
Alice
&
Eve
2020
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Alice & Eve

A Celebration of Women in Computing

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Preface

Where are the women in computer science? Sure, everyone trots out first programmer Ada Lovelace, the human computers for the Manhattan Project and Bletchley Park, and of course Rear Admiral Grace Hopper, who invented the compiler and COBOL, a pioneering language that's still in use today. But what do we know about other women in the field? Why are there so few, why is that a bad thing, and what can we do about it? This booklet tries to help you find your own answers, by illustrating the lives and careers of some women who fought prejudice and bias to make names for themselves. Their stories will inspire the next generation.

For more inspiration, here's a story from the Python community. Python was never an "old boys" network, and there were occasional women participating, but nevertheless, we were a group of mostly white men. For example, in 2011 just one percent of the speakers at PyCon US were women. Then the Python Software Foundation appointed Jessica McKellar Director of Diversity. Together with other women in the community she started turning this number around. Their strategy was a mix of activism and policy changes: they talked about the need for more diversity, Jessica gave a keynote on the topic, they actively solicited women speakers from the community and from their own extended networks, PyCon instated subsidies for women and minority groups to attend the conference, and an improved Code of Conduct for the conference was enacted and actively enforced. The results were significant: by 2016, the number of women speakers was 40 percent.

What are you going to do to turn things around in your own community?

-Guido van Rossum, creator of Python

From the Editors

It is our pleasure to present Alice & Eve: A Celebration of Women in Computing.

This booklet portrays twenty-five women, highlighting their pivotal role in the field of computer science. The booklet has been written for the occasion of the Alice & Eve exhibition —the title Alice & Eve refers to the symbolic names from protocols for computer communication, in which Alice and Bob exchange messages, which are then intercepted by Eve. The exhibition will be first be on display at the University of Twente and then travel to various other places in the Netherlands. The opening is at the Alice & Eve conference, on the 24th of January, 2020.

Our aim with the booklet and the exhibition is to change the unfamiliarity with women who made breakthroughs in computer science. When people think of pioneers in computer science, they think of names like Alan Turing, Edsger Dijkstra, Gordon Moore, Steve Jobs and Bill Gates. Women are not in that list. And that is strange, because women have made crucial contributions to the field of computing.

It is our hope that, after reading the booklet or visiting the exhibition, you think Grace Hopper, Barbara Liskov, and Sanghamitra Bandyopadhyay when thinking of computer scientists. And, by presenting these role models, we like to show that it is very normal for women to participate in the scientific top.

Further, twenty-five is a small number. We had to choose, leaving out contributions over many others. Thus, we hope that this booklet is only a starting point for a large gallery of famous female computer scientists.

We kindly thank our sponsors for providing the budget needed to organize the exhibition and booklet.
Enjoy both of them, and let them be an inspiring eye opener for everybody!

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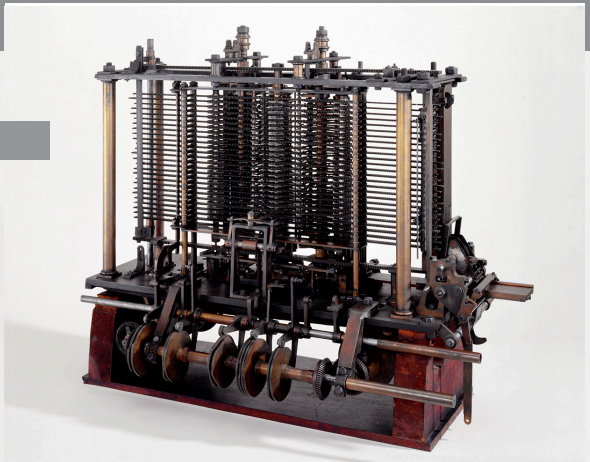
Ada Lovelace 1815 - 1852

The Enchantress of Numbers

Although she lived long before the invention of modern computers, Ada Lovelace can be considered one of the most famous women in the history of Computer Science. Admittedly, Augusta Ada Byron, as she was born in London, did not have a smooth start: her father, the famous poet Lord Byron, left the family even before they could celebrate her first birthday. In order to avoid the 'romantic ideals and moody nature' of her poetical father to which Ada's mother ascribed the failure of their marriage, Ada got divulged in - as unusual as it was for that time and place - a rigorous course of Logic and Reason, Mathematics and Science. Nevertheless, it seems that Ada's comprehension of those courses was greatly influenced by the imagination that she inherited from her father.

Lord Byron, Ada's father

As of today, Ada is most famously known for her work on the design of the ‘Analytics Machine’, the first ever general-purpose computer - a design that, by the way, would not be realized until 2002 (and it worked). Starting at the age of 17, it took her little time to prove she was a pioneer, being one of the first to believe that the computer could serve applications beyond pure calculation. Rather, she pondered that any piece of content - music, text, pictures and even sound - could be translated into a digital form, made manipulable by the machine. A pivotal point not only for Ada, but for the entirety of Computer Science occurred in 1843, when she was commissioned to translate an article by Italian engineer Liugi Manebrea and personally augmented it with some notes.



Ada’s analytics machine

One of these notes addressed how the computer could be programmed in such a way that it could calculate Bernoulli numbers. The note consisted of a list of coding instructions including destination registers, operations and even commentary - indeed, something that would be familiar to any C++ coder today. In retrospect, as it appears, this particular note might have been the first algorithm ever written.

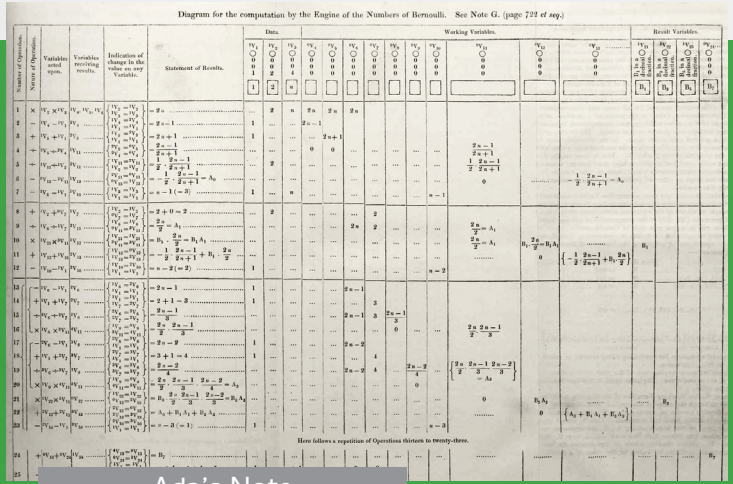


Diagram for the computation by the Engine of the Numbers of Bernoulli. See Note G. (page 722 *et seq.*)

Ada's Note

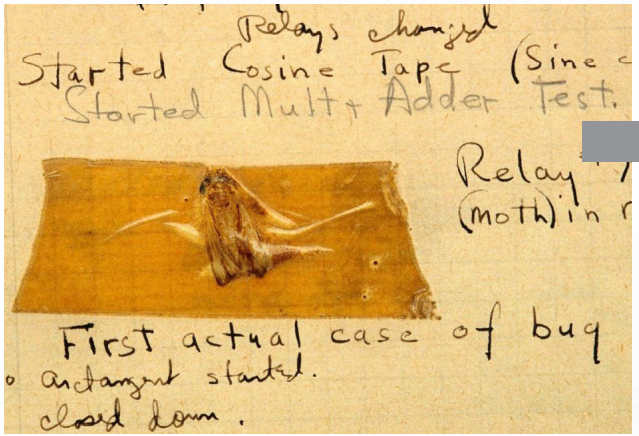
Ada's contribution to Computer Science is profound, both technically and philosophically. She did not only predict the rise of applications such as iTunes and Netflix 150 years before they were actually realized, she also brought together reason and imagination, that were, before her contributions, polar opposites of each other. Today, her legacy remains visible in every-day life, with the respectable programming language 'Ada' still being used around the globe in, e.g., the healthcare and aviation industries. Lastly, one must not forget that her contributions were done at a time and place where her gender was not necessarily contributory to her role as a computer scientist. Each year, therefore, on the second Tuesday of October, Ada Lovelace Day is celebrated, to raise the profile of women in Science, Technology, Engineering and Mathematics (STEM), and, at the same time, to create new role models for women in these particular fields.

Ada Lovelace Portrait

Grace Hopper 1906 - 1992

The Queen of Software

While she was working on the Mark II, an electromechanical computer financed by the United States Navy, Grace Brewster Murray Hopper found something peculiar that was impeding the operation of one of its relays: a moth. As such, in order to operate again, the relay had to be 'debugged'. Indeed, this term might sound familiar. One of the key terms in engineering - debugging, that is - originates from an actual bug discovered by Grace Hopper. This brief but amusing anecdote connects two important areas in which American computer scientist Grace Hopper would get to flourish: on one side, the American military, and, on the other side, the early computer industry, nurtured by the Second World War and, after that, the Cold War.



The bug Grace Hopper found

At the age of 34, Grace made a courageous attempt to enlist to the United States Navy. When this attempt failed, she decided to pursue a computing career, while, at the same time, joining the Naval Reserve. This decision appeared to be fruitful: in 1944, she became one of the first programmers of the Harvard Mark I, a general-purpose electromechanical computer that was used in the final stages of the Second World War. Her contribution manifested itself in a rather mundane object: the 561-page user manual that she single-handedly wrote. Remarkably, the team used computing principles that were already worked out in the 1800s by fellow woman in Computer Science Ada Lovelace. One of such principles was the usage of a library of commonly-used subroutines.

Grace Hopper and the Mark I

Grace's trailblazing work did not end along with the Second World War. While working for the Eckert-Mauchly Computer Corporation, she created the world's first workable compiler, known as the A-0 system. Finished by 1952, the compiler translated ordinary English into symbolic mathematical code and, thus, made programming much more accessible to ordinary folks. The development process that she used to create this compiler, which could be described as open and collaborative, was used again when she served as the technical lead in the coordination of the development of COBOL. This would become the first standardized business language for computers.

Grace Hopper at UNIVAC 1960

When Grace retired from the military in 1986, she had been one of the longest-serving officers in the United States military, having computed rocket trajectories and calibrating minesweepers for a respectable period of 42 years. In 1991, she became the first woman to receive the highest technology award of the U.S., recognizing her as a female computer pioneer. Indeed, in those years, it had not remained unnoticed that she accomplished all this being a woman. Hence, a part of her legacy is the creation of the Grace Hopper Celebration of Women in Computing, an annual conference designed to bring the research interests of women in computing to the forefront.

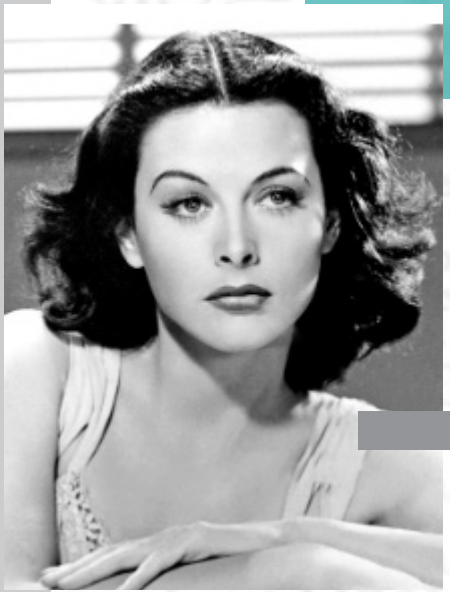
Grace Hopper

Hedy Lamarr 1914 - 2000

Lady Bluetooth

Once called the most beautiful woman in film, one is forgiven to associate Austrian-born Hedy Lamarr initially with her screen presence. And, admittedly, she has starred in many notable movies, such as 'Algiers' (1938) and 'Samson and Delilah' (1949). Notoriously, it was the 1932 German film 'Extase' that brought her to the attention of these Hollywood productions. Here, she would - for the first time in cinema history - depict a female orgasm. The scene prompted censorship in many countries as well as the personal condemnation of Pope Pius XI. Equally enraged by the obscenity was Hedy's Viennese husband Fritz Mandl. This arms dealer and Nazi sympathizer wanted to buy up all the copies of the overly exposing film. Rumour has it that Italian fascist Benito Mussolini refused to give up his copy.

The marriage - which she described as slavelike - ended in 1937. After having secured a ticket to Hollywood, she would quickly resume her cinematic career across the Atlantic Ocean. As historian Pamela Hutchinson notices: “[Her] characters, often exoticised in a nod to her European heritage, were beautiful creatures to be looked at, absorbed by the male gaze, and with very little to say.” Especially the latter started to irritate Hedy herself, claiming that “any girl can be glamorous. All you have to do is stand still and look stupid.”



Hedy Lamarr

Hedy was done with standing still. Friend and aviation tycoon Howard Hughes became aware of this and provided her with equipment to run experiments in her trailer during her free time. She was prolific, coming up with an improved traffic stoplight and effervescent cola tablets. In 1941, amidst the Second World War, Hedy would prove that it is indeed her technical mind that is her most prominent legacy. Together with composer George Antheil, she patented a 'Secret Communication System', allowing torpedoes to sidestep enemy efforts at radio interference. The system made use of frequency-hopping spread spectrum techniques that allowed both the transmitter as the receiver to 'hop' to new frequencies together. Doing so prevented the interception of the radio waves by the Axis powers. Today, the spread-spectrum technique that Hedy pioneered has become 'the crutch of secure military communication as well as mobile phone technologies' - such as Bluetooth, GPS and WiFi. Without Hedy's inventive mind, it has been claimed, the latter would not have existed.

Hedy Lamarr at work

Unfortunately, the U.S. Navy did not adopt the technology until the 1960s Cuban missile crisis, which is why Hedy never earned a penny with the patent. ‘Looks over action’ prevailed as well during the remainder of her lifetime. While she received a star on the Hollywood Walk of Fame in 1960, it wouldn’t be until 1997 that she became acknowledged for her technical contributions. This year, three years before her death, Hedy and George were honoured with the Electronic Frontier Foundation’s Pioneer Award. Moreover, in 2014, they became posthumously inducted into the National Inventors Hall of Fame for their Secret Communication System.

WESTERN EUROPE EDITION

THE STARS AND STRIPES

Unofficial Newspaper of U.S. Forces in the European Theater

Vol. 2—No. 128 1 Fr. Monday, Nov. 19, 1945

Hedy Adds New Twist to War

Actress Invents Control Device While Toying With Torpedo Idea, Has Patent to Prove It

HOLLYWOOD, Nov. 18 (AP).—It could not have been a press agent's stunt, because the timing was too perfect, but the report from London that film actress Hedy Lamarr had patented a radio steering device for torpedoes at least had a patent to back it up.

In an interview, Hedy modestly admitted she did only "creative work on the invention," while the composer and author, George Anthell, "did the really important chemical part."

Hedy was not too clear about how the device worked, but she remembered that she and Anthell sat down on her living room rug and were using a silver match box with the matches simulating the wiring of the invented "thing".

territory as soon as they crossed the channel, but German aviators were over friendly territory most of the way to England... I got the idea for my invention when I tried to think of some way to even the balance for the British. A radio controlled torpedo, I thought would do it."

Hedy asserted that the "control" device works on aerial as well as submarine torpedoes.

She said it works on anything and added that it was "lots of fun planning the invention and watching them pick, sort and put together all the little thingamabobs that went into the device." She said it was lots more fun being scientific than going to the movies.

She coyly dodged a query as to whether any company was interested in producing the device but did admit that as far as she knew no-

An article about Hedy

Jean Jennings Bartik

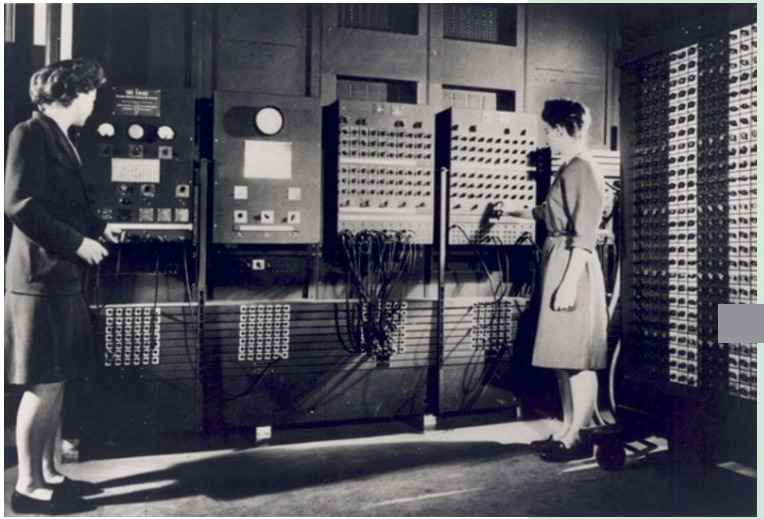
1924 - 2011

After finishing her degree in Mathematics and looking for an adventure, farm-born Jean Jennings Bartik went to work for the United States Navy. Here, together with approximately a hundred more women, she performed routinized math tasks by hand. Primarily, this meant the calculation of artillery trajectory tables. The Navy would become the starting place of her revolutionary career in Computer Science. It would encompass both her involvement in the programming of the first electronic general-purpose computer (the ENIAC), as well as her contribution to the stored-program computer architecture. It was equally in the Navy where she developed a strong feminist voice that she would uphold throughout the rest of her life.

Indeed, Jean was one of the original six women of the ENIAC team that succeeded in programming, for the first time ever, a fully-electronic general-purpose computer. What differentiated this computer from its predecessors was that it could perform a number of applications, rather than only one. As such, it was no longer needed that a new computer was made for every new application, be it the calculation of rocket trajectories or artillery firing tables. There would be only one computer performing several tasks depending on the software run on it. This pivotal point in the history of Computer Science meant the start of software and hardware coming to live separate lives. Finally, completed in 1945, the ENIAC proved to be highly successful: it could perform in 30 seconds a calculation that took the human 'computers' approximately 20 hours.

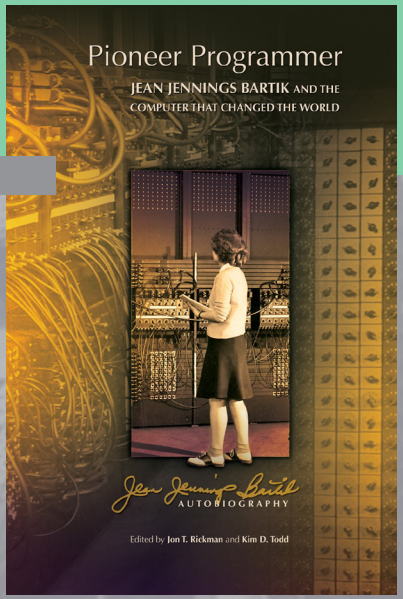
A Picture of Jean

After the Second World War, Jean assembled and trained the team that would convert the ENIAC into a stored-program computer: by storing computer programs in the same memory as its data, it would be possible to easily modify those programs even while running. As such, the programming time got reduced from days to hours. Up to her retirement in 1951, Jean continued on improving this stored-program computer architecture with its successor, the UNIVAC Computer. Due to its special architecture, the UNIVAC would outshine its closest competitors by being a thousand times faster.



Jean and the ENIAC 1946

Jean never made it a secret that she felt discriminated against for being a woman. “If the ENIAC’s administrators had known how crucial programming would be [...] they might have been hesitant to give such an important role to women,’’ she once proclaimed. Her criticism was justified. When the ENIAC was finally unveiled at the start of 1946, the women of ENIAC were not even invited to the pompous event. The experience inspired Jean to write an autobiography about all the instances where she and her peers were ignored in history. After having raised her voice at multiple events, Jean finally got acknowledged for her pioneering work. Among others, she has been inducted in the Women in Technology International Hall of Fame in 1997.



Jean’s autobiography

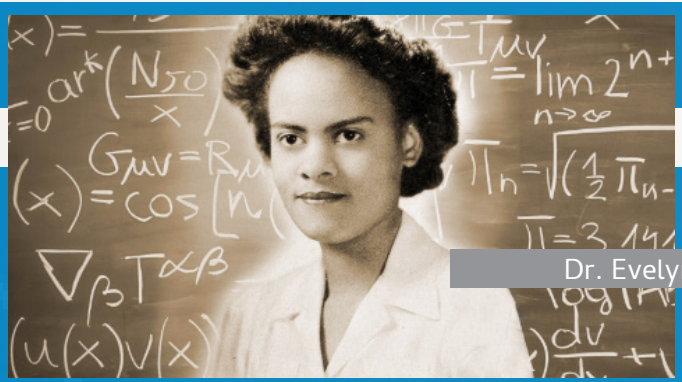
Evelyn Boyd Granville

The Hidden Figure

1924

The 2016 Academy Award-nominated film “Hidden Figures” revolved around Project Mercury, a project that saw John Glenn become the first American to orbit the earth in 1962. The film was emancipatory in nature, as it paid special attention to the way the recorded history of this project had been downplaying the accomplishments of African-American women contributing to this endeavour.

In total, Hidden Figures succeeded in shedding light on the work of seven African-American women that pioneered in the field of Mathematics - one of which is NASA scientist Katherine Johnson. Unfortunately, the film failed to include the work of another pioneer whose contributions to the field had been equally groundbreaking. Perhaps even more than the seven pioneers mentioned, this one, Dr. Evelyn Boyd Granville, could be equally described as a hidden figure.



Dr. Evelyn Boyd Granville

Attending high school in 1930s Washington D.C, Evelyn experienced racial segregation at the Dunbar High School. Nevertheless, she never experienced the same discrimination when it came to gender: “Fortunately for me, as I was growing up, I never heard the theory that females aren’t equipped mentally to succeed in Mathematics”. Even if she had, though, she would have proven it wrong by becoming the nation’s second black woman to receive a PhD in Mathematics from Yale University in 1949. She would continue to work professionally as a mathematician for the subsequent seven years.

Yale University

In 1956, however, Evelyn launched her career in the United States' space program by accepting a position at IBM that, at that time, was a contractor to NASA. Evelyn personally designed computer software that helped the latter to analyze satellite orbits for the aforementioned Project Mercury missions. As such, Evelyn became instrumental in developing orbital calculations that eventually launched rockets - and even people - into space. Her contribution to the space program would not stop here. In 1962, Evelyn enlisted to the subsequent Apollo Program that would eventually see the first humans landing on the moon. Before that would happen seven years later, though, she returned to IBM in 1967 to resume her career as a mathematician.

A capsule from Project Mercury

Although having received numerous awards for her contributions to both Mathematics as Computer Science, Evelyn mostly has a rich legacy focused on sharing her incredible knowledge with the next generations through numerous organizations and boards. In addition, she co-authored a didactic textbook for the teaching of Mathematics to elementary school students. Most notably, when asked to summarize her major accomplishments herself, Evelyn proudly stated the following: “Being an African American woman, letting people know we have brains too”.

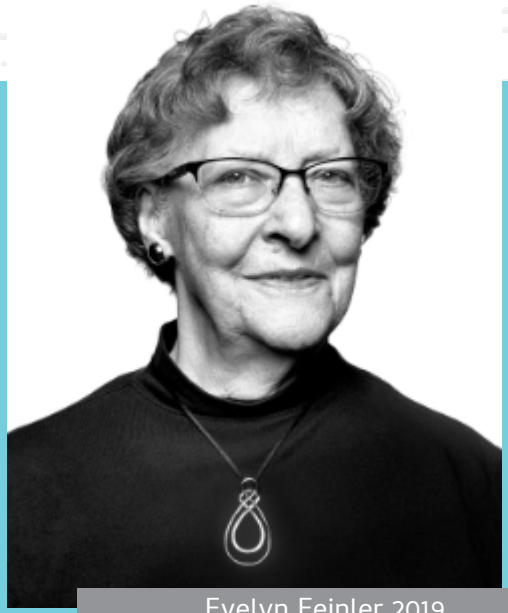
Dr. Evelyn Boyd Granville 2019

Elizabeth Feinler 1931

The Internet Herself

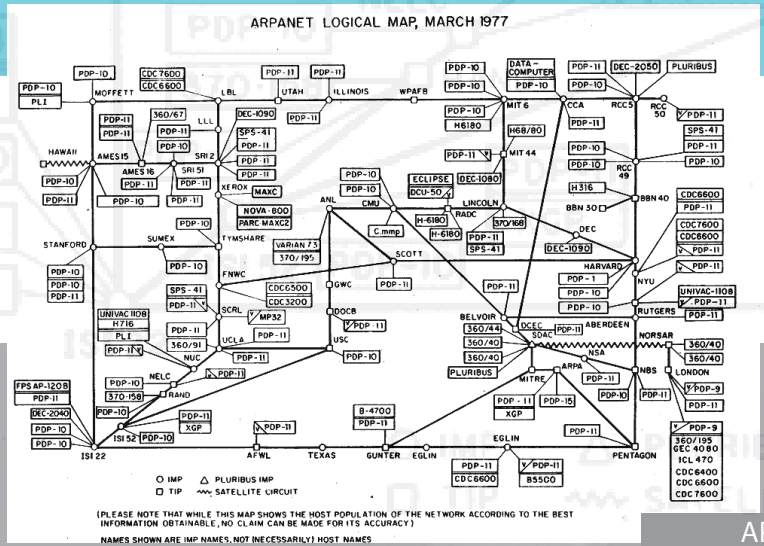
When the Arab Spring saw many North-African dictatorships being toppled, many spectators agreed: a new era of revolutions has been introduced and its primary weapon is the Internet. To answer the question of why the Internet allowed the organizing and gathering of protestors, one must have a look at its precursor. The 1969 established ARPANET was the first operational packet-switching network and equally the first network to implement the TCP/IP protocol suite. Its funder, the U.S. Department of Defense, had one demand for this communication network: it ought to survive a nuclear attack. Although contested, it is because of this that the ARPANET architecture got decentralized and distributed rather than taking the shape of a hub system with a central computer; messages passed from node to node. As a result, it would be more difficult to impose control over the entire network. Also, it would not be detrimental when one of the hubs - later called 'routers' - would be lost. When, in 1990, the ARPANET weaved into the Internet, this decentralization got passed along as well.

It is American information scientist Elizabeth Feinler that was the principal investigator to help run the ARPANET at the Network Information Center (NIC). After taking up the small task in 1972 of writing a handbook for its first demonstration, she saw herself becoming the centre's manager in a mere two years. One of Elizabeth's main objectives was to oversee the distribution of the ARPANET's 'white-' and 'yellow pages', which were directories of people and services on the network. Moreover, the centre oversaw the Requests for Comments, describing how the network would actually work. A third task was to run the central address servers. These servers told the network where everyone was located and it was equally the go-to-place for a new address.



Evelyn Feinler 2019

Elizabeth described the NIC as “prehistoric Google”. “People came to us for everything”. Indeed, she even maintained an ‘Internet hotline’ that you could call for urgent questions. Author Claire Evans recalls that, ‘if you wanted to add your computer to the early internet [...] you would call this office. And this woman would answer the phone and she was the one”. Reporter Anne Strainchamps would reply to this: “[You] are saying the Internet actually WAS a woman.”



ARPANET’s logical map 1977

When, by the late 1980s, central address servers became obsolete, Elizabeth's last main task at the NIC was the development of the Domain Name System. Under her auspices, top-level domain-naming scheme of .com, .edu, .mil, .org, and .net were developed and still widely used today. Upon her retirement in 1996, Elizabeth decided to become an active volunteer for the California-based Computer History Museum. Here, she takes pride in her work to save for future generations 'the history of what has turned out to be one of the greatest inventions of the modern world': the Internet.

Elizabeth Feinler at work

Frances E. Allen 1932

The Would-Be Math Teacher

When Frances E. Allen sidetracked from her journey to becoming a Mathematics teacher, she probably did not plan to become a true computer revolutionary. And yet, almost 50 years later, she would become the first female recipient of the renowned Turing Award, often considered to be the Nobel Prize of Computing.

To understand how this came about, one must return to the placid town of Peru, New York. After obtaining a Bachelor's degree in Mathematics in 1954, it is here where Frances decided to teach math to high school students. Both the place as the profession were not arbitrarily chosen. Peru had been her own birthplace, where she grew up on a dairy farm that knew no electricity, plumbing or even central heating - Frances herself had dubbed it the 'Depression Farm'. Convinced that education could empower the local children, she believed that she was the designated person to introduce them to the world of algebra and trigonometry. However, after obtaining her Master's degree in Mathematics in 1957, she found herself deeply in debt; looking for a more lucrative job that would pay her loans until she could return to teaching.

This opportunity was provided to her by IBM's research division, where her first assignment was to teach Fortran to a skeptical staff of programmers. Rather than communicating with the computer in either 0s or 1s - as the 'hardware kings' of IBM had done thus far - this recently developed programming language would allow for communication with the computer in a way closer to human understanding. It was made possible by a compiler program, translating instructions written in a 'human' language into the digital code of the machine.

Frances E. Allen

Frances E. Allen receiving the AMC Turing Award in 2006

When Fortran succeeded in making programs as efficient as equivalent hand-coded programs, Frances was so impressed that she would not leave IBM until her retirement 45 years later; becoming ever more devoted to making compiler technology more efficient. Notably, in the early 1960s, she worked on compiler optimization during a secret project for the U.S. National Security Agency, where a special computer set out to harvest intelligence from intercepted communications from spy listening posts all around the world. Moreover, from 1980 to 1995, Frances headed valuable research that worked on compiler software for parallel machines. With the rise of the microprocessor, namely, IBM was in need to convert its traditional mainframes into parallel computers to ensure its survival. In response, the company made her the first female IBM Fellow.

Frances E. Allen at the opening event of the Computer History Museum's Revolution exhibition

It is her theoretical and practical contributions to both compiler technology and parallel programming that eventually made Frances the first female recipient of the Turing Award. And, although she has never returned to becoming a math teacher, she has continuously shared her innovations at academic workshops and lectures throughout her impressive career.

Frances E. Allen receiving the Erna Hamburger Distinguished Lecture Award 2008

Qiheng Hu 1934

The Global Connector

In 1992, philosopher Andrew Feenberg made a significant contribution to the philosophy of technology by coining the term 'subversive rationalization', a term to describe the way in which technologies are adopted and used differently over time. Importantly, as Andrew claims, such a metamorphosis results in a "democratizing trend that may convert a given technology from an instrument of social control to one that is guided by democratic social forces". To substantiate his claim, he often refers to one of the zeniths of the digital age: the Internet. Clearly, he would say, the Internet has shown to possess quite a liberating effect. Most recently, it has contributed greatly to the toppling of North-African dictatorships in the 'Twitter Revolutions' of the Arab Spring.

Andrew Feenberg 2012

Only two years after Andrew introduced his concept of technological empowerment, Chinese computer scientist Qiheng Hu decided to bring the Internet to her home country. In 1994, that is, she became responsible for setting up the first TCP/IP connection in China, coupling her country with the 'Global Internet'. Less than three decades later, China has become the country with the most Internet users worldwide.

Qiheng Hu

Madam Hu, as she is charmingly addressed by the Chinese, started her career in the 1980s at the Institute of Automation after graduating from the Moscow Institute of Chemical Machinery in 1963. After being promoted to Vice President of the Chinese Academy of Sciences in 1988, she got involved in talks at the National Science Foundation that eventually led to the setting up of the first Internet connection in 1994.

Eight years later, Qiheng's devotion to the Internet had not withered, seeing her co-found the Internet Society of China (ISC) in 2001. This civil society, of which she is now the President, remains to dedicate itself to the promotion of Internet access and application for school students in the peripheral and disadvantaged areas of China. As she would say during her Internet Hall of Fame induction speech in 2013: 'The Internet has dramatically accelerated the stepping forward course of my country'. Thanks to the efforts of Qiheng, 58% of the Chinese people now actively make use of the Internet.

Madam Hu speaking at a co-organised event by Internet Society China and Google 2009

However, whether or not the Internet is as 'forward stepping' as Feenberg claims is a topic of continuous debate: has the Arab Spring made life better for citizens after all? Do Tech Giants like Google, Facebook and Twitter determine what we know? The Chinese Internet equally remains to be tightly controlled by the Communist Party; frequently used for the dissemination of one-sided propaganda. In response, philosophers have claimed that subversive rationalization is a myth: the Internet is repressive, rather than liberating. Just like any technological invention, the Internet also has its dark sides. Nevertheless, Qiheng remains committed to the idea of strengthening it: protecting user rights, reducing the digital divide and raising public awareness throughout.

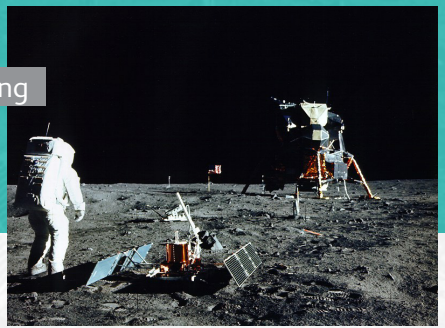
Madam Hu speaking at the U.S. China Internet Industry Forum 2008

Margaret Hamilton 1936

The Woman who sent Man to the Moon

‘That’s one small step for man, one giant leap for mankind’, as astronaut Neil Armstrong legendarily pronounced when he descended the ladder of the Apollo 11 moon lander. On July the twentieth of 1969, Neil became the first human being in history to set foot on the surface of the Moon, an achievement that would have great cultural, philosophical and even political significance.

In the spirit of the age, it was not quite surprising that these first steps were taken by a man. After all, 1960s United States still saw women being encouraged to take on more domestically appropriate jobs - if not to stay at home. So much more the surprise that it was actually a woman - by the name of Margaret Hamilton - that was the lead developer for Apollo’s flight software. Nay, not just a woman, one might emphasize. What made Margaret even more of an anomaly was the fact that she was also a working mother. Not her gender nor her motherhood, though, prevented her from becoming ‘The Woman that sent Man to the Moon’.



Footage from the Apollo 11 moon landing

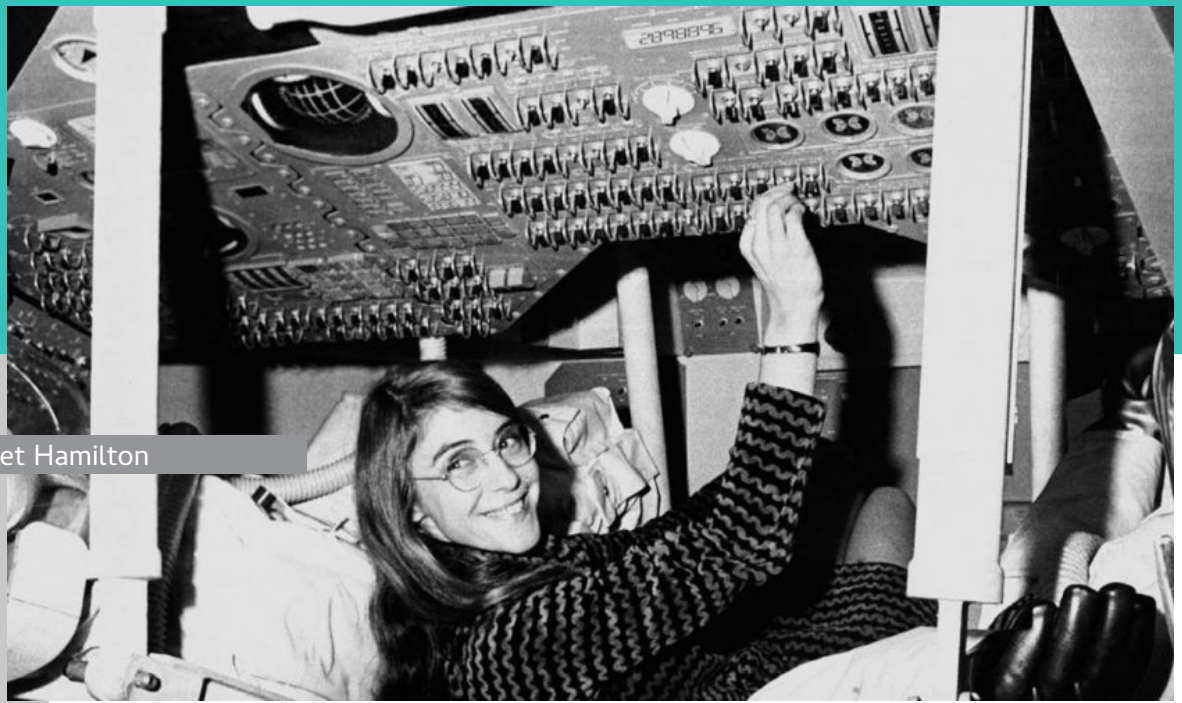
Ironically, Margaret's matriarchal climb to the top had quite a patriarchal start: in 1960, she took a temporary position at MIT's meteorology department only to support the family while her husband was earning his undergraduate degree. Caught up in MIT's laboratory, though, it would soon become clear that her position as a software engineer was to become a permanent one. Whereas she initiated her career by developing software for weather prediction, she soon started to work on the SAGE Project. Here, she would write software for the detection of enemy aircraft during the Cold War.

Margaret and the navigation software that she and her MIT team produced

The tensions between the United States of America and the Soviet Union equally manifested themselves in quite a different setting: a race to the Moon. Indeed, the winner of this 'space race' would be technologically superior over the other, and, therefore, both nations endeavoured to win it. Given that Margaret's work on the SAGE project had left her highly recommended for the position, she became the lead programmer on Apollo's on-board software. She proved to be indispensable throughout: due to unexpected error messages popping up only three minutes before the landing, it was almost decided that the mission should be aborted. Having done her job well, Margaret quickly identified those messages as erroneous, allowing the 'giant leap for mankind' to proceed.

Margaret Hamilton accepting an award 2019

Margaret's love for software engendered more than 130 publications, two companies and it eventually earned her a Presidential Medal of Freedom. Overall, the importance of software made Margaret realize that it deserved just as much respect as any other engineering discipline. Along with some peers, she therefore coined the term 'software engineering', a term widely adopted today but fought for in the 1960s.



Margaret Hamilton

Mary Allen Wilkes 1937

The Poet of Bits

In 1945, American engineer Vannevar Bush envisioned computers emerging in a rather intimate fashion: “a future device for individual use, which is a sort of mechanized private file and library”. He dubbed the computer a ‘memex’ and he imagined it to have a direct entry in the form of a keyboard. For Vannevar, the notion of intimacy was of special importance. He wished to make “close, personal connections between man and machine”.

The memex, though, would not present itself for forty more years. Remarkably, renowned engineer Ken Olsen would even declare during a 1974 meeting that he “[could not] see any reason that anyone would want a computer of his own”. In retrospect, he could not have been more wrong. When the memex finally got introduced to the big audience at the start of the 1980s, soon everyone wanted to have one. Not that the device became known as the memex, though. Rather, we know it as the ‘Personal Computer’.

Amidst all of these calendar years, one must not forget the one of 1959. It was in this year that a student by the name of Mary Allen Wilkes visited the Massachusetts Institute of Technology (MIT) to return with a job as a computer programmer. Fortunately so, for five years later, she would write crucial code for the Laboratory Instrument Computer (LINC), the first ever personal computer. Surely, one can imagine the era that she heralded.

Mary Allen Wilkes

Interestingly, Mary herself did not anticipate a career in programming. Rather, she wished to go into law. Due to the sexism of the time, though, it was likely that taking such a path would promise her 'a life in front of the typewriter', rather than becoming an attorney. Therefore, advised by her teachers, she decided to become a programmer. That profession was - for those who noticed - given to her rather nonchalantly. Although she did have experience with symbolic logic due to her background in Philosophy, the nonchalance was primarily due to her gender: the MIT was hastily looking for 'poets of bits'; precise and picky minds. Women, in that respect, seemed perfect for the job. At the MIT, then, Mary was soon enlisted to the LINC project. Here, she was given the task to write 'LAP6', its operating system. In late 1964, she succeeded.

Mary Allen Wilkes with LINC at home 1965

Funnily enough, just before that moment, the LINC had been relocated to St. Louis. As Mary had no desire to relocate herself, she had one shipped to her parents' residence in Baltimore, making her the first person on Earth to have a personal computer in her own home. One must remember that, having the size of a refrigerator, this 'PC' was not quite as elegant as we know it today. Shortly after this triumphant moment, Mary audaciously attended Harvard Law School where she nonetheless fulfilled her childhood dream: becoming a successful lawyer. Far away from the typewriter, that was.

Mary Allen Wilkes

Barbara Liskov 1939

The Inventor of Abstract Data Types

When, in 1961, Los Angeles-born Barbara Liskov decided to apply for the graduate Mathematics program at Princeton, she received a little postcard that was as blunt as it was brief: Barbara was a woman and Princeton did not accept female students. In retrospect, though, this gruff rejection might have been a blessing in disguise. Namely, disappointed by her own naivety, Barbara decided to look for a job instead. This brought her to the Mitre Corporation, having its initial focus on the U.S. Air Force SAGE-Project. It is here where she discovered her love for computers and programming.

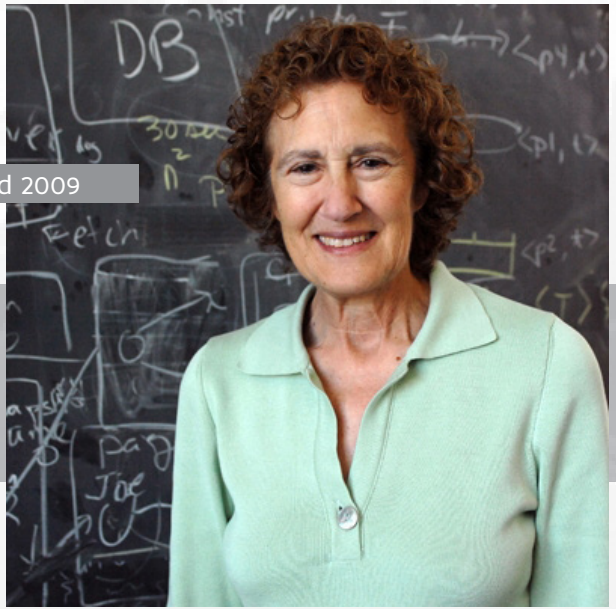
Barbara Liskov

At Mitre, Barbara quickly recognized that any software application is a complex structure of interlocking parts, being continuously modified by a large team of software engineers. She reckoned that any change in the code could have unintended effects on the other parts of the software, requiring programmers to essentially rewrite the entire program. To combat this inconvenience, Barbara designed 'CLU'. Being the first language to support data abstraction, it is frequently referred to as the first ever object-oriented programming language. By structuring computer programs in discrete chunks, changes in the program would now be less likely to affect code outside the designated boundaries. Together with the design of Argus - a distributed programming language - Barbara's residency at Mitre would contribute profoundly to languages like Ada, C++, Java and Python. In turn, those languages are widely used for the creation of software applications for - among others - personal computers and the Internet.

Perhaps the success at Mitre motivated her to go back to school. Stanford University had fewer problems with her gender and, in 1968, she became the first woman to receive a PhD from a U.S. Computer Science department. The career that followed would see even more major breakthroughs in fundamental areas, such as in operating and distributed systems as well as in programming methodology. Notable contributions are Thor, an object-oriented database system, and the Liskov substitution principle, a particular definition of subtyping that got named after her.

Barbara Liskov while designing abstract data types

“It’s hard to imagine what today’s programming and distributed systems would be like without Barbara’s many seminal contributions”, is why colleague John Guttag wished to nominate Barbara for a Turing Award. The following year, in 2009, she became the second female recipient ever. And, as mundane as her hobbies might appear - gardening and reading mystery novels - as modest as Barbara has stayed. After going out to dinner with family to celebrate the award, her son noticed that she seemed relieved that the furor finally passed. Now, she could return to the research that had always been driving her. At the age of 80, she continues to do so at MIT, focusing on Byzantine fault tolerance and distributed computing.



Barbara Liskov wins Turing award 2009

The Bletchley Park Codebreakers

The Bletchleyettes

Almost 90 kilometres northwest of London, one can find the Victorian manor of Bletchley Park. During the Second World War, this redbrick estate housed the 'British Government Code and Cypher School'. Here, a team of geniuses set out to penetrate the secret communications of the Axis powers. Under the auspices of Alan Turing, they succeeded twice. Firstly, in 1940, they created an electromechanical device dubbed 'the bombe' to decipher the Germans' infamous Enigma-encoded messages. Secondly, when Adolf Hitler ordered their messages to become more complex, they developed 'the Colossus'. This enormous fully-electronic computer could break even the most sophisticated messages. As a matter of fact, Colossus' very first intercepts provided U.S. General Dwight Eisenhower with some valuable information regarding the soon-to-follow Normandy Landings in 1944. It is said that, without the efforts raised by the Bletchley Park codebreakers, the outcome of the war would have been uncertain. Possibly, it would have lasted two to four more years. Unfortunately, due to persistent secrecy shrouding their activities, recognition remains low or non-existent.

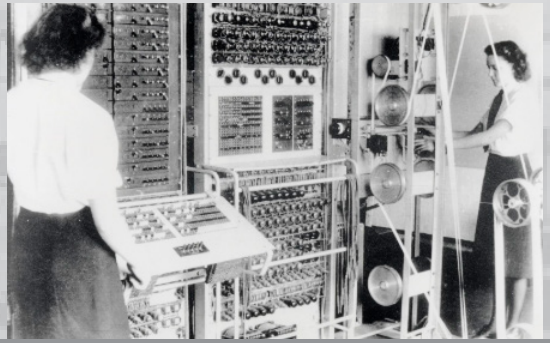
Equally concealed are the many efforts made by the approximately 8.000 female workers that, together, constituted three-quarters of the total workforce. Given that many men were sent to war, it was believed that women, too, could be of value with respect to the Bletchley Park-related cryptography activities. Some women were recruited from the university, others originated from trusted family connections. When the personnel needs of Bletchley continued to grow in 1942, women were even recruited from a cryptic crossword competition published in the Daily Telegraph. Once selected, these 'Bletchleyettes', as they were referred to, held numerous positions. Some took up clerical duties, others operated cryptographic machinery. Some even became true code-breaking specialists, such as Mavis Batey, Jane Fawcett and Joan Clarke.

Mavis Batey

Jane Fawcett

Joan Clarke

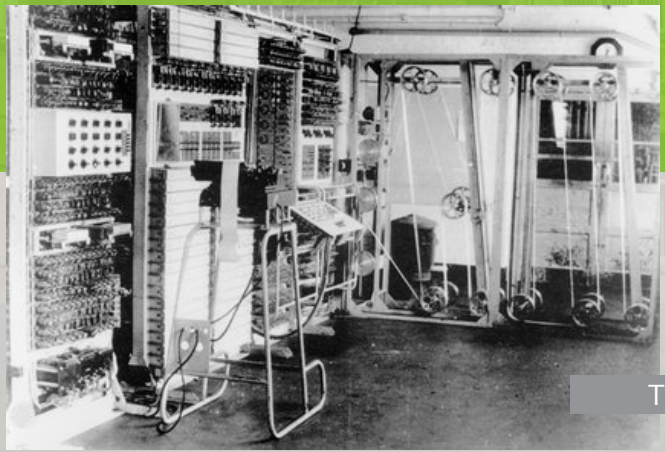
Bletchley Park Manor



Colossus Mark 2 code breaking computer being operated by Dorothy Du Boisson (left) and Elsie Booker (right) 1943

Some of the Bletchley Park Codebreakers

As it appears, Bletchley Park was not only the place whence the Germans were attacked most fatally - albeit with Mathematics rather than bayonets - it was equally the birthplace of the first fully-electronic and programmable special-purpose computer: the Colossus. Unfortunately, due to primarily male employees being associated with this computer, the entirety of Bletchley Park seems to be remembered as a male endeavour. In response to this imbalance, commemoration efforts have been made over the past years to bring these women together; giving them a voice. This task was complex, though: even 70 years after the war ended, the women of Bletchley Park still take serious their oath of secrecy. As a matter of fact, not rare is the occurrence that the friends and families of these women learn about their participation only by reading about it in a book or newspaper, rather than hearing it from them directly.



The Colossus

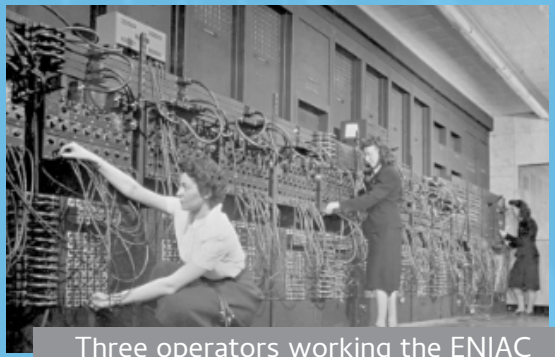
The ENIAC team

The Sensational Six:

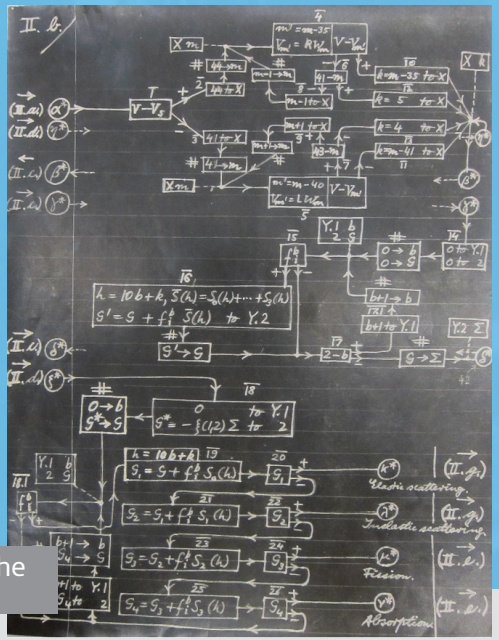
Betty Jennings
Marlyn Wescoff
Ruth Lichterman
Betty Snyder
Fran Bilas
Kay McNulty

One can say that, in 1945, two teams were competing in a race to realize the first ever general-purpose computer. One team was led by, among others, the famous computer scientist Grace Hopper. Her computer, the Mark I, soon became the most easily programmable big computer, being able to switch tasks simply by getting new instructions through punched paper tape rather than requiring a configuration of its cables. Because of this, Grace quickly deemed her computer superior over the other. She made a valid point. The other one, named the ENIAC (Electronic Numerical Integrator and Computer) could only be 'programmed' by altering cable connections. As Grace would say: "you plugged the pieces and essentially you built a special computer for each job". As a result, the time it took for the ENIAC to be reprogrammed, which could be an entire day, wiped out the advantage it had in processing speed: given that the ENIAC was a fully electronic computer, while the Mark I still used slow and clackety electromechanical relays, the first was more than eight times faster once it was running.

To make the ENIAC as ‘general-purpose’ as the Mark I - and to outstrip it as well - a group of six women endeavoured to demonstrate that the programming of a computer is as significant as the design of its hardware. More profoundly, they showed an early understanding of a defining fact of the subsequent computer age: hardware would become commoditized and programming would be the locus of its true value, something that eluded most men until the arrival of Bill Gates in the 1970s.



Three operators working the ENIAC

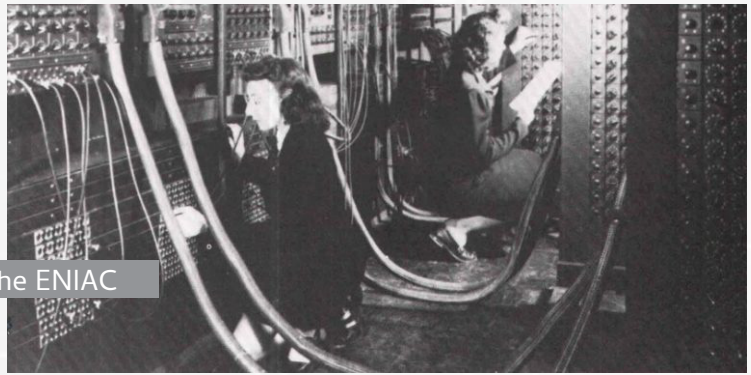


A diagram of the original demo of the ENIAC

The women of ENIAC, who started their careers at the United States Army as human ‘computers’ calculating artillery trajectories by hand, were asked to delegate the various tasks for which the ENIAC was needed not to the hardware - as it was done up to that moment - but to the software. And they succeeded. Using (nested) subroutines and modularization, computer code could be repeated for new tasks without the need to continuously reset the hardware, the arduous task they had set to eliminate. At the end of 1945, the ENIAC was used in practice for the first time.

The ENIAC machine

Regrettably, the six women mentioned now were not recognized for their trailblazing work until the 1980s. Interestingly, when researcher Kathy Kleiman, at the start of the 1980s, came across a photograph of the six women standing next to the ENIAC, a representative of the Computer History Museum told they were 'refrigerator models' standing in the photograph only to make the product look good. Nevertheless, due to the efforts of Kleiman and her peers, the Women of ENIAC have finally become recognized for their major contributions. Most notably, in 1997, the six women were being inducted into the Women in Technology International Hall of Fame.



Kay McNulty on the left working the ENIAC

Linda van der Gaag

When there is a risk, this means that there must be something that is unknown and, because of that, has an unknown outcome. Since the 1970s, due to its moral significance, the field of Philosophy has seen increased attention to risk-related issues: how to address such instances where one possesses only limited information about the situation under investigation? Suppose, namely, that a doctor needs to determine what is going to be the most effective treatment for one of their patients. Equally suppose that there are many of such treatments and that some are better than others - although it being unknown which ones. Clearly, some of the treatments will improve the patient's well-being whereas others not so much. Now, at some point, the doctor needs to make a decision. But which one? Evidently, the presence of risk and the grave consequences that their decision might entail are troublesome - to say the least.

Dutch computer scientist Linda van der Gaag has equally sought to confront the issue of risk. Although risk reduction has become a standard term in Computer Science, Linda takes an innovative approach. Since 2000, she has led the way in creating software for ‘Decision Support Systems’. Formulated crudely, such systems are computer programs that calculate mathematical models to map the factors of uncertainty that are problematizing decision-making within a given situation. Subsequently, those mathematical models are to support the relevant stakeholder in doing so nonetheless.

Linda van der Gaag

Linda believes her support systems can be used throughout all of society, from the detection of swine fever in pig herds to the construction of bridges. However, her personal interest lies in applying them to processes of nature: “How can one apply Mathematics to calculate the effects of certain interventions with nature?” she wonders. In line with this interest, she has already worked together with the Netherlands Cancer Institute to develop a decision support system that predicts the normally uncertain growth of certain tumours. Just as the anecdote introduced earlier, this system aims to support medics in connecting cancer patients to their respective treatments at a level of speed and accuracy going beyond that of which a human doctor is capable.

With her ingenious combination of Computer Science and Applied Mathematics, Linda continues to develop her concept of decision support systems at the University of Utrecht. A remarkable fact: unlike other groups in her area, the majority of researchers working together with Linda are actually women. According to Linda, this is simply because women appreciate applying Computer Science to other areas as well, such as Biology and Medicine. Interestingly, when Linda decided to study Mathematics herself upon finishing high school, her dean advised her otherwise: Mathematics was a 'boys' program'. Evidently, she proved him wrong.

Linda van der Gaag for the advisory board of the Centre of Complex System Studies at the University of Utrecht

Sana Odeh

Whereas the Western world hardly sees the enrollment of women in Computer Science rise above 20 percent, Arab countries seem to defy this unfortunate trend. Indeed, that same percentage seems to be close to 50 percent in the Middle East; even crossing it in countries such as Palestine, Egypt and Saudi Arabia. According to Clinical Professor of Computer Science Sana Odeh, this is because “Arab women don’t believe it is a man’s world when it comes to these fields”. Rather, she claims, they see the creative solutions that a subject such as Computer Science can offer; with which they can go on to apply it in a way that society benefits from it.

Sana Odeh

The great number of female technologists in the Arab world is what inspired Sana to make it part of her personal research agenda. While setting up the curriculum of the Computer Science Department at the New York University of Abu Dhabi, she founded and became chair of 'Arab Women in Computing'. Officially initiated in 2012, this organization has already expanded to seventeen countries, stretching from Morocco to Lebanon. Its mission is the same throughout: to support and help elevate the status of women in the Arab world. During the many international conferences organized by it, the 2.000 female members discuss how to manage male counterparts, how to deal with stringent family commitments and what is the importance of female role models.

Sana Odeh at the 5th Arab Women in Computing Conference

Evidently, the latter is a bridge to Sana herself. During her ongoing residency in Abu Dhabi, she has devoted herself to research into web- and mobile technologies, game programming and both the evaluation as the implementation of e-learning systems. Moreover, Sana's curriculum attributes a prominent place to the development of information technologies for the developing world. Related to this is the 'International Hackathon for Social Good' that she has been organizing almost annually as of 2011. Here, she endeavours to develop innovative applications relevant to fields such as health, education, business and science; all for the benefit of social good in the Arab world. The latest version of it, having taken place in 2018, saw 'hackers' from 60 different universities make their way to the Abu Dhabi campus.

Sana Odeh teaching migrant workers their rights

Notably, Sana's prominence in the field has not remained unnoticed. Already in 2010, she received a Special Award from Google itself. As it bombastically commented: "[We] believe strongly in your mission and the impact you are having". Furthermore, in 2016, Sana became a finalist to receive a World Technology Award, dedicated to celebrating the world's most innovative individuals and organisations in science, technology and its adjoining fields. What Sana might cherish the most herself, though, is the five recognition awards that she has been receiving at the Grace Hopper Celebration of Women in Computing Conferences.

Sana Odeh receiving the Grace Hopper Award 2018

Nancy Hafkin

Many political philosophers agree on the equalizing and empowering potential of Information and Communication Technologies; embracing them with great enthusiasm. Applied ethicists such as Emma Rooksby even believe that the access to information - made possible by these technologies - should be considered a primary good. However, due to this importance, there is equally an increasing concern over the uneven distribution of this great 'information wealth' - often dubbed the 'digital divide'.

U.S.-born Africanist Nancy Hafkin expressed similar concerns already at the end of the 1970s with regard to the African continent. She voiced her concern especially in the context of education: "Many university libraries hadn't gotten new books or journals for more than a decade. [...] This was the beginning of an information age, and Africa had no entry to it. Those that had the least access to information needed it the most"

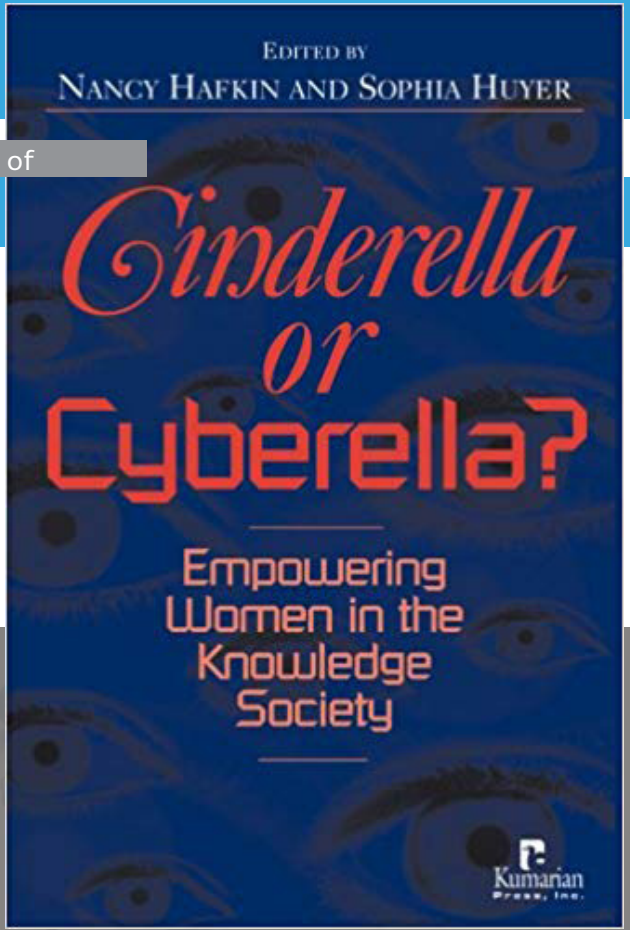
Nancy Hafkin 2013

At the time of voicing these concerns, Nancy had already relocated to Africa herself some years before. While her husband was contributing to the building of an equitable new order in Ethiopia, Nancy found herself a small assignment at the African Training and Research Center for Women in Addis Ababa. This part-time job would be the stepping stone to becoming the head of the Pan African Development Information System (PADIS), slowly introducing the entire continent to the world of ICT.

PADIS first started to use electronic networking in 1988, exchanging information using low-cost, modem-based electronic communications. This was a daunting task: modems were slow, constantly broke and costs were astronomically high - even ignoring the fact that, at times, they had to be smuggled in due to strict regulations. In 1990, though, new and cheap store-and-forward technologies, such as FidoNet and uucp, made it possible to set up the first email networks of Africa; providing low-cost email, file transfer and database access. Under Nancy's watch, 24 African countries set up their first email networks between 1991 and 1995; an accomplishment for which she would eventually be inducted into the Internet Hall of Fame in 2012. Notably, all this was done using dial-up connections on regular telephone lines; full Internet TCP/IP connectivity was not yet possible. That would happen another five years later, when Eritrea would become the last African country to obtain full Internet connectivity. Nancy herself was only a witness of that, though, for she retired three years earlier in 1997.

Nancy being inducted into the Internet Hall of Fame

The book Nancy Hafkin is co-author of



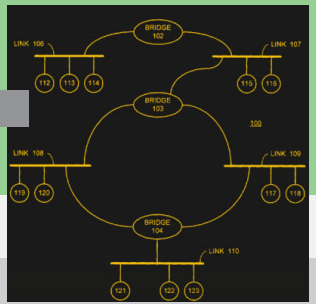
To say the least, throughout her career, Nancy has maintained a focus on the importance of women in technology: "if a country does not invest in female resources, it loses half of the productivity it might have". The topic would become thematized in her post-retirement years. Notably, she co-wrote the book 'Cinderella or Cyberella?', in which she discusses how ICT can be used for the overall empowerment of women.

Radia Perlman 1951

The Mother of the Internet

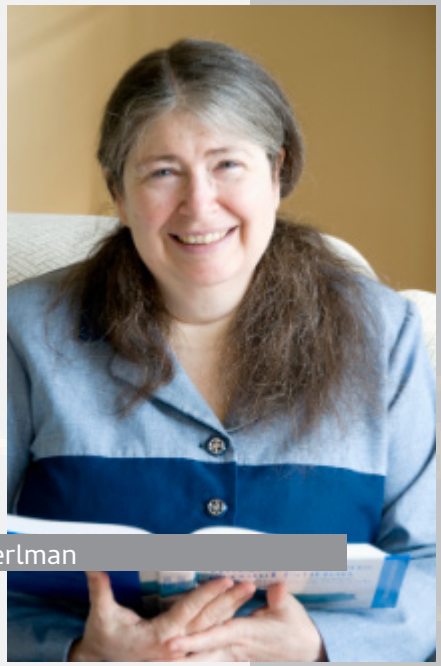
If there is one lesson to be drawn from the historical narratives of innovations, it is that creativity is a collaborative process. This is true for every era of creative disruption, such as the Scientific and Industrial Revolution, but it is most certainly true for the digital age as well. As historian Isaac Walterson previously proclaimed: “An invention [...] usually comes not from an individual brainstorm but from a collaboratively woven tapestry of creativity”. The same is true for the following digital age phenomenon: the Internet, the global system of interconnected computer networks that link devices worldwide. Therefore, it seems erroneous to attribute it to a single ‘Father of the Internet’. Nevertheless, some individuals have been referred to as such due to their crucial involvement. Computer engineers Vinton Cerf and Bob Kahn, for example, created some of the foundational protocols for its establishment. Similarly, U.S. Senator Al Gore provided some of the vital funding for the Internet to be developed.

Equally crucial has been the involvement of Dr. Radia Perlman, who is often referred to, not as the father, but 'The Mother of the Internet'. Radia is most famous for her invention of the Spanning Tree Protocol (STP). She invented this protocol in 1984 to address the issue of 'bridge loops'. Formulated crudely, bridge loops refer to the existence of interconnected paths between the nodes of an Internet network that a data packet can follow to reach its destination. Being forwarded continuously, though, these data packets ultimately loop perpetually through the network, causing the latter to crash eventually. Radia believed the solution could be found in the fact that the network nodes possess unique 48-bit MAC addresses. Using these addresses, she devised a network protocol to ensure that the nodes could communicate with each other. This allowed the network to designate one root node in the network that determined the shortest path for the data packet to reach its destination. Other redundant ones could now be deactivated, loops were eliminated and a network crash was prevented.



Visualisation of Spanning Tree Protocol

"I think that I shall never see ... a graph more lovely than a tree,'' is how Radia starts the famous poem in which she explains how TCP works. From the numerous network contributions she made, it is this protocol that provided her with the title 'The Mother of the Internet'. Indeed, it has been claimed that the Internet as it exists today would not do so without her genius invention. It is therefore of no surprise that she was listed as one of the twenty most influential people in IT by Data Communications Magazine.



Radia Perlman

Notably, Radia herself is not keen on the maternal moniker given to her. Just as Isaac, she does not believe one single individual deserves credit for inventing the Internet. Moreover, she believes it is strange that the title emphasises gender. “I mostly don’t even think about gender,’’ she once steadily claimed.

Radia Perlman

The Computing Girls of Van Wijngaarden

The Unsung Heroes

Eddy Alleda, Dineke Botterweg, Ria Debets, Marijke de Jong, Bertha Haanappel, Emmy Hagenaar, Truus Hurts, Loes Kaarsenmaker, Corrie Langereis, Reina Mulder, Diny Postema and Trees Scheffer

When the Second World War ended in 1945, the Dutch were determined to rebuild the ruins that the previous years had left them with. Since the Dutch government believed that Mathematics could play a vital role in this reconstruction, they hired mathematician Aad van Wijngaarden to set up the 'Mathematical Centre'. Here, commissioned by the government, a team of mathematicians would perform calculations for, among others, the nautical and aviation industries.

A major part of this team of mathematicians was a group of 12 women that would perform calculations by hand. Most of them came directly from high school, having been selected for their excellent performance during those years. At the Mathematical Centre, they would function as 'human computers', taking up complicated calculations requiring them to differentiate, integrate and iterate; digit by digit, they would compute entire table books. As computer pioneer Jaap Zonneveld would remark years later: "they were not only named the computers, they were the computers".

Aad van Wijngaarden

In 1954, for which Aad had made several educational trips to the United Kingdom and the United States, the first - successful - electromechanical computer was created on Dutch soil. This computer, the ARRA II (Automatische Relais Rekenmachine Amsterdam), would take over the arduous calculatory tasks that had previously been done by the group of women. Nevertheless, its introduction did not make those women any less indispensable. Rather, it rendered them deft programmers: they would no longer do calculations by hand, but they would write programs for the computer to do it for them. As programmers, the women contributed to memorable achievements, such as the engineering of the Fokker F27, which would become one of the most successful passenger airplanes in history.

The Computing Girls of Van Wijngaarden: Left to right in the back (standing): Marijke de Jong, Dineke Botterweg, Eddy Alleda, Diny Postema and Emmy Hagenaar. Left to right sitting down: Ria Debets, Truus Hurts and Bram Loopstra (MC employee, naturally not a computing girl)

According to historian Gerard Alberts, Aad and his ‘computing girls’ marked the start of Dutch Computer Science. Not only did they play a crucial role in the advancement of the hardware industry, but they equally created the programming languages Algol 60 and Algol 68. Some of the concepts introduced in these languages are still used today.

Some of the Computing Girls at a reunion in 1986. From left to right: Truus Hurts, Dineke Botterweg, Bertha Haanappel, Eddy Alleda

On a less serious note, the Mathematical Centre also seemed to engender an atmosphere of fun. The women were known for laughing and chatting throughout the mathematical work, joining in on parties and vacations. Moreover, Aad showed a great attachment towards his girls, making sure they were taken care of in every possible way. As a matter of fact, the centre even saw the emergence of love and romance. Ria Debets, for example, married famous computer scientist Edsger Dijkstra in 1957, who had previously provided the girls with a necessary crash course into programming.

Franciska de Jong 1955

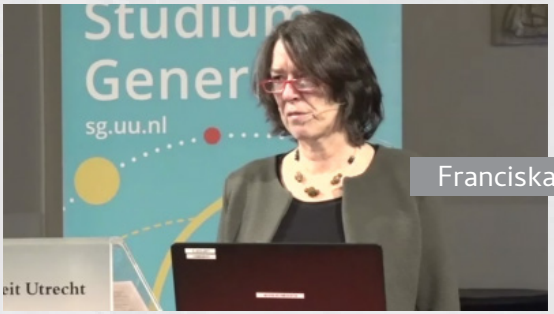
Author Nellie McClung once claimed that “people must know the past to understand the present and face the future”. Knowing the past, though, might result a complex endeavour. Take, for instance, the rebuilding of Balkan states after the Yugoslav Wars. It has been mentioned that, to succeed in doing so, the articulation of war experiences among its great variety of citizens - from Croatians to North-Macedonians - is a necessary condition. How to do this, though? How can the voices of such a variety of citizens, all having had different experiences during that war, be collected and made comprehensible to all? Not to forget, of course, that they all speak different languages.

The six Yugoslav republics between 1945 and 1991

The articulation of these ‘Balkan Voices’ is exactly what language technologist Franciska de Jong intends to do with a project going by the same name. To do so, she embarks on creating ‘language models’, which are statistical representations of spoken words and their underlying connections. Eventually, using speech recognition technologies, those language models must ensure the oral history of the Yugoslav Wars to become a written one. As already mentioned, this is a complex task as the former Yugoslavia knows a great variety of languages. Nevertheless, the year 2014 saw Franciska and her research colleagues presenting its first results: a collection of 400 interviews recorded in Croatia for the documentation of personal war-related experiences.

Franciska de Jong

The way Franciska uses Computer Science and Language and Literature to complement each other stems from a time long before the 'Balkan Voices'-project was initiated. After her PhD in Language Theory, she did pioneering work in the area of automated machine translation at Philips Research in 1985 - at that time a tough problem that seemed impossible to solve. After that, she has become Full Professor of Language Technology at the University of Twente in 1992 and, as of 2015, she has equally become Full Professor of e-Research for the Humanities at the University of Utrecht. Her current research interest is in line with the course of such a career: creating access technologies for digital libraries, text mining, cross-language retrieval and the disclosure of cultural heritage collections. Evidently, 'Balkan Voices' is a great example of the latter. Moreover, being the executive director of CLARIN ERIC, Franciska devotes herself to providing scholars in the Humanities and Social Sciences access to digital language data and processing tools all across Europe.



Franciska de Jong speaking at a studium generale

Indeed, Franciska has contributed greatly - and still is - to the ‘marriage’ of the Humanities and Computer Science. She seems to be a spiritual heir of Ada Lovelace, who equally pondered that such a combination could enable opportunities for collaborative creativity. As Franciska herself once steadily claimed, she will not abide by the belief that people can only possess ‘alfa’ or ‘beta’ qualities. She possesses both.

Ada Lovelace

Frances Brazier 1957

Mother between the Patriarchs of the Internet

After having reviewed the history of the digital age, author Walter Isaacson asks himself the following question: what lessons might be drawn from this tale? For him, the most important lesson is that "[innovation] comes from teams more often than from the lightbulb moments of lone geniuses". Agreeing with him is Radia Perlman. Even though she invented one of the most crucial protocols of the Internet, she refuses to accept the honourable title of 'Mother of the Internet'. On the contrary, she does not believe one individual deserves credit for developing the Internet. Rather, she claims, it is the collective accomplishment of a great number of people.

Radia Perlman

Interestingly, the Dutch annals of Internet history know a similar tale. That is the tale of Toronto-born computer scientist Frances Brazier, having been referred to as the ‘Mother between the Patriarchs of the Internet’. The reason for this nickname is her instrumental role in the 1989 establishment of the first Internet Service Provider (ISP) in both The Netherlands as in all of Europe. NLnet, as it was called, pioneered in providing individuals and organizations with services for accessing, using and participating on the Internet. Its success was immense: up to 1995, NLnet would remain responsible for a quarter of all European Internet traffic.

Frances Brazier

Although Frances admittedly enjoys being a pioneer - and even prides herself for being so with respect to the administrative launch of NLnet - she does not claim full credit for its foundation. Equal to Radia, she believes the establishment of the Internet in both The Netherlands as in Europe was the result of teamwork. As of today, Frances remains committed to the idea that research calls for interdisciplinary collaboration: “I strongly believe in bringing together different fields of knowledge and in the synergy that this delivers”. ‘Cooperation leads to inspiration’, it seems. Frances herself can equally be described as interdisciplinary, having a background in both Mathematics as Cognitive Psychology.
Building bridges remains important for her current focus of research as well: Participatory Systems Research. Here, she works together with lawyers, policymakers and energy experts to design “socio-technical ecological systems that enable and support participation in today’s changing organizations and society”.

The abovementioned nickname given to Frances suggests that the field of Internet engineering was above all male-dominated. Frances confirms this herself, which is perhaps why she has become a prominent member of the National Network of Women Professors, striving for female role models. It must be noted, of course, that Frances is something of a role model herself: she has over 200 refereed academic papers, served on multiple programme committees and is a member of three editorial boards.

Frances Brazier for an interview in 2014

Lynda Hardman 1960

On the eve of the 1990s, computer scientist Sir Tim Berners-Lee believed it would be pitiful if the pool of information floating on the Internet would do so perpetually unorganized. Rather, he pondered that there would be value in arranging the information into a web-like structure, allowing for creative puzzle-solving where people could “add useful ingredients to each other’s half-formed notions”. By connecting all tiny bits of information, as he believed, it could even lead to the cure for AIDS. An ingenious maneuver would make it all possible: Hypertext, meaning the coding of words on the Internet in such a way that, when clicked on, they forward the reader immediately to other pieces of relevant information. Perhaps one can already guess the name of Tim’s ‘little’ project. Does ‘the World Wide Web’ ring a bell?

For Scottish computer scientist Lynda Hardman, it was the arrival of Hypertext that heralded for her a prosperous career in Computer Science. It meant the bridge from graduating in Mathematics and Physics at Glasgow University to becoming a part of the computer industry - developing software for processing Hypertext.

Lynda Hardman

Scotland might have been the birthplace of Lynda's career in Computer Science, but it was in the Netherlands where it blossomed. After moving here to accompany her Dutch husband, the locus of her career would no longer be Hypertext-related software. Nevertheless, it would still very much be connected to the 'linked data cloud' that had become the World Wide Web. While holding positions at the Centre for Mathematics and Informatics (CWI) and the universities of Eindhoven and Amsterdam, she wondered how computers could present the enormous pool of Web content to their users in a way that they actually wanted it. In other words, how to make the computer truly 'understand' their human counterpart? Currently, as Professor of Multimedia Discourse Interaction at the University of Utrecht, she continues to ponder on that question. Projects she has embarked on over the years, such as the 'LinkedTV' and 'K-Space', have certainly guided her endeavour. The former, for example, set out to seamlessly interweave television and Web content into "a single, integrated experience".

Lynda Hardman for CWI

Outside of the digital realm, Lynda is - just as much as Tim - interested in bringing together people and their respective knowledge. As the past President of the Informatics Europe Association, she tried to accelerate European ICT-innovation by bringing together people from different countries and organizations. As the current director of Amsterdam Data Science, she continues to do so. Moreover, as a member of the Management Team at the CWI, she was eager to promote diversity among its employees. Now, at the age of 59, 234 publications into her career, the University of Utrecht seems to become her final stop: “I hope to stay here until I retire”.

Lynda Hardman receiving an award as president of the Informatics Europe Association

Rosalind Picard 1962

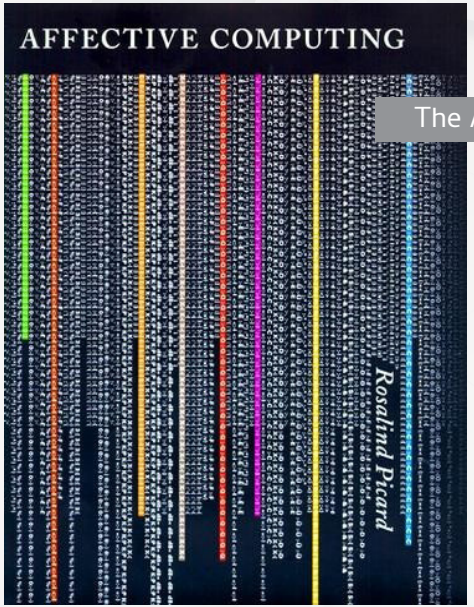
When we are talking about women in Computer Science, do we mean the women that create or the women that are being created? Indeed, this question might be a bit far-fetched, but, truth be told, the world did just witness the first robot being given legal personhood. Sophia, as 'she' is called, received Saudi citizenship. Although contested, this decision should not have been completely unimaginable. Over the previous years, advancements made in the field of Social Robotics have made it increasingly difficult to pinpoint the essential difference between 'human beings' and 'robots'; 'us' and 'them'. If we deserve personhood, then why don't they?

The boundary-blurring effects of Sophia-like robots are due, in part, to the advancements made in the field of Affective Computing, as it was coined by computer scientist Rosalind Picard. Since 1995, this particular field has been concerned with the development of machines that can interpret the emotional state of human beings and adapt their behaviour accordingly; giving themselves an empathetic response in return.

Rosalind herself sees great potential in providing machines with such an ability in the fields of - among others - healthcare and education. Especially in the former, Affective Computing seems to be of added value. Social robots used in this domain seem to benefit from emotional awareness as this allows them to better judge their patients' emotional states and adapt their program appropriately. As such, the world has already welcomed social robots such as Pepper and Buddy to accompany the elderly in an ever more aging population.

Pepper the robot

As of today, the presence of Affective Computing is ubiquitous: virtual assistants analyze your state of emotions before they greet you and kitchen robots recognize it when you are in need of a medic after having cut your finger - only to mention two examples. One must thank Rosalind for this ubiquity. After publishing a book on Affective Computing in 1997, she further developed the concept at the MIT Affective Computing Research Group that she directed. Moreover, she used her expertise to co-found the companies 'Affectiva' and 'Empatica', where she continued to develop machines for the interpretation of emotional states.



The Affective Computing book from 1997

Rosalind's efforts have not been fruitless. In 2019, she received one of the highest honors accorded to an engineer: election to the National Academy of Engineering. Deservedly so, as the field of Affective Computing is a complex combination of Computer Science, Psychology, Physiology and Cognitive Sciences. For Rosalind, though, this complexity is not an issue. Rather, she claims, it helps her to get closer to her religion: "Digging into the models of how emotions work, I find I feel even greater awe and appreciation for the way we are made, and therefore for the Maker that has brought this about".

Rosalind Picard

Catholijn Jonker 1967

When the computing revolution erupted at the end of the 1950s, (electro)mechanical technologies saw themselves being replaced by their fully-digital counterparts. Throughout this revolution, it was often thought that the novel digital electronics had the potential to completely take over human tasks. Moreover, it was equally believed that this potential should be pursued.

Catholijn Jonker

In his 1960 book ‘Man-Computer Symbiosis’, computer scientist Joseph Licklider believed such theorists were mistaken. Rather than pursuing computers to think completely on their own, he argued that it would be much more fruitful to bring humans and computers in, indeed, a ‘man-computer symbiosis’: “[In] not too many years, human brains and machines will be coupled very tightly”. As he stated, the sensible goal was to create an ambiance in which humans and machines “[cooperated] in making decisions”. This vision of augmented intelligence, seeing computers complement humans rather than replace them, remains triumphant up to this day. Indeed, it is still believed that humans and computers working in partnership are more powerful than an artificial intelligence computer working on its own.

Joseph Licklider (right)

The philosophy of man-computer symbiosis is exactly the theme of Dutch computer scientist Catholijn Jonker as well. Upon her appointment as a Full Professor of Interactive Intelligence at the University of Delft in 2008, her inaugural speech was loud and clear: the partnership between humans and computers is paramount. She demonstrated this with one of the centrepieces of her work: the Pocket Negotiator, being equally discussed in the abovementioned speech. The Pocket Negotiator is an intelligent - and currently the only - support system for decision-making in complex situations. Catholijn, whose responsibility is the software for this system, explains that it aims to see robots and humans working closely together in a way the former can supplement the latter in making informed decisions in democratic processes.

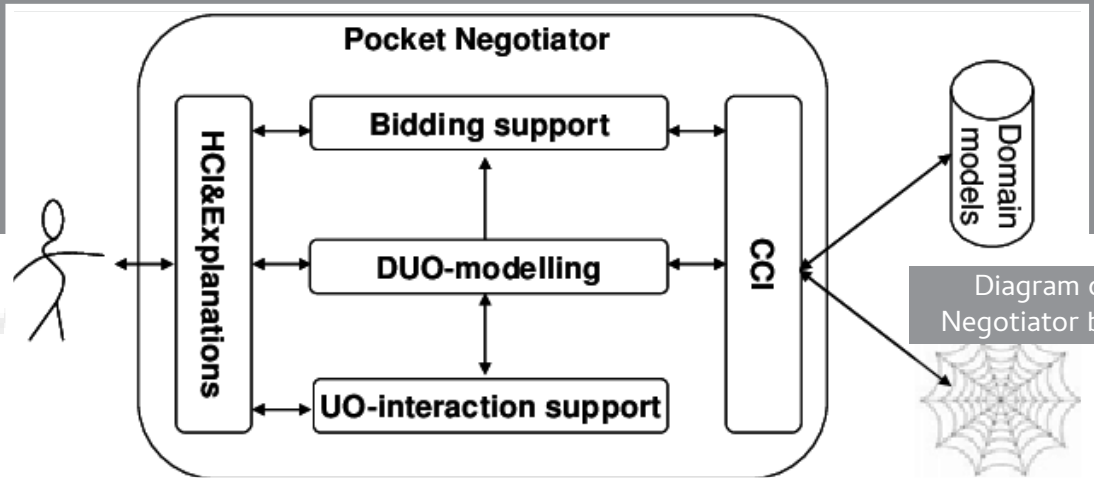


Diagram of the Pocket Negotiator by Jonker (2001)

Currently, with the ongoing research project ‘Compaan’ at the University of Delft, Catholijn continues to establish man-computer symbiosis. It aims to create ‘a smart participation hub for the optimal use of the synergy between human and artificial intelligence to support policymaking’. Simultaneously, Catholijn continues to develop GENIUS, which is the internationally most used platform to support research into negotiation mechanisms and agents. Moreover, before settling down in Delft, Catholijn has been (associate) Professor of Artificial Intelligence in both Amsterdam as Nijmegen. Lastly, it is worth mentioning that Catholijn takes pride in promoting diversity in higher academic ranks, advocating the inclusion of - among others - members of the LGBT collective, women and people of different ethnic groups.

GENIUS

General Environment for Negotiation with Intelligent multi-purpose Usage Simulation.

GENIUS logo

Catholijn Jonker for TU Delft

Sanghamitra Bandyopadhyay 1968

In high school, Biology was not the most favourite subject of Indian computer scientist Prof. Sanghamitra Bandyopadhyay. As a matter of fact, she was a bit scared of it; avoiding it for a long time even during her Bachelor's in Physics and her Masters in Computer Science. However, while obtaining a PhD in Computer Science at the Indian Statistical Institute - which she obtained in 1998 - she entered the realm of Biology nonetheless. More specifically, her team was asked to recognize patterns in the interaction and interference of small RNA molecules. Ever since, Sanghamitra decided that computational biology, bioinformatics and evolutionary computation should become her line of inquiry. And luckily so, for in 2014, Sanghamitra and her peers identified a new genetic biomarker for breast cancer using the "synergistic relationship between Biology and Computer Science".

Currently, as the first female director of the same Calcutta-based institute where she obtained her PhD, Sanghamitra continues to work on the optimization of computer algorithms that enable her to automatically search for patterns and knowledge in large biological data sets. “Sifting through them and finding what we can, can only be done computationally, not manually,’’ she claims. Moreover, she has advanced evolutionary algorithms with applications in bioinformatic analysis and gene regulatory networks. This eventually led to the identification of the previously mentioned biomarker for breast cancer, but it has also resulted in the determination of co-occurrence of HIV-1 and the role of white matter in Alzheimer’s disease.

Sanghamitra Bandyopadhyay

In order to biologically validate their computational findings, Sanghamitra expresses the importance of collaboration. “But in India”, she claims, “enabling collaborations between biologists, chemists and physicists has proved the be difficult. This is something that needs to be worked out in our Indian culture, because appreciating others’ work and solving problems together are necessary for scientific findings to progress”. Culture-related hindrance is, laudably, less apparent for reasons of gender. 35% of people with specialist technology roles in India are women, compared to 17% in, for example, the United Kingdom.

Sanghamitra Bandyopadhyay for the Infosys prize 2017

Although Sanghamitra shows no sign of slowing down, her contributions to computational biology have already engendered more than 300 research articles and six authored and edited books. In 2010, her zeal got rewarded with the locally-famous Shanti Swarup Bhatnagar Prize in Engineering Science. This award is given annually to Indians with notable and outstanding contributions to science. Moreover, Sanghamitra is on the Science, Technology and Innovation Advisory Council of Prime Minister of India. One might think that this position at last delimits her workspace to a single country, for she has equally held university positions in Australia, Germany, China and Mexico - among others.

Sanghamitra Bandyopadhyay receiving the Shanti Swarup Bhatnagar Prize in Engineering Science 2010

Felienne Hermans 1984

The Woman with a Mission

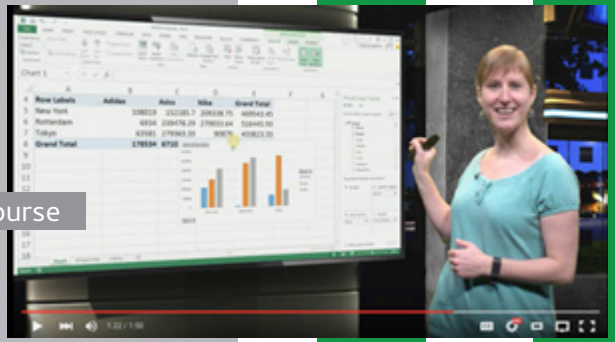
'A woman with a mission', is how Professor Geert de Snoo introduced computer scientist Felienne Hermans at the 2019 opening of her new research group called PERL - short for Programming Education Research Lab. This Leiden-based research group tries to discover what is the best age to learn programming, what concepts leave children confused and how a teacher can educate its pupils on the art of coding when they do not know a lot about it themselves.

The PERL group is just another manifestation of Felienne's self-given mission: answering the question of how we can teach all people to program. Her message seems to be a spiritual heir to the (in)famous scientia potentia est: 'programming is power'. Indeed, Felienne believes that the skill of programming will have people - from car mechanics to biologists - realize what possibilities are opened by the use of computers, how to address and ameliorate societal problems and - on a less serious note - support the creation of cool games, websites and art.

Admittedly, the initial locus of Felienne's career had quite a different nature: Excel Spreadsheets. The topic of her PhD dissertation was the societal impact of spreadsheets and, simultaneously, she founded a company called Infotron. Here, she devoted herself to the development of PerfectXL, a tool to detect spreadsheet errors.

Felienne Hermans

Having said this, Felienne's 'spreadsheet life' was taking place mostly at the University of Delft, where she obtained her PhD in 2013. Her current residency at the Leiden Institute of Advanced Computer Science is concerned mostly with the aforementioned mission. This is clearly reflected in her academic publications. She investigates, for example, the effect or reading code aloud on the comprehension of it. Outside of academia, Felienne is equally active. She has produced several MOOCs - massive open online courses - on programming in Scratch; targeting both children as teachers. Moreover, she created a freely-available e-book for children on the development of games.



Felienne Hermans teaching a data analysis course

Felienne's contribution to the uptake of programming extends beyond the online realm. She can be found teaching concepts of coding in a local high-school each and every Saturday. In addition, she was part of the FIRST LEGO League, assisting children with building a robot. Lastly, she co-organizes the annual event Joy of Coding, a one-day conference held in Rotterdam. Here, she brings renowned speakers together to 'cover diverse aspects of the craft and reflect on recent trends in industry and academia.'

Felienne's efforts have not remained unnoticed. In 2017, she won the prestigious SURF Education award. Moreover, in 2018, she was awarded the Open Education Consortium Award. And deservedly so, as already 10.000 Dutch children are following her free programming classes.

Felienne Hermans receiving the SURF Education award 2017

Epilogue

Dear Reader,

At this moment, you have come across 25 informative portraits of women and/or teams of women that have proven to be indispensable for the development of Computer Science as we know it. They take us on a historical journey across the realms of hardware, software and the many astonishing fields of application amidst - from the calibration of minesweepers buffeted by the Second World War to the identification of biomarkers using evolutionary algorithms. Piece by piece, these women have trailblazed what it means to live in a digital world. Sometimes, they did so collaboratively; sometimes, they did so on a lonely height.

For each small portrait, this booklet has paid specific attention to a number of aspects. Naturally, time and energy have been allocated mostly to the women's specific technical achievements. Although these achievements stand in their own right, the booklet has not shied away from addressing how many of the selected women have had to undertake additional measures to become noticed in comparison to their male counterparts. The recorded history of Computer Science has been downplaying many of their accomplishments and this booklet is one of the many efforts to assign to them the historical prominence that they deserve.

Aside from the technical details, the booklet also invites you to look beyond exactly those; to see how their technical actions have had and probably will have profound effects on philosophical levels as well. Ada Lovelace's notion of 'poetical science' urges us to not lose track of the Humanities, Mary Allen Wilkes' contributions to the Personal Computer changed the way in which people communicate with each other and Qiheng Hu's introduction of Chinese Internet prompts us to rethink the importance of democracy. More radically, with the high-paced developments in Affective Computing - coined by Rosalind Picard - Computer Science is even on its way to provide us with the challenge of what it means to be a human being.

What has hopefully become noticeable is that the selection of women has been diverse. Ada takes us back to the 1800s, but many women guide our attention to the here and now, such as Lynda Hardman and Radia Perlman - even Barbara Liskov at the respectable age of 80. This diversity manifests itself not only temporally, though. Spatially, the booklet has included women from India, the United Arab Emirates and Austria - among others. Given that this booklet accompanies a Dutch exposition, also Dutch computer scientists have not been neglected. Of course, throughout Computer Science history, the main stage of revolutionary developments has frequently been either the United Kingdom or the United States. Therefore, the majority of women originate from these places.

Nevertheless, one must not forget that this selection is exactly and only that: a selection. There are many more women in Computer Science that might not have made it to this particular list, but their accomplishments are anything but negligible. Think of the 17th-century astronomer Nicole-Reine Etable de la Brière Lepaute, who pioneered the method of dividing large calculations into independent parts, putting together the results of those parts and checking for errors afterwards. Indeed, today, every arbitrary computer scientist would say that such a method is at the foundation of the field. Think of the Canadian scientist Beatrice Worsley, who wrote the first ever PhD dissertation on modern computers. Think of Stacey Jeffery, who is currently endeavouring to develop the first algorithms for a quantum computer. Think of Alice Lee, Adele Goldberg, Brenda Laurel, Joan Ball, Lynn Conway, Karen Spärck Jones and the many other women that played a role in lifting Computer Science to its current height.

Moreover, Computer Science is not an enterprise belonging only to the Anglosphere. Although this booklet has already emphasized so by including women from many corners of the world, one is invited to take into account more explicitly the women that have been neglected in the often English narratives. Think of the late Ukranian computer scientist Katerina Yushchenko, who developed the Address programming language. Think of Spain-born Asunción Gómez Pérez, who is currently working on Artificial Intelligence as a Full Professor at the Technical University of Madrid. Think of Sara Al Amiri, project manager of the Emirates Mission to Mars. Think of Lixia Zhang, Marielle Stoelinga, Anne-Marie Eklund Löwinder, Mercy Orangi, Marieke Huisman, Doina Precup, Cecilia Aragon and the many other women beyond the English-speaking nations that also lead a shoulder to the effort.

A final remark seems in order. Although this booklet has paid - and deservedly so - special attention to the many accomplishments of women in Computer Science, it deserves to be mentioned that, at times, they have been backed up by worthy men. Think of Howard Hughes, encouraging Austrian-born Hedy Lamarr to explore her passion for engineering. Think of Adriaan van Wijngaarden, who always praised his 'computing girls' for their great work and passion for the field. As feminist artist Madonna once proclaimed: 'There are some very good men worth backing, but not because they're men - because they're worthy.'

-Niels van Huizen

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TNO

Austrian-born actress Hedy Lamarr was once named the most beautiful woman in film. Historian Pamela Hutchinson observed that her characters were “beautiful creatures to be looked at, absorbed by the male gaze, and with very little to say.” Especially the latter started to annoy Hedy herself. “Any girl can be glamorous,’’ she claimed. “All you have to do is stand still and look stupid.” And she was done with standing still. She picked up her long-lost hobby - engineering, that is - and started tinkering in her trailer. It took her little time before she created the technology that underpins today’s most important communication technologies, such as Bluetooth, GPS and WiFi.

The story of Hedy is extraordinary, unknown and one among many. And especially that unfamiliarity is remarkable. Unfortunately, as it appears, the history of Computer Science is too often remembered as a male endeavour. The many groundbreaking contributions that women have made are frequently downplayed. This booklet aims to break that unfamiliarity; to grant the many women that have contributed to the field their rightful place in the grand narrative. Indeed, we invite you to meet Alice and Eve, representing the 25 remarkable female computer scientists included in this booklet and, of course, the many others that deserve equal inclusion. Starting at Ada Lovelace and ending with Félienne Hermans, we take you on a celebratory journey across the annals of computer history and expose the female touches.