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Reasoning, Action and Interaction in AI Theories and Systems

Essays Dedicated to Luigia Carlucci Aiello

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Foreword

Often times, we celebrate people at the end of their scientific career, when we look back at their accomplishments. The occasion for this book is different. It is a pleasure, in this case, to celebrate someone who has pioneered scientific developments in artificial intelligence and has served the scientific community with great energy, and who will certainly remain active in research for many years to come. This book is dedicated to Luigia Carlucci Aiello, better known as Gigina. The Festschrift makes its appearance exactly 50 years after the "official" birth of artificial intelligence (at the historical Dartmouth Conference) at the same time as a similarly round birthday for Gigina.

At Dartmouth College, the initial program for AI was set up by John McCarthy, Marvin Minsky, Herbert Simon and a few others. Alan Turing had been dead only a few years and the brightness of the English mathematician's ideas about computational intelligence was still lingering. The Dartmouth Conference set the scene for exciting research activity in this new field. Even though, at times, the results turned out remarkably different from the initial expectations, the field of AI expanded, adapting to the changing world and continues to flourish today. One of the most emblematic stories of AI is computer chess.

The ambition of being able to compete with the best chess players has been one of the original challenges that have characterized artificial intelligence. At the time of the Dartmouth Conference, in 1956, the belief existed that within some ten years, it would be possible to realize a program that would prevail over the best human players. The truth is that at the beginning of the 1990s, this goal was far from being achieved– the best chess programs were not at the level of the 100th best human chess player.

Later, IBM invested enormously in a special project that led to the development of Deep Thought, first, and then of Deep Blue. Deep Blue was based on special hardware and substantially exploited brute force, with its capability of exploring 200 million moves per second. The system, after a first failed challenge, succeeded in 1997 in overcoming Garry Kasparov, generally considered the best human chess player of all time. Kasparov left the game site furious, claiming that the operators of Deep Blue had cheated, for instance by contravening the agreements about operating the computer between games. In any case, he never accepted the result. Nonetheless, IBM declared victory, and Deep Blue never played again. The results of Deep Blue formed the basis of a number of other practical projects that IBM sustained in the following years. Even though Deep Blue was not known to have incorporated aspects that are typical of human intelligence, the AI community took advantage of the result and declared that one of the best known goals of AI, put forward by the founders of the discipline, had been attained.

1997 marked a milestone, but it was not the end of the story. The following years saw the development of a new generation of programs, running on traditional hardware (powerful PCs), but based on strategies that come closer to those used by humans, including pattern matching, machine learning, opponent modeling, reasoning and planning. In general the new programs, like Deep Junior (world champion in 2006), Shredder, or Zappa, are specifically built for competing at the world championship of computer programs. Yet in 2003, Deep Junior challenged Garry Kasparov, with a tie as the final result. However, this time Kasparov declared himself satisfied with a tie result, and clearly played the final two games on the defensive, impressed by Junior's capability to change strategies in the course of the game. Kasparov seemed to recognize that the future of "chess intelligence" had been declared.

Critics of artificial intelligence have often condemned it for philosophical reasons, ethical reasons and technical reasons. We will not discuss this issue here. Let us just say that in the practical world artificial intelligence has produced many positive results. They may not always appear so clearly because of a paradox: AI is often considered the computer science of the future and, as a consequence, whenever there are practical results, they cannot be attributed to artificial intelligence.

Gigina was born in Fabriano, Marche, a remarkably beautiful region of central Italy, full of historical and artistic monuments that form the casual backdrop for everyday life. Fabriano is famous for its paper industry (there, Gigina and her collaborators must have learned about "paper" production).

After high school she moved to Pisa, where she studied mathematics at the Scuola Normale Superiore with some renowned Italian mathematicians, such as Ennio de Giorgi. At that time, she fell in love doubly: with the theory of computation and with her husband Mario Aiello, an outstanding computer scientist. With him and with other Pisa friends, including Giuseppe Attardi, and Gianfranco Prini she published various brilliant works. At the time, Pisa was the recognized center of computer science research in Italy. In that environment a whole group of young scientists at the Istituto per l'Elaborazione dell'Informazione (Institute for Information Processing) of the National Council for Research began to develop research in artificial intelligence: these include, among others, Ugo Montanari, Giorgio Levi, Franco Sirovich, Alberto Martelli and Franco Turini. Several important papers that appeared in the *Artificial Intelligence Journal* were produced in Pisa at that time. Gigina became a protagonist in the AI scene. In Italy, the scene also included Marco Somalvico and his robotics group at Milan Polytechnic, and, very soon research activity in AI started in Turin and in various major universities. When their son Marco was still a small child, Gigina had to cope with a personal tragedy: the loss of her husband Mario. Subsequently, she decided to move to the United States, to work at Stanford for a few years, in a research environment inspired mainly by John McCarthy. When she came back to Italy she soon took the position of full professor in Ancona, certainly one of the youngest full professors (and female professors!) in Italy. From there she moved to University La Sapienza in Rome, where she taught

and established a group including a large number of well-known AI scientists, and where she teaches artificial intelligence now. For two years she also directed IRST in Trento, a major research center in AI, Microsystems and Surfaces.

In the Italian AI research scene in the late 1970s and early 1980s, there were several universities active in AI: Pisa, Rome, Turin, Genova, Milan, Padova, Udine, Brescia, Florence, Bologna, Napoli, Bari, and Palermo. Within the National Council of Research, Istituto per l'Elaborazione dell'Informazione and Istituto di Linguistica Computazionale in Pisa, and Istituto di Psicologia in Rome were also major players. Industrial research was also active, at CSELT in Turin, at Tecsiel and Olivetti, plus at a number of smaller companies. An interest group on AI was established within the Italian Association for Computer science (AICA) in those years. In the mid-1980s, IRST was established in Trento as an important institute devoted mainly to AI. In 1987, thanks to the effort of Marco Somalvico, the major AI conference–IJCAI–was held in Milan. In 1988, the Italian Association for Artificial Intelligence (AI*IA) was established and Gigina was appointed its first President. The Association has brought about a notable set of activities, including a good-quality biennial conference in odd years, a convention in even years, a number of workhops organized by special interest groups and a magazine. The first conference, held in Trento in 1989, had almost 300 participants. AI*IA has become a serious enterprise and AI has received continuous attention in Italy since.

In the meanwhile, the European organizational scene was set between the 1970s and 1980s. Wolfgang Bibel and others worked on establishing a European AI society. At the Amsterdam AISB conference, the European Coordination Committee for Artificial Intelligence was established as an umbrella organization whose members are national AI societies. AICA was among the first, and was later replaced by the novel AI*IA. It was also decided to hold the first European Conference for Artificial Intelligence in Orsay in 1982, the first (even if recorded as "Fifth" to take into account the previous events within AISB) of an ongoing series of important biennial conferences. Bibel was elected the first ECCAI Chair, and further national AI societies including several in the Eastern Block were initiated. ECCAI also established various activities including committees for advising the European Commission. Gigina was among the few key figures in these developments.

Outside Europe, for many years Gigina has been a major actor in the two main international scientific forums of artificial intelligence: IJCAI, as General Chair of IJCAI 1999 in Stockholm, Chair of the Trustees, and on the editorial board of the *Artificial Intelligence Journal*, where she has collaborated to steer the development of the field.

Luigia Carlucci Aiello's research activities have addressed a wide range of topics. Her first interests back in the early 1970s were in the field of pattern recognition. Soon after, she shifted into programming language semantics, program properties and their automatic proofs. She defined a semantics for PASCAL in LCF (Logic for Computable Functions) and machine checked several proofs of (nontrivial) properties. She designed and implemented a theorem prover named PPC (Pisa Proof Checker), published papers describing the (object-oriented) program-

Luigia Carlucci Aiello

ming paradigm used in its development, and its evaluator (an interpreter for the full lambda calculus), and participated and contributed to the development and use of Wehyrauch's FOL system. At the same time, she has investigated the advantages of using meta-level knowledge in AI systems, both to control search and to reason in multi-agent systems. She was involved in the first experiments in Italy on the application of artificial intelligence techniques to the development of expert systems for medical diagnosis and of intelligent tutoring systems. Since at least 1990, she has been active in the field of nonmonotonic reasoning, where her interests have spanned from the characterization of default proofs, to tableau systems for default logic, to modal characterizations of default logic and definability of concepts of natural kinds. Her latest research activity has been in the fields of cognitive robotics, AI techniques applied to security, and AI planning.

In launching this Festschrift initiative, we have involved a number of people who have worked in research with Gigina, or have been her students, who have then embarked on an important path of their own. Others have shared with Gigina a leading role in the strategic service of the AI community, internationally or as presidents of the Italian Association for Artificial Intelligence.

Alberto Martelli, Eugenio Omodeo and Franco Turini are some of the colleagues and friends that worked together with Gigina in that magic period in Pisa.

Gigina with the students of the first AI course she taught in Rome in 1992

Marco Cadoli, Alessandro Micarelli, Daniele Nardi, Fiora Pirri (and Marco Schaerf) are representatives of the large group of AI scientists who have taken the first steps (and often many subsequent steps) with Gigina in Rome.

Pietro Torasso, Roberto Serra, Marco Gori and Marco Schaerf have all followed Gigina as AI*IA Presidents (as has Oliviero Stock, who was also a student of a very young Gigina in Pisa).

Wolfgang Bibel, Alan Bundy, Robert Kowalski, Erik Sandewall, Jrg Siekmann, and Wolfgang Wahlster are certainly among the small group of the most influential scientists in AI. They share with Gigina a passion for reasoning and logic, and have been essential parts of her intellectual milieu. Most of them have worked with her in leading positions in the international AI community, in ECAI, IJCAI Inc. or the AI Journal.

Paolo Traverso worked with Gigina during her period as IRST director. And last but not least, Roberto Cordeschi, a friend of Gigina's and an AI historian, especially in recent times has helped understand the initial years of AI, the period before Gigina's intervention.

This collection is a detailed insight into many aspects of AI and the relationship between theoretical and applied research.

The first set of papers is dedicated to the foundations of AI.

The paper by Roberto Cordeschi, "Searching in a Maze and in Search of Knowledge: Issues in Early Artificial Intelligence" gives an account of the origins

of heuristic programming and the shift to knowledge-based or real-life problem solving that followed the initial days of AI.

Wolfgang Bibel in his "Research Perspectives for Logic and Deduction" provides an authoritative manifesto for the role of logic and deduction within AI or, better, within what he has called Intellectics.

Questions and techniques related to computational logic are the themes for various subsequent chapters.

Jörg Siekmann et al.'s paper "Reductio ad Absurdum: Planning Proofs by Contradiction" addresses the questions: how can we proof plan an argument by reduction ad absurdum? When is it useful to do so? What are the methods and decisions involved?

In "Computational Logic in an Object-Oriented World," Bob Kowalski investigates transformations between object-oriented and abductive logic programming systems and argues that ALP multi-agent systems can combine the advantages of logic with the main benefits of object orientation.

In "Best-First Rippling," Alan Bundy and colleagues address the limitations of rewriting systems based on continuous incremental reduction of differences between formulae by introducing a more flexible and efficient best-first technique.

Marco Cadoli and Marco Schaerf's "Partial Solutions with Unique Completion" looks at the computational complexity of several reasoning problems, their formulation by means of quantified Boolean formulae and their solution through an appropriate solver.

In "The Computerized Referee," Eugenio G. Omodeo and colleagues present a system that either certifies a text as constituting a valid sequence of definitions and theorems, or rejects it as defective, and they discuss a series of new enhancements to the system.

Other general themes are the subjects of the subsequent two papers.

In the paper "About Implicit and Explicit Shape Representation" Fiora Pirri addresses a different topic: the analysis of shape and form as the basic features for understanding the relation between images, offering a novel approach to shape approximation and similarity measures and their use.

In "Agents, Equations and All That: On the Role of Agents in Understanding Complex Systems," Roberto Serra and Marco Villani offer a different perspective on a familiar matter; they show how differential equations can describe interactions among agents and point out that the capabilities of the former are broader than is often assumed.

The theme of intelligent robotics is prominent in the set of papers that follow.

In "Coordination of Actions in an Autonomous Robotic System", Erik Sandewall describes the design and formal characterization of a cognitive process, called an action coordinator, that manages restrictions in real-world actions.

Robots in soccer is a very popular theme and could not be passed up in this collection. In "AI and RoboCup", Daniele Nardi and Luca Iocchi provide an AI research perspective on RoboCup, based on the experience accumulated in several years of RoboCup activity.

"Planning Under Uncertainty and Its Applications" by Paolo Traverso is on a theme that bridges between robotics and several other areas. Traverso discusses solutions to the problem of actions that may have different effects that cannot be predicted at planning time and some applications in different domains.

The subsequent set of chapters is dedicated to AI and the Web.

In "Reasoning About Web Services in a Temporal Action Logic" Laura Giordano and Alberto Martelli present an approach to reasoning about Web services, described by specifying their interaction protocols in an action theory based on a dynamic linear time temporal logic.

Alessandro Micarelli and colleagues in "Intelligent Search for the Internet" approach the key theme of personalization and adaptation of human–computer interaction to overcome information overload, by means of machine learning techniques and AI-based information representations.

The history of artificial intelligence has seen many attempts to compete with humans at games.

In "Cracking Crosswords: The Computer Challenge", Marco Gori and colleagues go further and tackle the cracking of crosswords and describe a system which relies strongly on interaction with the Web for clue answering.

The subsequent two papers focus on techniques particularly relevant for specific classes of problems.

Pietro Torasso and Gianluca Torta in their "Model-Based Diagnosis Through OBDD Compilation: A Complexity Analysis" address the problem of evaluating the complexity of diagnostic problem solving, characterized by a potentially exponential size of the search space, often circumvented by compilation of the domain model.

In "Examples of Integration of Induction and Deduction in Knowledge Discovery," Franco Turini and colleagues investigate the use of classification trees in two quite different application areas — business documents and geographic information systems — complementing the use of induction from examples with the exploitation of some form of deductive knowledge.

The final paper in this collection, "SharedLife: Towards Selective Sharing of Augmented Personal Memories" by Wolfgang Wahlster and colleagues, is concerned with a very ambitious topic, namely, the building of an augmented personal memory from the recording of physical and communicative interaction of an individual in an instrumented environment, and its use with the goal of supporting communication between individuals and learning from the experiences of others.

We wish to thank all authors for their enthusiastic participation; Sara Kaufman and Davide Micaletto for their help in producing a polished final version of this book. Some of the best young scientists have grown close to Prof. Luigia Carlucci Aiello and have been inspired by her continuously. May this tribute to her be of inspiration to an even larger, new generation of AI scientists.

Oliviero Stock and Marco Schaerf

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Table of Contents