**COMPUTER EVOLUTION**

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The following "slides" outline the major topics of presentation in each of the episodes of the video series The Machine That Changed the World which was produced by [WGBH Television](http://www.boston.com/wgbh/) in Boston MA, in cooperation with the British Broadcasting Corp., with support from [ACM](http://www.acm.org), [NSF](http://www.nsf.gov/) and [UNISYS](http://www.unisys.com/).

There is a book which accompanied the series that you may want to reference:

Palfreman, Jon, and Doron Swade. The Dream Machine: Exploring the Computer Age, BBC Books, London, 1991, 208 pp.

For more links to the history of computing pages [click here](http://ei.cs.vt.edu/~history/index.html).

We would appreciate receiving suggestions for additional links from this page to other pages that amplify the topics covered in this video series, or provide "side-bar" information on topics that were, of necessity, omitted from the show. Please send me [e-mail](mailto:janlee@cs.vt.edu). We also encourage teachers to give homework assignments that would result in the development of web pages that could be added to this site. This is particularly important for the last two episodes!. Remember that this video series were originally broadcast in 1991 and in the intervening years many things have happened in the computer business -- the World Wide Web for one! So if there are things we need to bring up-to-date, perhaps we can do it through the medium of this Web page rather than attempting to redo the original video.

**Episode I - Great Brains**

Commentary by Paul Ceruzzi (Smithsonian Institute) and Doron Swade (Science Museum, London)  
What is a computer?  
The Need for Tables  
People as Computers  
[Charles Babbage](http://ei.cs.vt.edu/~history/Babbage.html) (1791-1871)  
The Jacquard Loom -- source of the ideas about punched cards  
[The Difference Engine](http://ei.cs.vt.edu/~history/DiffEng.GIF)  
The Analytical Engine  
[Ada Augusta King](http://ei.cs.vt.edu/~history/Ada.GIF), [Countess of Lovelace](http://www.uta.fi/~majyho/guru/Lovelace.html), [programmer](http://www.scottlan.edu/lriddle/women/love.htm)  
Adaptability of Computers to a Variety of Problems  
[Konrad Zuse](http://ei.cs.vt.edu/~history/Zuse.html) (1910-1995)  
[Not mentioned in the video, Zuse's machines were designated as the Z1 (1935-38), Z2 (1938), Z3 (1941) and Z4 (1945). The Z4 eventually led to s series of machines built by Siemens Corp.]  
The [ENIAC](http://ei.cs.vt.edu/~history/UNIVAC.Weston.html) -- Electronic Numerical Integrator and Calculator (unveiled 1946)  
Built by [John Mauchly](http://www.unisys.com/eniac/rare.html) and J. Presper Eckert.  
[University of Pennsylvania](http://www.seas.upenn.edu/~museum)  
Firing Tables  
Herman Goldstine, Army Lieutentant Aberdeen Proving Ground  
The Stored Program Concept (1946)  
[John von Neumann](http://ei.cs.vt.edu/~history/VonNeumann.html) (1903-1957)  
Patent Problems  
[The First Computer Company](http://www.library.upenn.edu/special/gallery/mauchly/jwm10.html)  
[The Manchester Machine](http://www.man.ac.uk/Science_Engineering/CHSTM/nahc.htm) (1948)  
"[Freddy" Williams](http://www.cs.man.ac.uk/mark1/williams.html), developer (and developer of the Williams Tube)  
[EDSAC -- University of Cambridge](http://www.dcs.warwick.ac.uk/~mck/Edsac96/Edsac_Simulator.html) (1949)  
[Maurice Wilkes](http://ei.cs.vt.edu/~history/Wilkes.html) (1913-)  
Supercomputers  
[Alan M. Turing](http://ei.cs.vt.edu/~history/Turing.html) (1912-1954), a paper by John M. Kowalik, student in [CS 3604](http://ei.cs.vt.edu/~cs3604)  
[COLOSSUS](http://ei.cs.vt.edu/~history/colossus.rebuilt.html) (1943)  
[The Turing Test](http://mrh.slip.netcom.com/scraptest.html)  
Donald Michie (1923-)

and one who was missed from the video but who is very much involved in breaking the German Enigma Codes with Alan Turing and Donald Michie during the Second World War, and who was involved in the development of the Manchester Machine, is [I. J. Good](http://ei.cs.vt.edu/~history/Good.html). Good is a faculty member in our Statistics department here at Virginia Tech! An excellent story on Jack also appeared in the [*Roanoke Times*](http://www.newrivervalley.com/decode/).

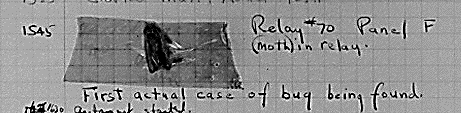
The ENIAC was 50 years old in 1996. The University of Pennsylvania put on a series of events during the year and established a [WWW Home Page](http://www.seas.upenn.edu/~museum) to keep you abreast of developments. It is intended that this page will also include a simulation of the ENIAC.

**Episode II - Inventing the Future**

The Growing Market for Computers  
[The First Computer Company](http://www.library.upenn.edu/special/gallery/mauchly/jwm10.html)  
Bureau of the Census Machine  
[UNIVAC](http://ei.cs.vt.edu/~history/UNIVAC.Weston.html) -- [A magazine advertisement of the time,](http://ei.cs.vt.edu/~history/SylvaniaUnivac.GIF)  
courtesy Unisys & GTE Sylvania, through WGBH Press Kit.  
Magnetic Tape  
Lyons Electronic Office- LEO  
John Pinkerton   
Commercial Applications  
[Cambridge University- EDSAC](http://www.dcs.warwick.ac.uk/~mck/EdsacWWW/MacEdsac.html)  
McCarthyism - Impact on Mauchly  
Henry Strauss  
Remington Rand  
[1952 Presidential Election](http://www.library.upenn.edu/special/gallery/mauchly/jwm11.html)  
IBM Enters the field  
SSEC - Selective Sequence Electronic Computer  
The First Drum Machine- IBM 650  
[Snow White and the Seven Dwarfs](http://www.computer.org/cspress/catalog/bp07383.htm)  
Programming Languages- Errors  
FORTRAN, COBOL  
Process Control and Automation  
[Bank of America](http://www.computer.org/cspress/catalog/bp07383.htm) - [ERMA](http://www.cbi.umn.edu/images/CBI/ge.htm)  
[Magnetic Ink Character Recognition - MICR](http://www.sensible-solutions.com/r_ckhis1.html)  
[The Transistor](http://ei.cs.vt.edu/~history/Transistor.GIF)  
[Brattain, Bardeen, Shockley](http://www.altavista.software.digital.com/inethistory/timelin2/1947/date1nf.htm) (this link appears to have disappeared, we are looking for a good replacement)  
Integrated Circuit- [Kilby](http://www.ti.com/corp/docs/history/kilby.htm) & [Noyce](http://www.altavista.software.digital.com/inethistory/timelin2/1968/date2nf.htm)  
Computers and Space

Episode II of "The Machine That Changed the World"" had the opportunity to give credit for the 'invention' of the computer to one [John Vincent Atanasoff](http://ei.cs.vt.edu/~history/Atanasoff.html). Atanasoff, together with a graduate student, Clifford Berry, developed a special purpose computer in the late 1930's that contained many of the elements of the modern computer. However, the development of the machine was hampered by the outset of World War II, and both Atanasoff and Berry moved to other work. In a later court case between Honeywell and Sperry Rand, the judge found the original patent claims by John Mauchly and J. Presper Eckert to be invalid, stating that the inventor of the computer was "One, [John Vincent Atanasoff](http://ei.cs.vt.edu/~history/do_Atanasoff.html)".

Another missing person is [Grace Murray Hopper](http://ei.cs.vt.edu/~history/Hopper.Danis.html). Dr. Hopper was perhaps the first modern woman to be involved in computers (Ada King, Countess of Lovelace possibly being the first in the 19th century). She started work for [Howard Aiken](http://cc.kzoo.edu/~k98hj01/aiken.html) in 1943 on the Harvard Mark I Calculator (also called the IBM ASCC). Subsequently she became deeply involved in the development of high level languages for computers, creating the concept of a compiler, and two early languages. She was highly influential in the development of COBOL and its usage in military installations. She became the [highest ranking female Navy person](http://ei.cs.vt.edu/~history/%20Hopper.GIF) of her time (Rear Admiral) and a role model to thousands of young women. She is perhaps best known for her discovery of the first computer bug in the Harvard Mark II computer. The bug now resides at the National Museum of American History in Washington DC.



**Episode III - The Paperback Computer**

Books in a Library  
Commentary by Mitch Kapor and Robert Taylor.  
[Sketchpad - Ivan Sutherland](http://www.sun.com/960710/feature3/ivan.html#ahead)  
Commentary by Ted Nelson (son of Ozzie and Harriett)  
[Doug Engelbart](http://www.superkids.com/aweb/pages/features/mouse/mouse.html) - [The Mouse](http://www.bootstrap.org/dce-patents.htm). Engelbart also produced an extremely foresighted paper on "[AUGMENTING HUMAN INTELLECT: A Conceptual Framework](http://www.histech.rwth-aachen.de/www/quellen/engelbart/ahi62index.html)" published on 1962. It is a classic that should be on the reading list for all computer science majors. This paper is on-line courtesy of students at the Technical University Aachen, Germany.  
  
Xerox PARC- [Alan Kay (a biography by Scott Gasch)](http://ei.cs.vt.edu/~history/GASCH.KAY.HTML)  
Children - Jean Piaget  
Games- Illusions  
[The Alto Computer](http://ei.cs.vt.edu/~history/Alto.GIF)  
Chips - Microprocessors  
Ted Hoff  
[Altair 8800](http://www.ncsc.dni.us/fun/user/tcc/cmuseum/altair.htm)  
[Homebrew Computer Club](http://ei.cs.vt.edu/~history/TMTCTW.html#nerds#nerds)  
[Steve Jobs and Steve Wozniak](http://ei.cs.vt.edu/~history/WozJobs.GIF), photograph courtesy of the Apple Computer Company, through the WGBH new release on this video. See also ["The Triumph of the Nerds"](http://ei.cs.vt.edu/~history/TMTCTW.html#nerds#nerds) and a biography of [Steven Wozniak](http://ei.cs.vt.edu/~history/WOZNIAK.HTM) by Manish Srivastava.  
Blue Boxes - Personal Computers  
Lee Felsenstein - IBM 5100  
IBM PC - 1981  
Macintosh - 1984  
Macintosh computer interface  
Environments  
Users  
The first spreadsheet by [Dan Bricklin](http://ei.cs.vt.edu/~history/BRICKLIN.Fleming.HTML) Lotus 1,2,3 - [Mitch Kapor](http://ei.cs.vt.edu/~history/Kapor.Schneider.html)  
[Microsoft - Bill Gates](http://ei.cs.vt.edu/~history/TMTCTW.html#nerds#nerds) (an [early history](http://ei.cs.vt.edu/~history/Gates.Mirick.html) by John Mirick and a [biography](http://ei.cs.vt.edu/~history/Gates.html) by Stacey Reitz.)  
[Sesame Street](http://www.pbs.org/programs/1996/december/descriptions/sesamestreet.html)  
[Handicapped - Assistive Technology](http://ei.cs.vt.edu/~cs3604/lib/Disabilities/murhpy.AT.html); an article by Christopher R. Murphy ([CS 3604](http://ei.cs.vt.edu/~cs3604), Spring 1997)  
Chained computers  
New Projections  
Illusions  
Virtual Reality: (Two articles by [Scott Tate](http://ei.cs.vt.edu/~history/Tate.VR.html) and [Keith Mitchell](http://ei.cs.vt.edu/~history/Mitchell.VR.html), [CS 3604](http://ei.cs.vt.edu/~cs3604), Fall 1996.)   
[Henry Fuchs - UNC](http://www.cs.unc.edu/~fuchs)  
[Fred Brooks, Jr.](http://heg-school.aw.com/cseng/authors/brooks/about-brooks.html)



**Episode IV -- The Thinking Machine.**

**Artificial Intelligence (A.I.)**

Late 1950s - [Marvin Minsky](http://www.medg.lcs.mit.edu/people/doyle/gallery/minsky/) and [John McCarthy](http://www-formal.stanford.edu/jmc/) set up an A.I. Dept. at MIT.  
1960 - Slagel's program for freshman calculus; from "number crunching" to intelligent problem solving.  
Mind vs. Brain approach; mind = software, brain = hardware. (The notion that a thinking computer need not be modeled on the actual biology of the brain is in vogue.)  
Block stacking program - lack of "common sense."  
1970 - Edinburgh University, "Freddie" image recognition application.  
1970s - Stanford Kart; motion planning. (Huge computational resources and time required to navigate through a room which a four year old child can do in real time.)  
Joseph Weizenbaum's [ELIZA](http://ei.cs.vt.edu/~cs3604/lib/Ethics/eliza.html).  
Russian to English language translator - earliest of the non-numerical applications. (Hype not lived up to.)  
Underestimation of the difficulty of A.I. (Tasks difficult for humans are found easy for computers and vice versa. Computers lack background knowledge.)  
Future of A.I. looks bleak - Dreyfus' "What Computers Can't Do."  
[Terry Winograd](http://pcd.stanford.edu/pcd-members/terry.html)'s SHRDLU - intelligence within microworlds.  
[Expert Systems](http://www.eas.asu.edu/~drapkin/556/dendral.html) - Feigenbaum's [DENDRAL](http://www.eas.asu.edu/~drapkin/556/dendral.html). (Deep but very narrow areas of specialization. Expert systems found to be "brittle.")  
"Idiot savants."  
Early 1970s - story understanding via scripts and frames. (Minsky.)  
Modeling commonsense. (Children possess broad and shallow knowledge. People learn by extending the fringe of what they already know, therefore computers make bad pupils as they lack "basic knowledge.")  
1984 - [Lenat's ten-year CYC project to catalogue "commonsense."](http://www.cs.umbc.edu/~narayan/proj/doc.html) (Create an encyclopedia of commonsense basic knowledge.)  
A new look at modeling intelligence by modeling the biological brain.  
1950s and 1960s - [Perceptrons.](http://ei.cs.vt.edu/~history/Perceptrons.Estebon.html) (an article by Michele Estebon, [CS 3604](http://ei.cs.vt.edu/~cs3604), 1997).  
Late 1970s - [Neural networks](http://ei.cs.vt.edu/~history/NEURLNET.HTML); Connectionists.  
Self-driven vehicle - "trained" to drive.  
Selective training - tank recognition failure.  
NetTalk.  
Large networks require large training times.  
Brain - a collection of special purpose machines --> general intelligence/ commonsense.  
A.I. - history of fascinating failures.

**Episode V -- The World At Your Fingertips.**

Rapid development of computers. (Forty-five years ago: ENIAC; $3,000,000 cost; believed only ever six needed. Now: millions of cheap computers; interconnected.)  
Print media --> Digital media. (More options for indexing and searching.)  
450 books on one CD.  
Digital world vs. analog "real world." (Patterns of digital pulses; 1 and 0.)  
Real world digitized into digital form - permanence; no degradation. (Digitized picture cannot age; perfect memory.)  
Digitized information amenable to rapid transmission. (Information sent down wires at the speed of light.)  
Global communications lead to shrinking world - disappearance of "place" as an attribute.  
Physical presence vs. "electronic presence" --> new forms of social interaction.  
Global communities - distance no longer an obstacle. (Financial traders part of global financial community - physically separate but part of the same "community.")  
Stock market. (As many trades in a day as it used to be in a week.)  
Increase of information travel rate.  
Timeliness of information.  
London Stock Exchange - physical "marketplace" rendered redundant.  
New social gatherings - linked by common interest, not geography.  
Internet and USENET - new forum for exchange of ideas.  
Cold fusion - quicker interchange of ideas via USENET news than possible via existing journals.  
SeniorNet - computer networks entering everyday lives.  
Electronic presence. (Left by electronic traces we leave behind as part of our day to day lives. Constant information gathering.)  
Data pollution - wrong information propagated between computers and databases. (Disrupts thousands of lives per year.)  
Invasion of privacy - casual information gathering can give rise to distorted views of individuals.  
Electronic sweat shops.  
Technological evolution outpacing social evolution. (Alvin Toffler, "Future Shock.")  
1987 Stock Market crash. ("Programmed selling" instigated avalanche of selling leading to 508 point crash.)  
Speed of light as a constraint.  
Effect on stability of social systems.  
Singapore - developed nation status via transformation into an "information society."  
"Digitization" of Singapore - Land Data Hub. (Database on all aspects of Singapore; complete electronic record.)  
Singapore - total electronic efficiency.  
Social engineering and control of people vs. tool for democracy.  
MINITEL - large growth from one to 12,000 choices.  
1986 - Student protests against admissions policies successfully coordinated via MINITEL.  
The future is digital!  
Dependence upon computers.  
Computers programmed in "craftsmanlike" manner.  
Software errors - no reliable engineering techniques for the production of software.  
Software bugs - human consequences; Therac-25 radiation machine software malfunction.  
AT&T telephone system crash caused by a single line of bad code. (Bug causes 20,000,000 phone calls being unable to connect and cripples phone network.)  
Untestability of large software systems.  
1989 - Dallas Fort Worth airport computer failure.  
Unlike traditional engineering, small errors can completely cripple entire software systems.  
Wheel turns full circle: Babbage's inspiration stemmed from the desire to eliminate errors. However, computers are still prone to errors via programmers, as in Babbage's time.  
Communication central to digital future.  
Uses of computers different from original goals.  
Computer a medium, not a machine.

**Additional stuff and thoughts:**

This last episode of "The Machine That Changed The World" was produced in advance of the development of the World Wide Web, and thus cannot be expected to cover this development. However, the fact that the WWW is now a part of our lives is a proof of the fast pace of innovation in this field. Though in no way comprehensive, here is a list of some recent developments that might have been included in this series of videos:

* [Radio Frequency Technology in Commodity Tracking by Scott Tate](http://ei.cs.vt.edu/~history/TATE.RF.HTML), [CS 3604](http://ei.cs.vt.edu/~cs3604), Fall 1996.
* It has come the ability to circumvent the established telephone systems by the use of the Internet and the WWW. This raises the question of the "[Internet Telecommunications Software: Need to Grow or Need to Pay?](http://ei.cs.vt.edu/~history/CHUH.INT_TEL.HTML)" by Jacob Chuh, [CS 3604](http://ei.cs.vt.edu/~cs3604), Fall 1996.
* [Supercomputers](http://ei.cs.vt.edu/~history/SUPERCOM.Calle.HTML) were in vogue in 1990, but they were not part of the video series. One of the key persons (some will say THE key person) in the development of modern supercomputers was [Seymour Cray](http://ei.cs.vt.edu/~history/Cray.Pepper.html). Cray died as a result of a traffic accident in 1996.

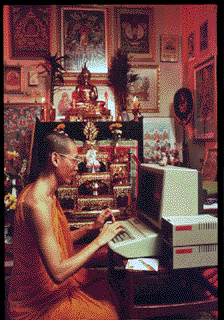
**Computer Trivia:**

A good source of computer trivia is the Annual ACM/Computer Museum Computer Bowl. The questions and answers to several year's questions have been published in the *Communications of the ACM*. The 1994 set were included in the August 1994 issue of [*ACMemberNet*](http://ei.cs.vt.edu/~history/ComputerBowl.1994.html).

**[The Triumph of the Nerds](http://www.pbs.org/nerds/)**

A 1996 PBS video, based loosely on the book by Robert Cringely "The Rise of Accidental Empires" includes interview and comments from Bill Gates, Steve Wozniak, Steve Jobs, and many others.

From the Publicity Release Package of WGBH.



The video tape series entitled "The Machine That Changed The World" is no longer available for purchase, but information about copies can be obtained from the [Association for Computing Machinery](mailto:mandelbaum@hq.acm.org) (one of the original sponsors of the series).

There is no web site or e-mail address available as of 96/10/02.

This collection of materials relating to the history of computing is provided courtesy of the [Department of Computer Science](http://www.cs.vt.edu) at [Virginia Tech](http://www.vt.edu), and is sponsored in part by a grant from the [National Science Foundation](http://www.nsf.gov) ([CDA-9312611](http://ei.cs.vt.edu)).

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