Events and Sightings

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Restoration of the Differential Analyzer at the Tokyo University of Science

At one time, there were at least three mechanical differential analyzers in Japan, installed at the University of Tokyo (4 integrator units, 1942?), University of Osaka (3 integrator units, 1944?), and University of Tokyo (8 integrator units, 1954). Later, the Osaka machine was sent to the Tokyo University of Science and kept in its Museum of Science for exhibition. It was certified as an Information Processing Technology Heritage in 2009. The two other analyzers were abandoned.

Hearing that the Manchester Museum of Science and Technology restored its differential analyzer, we were tempted to resurrect our survivor as well. After determining that a "heritage" computer could actually be modified, in April 2013, a new project was kicked off to restore the differential analyzer to working condition. The project core was made up of the Tokyo University of Science, National Institute of Informatics (NII), and National Institute of Information and Communications Technology (NICT).

The first step was to examine the current state of the machine. Since the machine was assembled after being moved from Osaka by nonengineering people, there were many components incorrectly connected. To keep parts from rusting, shafts, gears, and adders had been painted with layers of lacquer. In addition, the driving belts of the torque amplifiers were broken, and disc surfaces were scratched. It was quite a miserable sight. On 15 June, a team of students from the Mechanical Engineering Department was summoned to the museum to measure every dimension of the machine and to draw precise plans. After that, two of the three sets of integrator units and torque amplifiers were removed from the bay frames and taken to the NICT machine shop for repair.

On 20 September, the remaining shafts and gears were removed from the bay frames, dipped in a vat filled with thinner, and kept there for two or three days and nights. The student team was then asked to remove the lacquer by patiently washing each part. The cleaned shafts and gears were returned to the original positions in the bay frames. Then they were turned freely. In August, at the NICT machine shop, the first integrator unit was thoroughly studied and all parts were removed, cleaned, and checked to see if they were worn out. Some parts were missing. In those cases, the worn or lost parts had to be made anew.

For the large integrator disc to be reformed, its axis was clamped on a turning lathe, and the surface was scraped carefully until a flat plain appeared. Parts of the torque amplifier were also completely removed. The drum surfaces of the primary and secondary stages were ground, and in so doing, a few prototypes of string holder mechanisms were designed and tested. Because the designers foresaw that the strings would need to be adjusted often, and the space in the torque amplifier was so small, the string holder could be handled easily. However, the material of the friction strings posed a problem. In an interview, Professor Emeritus Masaru Watanabe, who had actual experience with both of the differential analyzers at the University of Tokyo, recalled that they used koto string for it long ago. (*Koto* is a Japanese classical musical string instrument.) Koto string is still available, so it was chosen for the first stage. For the secondary stage drum, kevlar cord, a kind of poly chemical substance, was the sole solution. The first torque amplifier and integrator set was combined in December, although the output torque proved far weaker than expected.

In January and February 2014, the amplification ratio was measured by repeatedly changing the tension, friction, and number of turns. Wrapped with sample string, the drum was rotated slowly on a lathe, and both ends of the string were pulled by a pair of spring scales to calculate the ratio. Finally, an amplification on the order of a thousand was achieved.

By the beginning of April 2014, the first set was complete, so the restoration for the second set of integrator and amplifier began. This process moved rapidly, and the second set was completed in a few days. The two sets of integrator units and torque amplifiers were transferred back to the Museum of Science on 9 April. Laborious adjustments between the gears of integrator and cross shafts were needed, by raising, lowering, or tilting little by little, before the first set became operational. The typical test with a single integrator was an exponential function, so shafts and gears were set up for $\int y\,dx = y$. The torque amplifier motor was switched on, followed by the independent variable motor, and the output value seemed to increase exponentially. Bravo! A fortnight later, the second set became ready for operation. Shafts and gears were set up for the circle test, an example well known by differential analyzer geeks. All motors were turned on. The restored differential analyzer worked beautifully. For a complete circle to be drawn, it took about 6 minutes and 40 seconds (see Figure 1).

Since the output table had not yet been repaired, two rotary encoders were connected to the corresponding cross shafts. The output of the encoders was picked up by a PC, and a graph similar to that of the output table was

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drawn by the PC. Shortly after the whole machine became workable, the Museum of Science held an exhibition of analog computers. Needless to say, the differential analyzer was one of the highlights. Dizzy movements of discs, wheels, shafts, and gears gave visitors a strong impression of the differential equations being solved by means of mechanical integration (see Figure 2).

The members who undertook the restoration understood well the principles behind the differential analyzer. Nevertheless, the real machine proved to be far more complicated, with various sorts of tricky gadgets to insure stability and accuracy such as a lashlock, flywheel, and frontlash unit. We discovered many engineering techniques from the past two or three generations.

In conclusion, it must be stressed that this restoration project was entirely supported by the NICT machine shop. The machine shop possesses a fleet of machine tools, preserves every kind of raw material, and stocks many machine parts. Each time new pieces of any part were requested, they were supplied instantly, à la Aladdin's lamp. This reminded me of Arthur Porter's recollection: "Fortunately, the physics laboratories were equipped with excellent machine-shop capabilities, and I had no difficulty in building the apparatus and performing the investigations."[1] Our project was similarly fortunate because of the cooperation of the NICT machine shop.

Reference

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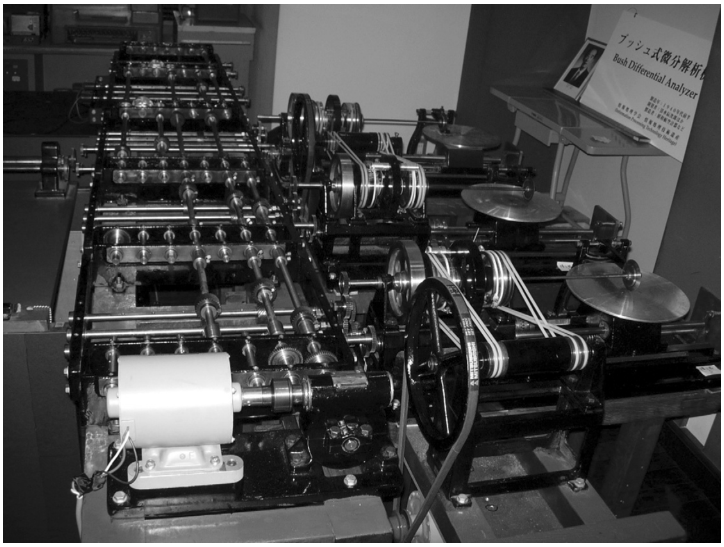

Figure 1. Tokyo University of Science differential analyzer. Following an extensive restoration project, it was returned to working order.

Figure 2. Restored differential analyzer. The working system was exhibited to members of the Board of Directors from the Information Processing Society of Japan.

Celebrating the 50th Anniversary of MIT Project MAC

Project MAC was created at the Massachusetts Institute of Technology in 1963 to make computing power available to many research projects. MAC was later known as the MIT Laboratory for Computer Science (LCS) and the MIT Computer Science and Artificial Intelligence Laboratory (CSAIL). CSAIL celebrated 50 years of computer science and artificial intelligence research with a symposium in MIT's Stata Center in Cambridge, from 28–29 May 2014.[1]

Attendance was limited to 250 people and included current MIT professors, students, and researchers; former participants in MAC, LCS, and CSAIL; and other distinguished members of the computing profession.

MIT President L. Rafael Reif and CSAIL Director Daniela Rus introduced the 23 talks in the Steve Kirsch Auditorium. Former participants in MAC, LCS, and CSAIL have founded more than 100 companies, and leaders of several of these spoke at the

Figure 3. Robert M. Fano, founding director of Project MAC, received the Founder's Award at the 50th anniversary celebration of Project MAC. (Courtesy of Jason Dorfman.)

symposium, including the founders of iRobot, Akamai, 3COM, and Boston Dynamics. Talks included reminiscences, current research results, and directions for further progress in computer science, networking, education, robotics, and artificial intelligence. MIT has posted video recordings of the presentations[2] and photos from the event[3] on the CSAIL website.

A banquet at the Cambridge Marriott Hotel included a Founder's Award given to Robert M. Fano, the founding director of Project MAC (see Figure 3). He gave an entertaining talk that recounted the early days of Project MAC.

Project MAC History

J.C.R. Licklider suggested Project MAC to MIT Professor Robert Fano in 1962. Licklider was then the director of the Information Processing Techniques Office of the US Department of Defense Advanced Research Projects Agency (ARPA).

Project MAC began on 1 July 1963, with a budget of $2.2 million. The project's goals were to bring together many researchers interested in computers, including those interested in artificial intelligence and multiple access computer systems, and to investigate how online computing could assist people in their intellectual work. MAC supported large and small research projects at MIT; in its first year, Project MAC supported over 200 researchers.

Many Project MAC participants initially used MIT's time-sharing system CTSS,[4] including the group building Multics (http://multicians.org), the time-sharing system successor to CTSS. The Artificial Intelligence Laboratory[5] built its own time-sharing system named ITS.

For more history, see the four articles on the history of Project MAC that were published in *IEEE Annals* in April 1992.[6]

Significance

In the early 1960s, many academics didn't believe that "computer science" should be viewed as a discipline, any more than "slide rule science." The computer was seen as a tool, rather than an interesting subject in itself.

Fano and Licklider believed that providing convenient computer access to a community of users would change research goals and facilitate new methods and that building the tools to provide this access was an interesting field of study on its own.

Project MAC's experience supported these predictions. As Fano remarked, the original emphasis on sharing CPU cycles was overshadowed by users wanting to share programs and data, and the file system engineering needed to make this work. Early versions of inter-user mail and instant messaging contributed to Licklider's vision of the computer as a communication device. The MAC desire to build a prototype "computer utility" computing service anticipated problems of reliability, availability, privacy, and security that have become critical to many users of cloud services.

Previous Project MAC Anniversaries

I personally attended two previous Project MAC anniversary celebrations, the 25th in 1988[7] and the 35th in 1989.[8] Sadly, some friends and colleagues have passed away and thus weren't there for the 50th.

The previous anniversaries were hosted in a larger MIT auditorium that accommodated more attendees. Talks covered the past, present, and future of computer science.

Multics Reunion

Former contributors to the Multics operating system stayed for the afternoon of 29 May 2014 for a Multics Reunion[9] hosted by CSAIL (see Figure 4). MIT Professor Fernando J. Corbató, the leader of the Multics development effort at Project MAC, was joined by Multicians who worked at MIT, Bell Laboratories, General Electric, Honeywell, and other organizations that used Multics during its 35-year history. In a lecture hall at the Stata Center, there were presentations on the Multics history and legacy, future systems that are building on Multics concepts, and proposals for observing the 50th anniversary of Multics in 2015.

References and Notes

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Figure 4. Multicians reunion group photo. (Courtesy of Jason Dorfman, CSAIL/MIT.)

Norbert Wiener in the 21st Century: Driving Technology's Future

The IEEE conference "Norbert Wiener in the 21st Century: Driving Technology's Future" took place on 24–26 June 2014 in the Westin Hotel in Waldham, near Boston, Massachusetts. This conference was held to honor the double anniversary of Wiener's birth and death (he was born in 1894 and died in 1954) and it commemorated his life and work. Wiener's most famous books, *Cybernetics: Or Control and Communication in the Animal and the Machine* (Hermann & Cie, 1948) and *The Human Use of Human Beings* (Riverside Press, 1950) influenced mathematics, science, and technology as well as biology, medicine, the humanities, and social sciences.

Many of his technical publications and most of his other books, including *God & Golem, Inc.: A Comment on Certain Points Where Cybernetics Impinges on Religion* (MIT Press, 1964) and the posthumously published *Invention: The Care and Feeding of Ideas* (MIT Press, 1993), were addressed and quoted in the various technical and also humanities-related conference talks. The program included sessions with titles such as "Filter Theory," "Non-linearity," and "Control" as well as "Wiener's Philosophical Roots," "Current Philosophy," and "Changing Society." About half of the contributions were mathematical-technical oriented, and most of them had been reviewed for the North American Fuzzy Information Processing Society (NAFIPS) Conference that was held as a part of this 2014 Conference on Norbert Wiener in the 21st Century. Talks in these sessions were given by members of the fuzzy community and their subjects were "Fuzzy Numbers," and "Z-Numbers," "Fuzzy Rules," "Fuzzy Control," "Fuzzy Clustering," "Fuzzy Optimization," "Type-2 Fuzziness and its Applications," and "Fuzzy Math."

The historical connection between Wiener's fusion of communication engineering and statistical time series included filtering, extrapolation, and prediction into a common technique,[1] and Lotfi A. Zadeh's foundation of the theory of fuzzy sets was presented in Rudolf Seising's keynote talk entitled "Yellow Peril, Spray Can, and Z-Mouse. From Wiener's Prediction and Filtering to Zadeh's Fuzzy Sets: A Historical Sketch." He showed that Zadeh tied directly into Wiener's statistical basis of filter theory by forming new concepts but then immediately surpassed it.[2]

Other keynote speakers started their speeches with Norbert Wiener but dealt with different disciplines. For example, the historian of engineering and professor of aeronautics and astronautics David A. Mindell spoke in his speech entitled "Wiener and the Engineers: The Cybernetic Moment" on Wiener's connection to feedback control engineering in his time. He embedded Wiener's work into a larger context. In Andrew Pickering's speech, "The Next Macy Conference: A New Synthesis," the sociologist emphasized that a new attempt would be necessary to again try integrating technical and social sciences research and the humanities. Mary Catherine Bateson, cultural anthropologist and daughter of Margaret Mead and Gregory Bateson, evoked many memories of Wiener and other Cybernetic Group's members and their intentions, and she spoke on the need to extend Wiener's cybernetics to natural systems in order to understand that mankind destabilizes the homeostatic systems of planetary life.

During a PhD symposium held the afternoon before the conference started, PhD students gave short talks on their research projects.

In his speech on "Ubiquitous Surveillance and Security," Bruce Schneier emphasized that not only is the Earth in danger but so are human societies! Schneier provided important insights on the benefits and risks of information and communication technology that especially significant for the audience because of the recent news on the NSA's actions. Finally, journalists Flo Conway and Jim Siegelman, authors of the book *Dark Hero of the Information Age* (Basic Books, 2006), offered a competent and emotional inspection into life and work of Wiener.

Humanities-related topics were dealt with in various tracks or sessions of the conference, such as "Biography," "Cybernetics and Creativity," "Systems in Society," "Being Human," "Art and Design," "Wiener's Philosophical Roots," and "Current Philosophy." In addition, four special panels dealt with "Management Cybernetics," "Digital Monozukuri," "Wiener and Innovation," and "Cybernetics, Art and Creativity." There were also transdisciplinary sessions, such as "Systems in Society," "Health, Data, People," "How We Communicate," "Soft Computing in Education," and a thread on "Medical Applications."

Last but not least, Wiener's two autobiographies, *Ex-Prodigy: My Childhood and Youth* (MIT Press, 1953) and *I Am a Mathematician* (MIT Press, 1956), and his novel *The Tempter* (Random House, 1959) were considered in several of the special sessions and other talks. And in a "Writing" session, Heather A. Love used Wiener's concept of the cybernetic feedback loop in literary critics and presented a case study to read Ezra Pound's modernist poetry in his "Chinese History Cantos." Karen Faerber-Hall considered Wiener's interests in science fiction and his relationships with writers John W. Campbell and Isaac Asimov, and she emphasized "Wiener's concern about the danger of ceding control of moral judgment to machines." Pierre Cassou-Noguès interpreted Wiener' short science fiction stories written in the 1950s: "The Brain," "The Miracle of the Broom Closet," "The Day of the Dead," "A Scientist Reappears," and "Under the Stone." The first two appeared in the journal *Tech Engineering News* under the pseudonym W. Norbert, while the others remained unpublished.

This was a great meeting of scientists, historians, biographers, and researchers from engineering and the humanities, and I'm sure, Wiener would have appreciated the interdisciplinary discussions that took place.

For more details, visit the conference website, http://21stcenturywiener.org. The conference proceedings were published as a pen drive (IEEE catalog no. CFP14YAM-USB, ISBN 978-1-4799-4563-4). Copies of this publication are available from Curran Associates (curran@proceedings.com).

References and Notes

1. This was the aim of Wiener's NDRC report, "The Extrapolation, Interpolation and Smoothing of Stationary Time Series" (NDRC report 6037, 1 Feb. 1942), that later became a book volume, also called the "yellow peril."
2. For historical details on the pre-hisotry and history of fuzzy set theory, see R. Seising: *The Fuzzification of Systems. The Genesis of Fuzzy Set Theory and Its Initial Applications: Developments up to the 1970s*, Studies in Fuzziness and Soft Computing, vol. 216, Springer, 2007.

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