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Eric P. Matthews
Southern Illinois University Carbondale

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Eric P. Matthews
College of Applied Sciences and Arts,
Southern Illinois University Carbondale

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Abstract

The personal computer has been integrated into the fabric of everyday life, medical imaging is no different. In this article the author introduces a brief historical study of the developments that have led to the modern computer. Emphasis is placed on the computer in medical imaging.

Introduction

The field of diagnostic imaging is ever-changing and evolving. In the past 3 decades, computers have become increasingly integrated into the field of medical imaging (Gurley & Callaway, 2006; Seeram, 1994; Siegel & Kolodner, 2006). Not only in radiology, but in every day life computers have reached the point where they are beginning to be taken for granted. As a result, few people outside of the computer sciences have a firm understanding of the developments that have led to the modern computer. Therefore, this article will attempt to introduce the basic history of computers, particularly as they relate to medicine. The reader should be aware that this work is in no way a comprehensive history of the development of the computer.

A Brief History of Computers

The first widely accepted "computer" is the abacus of ancient Mesopotamian design. The reason most people consider the abacus a computer is because it fundamentally fulfills all of the necessary requirements for a modern computer, including memory, control unit, input/output and logic (calculation) unit. Originating in around 3500BC, the machine was capable of definitive control, it was capable of calculation and memory, and it was capable of repetitive action by different users. It was the primary method of calculation for centuries (actually millennia) (Bushong, 2004; Dreyer, Hirschorn, Thrall, & Mehta, 2006; Hunter, 1986; Oakley, 2003).

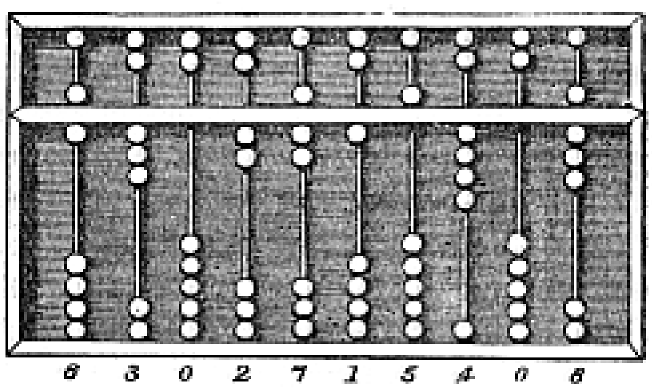

Figure 1. Abacus (*Image courtesy of Wikipedia*).

Some 4,000 years later, in 1642, Blaise Pascal (1623-1662) was experimenting with a mechanical device capable of storing information and making simple calculations. He ultimately devised a simple machine, capable of addition and subtraction. Unfortunately, his machine was treated as a novelty, something that was interesting but, not essential (Oakley, 2003).

Several years later, Gottfried Leibniz (1646-1716) determined that calculations may be simpler (or at least easier) if the system used to make the arithmetic conversions was easier. He hypothesized that using a system based upon the numbers "0" and "1" should be sufficiently simple, or binary, to ease the calculations necessary to make a calculator useful. He correlated his zero and one "language" into a system based upon a finger. If the finger were extended, it translated to on. If the finger were flexed, it translated to off. In the language Leibniz derived (based upon zeros and ones, correlated to the fingers of the human hand), the digital system was born (Oakley, 2003).

The next major evolution in computers came about during the industrial revolution. A systematic means of input that was mechanically repetitive needed to be devised. During the 18th century, the industrial revolution was increasing the need for manufactured goods. The first and most immediate need was for increased textile production. The hand-operated loom then in existence was too slow to keep up with the needs of the evolving market. In 1725, to ease the burden on manual looms and increase production, Basile Bouchon created a system of punch cards that would automatically make a repetitive pattern in loomed fabric. This automatic pattern control greatly increased output in the textile industry; the technique was perfected in 1801 by Joseph-Marie Jaquard. His loom device was the very first mechanical control program developed. However, it was not a functional computer, because no calculations took place (Hunter, 1986; Oakley, 2003).

Figure 2. Jacquard Punch-Card Operated Loom (*Image courtesy of Wikipedia*).

The first modern computer was most probably invented by Charles Babbage (1791-1871) in 1835. In that year, his analytical (or difference) engine was devised. It used a system of gears (and their cogs) to carry out calculations. However, the machine itself was governed by the punch-card system pioneered by Jacquard. Due to spiraling costs, the machine was never fully developed however, the computer era had begun (Bushong, 2004; Hunter, 1986; Oakley, 2003).

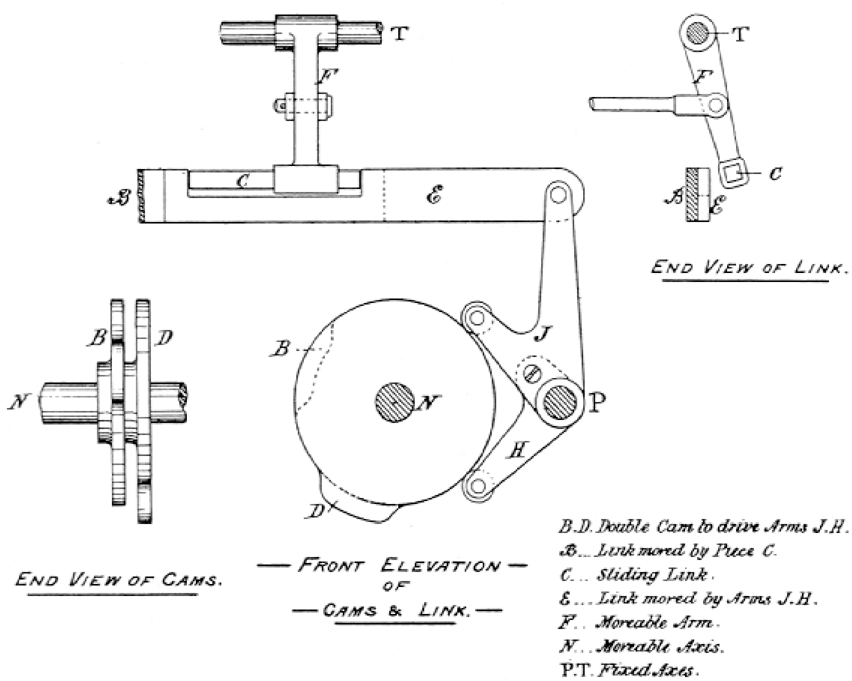

Figure 3. A Portion of Babbage's Analytical Engine (*Image courtesy of the Analytical Engine*).

Several inventions and innovations subsequently developed that helped lead to our modern understanding of computers and their use. First, the telegraph was invented. Utilizing a system of communication developed by Samuel Morse the technology allowed for virtually instantaneous long-distance communication. The teleprinter was developed, allowing a printed message to be transmitted via telegraphy. In 1876, Alexander Graham Bell unveiled the means by which verbal communication could be accomplished (the telephone) across electrified wire. Around the same time the modern keyboard (QWERTY) was invented. All of these inventions would be pivotal in the development of the modern computer. All they needed was the impetus to initiate the development, that impetus turned out to be the United States Census of 1890 (Hunter, 1986; Oakley, 2003).

To facilitate the processing of the enormous data collected for the 1890 census, Herman Hollerith (1860-1946) developed a tabulating machine based upon a conglomeration of the technologies previously discussed. The machine used manually entered punch cards (the keyboard and punch-cards) to translate information into electronic signals that could be sent to a central collecting agency (the US Census Bureau) for compilation. There, the information was accumulated and further tabulated; eventually the entire census for that decade was compounded in this manner. The idea of utilizing a computer to process large amounts of information had been born. The ensuing rush to capitalize on this idea was exploited by the Tabulating and Recording Company, who in conjunction with other like minded industrial firms joined together in 1924 to form International Business Machines (IBM) (Bushong, 2004; Oakley, 2003).

The first mechanical means of entering large amounts of information into a computer (without keyboarding) was developed by John Logie Baird (1888-1946). In 1926, he developed the means to electronically scan information into a computing system, formulating the basis of television transmission. This system was perfected by Vladimir Zworykin in 1929 who built on Baird's work by transmitting the scanned information via electron beam (utilizing a waveform) to a cathode ray tube allowing the images to be viewed (Oakley, 2003).

The origins of the *Universal Computer*, a machine capable of functions beyond simple math, are varied. During the 1930's, both American and German scientists began experimenting with the development of an electro-mechanical device that could carry out any function the user desired. Obviously, due to the geo-political climate of that decade, the desired functions were predominately military in nature. The Z3, the first computer to use a pre-stored program, was developed to facilitate the breaking of German codes. In conjunction with the *Colossus* (a vacuum-tube computer) the pre-stored programs were used effectively during the war to break German military ciphers. The machines were also used to facilitate some of the in-depth physics computations required to develop the first atomic weapons (Oakley, 2003).

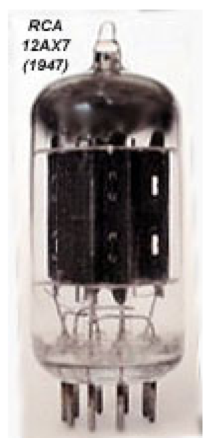

Figure 4. Vacuum Tube (*Image courtesy of Wikipedia*).

The obvious progression from vacuum-tube technology was thermionic valves. These were far quicker than vacuum tubes, but slower than modern electronics. Thermionic valves were used to develop the IBM Automatic Sequence Controlled Calculator (ASCC). More widely known as the *Harvard Mark I*, the ASCC was a massive machine measuring approximately some 46 x 8 x 2 feet.

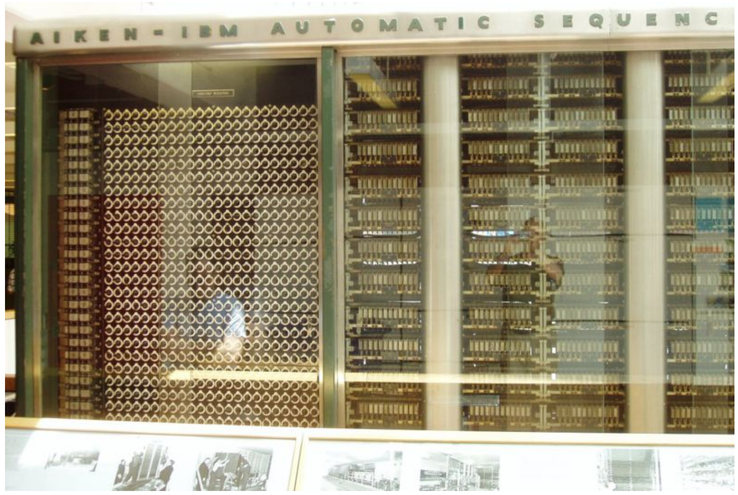

Figure 5. Harvard Mark I (*Image courtesy of Wikipedia*).

Despite its' enormous size, the Mark I was still exceptionally limited in what it could achieve (Bushong, 2004; Hunter, 1986; Oakley, 2003).

The first fully digital, electronic computer (highly comparable to today's PC) was the Electronic Numerical Integrator and Calculator (ENIAC). ENIAC had originally been designed as an artillery projector, but was reprogrammed to do in-depth calculations for the hydrogen bomb development project. Like the Mark I, ENIAC was enormous in size; the computer took up a space approximately 8 x 3 x 100 feet and weighed in at almost 30 tons. However, unlike the Mark I, ENIAC contained Diodes, Capacitors, Relays and Resistors; derivatives of all these devices may be found on the modern circuit board (see figure 6) (Bushong, 2004; Hunter, 1986; Oakley, 2003; Weik, 1961).

The UNIVAC (UNIVersal Automatic Computer) was the successor to ENIAC. This computer replaced punch cards with magnetic tape for the input device. UNIVAC was originally developed to tabulate the 1950 US Census, as such it was paid for by the census bureau. However, it was made commercially available and sold on the open market to a multitude of corporations (Bushong, 2004; Hunter, 1986; Oakley, 2003).

In the late 1940's other electronic developments were taking place outside of the computer industry that would eventually aid the development of modern personal computers; namely, the development of the transistor (one of the first solid-state semiconductors). By 1953, the first computer utilizing transistors had been developed in England. That same decade, the first international computer language, *FORTRAN*, was developed. In 1958, the first integrated circuit was manufactured. This first microchip was capable (as are modern chips) of either processing or storing information (Hunter, 1986; Oakley, 2003).

The 1960's saw a rapid expansion in the technology of computing. The year 1963 witnessed the advent of the 7-Bit American Standard Code for Information Interchange (ASCII). The ASCII language allowed any computer to communicate with any other machine. This allowed for the rapid exchange of textual information between separate machines. This language is still in use today. In 1968, Intel™ released their first 1kilobyte memory chip (Oakley, 2003).

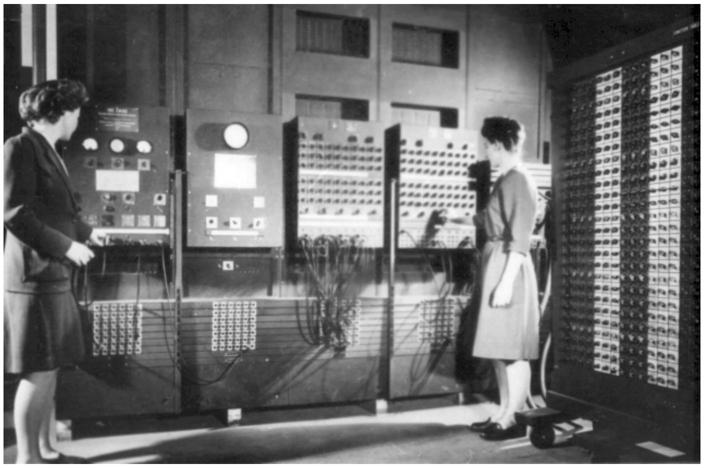

Figure 6. Two Women Operating ENIAC (*Image courtesy of the United States Army, retrieved from Wikipedia*).

The 1970's saw the continued rise of computer technology. In 1972, Intel™ released to the public the 4004, the first microprocessor. This, in effect, led to the development of the microcomputer. Ultimately, microcomputers lead to the PC revolution which allowed cheap (yet effective) computers to be widely available to the public at an affordable cost (Oakley, 2003).

The 1970's also saw the first advent of the integration of computers into medical imaging. Using a microprocessor, capable of thousands of simultaneous computations (25,000), allowed the radiologic technologist to image a slice within a volume. In 1974, Sir Godfrey Hounsfield utilized this slice-imaging ability to develop the first Computed Tomography (CT) machine for clinical use. Effectively, this was the start of the digital imaging age (Oakley, 2003; Seeram, 1994).

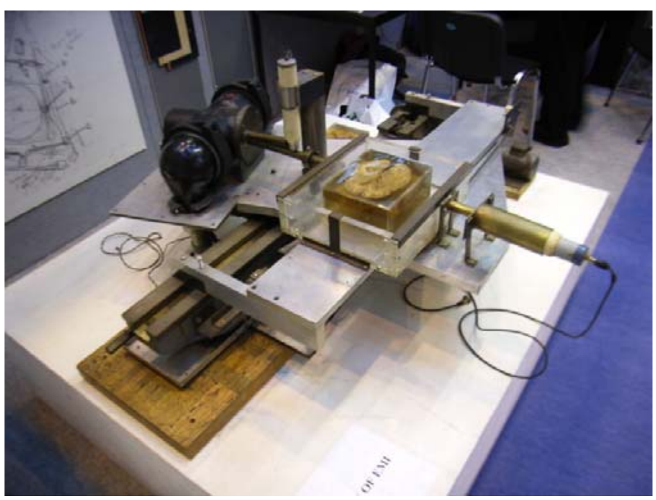

Figure 7. Godfrey Hounsfield's Prototype CT Scanner (*Image courtesy of EMI).*

In 1978, the first Analog to Digital Converter (ADC) was released. Initially, this was of primary use in Digital Subtraction Angiography (DSA); however, the ADC has subsequently found its way into a multitude of applications. These applications include fluoroscopy, digital scanners, and Charged Coupling Devices (CCD’s). An ADC converts analog, or continuously varying, signals into constant stream signals (digital) (Oakley, 2003).

In 1985, the original standards for digital imaging systems were released by the National Electrical Manufacturers Association (NEMA) and the American College of Radiology (ACR). These standards were put in place to ensure that images produced digitally, by machines of various manufacture, were transferable between systems. These standards would evolve into the modern Digital Imaging and Communications in Medicine (DICOM) standards that are used in today’s medical practice (Oakley, 2003).

Conclusion

From the abacus to the modern PC, all computers have four primary commonalities. For a computer to be considered such, it must have an input/output device, a logic unit, a memory unit and a control unit (or control capacity). Throughout their development, computers may be said to have undergone four primary generations. Those generations are: (a) vacuum-tube computers, (b) individually packaged transistor computers, (c) integrated circuit computers, and (d) large scale integrated computers. The first general purpose computer was the Mark I, the first general purpose electronic computer was ENIAC. The first commercially successful computer was UNIVAC.

All of these advances were necessary to allow the integration of computer science into medical imaging. This integration has enabled diagnostic imaging to remain at the cutting edge of the science and technology fields, enabling speedier, more dynamic examinations with a higher degree of accuracy and patient comfort.

References

Bushong, S. C. (2004). *Radiologic science for technologists: Physics, biology, and protection* (8th ed.). Saint Louis, MO: Mosby.

Dreyer, K. J., Hirschorn, D. S., Thrall, J. H., & Mehta, A. (eds.) (2006). *PACS: A guide to the digital revolution* (2nd ed.). New York: Springer.

Gurley, L. T. & Callaway, W. J. (2006). *Introduction to radiologic technology* (6th ed.). Saint Louis, MO: Mosby.

Hunter, T. B. (1986). *The computer in radiology.* Rockville, MD: Aspen.

Oakley, J. (2003). *Digital imaging: A primer for Radiographers, Radiologists and health care professionals.* Cambridge, England: Cambridge University Press.

Seeram, E. (1994). *Computed Tomography.* Philadelphia: W.B.Saunders.

Siegel, E. L. & Kolodner, R. M. (eds.) (2006). *Filmless radiology.* New York: Springer.

Weik, M. H. (1961). *The ENIAC story*. Originally published for the Ordnance Ballistic Research Laboratories, Aberdeen Proving Ground, MD. Retrieved July 22, 2007 from http://ftp.arl.mil/~mike/comphist/eniac-story.html.