

Seminar report

History of Computing: Keyboards

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Tiivistelmä — Referat — Abstract

Keyboards have served an integral role in computer input. However, we didn't always have keyboards over the history of computing, but we had to use different methods of input. One of those was using a keypunch to punch holes into cards and paper tape. Keyboards also remind us of typewriters, as they share a similar form. In this paper, we first look at the predecessors of keyboards. The keypunch will lead us to the first computers where the first keyboards were introduced. As there were no standards for the first keyboards, there were several designs and variations depending on who made them.

The layout for the keyboard is also essential. While the QWERTY layout is the most dominant layout currently, there had been others as well. Even QWERTY is not a single layout, but a general group of layouts. Many layouts are different depending on which country they are used in. For languages that don't share the same roots or even the same characters as English, such as Chinese, the keyboard will also have a completely different history path.

Finally, mobile phones have been a prominent portion of the computer sphere in recent years. We look at how keypads on telephones and later mobile phones evolved over time into what we have today.

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1 Introduction

The two most used input devices for modern-day computers are the keyboard and the mouse. This paper looks into the history of the keyboard, to understand how we got here and where we might go in the future. The starting point for investigation is to see what devices were the predecessors of the keyboard. These would be the typewriter, which highly resembles the keyboard aesthetically, and the keypunch, which was used for inputting instructions and data for early machines and computers.

Moving on from the keypunch, we get to the earliest computers that used keyboards. After establishing keyboards had established a place for themselves as the standard input device for computers, it was clear that they would be included with the first commercial personal computers. However, while keyboards themselves were the default input device, there weren't any clear standards on how they should be arranged other than the QWERTY layout. The QWERTY layout only described the positions of the letters, but not the symbols or even numbers.

The history of keyboard layouts is also interesting to see how they evolved. Almost all modern-day keyboards somehow incorporate the QWERTY layout, but will often have minor or major differences between each other. Even languages that don't share characters with English are often built on the QWERTY layout. One of these languages would be Chinese, for which a typewriter and keyboard went through very different paths than their Western counterparts.

Finally, we look at the keyboards in mobile phones and where they came from. Modern mobile phones are powerful computers and over half of all website visits are done using a mobile device. Therefore, it is important to look at their keyboards as well, while not physical. We look at how the original keypads evolved from telephones to mobile phones and how the transition from physical button phones and touchscreen phones changed how writing was done.

2 Precursors of Keyboards

To understand how the modern keyboard came into existence, it is important to understand its predecessors. While the typewriter is an obvious example, it is only similar in form, but not quite so in function. The typewriter is, simply put, a substitution for writing by hand. The function of a keyboard is to interface between the user and the computer. Therefore, one of the predecessors would also be the keypunch. Both ended up having a keyboard that doesn't differ too much from the ones we use today.

2.1 Typewriters

There had been several attempts at making a typewriter in the early 19th century. However, they were cumbersome and slower to use than writing by hand, so they were mostly a novelty [8]. While the first patent describing a typewriter was made in 1714, no typewriter reached or attempted commercial success until the 1870s [31].

2.1.1 The Writing Ball

The writing ball was invented by Rasmus Malling-Hansen [29], a Danish pastor, in 1865. The ball was different from earlier typewriter designs in that the pistons used to print onto the paper were vertical and straight, so they were less likely to jam. Due to not having a jamming issue, the keys could be assigned in an order that could improve faster writing speed.

Commercial production for it started in 1870 and it sold quite well for the time. However, only a few years after its roll-out, a new typewriter was on its way, and unfortunately for the fast writing ball, it overtook the typewriter market.

2.1.2 Sholes & Glidden Type-writer

Christoper Latham Sholes, an American inventor, read about a writing machine in the journal *Scientific American* in 1867, which inspired him to make his own. To solve the issue of the arms jamming, he decided to separate the keys that were likely to come after each other. This led to the now common "QWERTY" [31] keyboard layout. The writing speed, while far faster than a pen, ended up being slower than the Hansel writing ball.



Figure 2.1: Friedrich Nietzsche's typewriter, a Malling-Hansen Writing ball, model 1878. [17]



Figure 2.2: Remington Standard No. 2 Typewriter [18]

He patented his typewriter in 1868 [8] and continued making improvements to his design. In 1973, he signed a contract with E. Remington & Sons, at the time a firearm manufacturing company, to manufacture the typewriter and sales started in 1874. Initially, the typewriter was called the Sholes & Glidden Type-writer, named after Sholes and the mechanic who helped build it, Carlos Glidden. However, the typewriter was later renamed the Remington.

However, the Remington was not an immediate success. One of its main flaws was that it could only print capital letters, which could sound impersonal or even insulting. The issue was fixed in the successor model, the Remington No 2, released in 1878. The new model included a shift key, which allowed shifting the keys from lowercase letters to capital letters. Following this change, the typewriter started seeing more success, especially in offices.

2.2 Keypunch and Punched Cards

Keypunches were used to make punched tape and cards, which could be used for automating machines. The first machines to be automated using them were looms, feeding instructions into them. Later they were also used to hold data, which was in great demand in the late 19th century.

2.2.1 Automated Looms

The idea of using perforated tape to automate looms was invented by Basile Bouchon in 1725 [21]. He was the son of an organ maker and became familiar with how they were made. He got the idea for using the perforated paper for instructions from how they used paper to mark specific locations for drilling holes in the organ pipes. The loom simply checked whether a hole was present or not, by either allowing the handle to go to the other side or preventing it. However, due to the paper being impractical to make, maintain and repair, it was not very successful.

The first practical application of the automated loom was made by Joseph-Marie Jacquard in 1804-1805 [7]. He improved the design by using chains of punched cards instead of paper tape. He built an attachment that could automate a regular loom. The combination became known as the “Jacquard Loom", which could make complex patterns automatically. The Jacquard Loom became such a huge success that other silk weavers feared it might take over their jobs.

2.2.2 Punched cards

While the punched cards and tape were used for automating looms, they only held instructions. Charles Babbage, an English mathematician, had the idea to use them to hold data as well as instructions in the 1830s [12]. He conceived a general-purpose computing device called the “Analytical Engine”, which used two types of different punched cards, some for instructions, “operation” punched cards, and others for holding data, “variable” punched cards. Unfortunately, he passed away before being able to build the machine.

For the 1890 US census, Herman Hollerith developed a pantographic card punch, which allowed fast and accurate creation of punched cards [14]. The pantographic card punch worked by having 2 needles connected to an arm, which translates the motion of the needle on the end of the arm onto the needle in the middle. The needle at the end of the arm was the guide, while the needle in the middle of the arm was for punching the actual punched

card as seen in Fig 2.3. Using the pantographic card punch, it was possible to create up to 700 cards per day.

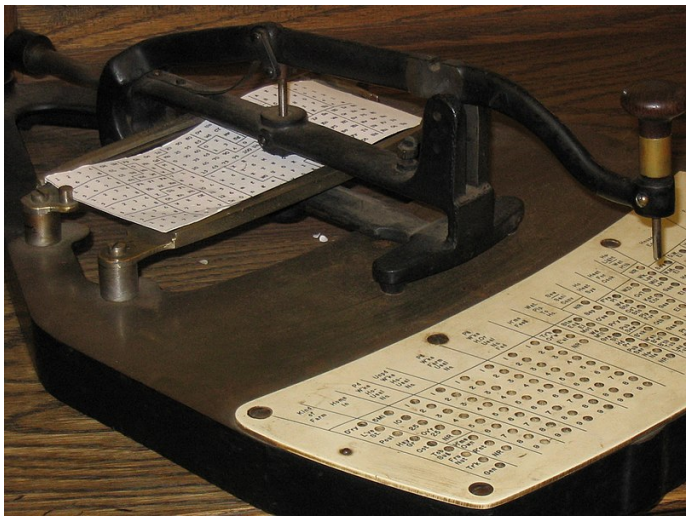


Figure 2.3: A Hollerith pantograph card punch. [24]

Hollerith improved the design and created the "Hollerith Type 001 Numeric Key Punch", which became the IBM 001 when Hollerith's company became the IBM. The IBM 001 had typewriter-like keys and was roughly twice as fast as the pantographic model. It was likely used for the 1910 or 1920 US census.

Between the IBM 001 and the IBM 032 keypunches, several improvements were made, but IBM 032, developed in 1933, was the first one to offer a full alphanumeric keyboard [14]. By 1949 they had developed mature models, the IBM 024 and IBM 026, which were considerably faster than their earlier counterparts [15]. They could punch up to 200 cards per hour.

The keypunches worked by having a set of columns on the punch card [15]. Pressing a key, or a combination of keys, would punch a combination of holes matching that character onto the column and then move the card to the left by 1 column. If a mistake was made, and the mistake couldn't be remedied by punching the column again, the whole card had to be discarded. To alleviate manually punching the previously mis-punched cards entirely, the DUP-key could be held to automatically punch the same holes as on the previous card.

3 Computer Keyboards

While keypunches and typewriters were used until the latter half of the 20th century, keyboards were finally starting to make their stand. The first computers with CRT displays started to appear in the 1950s and with increased interactivity, punched cards started to hinder usability.

3.0.1 Early Computers

The ENIAC, Electronic Numerical Integrator and Computer was the first general-purpose digital computer designed by physicist John Mauchly and electrical engineer J. Presper Eckert at the University of Pennsylvania in 1943-1946 [36]. They saw the problem with the input speed of punched cards. While they used a punched card reader for input and a keypunch for output, they also used preconfigured instructions on a plugboard. These commands could be run at electronic speed, which was much faster than the speed of the card reader. However, the plugboard also had a downside, to create a new program, rewiring the plugboard would take days.

The first computer to use a keyboard was the Whirlwind I [13], developed by a team led by Jay Forrester at MIT in 1951 [22]. The U.S. Navy commissioned MIT to design a computer for a flight simulator. They were inspired by a demonstration of ENIAC and also decided to make a digital computer. The simulation would be run in real-time, so instructions could not be written beforehand onto punched cards and required another solution.

3.0.2 Commercial Home Computers

The first successful personal use computers appeared in 1977 [6]. Three different computers were released in the same year: the *Apple II* by *Apple Computer, Inc*, the *TRS-80* by the *Tandy Radio Shack* and the *Personal Electronic Transactor*, *PET*, by *Commodore Business Machines*. Each of these computers had wildly different keyboards. However, the Apple II and the TRS-80 keyboards had common features of modern keyboards, while the similarities begin and end with the QWERTY layout for the PET keyboard. It had various line symbols for drawing graphics as shift keys as seen in Figure 3.1. Number keys aren't present in the figure, however, there was a numpad to the right of the keyboard.



Figure 3.1: The keyboard of the PET [5].

Keyboard Connectors

The keyboard connectors used for these and other computers were mostly custom for each computer model. It wasn't until 1987 when the PS/2 connector debuted that one type connector type became the most dominant [20]. It shared the same design as the mouse port, so the only easy way to distinguish them was with their color. The keyboard port was commonly blue/purple and the mouse port was green/turquoise. The only real problem with this connector type was that it wasn't hot-swappable, so if one wanted to change to a different keyboard, they'd also have to restart the computer.

While popular, the PS/2 connector wasn't still quite universal and only worked for the keyboard and mouse, so in 1998 the Universal Serial Bus connector, USB, was introduced [16], which could connect many more types of devices as well. While support for previous ports was kept for a while, most other ports that could be were eventually replaced by USB. Over the years since then, the USB standard has been improved and the connector type has been revisited. The original USB-A connector could only be inserted in one orientation, which caused some frustration, the current USB-C connector can be inserted in either orientation.

4 Keyboard Layouts and Languages

While the QWERTY layout has stayed dominant since its introduction, other layouts have been designed and researched. Some layouts were designed to improve writing speed, while others were designed based needs of different languages. Even then, the QWERTY layout has remained the de facto standard, even in languages that don't primarily use Latin-based alphabetic characters.

4.1 Latin-script Keyboards

Even though the QWERTY layout is the most common layout, there are some minor and major variations of the QWERTY layout. Most notably differences can be found between region-specific keyboards. The placements of special characters can also vary wildly. Furthermore, many languages use accented characters, such as the *å*, *ä*, and *ö* characters, which have dedicated keys in common Finnish keyboards.

4.1.1 The French AZERTY Layout

An example of a keyboard layout that varies from QWERTY would be the French AZERTY layout. It was designed in the late 19th century as an adaptation of the U.S. typewriter layout to better suit French writing [34]. The alphabetic character positions don't differ much from the QWERTY layout, with the letters *A* and *Q* swapped, *W* and *Z* swapped and the letter *M* being moved to the home row, the middle row where one's fingers rest on, onto the right of the *L* key.

Weirdly, the AZERTY layout had dedicated keys for only some accented letters used in French [34]. Even the period, used to end sentences was behind a 2 key combination. While flawed, it quickly set down its roots, and newer layouts, better suited for French, couldn't depose it. There had been multiple alternative layouts proposed, such as the early ZHJAY layout in 1907 and the BÉPO layout in 2002. Fortunately, the AZERTY layout standard was being finally improved in 2019 [3]. The new layout kept most of the old functionality while adding the missing common characters and improving. However, as the standard is voluntary, it remains to be seen whether it eventually completely replaces the old layout or if both will be used.

4.1.2 Efficiency Based Layouts

While QWERTY and layouts adjacent to it are the most popular, other layouts have been developed. Many of them have been designed from the ground up based on efficiency needs.

One of the most prominent layouts was the Dvorak layout, designed by Dr. August Dvorak in the 1920s and 1930s [9]. Dr. Dvorak was not satisfied with the random nature of the QWERTY layout, which was designed to avoid jamming, and wanted to design a layout that was more ergonomic. He described the design in his book *Typewriting Behaviour* in 1936. He designed it so that 70 percent of typing would be done on the home row. As seen in Figure 4.1, the least common letters are on the bottom row, which is considered to be the hardest to reach.



Figure 4.1: The Dvorak keyboard layout [9].

It is hard to say whether Dvorak was actually better than QWERTY, but it certainly came too late to have a big enough impact. Hundreds of thousands of typewriters were already using QWERTY by the time Dvorak was released, which would have cost millions to convert over [9]. While physical hardware would be difficult and expensive to switch, software is much more flexible. Most modern operating systems have support for switching to Dvorak, which enables use for enthusiasts. It is difficult to compare typing speeds formally, as most people have already formed a bias for QWERTY.

Stenography

Not all keyboard layouts were designed for the same purpose either. In stenography, the objective was to write quickly using shorthand, an abbreviated symbolic writing method. Stenography is mostly used for fast transcribing, with the need to keep up with spoken language, most commonly seen in court reporting and live captioning [28]. The first successful stenographs were made in the late 19th century [35]. It was created because of the need to accurately document speech. Early typewriters were simply not fast enough. Even today, the average typing speed using a computer is only roughly 40 to 60 words per minute [30].

To qualify to become a court reporter, one must be able to write and keep up with spoken English, which can reach up to 225 words per minute [27].

Using a stenotype, it is possible to write syllables or even whole words with just 1 or 2 strokes [28]. It works by using chords, pressing multiple keys at once, to form parts or short words in a single stroke. As such, a stenotype only works for the language it was designed for, and writing a different language would require additional training. As seen in Fig 4.2, there are multiple keys for the same character. This is because the sections represent different parts of a phrase. The left side of the stenotype is used for the initial consonants, while the right side is used for the final consonants. The vowels are hit using the thumbs and numbers can be typed using the number bar.



Figure 4.2: The layout of the keys on an English stenotype [37].

4.2 Logographic Writing Systems

While most writing systems are phonogramic, writing systems in which the characters are based on sound, in logographic writing systems, the characters are based on meaning. In logographic writing systems, the number of different characters can be massive, and therefore not easily directly mappable onto a keyboard. A Modern example of the use of a logographic writing system would be the Chinese writing system, and by proxy the Japanese writing system which uses Chinese characters as a part of its own system.

While there are more than 100 000 characters in the Chinese language, only a small subset of them is used in everyday life [10]. There is a list of 3500 essential characters every child should learn while in school, but many learn up to somewhere between 5000 and 6000 characters. While much smaller, it is still an infeasible amount of characters to fit on a keyboard.

4.2.1 Chinese typewriter

Typewriters in the early 20th century required 2000 to 8000 different character keys for them to be considered viable [2]. Inventors started experimenting with ideas to break down the

characters into their basic components, which could then be used to build the characters with fewer keys.

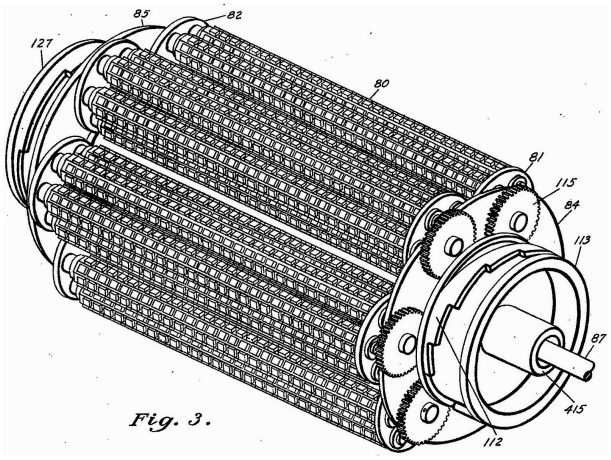


Figure 4.3: The character rollers in Figure 3 of Lin Yutang's patent for his typewriter.[39]

In the mid-1940s Lin Yutang invented a typewriter with only 72 keys [2] [39]. While it only had a total of 72 keys on the surface, it still had 8352 slugs inside the machine. The keys were split into 3 sections, the top section with 36 keys, the bottom section with 28 keys, and 8 selection keys.

The idea of the system was to one key from both the top and bottom sections to choose two parts of a character. The combination of two keys, however, didn't return a single character, but a set of 8 or fewer characters. With the amount of different key combinations, it was possible to create $36 * 28 = 1008$ sets of eight or fewer characters. The sets of characters were stored on a large roller, which held 6 rollers in a hexagonal pattern, each of which held another 6 more rollers. The smallest rollers were formed of hexagonal tubes with characters on small metal plates as seen in Figure 4.3. Finally, the set of 8 chosen characters would be shown through a magnifying lens, a "magic eye", which was directed at the set. The user could then choose the desired character using the 8 selection keys.

4.2.2 Chinese keyboards

Entering the computer era, having thousands of separate connections, even with fewer actual keys, was not feasible so the system had to be changed again. In 1973, researchers at Jiaotong University in Shangai, China, developed the first "medium-sized" keyboard consisting of 32 rows of 20 keys, with a total of 496 keys for typing characters [23]. Each character key represented a radical that could be combined with other radicals to create characters. While this keyboard system would have worked for a computer, it was never widely used.

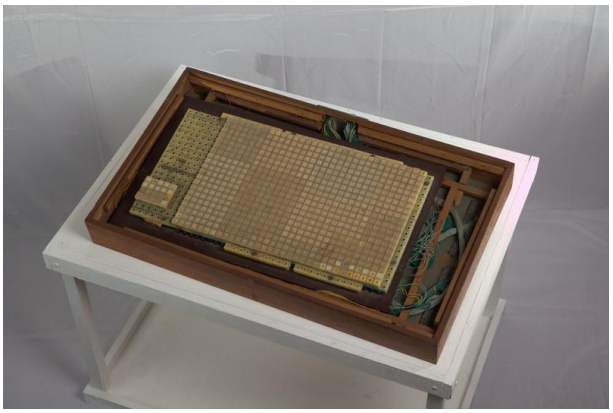


Figure 4.4: Remains of the "medium-sized" keyboard prototype.[23]

Not long later, the Cangjie input method was developed by Chu Bong-Foo in 1976, which became one of the currently used methods today. In Cangjie, the characters are formed by typing the building blocks of the characters.



Figure 4.5: Example of how to write "Cangie method" in Chinese using the Cangjie input method. [33]

Going back in time a bit, in the early half of the 20th century, there was rampant romanization, conversion to Latin script, of the Chinese language by non-official means [11]. It led to the names of places such as Beijing turning into Peking. A few attempts at making a general romanization of the language had been made, but none had succeeded. It was not until the 1950s that a group of linguists came together and created pinyin.

Pinyin works well for keyboards as they could just take the already existing "QWERTY" layout and use it. However, some pronunciations can have different characters depending on the context. Therefore the user must first write the words based on how it sounds, and then choose the actual character from a list. The first ISO standard for pinyin was published in 1982, which covered the romanization of Chinese characters. [26]. A similar solution is used for Japanese keyboards, where the Chinese characters are written phonetically and then the

appropriate one is chosen from a list of suggested characters.

5 Mobile Device Keyboards

As mobile phones are getting more advanced, it would be an understatement to not call them computers. They also have keyboards, so it is interesting to see where they came from and how they evolved over time.

5.1 Early Telephone Input

Telephones started becoming more popular in the early 20th century in the United States, so more telephone exchange centers were being built. Each exchange center could support up to 10,000 connections, so calling outside of the center required knowing the name of the receiving center as well [19]. When machine-operated exchange centers were being built, the caller could enter the number using the dial and be connected without having to interact with the operator. However, calling outside of the exchange center still required connecting to the operator first as there was no way to input the name of the receiving center.

As the need for more phones grew in big cities, it was shown that phone numbers would eventually reach 7 digits [19]. W. G. Blauvelt, from the American Telephone and Telegraph Company, proposed a solution for the problem in 1917. He suggested that the number positions could also represent letters, and having the phone number consist of the first three letters of the telephone exchange center followed by four digits. In hindsight, this doesn't seem to change the length of the phone numbers at all, as before they were the name of the telephone exchange plus 4 digits. However, it did allow the dialing of numbers at a different exchange.

In the proposal, the numbers 1 and 0 would be left empty, with the rest of the numbers having 3 letters assigned to each of them as seen in Figure 5.1. The letters could then be mapped back to numbers, so a phone number starting with *WOR*, would simply be 967 for the machine. As the letters Q and Z were uncommon, they were not included. Eventually, they were added as well.

While telephone exchange names were phased out in the 1960s [32] as area codes were introduced for long-distance calling, the letters on the dials stayed in the U.S. As the letters were just a proxy for the numbers, they could be used for things such as advertising. It made remembering long phone numbers much easier, as one would have to only remember a couple of digits and then a word relating to the product. For example, a company selling

computers could tell the customers to call the number *1-800-COMPUTERS*, which would be much easier to remember than its number-counterpart *1-800-266788377*.

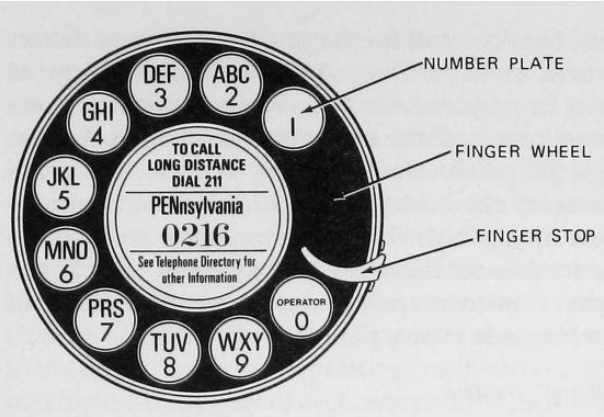


Figure 5.1: Proposition for the positions of the letters on the phone dial [19].

5.2 Mobile Phone Keyboards

As mobile phones started appearing in the late 1970s and early 1980s, it wasn't clear how to arrange the buttons. There were primarily 2 options for the arrangement: the first was to use the pattern commonly found on calculators where the numbering started from the bottom and the other pattern was to start from the top. To keep things orderly, a standard for arranging digits, letters, and symbols on telephone systems was made in 1988 by the International Telecommunication Union, ITU [25]. The option chosen by the ITU was the latter, with the buttons in a $4x3$ array. Aside from numbers, it also featured the lettering system that Blauvelt proposed in 1917, including the letters Q and Z. It also had places for two extra symbols on the bottom row: * on the left and # on the right, with 0 in between.

5.2.1 Mobile Phones with Physical Buttons

Most mobile phones would follow the standard and people learned to type with the keypad. Unlike with older telephones, the letters weren't just numbers masquerading as letters. When entering a number into a number field, the buttons would act as normal numbers. However, when entering text into a field, the buttons would transition to a writing mode, where for example pressing the 2-button once would enter the letter a and two times in quick succession would enter the letter b.

While many people would learn to write quickly like this, it was cumbersome and unintuitive for new users. Not everyone was satisfied with this type of keypad for writing text, so Nokia

created the *Nokia 9000 Communicator* phone in 1996 [4]. On the front, it looked like a regular phone with a 4-by-3 keypad, but it could be opened like a book to reveal the first full QWERTY keyboard on a mobile phone. It also featured many features of current-day smartphone devices such as email, web browsing, and word processing.

5.2.2 Mobile Phones with touchscreens

Before touchscreens became the mainstream mobile phone feature in the mid-2000s, the first touchscreen phone was released already in 1994, the *IBM Simon Personal Communicator* [1], making also the first smartphone. As a touchscreen phone, it didn't require a physical keypad and offered a virtual 4 by 3 keypad as well as a full QWERTY keyboard. As typing on a touchscreen didn't give any haptic feedback, they included a rudimentary predictive typing feature, which showed 6 characters most likely to come next based on what had been already written. The IBM Simon was revolutionary, but it didn't garner much public attention and sold only 50,000 units.

There were some other attempts at touchscreen phones, but what made the breakthrough for the *iPhone* in 2007 [38] was it used a capacitive touchscreen. Capacitive touchscreens supported touching multiple locations, whereas resistive touchscreens, which had been the prominent type of touchscreen on other attempts, didn't without clever techniques. The touchscreen on the iPhone was also very responsive, which made it intuitive to use. Of course, the iPhone had the same issue as the IBM Simon, there is no haptic feedback on a virtual keyboard. However, by this time, auto-correction features were much more advanced and the emergence of easy software updates allowed improvements over time as well.

The issue of not having a suitable keyboard layout doesn't really exist anymore with touchscreens. Users can install almost any layout, most commonly to make typing a different language easier, but efficiency-based layouts such as the Dvorak layout are also available. To make typing even easier, there are various tools other than auto-correct and predictive typing. Swipe typing could be one example. The user can swipe across the letters and the phone will analyze the drawn pattern and try to predict what the user had drawn. For some, it might be faster than typing each letter individually.

6 Conclusions

We can see that keyboards have taken quite an elaborate path from typewriters and keypunches to various different kinds of keyboards. As they became more modular parts of a computer rather than static ones, standards were introduced so most keyboards would work on most computers. Then keyboards met with the keypads of telephones and keyboards of other languages. It's a quite complicated timeline with multiple beginnings and branching paths.

Therefore, it makes sense that not everything could fit into this paper, such as teleprinters, which played a fairly big role in computer terminal input, before keypunches were introduced. Another missing aspect would be laptop keyboards, which had to have a more compact keyboard layout as full-sized keyboards were too wide. Of course, there are also many more languages and types of layouts that could not fit into the paper but would be interesting to know the history for.

Another interesting aspect that could be investigated would be the accessibility of keyboards over the years. While keyboards were mostly used for working aspects before, nowadays computers have become so widespread it is almost impossible to function in modern society without access to one. How well disabled people have been accommodated is an important question and topic to think about.

Bibliography

[1] D. Aamoth. *First Smartphone Turns 20: Fun Facts About Simon*. https://time.com/3137005/first-smartphone-ibm-simon/. Accessed 15 May 2023. 2014.

[2] R. Adal. *History of technology: How China sidestepped QWERTY*. 2017.

[3] AFNOR Groupe. *French keyboard: a voluntary standard to make typing French easier*. https://www.afnor.org/en/news/french-keyboard-voluntary-standard-typing-french-easier/. Accessed 7 May 2023. 2019.

[4] R. Baguley. *The Gadget We Miss: The Nokia 9000 Communicator*. https://medium.com/people-gadgets/the-gadget-we-miss-the-nokia-9000-communicator-ef8e8c7047ae. Accessed 15 May 2023. 2013.

[5] R. Bolo and M. Bolo. *Commodore PET 2001 computer. On display at the Musée Bolo, EPFL, Lausanne*. https://commons.wikimedia.org/wiki/File:PET_2001_Series-IMG_1724.JPG. Accessed 16 May 2023. 2011.

[6] E. Britannica. *personal computer*. https://www.britannica.com/technology/personal-computer. Accessed 16 May 2023. 2023.

[7] Britannica, The Editors of Encyclopaedia. *Jacquard Loom*. https://www.britannica.com/technology/Jacquard-loom. Accessed 20 April 2023. n.d.

[8] Britannica, The Editors of Encyclopaedia. *typewriter*. https://www.britannica.com/technology/typewriter. Accessed 3 April 2023. n.d.

[9] R. Cassingham. *The Dvorak Keyboard: the Basics*. https://dvorak-keyboard.com/. Accessed 8 May 2023. n.d.

[10] CLI Team. *How Many Characters Are There in Chinese?* https://studycli.org/chinese-characters/number-of-characters-in-chinese/. Accessed 5 April 2023. 2022.

[11] CLI Team. *What is Pinyin?* https://studycli.org/learn-chinese/what-is-pinyin/. Accessed 5 April 2023. 2022.

[12] Computer History Museum. *The Engines*. https://www.computerhistory.org/babbage/engines/. Accessed 20 April 2023. n.d.

[13] Computer History Museum. *What Happened on July 4th*. https://www.computerhistory.org/tdih/july/4/. Accessed 21 April 2023. n.d.

[14] F. da Cruz. *Early Card Punch Machines*. http://www.columbia.edu/cu/computinghistory/oldpunch.html. Accessed 20 April 2023. 2007.

[15] F. da Cruz. *The IBM 026 Key Punch*. http://www.columbia.edu/cu/computinghistory/026.html. Accessed 21 April 2023. 2001.

[16] Eaton. *USB: Port Types and Speeds Compared*. https://tripplite.eaton.com/products/usb-connectivity-types-standards. Accessed 16 May 2023. n.d.

[17] D. Eberwein. *Friedrich Nietzsche's typewriter, a Malling-Hansen Writing ball, model 1878*. http://www.malling-hansen.org/friedrich-nietzsche-and-his-typewriter-a-malling-hansen-writing-ball.html. Accessed 3 April 2023. n.d.

[18] J. M. Ewalt. *Remington Standard No. 2 Typewriter*. https://americanhistory.si.edu/collections/search/object/nmah_687313. Accessed 3 April 2023. n.d.

[19] M. Fagen. *A History Of Engineering and Science in the Bell System, The Early Years, (1875-1925)*. 1975, pp. 576–579.

[20] D. Farquhar. *Types of keyboard connections, illustrated*. https://dfarq.homeip.net/types-of-keyboard-connections-illustrated/. Accessed 16 May 2023. 2022.

[21] History-Computer. *Basile Bouchon – Biography, History and Inventions*. https://history-computer.com/basile-bouchon-biography-history-and-inventions/. Accessed 20 April 2023. n.d.

[22] History-Computer.com. *Whirlwind – Complete History of the Whirlwind Computer*. https://history-computer.com/whirlwind-complete-history-of-the-whirlwind-computer/. Accessed 21 April 2023. 2022.

[23] Hsinchu City Cultural Bureau. *In 1973, Jiaotong University developed the first Chinese keyboard*. https://hccg.culture.tw/home/zh-tw/NCTU_PC_EQUIPMENT/597871. Translated from Chinese to English with Google Translate, Accessed 5 April 2023. n.d.

[24] Indolences, a Wikipedia user. *Hollerith card punch. Photo taken at the Computer History Museum*. https://commons.wikimedia.org/wiki/File:CTR_census_machine.JPG. Accessed 20 April 2023. 2005.

[25] International Telecommunication Union. *Arrangement of figures, letters and symbols on telephones and other devices that can be used for gaining access to a telephone network, E.161*. 1988.

[26] *ISO 7098:1982 Documentation — Romanization of Chinese*. https://www.iso.org/standard/13682.html. Accessed 5 April 2023. 1982.

[27] Jamie. *Captioning Student's Thoughts*. https://web.archive.org/web/20060310062955/http://www.captions.org/2006/02/captioning-students-thoughts.html. Accessed 8 May 2023. 2006.

[28] K. Mak. *What is steno?* https://stenoodie.com/stenography/. Accessed 8 May 2023. 2013.

[29] Mallin-Hansen Society. *The most famous of Rasmus Malling-Hansen's inventions: The Writing Ball*. http://www.malling-hansen.org/the-writing-ball.html. Accessed 3 April 2023. n.d.

[30] onlinetyping.org. *Average typing speed (WPM)*. https://onlinetyping.org/blog/average-typing-speed.php. Accessed 8 May 2023. 2020.

[31] R. Polt. *A Brief History of Typewriters*. https://site.xavier.edu/polt/typewriters/tw-history.html. Accessed 3 April 2023. n.d.

[32] Rockland Telephone History Center. *SOME HISTORY ABOUT HOW PHONE NUMBERS CAME ABOUT*. http://www.rocklandtelephonemuseum.com/exchangehistory.html. Accessed 15 May 2023. n.d.

[33] Samwingkit, a Wikipedia user. *Coding of "Cangjie method" in traditional Chinese characters*. https://upload.wikimedia.org/wikipedia/commons/4/4a/%E5%80%89%E9%A0%A1%E8%BC%B8%E5%85%A5%E6%B3%95_%E6%8B%86%E7%A2%BC.jpg. Accessed 3 April, 2023. 2007.

[34] H. Schofield. *2016*. https://www.bbc.com/news/blogs-eu-35365604. Accessed 7 May 2023.

[35] stenograph.com. *History of Writing Machines*. https://www.stenograph.com/history-writers. Accessed 8 May 2023. n.d.

[36] M. R. Swaine and P. A. Freiberger. *ENIAC, computer*. https://www.britannica.com/technology/ENIAC. Accessed 21 April 2023. 2008.

[37] Waldyrious, a Wikipedia user. *Diagram of the English layout for a stenotype machine keyboard*. https://commons.wikimedia.org/wiki/File:Stenotype_en_layout.svg. Accessed 8 May 203. 2020.

[38] T. V. Wilson, N. Chandler, W. Fenlon, and B. Johnson. *How the iPhone Works*. https://electronics.howstuffworks.com/iphone.htm. Accessed 15 May 2023. 2007.

[39] L. Yutang. *Chinese typewriter*. U.S. Patent 2613795 A, 1946.