Conference report

Binding Environmental Sciences and Artificial Intelligence on ECAI'98

U. Cortés [a], M. Sànchez-Marrè [a,*], I. R-Roda [b] and D. Riaño [c]

[a] *Software Department, Technical University of Catalonia (UPC), Jordi Girona 1-3, E08034 Barcelona, Catalonia, Spain*
E-mail: {ia,miquel}@lsi.upc.es

[b] *Chemical and Environmental Engineering Lab., University of Girona, Campus de Montilivi, E17071 Girona, Catalonia, Spain*
E-mail: ignasi@lequia1.udg.es

[c] *Computer Science Department, Ctra. de Salou s/n, Universitat Rovira i Virgili, E43006 Tarragona, Catalonia, Spain*
E-mail: drianyo@etse.urv.es

Keywords: Artificial Intelligence, Environmental Sciences, Decision Support Systems

1. Preamble

Continuously evolving economic, social and cultural pressures on natural resources, including excessive uses and pollution, are causing threats which are increasing the dangers to the state of the earth, due, above all to overpopulation, increasing of industrial activities and global consumption, and increasingly dangerous types of waste on land, air and water. Society is trying to balance the production of goods with the proper conservation of environment. This task proofs not only to be hard from the technical and economical point of view but also creates controversy.

Artificial Intelligence has been widely and successfully applied to environmental management problems as for example in using expert systems advising emergency response teams about how to deal with industrial accidents [1], in using expert systems to assist in granting hazardous waste site permits [27], in modelling water quality [28], and many other environmental engineering applications [5,23,29]. The first real applications of Expert Systems to environmental issues appeared in the early 80's. See, for example, the seminal work by Guariso [13,24].

But all this interest have had a very sparse impact in the general Artificial Intelligence Conferences. That is why we are honored to report on the ECAI'98 Workshop on Binding Environmental Sciences and Artificial Intelligence (BESAI'98). The organization of this Workshop has its roots in the IJCAI'95 Workshop on Artificial Intelligence and the Environment [17] that is to our best knowledge the only initiative of its kind in the frame of a big Artificial Intelligence Conference.

BESAI was in our opinion a good starting point to bring together scientists from a broad spectrum applying AI techniques to environmental issues and from other areas to help each other to solve problems in a hot and sensible area as Environmental Sciences are. And to create an appropriate forum to present and discuss new initiatives.

Environmental Studies and Artificial Intelligence are both of strategic interest for society and this is reflected for example in the Information Society Technologies Programme (IST) call [15]. The interaction of researchers from both areas can provide society with nice solutions for many real applications, in order to better understand, manage and protect the environment. The encounter between these fields is a new challenge for many researchers of both communities.

1.1. The workshop

For this workshop edition we received about 25 expressions of interest and after a selection, based on the judgment of three referees for each paper, the organising committee accepted 13 papers from 11 groups

*Corresponding author.

AI Communications 12 (1999) 261–265
ISSN 0921-7126 / $8.00

widely distributed. The technical issues addressed by the selected papers for this workshop come from all environmental fields, but there is a great strength on the applications to Water issues as most of the papers were devoted to Wastewater Treatment plants applications talking about: the instrumentation and Knowledge-Based Systems [2]; the application of Neural Networks to prediction [3]; the construction of Ontologies [6]; the use of Model-Based Reasoning for prediction [11]; the automatic rule construction [20]; Case-Based Reasoning applied to Biological Systems [26] and Case-Based Reasoning applied to Wastewater Treatment Plants [21].

Paggio et al. presented the current state of TRACE, an ongoing research funded by the EU with an application to Environmental Decision Support System, and contributions emphasizing integration of various technologies [19]. In the same line of having a Decision Support System, Sazonova and Osipov [22], contributed with a paper oriented to catching–prediction in fisheries.

Also we had nice applications to the modelling of Climatic Data [18], to automatic sensing of odours in Waste Treatment plants [4] and the applications to CBR to azeotropic distillation [16], these papers add the practical taste to the sessions.

In a more horizontal approach to environment supervision we had the paper by Hart et al. [14] that makes a very interesting and general reflection about the possible role of Artificial Intelligence and its applications to Environmental Management Systems where, the use of AI techniques appeared once again as a central idea for designing and constructing reliable support tools in the decision taking process.

1.2. Organization

The paper is organized as follows: in Section 2 we present the I. R-Roda's opinion about BESAI'98 from the point of view of Environmental Sciences. In Section 3 we present the D. Riaño's opinion from the point of view of an Artificial Intelligence researcher. In Section 4 we give our own conclusions and present some plans for the future.

2. Environmental sciences point of view

BESAI was an appropriate meeting considering the relevance of the interaction between environmental sciences and Artificial Intelligence fields. The workshop was an interesting experience to drop into a world of environmental engineers and artificial intelligence researchers the discussion of new approaches to face management of environmental systems and new ways to solve problems.

As pointed out in BESAI, managing environmental systems is not an easy task as it requires a wide range of expertise, including environmental sciences, engineering, social sciences, economics, and politics [8]. However, this is the world that we are facing and managing and we must learn to deal with these complex systems, we must try to understand their behaviour, and last but not the least, we must be able to build tools to solve them precisely and very rapidly, because of the social, political and economic impacts of the potential solutions.

Over the last years environmental engineering has undergone significant advances in both theory and practice. Experience gained from the operation of numerous systems, coupled with the results of recent research in the field, has led to improved environmental systems management. From an AI point of view, the broad introduction of Knowledge-Based systems and Case-Based systems, followed by the explosion in the use of Neural Networks, and along with the fuzzy systems spearheaded the thrust of a rejuvenated artificial intelligence to play an utilitarian role in the engineering practice [25].

In spite of this encouraging concurrent advance in both fields, the interaction between researchers related to these areas has not been an easy task, as reflected in relevant literature where few shared references appear. This is easy to understand if we analyse the context: AI requires a rigorous approach based on a strong theoretical and knowledge-based point of view faced against the more practical work of engineers. Moreover, it is a really difficult task to explain in detail but in a few words, the domain where the research has been carried out, e.g., wastewater treatment plants in my case. From the environmental side it is needed that more tools are available to create knowledge bases that could be shared with other researchers or reused in several applications.

That is why the significant participation, in BESAI, of chemical engineers and researchers from related fields far from AI was so surprising and positive, considering that the workshop was included as part of the main global European Conference in Artificial Intelligence (ECAI'98). This presence was also reflected in the organising committee of BESAI (with four environmental engineers and only two AI researchers) and

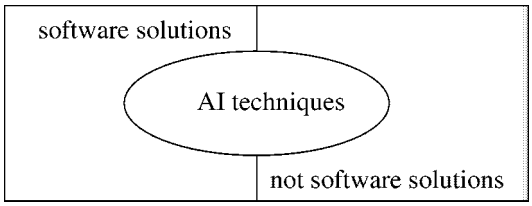

Fig. 1. AI techniques and software for environment.

in the list of contributors with almost half of the authors being environmental or chemical engineers.

We should try to think about the reasons why environmental engineers, given the choice, prefer to defend their automatic management contributions in AI congresses, instead of presenting their work in specific forums related to their field. Though specific topics can be presented there, such as advanced control and process automation, environmental management practitioners require quick, easy, and autonomous solutions based on mathematical algorithms and complicated models which reproduce in detail the behavior of the process. Advanced AI techniques are not widely accepted into this context, basically due to the lack of understanding of the tools. In my particular opinion, the main reason of this lack of understanding could be due to the particular nomenclature used in AI field, where, e.g., variables are named attributes, or process is named domain. Considering our outstanding position, it must be our effort to explain clearly the steps that have been followed to develop the approach, trying to obtain a consensus between the nomenclature used in both fields.

As final balance of the workshop, we consider the workshop as a good starting point to encourage environmental engineers and AI practitioners to join together in research projects. The results of this work must be reflected in future similar workshops organised both in AI and specific environmental domain conferences.

3. Artificial Intelligence point of view

In this section we present a double analysis of the AI approach to environmental domains. On the one hand, we discuss some of the ideas about the adequacy of AI techniques for environmental applications which appeared in the BESAI workshop, and on the other hand an overview on how I perceive the interaction between environmental processes and AI methodologies.

A broad study of the environmental sciences divides the problems they deal with into three groups: those which do not require the contribution of software as mechanical or chemical processes; those which require a traditional software contribution by means of a software engineering approach which integrates databases, concurrency, real time, monitoring, graphics, etc.; and those which require some AI technique. Figure 1 shows our interpretation about the above division. The BESAI workshop was an interesting rendezvous between environment scientists and AI engineers that brought to light some of the current AI boundaries in Fig. 1 and gave some ideas about how to extend them. Whereas the traditional software defends an *ad hoc* solution to the problem which can be achieved either by direct programming or by using some intermediate case tool as TRACE [19], the AI software is worried about separating the knowledge involved in the problem from the actuation required. So, many efforts are devoted to modelling and identifying the environment domains with rule bases [6,20], case bases [16,21,26], qualitative models [18], artificial neural networks and soft computing [3,4], transition networks [11], semantic nets [22], fuzzy sets, etc. As far as the actuation over the environmental process is concerned, the BESAI workshop showed that supervision, prediction, planning and improving the social effects (e.g., odor and noise reduction, flora and fauna preservation, ecological factory processing, etc.) are some of the main intersections between the Environmental and the AI communities.

The boundaries of the AI solutions to Environmental, Ecological and Biological (EEB) problems can be extended by considering the kind of difficulties to which AI techniques are used to and whether these difficulties are usual in the EEB systems: data difficulties (e.g., complex, sensitive, incomplete, imprecise, and variable information, the amount of data in sensor-based systems, etc.) and unreal situations (e.g., predictions, plans, simulations, etc.). In this framework, I observe that AI can be situated in a two dimensional space defined by the autonomy degree axis and the application domain axis. Up to now, AI-EEB systems have been closed in a zone of the above space that is limited to supervision and recommendation tasks (autonomy degree) in specific fields like biology preservation, water treatment, waste processing, meteorology or forest management (application domains). These applications have been developed under a specific perspective [3,4,16,22] or by means of general purpose tools as Environmental Decision Support Systems (EDSS) [19] or Intelligent-System shells as G2 [2] or DAI-DEPUR [21].

The future of AI-EEB systems which can be drawn from the BESAI workshop is that on the one hand, AI systems will acquire more relevance in assessment, control and decision making tasks (autonomy degree) and on the other hand, the application fields will be extended to consider new aspects of ecology [14] as considering the replacement of a polluting manufacturing process with a cleaner one, recycling and reusing, or legislation automatic assessment (application domains).

4. Conclusions

Among the key points in the application of AI techniques to real problems in this area relies on the knowledge-based facilities that they provide to accelerate the problem identification. Today, Knowledge-Based Systems are used as a solid basis for a better decision for action in many real applications.

The main objectives among the attendees were to develop the knowledge and technologies needed for the rational management of natural resources; to improve the scientific base, methodologies and decision support tool to provide better understanding of the functioning of ecosystems and allow integrated management and sustainable use of natural resources; to develop intelligent support decision systems, including evaluation and validation of intelligent tools for the fast assessing of natural and technological hazards.

One of the main conclusions of BESAI was to recognize that the number of applications of AI-based systems is increasing very rapidly and this is not only restricted to traditional hardware controlling devices. Despite of this positive impression AI applications to environmental problems still lower in comparison with the presence of AI systems in other fields as medicine or manufacturing.

Since the arrival of the Internet, the possibility of interconnecting machines and sensors is enabling the distribution of the computation, opening new and cheap and more rational ways to effectively solve problems [2]. Using Internet and/or Intranets, the accesses to stored information becomes easier allowing controlling the effects of actions and solutions in a better way; also the time to reach and to authorise decisions will decrease as pointed out by El-Swaify and Yakowitz in [9].

A selection of the BESAI papers was included in a special issue on *Environmental Modelling & Software* [7]. We hope that ECAI will host new editions of this workshop and that the number of papers will increase.

References

[1] N.M. Avouris, Co-operating knowledge-based systems for environmental decision-support, *Knowledge-Based Systems* **8**(1) (1995), 39–53.

[2] J. Baeza, D. Gabriel and J. Lafuente, An expert supervisory system for a pilot WWTP, in: *BESAI'98*, 1998, pp. 31–35.

[3] L. Belanche, J. Valdés, J. Comas, I. R-Roda and M. Poch, Modelling the input-output behaviour of WWTP with soft-computing techniques, in: *BESAI'98*, 1998, pp. 91–105.

[4] A. Bockreis and J. Jager, Odour monitoring by the combination of sensors and neural networks, in: *BESAI'98*, 1998, pp. 76–90.

[5] K. Branting, J.D. Hastings and J.A. Lockwood, CARMA: a pest management advisory system, *AI Applications* **11**(1) (1997), 29–48.

[6] O. Cabezut-Boo and A. Sánchez-Aguilar, Towards an ontology of wastewater treatment. The identification phase, in: *BESAI'98*, 1998, pp. 16–30.

[7] U. Cortés and M. Sànchez-Marrè, Binding environmental sciences and artificial intelligence in environmental modelling and software, *Environmental Modelling and Software* **14**(5) (1999), 335–337.

[8] U. Cortés and M. Sànchez-Marrè, eds, Workshop Binding Environmental Sciences and Artificial Intelligence (BESAI'98), *European Conference on Artificial Intelligence (ECAI'98)*, Workshop Notes, 1998.

[9] S.A. El-Swaify and D.S. Yakowitz, eds, *Multiple Objective Decision Making for Land, Water, and Environmental Management*, Lewis Publishers, 1998.

[10] I.G. Haagsma and R.D. Johanns, Decision support systems: An integrated approach, in: *Environmental Systems*, Vol. II, P. Zannetti, ed., 1994, pp. 205–212.

[11] J.M. Gimeno, J.M. Béjar, U. Sànchez-Marrè, U. Cortés and I. R-Roda, Modelling WWTP dynamics by means of transition networks, in: *BESAI'98*, 1998, pp. 121–135.

[12] G. Guariso and B. Page, eds, *Computers Support for Environmental Impact Assessment*, IFIP, North-Holland, 1994. ISBN 0-444-81838-3.

[13] G. Guariso and H. Werthner, eds, *Environmental Decision Support Systems*, Ellis Horwood-Wiley, 1989. ISBN 0-77458-0255-9.

[14] J. Hart, I., Hunt and V. Shankararaman, Environmental Management Systems – a role for AI?, in: *Workshop Binding Environmental Sciences and Artificial Intelligence (BESAI'98)*, U. Cortés and M. Sànchez-Marr, eds, 1998, pp. 1–15.

[15] http://www.cordis.lu/fp5/home.html.

[16] J.P.M. King, R. Bañares-Alcántara and Z. Manan, Minimising environmental impact using CBR: an azeotropic distillation case study, in: *BESAI'98*, 1998, pp. 106–120.

[17] C. Mason, ed., Workshop on Artificial Intelligence and the Environment, IJCAI-95 Workshop Program Working Notes, 1995.

[18] L. Mora-López and R. Conejo, Qualitative reasoning moel for the prediction of climatic data, in: *BESAI'98*, 1998, pp. 61–75.

[19] R. Paggio, G. Agre, C. Dichev, G. Umman and T. Rozman, TRACE: A development platform for environmental decision support systems, in: *BESAI'98*, 1998, pp. 166–180.

[20] D. Riaño, Learning rules within a framework of environmental sciences, in: *BESAI'98*, 1998, pp. 151–165.

[21] M. Sànchez-Marrè, U., Cortés, I. R-Roda and M. Poch, Case learning through a similarity measure for continuous domains, in: *BESAI'98*, 1998, pp. 46–60.

[22] L. Sazonova and G. Osipov, Intelligent system for fish stock prediction and allowable catch evaluation, in: *BESAI'98*, 1998, pp. 181–196.

[23] A. Shepherd and L. Ortolano, Water-supply system operations: Critiquing expert-system approach, *J. of Water Resources Planning and Management* **122**(5) (1996), 348–355.

[24] D. Sriram and R. Adey, eds, *Applications of Artificial Intelligence in Engineering Problems*, Springer-Verlag, 1986. ISBN 0-905451-47-3.

[25] G. Stephanopoulos and C. Han, Intelligent Systems in process engineering: a review, *Comp. Chem. Enging.* **20**(6–7) (1996), 743–791.

[26] F. Verdenius and J. Broeze, Generalised and instance-specific modelling for biological systems, in: *BESAI'98*, 1998, pp. 136–150.

[27] J.L. Wilson, K. Mikroudis and H.Y. Fang, GEOTOX: A knowledge-based system for hazardous site evaluation, in: *Applications of Artificial Intelligence in Engineering Problems*, D. Sriram and R. Adey, eds, 1986, pp. 661–671.

[28] J. Wright, L. Wiggins, R. Jain and T. John Kim, eds, *Expert Systems in Environmental Planning*, Springer-Verlag, 1993. ISBN 3-540-56063-7.

[29] C.T. Yang and J.J. Kao, An expert-system for selecting and sequencing wastewater treatment processes, *Water Science and Technology* **34**(3–4) (1996), 347–353.

[30] P. Zannetti, ed., *Environmental Systems, Vol. II. Computer Techniques in Environmental Studies V*, Computational Mechanics Publications, 1994. ISBN 1-85312-272-6.