

## GUEST EDITORIAL PREFACE

# Special Issue on Artificial Intelligence and Assistive Medicine

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In 2012 we started the "International Workshop on Artificial Intelligence and NetMedicine" (NetMed)<sup>1</sup> with the aim to bring together scholars and practitioners active in artificial intelligence driven health informatics, to present and discuss their research, share their knowledge and experiences, define key research challenges and explore possible international collaborations to advance the intelligent practice of medicine over the internet.

In facts, the digitalization of data and the rise of the web had a paramount impact in the way the practice of medicine is carried out and the health-related services are delivered. Of course, telemedicine is included in this large change and a long road has been traveled since the first pioneering point-to-point communication episodes. Nowadays medical telerreporting and second-opinion over the internet are cost-effective and widely adopted practices. Physicians and general practitioners make daily use of tele-consultation over the WEB, VOIP, chat and video-conferencing so that the practice of medicine is often performed in a collaborative manner as a teamwork over a network. Social networking favors the constitution of large communities of members sharing similar medical interest: in other words, telemedicine is rapidly turning into what we call "netmedicine", which simply denotes every health-related activity which is carried on through the Internet.

Since its inception and along all its history, artificial intelligence served the medicine, under both its souls, the logistic and the conessionistic ones. In the current digitally networked and hyperlinked e-health scenario, artificial intelligence can serve the netmedicine, playing new important roles. For example, today we urge intelligent software to semantically interpret and

filter diagnostic data, automatically classify and convey medical information, virtualize nurses and hospital lanes to reduce the costs of healthcare, etc.

Artificial intelligence and netmedicine are at the heart of the new challenges that our times are presenting to us: in the last 15 years, reports from the United Nations<sup>2</sup> and the World Health Organization<sup>3</sup> shed light on the rise in the ratio between the people aged 65 or more and the labor force; their estimates point up the fact that the number of the “65+” will triple from 524 million in 2010 to 1.5 billion in 2050, rising from the 8% of the world population to the 16%. The consequences are clear: the increasing of the population affected by chronic diseases, the rise of the number of health-related emergencies and thus a higher healthcare expenditure. Moreover, we are part of an epoch in which the medical systems that the governments operate to fulfill the healthcare requirements of the society are always looking to offer higher quality at the lowest cost. Nevertheless, it seems that the current systems are unsustainable as the rate of senior society members to the active employees is increasing and the curve of required medicine cost for the last 10 years of people’s life is more than the corresponding medical cost used for the rest of their life. The question is then whether we can “flatter” or smoothen the lifetime cost curve for the provided healthcare services.

Thus, after the 2012 and the 2013<sup>4</sup> edition of the workshop focused on netmedicine and the impact of artificial intelligence, we decided to slightly change the name and the topic of the workshop following the intuition that artificial intelligence and netmedicine can serve the challenges deriving from the ageing of the world population. Hence, in 2014, we organized the “3rd International Workshop on Artificial Intelligence and Assistive Medicine” (AI-AM/Net-Med 2014)<sup>5</sup> with the aim to highlight the powerful contribution that can be given by artificial intelligence, web-based technologies, voice interaction (and many others) in order to increase the time people can actively stay in their preferred environment in safety and to prevent, at the same time, their social isolation.

This is a big challenge for artificial intelligence as well as for the always evolving digital technology. How can we be proactive rather than post-active in order to early detect, make diseases prognosis and give the right assistive medical support on time? Answer to this question can offer the exploitation of AI methods in combination with the sensor networks and the widely popular and low cost devices like smart phones, tablets, digital TVs, web cameras and all the smart gadgets that appear in the market.

This special issue of the “International Journal of E-Health and Medical Communication” collects a selection of the papers presented at the “2nd International Workshop on Artificial Intelligence and Netmedicine” (NetMed 2013) and at the “3rd International Workshop on Artificial Intelligence and Assistive Medicine” (AI-AM/NetMed 2014). The papers have been revised and extended by their authors and represent a bright example about the role that artificial intelligence is actually playing in e-health, netmedicine, assistive medicine, personalized and ubiquitous healthcare. The papers have been carefully selected by the program committees of the two editions of the workshop as the most representative of the involved topics:

- Ubiquitous real-time assistive healthcare
- Tele-health and tele-monitoring over the internet
- Ambient and active assisted living
- Wearable and/or unobtrusive smart healthcare systems
- Multi-agent architectures for patient monitoring and early diagnosis
- Virtual nurses, caregivers and hospital lanes
- AI in health and hospital information systems
- Fusion and interpretation of multimodal medical data and events

- Medical ontology modelling and evolution
- Semantically diagnosis modelling
- Reasoning with the uncertainty of medical data/knowledge
- Mining on medical data/knowledge
- Patient centric and evidence based decision support systems
- AI tools and applications in the assistive medicine domain

More specifically, three papers come from the 2013 edition of the workshop and three from the 2014 edition. In their “Towards multi-agent health information systems” Claudi et al. propose a multi-agent based architecture for health and hospital information systems, adapting them to the requirements coming from a continuously changing society. In fact, the model in their paper joins the international standards for the architecture of clinical documents with the modularity, flexibility, distribution and security offered by the multi-agent architecture and agent oriented standards (such as those by FIPA-IEEE for agent management and interactions), offering a way to integrate legacy systems with new data formats. Moreover the proposed architecture can be ideal in mobile e-health scenarios keeping an eye in preserving the privacy of patient even when data are needed far from where information are physically stored.

“A Low Cost Pupillometry approach” uses computer vision to perform unobtrusive audiovisual monitoring. In particular Petridis et al. propose a method to monitor pupil sizes in real time by using a low-cost web camera. Pupillometry is an important tool in a wide range of applications, ranging from functional damages in the cerebral to preconscious. The presented method starts from a “face and eyes detection” phase and then adopts spatial filtering for optimal iris and sclera location and radius. Authors include an extensive evaluation which shows good results: the proposed approach outperforms most of related algorithms for iris center detection.

The third paper selected from NetMed 2013 workshop is “Combining Artificial Intelligence and NetMedicine for Ambient Assisted Living: A Distributed BDI-based Expert System”. Sernani et al. present a multi-agent architecture to model a distributed sensor network to perform unobtrusive real-time monitoring in a home environment and to help a patient in his daily activities in the most natural ways. Beside the multi-agent architecture the proposed system includes an “intelligent” module based on the Belief-Desire-Intention paradigm to analyze data and proactively decide to trigger alarms if anomalies are detected. The system should act as a “virtual caregiver”, allowing health operators to monitor a patient even if not always physically present in his home.

In their “Exercise intensity forecasting: application in elderly interventions that promote active and healthy aging” Billis et al. apply time-series forecasting to the heart rate of the patient during physical activities (e.g. for rehabilitation). In fact, timely decision upon changing intensity level of exercise is of crucial importance so as to maximize the health outcomes. Prediction of future heart rate values based on the trainee’s history profile may prove to be a useful decision making tool in that case. With their tests and their evaluation, authors provide evidence of the robustness of the state-of-the-art forecasting soft computing algorithms (such as Support Vector Regression and Gaussian Processes): in particular the most relevant result is that forecasting is more accurate when the data represent one or more anomalies.

In this special issue also experiences from AI application in assistive medicine, e-health and netmedicine are included. In “Automatically Assessing Movement Capabilities through a Sensor-Based Telemonitoring System” Miralles et al. present the first results from the FP7 European project “BackHome”. In the context of TeleMonitoring and Home Support Systems (TMHSS) their paper proposes an approach to the assessment of patient’s mobility as a fundamental aspect of his quality of life (the keyword active assisted living is becoming more popular every day).

By using data gathered from motion sensors, power meters and a mobile app and by training the classifiers with users's answers to questionnaires, authors aim to automatically respond to the question "Today, how was your ability to move about?". Authors shows preliminary results from different classifiers (Decision Trees and k-Nearest Neighbours); more results have to come, since the project is still ongoing.

Results from another FP7 European project, i.e. "Dem@Care", are presented in "Multi-sensing Monitoring and Knowledge-driven Analysis for Dementia Assessment". More precisely, Stavropoulos et. al. describe "DemaWare" a service-oriented platform for the timely assessment and monitoring of people with dementia in an ambient assisted living context. The system includes a hardware layer and a middleware layer to manage the hardware to retrieve raw sensor data from a variety of sources; such data are stored in a knowledge base as RDF triples. The complex activities of the patient are inferred via SPARQL rules and authors use defeasible logic to deal with conflicts. The inferred knowledge is presented in end-user applications that support various scenarios, such as the monitoring in nursing home environments.

By organizing the AI-AM/NetMed workshops and by publishing this special issue we hope to contribute to fill a gap in current research on AI-related techniques in assistive medicine, e-health and netmedicine. In our vision, artificial intelligence can provide physicians and health operators with a powerful means to enhance the effectiveness and importance of their decisions without reducing their decision areas. And what about the further future? Will we be alive when someone will organize a scientific conference about how Artificial Intelligence will be contributing to generate a single, universal "Big Doctor" available through the Internet?

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## ENDNOTES

- <sup>1</sup> <http://airtlab.dii.univpm.it/netmed2012/>
- <sup>2</sup> United Nations. (2002). *World population ageing, 1950-2050*. United Nations New York.
- <sup>3</sup> World Health Organization. (2011). *Global health and ageing*. World Health Organization, Geneva, CH.
- <sup>4</sup> <http://airtlab.dii.univpm.it/netmed2013/>
- <sup>5</sup> <http://airtlab.dii.univpm.it/netmed2014/>