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THESIS

Takahiro Fujiwara

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UNIVERSITY OF DUNAÚJVÁROS

COMPUTER SCIENCE ENGINEERING BSC

THESIS

REPRODUCING THE CLASSIC CALCULATOR USING MODERN WEB TECHNOLOGY

Takahiro Fujiwara

Candidate of Bachelor of Sciences in Computer Engineering

<reg.Number of thesis (e.g. A-003-INF-2021.)>

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Abstract

The purpose of the abstract is to enable the student to summarize his / her dissertation in a concise way that is understandable to others. Another goal is to comply the thesis with keeping the formal requirements and the logical structure, therefore an attention-grabbing text can be created at the same time. The recommended length of the abstract is half, but not more than one A4 page, where subheadings, literary references, and footnotes are prohibited.

The beginning of the abstract contains the suggestions and the goals. After this, the rest of the abstract contains an explanation of the applied methods, omitting the exact details, but highlighting the new results.

The abstract contains only the necessary and interesting information that reflects the dissertation properly. It is very important that new features, for example the development and optimization of a new method, are really emphasized.

Table of Content

1. Introduction

The category of simulating real-world operations on a computer includes flight simulators, car driving simulators, and train driving simulators, which are well known for their use in games and training software. While all computers come equipped with a calculator function, the attempt to reproduce historically valuable calculators on a computer is not mainstream.

However, historical scientific and technological heritage has academic research value. Technically, the precursor to the computer was the calculator, but rather than being replaced by computers, calculators have undergone a separate evolution and bring their own unique value as household or office items. The technological innovation that realized handheld calculators small enough to fit in the palm of your hand, in particular, offers many points of interest such as display devices.

Out of gratitude to the pioneers who built up the culture of handheld calculators, I decided to research early calculators and reproduce them using modern technology. I hope that this will give new thoughts and valuable insights to many people.

1.1. Aims and Objectives of Thesis

There is a lot of information about how to use modern web technology, however, information on how to use it to simulate the look and behavior of real products is extremely rare.

Centered on the above, this paper hypothesizes that "modern web technologies can simulate real items at a practical level". Thus, the main aims and objectives of this paper are follows:

- Research the history of Classic Calculator and decide the target product.
- Prepare the source materials. Permission is also required.
- Define simulation points and create a basic outline of web page.
- Find and apply ways to simulate it by modern web technologies.
- Consider a method of similarity testing and evaluate the similarity.

1.2. Structure of Thesis

This thesis is composed of five major chapters. This sub-chapter provides a summary and introduces the structure of the entire thesis:

1. The 1st chapter provides an expansion of the title with more details on the topic to be tackled in this thesis, further explaining the relevance of the research, the scope of the research, and more detailed objectives that the thesis aims to achieve.
2. The 2nd chapter covers calculator history, focusing on electrical calculators before handheld calculators. It introduces the SHARP QT-8B, one of the first handheld calculators, and its base model, the QT-8D.
3. The 3rd chapter provides the simulation points on QT-8B. Also introduces the specific technologies. Next, the ways to simulate it with modern web technologies. Provides Web page design.
4. The 4th chapter provides the simulation result and its similarity between real photo and simulation work. First, outline of AI technology for similarity check. Next, actual measurement of similarity between real photo and simulation work.
5. The 5th chapter provides the deliverables to be published on the web, future possibilities, and suggestions for further research.

1.3.Reproducing Classic Calculator on Web Technology

1.3.1. Reproducing – Why Simulate Classic Products?

Reproducing the heritage of historical science and technology can not only learn how the technology needed in modern times has developed, but also pass on knowledge and experience for creation to the next generation. This knowledge not only enriches our understanding of the past, but also inspires us to imagine and shape the future.

1.3.2. Why Calculator?

The calculator is a ubiquitous device that we are all familiar with. We use it in various aspects of our lives, such as shopping, studying, and business. As Computer Science students, we even learn how to program a calculator. With the rise of digitalization in technology and life, these functions are now readily available on personal computers and smartphones. As a result, the need for dedicated calculator hardware is decreasing. This could lead to dedicated calculator hardware becoming as rare as public pay phones and classic cars. In the future, there might be an interest in classic calculators, similar to the interest in classic cars.

In such a timing, I felt the significance of revealing the historical value of the early calculator and preserving and publicizing it, so I decided to take on it myself.

1.3.3. Why Simulate It on the Web Technology?

Firstly, by using web technologies, we can digitize and preserve the early calculator, and make it publicly available on the internet. Modern web technology allows us to simulate the operation of a calculator, so anyone can experience the operation of an early calculator on a web browser. These allow anyone to access and learn about the early calculator from anywhere in the world.

Secondary, it is mentioned in “1.1Aims and Objectives of Thesis” there is a lot of information about how to use modern web technology, however, information on how to use it to simulate the look and behavior of real products is extremely rare. Through this paper, I decided to try to see how much simulation can be done with Modern Web Technology.

1.4. Scope of the Research

When conducting a simulation of a handheld calculator, the research scope is as follows.

- Choose only one calculator to simulate.
- The calculator in question must be the first of its kind in the world.
- The simulation scope mainly includes display and sound.
- Simulate button operations as much as possible.
- The similarity results will be determined using existing available tools.

1.5.Steps for Simulating Real Products

Now, you understood the importance of

1. Research the Classic Calculators.
2. Find the target product to Simulate
3. Research the simulation method
4. Development
5. Find the evaluation tool
6. Evaluate
7. Complete the documentation

2. Research the Classic Calculators

There are many definitions of early calculators, including desktop, portable, and handheld models. Early calculators could be placed on a desk, but not in the palm of your hand. At first, research the history of calculators and identify a suitable "something world's first" product for simulation.

2.1.History of Calculators

The history of calculators or history of computers has the same origin. Later, computers became devices that could be programmed with algorithms. Machines that simply perform calculations prepared by humans came to be called calculators [1].

The calculator, a key part of science and technology history, is shown in *Figure 1*.

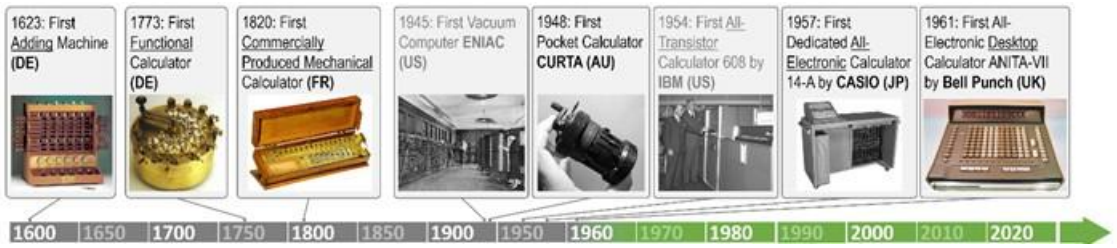

Figure 1. History of Calculators1 (Source: Author's own work)

The ENIAC (1945, US) was the world's first computer. The IBM 608 (1954, US), was the first full transistor calculator, followed. Both could be programmable computer/calculator, so, I would like to classify these as a computer here. See *Figure 2*.

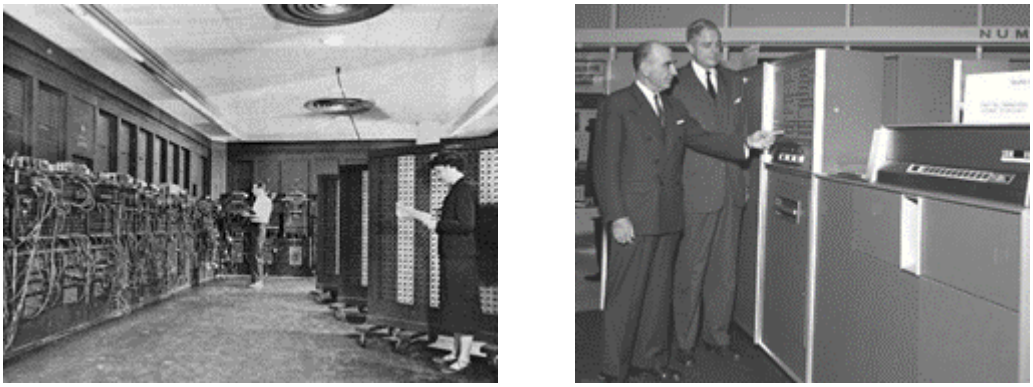

Figure 2. left – ENIAC (1945, US, source: ____),
right – IBM 608 (1954, US, source: _____)

2.1.1. The Advent of the Desktop Calculator

Therefore, the world's first dedicated calculator would be the CASIO 14-A (1957, JP, Figure 3). However, this machine was not a desktop calculator as the desk itself was part of the calculator. The world's first desktop calculator is the ANITA Mk7 by Bell Punch and Sumlock-Comptometer (1961, UK, Figure 3). It used vacuum tubes and cold cathode switching tubes for logic circuits and Nixie tubes for numerical display.

Figure 3. left – CASIO 14-A (1957, JP, source: _____),
right – Bell Punch and Sumlock-Comptometer ANITA-VII (1961, UK, source: _____)

2.1.2. The Advent of Portable Calculator

The next era is finally the era of battery-powered portable devices. See *Figure 4*.

Figure 4. History of Calculators2 (Source: Author's own work)

The "world's first" battery-operated portable calculator is SONY ICC-500W (1967, JP). Although it's called portable, as you can see from the photo shown in *Figure 5*, it looks like a desktop calculator with a handle. But the weight is lighter than desktop calculators, have a look at *Table 1* (FYI: Sony withdrew from the calculator business in 1972, unable to find a position for itself amid price competition with other companies).

Figure 5. left – SONY ICC-500W (1967, JP, source: ____),
right – ads on newspaper NIKKEI 1967.05.20. (source: _____)

2.1.3. The Advent of Handheld Calculator

In 1967, when Sony released the world's first battery-operated portable calculator, the prototype of the modern handheld calculator was announced by Texas Instruments Cal-Tech (1967, US). This influence was so great that it is said to be the prototype of the modern calculator. Although it was never commercialized, Canon later purchased the blueprints, made improvements, and released it with the name Canon Pocketronic(1970 Oct, JP)

Figure 6. left – Texas Instruments Cal-Tech, prototype (1967, US)
right – Canon Pocketronic (1970 Oct, JP)

2.1.4. What Are the Released Handheld Calculators?

I would like to pick up the world's first commercialized handheld calculator. In that case, Cal-Tech or Canon Pocketronic would not apply. Next, in 1969-1970, SANYO and SHARP calculator appear. SANYO's information is scarce and now part of Panasonic, making fact-checking is impossible. The leading information is that SANYO ICC-0081 was announced in 1969, but sales began at the same timing of the SHARP QT-8B.

Figure 7. left – SHARP QT-8B (1970, JP),
right – Sanyo ICC-0081 (1970, JP)

2.2. About the first handheld calculator here

It is generally considered to be the world's first handheld calculators are SHARP QT-8B, SANYO ICC-0081/ICC-82D, and Canon Pocketronic. There is an article that states that Canon Pocketronic's announcement was the same as SHARP's selling timing, but it was released half a year later. Considering this, the world's first handheld calculator was the SHARP QT-8B and SANYO ICC-0081 / ICC-82D.

Table 1. Significant Calculators in the History of Science and Technology

Year	Company, Country	Model Name	Remarks	Display Technology	Weight (kg)	Size	Battery
1957	CASIO, JP	14-A	World First Desk Style				
1961	Bell Punch and Sumlock, UK	ANITA-VII	World First Desktop	NIXIE			
	SHARP		Desktop				
1967	SONY, JP		World First Portable	NIXIE			yes
1967	Texas Instruments, US	Cal-Tech	Prototype	Print to paper tape			
1970	SHARP, JP	QT-8B	One of World First Handheld	VFD			yes
1970	SANYO, JP		One of World First Handheld	NIXIE			yes
1970	Canon, JP	Pocketronic	One of World First Handheld	Print to paper tape			

2.3.Reason for Choosing SHARP QT-8B as Simulation Target

I decided to target the SHARP QT-8B for my simulation in one of the world's handheld calculators. The reasons are as follows.

- To create the first handheld calculator, a vacuum fluorescent display (VFD) was used for segment letters, reducing power consumption and costs. This distinctive display design enhances easy-to-understand simulation.

Figure 8. Number display samples, left to right: VFD(recent), NIXIE, LCD.

- The operation of calculators is totally different from today. Experiencing this operation makes feeling the past-present difference easier.
- A lot of information remains, it seems that it was widely mass-produced.
- When I contacted Sharp Corporation about my simulation project, they kindly agreed. This has great significance for this simulation project.
- I found a used SHARP QT-8D calculator, same to QT-8B except power section. It is useful for operation verification and sound recording, etc.

Figure 9. left – SHARP QT-8B (1970, JP), middle – battery charger, right – QT-8D (1969, JP)

2.4.Introduction about SHARP QT-8B

2.4.1. Outline of QT-8B

The SHARP QT-8B, also known as the Micro Compet, was a portable electronic desktop calculator and the first mass-produced calculator to be battery-powered. It was introduced in May 1970 and was based on its immediate predecessor, the QT-8D, which was introduced in late 1969. The QT-8B replaced the QT-8D's integrated power supply with a rechargeable battery pack. It has the same calculating integrated circuits as the QT-8D and is of similar appearance and dimensions; the power supply is the only major difference. The QT-8B's release price in Japan was 117,000 JPY. The U.S. price in mid-1971 was $495, equivalent to about $2,700 in 2010.

2.4.1. QT-8D operation for calculation

As you can see from the photo, the operation of the QT-8B is different from that of a typical calculator. There is no single button for + − × ÷ =, there are only combination buttons as − =, × ÷, + = as shown in *Figure 10*. This is because the idea of an adder like a cash register is introduced. The multiplication and division operations also seem to have been influenced by computer logic. Note that not all calculators of this era operated like this.

Figure 10. Operation buttons on the QT-8B

2.4.2. Display technology in QT-8B

The SHARP QT-8B's display is a vacuum fluorescent display as called VFD, the first of its kind to be used in a production calculator. It has eight digits of precision, with both a minus sign and an overflow indicator dot on the right-hand side. The decimal point is "floating"—it is positioned automatically by the calculator logic. This was an advanced

feature for the time; many desk calculators of this era had fixed decimal points and required very wide displays to maintain a minimum level of precision across the entire range of numbers available. The QT-8B's floating decimal allowed its display to be much narrower while still keeping eight digits of precision.

Figure 11. Vacuum fluorescent display (VFD) in SHARP QT-8D (source: __)

2.4.3. Characteristics of VFD Display

A Vacuum Fluorescent Display (VFD) uses a mesh, or control grid, to manage the electrons emitted from the cathode. When the cathode is heated by an electric current, it releases electrons. These electrons are then controlled and diffused by the mesh. The accelerated electrons that reach the anode cause the phosphor to emit light, creating the bright and high-contrast display characteristic of a VFD.

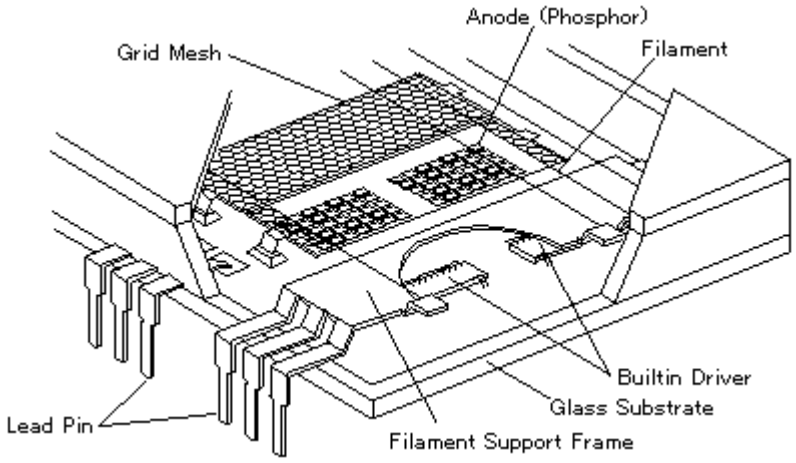

Figure 12. Basic Structure of VFD Display (Source: Noritake)

3. Simulation Points and Corresponding Web Technologies

Here, clarifies the part to be simulated first, and then explain how to achieve it.

3.1. Concept of Simulation Method

This section clarifies the part to be simulation, there are 5 main parts as image, finger movement, pushing sound, 3D perspective, VFD display.

3.1.1. Using photo of real product

To immerse audience in the world of classic calculators, I will utilize photographs of the actual devices. This approach transcends mere simulation, offering a tangible connection to these technological artifacts.

3.1.2. Simulate the Finger Movement

Simulate finger shadows on real photos. *Figure 13* shows moving finger on the picture. The left picture shows nothing, middle picture shows moving finger on the "9", right picture shows try to press the "9" button.

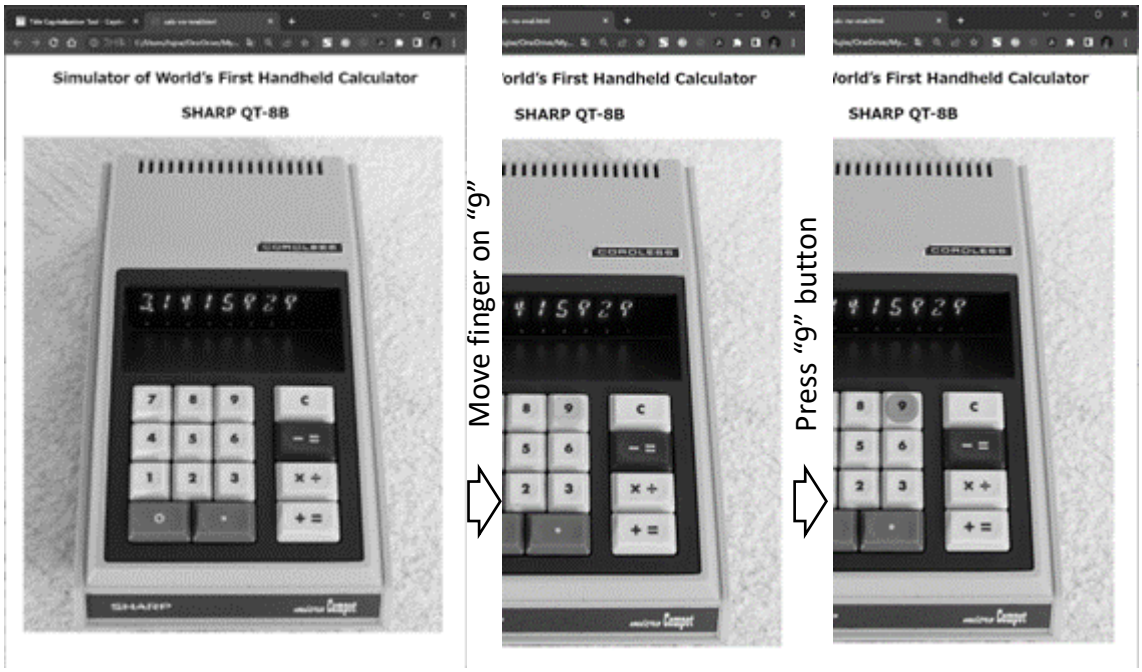

Figure 13. Simulation of moving finger on the picture.

3.1.3. Simulate Button Pushing Sound

Enhancing the real experience can be achieved by producing a sound when a button is pressed. Each button should have a slightly different sound, and you can recreate it by recording and playing back the sound of each button.

3.1.4. Simulate 3D perspective

The photographs are taken from a diagonal overhead perspective, mimicking the angle at which the device would be used, thereby creating a sense of depth. Objects closer to the camera appear larger, while those further away appear smaller. As a result, a quadrilateral placed on a plane may appear as a trapezoid in the photographs.

The display panel is positioned at an angle that makes it easy to see when sitting down. This is expressed as wide at the top and narrow at the bottom.

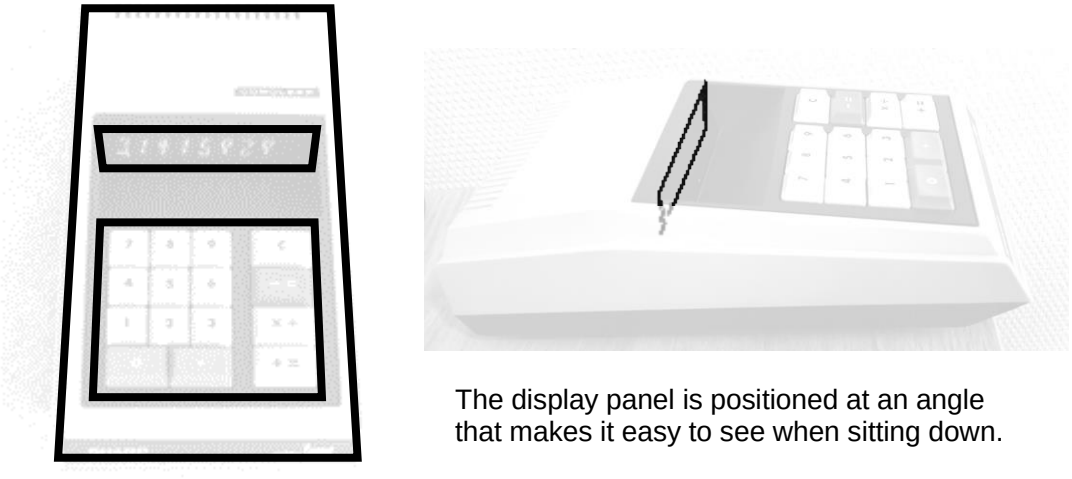

Figure 14. 3D perspective on the photograph (source: author's work)

3.1.5. Simulate VFD Display

The simulation replicates real-world phenomena such as the glow of the display and the mesh on the surface of the VFD, as well as reflections and blurring. This is the most significant point of the simulation. The character designs will also be the same as the original. See *Figure 15*.

Figure 15. Display on SHARP QT-8B

3.1.6. Simulate the Calculate Operations

In modern times, this method of operating a calculator feels very unique. An example of how to use it is included in the instruction manual at the time.

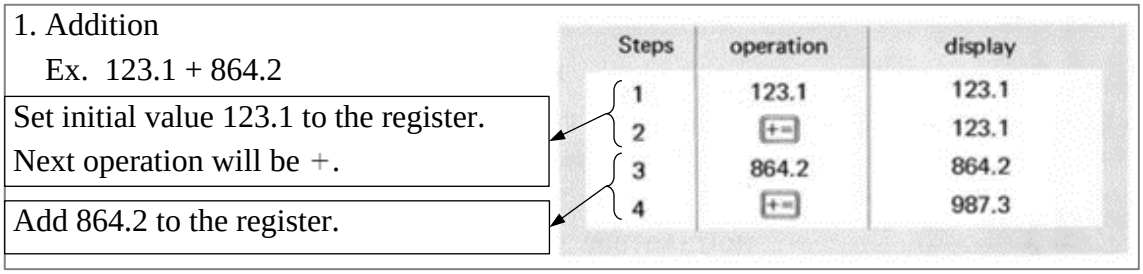

Figure 16. Addition operations from QT-8B Instruction Manual

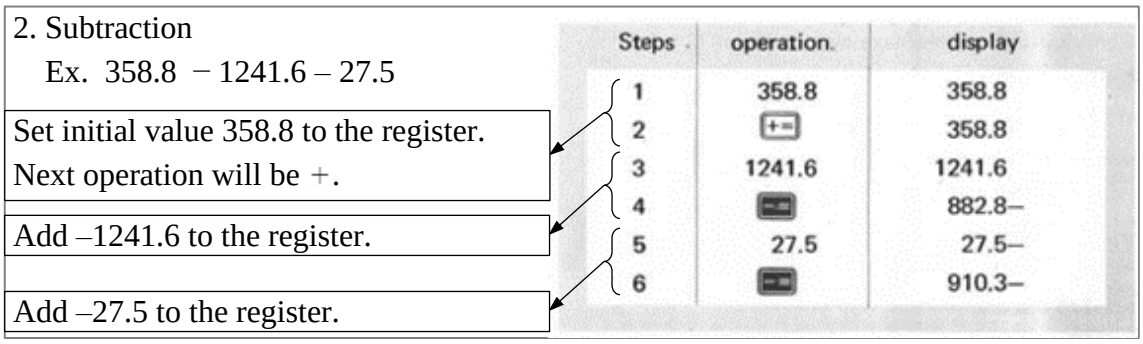

Figure 17. . Subtract operations from QT-8B Instruction Manual

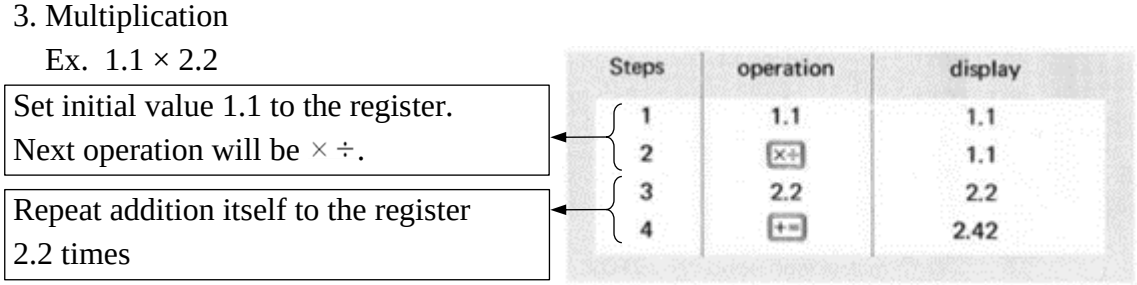

Figure 18. Multiplication operation from QT-8B Instruction Manual

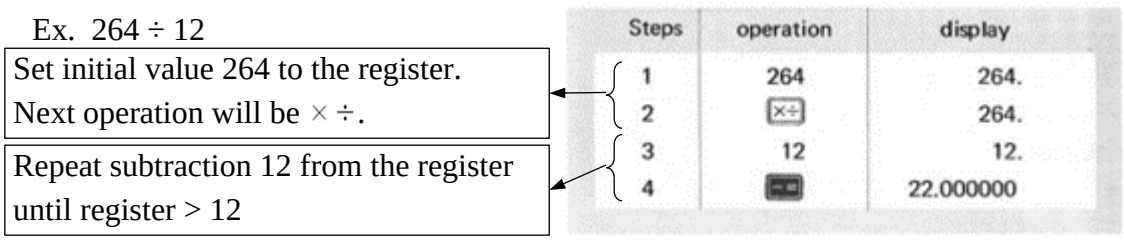

Figure 19. Division operation from QT-8B Instruction Manual

3.2.How to Achieve Simulation With Modern Web Technologies

There are several ways to achieve this, but my approach is to place a real photo underneath and position transparent buttons and display areas on top of it. The display simulates illuminated characters on a pitch-black display.

3.2.1. Using photo of real product

First, create the basic code in HTML. In this example, the display part uses the <input> tag in read-only mode, the photo uses the <img> tag, and the buttons use the <button> tag. See *Figure 20*.

```
    <div class="calculator" id="calculator">
        <img id="image" src="P1000257s.jpg" alt="Sharp QT-8B" />
        <div class="overTheImage">
            <input type="text" class="display" id="display" readonly />
            <br/>
            <button onclick="appendNumber('7')" id="D7"></button>
            <button onclick="appendNumber('8')" id="D8"></button>
            <button onclick="appendNumber('9')" id="D9"></button>
            <button onclick="clearDisplay()" id="C"></button>
            <br/>
            <button onclick="appendNumber('4')" id="D4"></button>
            :
        </div>
    </div>
```

Figure 20. Codes of main HTML, focus on explaining picture overlay

In the above, the 2nd line `<img id="image" src="P1000257s.jpg" alt="Sharp QT-8B" >` is the for the base image and the 3rd line `<div class="orthoimages">` is for the overlay part, which are provided by following CSS code. See *Figure 21*.

```
.overTheImage {
  position: absolute;
  top: 0; left: 50%;
  transform: translate(-50%, 0);
  width: 700px;
  padding-top: 240px;
  padding-bottom: 100px;
  padding-left: var(--keyboard-offset-L4);
}
```

Figure 21. Codes of CSS, focus on explaining picture overlay

The 2nd line `position: absolute;` is given for the element `<div class="overTheImage">` in the HTML, then this element is excluded from the normal flow of the document. In other words, an overlay on top of the image is achieved. Basically, the different point is only this for the overlay. Now we can place regular buttons or texts on the image.

3.2.2. Simulate the Finger Movement

There are two methods to simulate moving a finger over a photo. One is to cast a shadow at the mouse pointer's position. The other is to capture the mouse's hover event and cast a shadow at that location. Casting a shadow at the mouse pointer's position can be considered more realistic, but it has the problem of making it difficult to understand which position is pressable. The hover event makes it clear that it can be pressed there. I used the mouse hover event method which is able to define with CSS.

```
:root {
  --opacity-level-idle: 0.0;  /* when debug for checking area, change 0 -> 0.5 */
  --opacity-level-hover: 0.1;
  --opacity-level-active: 0.3;
}
button{
  background: rgba(0, 0, 0, var(--opacity-level-idle));

button:hover {
  background: rgba(0, 0, 0, var(--opacity-level-hover));
}
button:active {
  background: rgba(0, 0, 0, var(--opacity-level-active));
}
```

Figure 22. Simulate finger movement by CSS, using hover handler.

3.2.3. Simulate Button Pushing Sound

Playing the sound is achieved using JavaScript. Need to consider the sound volume and its default level. See

```
const NumKeyS = new Audio('NumKey1.mp3');
function Digit() {
  NumKeyS.volume = Slider.value;
  NumKeyS.play();
  :
```

Figure 23. Sound support by JavaScript.

The audio data I use is recorded from the actual SHARP QT-8D machine. The sound of each button is slightly different, so I recorded all the buttons. A dedicated application "AudaCity" was used to reduce the file size and make the best sound duration.

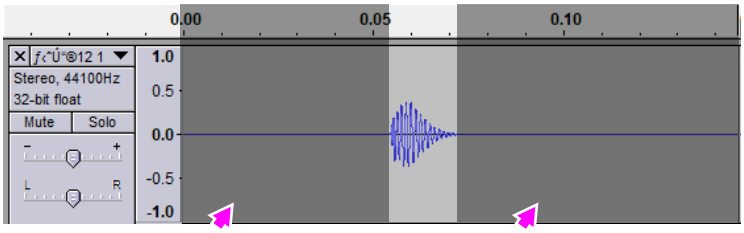

Figure 24.Removing part from the sound recordings.

3.2.4. Simulate 3D perspective

As shown in *Figure 14*, the photo used in this work is taken from the perspective of a seated position operating the calculator. To give the impression of actual operation, the surface of the button panel is represented in perspective. The display is set with different parameters to appear upright.

```
<style type="text/css">
.perspective {
  display     : inline-block;       /* 奥行表示のためのブロック化 */
  transform   : perspective(200px)  /* 深さ */
                rotateX(30deg);     /* 角度 */
}
</style>
```

Figure 25. NEED UPDATE Perspective for buttons by CSS

```
<style type="text/css">
.perspective {
  display     : inline-block;       /* 奥行表示のためのブロック化 */
  transform   : perspective(200px)  /* 深さ */
                rotateX(30deg);     /* 角度 */
}
</style>
```

Figure 26. NEED UPDATE Perspective for display area by CSS

These methods align the shadows of the buttons and display characters with the photo's depth. See *Figure 27*.

Figure 27. NEED UPDATE Perspective buttons and display on photo.

3.2.5. Simulate VFD Display

Simulating the font of a VFD display can be a challenging task due to its unique design. Fortunately, there is an individual who has taken an interest in this unique design and have made it usable as a web-font. Since it's free, I decided to use it in my work.

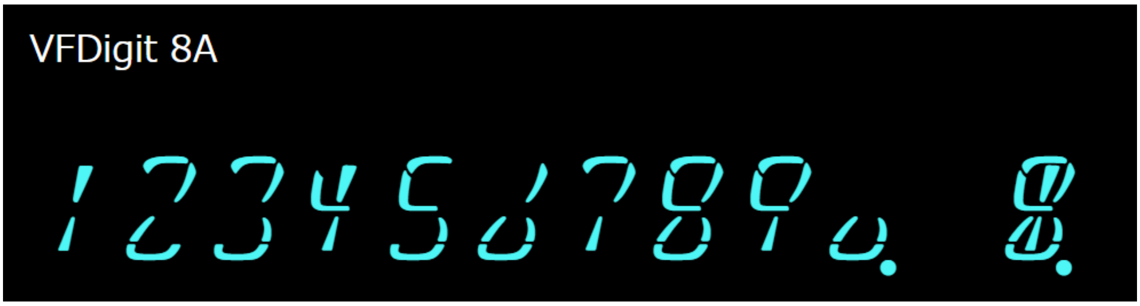

Figure 28. Font "VFDigit", same design to SHARP QT-8B

Design is good. However, the real VFD display has a mesh above the light emitter. So, need to set a mesh design on the display even on the HTML/CSS. It is similar technology as "Overlay text on the image", in the sub section "3.1.1Using photo of real product".

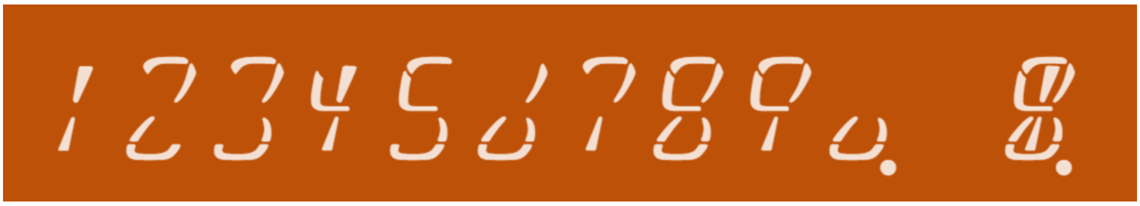

Figure 29. NEED UPDATE: Mesh on the font

Moreover, the real product has a phenomenon such as the glow as well as reflections and blurring. These effects can be provided by CSS. NEED DETAIL. Aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb bbbbbbbbbbbbbbbbbbbbbbbbbbbbb

3.2.6. Simulate the Calculate Operations

The operation keys of this model differ from modern calculators, requiring discernment of its logic. Based on the manual and actual operation, I inferred the program structure. *Figure 30* describes Addition, Subtraction, and Clear operations.

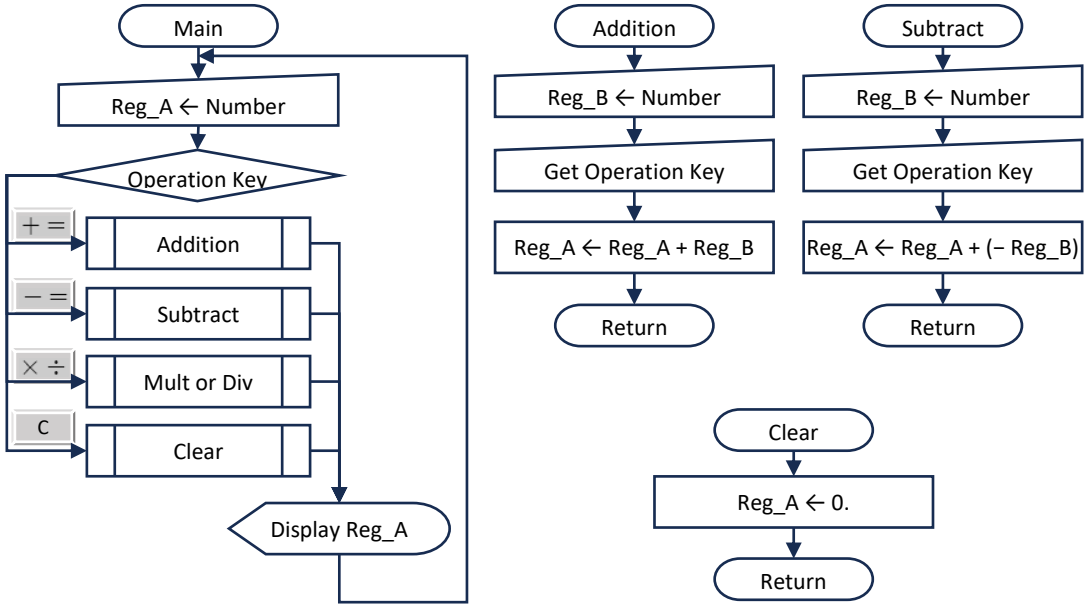

Figure 30. Flowchart for Basic operations investigated by author (without Mult or Div)

Figure 31 outlines Multiplication and Division operations. It seems multiplication is essentially repeated addition, and division is counting how many times the divisor can be subtracted from the original number. However, floating-point calculations are omitted.

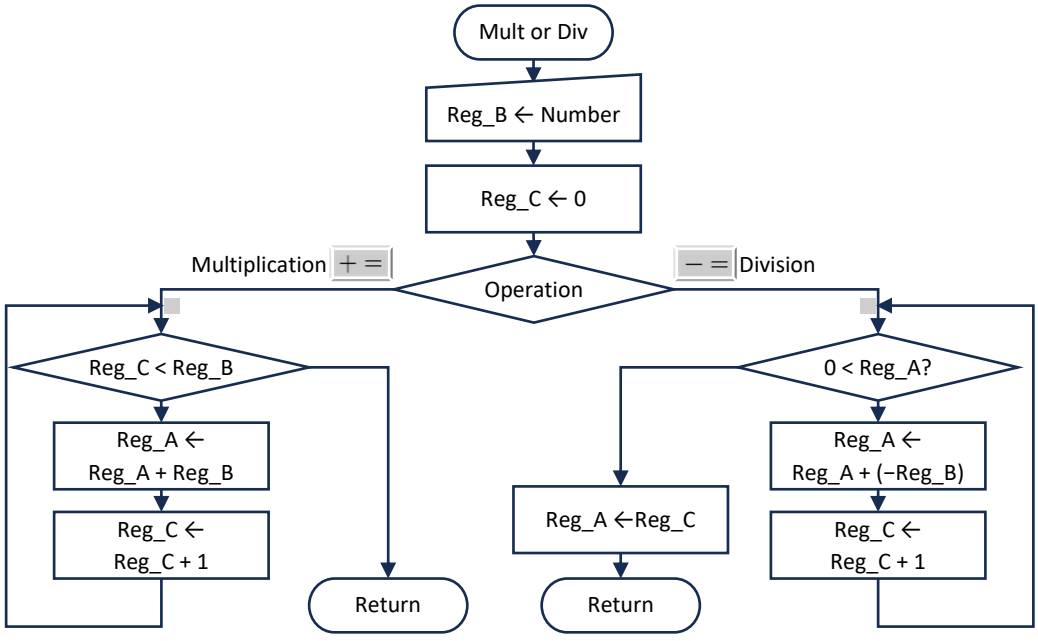

Figure 31. Flowchart Multiplication and Division functions investigated by author

4. Execution and Development Environment

This chapter describes the execution and development environments.

4.1.Execution Environment

The execution environment runs on a web server and a web browser on the client PC, as shown in the diagram below. The Client PC can be any computer, including macOS, Windows, and Linux, as long as it runs a Modern Web Browser.

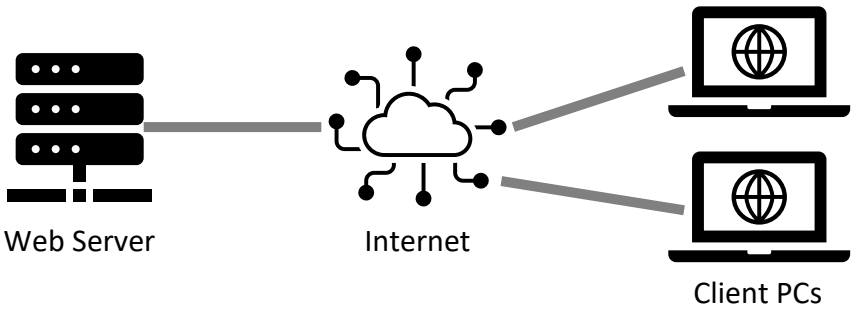

Figure 32. Execution Environment

Modern Web Browser: There is no actual definition for this word. This time, HTML5

4.2.Development Environment

5. Simulation Result and its Similarity Check

6. Rules of Headings and Subheadings

Each heading / title (Heading 1 style) start in new blank page.

The headings are followed by at least 1-2 paragraphs! Never include headings that are directly followed by a new, lower-level heading. Insert at least 1-2 paragraphs (through 2-3 lines each) of text bellow each heading. Furthermore, where a chapter has only one subchapter, the division of the subchapters is unnecessary. In this case, the whole content must be described within the chapter (without sub-chapter).

6.1.Rules of References

The following sub-chapter overviews the rules of references in the different cases of thesis elements.

6.1.1. Rules of Bibliography References

Readers can get information of the depth of Candidate's scientific work and research from the bibliography list at the end of the thesis. References also prove that Candidate has avoided plagiarism and acknowledges his/her sources of information.

If Candidate makes non-literal reference from one specific scientific literature in case of one sentence, does so that in front of the punctuation mark at the end of the sentence, e.g.:

This is an example sentence to illustrate the reference type discussed above [1].

If a full paragraph is referenced from a piece of literature, put the reference number at the end of the paragraph, after the punctuation mark at the end of the sentence.

This is an example paragraph to illustrate the reference type discussed above. This is an example paragraph to illustrate the reference type discussed above. This is an example paragraph to illustrate the reference type discussed above. [1]

If there are more scientific sources of the paragraph(s), use references at the end of the text, divided them by . (comma) in case the references are in different part of the list of bibliography. In case they are after each other in the list, use references divided by – (hyphen). The following example shows the appropriate reference format for a sentence:

This is an example sentence to illustrate the link type discussed above [1-4], [5], [10].

The following example shows the appropriate reference format for one or more paragraphs:

> This is an example paragraph to illustrate the more than one references type discussed above. This is an example paragraph to illustrate the reference type discussed above. This is an example paragraph to illustrate the reference type discussed above. [1-4], [5], [10]

In each case of literal quotation Candidate should enclose it in “ (quotation marks), align the quotation to the right and format italics, and place the reference at the end of the quotation. The dissertation can be continued in a new paragraph. For example:

> *„This is an example for a literal reference.” [1]*

6.1.2. Requirements for Reference of Images

The figures are placed in the dissertation according to Figure 1, as template provides, so centered, space before 18pt, line height is 1.5, with the appropriate resolution and size for easier readability. Each figure must be followed by its fig. caption. Each fig. caption must be inserted as a reference and contains a fig. number and a title. The format of the fig. caption as template (TNR, 12pt, italic, centered, space before 0pt, after 18pt). If Candidate uses/inserts a figure from outer source, the literature reference has to be inserted at the end of the fig. caption enclosed by […]. If Candidate uses self-edited figure, the fig. reference is the following text enclosed by (…): (self-edited figure). Candidate has to refer to each figure by its fig. number in the text, where it is mentioned, e.g. (Figure 1)!

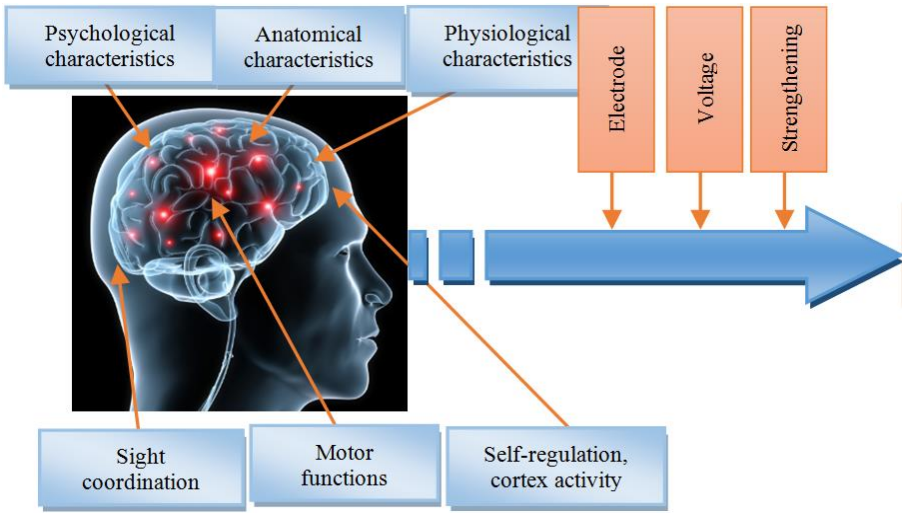

Figure 1: A simple model for processing bioelectrical signals [1]

Figures can also be inserted on the previous or next page, avoiding blank spaces at the bottom of the page.

6.1.1. Requirements for Reference of Tables

Just like figures, tables should be referenced in the text too (e.g. Table 1 shows the results of the research). Creating table captions with ref. number is like fig. caption (use Word references service). Table caption is centered with 1 normal style blank row before and after (or the better to use 12pt spacing before and after). Combine it with the appropriate colors for easier readability. The style in Table 1 example table is optional but recommended. If the table is broken by a page, do not leave it "cut in half", use page break.

Table 1.: Results [1]

Course	Groups	Average	Deviation	Impact	t-test
Mathematics	G1 G2	3,036 3,15	0,769 0,933	0,14*	t = 0,53 (p < 0,05)
Electronics	G1 G2	3,345 3,3	0,886 0,979	0,05*	t = 0,19 (p < 0,05)
Programming	G1 G2	3,254 3,3	0,927 0,979	0,05*	t = 0,18 (p < 0,05)

**small impactg (d<0.5).*

Tables can be inserted on the previous or the next page to avoid large blanks.

6.1.2. Requirements for Reference of Annexes

The appendices should be referred to in the text as with the figures and tables, e.g.: ”I have depicted the current state in the manner found in Appendix 1.”

6.2.Source Code in the Text

Source code parts recommended to be display in the thesis as text not as figures. Format them differently than body part (e.g. apply `Consolas font type`). Long codes (e.g. multi-page codes) have to be placed as appendices. In thesis body Candidate should highlight the essential elements only. The most elegant way to represent the algorithm is to use language-independent description. Do not cut and insert the code-base written in a specific language into the thesis body. Here are some samples bellow:

The following language-independent source code snippet contributed significantly to the optimization of the xy algorithm:

```
Algorithm arrayMax(A,n)
   currentMax ← A[0]
   for i ← 1 to n-1 do
      if A[i] > currentMax then
         currentMax ← A[i]
{ increment counter i }
return currentMax
```

The following C# source code snippet contributed significantly to the optimization of the xy algorithm:

```
int? currentMax = null;
int index = -1;
for (int i = 0; i < array.Length; i++)
{
   int currentNum = array[i];
   if (!currentMax.HasValue || currentNum > currentMax.Value)
   {
      currentMax = currentNum;
      index = i;
   }
}
```

7. Summary

Candidate should summarize the essence of the dissertation in this chapter, with a strong emphasis on his/her own results. Recommended size is up to 1 page.

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List of Figures

List of Tables

List of annexes

Annex 1.

Efficiency of combat nerve gases

The appendices of the dissertation should be numbered if there are more of them. Candidate has to refer to the relevant Annex in the list of Annexes with a cross-reference.