Raffaella Folgieri

Engineer, Bioinformatics and PhD in Computer Science,

Università degli Studi di Milano.



- Assistant Professor and Researcher in Cognitive Science, with focus on Artificial Intelligence, Robotics and Virtual Reality.
- Member of Italian Society of Engineering and of SIREN (Italian Neural Networks Society).
- Member of Japan Society of Kansei Engineering (emotional engineering).
- Member of HiPEAC (High Performance and Embedded Architecture and Compilation)
- Member of the board of Directors of GWMH (Global WoMen Hub)
- Main fields of interests: Machine Learning and AI; Brain Computer Interaction; Virtual Reality; Bioinformatics; Robotics; Quality assessment in complex software development; Project Management.

RESHAPING THE FUTURE

AI & IOT the importance of interdisciplinarity

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Milano, 2022



"Internet-min"

Linked In 1 9,132 Connections

Made

28,000 Subscribers Watching

Spent Online

NETFLIX

S

Snaps Created

> 69 Million Messages

> > Sent 3 Million Images Viewed

Smart Audio Devices Shipped amazon echo

-

1.4 Million 21.1 Million

SECONDS

Tik Tok

facebook.

Content Uploaded

414,764 Apps Downloaded

You Tube

695,000 Stories Shared

Coxede play

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200,000 People Tweeting

2 Million Swipes

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197.6 Million Emails Sent

2 Million

Views

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Al approaches

Many definitions, depending on the adopted approach:

- Thinking humanly
- Thinking rationally
- Acting humanly
- Acting rationally

Note that we are not saying that Humans are irrational, but simply that they are not perfect (mistakes make us human)



THINKING HUMANLY	THINKING RATIONALLY	Attention to thinking and reasoning process
ACTING HUMANLY	ACTING RATIONALLY	Attention to behaviours/acting
Success if there is similarity with a human execution	Referring to the ideal concept of intelligence = rationality	

A system is rational if, considering its knowledge, it «does the right thing»





SVM: Ensembles Based on Random Projection for Gene Expression Data Analysis



Artificial Neural Networks-based econometric models for tourism forecasting

- Usually linear regression technique but ANN outperform
- ANN can make long-term prediction
- ANN as a Decision Making support (proactive and reactive solutions to improve tourist services)



APPI IFC

RESEARCH

- ... also
- Machine learning, ANN:
 - Decisions support-tools for diagnosis and prognosis
 - Decisions support-tools in finance/economics
 - Decisions support-tools in tourism
 - Fraud detection
 - Communication (sentiment analysis)
 - Sport training
 - Self-adaptive rehabilitation supports



Gaetano Pini (Milan)



Application of Artificial Neural Networks to the detection of orthopedic post-surgery pain for the identification of objective evaluation algorithms

APPLIED

RESEARCH

- Support to doctors
 - Evaluation of the clinical complexity
 - pain therapy
 - delirium

Al in sports



- AI methodology to be adopted:
 - NMF (Non-negative Metrics Factorization) based solution (Fuzzy ANN, Convoutional NN, ANN, SVM, GANS...)
 - Possible cognitive tools: BCI (Brain Computer Interface) and VR (Virtual Reality devices) for advanced training
- The platform will provide:
 - a workbench for coaches (video, historical data, competitors' data, best team configuration, players physical and psychological condition, strategy design team and single players sessions)
 - a tool for video analysts
 - an app for players to check, monitor and improve their physical and psychological condition and performance
- The output of the AI-based decision making support tool will provide both predictions (proactive and reactive) and analytics













- Not programmed. Learns from data (ANNs)
- Speaks English

42 allows us to study learning behaviours, creativity and empathy in machines

It shows the potentiality of cross-fertilization among different disciplines

* «The Hitchhiker's Guide to the Galaxy»: 42 is the "Answer to the Ultimate Question of Life, the Universe, and Everything", calculated by the supercomputer named Deep Thought over a period of 7.5 million year

EEG-based Brain Computer Interface (BCI)

A.I./ICT paradigm: control and interaction through cerebral impulses



Possibility to investigate, understand (and replicate) mechanisms in emotional and cognitive response to specific stimuli







BASE

RESEARCH

Brain Imaging: new perspective

- The invisible become visible (fMRI, PET, EEG)
- Application of A.I. algorithms (ANN, SVM...) to Brain Imaging allowing visible and quantifiable processes previously hidden

BASE

RESEARCH

• Living Brain: real time measure of cerebral reactions to stimuli and situations



SMART WORLD

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State of the art: stimuli, emotions and movement

- Response to sensory stimuli and emotion recognition
- Cognitive mechanisms (e.g. creativity and problem solving)
- Effects of cognitive priming
- Man-machine interaction through cerebral rhythms (wheelchairs, mechanical arts, cars, robots, drones, games)



Applications (scaring?) of BCIs

• Truth machine Distance control

Martinovic, I., Davies, D., Frank, M., Perito, D., Ros, T., & Song, D. (2012, August). **On the Feasibility of Side-Channel Attacks with Brain-Computer Interfaces.** In *USENIX security symposium* (pp. 143-158).

• 2045 initiative





Images and videos recontruction

Presented clip

Clip reconstructed from brain activity





Shinji Nishimoto, An T. Vu, Thomas Naselaris, Yuval Benjamini, Bin Yu & Jack L. Gallant, **Reconstructing visual experiences from brain activity evoked by natural movies,** Current Biology 2011, <u>PDF 1.4M</u>).

Reconstruction of images and videos

Images and video reconstruction by brain rhythms



Video reconstruction by Nishimoto et al.

• Signal collection and transformation in letters, sentences

BCI and TMS: telekinesis

- Man-man communication mediated by technology
- BCI and TMS to induce a movement at a distance
- A researcher in front of a game expresses the will to push a button. Another (who doesn't see the game) at a distance, receives the stimulus to move his finger and pushes the button.
- TMS deviced used to stimuli the motor cortex of the second researcher to take the action



Brain-to-brain (B2B) communication system overview.

Conscious Brain-to-Brain Communication in Humans Using Non-Invasive Technologies

Carles Grau, Romuald Ginhoux, Alejandro Riera, Thanh Lam Nguyen, Hubert Chauvat, Michel Berg, Julià L. Amengual, Alvaro Pascual-Leone, Giulio Ruffini

BCI and TMS: telepathy (words)

- Transmission of words
- In India someone think "HELLO", then transformed in a binary code (with the association of hands and feet movement) and in France another individual receives and decode the greeting.





Emitter (EG-based BCI) and receiver (TMS) in the B2B system

Conscious Brain-to-Brain Communication in Humans Using Non-Invasive Technologies, Carles Grau, Romuald Ginhoux, Alejandro Riera, Thanh Lam Nguyen, Hubert Chauvat, Michel Berg, Julià L. Amengual, Alvaro Pascual-Leone, Giulio Ruffini

0, 1, 1, 0, 0, ... internet

BCI and TMS: telepathy (sentences)

- Exchange (at a distance) of questions and answers
- EEG-based BCI and TMS
- YES/No answers



Architecture of the BBI experiment named "20 Questions".



INTERDISCIPLINARITY

The importance of interdisciplinarity

- Innovation come from cross-fertilization
 A.I. is everywhere (enabling technology)
 Explainable A.I.
- •A wider audience
- •Funds for research
- Improve the abilities

 of the artificial
 systems integrating
 the human intelligence
 (creativity, judgement, insight)

to extend velocity, accuracy, attention to details)

Without the cooperation of **researchers** in several disciplines, many of today's **important** discoveries wouldn't have been possible



REAL vs VIRTUAL



BASE

RESEARCH

Lucchiari, C., Vanutelli, M. E., Folgieri, R. (2018). Is three better than two? A study on EEG activity and imagination abilities in 2D vs 3D stimuli. In *Electronic Imaging & the Visual Arts. EVA 2018 Florence*, ISBN: 978-88-6453-706-1, pp. 41-47

E. Calore, R. Folgieri, D.Gadia, D. L. R. Marini. Analysis of brain activity and response during monoscopic and stereoscopic visualization. *Stereoscopic displays and applications XXIII*, Burlingame, California, USA, 2012

Studies using Virtual Reality



- To understand Human behaviour and reactions to stimuli
- To reveal Cognitive functions

Selected works

D. Marini, R. Folgieri, D. Gadia, A. Rizzi. Virtual reality as a communication process. VIRTUAL REALITY, vol 16, 2012.

Folgieri, Raffaella, and Claudio Lucchiari. "Boosting physical and psychological well-being in rehabilitation through cognitive technologies preliminary results." In Humanitarian Technology Conference (IHTC), 2017 IEEE Canada International, pp. 75-79. IEEE, 2017.

R. Folgieri, A. Banzi, D. Grella. A New Cognitive Approach to Art Experience: Priming, EEG-based Virtual Reality and Digital Storytelling. EVA: PROCEEDINGS E REPORT, Firenze University Press, 2014.

Folgieri, R., Granato, M. (2015). Augmented reality to improve users experience in art: an application of epson moverio and google cardboard devices. Cappellini, V. (Ed.). Electronic Imaging & the Visual Arts: EVA 2015 Florence. Firenze University Press. (pp. 110-115).

R. Folgieri, C. Lucchiari, D. Marini. Analysis of brain activity and response to colour stimuli during learning tasks: an EEG study. IS&T/SPIE electronic imaging, International society for Optics and Photonics, Burlingame, 2013.

R. Folgieri. A community of practice and project-based learning matching innovation and tradition. Proceedings of Global TIME 2012 AACE's conference, 2012.

E. Calore, R. Folgieri, D. Gadia, D. L. R. Marini. Analysis of brain activity and response during monoscopic and stereoscopic visualization. Stereoscopic displays and applications XXIII, Burlingame, California, USA, 2012.

R. Folgieri, L. Dei Cas, F. Soave, C. Lucchiari Art in the neuroscience ERA : how the brain understands and creates art / (Proceedings and report). - In: Electronic imaging & the visual arts : EVA 2016 / [a cura di] V. Cappellini, E. Del Re. - Prima edizione. - Firenze : Firenze University Press, 2016. - ISBN 9788866559733. - pp. 90-95

3D Technology

• The observation of an action performed by others triggers in the observer the same neural networks, as if we were in the first person to carry out the action.

Idea: action observation could be used as an effective way to learn or improve the performance of a specific motor skill.

(successfully applied in sport and rehabilitation).

• However, this requires a high level of concentration on the body part of the subject.



BASE

RESEARCI

Cognitive rehabilitation

• Project in cooperation with the **Gaetano Pini**

Orthopaedic Institute in Milan

older patients need traditional physical therapies and neurological treatments





Azienda Ospedaliera

Ortopedico

GAETANO PIN





APPLIED

RESEARCH

Museums applications and priming

APPLIED RESEARCH

- BCI used to study
 - the effects of priming
 - 2D vs 3D
- Application:
 - Augmented reality (Epson Moverio devices)

The app allows to feed additional information on masterpiece in a museum:

- ✓ Visitor experience becomes "social"
- ✓ Allows to connect masterpieces and artists to the "intangible" culture historically of to popular tradition

NEW PROJECT: MUSEUMS AND WELL-BEIGN (16/6/2022)





Other in fieri projects

• Learning Disorders(cognitive tools, BCI e transcranial stimulation), San Paolo Hospital (Milan, Italy), LD offices Università degli Studi di Milano and Università Cattolica del Sacro Cuore (Milan) APPI IFD

RESEARCH

- Cognitive empowerment and well-being
- Sleeping disorders
- MUSIC and emotions (Open University UK)
- NFTs (Non Fungible Tokens)

DRACLE

BASE RESEARCH

acronym:

scholars and artists cooperating in this project (Dario, RAffaella, Claudio, Ludovico and Elide).

Context: Neuro-aesthetic research aimed at joining scientific research and Art, reducing the distance between "Hard Sciences" and "Humanities".

Installation "The Creative Mind" used for:

- collecting data
- analyze the individual creative process through a direct connection to the brain of a person, manipulating audio and video representation on a screen.

Provide a real-time audio/visual representation of the creative process of our brain.

The experiment: the performance

the graphical and acoustic computer interface (brain rhythm performance)

BASE

RESEARCH



OPPORTUNITIES

Surveillance System for Disaster

Management

Explainable AI (finance)

Digital Health Data

Traffic Sign Recognition

Automation in industry

BENEFITS

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DECISION MAKING

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QUALITY of LIFE

5 CHALLENGES





St. Mar

SIGNIFICANT

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FAIR data principle

TRANSPARENCE/TRUST

NOT ONLY productivity

THE FUTURE

EASY ACCESS to information

METAVERSE



Humans, machines and emotions

- Till some years ago, AI ignored the importance of the emotions
- Emotions are fundamental in communication and understanding among humans
- We can extend this concept to AI in the whole

Al and Cognitive technology

- To improve the abilities of the artificial systems integrating the human intelligence
 - creativity, judgement, insight, to extend
 - velocity, accuracy, attention to details.
- We could obtain a **product we could use in every context**, with a certain warranty of results.
- Idealistic objective (freedom from work) but also economic goal

But... will AI (or it already is) be really able to create such kind of systems?

Emotions and cognitive processes

- Will these intelligent machines, in future, be able to **perfectly replicate human cognitive processes?** In this case, will their emotions be "real"? What is the boundary?
- Do emotions and sentiments really need a "biological mind", or not?



A WAVE OF OPPORTUNITIES

Folgieri, 2022

Examples of applications

Banks, Telco, Retail

Perspective customs Customer satisfaction Selected customers Selected payers



Effective marketing campaign Credit risk decreasing Fraud detection Chum rate decreasing

Medicine/Security (biomedicine, biometrics) Screening Diagnosis/Prognosis Drug discovery Security Face recognition Signature/fingerprint/iris ver. DNA identification

ICT: interfaces, Internet

Handwriting, speech **Brain Computer Interfaces** Ranking, recommendation Spam filtering Text categorization and translation



Fraud detection Effective interface design User experience User profiling

THREATS

Man-machine empathic communication and its future

- Many ethical and legal issues.
- What if these intelligence could be used to control employers in a company, or to evaluate the applicants to a selection, or the defendants in a trial?
- In future, smart devices could know our phisical and psichological conditions (with consequences for privacy and psichology - think to the film 'Her')

CONCLUDING

THANK YOU

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Un questionario veloce (5 mins)

Tesi di laurea Michael Vitale:

https://docs.google.com/forms/d/e/1FAIpQLSeFykza CXkdIz7LfnK8uoKm0I2jIIXVcdyM9GwRJMP_XLYQfQ/vie wform

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