GENERATIVE AI FOR TRADITIONAL FORM CONVERTER

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A PROJECT SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF BACHELOR OF ENGINEERING (COMPUTER ENGINEERING)
FACULTY OF ENGINEERING
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI
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Abstract

Generative AI for Traditional Form Converter is a project developed through a web application called PaperlessTransform Application to solve the problem of taking a long time to convert paper forms into web applications. The development of this web application uses artificial intelligence to analyze the types of data of questions.

As the demand for form conversion increases, system developers need to analyze forms and design database systems, design web application pages, and develop new systems. This results in increased work time. In addition, system developers face increased workloads, causing personnel to spend inefficient time on their work. Our project focuses on developing a web application that can convert documents in the form of paper forms or electronic files into web application formats. It uses optical character recognition techniques to convert text images into text formats to process the text from the converted text images to detect questions in the form format.

The project team focuses on developing a web application that has the ability to detect questions and store web form data. The aim is to reduce the burden on system developers. The results after testing the web application in the work show that the web application can detect questions in the form and store data at a satisfactory level. Therefore, it can be concluded that the project can significantly solve the problem of increased work time for system developers.

Keywords: Web Application / Optical Character Recognition (OCR) / Database Design

หัวข้อปริญญานิพนธ์	เว็บแอปพลิเคชัน AI สำหรับการแปลงฟอร์มกระดาษเป็นเว็บฟอร์ม
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ผู้เขียน	นายประภากร บุตรโยจันโท
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ปีการศึกษา	2567

บทคัดย่อ

Generative AI for Traditional Form Converter เป็นโครงการที่จัดทำขึ้นผ่านการพัฒนาผ่านเว็บแอปพลิเคชั่นในชื่อ Paper-lessTransform Application เพื่อแก้ไขปัญหาการใช้ระยะเวลานานในการแปลงแบบฟอร์มกระดาษเป็นรูปแบบเว็บแอปพลิเคชัน โดยการพัฒนาเว็บแอปพลิเคชันนี้ได้มีการใช้ประยุกต์ใช้ปัญญาประดิษฐ์สำหรับการวิเคราะห์เกี่ยวกับประเภทของข้อมูลของคำถาม ตามความต้องการที่เพิ่มขึ้นของการแปลงแบบฟอร์ม ดังนั้นนักพัฒนาระบบจึงจำเป็นต้องวิเคราะห์แบบฟอร์มและออกแบบระบบฐานข้อมูลพร้อมทั้งการออกแบบหน้าเว็บแอปพลิเคชัน รวมไปถึงการพัฒนาระบบขึ้นมาใหม่ จึงส่งผลให้ต้องใช้ระยะเวลาในการทำงานที่เพิ่มขึ้น นอกจากนี้ นักพัฒนาระบบต้องเผชิญกับปัญหาภาระงานที่มากขึ้น ส่งผลให้บุคคลากรใช้เวลาในการทำงานอย่างไม่มีประสิทธิภาพ โดยโครงการของเรามุ่งเน้นการพัฒนาเว็บแอปพลิเคชันที่สามารถแปลงเอกสารในรูปแบบของฟอร์มกระดาษ หรือ ไฟล์อิเล็กทรอนิกส์ให้เป็นรูปแบบของเว็บแอปพลิเคชัน โดยใช้เทคนิคการรู้จดจำอักขระด้วยแสงในการแปลงภาพข้อความให้เป็นรูปแบบข้อความเพื่อนำข้อความดังกล่าวจากการแปลงภาพข้อความนำมาประมวลผลในการตรวจจับคำถามในรูปแบบฟอร์ม ทางคณะผู้จัดทำโครงการมีการเน้นการพัฒนาเว็บแอปพลิเคชันที่มีความสามารถในการตรวจจับคำถามและความสามารถในการเก็บข้อมูลของเว็บฟอร์ม โดยมีวัตถุประสงค์เพื่อลดภาระของนักพัฒนาระบบ โดยผลลัพธ์หลังจากมีการทดลองใช้เว็บแอปพลิเคชั่นดังกล่าวในการทำงานแสดงให้เห็นว่าเว็บแอปพลิเคชันสามารถตรวจจับคำถามในแบบฟอร์มและเก็บข้อมูลได้ในระดับที่น่าพึ่งพอใจ ดังนั้นสรุปได้ว่าโครงการสามารถแก้ไขปัญหาการใช้ระยะเวลาในการทำงานที่เพิ่มขึ้น ของนักพัฒนาระบบได้อย่างมีนัยสำคัญ

คำสำคัญ: เว็บแอปพลิเคชัน / การรู้จดจำอักขระด้วยแสง / ออกแบบระบบฐานข้อมูล

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Finally, we would like to express our thanks to everyone, including our family, friends, and everyone who has contributed and supported this project. All the support and encouragement have been integral to its successful completion.

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LIST OF SYMBOLS

SYMBOL		UNIT
α	Test variable	m^2
λ	Interarival rate	jobs/ second
μ	Service rate	jobs/ second

LIST OF TECHNICAL VOCABULARY AND ABBREVATIONS

ABC	=	Adaptive Bandwidth Control
MANET	=	Mobile Ad Hoc Network
Test	=	Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nullam non condimentum purus. Pellentesque sed augue sapien. In volutpat quis diam laoreet suscipit. Curabitur fringilla sem nisi, at condimentum lectus consequat vitae.

CHAPTER 1 INTRODUCTION

1.1 Problem Statement

«««< Updated upstream Nowadays, there is a shift towards digitalization, whether it is using electronic devices to record instead of using paper or storing data in a database instead of recording on paper. However, there are many things that have not been transformed to be more digital, such as official documents and business documents that are still paper or forms that have been recorded on paper before. For things that have not been developed to be more digital, we are especially interested in improving the filling of paper forms. We found that the steps in the development process that change from paper forms to web forms require developers to analyze forms, create databases, and develop web applications, which takes a lot of time and the number of developers. We see that converting paper forms to digital forms by taking pictures of the forms and the system will create a web form for them. Improving the filling of paper forms to be more digital will help reduce global warming caused by excessive paper use.

1.2 Potential Benefits

Potential Benefitsof this web application include improved efficiency through automated form creation, enabling the rapid digitization of paper forms and saving valuable time that can be used for other tasks, and potentially reducing costs by eliminating unnecessary labor in form processing.

======= In recent year, the world has become more digitized than ever, whether it be using electronic devices for note-taking instead of paper or storing a data in a database rather than use a paper documentation, However, there are still many aspects that have not been transform to be a digital, such as a government organization that still rely on paper documentation or the data forms that have been previously recorded on paper. However, for those that have not been developed to be digital, we were motivated to improve the efficiency of form filling. And we found that the development process from paper-based forms to web forms required developers to do an analysis of the form, create a database, and develop a front-end and backend system. Which causes a developer time to spend and resources of developers. We acknowledge this difficulty and offer a solution that converts paper forms into web form ones so that the system can automatically create a web form by just taking a picture of the form. By decreasing excessive paper use, this development in digitizing form-filling procedures will not only increase efficiency but also lessen the environmental impact and help to slow down global warming. »»»»> Stashed changes

1.3 Objectives

- To reduce the workload and development process for developers.
- To acquire the knowledge and skills necessary for developing an AI-powered web application
- To acquire proficiency in utilizing a Large language models and adapt its capabilities to suit the requirements of this project.
- To be the secure all data and form management website

1.4 Scope of Work

The scope of this project involves the development of a web application that enables users to upload a PDF or image file. The web application will process text extraction using optical character recognition (OCR). The

primary function of the web application includes creating a form, editing a form, deleting a form, and filling a form. The final deliverable of this project will be a responsive web interface web application that allows users to manage the form and view the data, including ensuring data privacy and security measures to protect sensitive information by implementing authentication for the creator and a normal user. The project involves research of optical character recognition (OCR) for the text extraction from the image and the development of generative AI for data type generation, also a Thai language translation to English.

1.5 Limitation of Project

The limitation of the project will addresses a possible constraints and challenges that might affect its scope, execution, or outcomes. the limiting factor are include time, cost and risk etc.

- **OCR Accuracy:** The accuracy of OCR text extraction may vary depending on the quality of the uploaded document, such as low-resolution images, poor lighting, and the project does not support handwritten text.
- **Language Support:** While the system has the ability to translate text, the accuracy and availability of supported languages may be limited, with the project currently supporting Thai and English form only.
- **Required User Reviewing:** After the text extraction and layout detection, the system required a user to review and correct a input label that the system have process. The limitation required of user reviewing because of the lack of OCR accuracy and the system error.
- **Data Privacy and Security:** Despite the implementation of verification and security measures, there may still be vulnerabilities related to handling sensitive data, which are continuously checked and updated.

1.6 Project Schedule

For the first semester, our project focus on researching and design phase, We have researching all core fundamental concept and define a problem and background of the project. In the design phase, we have design a database design, UX/UI design, architecture design. And this phase also including a Optical Character Recognition proof of concept.

For the second semester, our project focus on implementing the form extractor and generative AI for the process of detect a form. We also focus on web application development and integrate a web application with the form extractor. also including the testing phase a system evaluation.

1.7 Expected Outcomes

This project aims to develop a fully functional web application that able to converting a paper-based form or pdf form into a web-based form by utilizing a generative AI for generate a data type of form label. And the web application should reduce a time developer have spend when they converting a form.

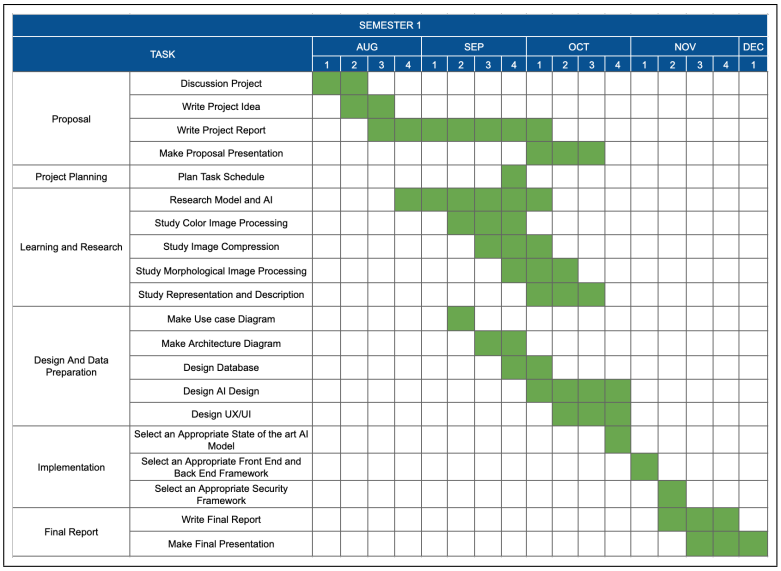

Figure 1.1 Schedule for first semester

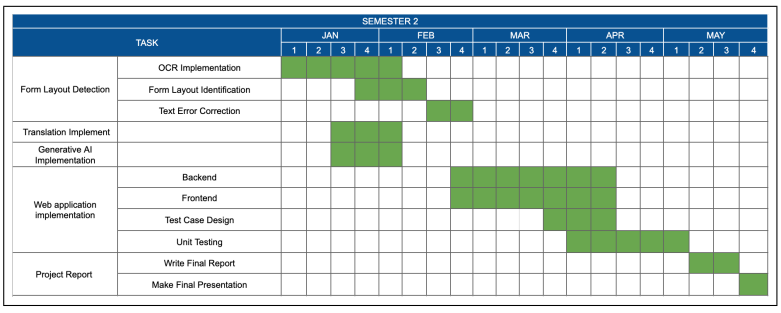

Figure 1.2 Schedule for second semester

CHAPTER 2 BACKGROUND THEORY AND RELATED RESEARCH

2.1 Introduction and Background

2.1.1 Introduction

This chapter will explain the details of the core concept and the solution planning. Theory and core concepts, languages and technologies, and related research will be discussed in this chapter. First, we will cover a core concept of artificial intelligence, machine learning, natural language processing and image processing etc.. Second, the languages and technologies that we interest in the project including a frontend and backend technology. Lastly, related research and competing solutions that are similar to our project will be in research and competing solutions.

2.1.2 Background

The digital transformation of businesses has been accelerated by the need for faster, more reliable ways to handle data. Although many organizations have begun to adopt digital processes, a significant number still rely on paper forms, which can slow down operations and increase the risk of errors. Manual data entry, in particular, is an inefficient method that often leads to mistakes, misinterpretations, and lost time.

To solve these problems, many organizations are looking for ways to turn paper forms into digital formats automatically. This is where AI comes in. AI tools can be trained to read forms and convert them into digital versions, speeding up the process and reducing errors. By automating this task, businesses can save time, lower costs, and reduce mistakes, allowing employees to focus on more important tasks.

This chapter will explain the main ideas behind the project. It will also discuss the technologies used in the project and look at similar research in the field of form automation.

2.2 Theory and Core Concepts

2.2.1 Artificial Intelligence (AI)

Artificial Intelligence (AI) refers to the study and development of intelligent machines and software that can reason, learn, communicate, and perceive objects, aiming to mimic human-like behavior. Coined by John McCarthy in 1956, AI is a branch of computer science that focuses on enabling computers to perform tasks typically requiring human intelligence, such as problem-solving, perception, and decision-making.

2.2.2 Machine Learning (ML)

Machine Learning is an application of Artificial Intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine Learning is crucial in building systems that can automatically learn to recognize patterns and improve over time with more data.

Machine Learning Method:

- **Supervised Learning:** A type of machine learning where the model is trained using a labeled dataset. This means the data comes with answers, so the model learns to make predictions or classify information correctly.
- **Unsupervised Learning:** A type of machine learning where the computer learns from data without labels or answers. Instead of being told what to look for, the model tries to find patterns or group similar data points together on its own.

- **Semi-supervised learning:** Like a mix of supervised and unsupervised learning. It uses a small amount of labeled data (with answers) and a large amount of unlabeled data (without answers) to train the model. The labeled data helps guide the model, while the unlabeled data helps it find patterns and improve accuracy.

2.2.3 Computer Vision (CV)

Computer Vision (CV) is a field of AI that uses machine learning to enable computers to interpret and understand visual information from the world, such as images and videos. It combines different methods and technologies.

Key functions of computer vision include analyzing images and videos to extract important information, understanding events and descriptions, and identifying patterns in scenery. CV employs methods that handle large volumes of data, making it applicable across various domains.

2.2.4 Image Processing

Image processing is the one technique in **Computer Vision (CV)** that is used to enhance and prepare images for analysis by applying various computational algorithms. In the context of form conversion, image processing plays a critical role in improving the quality of scanned documents or digital images before they undergo text recognition.

2.2.4.1 Image Acquisition:

The first step in image processing is acquiring the image, where an image is captured using a camera, scanner, or another device. Then the image is converted into a digital format that can be manipulated by algorithms.

Table 2.1 test table method1

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Tables should always on the left.

2.3 Text Processing Algorithms

2.3.1 Algorithm I

2.3.1.1 test

You can place the figure and refer to it as Figure 2.1. The figure and table numbering will be run and updated automatically when you add/remove tables/figures from the document.

2.3.2 Algorithm II

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2.3.2.1 Step I

2.3.2.2 Step II

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2.4 Development Tools

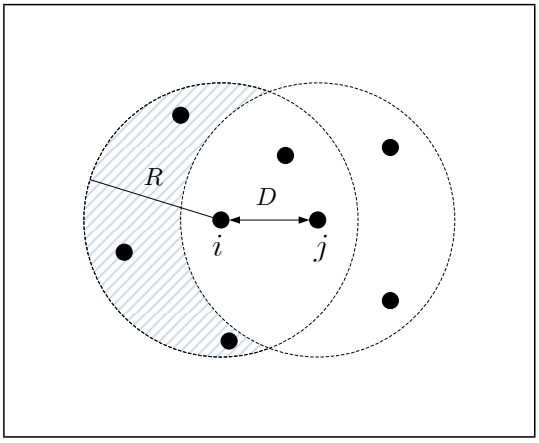

Figure 2.1 The network model

CHAPTER 3 DESIGN AND METHODOLOGY

This chapter will cover the features, architecture, functionalities, design methods, and diagrams of our web application. We will delve into the details of the application's functionality and architecture.

3.1 Project Functionality

3.1.1 System Requirements

- The web application must allow users to log in with email and password.
- The web application must allow the user to upload a form file to the system.
- The web application must allow users to fill the form without login.
- The web application must allow users to view the data of the form.
- The web application must allow users to edit the form before publishing.
- The web application must allow users to delete the form.
- The web applications must provide the option for all logged-in users to logout.

3.1.2 Feature List

3.1.2.1 Paper-Based Form Analysis System

The Paper-Based Form Analysis System will extract all the text from the document that is uploaded by the user via a web application. The system will then analyze the form's pattern ,extract the input labels, translate the text into English, and send the translated information to a generative AI for data type generation.

3.1.2.2 Form Schema generator System

The Form Schema generator System will receive information from the Paper-Based Form Analysis System and Form Schema generator System must be able to generate a form schema that compatible with a form library.

3.1.2.3 Web Form System

The Digital Form System must enable users to complete the form, store the data in the database, and see the data created by the form owner.

3.1.2.4 Registration and Authentication System

The Registration and Authentication System must enable a user to register and login to the system by using only email and password. This including a forgot password and the OTP for reset password.

3.2 Use Case Diagram

From the figure 3.1 The diagram shows a relationship between the user and the system by using a use case diagram. The user of the system is a developer that needs to transform a paper-base form into web application form and the user who going to fill the form. The system consists of 3 different systems, which are paper-based form analysis systems, form schema generator systems, web form systems and registration and authentication systems. The user can upload a paper-based form to the system, and the system will transform the form into a web-based form.

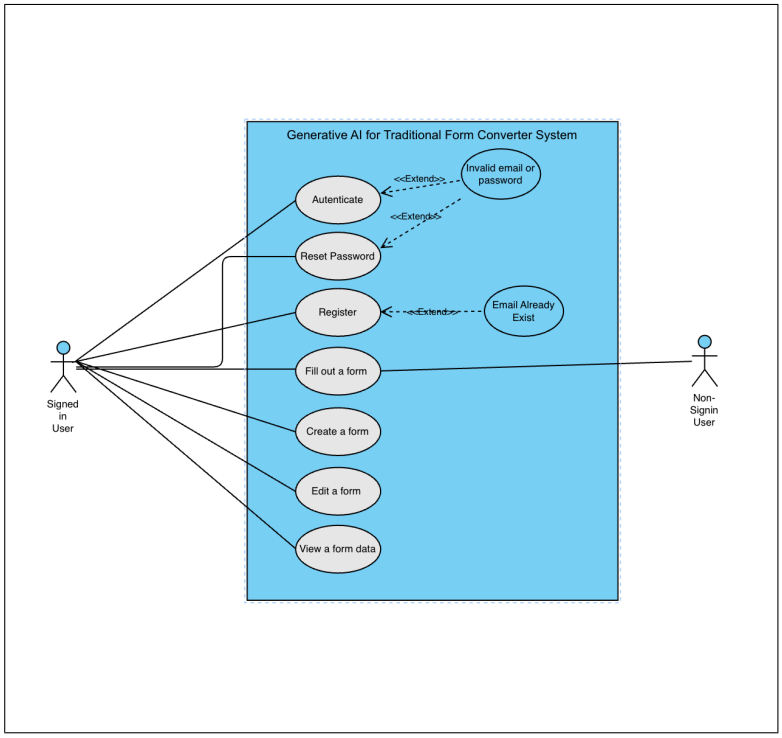

Figure 3.1 Use case diagram

3.3 Use Case Narrative

3.3.1 Autentication

Use Case Name: Autentication

Actors: Form Creator and Required Login User

Goal: Users log in to the system.

Preconditions: User is registered

Main Success Scenario:

1. User access the website.
2. User enter a email and password.
3. User submit a email and password.
4. System authenticate and navigate to the home page.

3.3.2 Register

Use Case Name: Register

Actors: Form Creator and Required Login User

Goal: Users register to a system.

Preconditions: User does not have an account

Main Success Scenario:

1. User access the website.
2. User click to create a new account.
3. User enter an email and password and personal information.

4. User submit information.

5. System saves user information and navigates users to the login page.

3.3.3 Create a form

Use Case Name: Create a form

Actors: Form Creator

Goal: Create a form by upload the form file.

Preconditions: User has logged in.

Main Success Scenario:

1. User go to home page.

2. User click at upload a form.

3. User select a file to upload.

4. System will process the file and navigate users to the edit form page to confirm a form before publishing.

3.3.4 Edit a form

Use Case Name: Edit a form

Actors: Form Creator

Goal: Edit a form to make a change.

Preconditions: User has logged in.

Main Success Scenario:

1. User go to home page.

2. User click at edit a form at the form user need to make change.

3. User make change a form.

4. User click back to the previous page.

5. System will process autosave and navigate users to the previous page.

3.3.5 View a form data

Use Case Name: View a form data

Actors: Form Creator

Goal: View the data that user have input

Preconditions: User has logged in.

Main Success Scenario:

1. User go to home page.

2. User click at view a data of the form.

3. User can see a form data

3.3.6 Fill up the form

Use Case Name: Fill up the form

Actors: Required Login Users and Anonymous User

Goal: Add a new data to the form

Preconditions: User has logged in or non-login user.

Main Success Scenario:

1. User access a form via the public link
2. User fill up a form.
3. User submit a form data.
4. System will save the data and navigate to the form page again.

Alternate scenario (user access the form required a login without login):

1. User access a form via the public link
2. System will navigate to the login page After login completes the user will redirect back to the form page.

3.4 Activity Diagram

From Figure 3.2 The Activity diagram shows the sequence how Generative AI for Traditional Form Converter System is working.

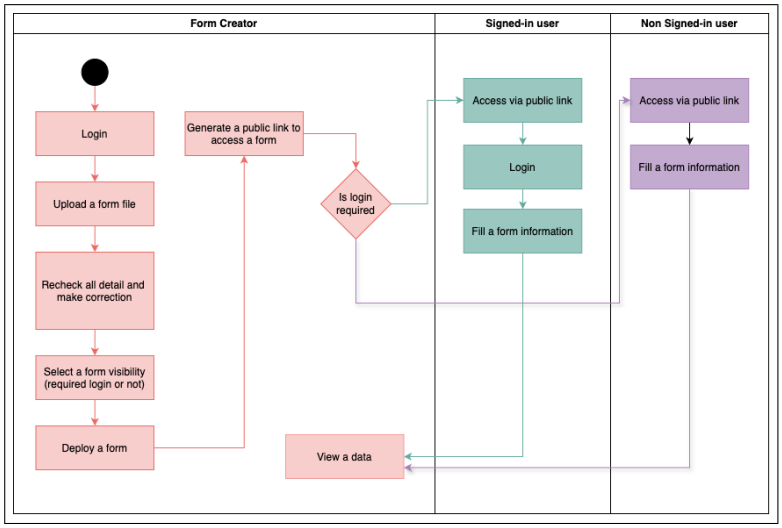

Figure 3.2 Activity Diagram

3.4.1 Form creator

- **Login:** Form Creator must login before use the system
- **Upload a form file:** After logging in, Form creator must upload a form file to add new form to the system.

- **Recheck all detail and make correction:** In this step, Form creator must check all the information that system has generated and make a correction if incase of error text found.
- **Select a from visibility:** Select a form visibility, whether the form creator need to form to be access by the user who signed-in or anyone can access.
- **Deploy a form and Generate a link:** In this step, the form will be saved and generated a link to allow user to access.

3.4.2 Signed-in user

- **Login:** If the form requires login, the user must log into the system.
- **Fill out information:** Once logged in, the user going to fills out the form and submit.

3.4.3 Non Signed-in user

- **Fill out information:** If login is not required, the user can directly fill out the form without logging in.

3.5 System Architecture

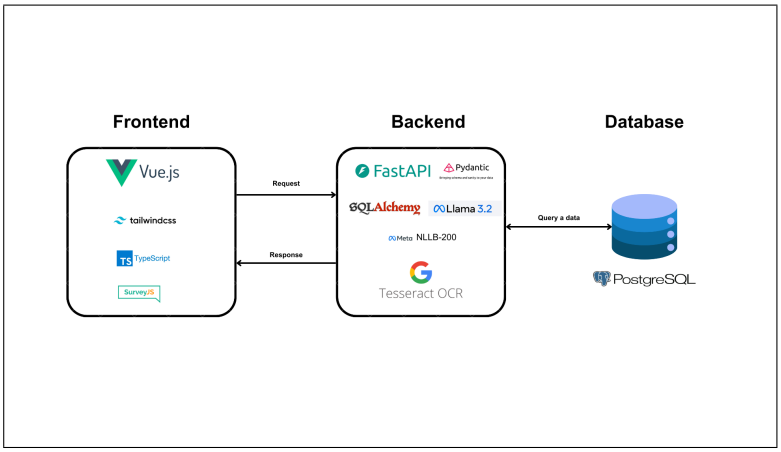

Figure 3.3 System Architecture

Figure 3.3, The diagram shown a system architecture in figure above, The System have divided into 3 part which front-end, back-end and database, each part have shown a technology stack, and here are the description of each component

- **VueJS** is a Front-end JavaScript library for building UI
- **TailwindCSS** is a CSS framework for styling the UI and used with React
- **FastAPI** is a Back-end framework for building REST API
- **PostgreSQL** is a relational database
- **Pydantic** is a python library used for data validation
- **SQLAlchemy** is a Python base Object Relational Mapper (ORM) and SQL Tool kit
- **SurveyJS** is a form engine Llibrary

- **Meta NLLB-200** is a Model for text translation
- **Tesseract OCR** is a OCR for extract text from image
- **Llama 3.2** is a generative AI from Facebook

3.6 Database Design

Figure 3.4 shown a project database design, the system consist three tables in our project database design are user, form, and formresult. table is used to store user data, formresult is used to store a result that the user has filled out, and form table is used to store a form schema.

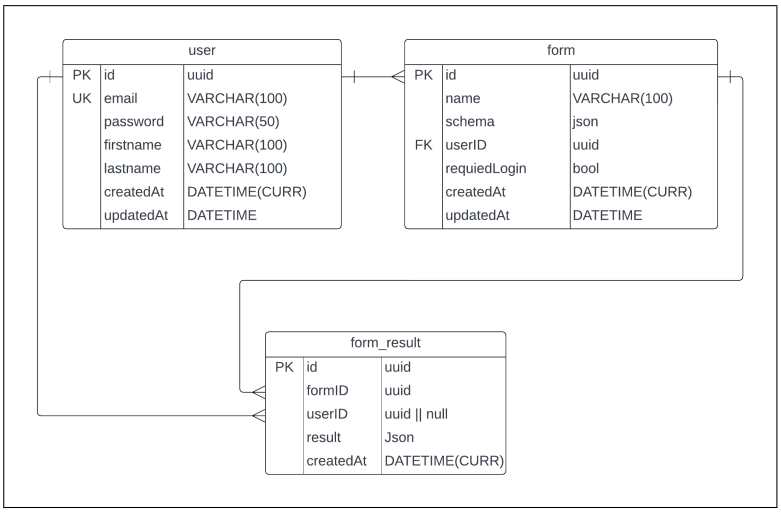

Figure 3.4 ER Diagram

3.7 User Interface Design

3.7.1 Login Page

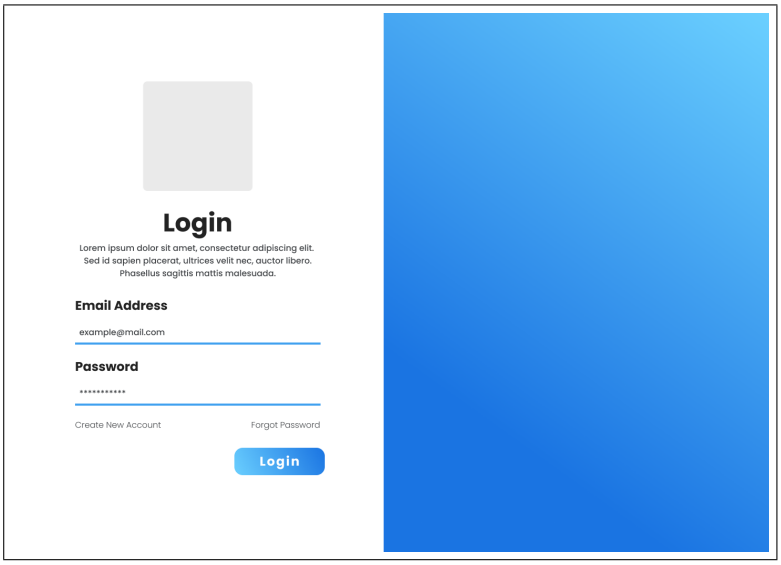

Figure 3.5 Login Page

Figure 3.5 represents the login screen of the web application. This page have a email field, password field and a login button to sent a credential to the back-end system.

3.7.2 Create Your Account

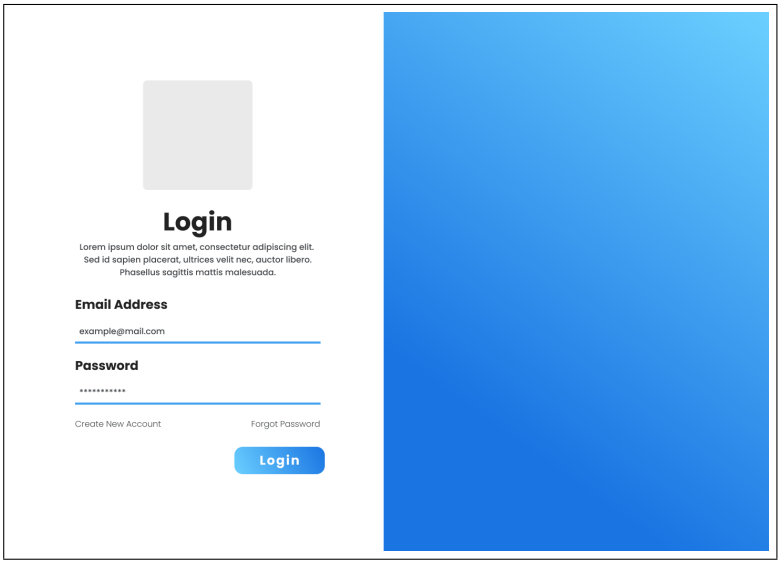

Figure 3.6 Create Account Page

Figure 3.6 represents the create account page of the web application. This page allow user to create their own account by the user must provide a following field which is name, email and password.

3.7.3 Forgot Password

At Figure 3.7 represents the create account page of the web application. When the user forgot their password, The user must navigate to this page by click at forget password from login page. And fill the email address to allow the system sent the One-time password (OTP) to email address.

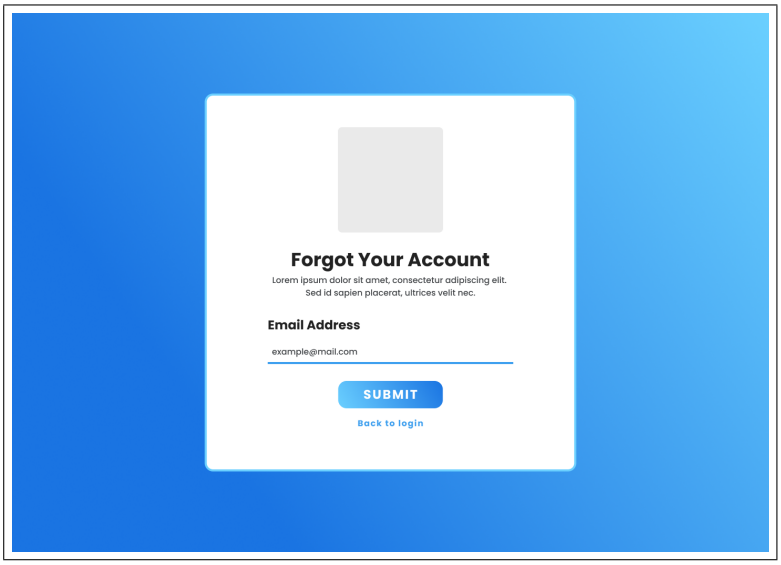

Figure 3.7 Forgot Password Page

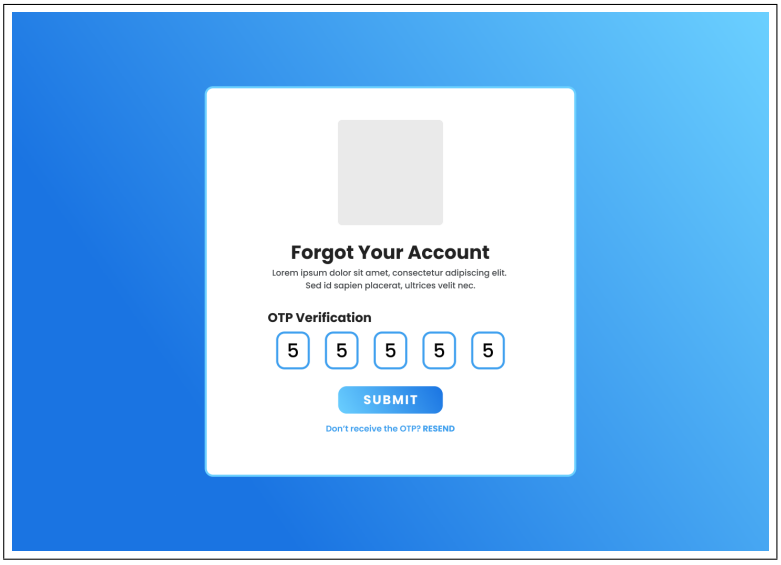

Figure 3.8 Forgot Password Page

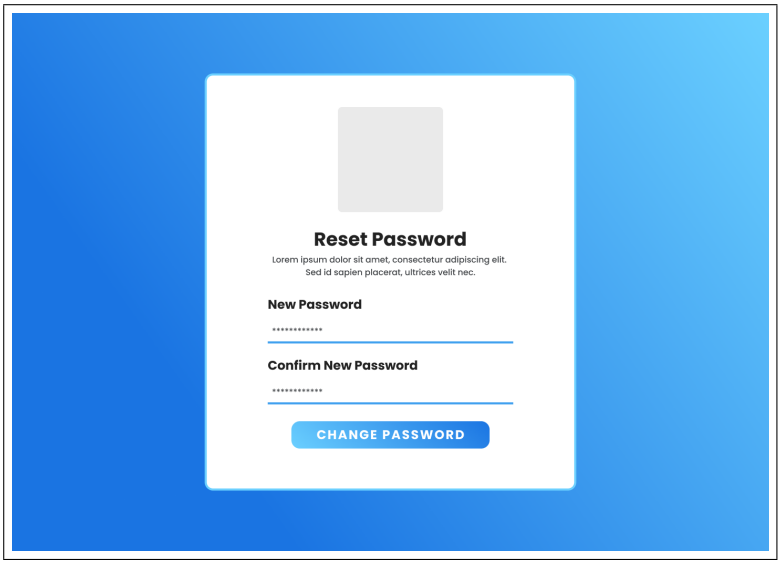

Figure 3.9 Reset Password Page

At the Figure 3.8, It represents a OTP confirmation page which required a OTP Code that the system have send to the email address. Figure 3.9, It represents a reset password pageIf it success the system will navigate to reset password page for enter a new password.

3.7.4 Dashboard

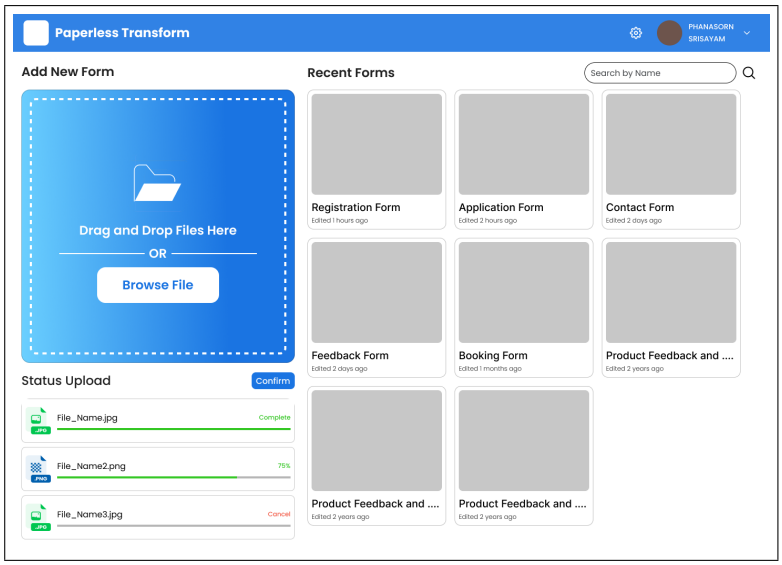

Figure 3.10 Dashboard Page

Figure 3.10 represents the dashboard page, it will show all the form that user have and the add form section at the left hand side, also have a upload status while file is uploading.

3.7.5 Edit Form

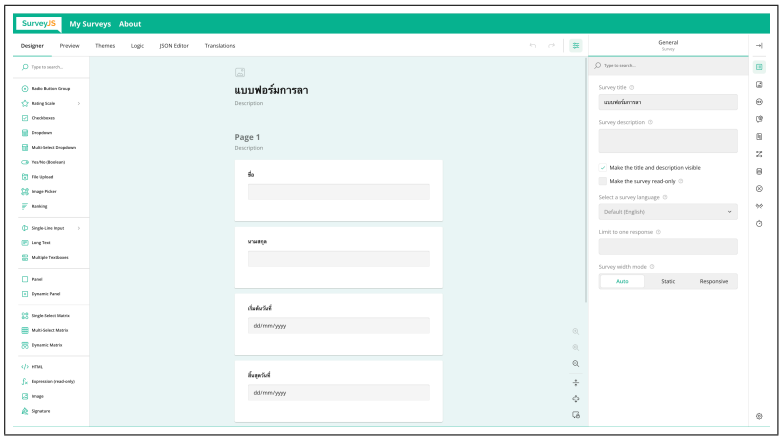

Figure 3.11 Edit Form Page

Figure 3.10 represents the Edit Form. The edit form page uses the SurveyJS library, which allows users to fully customize a form, including changing the color, adding a second page, and creating form conditions.

3.7.6 Form

Figure 3.10 represents the Edit Form. The edit form page uses the SurveyJS library, which allows users to fully customize a form, including changing the color, adding a second page, and creating form conditions.

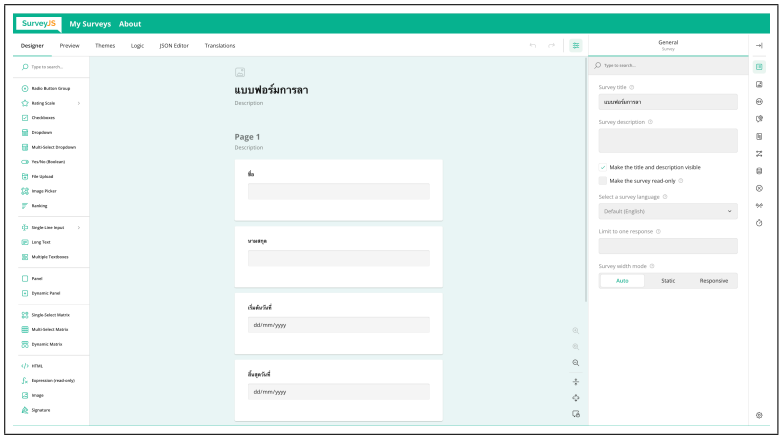

Figure 3.12 Edit Form Page

CHAPTER 4 IMPLEMENTATION RESULTS

You can title this chapter as **Preliminary Results** or **Work Progress** for the progress reports. Present implementation or experimental results here and discuss them.

ALL SECTIONS IN THIS CHAPTER ARE OPTIONAL. PLEASE CONSULT YOU ADVISOR AND DESIGN YOUR OWN SECTION

หัวข้อต่าง ๆ ในแต่ละบทเป็นเพียงตัวอย่างเท่านั้น หัวข้อที่จะใส่ในแต่ละบทขึ้นอยู่กับโปรเจคของนักศึกษาและอาจารย์ที่ปรึกษา

CHAPTER 5 CONCLUSIONS

Figure 5.1 This is how you mention when figure come from internet https://www.google.com

This chapter is optional for proposal and progress reports but is required for the final report.

THIS IS AN EXAMPLE. ALL SECTIONS BELOW ARE OPTIONAL. PLEASE CONSULT YOU ADVISOR AND DESIGN YOUR OWN SECTION

หัวข้อต่าง ๆ ในแต่ละบทเป็นเพียงตัวอย่างเท่านั้น หัวข้อที่จะใส่ในแต่ละบทขึ้นอยู่กับโปรเจคของนักศึกษาและอาจารย์ที่ปรึกษา

5.1 Problems and Solutions

State your problems and how you fixed them.

5.2 Future Works

What could be done in the future to make your projects better.

REFERENCES

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APPENDIX A

FIRST APPENDIX TITLE

Put appropriate topic here

This is where you put hardware circuit diagrams, detailed experimental data in tables or source codes, etc..

Figure A.1 This is the figure x11 https://www.google.com

This appendix describes two static allocation methods for fGn (or fBm) traffic. Here, λ and C are respectively the traffic arrival rate and the service rate per dimensionless time step. Their unit are converted to a physical time unit by multiplying the step size Δ. For a fBm self-similar traffic source, Norros [4] provides its EB as

$$C = \lambda + (\kappa(H)\sqrt{-2\ln\epsilon})^{1/H} a^{1/(2H)} x^{-(1-H)/H} \lambda^{1/(2H)} \tag{A.1}$$

where $\kappa(H) = H^H(1-H)^{(1-H)}$. Simplicity in the calculation is the attractive feature of (A.1).

The MVA technique developed in [5] so far provides the most accurate estimation of the loss probability compared to previous bandwidth allocation techniques according to simulation results. Consider a discrete-time queueing system with constant service rate C and input process λ_n with $\mathbb{E}\{\lambda_n\} = \lambda$ and $\mathrm{Var}\{\lambda_n\} = \sigma^2$. Define $X_n \equiv \sum_{k=1}^{n} \lambda_k - Cn$. The loss probability due to the MVA approach is given by

$$\varepsilon \approx \alpha e^{-m_x/2} \tag{A.2}$$

where

$$m_x = \min_{n \geq 0} \frac{((C-\lambda)n + B)^2}{\mathrm{Var}\{X_n\}} = \frac{((C-\lambda)n^* + B)^2}{\mathrm{Var}\{X_{n^*}\}} \tag{A.3}$$

and

$$\alpha = \frac{1}{\lambda\sqrt{2\pi\sigma^2}} \exp\left(\frac{(C-\lambda)^2}{2\sigma^2}\right) \int_C^\infty (r-C) \exp\left(\frac{(r-\lambda)^2}{2\sigma^2}\right) dr \tag{A.4}$$

For a given ε, we numerically solve for C that satisfies (A.2). Any search algorithm can be used to do the task. Here, the bisection method is used.

Next, we show how $\mathrm{Var}\{X_n\}$ can be determined. Let $C_\lambda(l)$ be the autocovariance function of λ_n. The MVA technique basically approximates the input process λ_n with a Gaussian process, which allows $\mathrm{Var}\{X_n\}$ to be represented by the autocovariance function. In particular, the variance of X_n can be expressed in terms of $C_\lambda(l)$ as

$$\mathrm{Var}\{X_n\} = nC_\lambda(0) + 2\sum_{l=1}^{n-1}(n-l)C_\lambda(l) \tag{A.5}$$

Therefore, $C_\lambda(l)$ must be known in the MVA technique, either by assuming specific traffic models or by off-line analysis in case of traces. In most practical situations, $C_\lambda(l)$ will not be known in advance, and an on-line measurement algorithm developed in [6] is required to jointly determine both n^* and m_x. For fGn traffic, $\mathrm{Var}\{X_n\}$ is equal to $\sigma^2 n^{2H}$, where $\sigma^2 = \mathrm{Var}\{\lambda_n\}$, and we can find the n^* that minimizes (A.3) directly. Although λ can be easily measured, it is not the case for σ^2 and H. Consequently, the MVA technique suffers from the need of prior knowledge traffic parameters.

APPENDIX B

SECOND APPENDIX TITLE

Put appropriate topic here

Figure B.1 This is the figure x11 https://www.google.com

Next, we show how $\mathrm{Var}\{X_n\}$ can be determined. Let $C_\lambda(l)$ be the autocovariance function of λ_n. The MVA technique basically approximates the input process λ_n with a Gaussian process, which allows $\mathrm{Var}\{X_n\}$ to be represented by the autocovariance function. In particular, the variance of X_n can be expressed in terms of $C_\lambda(l)$ as

$$\mathrm{Var}\{X_n\} = nC_\lambda(0) + 2\sum_{l=1}^{n-1}(n-l)C_\lambda(l) \tag{B.1}$$

Add more topic as you need

Therefore, $C_\lambda(l)$ must be known in the MVA technique, either by assuming specific traffic models or by off-line analysis in case of traces. In most practical situations, $C_\lambda(l)$ will not be known in advance, and an on-line measurement algorithm developed in [6] is required to jointly determine both n^* and m_x. For fGn traffic, $\mathrm{Var}\{X_n\}$ is equal to $\sigma^2 n^{2H}$, where $\sigma^2 = \mathrm{Var}\{\lambda_n\}$, and we can find the n^* that minimizes (A.3) directly. Although λ can be easily measured, it is not the case for σ^2 and H. Consequently, the MVA technique suffers from the need of prior knowledge traffic parameters.