­­­

Number Plate Recognition System

Subtitle zzzzzzzzzzzzzz

Ziqi Li

Bachelor’s Thesis

Spring 2025

Degree Programme in Information Technology

Oulu University of Applied Sciences

abstract

Oulu University of Applied Sciences

Degree Programme in Information Technology

Option of Software Engineering zzzzzzzzzzzzzzzzzz

Author(s): Ziqi Li

Title of thesis: Number Plate Recognition System

Thesis supervisor(s): Jukka Jauhiainen

Term and year of completion: Spring 2025

Pages: e.g. 24 + 5 appendices (or 1 appendix) zzzzzzzzzzz

This thesis presents the development and implementation of a Number Plate Recognition (NPR) system. The primary objective was to design a system capable of processing images to detect and recognize license plate text.

The system was built using a React-based frontend and a Python-based backend. The frontend provides an interface for uploading images, while the backend uses two identification solutions. The first is YOLO (You Only Look Once) for object detection and EasyOCR for text recognition. The second is Azure's Custom Vision for object detection and computer vision for text recognition.

The results demonstrate that the system can successfully detect license plates and recognize text under various conditions. Limitations include occasional misdetections due to blurred images or obstructed plates. Future development proposals include real-time video stream processing and further integration with intelligent traffic management systems.

This work provides an automatic vehicle recognition solution.

contents

abstract 2

contents 3

glossary 4

1 introduction 5

2 XXXXXX 6

2.1 First subheading at Heading 2 level 6

2.2 Second subheading at Heading 2 level 7

2.2.1 First subheading at Heading 3 level 7

3 XXXXXX 9

3.1 Tables 9

3.2 Figures 11

3.3 Formulas 12

3.4 Other illustrations and appendices 13

4 document accessibility and submission 15

4.1 Checking accessibility 15

4.2 Finalizing document submission 15

5 DISCUSSION 18

references 19

appendices 21

glossary

API Application Programming Interface: A set of rules for building and interacting with software applications.

Azure Vision A cloud-based computer vision service provided by Microsoft Azure for image analysis.

EasyOCR An open-source Optical Character Recognition (OCR) tool that supports multiple languages.

OCR Optical Character Recognition: A technology for converting different types of documents into editable and searchable data.

YOLO You Only Look Once: A real-time object detection algorithm that detects objects in images.

# introduction

The rapid advancement of intelligent transportation systems has increased the demand for automated vehicle identification technologies. Number Plate Recognition systems have emerged as a critical tool in this domain, with applications ranging from traffic monitoring and toll collection to enhancing public security. Despite the progress made in recent years, challenges such as varying lighting conditions, occlusions, and diverse plate designs still hinder the performance of existing systems.

The purpose of this thesis is to implement an NPR system that can accurately detect and recognize license plates from images. The system uses two recognition methods: YOLO + EasyOCR and Azure Vision API. This improves the accuracy and robustness of detection under different conditions.

YOLO + EasyOCR: This mode employs the YOLO (You Only Look Once) object detection algorithm to locate license plates in images, followed by EasyOCR for text recognition. This approach is computationally efficient and suitable for local processing, making it ideal for scenarios where rapid, offline recognition is required.

Azure Vision API: This mode integrates Microsoft's Azure Vision API . It is particularly effective in handling complex cases where advanced image processing and text recognition capabilities are needed.

By combining these two methods, the system achieves greater flexibility and adaptability, catering to a wide range of real-world scenarios. The dual-mode approach allows for both high-speed processing and high-accuracy recognition.

# SYSTEM ARCHITECTURE AND DESIGN

This Number Plate Recognition System integrates multiple technologies, including YOLO and Azure Custom Vision for license plate detection, EasyOCR and Azure Computer Vision for character recognition. The system consists of three main layers: the frontend, backend, and machine learning models. Below is a detailed explanation of the architecture.

图片包含 船, 滑雪, 水, 男人

描述已自动生成

## Frontend structure

The frontend of the Number Plate Recognition System is developed using React, a popular JavaScript library for building user interfaces. The primary purpose of the frontend is to provide an intuitive interface for users to upload images. The following sections detail the architecture and workflow of the frontend.

### Key Components

The file upload component serves as the initial user interaction point, enabling users to select and upload an image for processing. This is implemented with a file input element, where the handleFileChange function captures the selected file. The function updates the fileName state with the file's name and stores the file object in the imageFile state for subsequent processing. After the user has uploaded the file, click the Recognize button, it triggers the handleRecognize function, which validates the presence of an uploaded image. This function creates a FormData object to encapsulate the image file and sends an asynchronous HTTP POST request to the backend server.

Upon receiving a response from the backend, the application updates the logs state with the server's output. If an error occurs, the error state is updated with a message to inform the user. The application provides clear visual feedback, such as displaying the selected file's name in a text input element and presenting error messages or recognition logs in a designated message area.

### React State Management

React’s useState hook is leveraged for state management. The fileName state keeps track of the uploaded file's name, while the imageFile state stores the file object. The logs state holds results or output from the backend server, and the error state manages error messages for user feedback. Together, these states ensure a dynamic user interface.

Styling and layout are managed through an external CSS file (App.css), ensuring a clean and user-friendly interface. The design emphasizes simplicity, with clear sections for file upload, action buttons, and result display. Error messages and logs are styled for readability, enhancing the application’s usability.

### First subheading at Heading 3 level

In these guidelines, the main headings and second level sub-headings are the most used headings. This subsection also gives an example of a third-level heading. Sub-headings hierarchically structure the topic presented in the main heading into logical sections.

It is not advisable to structure too limited topics into separate sub-sections. It is recommended that a sub-section should contain at least two paragraphs. If necessary, unnumbered sub-headings can be used to structure the content, as in section 2.2.2.

### Second subheading at Heading 3 level

Lists and unnumbered sub-headings are always preceded by a topic sentence or a short introductory text. A list cannot begin directly under a numbered sub-heading.

Unnumbered subheading in the text

If necessary, it is also possible to use unnumbered subheadings, for which there is a style *Väliotsikko* *tekstissä* in the *Style* menu. They are not included in the table of contents.

Unnumbered subheading in the text

Unnumbered subheadings can be used in a long sub-section to structure, for example, parts of a whole, work instructions or successive steps. This way it is easier to find them in the text, even if the headings do not need to appear in the table of contents.

# visual aids

Written reports can typically be illustrated, for example with figures, tables, text examples, code examples or interview quotes. Figures, tables, diagrams, and formulas are inserted between the text for illustrative purposes. Each figure, table and formula are referred to in the preceding text. If there are several figures and tables, it may be appropriate to have some of them as appendices. The figure or table should not be placed immediately after the heading. Instead, the heading should be followed by a paragraph with an in-text reference related to the illustration.

Figures, tables, and formulas are numbered consecutively, each one separately. Other field-specific material or data may be numbered in an equivalent manner. Word tools can be used for numbering, but manual numbering is also possible for a thesis-length text.

## Tables

Tables are inserted in the relevant section of the text to illustrate the point being made. The content of the table is interpreted and referred to in the text. In this way, the reader can identify the relevant information in the table.

A good table is as clear and self-explanatory as possible. Row and column headings structure the content of the table. Tables are numbered and the table description should make it clear what the table is about. The table description is placed above the table, and it is formatted either by italics using the *Caption* style in the *Style* menu, or by using the automatic numbering function of the *Captions* group in the *References* menu, as in this template.

Previously published tables can also be used in the thesis. In this case the source is indicated after the table description (Table 1). To ensure accessibility, the table is not attached as a screenshot but should be created using the Word spreadsheet tool or a spreadsheet program such as Microsoft Excel. Instead of illustrating text content in a table format, use lists. If the essential content of the table is not summarized in the text or in the table description, an alternative text should be created for the table using the *Table Properties* function (Saavutettavasti.fi 2024.)

TABLE 1. Degrees completed at Oulu University of Applied Sciences in 2021 (Vipunen 2022, suodattimet 2021, Oulun ammattikorkeakoulu)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Fields of study | Bachelor’s Degrees | Master’s Degrees | Other | In total |
| Education | 42  + 1–4 | 12 |  | 57 |
| Arts and humanities | 33 | 30 |  | 63 |
| Social sciences | 1–4 | 1–4 |  | 1–4 |
| Business, administration and law | 225 | 33 |  | 258 |
| Information and communication technologies (ICT) | 162 | - |  | 162 |
| Engineering, manufacturing and construction | 321 | 48 |  | 369 |
| Agriculture, forestry, fisheries and veterinary | 30 | 6 |  | 36 |
| Health and welfare | 465 | 78 |  | 543 |
| Unknown | - | - | 186 | 186 |
| In total |  |  |  | 1 671 |

The table and table description should start at the same point as the rest of the text and should preferably be formatted to the width. Borders or background colours can be used to enhance the visual impact of the table and cells. Where appropriate, explanatory notes may be written below the table, as shown in Table 1.

The table and its description must be on the same page. If the table does not fit entirely on one page, the word *(continues)* is placed at the bottom right of the page and *TABLE 1.* *(continues)* is also added in the table description on the following page. A large horizontal table can be placed as an appendix using the section break (Appendix 1). It is also possible to attach separate files in Theseus.

## Figures

The term 'figure' is used to refer to illustrations such as photographs, maps, drawings, charts, diagrams, and screenshots. Figures are pasted into the relevant part of the text by selecting *Picture Format* menu in the *Arrange* group under *Position* by choosing *In Line with Text*.

The figure and its description are inserted in the left-hand margin. The figure description is formatted either in italics, the *Caption* style or, as in this template, with the automatically numbered *Insert Caption* function in the *Captions* group of the *References* menu (Figure 1). The source is indicated by an in-text reference after the figure.

A screenshot of a computer

Description automatically generated

FIGURE 1. Adding a figure description using the Insert Caption function. A caption from the study guide of Oulu University of Applied Sciences (Oulun ammattikorkeakoulu, 2024).

You should compress the figure if the file size is large. File compressing is done using the function *Picture Format* menu > *Adjust* group > *Compress Pictures* (Figure 2). The compress function opens in the top menu by clicking on the desired picture. Usually, the Web resolution provided by the function is sufficient.

A screenshot of a computer

Description automatically generated

FIGURE 2. Compress function (screenshot from Word)

To ensure the accessibility of the thesis, it is not recommended that passages with text, lists or other text material from sources are imported as figures, but they should rather be edited into body text or lists. An alternative text will be added to figures if the preceding text or figure description does not explain the figure sufficiently. The alternative text and figure description need to be dissimilar. The text is added by moving the cursor over the image and pressing the right mouse button. Then select the *View Alt Text...* option and enter the description text with a full stop in *Alt Text*.

## Formulas

The formulas are numbered, and the quantities are explained. The formula and the word FORMULA and its number are inserted on the same line in the right-hand margin. In the text formulas are numbered in the same way as figures and tables. Variables and quantities are italicized, but units of measurement are without italics (Formula 1). Using a formula editor is recommended, especially for complex formulas.

Linear momentum is calculated according to formula 1 (Benson, 1991,169).

FORMULA 1

= linear momentum

= mass

= velocity

## Other illustrations and appendices

In theses from different disciplines study materials may be called, for example assignments or cases. The following is a sample from a business studies thesis where it was necessary to introduce several cases. *Styles* menu style *Esimerkkiteksti* indents and condenses the text.

Example 1. There are four shareholders in a company: A, B, C and D. A has made a capital investment of EUR 25 000 in the company's invested free capital (SVOP) fund. [Tax Administration's example continues...]

Direct citations or samples from thesis material are formatted in the style of *Aineistositaatti* to stand out from the body text, such as the following citation from a student's course feedback:

*The group work was fun. It was very nice to practice meetings and negotiations in a relaxed atmosphere and I also got enough feedback.*

Code samples are preferably imported in a text format, as this allows them to be listened to by a screen reader. The contrast between the code text and its background should also be sufficient. (Manninen 30.3.2023.) Appendix 2 shows an example of how to edit a sample copied from the code editor.

Typical appendices of the thesis include for example questionnaires with the cover letter used during the thesis process, design documents, calculations and drawings, code samples, forms, presentation slides, concert handouts or patient instructions. Large design images or Excel sheets can be added as appendices to the work with landscape orientation to make them more reader friendly. The appendices are referred to in text in the same numerical order as in the case of figures and tables, so the appendices are arranged and numbered in the order of reference.

In Theseus, you can save text files, audio files, video files, drawings, or tables as a separate attachment to your work. A separate attachment is referred to in the thesis by mentioning the attachment in Theseus.

In different fields of education, the output of a thesis may be, for example, a separately published mobile app, a software program, a website or video or audio files. Refer to the output for example in the following way: The video is published on the oamkextra YouTube channel under the title [Oulun ammattikorkeakoulun yritysyhteistyö – Case Polar](https://www.youtube.com/watch?v=na4o0Z7kjPk).

# document accessibility and submission

Before uploading your thesis in Theseus, you need to make it accessible (Theseus s.a. a). Several issues affecting the accessibility of a thesis are already considered in this template. The author should plan and prepare the thesis material to be presented in an accessible way already during the planning phase. Any confidentiality issues should also be checked before uploading the file in Theseus.

## Checking accessibility

In an accessible Word file, you need to specify the language of the document and name it using *Title* (Saavutettavasti.fi 2024). In this Word template, English (UK) is defined as the default language and the text is formatted according to the accessibility guidelines with heading and text styles. There are no extra characters or spaces in the text. Figures and tables used have an alternative description or are presented in the text in such a way that the relevant information is clear without seeing the material. The background colour contrast of the text, figures, tables, and documents is sufficient. The template accessibility was checked using the *Check Accessibility* in the *Check Accessibility* group of the *Review* menu and discrepancies were corrected. In the first code text caption in Appendix 2 there is an example of a remark on poor colour contrast.

When finalizing the thesis, you need to ensure document accessibility and do an accessibility check. The basic guidelines are available at [Theseus accessibility guidelines](https://submissions.theseus.fi/en/accessibility-guidelines.htm) (Theseus s.a. a). More detailed guidelines can be found at [Accessible Word and PDF document](https://submissions.theseus.fi/en/Accessible%20WORD%20and%20PDF%20document.pdf).

## Finalizing document submission

The thesis heading structure can be displayed in Word by selecting *Navigation Pane* in the View menu. The same heading structure will be displayed in the left margin of the PDF version of the thesis saved according to Theseus instructions in the *Document Outline* view. In this template, the main heading style has *All Caps* on. In the text, however, use upper-case letters for the main headings. Otherwise, the layout of the thesis looks unfinished, as is the case with the main headings of the PDF file saved in Theseus in the example in Figure 3.

A screenshot of a computer

Description automatically generated

FIGURE 3. Illogical font sizes in the main headings of a PDF file

Template background information contains information as shown in Figure 4. This information must be edited in the final step, for example in the *Save As* view. It is important to check the author’s name (*Authors*) and the title of the document (*Title*). The title is displayed in the browser tab when reading the PDF file and is also required for accessibility reasons. The *Subject* field can be cleared. If not all items are displayed, the box can be expanded at the bottom right corner.

A screenshot of a computer

Description automatically generated

FIGURE 4. Document background information in Save As view (screenshot from Word)

The student saves his/her thesis in the Theseus database. Please read the instructions very carefully at [Theseus Submissions Page](https://submissions.theseus.fi/en/index.html) (Theseus s.a. b). Typical errors include not an up-to-date table of contents, thesis comments, an incorrect name of the degree programme in Finnish or English, an incorrectly named file or a different year on the cover page, abstract and Theseus entry form.

# DISCUSSION

The heading of the final numbered chapter of the thesis is typically the Discussion section. For discussion guidelines for different types of thesis report, see the Oamk thesis guidelines [Different Reporting Formats](https://vanha.oamk.fi/opinto-opas/en/content-of-studies/thesis) (Oulu University of Applied Sciences 2024).

Typically, the discussion section begins with a summary of the main purpose of the work, results and new knowledge gained. The results are evaluated in relation to the assignment or commission, objectives, or research questions. Depending on the thesis type, the reliability and applicability of the results in the professional field, the factors influencing the results and ethical aspects can be critically assessed and also topics for further research can be suggested. The author of the thesis also includes his/her own professional views and proposals in the discussion section.

references

Benson, H. 1991.University Physics. John Wiley & Sons, Inc. USA.

Hirsjärvi, S., Remes, P. & Sajavaara, P. 2014. Tutki ja kirjoita. 19th edition. Tammi. Helsinki.

Manninen, T. 30.3.2023. Accessability specialist. Federation of the Visually Impaired. Teams-interview.

Oulun ammattikorkeakoulu 2024. Opinto-opas. Opinnäytetyö. URL: <https://www.oamk.fi/opinto-opas/opintojen-sisalto/opinnaytetyo>. Accessed: 11.4.2024.

Saavutettavasti.fi 2024. Microsoft Word. Saavutettavuuskirjasto Celia. URL: <https://www.saavutettavasti.fi/saavutettavat-asiakirjat/word/>. Accessed: 11.4.2024.

Swales, J. & Feak, C. 2012. Academic Writing for Graduate Students – Essential Tasks and Skills. 3rd edition. University of Michigan Press ELT. Ann Arbour.

Theseus s.a. a.Opinnäytetyön saavutettavuusohjeet. URL: <https://submissions.theseus.fi/saavutettavuusohjeet.htm>. Accessed: 11.4.2024.

Theseus s.a. b.Theseus-tallennussivu. URL: <https://submissions.theseus.fi/>. Accessed: 11.4.2024.

Tolonen, T. 1.2.2018. Oops, I did it again! – eli mitä kaikkea voi mennä pieleen opinnäytetyötä tallennettaessa ja mitä kaikkea siitä voikaan seurata. Oamkin blogi. Rohkeasti kirjasto. URL: <https://blogi.oamk.fi/2018/02/01/oops-i-did-it-again-eli-mita-kaikkea-voi-menna-pieleen-opinnaytetyota-tallennettaessa-ja-mita-kaikkea-siita-voikaan-seurata/>. Accessed: 11.4.2024.

Vipunen 2022. Ammattikorkeakouluissa suoritetut tutkinnot. Opetushallinnon tilastopalvelu. URL: <https://vipunen.fi/fi-fi/_layouts/15/xlviewer.aspx?id=/fi-fi/Raportit/Ammattikorkeakoulujen%20tutkinnot%20-%20amk.xlsb>. Accessed: 6.9.2022.

appendices

If the thesis has appendices, this summary page will precede the appendices. The heading of the summary page is APPENDICES, using the *Numeroimaton otsikko* heading style, and this remains in the table of contents. The names and numbers of the appendices are written one below the other on this page. The following is an example of the list of appendices for this template.

Appendix 1 Additional instructions for using the Word template

Appendix 2 Example of improving accessibility

In this template, *Page Break* has been added to this page before Appendices 1 and 2. If you need to format the appendices, for example horizontally, create a new *Section Break* for the appendices.

**FURTHER INSTRUCTIONS FOR USING WORD TEMPLATE APPENDIX 1**

**Using styles step-by-step**

1. Select the part of the text where you wish to apply a style.

2. **Home - Styles**

* Click on the button Tyylin-ryhmän alakulman painike. in the bottom right corner of the **Styles** group to open the Styles dialogue box. You can also do the same by pressing **Ctrl** + **Shift** + **Alt** + **S**.

3. Select the style you want from the panel.

4. The text will now change according to the selected style. This allows you to quickly change any text to the required style.

5. You can also select a new style from the list and begin writing a new text. The text will automatically change according to the style.

6. MS Word includes shortcut keys for some styles. For example, the shortcut key for the **Normal** style is **Ctrl + Shift + N**.

**PLEASE NOTE!** Since styles are paragraph-specific, there should be a paragraph break (**Enter**) between the title and the text. This ¶ is the paragraph break character when the **Show All** function is selected in the document.

You can use the **Find** function to search for a specific word or part of a word in a document. The easiest way to use this is to press **Ctrl** **+ F**.

**Attaching text to the template**

If you paste text written elsewhere into this template, select **Keep Text Only** in the paste options.

A close-up of a white background

Description automatically generated

**Inserting a section break**

Add a section break if you want to format a part of the file differently from the rest of the text. For example, a single appendix can be flipped to landscape orientation. For instructions, see the Microsoft support page [Insert a section break](https://support.microsoft.com/en-us/office/insert-a-section-break-eef20fd8-e38c-4ba6-a027-e503bdf8375c).

**Updating the table of contents**

1. Right-click the table of contents and select **Update Field**. A pop-up window will appear.

A screenshot of a computer error

Description automatically generated

Select either **Update page numbers** only or **Update entire table**. Press **OK**.

Another method: **References - Table of Contents - Update Table**

**Creating a table of contents**

If you accidentally delete the table of contents, you can create a new one by following the steps below.

1. Select **References – Table of Contents.**
2. Select **Custom Table of Contents**. Only this selection provides pre-defined formatting required in the guidelines to the table of contents. This function creates table of contents with your custom headings using heading styles.
3. Select **OK** in the Table of Contents window.

A screenshot of a computer

Description automatically generated

**Naming tables and figures with Caption style**

The following provides instructions on how to add a numbered heading to a table or figure.

1. Add a table or a figure and right-click on it (the table must be selected first). Select **Insert Caption**.

A screenshot of a computer

Description automatically generated

1. Select the appropriate Note Caption from the drop-down menu: **TABLE** or **FIGURE**. If there are not any available, you can add a new label by selecting **New Label**.
2. Select the correct location: **Above selected item** (tables) or **Below selected item** (figures).
3. Add the table or figure name to the **Caption** field and click **OK**. The table or figure name must describe what is being presented in them.
4. In terms of accessibility, an alternative text must be added to figures or tables. Instructions: [Add alt text to a shape, picture, chart, SmartArt graphic, or other object](https://support.microsoft.com/fi-fi/office/vaihtoehtoisen-tekstin-lis%c3%a4%c3%a4minen-muotoon-kuvaan-kaavioon-smartart-grafiikkaobjektiin-tai-muuhun-objektiin-44989b2a-903c-4d9a-b742-6a75b451c669?ui=fi-fi&rs=fi-fi&ad=fi)

**Creating a basic table**

1. Select **Insert > Tables > Table** and choose how many rows and columns you want.
2. Click on the star icon in the left corner of the table (table selection).
3. Edit borders **Table Design > Borders > Borders**. Removing borders does not affect the number of rows or columns in the table.
4. The table is ready and you can add headings and texts to it.

**Quick table**

If you want to use tables that look the same throughout your work, you can save the table you have created as a quick table.

1. Create a table and edit it the way you want.
2. Select the table. The easiest method is to click on the arrow icon in the upper-left corner.
3. Select **Insert > Table > Quick Tables > Save Selection to Quick Tables Gallery.**
4. A pop-up window will appear. Enter the table name and any other information you want. Press **OK**.

A screenshot of a computer

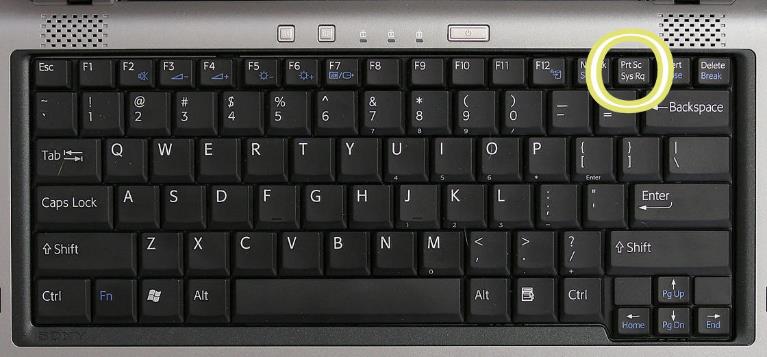
Description automatically generated

1. The table is saved to the gallery and you can use by selecting the table from **Insert > Tables >** **Quick Tables**.

**Instructions for appendices**

Here are some instructions on how to use a screenshot as an aid. For example, you can use it to take a screenshot of a questionnaire completed with Webropol software and attach it to your thesis.

**Snipping Tool** allows you to select exactly the part of the screen you want to attach. The same tool can be accessed by using **Windows + Shift + S**.



You can also use the **Print Screen / Prnt Scrn** key. Use the Print Screen key to take a picture of the entire computer screen currently open. By pressing **Alt + Print Screen** you take a picture of the open window only.

To add an image to your thesis, place the cursor to the desired section and press **Ctrl + V o**r right-click on the desired section and select **Paste**.

If you do not want to use the **Print Screen** button to paste a full screen image into your thesis, paste the image into a program such as **Paint** and crop it to your liking before pasting. You can also use Word's image tools to crop the image you want to include in the text. In this case, it is usually easiest to use the **Snipping Tool**.

**Other Word instructions**

In Word, you can search for other instructions in the **Help** menu.

**Word instructions for Mac users**

[Word for Microsoft 365 for Mac](https://download.microsoft.com/download/6/3/4/634e576c-136a-4638-b750-2f9d1b90a573/Word%20for%20MAC%20Quick%20Start%20Guide.pdf) (pdf)

[Microsoft 365 Quick Starts](https://download.microsoft.com/download/6/3/4/634e576c-136a-4638-b750-2f9d1b90a573/Word%20for%20MAC%20Quick%20Start%20Guide.pdf)

esimerkki SAAVUTETTAVUUDEN PARANTAMIsesta LIITE 2

**Tässä esimerkissä koodi on tuotu tekstinä, mutta kontrasti ei ole riittävä:**

**EXAMPLE OF IMPROVING ACCESSIBILITY APPENDIX 2**

**In this example, the code is imported as text, but the contrast is not sufficient:**

#include <Keyboard.h>

// Define buttons and corresponding pins

#define BUTTON\_COUNT 9

#define PIN\_1 5   // Green button,  keyboard 1

#define PIN\_2 6   // Red button,    keyboard 2

#define PIN\_3 7   // Yellow button, keyboard 3

#define PIN\_4 8   // Blue button,   keyboard 4

#define PIN\_5 9   // Orange button, keyboard 5

#define PIN\_SU 10 // Strum up,      keyboard Enter

#define PIN\_SD 16 // Strum down,    keyboard Backspace

#define PIN\_ST 14 // Start button,  keyboard Right Shift

#define PIN\_SP 15 // Star power,    keyboard Delete

#define DEBOUNCE\_TIME 20

byte buttons[9] = {PIN\_1, PIN\_2, PIN\_3, PIN\_4, PIN\_5, PIN\_SU, PIN\_SD, PIN\_ST, PIN\_SP};

// Button state arrays

byte buttonState[BUTTON\_COUNT] = {0};

byte buttonStateLast[BUTTON\_COUNT] = {1};

// Define an array of keyboard keys

char keyboardKeys[BUTTON\_COUNT] = {

  '1', '2', '3', '4', '5', KEY\_RETURN, KEY\_BACKSPACE, KEY\_RIGHT\_SHIFT, KEY\_DELETE

};

*FIGURE 1. Code definition section*

**In this example, the code has been made more accessible by adding a start and end text for the screen reader:**

Code begins.

#include <Keyboard.h>

// Define buttons and corresponding pins

#define BUTTON\_COUNT 9

#define PIN\_1 5   // Green button,  keyboard 1

#define PIN\_2 6   // Red button,    keyboard 2

#define PIN\_3 7   // Yellow button, keyboard 3

#define PIN\_4 8   // Blue button,   keyboard 4

#define PIN\_5 9   // Orange button, keyboard 5

#define PIN\_SU 10 // Strum up,      keyboard Enter

#define PIN\_SD 16 // Strum down,    keyboard Backspace

#define PIN\_ST 14 // Start button,  keyboard Right Shift

#define PIN\_SP 15 // Star power,    keyboard Delete

#define DEBOUNCE\_TIME 20

byte buttons[9] = {PIN\_1, PIN\_2, PIN\_3, PIN\_4, PIN\_5, PIN\_SU, PIN\_SD, PIN\_ST, PIN\_SP};

// Button state arrays

byte buttonState[BUTTON\_COUNT] = {0};

byte buttonStateLast[BUTTON\_COUNT] = {1};

// Define an array of keyboard keys

char keyboardKeys[BUTTON\_COUNT] = {

  '1', '2', '3', '4', '5', KEY\_RETURN, KEY\_BACKSPACE, KEY\_RIGHT\_SHIFT, KEY\_DELETE

};

Code ends.

*FIGURE 1. Code definition section*