

ARTIFICIAL INTELLIGENCE IN WESTERN EUROPE

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Addendum

ITALY

Our account of A.I. research in Italy covers work at the following major centers :

- Milan Polytechnic Artificial Intelligence Project (MP-AI Project) of the Istituto di Elettrotecnica ed Elettrotecnica, Politecnico di Milano, Milan (Director: M. Somalvico).
- Non-Numerical Information Processing Section of the Istituto di Elaborazione dell'Informazione del CNR , Pisa (Director : U. Montanari).
- Speech Understanding Group of the Centro per l'Elaborazione Numerale dei Segnali del CNR, Politecnico di Torino, Turin (director: R. De Mori).
- Artificial Intelligence Group of the Laboratorio per la Dinamica dei Sistemi e per l'Elettronica Biologica del CNR, Padua (Director: E. Pagello).

- 1. Milan.

In November 1971 Marco Somalvico has formed the Milan Polytechnic Artificial Intelligence Project (MP-AI Project) as a research project at the Laboratorio di Calcolatori of the Istituto di Elettrotecnica ed Elettronica of the Politecnico di Milano.

Its research activity has been based on the assumption that Artificial Intelligence is that discipline, within Computer Science, which studies the theoretical foundations, the main methodologies, the design and the construction of programs which allow the computer to operate mechanisms and to perform activities that are usually considered as exclusive of human intelligence.

We can examine, in the sequel, the main research directions which have been followed at the MP-AI Project [1].

A. Theory of Problem Solving.

The process of representing a problem in-

volves necessarily a passage between two different worlds, namely the world of the intuitive notion that the man has of the problem, and the world of the formal and precise description of the problem, that will be given to the computer.

This passage is achieved by means of an appropriate selection of only one part of the information which is pertinent to the intuitive knowledge of the problem; the selected information is then arranged in a structured form, thus yielding the representation of the problem.

However, even the most structured and rich representation, which might be obtained within this passage, will always present a difference from the informal knowledge about the problem.

This distance, which reminds the similar gap between physical phenomenon and physical law, can only be narrowed, but can never be wholly deleted.

The previous considerations have been the basic motivations for the development of a "theory of problem-solving" devoted to the understanding of the different aspects of the problem-solving process, and centered around the focal point of problem representation.

This theory of problem-solving, which is being developed at the MP-AI Project, is intended to achieve the following goals:

- formalization of problem representation methods [2,5,8];
- formalization of solution search techniques [3];
- formalization and selection of "good" problem representations [6];
- automatic evaluation and use of heuristic information [4, 10];
- generalization and operation of learning processes [7];
- structured organization of a problem in subproblems as a basis of automatic programming [9];
- design of a general structure for a problem solver [11].

The future research directions will be the theoretically guided

design and experimentation of a problem solver based on the obtained results.

B. Languages for Artificial Intelligence.

On the UNIVAC 1108 computer of the MP-AI Project, have been implemented, and experimented, the following interpreters: LISP, MICROPLANNER, PROLOG, MAGMALISP, REDUCE.

These interpreters have been utilized as tools for designing AI systems in problem solving, robot plan formation, natural language understanding, automatic deduction.

In particular, the characteristics and limitations of MICROPLANNER and PROLOG have been examined in detail.

Studies and a comparison between the procedural embedding and the axiomatic approaches to knowledge representation have been carried on [12, 13].

C. Robot Plan Formation.

The research activity which has been performed, has been devoted to utilize MICROPLANNER and FIRST ORDER PREDICATE CALCULUS as representation languages devoted to in plan formation [14,15,16,17].

Also, an algebraic theory of plan formation has been developed and two systems, written in LISP, have been developed [18].

In particular, the following results have been obtained:

- Formalization of environment representation;
- Formalization of robot manipulating activities (plans, actions);
- Development of a system for checking the correctness of plans;
- Development of a system for the optimization of plans;
- Development of a system for plan formation, of means-end type;
- Development of a system for plan formation, based on partial ordering of actions.

D. Role of Classical and Non-Classical Logic.

The PROLOG language has been experimented in application to robotics.

The limitations on the present day relational programming languages, have been considered, mainly in the adoption of search strategies.

When FIRST ORDER PREDICATE LOGIC is utilized as a programming language, it is

essential not only the possibility of proving a theorem but also the technique followed within the proof.

The logic programming language has been arranged in two levels, both using predicates.

Thus, the program becomes a couple, i.e. representation program and control program.

Interesting research results, have been obtained, mainly in the semantic domain of robotics, and in using temporal features in logic [19, 20, 21, 22].

E. Natural Language Understanding.

A quite large system, the DONAU (Domain Oriented Natural language Understanding) system has been developed for understanding Italian.

A first version of DONAU has been developed and tested, with success, in the semantic domain of robotics.

DONAU is written in LISP and MICROPLANNER and is based on the previous work done by the Artificial Intelligence Group of the University of Grenoble, France (director G. Veillon, with J.C. Latombe, A. Lux) in developing the PIAF system for the syntactic, morphologic, and phonetic analysis of French and Italian.

A joint research program on PIAF and DONAU has been developed and financially supported, between Milan and Grenoble.

The semantic analysis of the Italian input sentences is based on a discrimination net.

The extraction of operative information and the control of legality are part of the modular architecture of DONAU [23,24,25,26].

Also first studies in the semantic domain of data-bases have been developed [27,28].

F. Robotics.

In the Laboratory of Robotics of the MP-AI Project, a two arms, two light sensors, six force sensors, six degrees of freedom robot, the SUPERSIGMA robot, is now operating.

Its main tasks are devoted to the assembly of complex mechanical systems.

The SUPERSIGMA architecture is composed of eight NATIONAL SC/MP microcomputers, one LABEN 70 minicomputer; it will be eventually connected to the UNIVAC 1108 computer.

The research activity in this field has been devoted to the following goals :

- emergency recovery problem: the problem solving techniques have been applied to automatically solve the problem of recovering from the interruption of the execution of the normal assembly algorithm, when defective component parts are encountered [29, 30];
- assembly language: the MAL (Multipurpose Assembly Language) language has been developed for enabling the mechanical designer to describe the assembly algorithm; the MAL translator can execute either the source program (the deterministic assembly algorithm) or the output of a simple plan formation program which receives, as input, the SUPERSIGMA task representation;
- multimicrocomputer architecture: the use of eight microcomputer enables the conception of the whole SUPERSIGMA robot as a special computer (and not as a computer connected to the mechanical structure). This special computer has a set of machine instructions which is composed by the classical machine instructions of the LABEN 70 minicomputer augmented of new machine instructions (e.g., MOVE Δx_1 , GRASP, etc.). Such new machine instructions correspond to the problems whose solution algorithms are programmed in each microcomputer [31, 32, 33].
- manipulating of concurrent tasks: both the SUPERSIGMA architecture (with the parallel activity of the eight microcomputers) and the MAL design (with the execution of concurrent processes controlled by a circular precedence scheduler) enable the execution of concurrent manipulating activities; the efficiency increase in the execution of task in the goal of the present research activity [34];
- social and economic implication of robotics: the organization of work in the factory assembly lines is going to be greatly influenced by the advent of robots; these research problems are presently investigated [35, 36].

- 2. PISA .

This research group has been formed since 1971 by Ugo Montanari and has developed a great deal of theoretical and experimental research in A.I.

A. Problem Solving.

The chromosome matching has been considered as a target for investigating the efficiency of the Hart-Nilsson-Raphael algorithm; new properties of this algorithm have been introduced.

The foundations of dynamic programming and the relationships with heuristic search methods have been investigated by showing that the AND/OR graph is a general model of dynamic programming and that each dynamic programming problem can be reduced to the problem of finding an optimal solution tree in an AND/OR graph [38,39,40].

In particular, a heuristic search algorithm has been presented, which combines the advantages of dynamic programming, i.e., the identification of common subproblems, with the advantages of branch-and-bound, i.e., the use of heuristic estimate to speed up the search [41].

The study of deriving, from a decision table, a decision tree which is optimal in same sense, has been recently investigated.

In particular, the minimization of the average execution time has been obtained by utilizing heuristic information [42].

The generalization of AND/OR graphs has been investigated, and the relationship with grammars has been introduced [43].

B. Theorem Proving.

In the line of Kowalsky, the logic formalisms have been considered as programming languages, the proof checkers as interpreters.

Thus a powerful logic formalism and an efficient proof checker can allow to prove manually theorems whose automatic proof would be otherwise very far from the state of the art.

A new type of efficient unification algorithm has been designed [44].

More recently this unification algorithm has been merged with Boyer and Moore's technique for storing shared structures in resolution based proof checkers [45].

C. Languages for Artificial Intelligence.

A new version of LISP, MAGMALISP has been developed by Montanero, Pacini, and Turini in the last years.

The characteristic of its interpreter enables the availability of powerful primitive

ves useful for developing, within MAGMA-LISP, non-deterministic languages.

One of such languages, ND-LISP, has been proposed and implemented.

Levi and Sirovich have developed a pattern matching language and a discrimination network for efficient pattern matching.

This tools are available on an IBM 370 computer, together with INTERLISP.

The application to automatic and interactive program verifiers is currently being investigated.

- 3. TURIN.

Research activity in Speech Understanding has been carried on since 1971 [46].

The use of syntactic methods for automatically interpreting speech pattern, has been investigated.

The utility of such method is sustained because most of the phonetic knowledge of a language is available in terms of descriptions of spectral patterns or linguistic events [47].

The problem of representing and using such knowledge in a digital computer has been studied.

The details of the implementation of a syntax controlled acoustic encoder of a speech understanding system (SUS) have been discussed.

Moreover, the learning capability in the SUS system has been developed

Present research activity is devoted to choose a semantic domain, e.g., robotics, in which the application of the SUS is practicable.

- 4. PADUA

Since 1974, Enrico Pagello is developing a new group devoted to A.I. researches.

LISP, PROLOG, and REDUCE constitute the available languages for experimental activity.

The main research work is devoted to theoretical investigations on the role of logic in A.I.

In particular, the main research direction is constituted by the use of logic

as a programming language for describing both the problem and the control representation to a robot plan formation system [20, 21, 22].

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