AI ECOSYSTEMS

AI in Catalonia, a promising ecosystem

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Artificial intelligence (AI) was born in 1956 in a summer school organised by J. McCarthy in Dartmouth in which the most important personalities in the field at that time participated. AI emerged as *"the empirical science that studies the mechanisms for intelligent actions"* [1] with the aim of *"making machines do what Men do as intelligent beings"*, according to M. Minsky [2] . It was necessary to wait more than 60 years to see some of those dreams come true on a large scale. Indeed, the technological infrastructure required to achieve those goals in real time has only recently become mature enough. The Internet boom, smart sensors, the Internet of Things (IoT), Big Data, supercomputers and 5G are the triggers.

I am pleased to see that Catalonia is now a powerful kernel of AI with world-class international projection. This was possible due to the historical coincidence of some circumstances, as extraordinary as unique, about which I shall share my personal view [3].

I enrolled in the Computer Science Bachelor's degree at the end of the 80s, in one of the three pioneer faculties in the field in Spain, the Barcelona School of Informatics (Facultat d'Informàtica de Barcelona, FIB), which is part of Universitat Politècnica de Catalunya-BarcelonaTech. The FIB, recognised internationally and respected worldwide for the quality of the professionals trained, directly witnessed the arrival of AI in Catalonia. In 1980, Ramon López de Mántaras came to the FIB from the best universities in the world, bringing AI along with him. In 1981, he finished his second PhD thesis, which was written in Catalan and was the first PhD thesis in AI in Catalonia, entitled *Algorismes d'aprenentatge en reconeixement de formes: Aplicació a la robòtica* (Learning Algorithms in pattern

recognition: Application to robotics)[4].

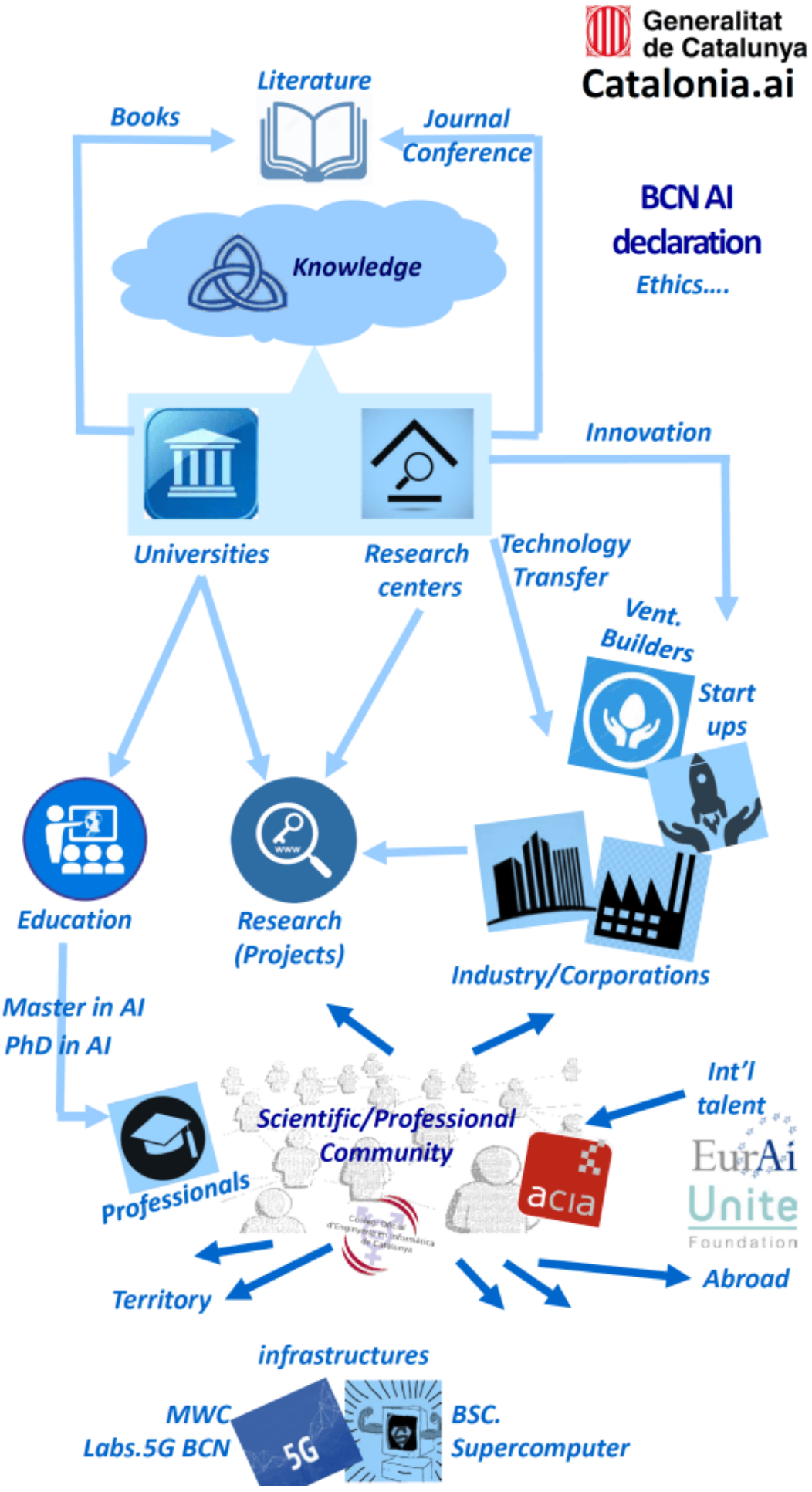
His outstanding value, both as ascientist and as a person, enabled Professor López de Mántaras to leave a long-lasting footprint at the FIB school, and shortly afterwards he undertook a second initiative, in my opinion decisive, for Catalan AI. In the mid-80s he was the main driving force in the creation of an AI department in the Centre d'Estudis Avançats de Blanes (the Centre of Advanced Studies of Blanes), the primal seed of the Artificial Intelligence Research Institute (IIIA), founded in 1994 as the first AI research centre in Spain, belonging to the CSIC (the Spanish National Research Council) and located on the Campus of the Autonomous University of Barcelona.

Meanwhile, his disciple, Professor Ulises Cortés, continued his research in AI at the UPC. Being a scientist with a high degree of initiative, he was pioneer in the creation of the first stable research group in AI at the UPC by the end of the 80s, mostly nourished by FIB students (myself among them), in a period where research groups were not yet formally recognised entities in university systems. It later crystallised into the Knowledge Engineering and Machine Learning Group, KEMLG, officialy certified as a Consolidated Group by the Catalan government, from its formal creation, an excellence certification given by the Catalan government. Today KEMLG is part of the Intelligent Data Science and Artificial Intelligence Research Centre, IDEAI at the UPC.

I had the privilege of being a direct scientific descendant of this lineage and I have seen new AI branches spring from these roots and extend across the whole country; growing AI research groups in the Catalan provinces when the Catalan university system was being decentralised. I have witnessed research groups crop up in Girona, Tarragona, Lleida, among others, founded by students from the FIB or the IIIA. All this redounds to the consolidation of a scientific community around AI, highly united, extended all over Catalonia which ,in 1994, formally constituted the Catalan Association for Artificial Intelligence (ACIA). In 2019, ACIA celebrated its 25th anniversary and has more than 200 members. Today, ACIA is the backbone of the scientific AI Catalan community, including alumni, professionals from the sector and some institutional associates. In spite of being the association of a small region, ACIA has been a local chapter of the European Association for Artificial Intelligence (EurAI) since 1995 and has organised an annual international conference since 1998. It should be noted that the proceedings of this conference are published by IOS Press, one of the most prestigious publishers of AI books in Europe. Over all these years the Catalan AI community also took off internationally and, thanks to ACIA, close links have been established with AI researchers that were trained in Catalonia and are now working all over the world. This is a relevant runoff talent that Catalonia lost in the past years and the role of ACIA in keeping it linked to the Catalan scientific community is a very valuable attribute. It is worth mentioning that 10 members of ACIA are EurAI Fellows. The EurAI fellowship is a highly selective programme that started in 1999 and has since then distinguished a total of 169 scientists (less than 3% of their associates). The awarded fellows belong to 20 different European countries and only France, Germany, the United Kingdom and Italy have more fellows than Catalonia.

Regarding AI training activities, a crucial driving force of the development of AI in

Catalonia, the UPC, under the lead of Pr. Ulises Cortés and KEMLG, started the first PhD programme in Artificial Intelligence in Spain in 1985. In 2005/2006,the UPC also established the first and unique official Master's in Artificial Intelligence in Catalonia, conceived as a clear national option and implemented from its creation in coordination with the University of Barcelona (UB) and the University Rovira i Virgili (URV) in Tarragona. The Master is international and attracts more than 50% of international students. In 2018-2019,it had more than 80 students enrolled.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AI Ecosystem in Catalonia
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Besides the research carried out at universities, a number of AI research centres also emerged over the years, complementing an intensive knowledge-creation scenario through all its branches (computer vision, robotics, machine learning, data science, intelligent decision support systems, distributed AI, reasoning, natural language processing, knowledge representation, speech recognition, and many more). Among these research centres involved in AI and Robotics research are the Institute of Robotics and Industrial Computing (IRI), the Computer Vision Centre (CVC), the Centre for Language and Speech Technologies and Applications(TALP) and the recent Intelligent Data Science and Artificial Intelligence Research Centre (IDEAI). The most recent IDEAI was created in 2017 and has around 60 permanent researchers in AI that came from 6 pre-existing research groups at the UPC, and more than 150 PhD students. KEMLG is now part of IDEAI and played a central role in its foundation.

All these circumstances nurtured the conditions needed to attract international figures like Ricardo Baeza, Luc Steels and Simeon Simoff, to mention a few, to conduct part of the research in Catalonia and leave their legacy here.

On the other hand, other scientists like Professor Mateo Valero have been crucial in the development of large technological infrastructures, pioneer in Spain as well. Thanks to him, Catalonia had the first supercomputer in Spain, the MareNostrum, installed in Barcelona in 2005, in the Barcelona Supercomputing Centre (BSC), an international reference crucial for processing big data. Regarding other infrastructures, Barcelona has recently created the Labs.5G Barcelona, in connection with the Mobile World Capital, to support innovation in 5G technology.

All these elements attracted large companies (like Intel, Fujitsu or Siemens, among others) that set up AI projects in Catalonia. It also attracted start up accelerators and venture capital that offer a unique opportunity to develop new business around the most disruptive technologies.

AI has now become a central issue because, as mentioned above, technology now allows to scale it and make it productive and there is a strong scientific community leading international research in the field. Thus, in recent years, the added value of AI for the improvement of processes, technologies and systems has become clear. Also, there is a boom in the processes based on extracting relevant information from data, as well as the possibility to access massive data from social networks, sensors and continuous monitoring of systems-organizations-citizens. Robotics also benefits from current technological advances.

This enabled a very quick development of a network of SMEs and start-ups in Catalonia interested in introducing AI into their core business. On the other hand, multinationals like Amazon are opening research centres here. In fact, according to Price Waterhouse Cooper, Barcelona was recently identified as the fourth-ranked city of the technological future, right after Singapore, London and Shanghai, and AI is one of the key technologies with the

capacity to build this future. The ACCIÓ report identified 179 companies working in AI in Catalonia in June 2019, while Digital Talent Overview 2019 reports AI as the most demanding emergent sector in Barcelona with an expected shortage of 14200 ICT professionals in this city, most of them in the area of AI.

Properly used, AI can contribute in fields like mobility, healthcare, the environment, automation or governance, and today it is the target of interest of the productive sector that is swiftly swerving towards business, which academics are witnessing in amazement. Indeed, Big Data, Data Science and AI comprise a series of topics which use computational force to disclose the most complex reality and extract its strategic value. From these three, AI is the only one that is able to place formal management of knowledge on top of data. In fact, AI applications occur anywhere and everywhere and are still imperceptible.

Aware of this transformation and the associated challenges, the Barcelona AI Declaration (2017), led by the Catalan AI scientific community, is also a pioneer initiative in Europe in the ethics, legal, socio-economic and cultural debate on the future uses of a trustworthy AI. Catalan AI scientists are very active in several initiatives relating to ethics in AI, including the development of EC guidelines for it.

Furthermore, there is still another singular entity in this ecosystem that deserves mentioning. As stated already, ACIA is the backbone of the AI Catalan scientific community, but Catalonia has another singular entity that articulates part of the AI sector from a more professional perspective. This entity is the Official Professional College of Computer Engineers of Catalonia (el Col.legi Oficial d'Enginyeria Informàtica de Catalunya, COEINF, created by the Catalan Parliament in 2001, whose mission is to watch over the computer engineering profession. This professional organisation is a fundamental support of Artificial Intelligence in Catalonia. Since 2016, the COEINF has included a specific position on its board devoted to AI: The Vice Dean of BigData, Data Science and AI, responding to the relevance that these areas are acquiring in the professional sector. This position is responsible for the fruitful development of the corporate sector in these fields, including the need to reduce the gender gap in the sector. Showing its dedicated commitment to this matter, COEINF decided to create a commission to watch on this matter: donesCOEINF. The gender gap also became the object of consideration for the ACIA and on 8 March 2019, ACIA founded a working group for women in AI in Catalonia called "donesIAcat". The Vice Dean of Big Data, Data Science and AI of the COEINF is today part of a specific Intersectoral Working Group of AI recently created with members of some Professional Technology Colleges, with the aim of promoting its industrial uses.

Many scientists and entities are still missing in this report but I think it is sufficiently evident that, even though we are in a small region receiving minimum governmental investments and even though AI is a minority research area, it is extraordinary what Catalonia has achieved in about 35 years in the field.

Aware of the opportunities and potentials of AI, the Catalan government, advised by a team of experts, published its strategic plan on the subject and made it available for public discussion in July 2019. This participatory process was open to all citizens and entities that

wanted to contribute with suggestions until 15 October 2019. After that date, a definite proposal will be prepared for submission for approval from the Catalan Parliament [Catalonia.ai 2019].

The Catalan AI community has discreetly managed to play in the big leagues and gain international recognition in the field of AI, and the AI community is currently well structured at all levels in Catalonia.

With the appropriate resources, I envisage AI as one of the most powerful sources of development that we have as a country, placing Catalonia on the verge of closing the knowledge-development cycle with AI as the cross-cutting driving force. Our country is small enough to keep a close relationship among academics, enterprises and institutions, which constitutes a major potential for development as a country. The daily challenges appearing in all sectors like hospitals, mobility, schools, etc., become the major inspiration for transferrable research that scientists develop. The transfer of high quality research and technology will produce huge social benefits, and this is a unique opportunity for Catalonia to become a successful and permanent world-class international AI hub.

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