Preface to the Second Workshop on Artificial Intelligence for Human-Machine Interaction (AIxHMI)

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Abstract

The human-machine interaction (HMI) field is benefiting from the latest advances in wearable devices, sensing technologies, and artificial intelligence (AI) models. This is allowing the development of new applications in real-life, virtual and augmented environments, where AI is assuming a significant role especially considering strongly human-centered, real-time, and noisy scenarios.

The main motivations and relevance of the Artificial Intelligence for Human-Machine Interaction (AIxHMI) workshop regard (i) focusing on human-centered approaches and perspectives, (ii) exploiting AI approaches to provide a better interaction between humans and machines, (iii) moving AI to pervasive technologies relying on wearable devices and portable technologies, and (iv) presenting novel AI methods and proposals that exploit heterogeneous data sources, describing the human environmental interaction in real, virtual, and augmented scenarios.

Seven papers have been submitted to the second edition of AIxHMI. Out of these, six have been accepted for this volume as regular papers. Diverse fields of HMI were touched by these authors as well as by the three invited speakers.

The multidisciplinary field of Human-Machine Interaction (HMI) (in which we include the human-computer interaction field) pertains the bidirectional communication between human users and machines.

It is clear that under this definition are included a plethora of applications that interact with humans through interfaces and that can span from entertainment to medical systems, from industrial to transportation services.

The continuous technological advancements as well as the contributions of artificial intelligence (AI) are benefiting the evolution and improvement of HMI systems. However, numerous challenges arise, especially when wanting to exploit new minimally-invasive sensing technologies for the development of real-time user-centered applications.

A practical example may be represented by electroencephalographic (EEG) based brain-computer interfaces (BCIs), which rely on human-users' neural data to provide specific com-

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mands to an external application. Let us suppose that one of these systems comprises the use of wearable and wireless devices and that a precise and immediate feedback should be provided to its user. Among the possible issues that could arise there are the presence of excessive noise, the need for fast and non-computationally demanding algorithms for real-time neural signal interpretation, and the necessity of ensuring the users' safety as well as the protection of the collected data.

These challenges can be easily found in other control and sensing devices, where the correct integration of heterogeneous data may also be a concern, especially when facing multimodal sensing and when considering the environment a human user is immersed in.
In general, a HMI system should be reliable, safe, efficient, and accepted by its users.

Concerning this last point, users' emotional involvement is a key factor when interacting with a machine. Therefore, machines that are able to adapt to the emotional states of their users as well as to evoke specific emotions may provide better communication between the two actors of these systems.
Therefore, user experience has an important role in the development of HMI applications.

The Artificial Intelligence for Human-Machine Interaction (AIxHMI)[1] workshop wants to assemble contributors from universities, research institutes, and industries working in multidisciplinary fields that pertain but that are not limited to HMI, BCI, control systems, wearable sensing and devices, emotional intelligence, affective computing, human centered sensing and computing, human factors and ergonomics, user experience, interface and sensor design, virtual and augmented reality, and ethics and security in AI, having that the AI is a transversal discipline that influences all these aspects.

Seven submissions have been sent from Indian (1), Italian (3), Switzerland (1), and Norwegian (1) Institutions and Industries by 27 authors to the AIxHMI workshop and six have been accepted in this volume.

Accepted papers mainly pertained to three domains: electroencephalographic (EEG) signal processing and management, non-intrusive and multi-modal physiological signal sensing, and attention in virtual reality (VR).

In particular, *Mauro Mezzini* [1] presented a methodology exploiting spectrogram images as input to convolutional neural network based architectures devoted to the decoding of emotions from EEG signals. The work uses baseline deep learning models (i.e., ResNet and VGGNet [2]) on a dataset widely known by the EEG community, i.e., the *Dataset for Emotion Analysis using Physiological signals* (DEAP) one [3].

Artemisia Sarteschi and Domenico G. Sorrenti [4] contributed a work on respiratory rate estimation through a novel sensing mattress to provide a minimally invasive alternative to polysomnography for sleep monitoring. While only a single subject data are accessed, some evidences on the potential of these technologies are derived and discussed.

Instead, *Gabardi et al.* [5] proposed a novel frequency-based deep learning methodology to reduce noise in EEG signals presenting ocular or muscular artifacts, considering the noise spectral features to provide appropriate filters for separating these artifacts from the actual neural signal.

[1] https://aixhmi.unimib.it/

A different topic of HMI is explored by *Facchin et al.* [6], who exploit a VR environment to analyse the attention of participants while driving with different distractors. Different analyses have been performed to evaluate if brain stimulation can enhance attention in two groups of participants, i.e., elderly and young drivers.

Moving from attention to psychological stress detection, *Marthinsen et al.* [7] make a precise assessment of the optimal electrode subset to improve machine learning techniques both in terms of performances and computational costs. In particular, the authors collect EEG data from students before exam sessions and after holidays to have a clear overview of possible stressors.

Finally, *Malaspina et al.* [8] propose an experimental protocol to assess immersiveness while considering different user interfaces. Besides using self-assessment questionnaires, the authors propose the use of different behavioural and physiological signals to provide more honest indicators of game immersion by exploiting non-invasive and wearable devices.

Besides the oral presentation of the aforementioned papers, three invited speakers participated in the AIxHMI workshop:

- *Stefano Mazzoleni*, Associate Professor at the Department of Electrical and Information Engineering of the Polytechnic University of Bari (Italy).
- *Léa Pillette*, Researcher at IRISA (France).
- *Francesco Ferrise*, Full Professor at the Department of Mechanical Engineering of the Politecnico di Milano (Italy).

Stefano Mazzoleni contributed with a speech entitled: "AI-driven robot-assisted neurorehabilitation: from experimental trials towards a safe, reliable and effective human-robot interaction". In particular, a focus on novel robotic systems for rehabilitation of upper and lower limbs presenting characteristics of motor relearning is provided, making a clear assessment on the efficacy of these systems. An important point is made on the necessity of having safe, reliable and effective treatments, while considering scientific, technological, ethical, legal and social challenges bounded to robot-assisted rehabilitation.

Another HMI system is presented by *Léa Pillette*, who focused on EEG-based Brain Computer Interfaces (BCIs) and highlighted the absence of reliable BCIs outside of laboratory environments. A possible mean to improve the reliability of these systems is identified in an efficient user training, during which the users learn the production of different brain patterns that can be recognised by a machine. This justifies the question entitling the delivered talk: "Towards assessing and improving brain-computer interface user-training?".
Notice that neurofeedback is considered a key element for correct user training and thus an investigation on the influence of neurofeedback on BCI usability is provided as an intersection between HMI and VR.

The speech of *Francesco Ferrise* entitled "Emotion Elicitation in Virtual Reality: Techniques and Applications" is focused on the last cited topic. The importance of emotions in everyday life is highlighted and the novel introduction of VR based emotion generation explained. In particular, the use of simulated environments is seen as a way to immerse a user, allowing to study the user's emotional changes in different contexts, while being in a safe space. *Francesco Ferrise* gave us some tips and tricks to evoke emotions in VR and a look in future VR-based applications.

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