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Editorial

Women in Artificial Intelligence

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Artificial Intelligence (AI) research has expanded very quickly in recent years due to the increase in data and resources, along with the engagement of companies in proposing many challenging applications. AI is a field at the intersection of Computer Science and Mathematics, with a high Engineering component. It belongs to the area of STEM: Science, Technology, Engineering, and Mathematics.

Several studies have demonstrated the gender bias existing in STEM, as well as in AI [1]. The number of male researchers working in STEM is much larger than that of women, and this is a constant in most countries all over the world. In the field of Artificial Intelligence, this male bias influences the way intelligent systems are conceived, designed, and developed. This may have a significant impact on the future world, where digital transformation seems to be intrinsically connected to new Artificial Intelligence developments.

Even though they represent a small proportion of the sector, women produce interesting research in the AI field. However, sometimes they remain invisible for different reasons, thus increasing the lack of female referents for new generations and contributing to perpetuation of the imbalance. For this reason, it is relevant to lead actions that help to make visible the valuable work of female researchers in the different STEM sectors, especially in AI, which is now having an increasing influence in the construction of the new digital society.

This Special Issue aims to contribute to this task by providing an attractive compendium of AI research led by women over a wide range of fields and applications. The volume contains 17 papers for which the first author is a woman. From those papers, the reader will discover women working on cutting-edge topics in AI, from both theoretical and applied points of view. Papers have been classified according to two dimensions.

The first classification regards the eight domains of AI defined by AIWatch 2021 [2]. The distribution can be seen in Figure 1. It is worth nothing that the Special Issue includes some papers from each one of these eight main areas.

The 17 works constituting the Special Issue also show wide representation of different application fields. We have taken the taxonomy of economic sectors proposed in the AIWatch 2021 report [2] (see Figure 2). The taxonomy covers 16 sectors, one of them being "M. Other technical and/or scientific sectors". We considered "Gender" as part of this category.

We find the majority of papers in two domains: Ethics and Philosophy (five papers) and Learning (five papers). Let us begin by commenting about **Ethics and Philosophy**; this is particularly interesting because three papers analyse different aspects related to gender bias, which is an uncommon topic in scientific publications. Such a group of papers providing different perspectives in this field is a relevant contribution of this Special Issue.

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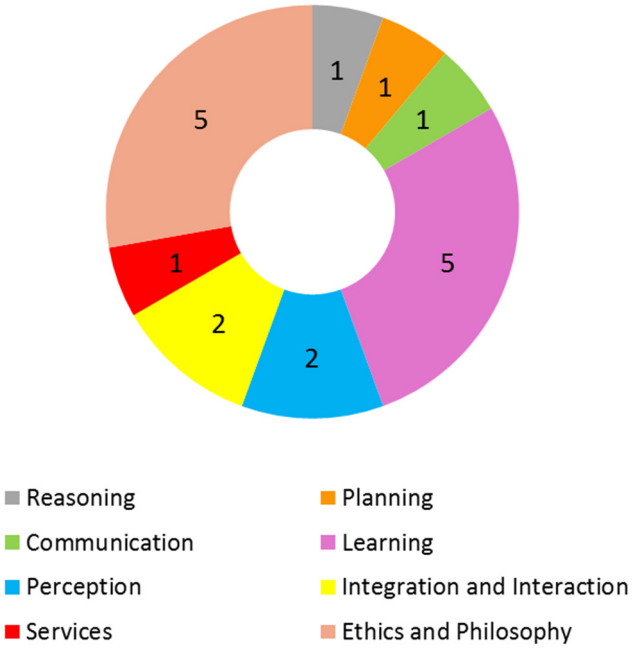

Figure 1. Distribution of the papers in the Special Issue by AI domain of research.

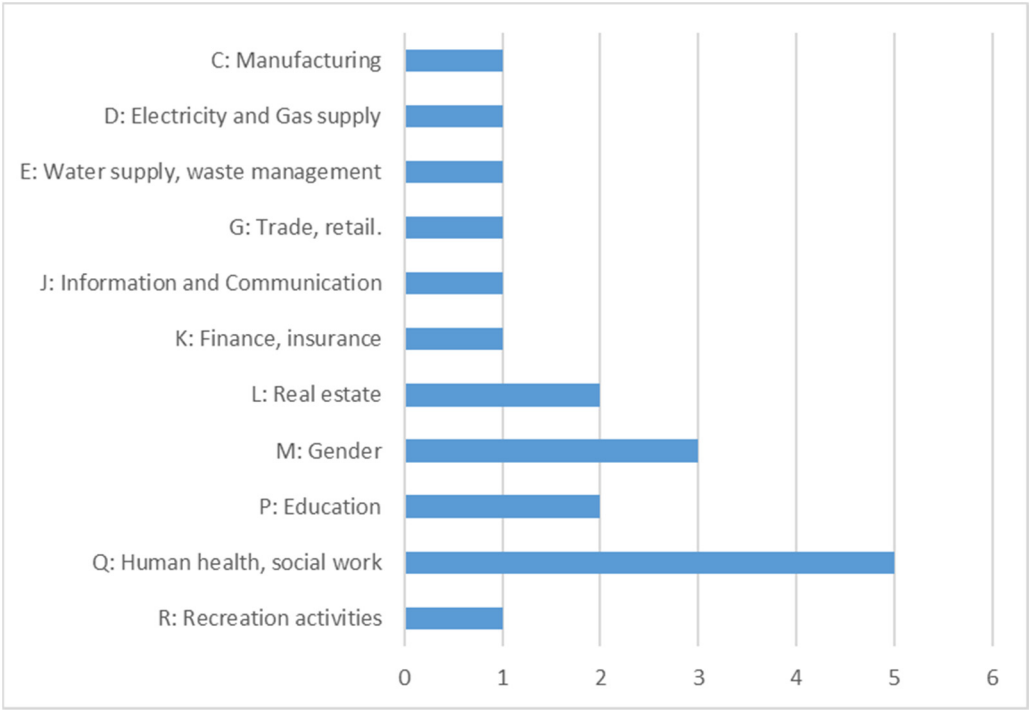

Figure 2. Distribution of the papers of the Special Issue by application sector.

Among those papers we have one work of the two Guest Editors (Dr. Aïda Valls and Pr. Karina Gibert) entitled "Building a Territorial Working Group to Reduce Gender Gap in the Field of Artificial Intelligence" [3], which revises the gender imbalance in AI during several stages throughout the life of a person (primary scholar, graduate, and professional) and proposes a network-based organisation general model for constructing AI-centred working groups that engage young females from the beginning until they become role models. The proposal was put into place with great success in the creation of several gender working groups in Catalonia and Spain; the specific example of donesIAcat, the

gender working group of the Catalan Association of Artificial Intelligence, created in 2019, is analysed as a real example of the proposed methodology.

In the same line, the paper [4] led by Dr. Lenka Lhotska from Czech Republic illustrates, through examples of women researchers and selected AI projects in medicine, the wide spectrum of applications developed by female researchers during the last fifteen years in the Czech Republic and, in particular, at the Czech Technical University in Prague. Women researchers have played an important and irreplaceable role in the construction of AI research in the Czech Republic, inspiring many young female students to join the community and start their research career in this area.

The paper by Dr. Genoveva Vargas [5] discusses the problem of the lack of datasets containing the relevant information required to analyse the role of women in Computer Science and Artificial Intelligence in depth. The author highlights that current datasets miss the information relevant to identify invisible patterns when studying the gender gap in different STEM disciplines. Therefore, the first step to understanding gender imbalance is building women's history by "completing" existing datasets. The lack of relevant data to analyse the needs and problems of women is not specific to the AI field but is a serious and general problem that affects all aspects, from economy to working conditions, including health, education, and all other fields. Traditionally, systemic datasets have been designed by male researchers and often lack the relevant indicators that would allow the elicitation of women's specific needs and problems; this paper is a small example within the ICT field of this critical phenomenon that requires urgent solutions in general.

There are other two papers about ethical issues in AI. In the paper "Ethical Issues in AI-Enabled Disease Surveillance: Perspectives from Global Health" [6], headed by Dr. Ann Borda, the authors present a study of qualitative perspectives for a responsible AI framework, to explore its potential application to disease surveillance in a global health context. AI-based disease surveillance helps to collect and analyse vast amounts of unstructured and real-time data to inform epidemiological and public health emergency responses, especially in poor countries.

The paper "The digital revolution in the urban water cycle and its ethical–political implications: a critical perspective", led by Lucia Popartan [7], provides a critical overview and interesting socio-political and ethical concerns related to water digitalisation and the role of AI techniques in this process. The study concludes that a hydro-social approach to digital water management is timely and necessary to guarantee the human right to water. The authors indicate that AI methods may be a relevant factor, but they need to have a non-discriminatory design, with democratic and participatory access and with an interdisciplinary view.

The second larger group of papers refers to **Learning** and contains a total of five papers, two of them designing and using novel techniques related to deep learning (a field currently undergoing great expansion), and three using other types of machine learning methods (clustering and classification).

The paper led by Nuria Valls [8] applies to the energy sector (D. Electricity and gas) and proposes a deep neural network built from a pipeline of simple neural networks to reproduce the steps of a benchmark algorithm for calorimetry reconstruction for the Large Hadron Collider beauty Experiment (LHCb) developed at CERN. The proposed model achieves to efficiently solve the problem in nearly constant time by reducing the computational complexity of the classic algorithms.

The third paper on deep learning is entitled "Recognition of mental workload of pilots in the cockpit using EEG signals" [9] and led by Aura Hernández-Sabaté. The authors propose a convolutional neural network to classify EEG (electroencephalography, sector Q. Health, social work) features across different mental workloads in a continuous performance task test. They present two different approaches to the fusion of EEG sensor signals with DL models trained and validated on self-designed games (one serious game and one flight simulator with specific scenarios).

The Special Issue also represents other areas of the **Machine Learning** field. The paper led by Shikha Suman [10] refers to the application field of unsupervised learning in Industry 4.0 (sector C. Manufacturing), in particular, additive manufacturing and large 3D printers. It presents a modification of the classical CURE strategy that scales up hierarchical clustering to large datasets by introducing bootstrap techniques into the basic algorithm and an automatic criterion to detect the number of clusters in the dendrogram. The proposal, named bootstrap-CURE, is applied to identify operation modes of 3D printers by analysing multivariate sensor data. The proposed methodology is scalable and significantly reduces computational costs, and it is being currently used at a leading real 3D printer manufacturer.

The work by Jessie C. Martín et al. [11] proposes a new predictive support tool to optimise the number of copies to print when a new book is published (sector G. Trade and retail), using data from the book, from the authors' social networks, and from the author's web mentions. The tool introduces the Combined model of Artificial Intelligence techniques (CAIT) that combines a classifier with a predictive model. First, it applies an XGBoost algorithm to classify the book into one of the possible book market segments. Next, a regressor also based in XGBoost is used to predict the appropriate number of copies to print.

The paper [12] led by Najlaa Maaroof is centred on the explainability of the output of complex automatic classifiers, a key step to allow users to make a good and informed decision, particularly in medical applications. The paper by Maaroof et al. proposes a method to generate explanations of classifiers in the form of a minimal set of short rules, using both numerical and qualitative variables. Two different machine learning methods for creating classification rules are analysed and compared in the case of RETIPROGRAM, an intelligent clinical decision support system that computes the personalised risk of developing diabetic retinopathy. Short explanations are obtained consisting of one representative rule and some counter-examples.

The issue includes two works on **Perception**: one on computer vision and the other on voice recognition (audio processing).

The paper [13] led by Syeda Furruka Banu contributes to early diagnosis of lung cancer. It proposes an accurate lung nodule detection and segmentation in computed tomography (CT) images. The proposed system combines nodule detection, based on fine-tuned Faster R-CNN to localise the nodules in CT images, with nodule segmentation, to enhance the ability to discriminate between nodule and non-nodule feature representations. The work shows promising experimental results.

In the paper "An Approach for Pronunciation Classification of Classical Arabic Phonemes using Deep Learning" [14], a group of researchers from Saudi Arabia, led by Amna Asif, face the problem of recognition of precise pronunciation of the large number of short vowels in Arabic alphabets, which cannot be dealt with using traditional audio processing techniques, contributing to the sector of P. Education. They present a new classification architecture based on convolutional neural networks. Identifying the vowels correctly is crucial in the Arabic language since a mistake in a short vowel can change the meaning of a complete sentence.

The **Integration and Interaction** area has two papers devoted to research on multiagent systems.

The paper led by Maite Lopez-Sanchez [15] focuses on a sensible topic in social networks: hate messages (sector L. Real estate). Although hate propagators are less than 1% of participants, they create a high amount of hate content (racial, gender, religion, etc.). The goal is to detect that hate content as soon as possible to avoid its propagation. In this paper, the authors propose an agent-based model to reproduce how the hate speech phenomenon spreads within social networks. Three countermeasures are modelled, simulated and evaluated: education, deferring hateful content, and cyber activism. Their effectiveness in containing the spread of that kind of messages is studied.

The second paper in this block is entitled "Probabilistic Models for Competence Assessment in Education" [16] and is led by Alejandra López De Aberasturi-Gómez. Current

trends for competence assessment propose hybrid solutions combining the benefits of automation with human judgment, such as using peer assessments to help the teacher in the evaluation of students in large classrooms (sector P. Education). The authors of this paper start with a probabilistic model based on Bayes inference and compare it with a model based on multiagent systems, called PAAS, where each actor relies on the judgment of others as long as their opinions coincide. To reconcile the benefits of Bayesian inference with the concept of trust posed in PAAS, the paper proposes a third peer evaluation model that considers the correlations between any pair of peers who have evaluated someone in common. An empirical study is done on synthetic data to determine the drawbacks and advantages of these three solutions.

The issue contains a single paper that simultaneously represents two areas: **Planning** (in its specific field of optimisation) and **Communication** (natural language processing). The research led by Tere Alsinet [17] deals with online discussions in social networks and a combination of sentiment analysis, a graph representation of the interactions among participants in the discussion, and a greedy local search optimisation algorithm to develop a quantitative model for measuring the polarisation degree in an online debate, such that this behaviour can be monitored to generate a warning signal when the debate polarisation reaches some threshold value (sector L. Real estate).

Two more papers complete the issue, which then covers all branches of AI, according to the AI Watch classification: one about **Reasoning** and the other on **AI services**.

The paper led by Zuzana Janková [18] studies several models of type-2 fuzzy sets based on different definitions of membership functions to handle uncertainty in international market financial data, which are inaccurate and incomplete (sector K: Finance, insurance). The results of this research show that type-2 fuzzy sets with dual membership functions are the most suitable for making predictions on the highly chaotic and unstable international stock markets.

Finally, a paper led by Immaculada Rodríguez [19] belongs to the AI services branch of AI and proposes a dynamic adaptive gamification method which takes into account initial players' profiles and also considers how these profiles may slightly change over time based on their interactions and opinions (sector R. Recreation activities). Then, the users are provided with a personalised experience through the use of game elements that correspond to their dynamic playing profile.

As we have seen, the issue has a wide representation of AI areas of specialisation and different application fields. In Figure 3, the global thematic coverage is visualised.

	AI branches							
AI application sectors	Reasoning	Planning	Learning	Communication	Perception	Integration and Interaction	AI Services	Ethics and Philosophy
A. Agriculture, forestry and fishing								
B. Oil and gas								
C. Manufacturing			[10]					
D. Electricity and Gas supply			[8]					
E. Water supply, Waste management								[7]
F. Construction								
G. Trade, retail			[11]					
H. Transportation and storage								
I. Accommodation and Food								
J. Information and Communication								[5]
K. Finance, insurance	[18]							
L. Real estate		[17]		[17]		[15]		
M. Other: Gender								[3][4][5]
P. Education					[14]	[16]		
Q. Human health, Social work			[9][12]		[13]			[4][6]
R. Recreation activities							[19]	

Figure 3. Classification of the papers regarding both AI branches and AI applications.

Analysing the configuration of authors of the papers, Figure 4 shows that the papers in this Special Issue have between 1 and 6 authors, but never more than 4 female authors. From a specific call for women-led papers, still, 35.3% of the papers have a minority of female authors; however, the first author is always a woman, as required in the call for papers.

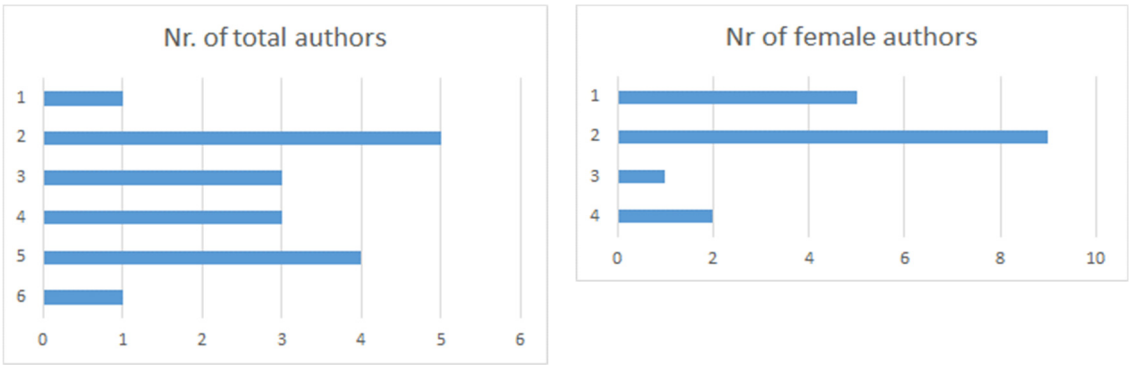

Figure 4. Distribution of the papers according to the number of authors (**left**); Distribution of the papers according to the number of female authors (**right**).

In Figure 5, it can be seen that the number of female authors slightly increases with the total number of authors, but the most frequent situation is to have 2 female authors (with 10 papers), and often they work alone (4 papers with a total of 2 authors, all female).

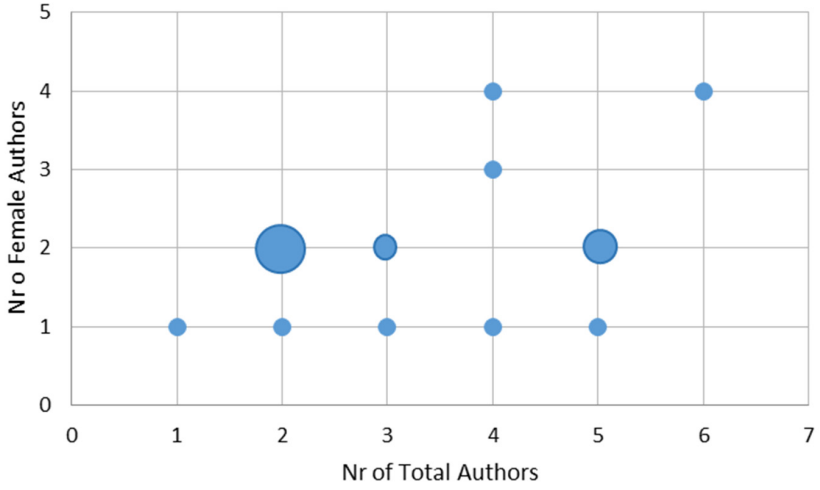

Figure 5. Relationship between total number of authors of the paper and the number of female authors. Size of the circle represents the number of papers at each point.

Regarding the origin of the working teams represented in this issue, this Special Issue was conceived during the 23rd International Conference of the Catalan Association of Artificial Intelligence, and although there was an international open call, it was intensively promoted during the conference. This explains why most of the papers reflect research conducted in Catalonia. However, the issue also contains five international papers with research done in France, Czech Republic, the U.K., and Saudi Arabia, also involving authors from other countries like Mexico and Australia. From the 12 remaining papers, international working teams are also represented in 7 of them, involving authors from other countries. In five of them, the first author is an international female under mobility who is developing research in Catalonia. They come from Bangladesh, Cuba, India, Yemen, and Romania. In fact, from the 58 authors integrating the issue, 26 (44.8%) of them are international, involving more than 12 countries, providing quite a wide international perspective of the female talent in AI.

The papers were evaluated by 52 international researchers from all over the world. Even though the usual proportion of women in AI is about 10% [3], we had 25% female researchers involved as reviewers. As guest editors, we thank all of them for their effort and great reviews, which made possible the publication of this issue.

In conclusion, apart from its intrinsic scientific value as a Special Issue itself combining interesting research works, the effort made in building this Special Issue intends to help enhance the visibility of where women in AI are, what they do, and how they contribute to Artificial Intelligence developments from different places, positions, research branches, and application fields in AI.

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