

# Initial Steps in Development of Computer Science in Macedonia and Pioneering Contribution to Human-Robot Interface using Signals Generated by a Human Head

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**Abstract** – This plenary keynote paper gives overview of the pioneering steps in the development of computer science in Macedonia between 1959 and 1988, period of the first 30 years. As part of it, the paper describes the worldwide pioneering results achieved in Macedonia. Emphasize is on Human-Robot Interface using signals generated by a human head.

**Keywords** – pioneering results, Computer Science in Macedonia

## I. INTRODUCTION

This paper represents a research work on the history of development of Computer Science in Macedonia from 1959 till 1988, the first thirty years period. The history can be presented in many ways and in this paper the measure of historical events are *pioneering steps*. The paper lists pioneering steps in development of Computer Science in Macedonia, and points out some of them which are worldwide pioneering results.

Many colleagues were directly contacted during the writing of this report; however the responsibility for this report is solely on the author. So it can be viewed as a personal view, although the author made every effort this report to be an objective presentation of the pioneering events of the development of Computer Sciences in Macedonia.

## II. 1959 -1967: PIONEERING STEPS BY PEOPLE FROM MACEDONIA, DONE OUTSIDE MACEDONIA

### A. 1959- People employed in nuclear energy research in institutes outside Macedonia

In the period 1959-1988 which is covered by this report, Macedonia was a state of the Yugoslavia federation. There were 6 states: Bosnia and Herzegovina, Croatia, Macedonia, Montenegro, Serbia, and Slovenia.

The development of science during 1950's placed significant importance on nuclear energy. At that time the principal institutes in Yugoslavia such as Vinca in Belgrade, Rudjer Boskovic in Zagreb, and Josef Stefan in Ljubljana

were engaged in support of nuclear energy research. People from Macedonia interested in advanced research and study were part of this effort. Most significant work was done by Aleksandar Hrisoho, who working together with Branko Soucek in Zagreb, wrote a paper about magnetic core memories in 1959 [1]. He received formal recognition for this work, the award "Nikola Tesla" [2]. He also worked on analog-to-digital conversion on which he wrote a paper [3], received a PhD [4], and was cited [5]. So it can be said that authors from Macedonia in early 1960's already achieved PhD and citation for work related to computer sciences. Their work was in languages other than Macedonian because they worked outside Macedonia.

### B. 1961-1967: People from Macedonia visiting programming courses outside Macedonia

During 1950's and 1960's there was advancement in computer architecture worldwide and European industry was part of it. First computers appeared which were programmed in machine language and in initial form of assembler language. People from Macedonia took part in participating in seminars and courses in computer programming. In 1961 Dimitar Bitrakov followed the course on machine language programming in Ljubljana. In 1964 he followed another course in Belgrade, on machine language named Autocode III. Both used European computers as models of computer architecture. Other Macedonian scientist following the courses offered on programming at that time was Dimitra Karcicka.

## III. 1968: START OF COMPUTER SCIENCE IN MACEDONIA

### A. 1964- 1968: Start of Computer Science in Macedonia

The event which influenced development of Computer Science in Macedonia happened in Soviet Union, where in 1964 Glushkov published a computer science book named Introduction to Cybernetics [6]. It was translated into English in 1966 [7] and in Serbian in 1967 [8]. Here is a list of the book chapters:

Ch1. Abstract theory of algorithms; Ch2. Boolean functions and propositional calculus; Ch3. Automata theory; Ch4. Self-organizing systems; Ch5. Electronic digital computers and programming; Ch6. The predicate calculus and the automation of the processes of scientific discovery.

As can be seen that was actually an advanced book in Computer Science and Artificial Intelligence. The most

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advanced chapter was Chapter 4, on self-organizing systems where Glushkov presented theory of neural networks, pattern recognition, and learning in perceptrons.

In 1967 that book appeared at a Book Fair in Skopje, at two people relevant for this story bought it. One was Dr Georgi Cupona, who was one of the initiators for establishment of Mathematical Institute with Numeric Center (MINC) in 1966, the first institution in Macedonia which in its title has computational aspects of mathematics. The second person, independently, was the author of this paper, at that time a high school student. Professor Cupona immediately recognized the importance of the book. First he suggested to his spouse Gorica Ilieva, to propose to the author of this text to work on the third chapter of the book (Automata Theory), as a high school maturation research project. Being a regular participant in mathematics competition in Macedonia and Yugoslavia, the author of this text was known to Dr. Cupona. In the beginning of 1968, Cupona decided that this book will be basis of a seminar, named Seminar on Cybernetics organized by MINC. Nine lectures were assigned to university professors from Mathematics, Biology, and technical departments. The tenth lecture, on abstract automata, Cupona assigned to the author of this text. At that time no university professor was working on abstract automata. So in May 1968, the author of this text delivered the first lecture on Abstract Automata, in front of university professors and other interested audience, and also wrote, with help of Dr Cupona, the first paper on Computer Science written in Macedonian language [9][10]. This event can be recognized as *a starting point in development of Computer Science in Macedonia*.

#### *B. 1965 – 1967: IBM and the first computer in Macedonia*

In 1965 IBM started production of its “scientific minicomputer” IBM 1130. With a price tag of \$30,000-40,000 IBM started a marketing offensive to offer that computer to United Nations and governments of many countries. Through the United Nations aid for Skopje 1963 earthquake, the first IBM 1130 was installed in Macedonia in 1967. The configuration contained magnetic core memory of 8K (16 bit words) with 512K disk space. Operating system was Disk Monitor System which was on disk, along with compilers and loaders. Programs were input from punched cards. The computer came as part of the UNESCO support, for development of the Institute for Earthquake Engineering and Engineering Seismology (IZIIS). The Computing Center was established, with the first Director being Dimitar Bitrakov.

The education on single-task Fortran programming in Macedonia started a year before, in 1966. It was delivered by Dr. Masanori Izumi, from Japan, in English language as part of the graduate study carried out by the Institute of Earthquake Engineering and Engineering Seismology (IZIIS). One of the early students and user of the computer was Dimce Petrovski.

It should be noted that in both Belgrade and Zagreb such computer came a year later, in 1968. It should also be noted that IBM 1130 was a revolution in computer science in Europe, not just an evolution. It brought a new philosophy: High level programming languages such as Fortran, made

some previous effort in Europe in developing computers irrelevant. In 1967 Macedonia was in the mainstream computer programming, a step ahead of other Yugoslavia states.

It can be said that Fortran programming and use of IBM1130 computer was initiated by IBM, both in Macedonia and worldwide. As opposite to that, the Computer Science itself was self-initiated in Macedonia, by a vision of Dr Cupona, and the author of this text as executor of his idea.

## **IV. PIONEERING STEPS 1969-1988**

### *A. 1968-1973: First generation of Computer Science majors in Yugoslavia and influence on development of computer science in Macedonia*

The trend of following Nuclear Sciences in 1950's and early 1960's has changed during 1960's toward interest in electronics. There were students enrolling in such programs in Belgrade, Zagreb, and Ljubljana. However, the University of Zagreb was the first to formally start a computer sciences program in 1970.

In 1968 students from Macedonia enrolled the Electrical Engineering Department in Zagreb (ETF Zagreb). ETF Zagreb was organized in units named “zavods” as opposite to “cathedras” which at that time were usual university units. A “zavod” gives a sense of orientation toward industry oriented work, in addition to study and teaching work (usually assumed for a cathedra). One of the zavods, on initiative of professor Stanko Turk, in 1970 was established as “Zavod za Racunarsku Tehniku i Informatiku”), which was about development of computer sciences. ETF Zagreb was the first university department in Yugoslavia which formally established such a computer science program (original “Racunaska tehnika i informatika”). So the mentioned three students from Macedonia were in the first generation of students in Yugoslavia that obtained a formal degree in computer sciences. Among few students of that first generation who obtained highest grade “excellent”, one was from Macedonia. Both the computer science major and concept of zavod, influenced the later development of computer sciences in Macedonia in at least two ways.

First was the name which was given later to the unit of the Electrical Engineering Department in Skopje, Macedonia, to be “Zavod za kompjuterska tehnika i informatika” after the same name from the Electrical Engineering department in Zagreb. The name for the major was “Kompjuterska tehnika I informatika” The names were originally proposed by the author of this paper on 1976..

Second was the influence of the book by professor Branko Soucek published in USA in 1972 named “Minicomputers in data processing and simulation” [11], which gave very advanced knowledge on computer science especially on computer interfacing and process control. From today's perspective we can say that it was most advanced book in computer science by an author from Yugoslavia at that time, and the undergraduate students in ETF Zagreb were able to

listen to lectures by the author of that book. The educational model of a computer used in the book was Digital Computer Corporation PDP 8-minicomputer. The book is about process computers, dealing with interfacing to a process and processing signals. In 1976 Soucek published his second book in USA, named "Microprocessors and minicomputers" [12]. That book also starts with PDP-8 as a model computer, but then goes toward microprocessors rather than toward process control. Students following first generations of master's and doctoral program at ETF Zagreb, among them the author of this text, were able to learn from that book.

*B. 1969- : First courses and book on Fortran programming at undergraduate level*

Although Fortran programming was taught in Macedonia since 1966 by foreign instructors, the undergraduate courses taught by Macedonian instructors started in 1969 on both Mathematics department (taught by Dimitra Karcicka) and Electro-Mechanics department (taught by professor Pane Vidincev). During early 1970's the first book on Fortran programming was published by Dimitar Bitrakov [13] in Macedonian language.

*C. 1970-: First employment in a computer science company*

During 1970's students from Yugoslavia were able to work in foreign countries. Two students from ETF Zagreb, Branko Doljak and Stevo Bozinovski enrolled in the educational program of IBM Deutschland. Doljak worked in the plant in Mainz and Bozinovski in the sales unit in Bayreuth. The geschäftsstelle (GS) Bayreuth was selling computers and had system engineering (SE) support. Bozinovski was "Werkstudent -IBM Mitarbeiter" and part of the SE support of GS Bayreuth. The education was in IBM educational centers in Dusseldorf, Hannover, Stuttgart, and Munich. The knowledge gained was on operating systems for IBM 1130, IBM System/3 and IBM 380/135, as well programming languages Fortran, Cobol, RPG, and PL/1.

Many other specializations abroad in computer science, especially in the USA, took place during 1970's and after that.

*D. 1970-: The first computer programs on Artificial Intelligence as part of development of Computer Sciences in Macedonia*

The author of this paper wrote his first Artificial Intelligence (AI) program in 1970 and it was a chess endgame two kings and a rock. Given any position with those three pieces on the chess table, computer program would recognize the position correctness and will play until it wins.

*E. 1971-: Recognition of a student work: First- of-May prize*

In 1971 the author proposed a work for First-of-May award of the University of Zagreb, about neural networks named perceptrons and teaching for pattern recognition [14]. A program was written simulating complete perceptron, with

connections from retina to associative units as well as connections from associative to decision units. The university prize was obtained delivered by the University Rector Dr. Ivan Supek

*F. 1971- : Innovation in digital electronics*

During early 1970's students from Macedonia were studying electronics in centers outside Macedonia, because there was not such a study in Macedonia. Although many students just followed the known solutions, there were original solutions proposed. One of them was proposed by the author of this text. While the previous circuits from Macedonian authors were in area of A/D conversion, this is the first original pure digital circuit, proposed by a Macedonian author. It is a simplest *controllable flip-flop, which is built only of 4 inverters*. It was known that two inverters can keep a binary variable, but to control it, until 1971 only the 2-NAND and 2-NOR solutions were known. The inverters-only flip-flop idea was gradually developed considering possibilities of Wired-AND connections of the 1971 Resistor-Transistor Logic (RTL) integrated technology. This 4-inverters flip-flop was used for the first time in 1972 in a work on a digital integrated circuit for simulation of conditioned reflexes [15]. The simulated neural network was also published in a journal [16] as well as in the book of professor Santic [17] who was mentor of this project. More details of obtaining this flip-flop are given in [18].

*G. 1973-: Stipend for talented students*

Following the first generation of its computer science students, who were graduating during 1972 and 1973, in March 1973 Electrical Engineering department in Zagreb opened a master's degree study in Computer Science.

In 1973 the author of this text obtained the newly established stipend for young talents from the Macedonian state government, for master's degree study at the University of Zagreb. The talent had to be shown in various areas and the evidence included mathematics competitions, best high school student recognition, first prize for poetry obtained in Bitola, and prize for drawing competition obtained in Skopje.

*H. 1976- : First educational materials in computer sciences in addition to Fortran programming materials*

From 1966 till 1976, the first 10 years of learning in Fortran programming, there were various written teaching materials in Fortran programming, including the books mentioned above.

During 1970's reorganization activities were carried out also at the Electro-Mechanical Department. In 1970 the major in Electronics was established. Part of that program was a course of Logic Circuits which was initially taught by professor Borivoje Lazic, from University of Belgrade. Among various department cathedras, the Cathedra of Cybernetics was established in 1972 under the leadership of Pane Vidincev. In 1977 the Department became part of the University Center of Mathematics and Technical Sciences

(UCMTN) with slightly different name, “Electrical and Mechanical Department”. The Institute of Electronics was established with Milco Kocare as director. In 1976 the author of this paper joined the Cathedra of Cybernetics at the time of university centers reorganization, and become assistant for teaching Logic Circuits and Organization of Digital Computers. The instructor of Logic Circuits that year was Borivoje Lazic from Belgrade.

The first booklet on computer science not related to Fortran programming was written by the author of this work in 1976 [19] and was about Operating Systems and Systems Programming. Basically it contained knowledge the author gained during his work in IBM in Germany of IBM 370/135 systems. The booklet was made available to the students enrolled in the course on Organization of Digital Computers which in that year was taught by Tome Bosevski, a nuclear engineer returning from Vinca, as proposed by Aksenti Grnarov, lecturer of the Cathedra for Cybernetics, who originally introduced this course.

In 1977 a booklet on logic circuits and computer programming was prepared [20] for the Mathematical School, organized by MINC. The material of the booklet was basically following the book [11].

In 1977 the booklet on digital integrated circuits [21] was prepared showing digital integrated circuits available from Electronic Industry (Ei) from Nis, Yugoslavia. It contained gates, combinational circuits, sequential circuits, memories, and interface modules.

#### *I. 1977- : The name “Informatika” appears in courses and institutions*

In 1977 the Medical Department introduced the course named “Medical Informatics” in its graduate program. The previously existing course of named “Cybernetics” was renamed “Biomedical Cybernetics”. In such way in 1977 the word “Informatics” formally became part of the higher education in Macedonia. Let us mention that three people were involved, Vanco Kovacev from Medical Department, Branko Trpenovski from Mathematics Department, and the author of this paper, who proposed the name of the new course and was fist instructor of an Informatics course.

In the same year the name “informatika” appeared as a name of an institution. The Institute of Applied Mathematics and Informatics was established at the Department of Mathematics. As mentioned before the first formal institution dealing with computer sciences was Mathematical Institute with Numeric Center, established in 1966. The author of this paper joined MINC in 1974, after submitting his Master’s Thesis at the Electrical Engineering department in Zagreb. MINC was truly research and application institution, and was not connected to teaching, although some of the employees were engaged in teaching various university courses. In 1976 university went into transformation into University centers, and one of the centers was University center for mathematical and technical sciences (UCMTN). It that reorganization MINC was dissolved and become part of the Mathematical department, where an institution was formed in 1977 named Institute for Applied Mathematics and Informatics.

#### *J. 1977- : Realization of hardware devices for external customers*

In 1976 an idea for development of hardware devices for customers was presented by the author of this paper to professor Pane Vidincev, head of the Cathedra for Cybernetics. The idea was accepted and the laboratory part for digital circuits development was built. At the beginning only this lab had only a professional lab table and a movable arm lamp. A space was assigned in the room where the Cathedra of Cybernetics had its analog computer. The Cathedra had two lab rooms, one with digital computer IBM1130 and the other with analog computer MEDA.

The first customer was Institute of Physiology in 1977. The device delivered was named “Programmer for Reaction-time meter” and was the first digital controller built in Macedonia and the first hardware product ever delivered to a customer by the Electrical Engineering Department. It was built with small scale integration elements using abstract automata principles. The student engaged in building the first controller was Mite Gjorgeski. Several controllers were built for external customers, and the new technology used was firmware. The firmware based controllers built in 1979 used chips 74188 PROM and 2708 EPROM.

#### *K. 1978- : First lab space dedicated to digital circuits for external customers*

In 1978 the first lab space was dedicated to development of digital devices for external customers, by placing a dedicated lab desk. Before that, the students interested in work with digital circuits had to be guests in labs of other Cathedras. This lab space was built inside the lab for Computing Machines and Automatics which was previously developed by prof. Vidincev, as part of Cathedra for Cybernetics. The lab space was later expanded to two lab desks and it was active till 1986 when it was moved in a new building, where a new lab was formed named Laboratory of Intelligent Machines, Bioinformation Systems, and Systems Software (LIMBISS).

#### *L. 1978- : First symposium related to computer sciences*

In 1978 the first symposium was organized related to computer science. It was named Biomedical Cybernetics and covered applications of computers in medicine among other topics. Participants were from Yugoslavia. The organizers were Stevo Bozinovski and Metodija Kamilovski from Electrical Engineering Department, and Dragan Mihajlov and Margita Kon-Popovska from Mathematics Institute. A symposium proceedings was published and was available at the time of the symposium.

#### *M. 1978- : First professional society in Macedonia related to computer sciences*

The first society related to computer sciences was Biocybernetics Society of Macedonia, formed in 1978, during the mentioned symposium. The president was professor

Dimitar Hrisoho from Medical department, brother of the aforementioned Aleksandar Hrisoho. The Society organized seminars and symposia, among other events.

*N. 1979- : First patent filed, as computer science development*

In 1979 first patent was filed with the Yugoslav patent institution by the author of this paper. It was about programmable controller. The patent was later approved. It was the first patent from Macedonia related to computer science.

*O. 1979- : First microprocessor in Macedonia*

The first microprocessor based application was developed by the author of this work in 1979 during the stay with the Institute for Information and Communication (Nachrichtentechnik und Informatik) of the Technical University in Munich. It was a system for generating square wave for a signal generator and was based on Texas Instruments TMS 9900 microprocessor [22].

The same year the first microprocessor Intel 8008 purchase in Munich and was brought to the Electrical Engineering Department and was introduced in the education process by the author of this text. In 1979 a booklet was prepared on microprocessors and microcomputers [23] containing single clock step micro-programming as well as interfacing.

*P. 1979- : Developing curriculum for a major in computer science*

In 1979 Electrical Engineering Department had a discussion for some time on future reorganization of the Department. The Cathedra of Cybernetics had a discussion on having own major with name Computer Technique, Informatics, and Automatics (orig "nasoka Kopjuterka Tehnika, Informatika i Avtomatika"). As propose by the author of this paper the organization unit for development of computer science would be named "Zavod za Kompjuterska Tehnika i Informatika". The basic curriculum for computer science was developed by Grnarov and Bozinovski. In principle Grnarov developed all the hardware oriented courses, and Bozinovski software oriented courses. Exception was the course on microprocessors and minicomputers" which was developed by Bozinovski.

In 1979 Mathematics and Natural Sciences Department developed a major in "Mathematics-Informatics". The Mathematics Department organized also specialization (one year program) entitled Informatics and Application of Computing Machines.

*Q. 1979- : Spreading computer science in Bitola, Macedonia*

In 1979 the author of this text was elected a faculty in the rank of university Lecturer, of the Technical Department in Bitola, Macedonia. The course was named "Numerical Methods and Digital Computers" and was taught at the

Mechanical Engineering program of the department. The engagement was allowed by prof. Dimitar Bitrakov from Mathematical Department in Skopje, and prof. Mihail Bombol from Technical Department in Bitola. The course was taught in Spring part of 1980 and had 20 students.

Later in 1985 the author of this work was elected as adjunct associate professor at the Technical Department in Bitola to teach the course on "Traffic Transport Cybernetics" which was part of transportation program. The course was taught during 1986. The course assistant was Cvetko Mitrovski.

*R. 1980- : The first industrial fair presentation of Institute of Electronics products*

In 1980 the author of this text presented the hardware and software products at the International Fair on Contemporary Medicine. There were 180 companies presenting their products and Institute of Electronics was one of them. The following hardware products were presented: stabilized voltage source, biostimulator, biopotential amplifier, biopotential pre-amplifier, tapping counter, reactionmeter RE79, universal 8 channel microcontroller, PROM-programmer, Programmer for reaction-time meter RE79. Software products consisted of statistical packages and two diagnostic packages for Cornel and MMPI psychiatry tests. The invitation flyer was prepared by three organizations: Institute of Electronics of the Electrical Engineering Department, Biocybernetics Society of Macedonia, and Association of health organizations of Macedonia. A catalog of the products was prepared for the booth visitors [24].

In 1980, after the fair, for continuous activities related to presentation of Electrical Engineering Department, the highest body of the Department, the Department Board ("Fakultetski Sovet") proposed Bozinovski for a state recognition "11 October" after a formal procedure, with expert committee recommendation, then Faculty Board ("Nastavnicki Sovet") recommendation, finally Department Board approval. Later other people applied for this recognition but using different procedures, not involving Faculty Board and the Department Board.

*S. 1981- : The first membership in an international professional society*

In 1981 Bozinovski become a member of the Institute of Electrical and Electronics Engineers (IEEE) an international society which covers computer sciences, and remained as member (Senior Life Member) till today. The same year he became a member of the New York Academy of Sciences, after he has been invited to join.

*T. 1982-1983: The first upgrade of an IBM computer with own hardware and software*

The first extension of a computer system capability using own hardware-and-software interface was done on the IBM Series/1 computer. It was installed at the Mechanical

Engineering Department, and it was a demand for using that computer as a process computer. It was rack-based and modular, with a unit for handling analog inputs and outputs. However it was not designed as laboratory computer, it had no interface panel toward its analog and digital ports. A project was funded by the Mechanical Engineering Department for building interface and software so that the computer can be used as laboratory computer for signal processing and process control. The people involved were Dragi Danev, Vladimir Dukovski, Ljuben Dudevski, Stevo Bozinovski, and the student Vladan Popovic. The project was completed in 1982 as hardware and in 1983 as software support for signal processing. After that the computer IBM Series/1 become the first process computer used by faculty and students from both Electrical Engineering and Mechanical Engineering departments.

*U. 1982 -: The first multitasking (multithreading) software*

In 1982 the first multi-task (parallel) programming was written and introduced as a way of programming, in the course of Systems Software. The multi-task (or multi-thread) programming was a capability of the Event Driven Language (EDL) which was part of the Event Driven Executive (EDX) operating system for the IBM Series/1 computer. It was noticed that the standard flow-charts used in single-task programming are not applicable, so an original representation was developed [25][26]/

*V. 1983 -: The first multitasking software architecture and the first Macedonian robot*

The first multi-task programming application was for the first Macedonian Robot [21]. It was built out of toy car to which three touch sensors, one voltage sensor, and one timer were added. The robot was named Adriel-1 (ADaptive Robot of the Institute of ELectronics). The demonstration was the known artificial intelligence task: search in a maze-like environment following the walls until it find a "door", actually a voltage source that the voltage sensor detects. The abstract automaton graph was used as method of designing the robot behavior. This multitasking software architecture of a robot was a worldwide pioneering achievement.

*W. 1984 -: The first government grant related to computer sciences*

In 1984 the first state grant was obtained for a computer science related project, named Macro-project Adaptive Industrial Robots. The institution providing state grants at that time was Macedonian Association for Scientific Activities (orig. "Zaednica za naucni dejnosti na Makedonija"). The policy at that time was funding macro-projects involving more than one institution and collaborating with industry.

The project built mostly vehicle robots. It had two research directions: Signal Processing Robotics, and Flexible Manufacturing Systems. After completion of the project in

1988, it had an extension with name Adaptive Intelligent Industrial Robots, till 1992.

*X. 1985 -: The first paper published in a journal of the series IEEE Transactions*

In 1985 the first paper from computer sciences in Macedonia appeared in a world-wide prominent journal, from the IEEE Transaction series, named IEEE Transactions on Systems, Man, and Cybernetics [27]. The paper was about teaching neural networks and was result of the author's work on his PhD Thesis.

At this point a macedonian author published a paper in a high ranking journal. Although it was a pioneering step and a milestone for development of computer science in Macedonia, the paper by itself was not a pioneering step in worldwide science. It did not open a new road in science. It was rather an incremental step, a contribution, to the efforts started by McCulloch and Pitts [28], who first opened a road toward artificial neural networks, and Rosenblatt [29] who first opened a road toward learning in neural networks.

*Y. 1985 -: The first Editor of a journal*

In 1984 Macedonian Society for Biocybernetics organized its thirds symposium, with title Biological and Non-biological Beings. The author of this paper was invited by the Journal Automatika to be the Guest Editor of a special issue, [30], dedicated to the mentioned symposium. The Introduction written by the Guest editor, established first connection between genetic engineering a robotics.

*Z. 1986 -: The first description of a speech control of a robot*

In 1986 the first result of signal processing robotics was achieved, the control of a robot using speech commands. The first language used for talking to a robot was Japanese, and that result was achieved in Japan [31]. However the Japanese group did not give description of the signal processing performed, because it was not the main goal of that group. Their goal was to build the first humanoid robot, named Wabot-1 and they did it. The first description of a speech processing for robot control was given by the project AIR in 1986 [32] and was published in 1989 [33]. It should be emphasized that Macedonian language is the second language which robots understood, after Japanese language.

*AA. 1987 -: Application of Artificial Intelligence in Operating Systems tuning*

Artificial intelligence has been important part of development of Computer Science in Macedonia since 1968 when the first contact with concepts of neural networks and pattern recognition has been made through the book [6]. First program was a chess endgame program and after that series of programs were written for pattern classification and learning in neural networks (e.g. [14]).

Tuning of operating systems has been of interest since 1984 [34]. Most advanced application has been made in 1987 when a IBM 4331 VM/SP operating system has been adaptively tuned for performance improvement [35].

*AB. 1988 -: The most important result of Computer Science in Macedonia: Controlling a robot using EEG signals*

In 1988 project AIR achieved to control a robot using human EEG signals [36][37][38]. Later it become evident that it was the only such result in 20<sup>th</sup> century. The second result of EEG control was achieved 11 years later, in 1999, but with an animal, a rat, using very invasive procedure, with electrodes inside the rat brain. This is arguably the greatest result of Macedonian computer science so far, this paper being written in 2016. Let us mention that the members of the team m besides the author of this work were Liljana Bozinovska, neurophysiologist, and Mihail Sestakov, a student.

*AC. 1988 -: A worldwide pioneering result: Brain-Computer Interface using CNV potentials*

In 1973 Vidal stated a challenge which became known ad Brain-Computer Interface challenge [39]. The challenge was to control external objects using biosignals. Before that challenge usually biofeedback method was used, where internal parameters such a heart rate was controlled. Usually a visual feedback was used. In the 1973 challenge Vidal gave a special attention to the Contingent Negative Variation (CNV) signal.

The first brain-computer interface using CNV potential was achieved in 1988 in Macedonia [40][41].

*AD. 1988 -: "Zavod za komjuterska tehnika in informatika" formally established*

The proposal given by the author of this text that a zavod or development of computer science should be built based on the ETF Zagreb model, become a reality in 1988. By formal decision of the Department Board ("Fakultetski Sovet") this Zavod was established.

*AE. 1989 -: A worldwide pioneering result: Controlling robots using EOG signals*

Here we will mention on achievement which took place in 1989. In 1989 the first control of a robot using electrooculogram (EOG) was achieved [37][38]. A robot was controlled to go forward, back, left, and right using just the signals from movement of the eyes.

## V. CONCLUSION

This work covers period of first signs of work on computer science by the people from Macedonia in 1959 till 1988 when

the most important result known so far was achieved by the Macedonian computer science.

The first signs of computer science work from Macedonian authors date back to 1959. At that time people from Macedonia were engaged in nuclear engineering research in other part of Yugoslavia and as part of it devices related to computer science were developed. The first computer came to Macedonia in 1967 by IBM initiative, and it was one year before coming to other part of Yugoslavia.

The year 1968 is viewed as start of development of computer sciences in Macedonia, because that year the first computer science paper was written in Macedonian language. The paper was on automata theory and was written by the author of this text, with initiative of professor Gorgi Cupona.

The most important achievement of Computer Science in Macedonia is the 1988 worldwide pioneering result of control of a robot using signals emanating from a human brain. Before 1988 that achievement was assumed to be a science fiction under the name of psychokinesis. Other worldwide pioneering results achieved before 1988 include control of a buzzer using CNV potentials, multitasking software architecture for control of a robot, and controllable flip-flop using 4 inverters only. It is also interesting that the Macedonian language was the second one used to control robots, after the Japanese language, which was first language used to control robots.

Macedonian nation has its place in the pioneering steps in development of computer science, worldwide.

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