 2020 Jul 13;192(28):E803. doi: 10.1503/cmaj.200736.

What happens in the brain during a potentially traumatic event, Infographics.

Courses by the United States National Institute for the Clinical Application of Behavioral Medicine (NICABM).

Contacts

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