ACTIVITY REPORT
Research Group on Artificial Intelligence.
Departament d'Enginyeria Informàtica
Escola Tècnica Superior d'Enginyeria
Universitat Rovira i Virgili

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Research Group on Artificial Intelligence

The research group on Artificial Intelligence is one of the research groups at the Computer Science Department in the Universitat Rovira i Virgili. It was funded in 1992, a short while after the University began to teach Computer Engineering. At present, the group has a staff of seven members.

The research of the group has been mainly conducted by two research projects (VIM and SMASH), and the collaboration with the groups of the Applied Physics and Software departments at the UPC (Universitat Politècnica de Catalunya, Barcelona). This activity report is divided according to those topics.

1. VIM: Virtual Multicomputer for Symbolic Applications

A European project in the framework of the Human and Capital Mobility titled: *Virtual Multicomputer for Symbolic Applications* (VIM: CHRX-CT93-0401). This project began in 1994 and although it was initially planned to finish in 1996 it was extended until the end of 1997. Our group participated in one of the research lines in the case for extension of this project.

Our participation in this project was centered in the elaboration of tools and techniques for the automatic construction and validation of knowledge based systems.

In particular, in relation to the construction of knowledge based systems, we have developed tools to extract domain knowledge (for example, in the form of rules) from non structured information [11]. Most of the work on rule extraction was carried out by David Riaño in his PhD thesis [76] which was supervised by Ulises Cortés from the UPC.

The implementation of a classifier system (SEDÀS) to be used in this framework [12] allowed us to obtain some theoretical results on the semantics of linguistic labels in knowledge acquisition systems [6]. Empirical results of this semantics will be published in [14].

We have also considered when the elicited knowledge does not come from a single expert but from a set of them. [2] describes a tool (EGAC) that synthesizes data matrices from several experts. The result of this tool can be used later to generate rules. We have integrated recently the classifier system SEDÀS and the aggregation method EGAC and we are integrating also an automatic generator of rules.

In the aspects related to validation of knowledge based systems (i.e., when a KBS behaves correctly) we have started from the knowledge of a set of experts over a set of cases. To validate the KBS we compare [10] the results of the KBS with the ones of the experts on the set of cases. We face this problem applying functions and techniques from knowledge integration.

Also in the framework of this project, we have collaborated with the GMD (Gesellschaft für Mathematik und Datenverarbeitung MBH) in Berlin to apply fuzzy logic techniques to

problems related to the compilation of programs in parallel machines (configuration decisions in mapping [35]). We have built a fuzzy logic based multi-stage inference system. The aspects of this system more related to fuzzy logic have been reported in [13]. This work was included in the case for extension of the VIM project.

The use of a fuzzy inference system has obliged us to face the aspects related to the defuzzification of the output of the system. In the mentioned work with Angela Sodan from GMD [13], we faced the defuzzification of a fuzzy set when the reference set is discrete with a new approach. We considered the defuzzification of a set in relation to a set of constraints. More recently, we have also studied defuzzification of fuzzy sets in a continuous domain. The results of this work, that was done in colaboration with Lluis Godo from IIIA CSIC (Barcelona), appear in [33, 49].

2. SMASH: Multi-agent systems for Medical Services in Hospitals

A Spanish project (CICYT: TIC96-1038-C04-04) to study and implement multi-agent systems and to apply them in medical domains. The project begun in August 1996 and is planned to finish on July 2001. According to the initial plan, in the first year we have begun to consider some reasoning methods and their adaptation to multi-agent systems. We have also studied the constructions of models to formalize the epistemic, intentional and communicative aspects.

We are also interested in the construction of formal belief models for rational agents. We define rational agents as those systems that are permanently engaged in the process of rational inquiry; thus, their beliefs keep evolving in time, as a consequence of their internal inference procedures and their interaction with the environment. The main topic in our work is to have a formal model of this process. In particular, we are exploring the possibility of making some changes in the classical possible worlds model in order to avoid the logical omniscience problem (see ÀM1, [29]).

We avoid logical omniscience and perfect reasoning by replacing possible worlds by conceivable situations, which are all the situations that the modelled agent is capable of considering. These situations are partially represented by sets of formulas (see AM3, [27]). At the moment, the main aim of our work is to show how this notion of conceivable situations may be used to model the process of rational inquiry in which a non-ideal rational agent is engaged. We define a wide class of agents, called rational inquirers, which are a general abstraction of any kind of non ideal agent (see AM2, AM4, [28]). The beliefs of this kind of agents evolve in time as a consequence of a multi-dimensional belief analysis. This analysis includes several components: a logical dimension, in which agents may perform some deductive inferences on their beliefs, using a modified version of analytic tableaux method; an exploratory dimension, in which agents may incorporate doubts in their analysis, may wonder whether they believe or not a given formula; and an experimental dimension, in which agents may perform tests in the real world and add the results of these tests into the analysis. We aim to show how the framework of conceivable situations may be successfully used to model the evolution of the belief set of this kind of agents.

Another aspect related with multi-agent systems that is studied in our group is the knowledge integration process (data fusion or aggregation of information). These processes are needed by a system in order to have a better representation of the environment or to make decisions. Note that, in fact, some of the results described below are previous to the beginning of the SMASH project.

We have studied aspects of knowledge integration when the knowledge is provided in several forms, for example, fuzzy sets [3] and mass functions (using evidence theory) [4]. We focus here in the synthesis of numeric values. We have defined the WOWA operator [9] that generalizes the Weighted Mean and Yager's OWA operator. We have shown that the WOWA operator is a particular case of the Choquet integral with a particular fuzzy measure. The use of the WOWA operator gives a new interpretation of S-decomposable fuzzy measures. We have applied the WOWA operator to constraint satisfaction problems [50] and to define a semantics of fuzzy sets [34].

3. Making and integrating Knowledge-bases for Knowledge-based systems

A spanish project (CICYT: TIC96-0878) which begain in 1996 and is planned to finish on 1999. The project is to study the use of several unsupervised automatic learning techniques for concept formation in ill-structured domains. From the resulting concepts a set of classification rules will be generated automatically. This set will become the knowledge base of a Knowledge-Based System. Given the heterogeneous nature of the available data, several distinct strategies for the automatic generation of rules will be generated, tested and put into practice. One of the most important characteristics of this project is the study of how to re-use partial knowledge bases in order to build up new Knowledge-Based Systems. The test field for the project will be the expert systems currently composing DAI-DEPUR, an architecture for a control system used in urban WWTPs (Waste Water Treatment Plants).

Int the first year we have studied several methods for automatic rule learning. We have studied the representation formalisms which are more suitable to both understand and apply rules. We have also implemented all the methods and generate a library of methods (see [76] for details) which is integrated in the global system located in: http://www.etse.urv.es/~drianyo/software/T6.tar.Z.

4. Modelization of Shape Memory Alloys

We have contributed to the construction of a high resolution thermal analysis system to study Shape Memory Alloys under changes of temperature and strength. The experimental system [1, 7] allow us to analize the effect of a certain programmation of temperature when the strength is fixed and, also, to visualize these effects with an optical microscope. We have obtained some preliminary results on the modelization of the behaviour of the system using neural networks and fuzzy rules [16].

5. Lists

1. Staff

Researchers	E-mail address	Incorporation date
Arantza Aldea	aaldea@etse.urv.es	2/1999-
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Antonio Moreno	amoreno@etse.urv.es	10/1995-
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Aïda Valls	avalls@etse.urv.es	10/1997-

2. Projects

1. VIM: Virtual Multicomputer for Simbolic Applications
   European Community project: CHRX-CT93-0401
   From January 1994 to December 1997
   Coordinator: Julian Padget (University of Bath)
   Main investigator at the Universitat *Rovira i Virgili*: Vicenç Torra
   Web page: http://www.maths.bath.ac.uk/~jap/VIM/

   Partners:
   - Christian Albrechts Universitaet Kiel, Germany.
   - CNR, Istituto di Cibernetica, Naples, Italy.
   - CSIC, Institut d'Investigació en Intel.ligència Artificial, Spain.
   - GMD, FIRST, Berlin, Germany.
   - GMD, FIT.KI, Bonn, Germany
   - Ilog S.A., France.
   - INRIA, France.
   - Università di Pisa, Dipartimento di Informatica, Italy.
   - Università di Salerno, Dipartimento di Informatica ed Applicazioni, Italy.
   - Universitat Politècnica de Catalunya, Department of Computer Science, Spain.
   - University of Bath, Mathematical Sciences, U.K.
   - University of Southampton, Department of Electronics and Computer Science, U.K.
   - University of Warwick, U.K.
   - Vrije Universiteit Brussel, AI Lab, Belgium.

2. SMASH: Multi-agent systems for Medical Services in Hospitals
   CICYT project (Spanish government): TIC96-1038-C04-04
   From August 1996 to July 2001
   Coordinator: Lluís Godo (IIIA-CSIC)
   Main investigator at the Universitat *Rovira i Virgili*: Vicenç Torra
   Web page: http://www.iiia.csic.es/Projects/smash/

   Partners:
   - CSIC, Institut d'Investigació en Intel.ligència Artificial
   - CSM - Consorci Sanitari de Mataró
   - Universitat de Lleida

3. Publications

3.1. Journals

[1] A. Amengual, A. Isalgué, F. Marco, H. Tachoire, V. Torra, V. R. Torra, Automatic equipment with improved performances (ATC and DSC) in shape memory alloys studies, *Journal of thermal analysis*, 38 (1992) 583-592.

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[AM1] A. Moreno, Avoiding logical omniscience and perfect reasoning: a survey, *AI Communications* 11 (2), 101-122, 1998.

[AM2] A.Moreno, Inquirers: a general model of non-ideal rational agents, *International Journal of Intelligent Systems* (in press).

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3.2. Chapters of books

[16] A. Isalgue, J.L. Pelegrina, A. Torralba, V. R. Torra, V. Torra, Meso-scale model of the Cu-Zn-Al single crystal SMA, en *Mechanics of phase transformations and shape memory alloys*, (Eds.) L.C. Brinson y B. Moran, (ISBN No. 0-7918-1437-8, New York (USA), 1994), pp. 71-84.

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3.3. International conferences

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[21] A. Moreno, Generalización de fórmulas lógicas y su aplicación al aprendizaje automático, *International Symposium on Artificial Intelligence*, 193-200, Monterrey, México, 1993.

[22] V. Torra, Preliminary approach in SMA modelling: the neural network, *Abstracts of the Discussion meeting on SMA: Static and dynamic effects in the Shape Memory Alloys hysteretic behaviour*, 25, Barcelona, España, 1993.

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3.4. Spanish conferences

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[39] V. Torra, U. Cortés, Consenso y clasificación para matrices de datos, *Actas de la V conferencia de la asociación española para la inteligencia artificial*, 216-225, Madrid, 1993

[40] V. Torra, Síntesis de funciones de pertenencia en la determinación de radios de influencia, *Actas del Cuarto congreso español de tecnologias y lógica fuzzy*, 157-162, Blanes, 1994.

[41] X. Drudis, D. Riaño, Shiva: modelo de representación multiagente, *Proceedings of the VI Conferencia of AEPIA*, 547-557, November, 1995.

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[LO1] B López, Hacia la profesionalización de la Inteligencia Artificial, IV Jornadas sobre la Enseñanza Universitaria de la Informática, 355-360, 1998, Andorra.

3.5. Teaching publications

3.5.1. Books

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[53] A. Moreno, B. López et al., Aprendizaje Automático, Eds. UPC, Col.lecció Politext, Àrea de computació i control, 36, ISBN 84-7653-460-4, 1994.

3.5.2. Others

[54] A. Moreno, Apunts d'Introducció a la Lògica

[55] V. Torra, Apuntes sobre el lenguaje Standard-ML

[56] V. Torra, Apuntes sobre λ-calculus

3.6. Research and technical reports

Note: The mentioned works that correspond to a preliminary version of articles in journals or works in conferences have to be added to this list.

[57] A. Moreno, Generalización de fórmulas lógicas y su aplicación al aprendizaje automático, Master Thesis, Research Report, LSI-93-17-R, Software Department, Universidad Politécnica de Cataluña, 1993.

[58] V. Torra, *Eina per a la generació automàtica de consens*, Master Thesis, Research Report, LSI-92-21-R, 79 páginas, Software Department, Universidad Politécnica de Cataluña, 1992.

[59] A. Moreno, Aprenentatge amb el mètode NGE, Research Report, LSI-93-17-R, Software Department, Universidad Politécnica de Cataluña, 1993.

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[63] D. Riaño, *Automatic Knowledge Generation from Data in Classification Domains*, Master Thesis, Universitat Politècnica de Catalunya, 1994

[64] V. Torra, *Contribució a l'estudi de funcions de síntesi per a la intel.ligència artificial*, PhD Dissertation, Software Department, Universitat Politècnica de Catalunya, May, 1994.

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[68] A. Sodan, V. Torra, Configuration Decisions for Mapping by Fuzzy Inference, Technical Report 1050, GMD-FIRST, Berlín, 1997.

[69] A. Sodan, V. Torra, Hierarchical Fuzzy Configuration of Implementation Strategies, Trabajo de investigación, Reference: Technical Report 1101, GMD-FIRST, Berlín, 1997.

[70] D. Riaño, *Feature and Instance Selection*, Research Report: DEI-RR-97-004, Computer Science Department, Universitat Rovira i Virgili, 1997.

[71] V. Torra, *Interpreting membership functions: A constructive approach*, Research Report: DEI-RR-97-010, Computer Science Department, Universitat Rovira i Virgili, Julio, 1997.

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[74] D. Riaño, *Selección de Instancias con forward*, Research Report: DEI-RR-97-018, Computer Science Department, Universitat Rovira i Virgili, 1997.

[75] A. Moreno, Modelling rational inquiry in non-ideal agents. Research Report DEI-RR-97-019. Computer Science Department, Universitat Rovira i Virgili.

[76] D. Riaño, *Automatic Construction of Descriptive Rules*, PhD Dissertation, Software Department, Universitat Politècnica de Catalunya, December, 1996.

3.7. Other publications

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4. AI-related Master thesis

[MSc1] Albert Borrull, *Adquisición de conceptos en el aprendizaje inductivo*, MSc., 1995, LSI, UPC. Directed by Antonio Moreno.

[MSc2] Aïda Valls, *Sedàs: mòdul general de classificació*, BSc., 1995, DEI, URV. Directed by Dr.Vicenç Torra and Dr.David Riaño.

[MSc3] Aïda Valls, Anàlisi de mètodes de síntesi d'informació, MSc., 1997, LSI, UPC. Directed by Dr.Vicenç Torra, and supervised by Dr.Ulises Cortés, UPC.

5. Organized conferences

[Conf1] ESTYLF97- *VII Spanish Congress on Fuzzy Logic and Technology*, 1997, Tarragona, Spain.
[Conf2] CCIA98- *I Catalan Congress on Artificial Intelligence*, 1998, Tarragona, Spain.