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Survey Paper

Survey of Hungarian KBS Tools and Applications in the Engineering Field

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This paper provides a survey of AI activity in Hungary, relevant to engineering applications, up to the beginning of the 90s. Firstly, the main characteristics of the KBS market phases and the directions of AI research are summarized. Then the background of national AI activity is outlined, followed by an overview of the development of logic programming products in Hungary and of research results. Next, a list of the better-known national KBS projects relevant to engineering applications and a short overview of the present results of national KBS R&D activities, are shown. Finally, three Hungarian horizontal products and some other PC shells used in Hungary are compared. Lack of space does not permit a mention of all the results and all of the institutions doing pioneer work in this subject. A reference list concerning the KBS research activities in Hungary is currently being compiled. This paper is based on a general-purpose overview prepared for the second Hungarian AI conference (Budapest, January 1991).[1]

Keywords: Artificial intelligence (AI), knowledge based system (KBS), expert system (ES), logic programming, Prolog, problem solving, engineering applications, KBS R&D, ALL-EX Plus, GENESYS, MProlog shell.

THE KBS MARKET AND AI RESEARCH

The KBS (Knowledge-Based System) market shows the following three phases of development:

> *Phase 1 (1983–85):* research in the "new", knowledge-based technology (general-purpose, "horizontal" Lisp-based tools for mainframes made by the "Gang of Four": KEE, S1, KC and ART).
> *Phase 2 (1986–88):* the new technology is appearing in the market (tools for mid-size computers and PCs, the end of the "Features wars", the "Big 8" U.S.-based consulting firms; "AI winter").
> *Phase 3 (1989–):* integration of conventional and knowledge-based technology (application-oriented i.e. "vertical" tools, integrated applications, demand for suitable integrated development methods).

A "technology-driven", prototype-centered system development approach is characteristic of the 2nd phase: the search for suitable applications for a given (horizontal) shell or tool (kit). Most of the KBSs were exploratory prototypes and standalone systems, and very few of them (about 20) were completed and put into production. At the end of this phase, the market seemed to freeze.

A characteristic feature of the 3rd phase is that it is more natural and acceptable: a so-called "problem-driven", model-driven development approach is suggested. There is a powerful demand for flexible, integrated development technology (tools and methods). Real applications are coming on-line: not prototypes, not standalone systems but large, integrated multi-user systems.

The present main directions of AI (Artificial Intelligence) research aim at the foundations of the 3rd phase of the KBS market. These are:

- *integration* with conventional software engineering techniques and mainstream computing,
- *cross-fertilization and interaction* between the different parts of AI,
- concentration on *developing a bridge* between research and the commercial marketplace,
- development of application-specific, *vertical* tools (besides or instead of the earlier horizontal tools).

Consequently, in the future it will be characteristic to

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develop intelligent integrated systems and apply intelligent integrated technology (tools and methods) to support the development.

AI IN THE HUNGARIAN CONTEXT

Before getting aquainted with the Hungarian situation, one has to remember the author's late professor László Kalmár from Szeged University (Hungary) who—in the mid-50s—designed a machine[2,3] which could be programmed in a mathematical formula language. With this and his logic machine built in the U.S.S.R., he was a forerunner of AI's aim: an information-technology revolution. Thereafter the country came into the limelight again in 1975 when the development of the Hungarian Prolog system started (see below). This was noteworthy also from an economic point of view; by 1988 more than 1500 MProlog systems were installed in 25 countries all over the world.

Today, the hardworking R&D teams in several fields of AI have achieved excellent results appreciated nationally and internationally in both the theoretical and the practical areas (and even in the market-place). Results in the mathematical bases of problem solving achieved by Hungarian researchers belonging to the national sources of logic programming—the "Németi school"[4,5] should be mentioned here. In Hungary there are significant results in the field of Knowledge-Based Systems, too, but—because of the national computer pool—these are mostly on PCs. The national KBS market is in the 2nd phase (having skipped the first one), although it has taken the first steps towards the 3rd one (e.g. products on intelligent, integrated engineering applications have been started, and vertical shells are being developed). Other special fields of AI are not dealt with here; it is only mentioned that significant research is being done into natural (Hungarian) language processing, speech generation/speech synthesis, image processing and robotics at several national institutes with results that are useful in practice; most of them are internationally acknowledged.

LOGIC PROGRAMMING IN HUNGARY

The first experiments in Prolog (PROgramming in LOGic) development in Hungary were supported not by theoretical but by (computational and applicational) practical resources. In 1975 the first Hungarian Prolog implementation[6]—in the Institute of Industrial Economy and Plant Organization of the Ministry of Heavy Industry (NIM IGÜSZI)*—was created. Several pioneer applications—mainly in the chemical and architectural fields— showed the specific features of logic programming.[7]

By the end of the 70s the Hungarian Prolog experts—in the first place on the grounds of their experience of applications—could already draft the demands for a Prolog system for solving real, practical problems. Following a requirement collection and specification phase, a new Prolog language and system were developed at SZKI between 1979 and 1982. This system was suitable for real practical problem-solving. It was called MProlog[8,9] because of its main characteristic: modularity. The same MProlog runs on PCs (e.g. IBM PC 286 and 386), workstations (e.g. SUN and VAX) and mainframes (e.g. IBM and Siemens).

So when the need for such systems became apparent all over the world—due to the unexpected increase of Prolog's popularity—the Hungarian experts already had their own Prolog product, good for practical problem-solving. One of the most important features of MProlog, partly because of the above-mentioned modular structure, is that it can be efficiently tailored to application fields. One of the remarkable successes (using this modularity) is an extension called TProlog.[10] This language can be used for high-level simulation, and was also developed by SZKI. Several extensions, such as three-dimensional graphics, window and menu operation and the MProlog toolkit (see later) and an object-oriented extension, FAIR,[11] were developed at SZKI Intelligent Software Co. (IQSOFT) to support various applications.

IQSOFT joined a major international project, aimed at exploring the possibilities of efficient implementation and application of logic programming on parallel computers; this is the Gigalips Project,[12] initiated by the Argonne National Laboratory, the University of Bristol and the Swedish Institute of Computer Science.

During 1986–90 MULTILOGIC Computing Ltd developed a Prolog interpreter and compiler called CS-Prolog (Communicating Sequential PROLOG)[13,14] running in mono- and multiprocessor environments (MS DOS, OS/2, UNIX, VMS and T414/T800 Transputer network). The main distinctive features of CS-Prolog are: dynamic process creation, process communication using messages, and complex distributed backtracking. In 1988–90 a Prolog-like object-oriented preprocessor called CSO-PROLOG[15] was developed for CS-PROLOG, also at MULTILOGIC.

Another language for logic programming, LOBO[16–18] was developed in the Applied Logic Laboratory Computer Technical R&D Co-operative (ALL)—connected to their theoretical activity (see below).

THEORETICAL QUESTIONS OF PROBLEM-SOLVING

At the beginning of the 70s young researchers in the MTA's institutes, e.g. in the Central Research Institute for Physics (MTA KFKI), NIM IGÜSZI (now SENSOR, Management Consulting Co.), SZÁMALK

* The English equivalents of the Hungarian institution name abbreviations used in the text are listed in Appendix A.

and the SZKI started intensive work in program verification, program synthesis and structural abstract specification methods. The researchers interested in theoretical problem-solving are now working at the Mathematical Institute of the Hungarian Academy of Sciences, SZÅMALK and ALL. (These people are the first ones who studied logic programming in Hungary.)

At the ALL, while developing logic tools for problem-solving, they worked on a general theory for logic programming. Based on this theory, the logic programming language, LOBO, was developed. LOBO is totally different from elements of the Prolog language family; its experimental implementation is ready. Additionally, a single constructive logic frame was outlined which was adapted for supporting both general and unique operation of logic programming. A situational logic theory of knowledge representation is under development. They are dealing with the logic principles of qualitative simulation and—cooperating with linguists and psychologists—with an original representation of tasks written in natural language that takes into account the stored data. Another promising subject is the automatic generation of logic specifications from program code.

Application research has been dealt with at a number of places. For example, an algebraic descriptive tool (a grammar) that can be used in construction designs has been developed at the Hungarian Institute of Building Science. These application research activities are continuing at BME. In the Computer and Automation Institute of the Hungarian Academy of Sciences (MTA SZTAKI) there is intensive work on a learning system promoting engineering technological process design. They have developed a model of multimedium presentation which guarantees the consistency of inner and outer presentation, and the joint use of different presentations. They have studied what makes the design systems more and more intelligent while communicating with the user (for other research see below).

In the institutes concerned with KBS tool development, researchers are also interested in the theoretical and methodological problems of knowledge acquisition (see below).

KNOWLEDGE-BASED SYSTEM PROJECTS IN HUNGARY

In Hungary, as in other countries, KBS developments were first started in the field of medicine. The first real applications also came from this area. Many hospitals, clinics, universities, and software houses took part in these projects.

In the following sections, a list of some of the better-known engineering-related projects in Hungary is given (with the names of institutions that took and/or are taking part in the development). Most of these projects are of the 2nd phase of the KBS market, but some of them show 3rd-phase characteristics. Many projects were cut after producing a prototype, while others have only recently started. Many projects were and are supported by the MTA or the OMFB. There are projects ordered by foreign firms, and others are carried out with foreign participation. The projects which are being worked on at the moment or the ones that have been utilized in some way (including as aids in education) have been marked with an asterisk (*).

Chemistry

—Prediction of chemical toxicity.* (CompuDrug.)
—Estimation of the hydrophobicity of compounds.*[19,20] (CompuDrug.)
—Estimation of the hazardous effects of organic chemical compounds on classes of living organisms.*[21] (CompuDrug.)
—Control of a fermentor factory.*[22] (CHINOIN Pharmaceutical Works, BME.)
—Consulting about choosing of statistical methods for evaluation of experimental results.*[23] (Institute for Drug Research.)
—Prediction of the chemical dissociational constants.*[24] (CompuDrug.)
—Identification of minerals.*[25] (MTA SZTAKI.)

Computing

—Remote diagnosis of a mainframe computer.*[26] (MTA KFKI.)
—Testing and specification of communication protocols.*[27,28] (MTA KFKI, IQSOFT.)
—Intelligent selection of data bases.*[29] (Central Statistical Office Computer Technical and Management Enterprise.)
—Configuring of Siemens computer systems (hw/sw). (Siemens AG—München, DANET—München, SZKI.)
—Design of fault-detecting tests for logical circuits.[30] (SZKI, MTA SZTAKI.)
—Mathematical programming model management.*[31] (MTA SZTAKI.)

Building industry

—Logic-based architectural design of multilevel appartment buildings.[32,33] (MTA SZTAKI.)
—Ceiling and hall construction, analysis and generation.*[34,35] (ÉTI, BME.)
—Consulting in the application of Hungarian building regulations.*[36] (ÉTI.)
—Geotechnical testing of damaged buildings.[37] (ÉTI, SZKI.)
—Aid for technical economic planning and design of building structures. (Institute for Building Economy and Organization, CNI Project Gostroy—Moscow.)
—Region management and management of council building sites. (1st District Council of Budapest, MULTILOGIC.)
—Integrated construction advising for building industry. (Computer and Software Co., SZÅMALK.)

Energy systems

—Noise diagnosis for early failure detection in nuclear power reactors.*,[38,39] (MTA SZTAKI, PAV, Csepel Steel Works.)
—Turbine-generator vibration diagnosis.*,[40] (VEIKI, SZÅMALK, PAV, Kalinyin Nuclear Power Plants—U.S.S.R.)
—Chemical diagnosis of the secondary steam-water cycle.*,[41] (BME, IQSOFT, PAV.)
—Complex failure analysis of power system networks.*,[42] (ERŐTERV, Hungarian Electricity Board.)
—Multi-purpose substation simulator shell and its applications.*,[43] (ERŐTERV, TITÅSZ—a local energy distributor.)
—Simulation of the dynamic interaction of the short circuit and the protection operation.* (VEIKI, ERŐTERV.)
—Design of optimal allocation of load between power plants. (Softline Technology OT—Finland, IMATRA VOIMA UY—Finland, SZKI.)

Other industrial applications

—Fixture design.[44] (MTA SZTAKI, BME.)
—Control of cement grinding processes.*,[45] (MTA SZTAKI, Central Research Institute for Silicate Industry, Cement Factory Hejôcsaba.)
—Advising on technical fitting work.* (BME.)
—Design support for a flexible manufacturing system.*,[46] (MTA SZTAKI, BME.)
—Intelligent CAD applications.*,[47,48] (MTA SZTAKI, BME.)
—Design and simulation of manufacturing cells.* (MTA SZTAKI, BME, MULTILOGIC.)
—Monitoring and diagnosis of pressing machines.* (BME.)
—Planning of quarterly schedules of plate mills. (INORGA-Kosice—Czechoslovakia, Kosice Iron Works—Czechoslovakia, SZKI.)
—Advising on flood emergencies. (Research Centre for Water Resources, SZÅMALK.)
—Advising on bauxite deposit exploration. (Hungarian Geological Survey Institute, SZÅMALK.)
—Advice for mechanical engineers on solving conceptual design problems.*,[49] (BME.)
—Supporting of strategic management decisions of companies. (SENSOR Management Consulting Co., SZKI.)

The systems listed above range widely from ones that solve complicated problems with a simple trial method, to KBSs explaining their complicated conclusions in natural language. About 30 systems are at the product level. More than 40 national institutes are engaged in KBS development and even more experts from a further 40 institutions are working on system building.

The composition of the Hungarian computer pool has led to a concentration of development in the micro category. Of course not all KBSs are built on Prolog; LISP, and traditional languages and technology also play an important role in the developments. A new trend has appeared in this field, which bases decisions on statistical pattern-recognition methods instead of/besides logic inferences.

KBS TECHNOLOGY—DEVELOPMENT AND RESEARCH IN HUNGARY

Work on KBS development tools was carried out in parallel with that on methodology, as well as with the application development. In this way the developers can also find answers for their application-methodological problems. As the first step, rule-based systems and tools were developed for building stand-alone KBSs on PCs. Now, though, the first versions(s) of tools are ready. These can also be integrated with other software components (e.g. data bases), sometimes used in networks.

An integrated tool, the MProlog Toolkit has been developed at IQSOFT (earlier the SZKI Theoretical Laboratory). Its aim is to provide services offering alternative solutions for KBS developers to create intelligent dialogues for building KBSs, giving effective and standardized interfaces to other software components, etc. The first Toolkit elements are the MProlog Dialogue (supporting intelligent dialogue), and the MProlog Shell (making it possible to build and execute MProlog programs as KBSs). Their PC 286 and 386 versions are also available on the international market. The first applications can be found in the medical, architectural, industrial and economic areas. The MProlog-SQL interface module kit helps to integrate MProlog-based KBSs to DBMSs; ORACLE and DB2 services can now be directly called from MProlog. A vertical MProlog-based shell, Z-EXPERT, supporting financial applications, is being developed, connecting to an Austrian project. The first implementation of an object-oriented hybrid language, FAIR,[11] has been completed; a vertical version, PRO-FAIR, is used as a network protocol specification language. Earlier there were attempts to connect MProlog programs with the image-processing services of SZKI. Further research activities at IQSOFT included parallel logic programming (as mentioned before) and relational knowledge bases.

A small-scale shell, named GENESYS was developed at SZÅMALK. This shell is used in building and executing special rule-based KBSs. It is also suitable for KBSs that can be operated in a LAN enviroment. The system building is supported by the GENESYS Environment. The first applications are in the medical, architectural, industrial, and financial areas. Experimental tools for knowledge acquisiton have also been developed: an implementation of RGA (Repertory Grid Analysis), realizaton of the ID3 learning algorithm, and a rule-generator named RULEGEN.

The ALL and MULTILOGIC developed the ALL-EX PC shell, which provides tools for handling uncertainty and also high-level simulation (with the help of an interface to CS-PROLOG). Applications to date are drawn from the medical, architectural, industrial, and economic areas.

MULTILOGIC's multiprocessor product, CS-PROLOG,[13,14] and object-oriented preprocessor, named CSO-PROLOG,[15] are suitable for creating and executing computational models requiring very high-level simulation. CS-PROLOG can be called from ALL-EX. A special tool has been produced for ALL-EX, to support an inductive type of knowledge acquisition. At MULTILOGIC a frame- and rule-based hybrid product named ALL-EX PLUS has been developed, with interfaces to dBase IV., CS-PROLOG and C. The first application area of ALL-EX PLUS (connected with CS-PROLOG) is in robotics.

An intelligent real-time industrial vertical shell, named REALEX was developed at the BME. Its prototype was written in LISP but it was later re-written in C. First applications are controlling a pressing machine, and controlling a fermentor factory. BME researchers also developed a simple rule-processing shell, called PANGEA, which is regularly used in handling engineering tasks. BME researchers cooperate with other institutes (MTA SZTAKI, PAV, etc.) on different topics in AI.

Several KBS research directions have been pursued at MTA SZTAKI. An intelligent "case-driven" shell-like tool called KAS-NES has been developed in connection with a medical application that has been on-going for some years. It can handle data related to cases (e.g. patients) as they develop over time. A qualitative modelling tool based on engineering knowledge and object-oriented principles is also under development. They also deal with research into certain tools and methods in human language communication between man and machine. Other research activity is aimed at investigating KBS techniques applicable in computer integrated manufacturing. The main directions of this research (initiated by the late professor József Hatvany) are: establishing a correspondence scheme between manufacturing problem domains and AI tools; combinations of KBS and operational research techniques for engineering purposes; application of KBSs with learning capabilities; investigation of new interaction techniques and strategies for CAD; development of advanced strategies for design and modular toolkits. Other (interdisciplinary) research topics are, e.g. the simulation and design of flexible manufacturing systems using KBS methods; the acquistion of general quality-assurance systems using AI methods; intelligent information systems: techniques for gaining knowledge from databases, automatic generation of information systems based on knowledge bases and implementation description; fault diagnostics based on fault-sensitive filtering supported by KBS procedures; mathematical programming systems using KBS techniques; and intelligent decision-support systems.

AI techniques in the traditional software technological environment are investigated at MTA KFKI. First results are an OPS5-ORACLE interface and an intelligent data dictionary. The goals of the research are to improve the present data- and process-modelling techniques, experiments on development techniques, and to carry out techniques for AI-based simulation. The research was based on the XRL hybrid shell which was implemented in cooperation with the Institute for Computer Sciences (Bucharest).

CompuDrug has developed a vertical tool named METABOLEXPERT which supports their chemical and medical-biological prediction KBSs. It helps to establish the unified conceptual system of the knowledge base through interviews with distant experts. An automatic rule generator was also developed for the purpose of system building.

Appendix B contains a comparison of the first Hungarian horizontal products (ALL-EX PLUS, GENESYS and MProlog Shell) with some small-scale foreign shells used in Hungary (ES/P Advisor, Level 5 Object, M.1 and Nexpert Object).

CONCLUSION

Strong relationships have been built up among Hungarian and foreign experts during the research work into the solution of theoretical and practical problems in AI. They have also started a team project on development. There are more and more joint ventures—involving foreign investment—for tool development and applications. Like everywhere else in the world, the two slogans are: interdisciplinarity and integration (see the 3rd phase of KBS market). The cooperation in some fields of AI can be seen in several of the above-mentioned national development projects. However, the most suitable equipment (e.g. mainframes, "big" shells) has not been available in Hungary for use by the talented researchers, experts and system builders, making efforts to produce both nationally and internationally acceptable results. There is a need for coordinated theoretical and methodological research. KBS applications can provide challenges to drive the AI (KBS) research forward, but results cannot be realized merely as side-effects of application projects. It would therefore be very useful to participate in more and more international projects of this kind.

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APPENDIX A

Abbreviations of the Names of Hungarian Institutions used in the paper:

ALL	:	ALL Computer Technical R + D Co-operative
BME	:	Technical University of Budapest
CompuDrug	:	CompuDrug Ltd; CompuDrug-U.S.A., Inc.
ELTE	:	Eötvös Lóránd University (Budapest)
ERÖTERV	:	Power Station & Network Engineering Co.
ÉTI	:	Hungarian Institute of Building Science
IQSOFT	:	IQSOFT—SZKI Intelligent Software Co. Ltd
MKKE	:	Economical University (Budapest)
MTA	:	Hungarian Academy of Sciences
MTA KFKI	:	Central Research Institute for Physics of Hungarian Academy of Sciences
MTA SZTAKI	:	Computer and Automation Institute of Hungarian Academy of Sciences
MULTILOGIC	:	MULTILOGIC Computing Ltd
MVMT	:	Hungarian Electricity Board
NIM IGÜSZI	:	Institute of Industrial Economy and Plant Organization of Ministry of Heavy Industry
NJSZT	:	John von Neumann Society for Computing Science
OMFB	:	National Committee for Technological Development
OTE	:	Postgradual Medical University (Budapest)
PAV	:	Paks Nuclear Power Plants
PSZI	:	Financial Data Centre
SOTE	:	Semmelweis Medical University (Budapest)
SZÁMALK	:	Computing Applications and Service Co.
SZKI	:	Computer Research and Innovation Center
VEIKI	:	Research Institute of Electrical Energy.

Appendix B overleaf

APPENDIX B

Comparison of some Small-Scale Shells with Hungarian Horizontal Ones

Tools vs features	ES/P Advisor	Level 5 Object	M.1	Nexpert Object	ALL-EX Plus	GENESYS	MProlog Shell
Problem characteristics							
KB representation	L, R	R, O	L, R	R, O	F, R	L, R	L, MP
solutions	M	M	M	M	U, M	M	U, M
certainty		X	X	(X)		X	
arithmetic	X	X	X	X	X	X	X
Rule firing							
forward		X	X	X	X	X	
backward	X	X	X	X	P	X	X
inductive					(X)		
End user interface							
screen	M	M, G	L	M, G	M	M	M
input	C	C	T	C	C, T	C	C
multiple- and/or uncertain answer	X	X	X	X	NK	X	X
interaction speed	M	F	M	F	M	F	M
Development environment							
KB editing	X	X	X	X	X	X	X
KB graphics		X		X	X	(X)	(X)
HOW & WHY	X	X	X	X	X	X	X
trace + debug	X	X	X	X	X	X	X
browsing			X	X	X	X	X
save cases	X	X	X	X	X	X	X
Systems interfaces							
embeddable	X	X		X		(X)	
DB hook		X	X	X	X	X	SQL
other languages	P	C	C, A	C	CS, C	P, C	MP, C, Pa
specialities	F	G		G	CS, G	KA	MP, LS, (F)
Sw considerations							
implementation language	P	C	(P), C	(A), C	CS, C	P, (C)	MP
compilation	X	X	X		(X)		
op. system	DOS	MS Window	DOS	DOS, UNIX	OS/2, T, (U)	DOS	DOS
Hardware requirements							
host	PC, V	PC, V	PC	M, PC, D, U	PC, V	PC, L	PC
min. memory (kb RAM)	128	2 Mega	192	512	640	640	640

KB representation	L:	logic-based
	MP:	logic-based (use the full MProlog)
	R:	rule-based
	F:	frame-based
	E:	example-based
	O:	object-oriented
solutions	M:	multiple U: unique
screen	M:	menu L: line-oriented
	G:	graphic
input	C:	choose T: type
multiple- and/or uncertain answer	NK:	"not known" is permitted
speed of interaction	M:	medium F: fast
DB hook	SQL:	full SQL interface
other language	P:	Prolog CS: CS-Prolog MP: MProlog
	Pa:	Pascal A: assembly C: C
specialities	F:	frame-based expansion is available
	G:	graphical end user interface
	CS:	interface to CS-PROLOG (simulation)
	KA:	knowledge acquisition tools (e.g. RGA) under development
	MP:	not interface to MProlog, but direct use of the full MProlog as KB language (with all MProlog interfaces)
	LS:	possibility of being large scale shell (porting based on MProlog porting)
implementation lang.	P:	Prolog CS: CS-Prolog MP: MProlog
	Pa:	Pascal A: assembly C: C
op. system	U:	UNIX
	T:	T414/T800 transputer
host	PC:	IBM PC 286 and 386 L: LAN
	V:	VAX D: DEC
	M:	Macintosh U: UNIX workstations.