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As the Epitome of Talent: John von Neumann and Hungarian-born Scientists Around Him

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This paper is dedicated to the lasting memory and impact of an outstanding scholar on the field of computing.

Abstract. John von Neumann (1903–1957) was a Hungarian-American mathematician, physicist, computer scientist, and polymath who made significant contributions to various fields of science and technology. He is best-known for his pioneering work in computer science, game theory, and the development of the Neumann architecture, which forms the basis of most modern computers.

Neumann's work laid the foundation for the development of the digital computer, and he is often regarded as one of the founding figures of the field of computer science. He made important contributions to the development of early computing machines, including the concept of stored-program computers, which enabled computers to store and manipulate instructions as data, and the idea of self-replicating machines, which has been influential in the field of artificial intelligence and robotics.

In addition to his work in computer science, Neumann made significant contributions to other fields, such as mathematics, physics, economics, and nuclear physics. He also played a key role in the development of the atomic bomb during World War II as part of the Manhattan Project.

Neumann's work has had a profound impact on modern science, technology, and society, and his legacy continues to inspire and influence researchers and practitioners in various fields. His visionary ideas and interdisciplinary approach to problem-solving make him a remarkable figure in the history of science and technology.

Keywords: John von Neumann, anniversary, talent, CS, digital computer.

1. Introduction

Neumann János − as the international scientific community knows him, John von Neumann − is undoubtedly the most well-known Hungarian mathematician of the 20th century, whom the Financial Times named "Man of the Century" in 1999. In Hungary, he is considered the "father of computers". Even with less bias, it can be stated that he belonged to the group of computer pioneers − such as the German Konrad Zuse, the British

Fig. 1. A late photo of John von Neumann.
Source*:* `https://biografieonline.it/foto-john-von-neumann`

Alan Turing, the Americans J. Presper Eckert, John Mauchly, Herman Goldstine, John Vincent Atanasoff − who had a fundamental impact on the history of information technology in the world. They laid the true foundations of modern informatics, building on 19th century precedents such as the algebra of British George Boole and the work of British Charles Babbage and Ada Lovelace in the development of programmable machines.

Describing the principles of operation of the modern computer and making it publicly available was just a small part of Neumann's extensive work, as his thoughts enriched numerous scientific fields during his fifty-four years of life.

In Hungary, Neumann is held in extraordinary respect. The John von Neumann Computer Society (NJSZT) − which adopted its name 55 years ago − has since become a well-established institution among Hungarian computer scientists, recognizing his significant and outstanding role in the evolution of computers. It is particularly interesting that Neumann was well-respected in Hungary even during the cold war, even though he had emigrated to the USA.

NJSZT has been involved in international talent nurturing programs from the very beginning, as well as in the community of competitive programming Olympiads, establishing a solid connection between von Neumann, Hungary, and the international network of teachers for decades.

This year marks the 120th anniversary of Neumann's birth, which is the occasion for Hungary to host the International Olympiad in Informatics in Szeged, where the IT Museum of the NJSZT is also located. The museum has been greatly influenced by the intellectual legacy of the University of Szeged, as well as the spirit of another computer pioneer, László Kalmár. The exhibition prominently presents the life's work of Neumann. In honour of the 120th anniversary of Neumann, the NJSZT has planned numerous celebratory programs for 2023, including a traveling exhibition based on the panels of our current study.

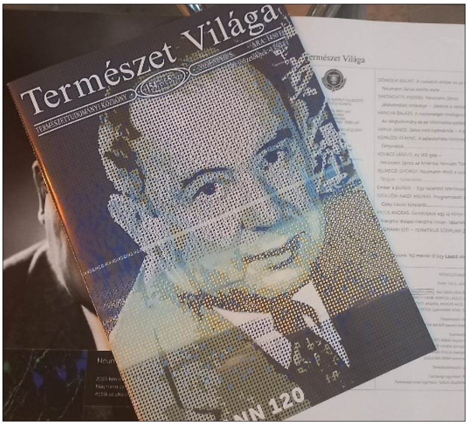

Fig. 2. The exclusive issue of "Természet Világa" magazine dedicated to Neumann.
Photo: `njszt.hu`

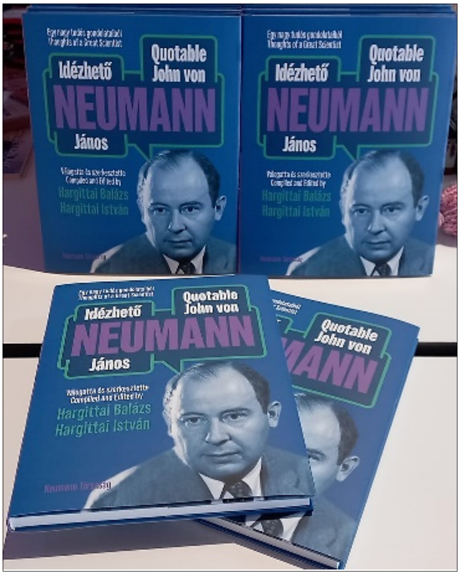

Fig. 3. A new bilingual (Hungarian-English) volume titled "Quotable John von Neumann" has been released by NJSZT. Photo: `njszt.hu`

2. Neumann, the Talent. The importance of Family Environment and Education

The first third of the 20th century saw the birth of several great scientists in Budapest, including Theodore von Kármán, a pioneer of rocket technology, Leo Szilard, Eugene Wigner, and Edward Teller, giants of nuclear physics, Neumann, the father of the computer, and John G. Kemeny, co-author of the BASIC language.

Fig. 4. Interior from the exhibition "Neumann Milieu" by NJSZT.
The paintings depict John von Neumann's aunt and maternal grandmother.
The furniture belonged to the Neumann family. Photo: `njszt.hu`

Neumann was born on December 28, 1903, and his childhood home was in the city centre of Budapest (at 62 Bajcsy-Zsilinszky Street). He came from a wealthy and highly educated Jewish family. His father, Miksa Neumann, was a respected banker who was granted a noble – baronial – title by Emperor Franz Joseph I and took on the prefix "of Margitta". According to family memories, the name Neumann referred to János' mother, Margit Kann, and the daisy, which symbolized her. János had two brothers, Mihály and Miklós. They grew up in great love, and the stained-glass window in the Neumann House (made by Miksa Róth, the most famous Hungarian glass artist) reminds us of all three of them: János as the rooster, Mihály as the rabbit, and Miklós as the cat.

It was typical of the family environment that famous scholars were guests at their dining table, and family members sometimes joked with each other in Ancient Greek. According to the summary of Endre Czeizel, the geneticist professor, Neumann had already mastered differential and integral calculus at the age of eight. Lipót Fejér and Rudolf Ortvay, mathematician/physicist professors, also visited them frequently. They also had dinner guests such as Frigyes Karinthy, the writer, Dezső Kosztolányi, the poet and Max Reinhardt, the theatre director. (Czeizel, 2011)

"Genius training" of early childhood continued in high school (Budapest Ágostai Lutheran High School), where Neumann became student of László Rátz. His other students included Eugene Wigner, the future Nobel Prize-winning physicist, and John Harsanyi, later Nobel Prize-winning economist studied in this community.

Jancsi – as Neumann was called during his childhood − received special attention from his teacher, László Rátz. They edited a mathematical journal together in high

Fig. 5. Selmeczi giving a guided tour at the “Neumann Milieu” exhibition.
Above him are the paintings by Cézár Kunwald depicting John von Neumann’s maternal grandfather (pointing at him) and teacher László Rátz. Photo: `njszt.hu`

school while others progressed with normal curriculum. His teacher organized meetings with professors from the Technical University for the exceptionally talented boy.

Later László Rátz became Hungary’s most famous talent developer. Since 2000, “Rátz László Teacher Lifetime Achievement Award” recognizes the most significant high-school teachers in mathematics, physics, biology, and chemistry in Hungary.

In 2023, NJSZT presented an exhibition titled “Neumann Milieu” at his high school with the original furniture of Neumann’s family. The interior designer György Selmeczi – who owns the objects – discovered that the paintings in his possession depict Neumann’s maternal grandparents. The portraits of Neumann’s grandfather, Jakab Kann, and his teacher, László Rátz, were placed side by side at the exhibition. Both oil paintings were created by Hungarian painter, Cézár Kunwald. According to Selmeczi’s assumption, Neumann’s father supported the school by immortalizing the teacher with his “house painter”. (Selmeczi, 2023)

John von Neumann was reserved but had a good sense of humour and expressed himself wittily. This is evident from the letters he wrote to his classmates. (Szabó)

He studied mathematics, experimental physics, and chemistry in Budapest, and philosophy, mathematics, physics, and chemistry in Berlin. At the request of his father, the young man with a fundamental interest in mathematics also obtained a “useful” chemical engineering degree in Zurich, Switzerland, but he obtained his doctorate in mathematics in Budapest.

John von Neumann followed the development of Hungarian science, and even during his lifetime, he was esteemed by Hungarian scholars. However, during the era of the infamous “Jewish laws”, World War II, and the Cold War, he became a prominent figure in the scientific community of his adopted country, the United States of America. He visited Budapest several times until World War II.

His first wife was Marietta Kövesi, they had a daughter, Marina von Neumann-Whitman (Marina later became a renowned economist and advisor to President Nixon). In 1938 Neumann divorced from Marietta and married Klára Dán, who was one of the world's first programmers and a perfect intellectual partner for him. They emigrated together to the United States.

3. Neumann, the Scientist Role Model and Gamer

After completing his university studies in Budapest, Neumann taught as a private lecturer at the University of Berlin (1926–28) and at the University of Hamburg (1929–1930). Between 1930 and 1933, he taught at Princeton University. In 1933 he was invited to the renowned Institute for Advanced Study (IAS) in Princeton, where some of the world's most distinguished scientists − including Albert Einstein and Kurt Gödel − worked.

The pure mathematics fascinated and occupied him throughout his life. Between 1926 and 1937, he focused mainly on mathematical and quantum mechanical questions.

In 1928, the minimax principle was formulated in connection with two-player, zero-sum games, stating that one should choose the option that minimizes the maximum loss. This gave birth to game theory, which evolved from a branch of mathematics and the observation of card games, board games, sports − including poker, favoured by Neumann. Game theory assumes rational decision-making (utility maximization) and the interactions it observes are not only present in games, but also in arms races and wars as well as many other areas (economics, politics, psychology, sociology, ...)

After contributing to the axiom system of set theory, he embarked on axiomatizing quantum mechanics. As a result of his work, his fundamental book, "The Mathemati-

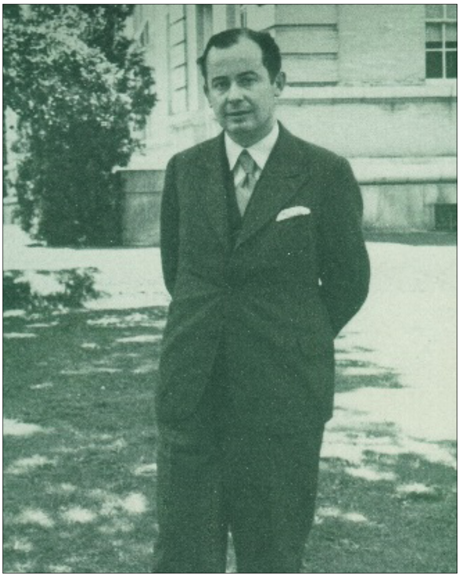

Fig. 6. John von Neumann in his youth, around the 1920s.
Source: Archive of the Budapest-Fasori Lutheran High School.

cal Foundations of Quantum Mechanics", was published in 1932. His further research, together with G. Birkhoff, proved that quantum mechanics requires a different logic than classical mechanics.

In 1944, Neumann published the book "Theory of Games and Economic Behaviours" with Oskar Morgenstern, making it clear how the examination of games can be useful in economics. The book was a milestone for psychology, economics, political science, and history, as their foundations – in many ways – lie in the concept of a game. Most researchers agree that game theory connects social sciences and is a great help in the analysis of human interactions.

John von Neumann did indeed have a deep love for games − as mentioned by his daughter in her autobiography, stating that her father always kept games at his fingertips. (Neumann-Whitman, 2012) If he had lived during the era of computer games, he would likely have become an avid gamer. From this perspective, he is also suitable as an attractive role model for children: not a recluse avoiding enjoyable activities, but a true humorous and playful mind.

4. Neumann and Historical Responsibility

In 1937, Neumann obtained US citizenship. By this time, World War II seemed inevitable, and he eventually became involved in military preparations against Nazism. His interest shifted increasingly towards the practical applications of mathematics. As an advisor, he participated in several US military projects. From 1943 he regularly visited Los Alamos, where he was involved in the theoretical and practical work related to the development of the first atomic bombs.

The secret program was the Manhattan Project, which had its starting point in a letter from Albert Einstein to President Roosevelt in 1939, initiated by Leo Szilard and Eugene Wigner. In the letter, Einstein strongly emphasized that new research indicated that a new, extraordinarily powerful bomb could be created from uranium. Einstein pointed out in the letter that Nazi Germany was also intensively engaged in similar research, and

Fig. 7. Eugene Wigner. Source: `wignerkozepiskola.hu`

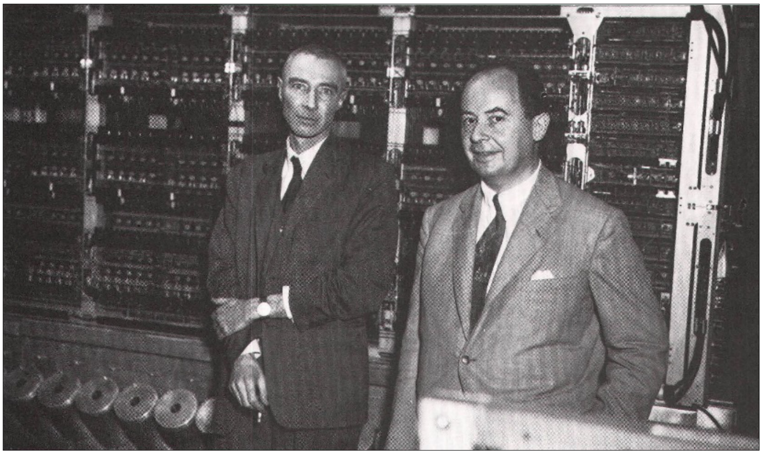

Fig. 8. J. Robert Oppenheimer and John von Neumann – standing in front of computer Alan Richards, photographer, 1952. From the Photograph collection. Shelby White and Leon Levy Archives Center, Institute for Advanced Study in Princeton, NJ.

as a result, the Third Reich had already halted the export of mined uranium in occupied Czechoslovakia.

Alongside Robert Oppenheimer, Enrico Fermi, Leo Szilard, Edward Teller, and Eugene Wigner became key figures in the project. At that time, Hungarian-born scientists of this generation were nicknamed „Martians" – most likely because they spoke to each other in Hungarian, which sounded exotic to American ears, and because their knowl-

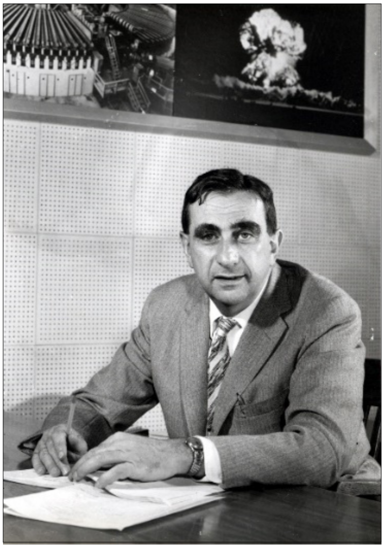

Fig. 9. Edward Teller, in 1958, as Director of Lawrence Livermore National Laboratory. Source: `https://commons.wikimedia.org/wiki/File:EdwardTeller1958_(dust_%26_scratches).jpg`

edge was almost „otherworldly." Moreover, Edward Teller's monogram was E.T., which stood for aliens. (Marx,1997)

During the study of shock waves generated by the detonation of atomic and hydrogen bombs, Neumann discovered complex mathematical relationships that could not be solved using classical methods. This led him to become interested in the possibilities of high-speed electronic computing. In the United States, the scientist – known as John von Neumann – participated in the atomic program, despite knowing the dangers and moral objections. Meanwhile, in the 1940s and 1950s, he became a leading expert and a prominent public figure considered as an opinion leader by U.S. presidents.

We consider it is very important what Marina, her daughter said at the opening of NJSZT's Informatics History Exhibition in Szeged: "...my father led a dual life: as a leading figure in the ivory tower of pure science, and as a man of action whose advisory and decision-making activities were constantly in demand in the long struggle to ensure that the United States would prevail in both the hot and cold wars that dominated the half-century from 1939 to 1989." (Neumann-Whitman, 2013)

He participated in the research and military application of nuclear energy and played a role in the direction of peaceful energy production: In 1954, he was appointed as a member of the five-member Atomic Energy Commission (AEC) of the USA.

5. The Father of Modern Computers

Although many people mistakenly refer to Neumann as the inventor of the computer, he was not an inventor. What we now call a computer was the result of a series of innovations. Major milestones: (Dömölki, 2016)

- 1941: Zuse, Z3: stored-program, relay-based computer.
- 1942: Atanasoff, ABC: electronic purpose-built machine.
- 1944–46: Mauchly-Eckert, ENIAC: electronic, general-purpose machine.
- 1944–45: EDVAC a stored-program, electronic, general-purpose machine.

In 1944, Neumann met Herman Goldstine at the Aberdeen train station, who was one of the leaders of the ENIAC construction and Goldstine told him about developing an electronic structure with enormous computing power. Neumann's eyes lit up: he was revered in his circle as an almost fearsomely knowledgeable "human computer", but for certain mathematical, physical, and military problems − even the combined capacity of a whole village of mathematicians, mechanical calculators, and years of work − were not enough.

In the fall of 1944, Neumann joined the designers of the EDVAC − a new computer to be built based on the experiences with the ENIAC − at the Moore School (University of Pennsylvania, Philadelphia, USA). Based on the results of their collaborative work, he formulated the operational principles of the EDVAC in his "First Draft on a Report of EDVAC". In this innovative approach to computer design, he provided a plan for the logical structure of the machine − instead of describing the hardware components − al-

Fig. 10. Herman Goldstine at the presentation of the Hungarian edition of the book "The Computer from Pascal to von Neumann," standing next to him is Győző Kovács, the Secretary-General of NJSZT, in 1987. Photo: NJSZT.

lowing for its realization in various hardware environments. The principles formulated by Neumann in this document:

- Fully electronic computer.
- Use of binary number system.
- Application of arithmetic unit.
- Application of central control unit.
- Internal program and data storage (the principle of stored program).

The first electronic computers − which were as big as a room − generated a lot of heat, had high energy requirements, and required frequent repairs, were initially custom-made machines. Neumann foresaw their military and scientific applications, but their widespread adoption − due to their size and cost − was not evident for a long time.

Neumann himself took on the direction of designing a new stored-program computer: this machine, the famous IAS, was completed by 1951 in Princeton. It fully met all the requirements of the Neumann's architecture. The scientist − who enjoyed hosting large parties and social events − threw a party to celebrate the unveiling of the machine: the highlight of the evening was the presentation of an ice sculpture model of the computer, alongside fine martinis. While the ice sculpture melted, the "grandchildren" of the IAS machine − referring to the spread of similar computer designs around the world − became widely adopted. (Neumann-Whitman, 2012)

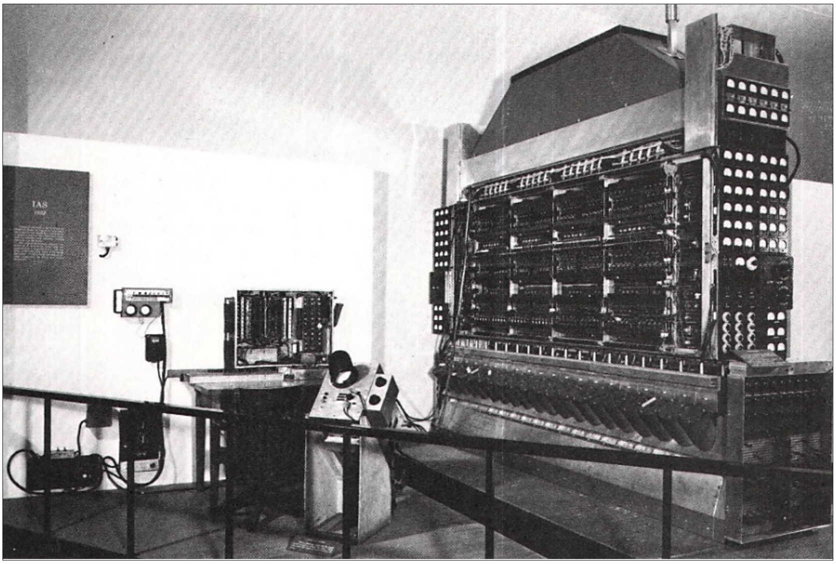

Fig. 11. Princeton IAS Computer, the complete system.
Source: `https://historyofinformation.com/image.php?id=5524`

The most advanced Neumann machine, the IAS, weighed nearly half a ton and utilized 1700 vacuum tubes. It had a memory capacity of approximately 5 kilobytes! with word lengths of 40 bits. It could perform 16,000 additions and 400 multiplications per second. This computer – which incorporated numerous innovations such as the efficient use of Williams tubes as memory and small oscilloscope screens as displays – remained in operation until 1958. It was relatively reliable compared to other computers of the time and was used for calculations in fields such as nuclear physics and numerical meteorology. (Aspray, 2004)

In Hungary – the first computer based on Neumann's principles – the M-3 was completed in 1959, based on a Soviet design, refined and further developed by the Cybernetics Research Group of the Hungarian Academy of Sciences (MTA KKCS). The day of the presentation of the M-3 is proposed by NJSZT as a new celebration: the Hungarian IT Day is 21st of January. Rezső Tarján, the deputy director of MTA KKCS, and Győző Kovács, the head of the first computer center based on the M-3, became dedicated supporters and promoters of Neumann's intellectual legacy.

Neumann considered the computer as a new scientific achievement of human progress. Therefore, he was not opposed to the emergence of new computers based on the refined Neumann principles and – if his health allowed – he followed the mathematical and programming challenges arising from these computers. "The genius of John von Neumann not only facilitated the birth of high-speed computers, but also the solution of mathematical problems, arising from their utilization," characterized the significance of the scientist by Hungarian mathematician, Gyula Obádovics. (Obádovics, 2003)

In the over half a century of digital computers the Neumann principles have been defining, whether it be the behemoth machines of the early days or the smart pocket

Fig. 12. Electron tubes from the first Hungarian von Neumann-inspired computer, M3.
Photo: `ajovomultja.hu`

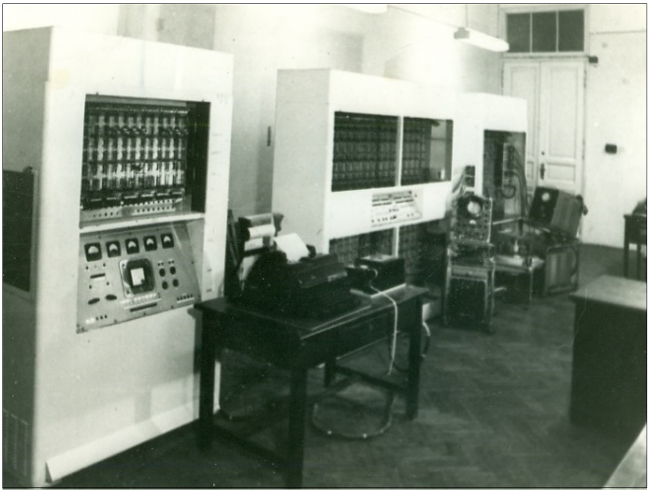

Fig. 13. The first Hungarian von Neumann-inspired computer, the M-3, in 1959.
Photo: `ajovomultja.hu`

devices of today. Of course, classical computer design principles are now supplemented with new knowledge, as we are living in the age of microelectronics and nanotechnology, and we may even be witnessing the dawn of quantum computing.

6. The Antechamber of Artificial Intelligence

“What kind of logical structure is sufficient for an automatic machine capable of self-reproduction?” Neumann posed the question. As a true mathematician, he also contemplated computers on a theoretical level. In early 1940s, he introduced the concept of "cellular automata," a mathematical model in which cells can take on different states. He developed a "Universal Constructor" with cells capable of assuming 29 different states. The main theme of his 1948 lecture titled "The General and Logical Theory of Automata" was the formulation of new logical principles for automata, including self-replicating automata. His last unfinished (posthumously published) masterpiece, "The Computer and the Brain," is about computers as automata. It aims to approach the understanding of the nervous system. He compares neurons and neural memory with artificial components, seeking analog and digital parallels.

Neumann stated: "In the future, science will be more concerned with the problems of regulation and control, programming, data processing, communication, organization, and system management." He recognized that the security and efficiency of a system are not determined by the elements it is composed of, but by how it is organized as a system and the quality and quantity of information that flows between the elements.

Since Neumann's ideas, the field of cellular automata has undergone significant theoretical development, and automation has evolved into a vast area encompassing robotics and artificial intelligence. A successful Hungarian entrepreneur, Gábor Bojár compares the revolution of computers to the emergence of speech and writing in human history: "but even those who express more cautious views acknowledge that we are living in an era of another industrial revolution, the foundations of which were laid by Neumann and his generation." (Bojár, 2022)

Indeed, Neumann played an incredibly significant and pioneering role in the development of cellular automata theory, which has had a profound impact on various fields such as life games (popularized by John Conway), evolutionary genetics, and the concept of self-replicating automata. His principles for creating reliable machines from unreliable components also shape the entire IT industry, and his propositions regarding

Fig. 14: The wax figure of John von Neumann exhibited in 2023 at the Madame Tussauds, Budapest. Photo: `njszt.hu`

the functioning of the human mind can serve as inspiration for both IT professionals and brain researchers alike. These fields are not so far apart, and Neumann's work has fundamental importance in many areas of IT.

7. Can we Survive Technology? Neumann, the Visionary

John von Neumann passed away in 1957, suffering from bone cancer, likely because of radiation exposure. He was a highly respected personality whose merits were recognized in various ways during his lifetime. He was a member of the National Academy of Sciences, President of the American Mathematical Society, and received the Medal of Freedom from the President of the United States (1956) − which Eisenhower presented to him at his hospital bed − as well as the Albert Einstein Medal and the Enrico Fermi Award from the U.S. Atomic Energy Commission (1956).

His legacy left to the world was of great interest. He was not even sure if what he had created would still be interesting "a hundred years from now." Immortality was granted to him through his theoretical mathematical summations and his practical contributions with real-world impact.

We owe him a lot in terms of weather observation as well. He was very interested in the role of computers in weather forecasting and even in climate modification. He put the ENIAC computer into service of numerical meteorology and the accurate prediction of weather. By numerically integrating the barytropic vorticity equations, he achieved the first successful 24-hour forecast for North America based on actual data from four selected days in the first two months of 1949. He continued to work on this topic with his later machines, and even organized conferences on computer modelling of climate processes.

In 1955, Neumann wrote an almost prophetic article titled "Can we survive technology?" for Fortune magazine. Although Neumann was not yet a "climate alarmist" (since the term did not exist at the time), he accurately foresaw the increasing globalization,

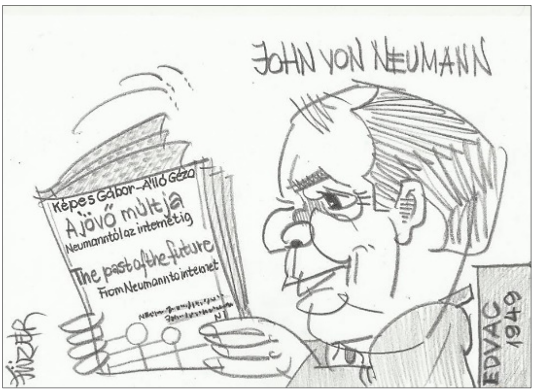

Fig. 15. József Füzér's caricature of John von Neumann.
Photo: `njszt.hu`

interdependence of humanity, and the opportunities presented by nuclear energy and automation, and treated the possibility of weather control as a fact. “Technologies are always constructive and beneficial, directly or indirectly. Yet their consequences tend to increase instability…” (Neumann, 1955)

He believed that the impacts of the achievements created by his generation were explosive in nature, and their magnitude was “the size of the whole world.” “For progress, there is no cure” he said, meaning that progress cannot and should not be stopped. The only thing we can do is to intelligently execute daily decisions.

“The one solid fact is that the difficulties are due to an evolution that, while useful and constructive, is also dangerous. Can we produce the required adjustments with the necessary speed? The most hopeful answer is that the human species has been subjected to similar tests before and seems to have a congenital ability to come through, after varying amounts of trouble. To ask in advance for a complete recipe would be unreasonable. We can specify only the human qualities required: patience, flexibility, intelligence.” (Hargittai *et al*., 2023)

It’s dizzying to think about all the interesting questions we could have read Neumann’s thoughts on, had he lived for almost 100 years, like his brother Miklós. What would he have said about the information society? Personal computers, video games, mobile phones? The end of the Cold War? The ecological crisis, climate change?

Neumann could have been a true role model for the generation facing the great challenges of the 21st century, the current students of Olympiads, whose task is to solve challenges determine the future of humanity. The stakes are high in nurturing this talent, as we search for the future Neumanns.

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G. Képes obtained an MA degree in Hungarian language and literature at Faculty of Humanities, Eötvös Loránd University in 2004, and also pursued studies in digital humanities at the same institution. Between 2004 and 2014, he served as the curator of the computing collection at the Hungarian Museum of Science, Technology and Transport. From 2014 to 2016, he was the head of department at the Hungarian National Digital Archive. Since 2016, he has been a senior researcher at the Neumann Society (NJSZT), and he has been the director of marketing since 2021. In 2014, he was awarded the Janos Kemény Prize for his publications on the history of informatics.

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