Extended version of the source material prepared[1] in February for the ECCAI report *The Future of Intelligent Systems in Europe* and published in *Informatica* **20.** (234-242).

The State of the Art of Artificial Intelligence in Hungary in 1996

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The main objective of this paper is to give a short overview of Hungarian AI and thereby to encourage and enable international scientific cooperation. We try to provide readers with information on different aspects of AI in Hungary. As everyone knows the Hungarian economic life is under reconstruction now. Research labs, staff and fields of activity have undergone major changes during the last six years which makes it difficult to get an up to date picture. We attached an Appendix were the exact addresses of institutes mentioned in this overview are listed.[2] This overview is an extended version of [Sántáné-Tóth and Eiben, 1996].

It is hoped that – during the **ECAI'96**[3] – *the Hungarian AI Dictionary* and the *Hungarian AI Bibliography* (an on-line database and a reprint collection) will give a much more complete view of Hungarian AI than this present attempt. (By the time of ECAI'96 an other collection, the *Hungarian AI Software Catalogue* was planned, but the interest proved to be small.) I would like to thank all colleagues for giving information themselves and on their recent AI work and for helping me to prepare the above collections and this present overview.

PROLOGUE

Hungarian Artificial Intelligence has its roots in the mid-50s. When Professor László Kalmár from Szeged University (Hungary) who designed a machine which could be programmed in a mathematical formula language. With this and his logic machine built in the USSR, he was a forerunner of AI's aim: an information technology revolution – based on non-Neumann architecture. Thereafter the country came into the limelight again in 1975 when the development of the Hungarian Prolog system (MProlog: Modular Prolog) and its applications started –

[1] as an updated version of the short overview by Eiben, G. and Sántáné-Tóth, E., in *NVKI-Nieuwsbrief*, 9/5 (oktober 1992.), pp. 155-157 and 10/1 (februari 1993.), pp. 27-28.
[2] The addresses of the individuals are in the "European AI Directory" and the "Hungarian AI Directory" (available at secretariat of ECCAI and of NJSZT, respectively).
[3] 12th European Conference on Artificial Intelligence, 11-16 August 1996, Budapest, Hungary.

[Szeredi, 1975], [Sántáné-Tóth and Szeredi, 1982]. 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.

By the early 80's in Hungary there were a number of AI labs doing research and/or applications in knowledge based technology. The most important centers were the Computer and Automation Institute of the Hungarian Academy of Sciences (SZTAKI), the Central Research Institute for Physics of the Hungarian Academy of Sciences (KFKI), the Computer Research and Innovation Center (SZKI Theoretical Laboratory, later IQSOFT) and the Computing Applications and Service Co. (SZÁMALK).

AI ASSOCIATION

In Hungary it is the *John von Neumann Computer Society* (NJSZT) – founded in 1968 – that primarily takes care of distributing leading scientific results in computing, getting technical experience and disseminating computer culture. The Hungarian AI community was officially formed by creating *an Artificial Intelligence and Pattern Recognition Section (AI&PR Section)* within the NJSZT in 1976. Among the nearly 2000 NJSZT members there were about 80 taking part in the work of the AI&PR Section.

In 1979 the seminary series "Theoretical and practical problems in programming" was started under the auspices of AI&PR Section, SZKI and SZÁMALK. For six years it provided a high level weekly forum for those who were interested. For example, the lectures that methodically surveyed the Japanese 5th generation project were regularly attended by 100 people from about 70 national institutes for six months. Experts and researchers working on different fields of AI ran more and more forums, among others monthly/quarterly seminars within the NJSZT and outside it. After several years of coexistence it turned out that the groups interested in the topic of pattern recognition an in the other topics of AI were almost disjoint. As a result, in 1990, the *Artificial Intelligence Group* (AI Group) and an *Image Processing Group* (IP Group) were founded as two separate sections, being the legal successors of the AI&PR Section, within the NJSZT. Regular Hungarian AI meetings are the triannual Hungarian Workshop on Image Analysis and the three AI Conferences (see below). The AI Group organizes other regular activities, such as the quarterly AI-day featuring lectures on selected topics, e.g. "Applications of Expert Systems", "Cognitive Aspects of AI", "Intelligent Decision Support Systems" and "Neural Networks". In addition to these meetings there are occasional lecture-afternoons of invited (foreign) speakers of both AI and IP Groups.

There has been an expressive AI-activity in the frame of the *Section of Medical Informatics* of NJSZT, founded in 1968. The first separate interest group of a field close to AI was the *Hungarian Robotics Association* (HRA). The HRA was founded in 1985 having 40 affiliated

institutions and more then 300 individuals. Their objective now is to turn the association into a consortium formed by industrial companies, R&D institutions, individuals, universities and ministries having interests or duties regarding reconstructing the Hungarian economy.

In 1996 the number of Hungarian persons who are interested in AI is more than 200 – see the "Hungarian AI Directory" – though in the "European AI Directory" the number of Hungarian colleagues is only 160. The NJSZT is a member of IFIP (since 1969), IAPR (since 1982), ECCAI (since 1983), IMIA and EFMI (since 1986 and 1988).

AI NEWSLETTERS

There is no AI periodical in Hungary. Nevertheless, there are journals regularly reporting on AI developments, for instance *Információ-Elektronika* published a thematic series on 5g. project in 1983/84 (based on the above mentioned seminary series). After publishing the first national volume of studies on Expert Systems in 1988 [Gábor, 1988], this journal devoted a special issue to the state-of-the-art of the expert system field in Hungary [Koch and Sántáné-Tóth, 1990]. (Unfortunately, this journal and others have stopped.) From 1992 the national monthly computer magazine *ÚjALAPLAP* publishes popularizing AI-series. Other Hungarian journals often publish AI related papers, too.

AI MEETINGS

The first regular meetings of the field concerned image processing. The triennial Hungarian Workshop on Image Analysis was first held in 1985, while the last one (with about 70 participants) in 1991 [Chetverikov and Álló, 1991].

The first two-day seminar devoted specifically to Artificial Intelligence was held in Visegrád in 1989 yielding proceedings in English, containing 15 contributions, see [Fekete, 1989]. There were also 20 other lectures not included in the proceedings. The Second Conference on Artificial Intelligence was held in 1991 in Budapest. This time there were about 300 participants from almost all institutions having anything to do with AI. During the three-day conference 46 lectures were delivered and compiled in an English proceedings, see [Fekete and Koch, 1991]. Due to the use of Hungarian as official conference language lots of foreign participants were from neighboring countries. The topics referred to by the speakers, without giving a complete list, are: theory and applications of expert systems, knowledge representation and acquisition, reasoning techniques, natural language understanding, pattern recognition, decision support systems, logic programming (Prolog), learning, cognitive psychology and education of AI. The 3rd nationwide AI conference with the same topics was held in Budapest, in 1993, see [Koch, 1993].

Besides national AI gatherings there are regular Austrian-Hungarian Conferences, most of them touch on AI-related topics. For example, Intelligent Systems in 1991, see [György, 1991] – this conference was held in cooperation with the Slovak Cybernetic Society, as well.
Main international events in Hungary (mainly in Budapest) during the last four years were the 5th International Conference on Computer Analysis of Images and Patterns, (1992), the 10th International Conference on Logic Programming (ICLP'93), the 5th International Conference on Computer Analysis of Images and Patterns (CAIP'93), IFIP/IFAC International Working Conference on Knowledge Based Hybrid Systems in Engineering and Manufacturing (KNOWHSEM'93), the 8th Symposium on Microcomputer and Microprocessor Application (1994), the 1st and 2nd EURASIP International Workshop on Image – and Signal – Processing (1994, 1995) and the 12th European Conference on AI (ECAI'96).

RESEARCH

The Hungarian Academy of Sciences, the National Committee for Technological Development and other sources provide financial support for R&D activities. The research centers of today are more or less the offspring's of those being active in the early period of Hungarian AI, see e.g. the surveys [Sántáné-Tóth, 1991]. Some of them, however, became victims of the rationalization/privatization wave and ceased to exist, or operate with a reduced staff. Many of them are being reorganized, sometimes split into a number of new companies – and new researchers are entering the scene, too. Research labs, staff and fields of activity are currently undergoing major changes which makes it difficult to get, and maintain, an up-to-date picture.

AI research in Hungary is confined to small teams at academic institutions, universities and smaller firms. The following *illustrative list* contains *some better-known on-going research projects* (institution, identification of the project, reference). Most of them are associated with international efforts.

Applications of AI in Engineering

ALL: AI in pharmaceutical design, see [Fabrikantova et al, 1991]
BDMF: AI in the process planning, see [Horváth and Rudas, 1995]
BME: abstract theory of architectural design, see [Holnapy, 1994]
BME: AI in measurement science, see [Dobrowieczki et al, 1994]
KFKI MSZKI: ES for accelerator beam scheduling, see [Lewis et al, 1995]
KFKI MSZKI: AI in computer network protocol engineering, see [Dibuz, 1993]
ME: AI in material testing machines, logistics, see [Cselényi and Tóth, 1995]
ME: ES application at the optimum design of engineering, see [Jármai et al, 1995]
ME: ESs in mining engineering, see [Buoz et al, 1994]

SZTAKI: process planning with reasoning and optimization, see [Márkus and Váncza, 1994]
VEIKI: ESs in NPP vibration diagnostics, see [Bessenyei and Kiss, 1995]

Artificial Life

ALL: active tissues from active elements, see [Chinarov et al, 1995]
SZTAKI: grammar systems – a grammatical approach to distribution and cooperation, see [Csuhaj-Varjú et al, 1994]

Cognitive Science

ELTE: way of thinking – the limits of relational though and AI, see [Mérõ, 1990]

Epistemological Foundations

ALL: Aristotelian phenomenology of human mind, see [Balaban and Gergely, 1994]
SZTAKI: computer epistemology, see [Vámos, 1991]

Foundation of Computer Science

ALL: first-order logical foundation of computer science, see [Gergely and Úry, 1991]
ML Ltd. and ALL: logic based simulation, see [Futó and Gergely, 1990]

Genetic Algorithms

KFKI MSZKI: continuous restoration ES, see [Kádár and Mergl, 1996]

Inductive Logic Programming

RGAI: theory of inductive logic programming, see [Alexin et al, 1996]
RGAI: theory of revision, see [Horváth and Turán, 1996]

Knowledge Based Systems

ALL: knowledge generating systems, see [Finn et al, 1995]
BKE: compensation planning, benefit advisory system, see [Gábor and Murugesan, 1995]
BME: design methodology of ES-GDSS tools, see [Gelléri, 1996]
BME: methodologies for supporting the transfer from knowledge representation to ESs in the field of banking, see [Gelléri and Toma, 1996]
ITA: KBS development environment (PECADS project CP 7599), see [Molnár, 1996]
SZTAKI: mathematical programming ESs, see [Biró et al, 1992]

(Further ESs see above, in "Applications of AI in Engineering".)

Knowledge Representation

ALL: information models of knowledge, see [Gergely and Pereverzev-Orlov, 1990]

BME: modeling measurement problems with constraints, see [Tilly et al, 1994]

SOTE: representing and manipulating of medical knowledge, see [Deutsch et al, 1994]

SZTAKI: pattern representation of knowledge [Vámos, 1995]

Machine Learning

RGAI: mathematical and computational problems in the learning theory, see [Turán, 1993]

Multi Agent Systems

KFKI MSZKI: integrating intelligent systems into a cooperating community for electricity management, see [Varga et al, 1994]

Natural Language Processing

MorphoLogic: Glosser, Gramlex, Multex-East, Elsnet Goes East (EC projects), see [Prószéky, 1994]

RGAI: natural language interface based on attribute grammar, see [Alexin et al, 1990]

Neural Networks

BME: neural filters, neural network in dynamic system modeling, see [Duray et al, 1993]

ME: use of ANN for prediction of roll forces in hot rolling of steels, see [Farkas et al, 1996]

SZTAKI: analogical paradigm (the integration of neural network and logic based architecture), see [Roska and Chua, 1993]

SZTAKI: neuro-fuzzy approach to pattern recognition and control, see [Monostori, 1995]

Parallel Logic Programming

IQSOFT: CUBIQ – parallel logic programming, graphical tool set and knowledge base tools, see [Umann et al, 1996]

KFKI MSZKI: LOGFLOW – massively parallel Prolog machine, see [Kacsuk, 1994]

ML Ltd.: distributed real-time Prolog, see [Futó, 1993]

Reasoning with Uncertainty

ALL: plausible reasoning as a foundation of machine discovery, see [Finn et al, 1995]

BDMF: design of fuzzy controllers, see [Rudas et al, 1995]

BME: fuzzy reasoning and control, see [Kóczy, 1995]

ME: fuzzy reasoning in vague environment, see [Kovács and Kóczy, 1995]

Speech Understanding

BME: speech recognition systems, see [Gordos, 1992]

NYTI: multilingual text-to-speech converter, see [Olaszy et al, 1992]

Vision, Signal Understanding and Image Processing

SZTAKI: texture analysis and applications, see [Chetverikov, 1995]

The main tendency of these AI research in Hungary aims to develop theories and methodology for supporting the solution processes of complex, real life problems. In addition, several research groups at Hungarian universities and the Hungarian Academy of Sciences are involved in **basic research activities in mathematics and computer science related to AI-research**. It is hoped that results of these successful groups can help to widen the Hungarian AI-research activities in the near future.

Hungarian AI people may turn to two institutions maintaining national R&D databases services, so that their work and/or products get registered. *The National Technical Information Center and Library (OMIKK)* serves current data from their R&D databases: Hungarian R&D Information Systems, -Institutes, -Projects and -Expert (in Hungarian and in English, too). The databases of the *Institute of International Technology (NETI)* contain information about new products, R&D results and free R&D capacities; these are accessible trough NETI, foreign hosts and the missions of the Republic of Hungary (embassies or commercial offices). The services of both institutes are going to be available via Internet.

DEVELOPMENT

In Hungary there are significant development in almost all the fields of AI (see e.g. the "Hungarian AI Bibliography" – unfortunately, the "Hungarian AI Software Catalogue" was planned, but the interest proved to be small). In the following we confine to **KBS tools and applications**. Up until 1991 the national KBS shells and applications were *logic- and rule-based*, mostly on PCs. After the weakening of the COCOM restrictions and the appearance of multi-national computer companies, shells for workstations and mainframes supporting multiple paradigms became available. Since then projects on intelligent, integrated applications are running and *application oriented* shells are being developed. In the meanwhile hybrid shells like ART, KEE, Level5 Object and G2 have been introduced and are now in use in a number of sites.

Below we give a representative list of some well known *Hungarian made AI languages and KBS tools* (together with the developing institution).

AI language systems developed in Hungary:

CS-Prolog, Communication Sequential Prolog Professional (ML Ltd. and ALL)

Mprolog, Modular Prolog (IQSOFT, formerly Theoretical Lab. of SZKI)

(It was the first Hungarian-made AI tool in the international AI market. By 1988 more than 1500 MProlog systems were used in 25 countries.)

The first Hungarian general purpose KBS shells:

ALL-EX PLUS, a hybrid sell (ALL and ML Ltd.),

GENESYS, a rule based shell (SZÁMALK),

MProlog Shell, a Prolog based shell (IQSOFT).

Other, problem-oriented KBS tools:

CAPE, for supporting protocol analysis (KFKI MSZKI)

CASSANDRA, for problem-oriented simulation systems (KFKI MSZKI)

CreditExpert, for evaluating of loans in shop level, directed from the center (ARAMIS)

DINE, an intelligent group decision support system (GDSS) shell (SZTAKI)

KAS-NES, a case-driven shell, based on statistical pattern-recognition methods (SZTAKI)

METABOLEXPERT, an in-house toolkit for building chemical and medical-biological predictive KBSs (CompuDrug)

OPSQL, an intelligent (knowledge-based) data dictionary coupling OPS5 and ORACLE DBMS (KFKI MSZKI)

PANGEA, a simple rule-based shell for handling engineering tasks (BME)

ProjectExpert, for supporting the define and design phase of project building (ARAMIS)

REALEX, a real-time shell for industrial applications (BME)

TenderExpert, a toolkit for evaluation of competitive bidding (ARAMIS)

ZEXPERT, an Mprolog-based banking shell (IQSOFT).

In the 80's work on KBS development tools was carried out in parallel with that on methodology, as well as with the application development. Some better-known **Hungarian KBS application projects** between 1985-1991 (indicating the application areas and the number of projects): building industry: 7, chemistry: 10, computing: 6, energetics: 7, medicine and health service: 16 and other industrial projects: 11 (see [Sántáné-Tóth, 1991]). In 1991 there were about 30 systems are at product level. More than 40 national institutes were engaged in KBS development and even more experts from a further 40 institutions were working on system building. During the last 5 years new projects have been started to develop integrated AI applications, using both the above mentioned tools and object oriented languages. During the last years the activity in research, development and application areas are diminished.

USE

Current AI techniques are not widely used in Hungary yet. Some AI applications are in use but most of them are in experimental or prototype phases. However there are internationally successful Hungarian made tools. In the following we chose three of them.

Hungarian made AI products in the international market:

CS-Prolog Professional:

By 1996 more than 150 CS-Prolog systems are in use in 14 countries.

MorphoLogic tools, i.e. spelling and grammar checkers, hypenators, thesauri:

From 1993 tools have been licensed by Microsoft, Lotus and other international software companies. In 100.000 application tools are used in Hungary. After the Hungarian market, Polish, Roman and Bulgarian markets are planned.

Recognita Plus, the Hungarian made OCR product (Recognita):

By 1996 140.000 installations are all over the world. They has distributors in 28 countries. (The University of Nevada Las Vegas conducts an annual test of page-reading systems. One of the winners of the 1996 test is Recognita Plus OCR program.)

MorphoLogic is bridging gaps between academia and industry in Hungary. They are developing tools which support intelligent text analysis, free text search, database indexing and bilingual "morphological dictionaries" which may be used in machine-aided translation.

EDUCATION

Although some topics of AI appeared in Hungarian higher educational programs as part of already established subjects in the beginning of the 80's, it was not earlier than the middle of that decade when AI became taught as a stand-alone subject on its own right first at the Budapest University of Economic Sciences (BKE) and at the Kandó Polytechnic of Technology (KKMF). Presently a basic one semester course, mostly called introduction to Artificial Intelligence is typically a compulsory part of the first three years for students of all Technical Informatics and Computer Science programs taught at universities and polytechnics in Hungary.

Three examples of educational AI programs follow. The AI education has originated during the mid 80s at the *Eötvös Loránd University (ELTE), Department of General Computer Science*. The AI module, as a separate part of the informatics education, was established in 1988. The compulsory basic course, which takes two semesters, gives an introduction to the main techniques of knowledge representation and the searching or inference methods involved. After that the students can progress by obtaining credits from the following subjects: knowledge based

technology and expert systems, AI languages, (especially Prolog and its applications), robotics, cognitive science, etc. New subjects are continuously added to the present list. A new course is under development about pattern recognition and neural networks. From 1992/93 a three year postgraduate program has been launched.

The second example is the *Technical University of Budapest (BME),* which has a long standing tradition in teaching applied Artificial Intelligence and related subjects. *Dept. of Measurement and Instrument Engineering* (and occasionally *Dept. of Process Control* and *Dept. of Telematics*) for already more than 20 years teach under-graduate, graduate and post-graduate courses in AI. Obligatory Msc courses: intelligent measurement systems (AI methods in design complex engineering systems), application of AI (an AI survey with emphasis on how AI methods should be interpreted and evaluated from the point of view of their technical usage) and robotics and vision. Optional Msc courses: AI – state-of-the-art, symbolic signal processing, artificial neural networks, KBSs, ESs, soft computing methods. There is laboratory practice associated with almost every subject. Ph.D. courses: advances in AI (intelligent real-time systems, 2nd generation ESs, knowledge-level analysis, agent systems, etc.), fuzzy logic, artificial neural networks.

The third example *is Kandó Polytechnic of Technology (KKMF), Institute of Informatics.* A new model for teaching AI has been designed at the institute in which emphasis is placed on the following aspects of AI: any intelligent action has requires at least a minimal degree of capabilities of sensing, information processing capacity, knowledge, learning and reaction (signaling, moving ability). According to this model the compulsory subject titled introduction to AI addresses contains the following major areas: sensory systems, incremental intelligence, classic and new search methods, genetic algorithms, classic and fuzzy logic and their applications, artificial neural networks, pattern recognition and image processing, machine learning and robotics. Elective specialization module contains three main courses: theoretical basis of AI, digital image processing and artificial neural networks. Other supplementary elective courses: robotics, decision support systems, ESs, knowledge-based technology and intelligent computer applications.

The other universities and polytechnics offer a number of courses for 3 and 5 years students to broaden and/or deepen AI knowledge. It can be stated that AI education is now one of the most dynamically evolving fields in the Hungarian higher education.

FUNDING

The *Hungarian Academy of Sciences (MTA),* the *National Committee for Technological Development (OMFB), National Research Foundation of Hungary (OTKA)* and other sources have given financial support to R&D activities related to AI, too. In recent years the European

Community programs for cooperation with countries of Central Europe have provided funding for several AI-related R&D projects in Hungary.

IMPEDIMENTS

To characterize the present situation it can be said, that although potential users are beginning to recognize the advantages of AI technology, a lot of projects are delayed by lack of financial support or interest, or because of the reorganization of the Hungarian economic, financial and scientific life. Several systems are used in-house, where they were developed, never making it to the market. Fortunately, in many fields – e.g. in engineering and financial spheres –extensive work is done in the area of information systems. Implementing such systems on a wide scale forms a good base for the development of usable intelligent (AI) systems in the near future.

SUMMARY

The modernizing wave of the Hungarian economic system raised special demands towards information technology today. The emphasis lies on the construction of the basic information infrastructure (*National Information Strategy* is under elaboration). In 90's the conventional technologies are in the focus of interest in Hungary (reengineering, reorganizing early applications, building integrated information services, etc.). Parallel with the massive computerization the interest for AI techniques is growing. Incorporation of AI techniques in everyday software technology has already begun – in Hungary, too. There are a number of talented AI researches, experts and system builders with notable (national and foreign) experience. AI education is being set up and thereby an institutional way of knowledge transfer is being formed. The latest developments indicate that AI in Hungary has reached maturity concerning theoretical work as well as applications.

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BKE: Budapest University of Economic Sciences, Dept. of Information Systems
Fővám tér 8., H-1056 Budapest

BME: Technical University of Budapest *Műegyetem rkp. 3., H-1111 Budapest*

CompuDrug: CompuDrug Ltd. *Hollán E. u. 5., H-1136 Budapest*

ELTE: Eötvös Loránd University, Dept. of General Computer Sciences
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IQSOFT: IQSOFT Intelligent Software Co. Ltd.
Teleki B. u. 15-17., H-1142 Budapest

ITA: Information Technology Foundation of HAS[4]
P.O.B. 49., H-1525 Budapest

KFKI–MSZKI: KFKI Research Institute for Measurement and Computing Techniques
P.O.B. 49., H-1525 Budapest

KKMF: Kandó Polytechnic of Technology – Institute of Informatics
P.O.B. 112., H-1431 Budapest

ML Ltd.: ML Consulting and Computing Ltd. *Gyorskocsi u. 5-7., H-1011 Budapest*

MorphoLogic: MorphoLogic *Németvölgyi út 25., H-1126 Budapest*

ME: University of Miskolc *Egyetemváros, H-3515 Miskolc*

[4] HAS: Hungarian Academy of Sciences.

NYTI: Research Institute for Linguistics of HAS, Phonetic Laboratory
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NETI: Institute of International Technology *P.O.B. 570., H-1398 Budapest*

NJSZT: John von Neumann Computer Society *Báthori u. 16., H-1054 Budapest*

OMIKK: National Technical Information Center and Library
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