CIVIL ENGINEERING INSIGHT STUDIO

A Project Report
Submitted in partial fulfilment of the requirements
Of

AI-Based Construction Analysis System

Internship at

SMARTBRIDGE in collaboration **APSCHE**

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1.INTRODUCTION

1.1 Project Overview

Civil Engineering Insight Studio is an AI-powered web application developed to assist in analyzing construction site images and generating useful engineering insights. The project focuses on simplifying construction monitoring by providing automated analysis through a user-friendly web interface. In traditional construction management, site inspections require manual observation, which can be time-consuming and sometimes inefficient. The application allows users to upload construction images and receive insights such as project type, construction stage, materials observed, and safety recommendations. The system provides descriptions for civil engineering landmarks or projects entered by the user. The system is built using Python programming language and Streamlit framework to provide an interactive web-based interface. It also provides a practical example of combining engineering knowledge with modern AI tools. Civil Engineering Insight Studio can be useful for students, engineers, and construction planners.

1.2 Purpose

The main objective of the Civil Engineering Insight Studio project is to develop an intelligent system that assists in analyzing construction site activities using image-based inputs. The project aims to reduce manual inspection efforts by providing automated construction insights. It helps users quickly understand construction progress, materials used, and safety conditions. The system also generates descriptions for civil engineering landmarks and projects for educational and documentation purposes. The application is designed to support civil engineering students, site engineers, and planners in monitoring construction work efficiently. It demonstrates how artificial intelligence can be integrated into civil engineering applications.

2. IDEATION PHASE

2.1 Problem Statement

Construction site monitoring and analysis are traditionally performed through manual inspections, which can be time-consuming and prone to human error. Engineers and supervisors must frequently visit construction sites to track progress and ensure safety compliance. This process becomes difficult when managing multiple sites simultaneously.

There is a need for an automated system that can analyze construction images and provide quick insights about project status and safety conditions. Lack of instant analysis may lead to delays and safety risks. Therefore, developing an intelligent system that assists in construction monitoring and provides automated analysis can improve efficiency and support better decision-making in civil engineering projects.

2.2 Empathy Map Canvas

The Empathy Map Canvas helps in understanding the needs and challenges faced by users such as civil engineers, site supervisors, and construction managers. These users often think about improving construction efficiency and ensuring safety compliance at worksites. They frequently express concerns about delays, lack of proper monitoring, and difficulty in tracking project progress.

Users observe challenges such as unsafe working conditions and inconsistent construction progress across different sites. They often feel stressed when construction monitoring requires constant physical presence. Engineers and supervisors desire a smarter solution that can provide quick insights without requiring manual inspection each time.

They need a system that helps them monitor construction remotely and receive reliable analysis results. The Civil Engineering Insight Studio project addresses these concerns by providing automated construction analysis. This improves decision-making and reduces workload. The empathy analysis shows that users value time-saving, accuracy, and safety-focused monitoring solutions in construction projects.

2.3 Brainstorming

During the brainstorming phase, various ideas were discussed to develop a solution that could simplify construction monitoring and analysis. The team focused on creating a system that could automatically analyze construction images and provide meaningful engineering insights. Different approaches were explored to integrate artificial intelligence with civil engineering practices in a user-friendly manner. The objective was to design a solution that reduces manual site inspection efforts and improves monitoring efficiency.

Key Ideas Generated

1. Develop an application that allows users to upload construction images for automated analysis.
2. Generate insights such as construction stage, materials used, and safety observations.
3. Provide landmark or project description generation for educational and documentation purposes.
4. Create a web-based interface accessible to engineers and students.
5. Implement AI-based analysis to support faster decision-making in construction monitoring.

Evaluation Criteria

The generated ideas were evaluated based on the following criteria:

- Technical feasibility using available tools and technologies.
- Ease of implementation within the internship timeline.
- Practical usefulness for civil engineering applications.
- Scalability and potential for future improvements.
- User friendliness and accessibility of the application.

3. REQUIREMENT ANALYSIS

3.1 Customer Journey Map

The Customer Journey Map describes how users interact with the Civil Engineering Insight Studio application from initial access to receiving analysis results. The primary users include civil engineering students, site engineers, and construction supervisors who need quick insights into construction projects.

Users access the application through a web browser and upload construction images or enter landmark/project details for analysis. The system processes the input and generates engineering insights that help users understand construction progress and safety conditions. The application simplifies decision-making by providing automated results without requiring manual site inspection. This journey ensures that users receive efficient, accurate, and user-friendly assistance in construction analysis.

Customer Journey Stages

1. **Access Stage:**
   The user opens the Civil Engineering Insight Studio web application through a browser.
2. **Input Stage:**
   The user uploads a construction image or enters a landmark/project name for analysis.
3. **Processing Stage:**
   The system processes the uploaded image or input using the AI-based response function.
4. **Analysis Stage:**
   The application generates construction insights such as project type, materials observed, construction stage, and safety suggestions.

5. **Result Display Stage:**
   The results are displayed on the web interface for the user.
6. **Decision Stage:**
   The user uses the provided insights for understanding construction progress or documentation purposes.

3.2 Solution Requirements

The Civil Engineering Insight Studio project requires both functional and non-functional requirements to ensure proper system performance and user satisfaction. These requirements define what the system should do and how efficiently it should operate.

Functional Requirements

1. The system must allow users to upload construction images through the web interface.
2. The application should analyze images and generate construction insights.
3. The system should provide information about project type, materials used, and construction stage.
4. The application must generate safety suggestions for construction sites.
5. The system should allow users to input landmark or project names for description generation.
6. The application should display analysis results clearly on the web interface.
7. The system must support multiple image uploads during usage sessions.

Non-Functional Requirements

1. The application should provide quick response time for analysis results.
2. The system must have a user-friendly interface accessible to non-technical users.

3. The application should run smoothly without system crashes.
4. The system must be reliable for continuous usage.
5. The application should be compatible with common web browsers.
6. The system should maintain basic data privacy and security.
7. The application should be scalable for future enhancements.

3.3 Data Flow Diagram (DFD)

The Data Flow Diagram (DFD) represents how data moves through the Civil Engineering Insight Studio system from user input to output generation. It shows how construction images or project details are processed and converted into analysis results.

Level 0 – Context Level DFD

At the context level, the system interacts directly with the user.

- **Input:** Construction image or landmark/project name entered by the user.
- **Process:** Civil Engineering Insight Studio processes the input using image handling and AI-based analysis.
- **Output:** Construction insights and project descriptions displayed to the user.

Level 1 – Detailed DFD

The system process can be divided into smaller steps:

1. **User Interface Module:**
   Accepts construction images or project details from the user.
2. **Image Processing Module:**
   Reads and prepares uploaded images for analysis.
3. **AI Analysis Module:**
   Generates insights such as project type, materials observed, construction stage, and safety suggestions.

4. **Result Generation Module:**
   Formats analysis results into readable output.
5. **Output Display Module:**
   Displays results through the Streamlit web application interface.

3.4 Technology Stack

The Civil Engineering Insight Studio project uses modern technologies to develop a web-based construction analysis system. The technology stack is divided into frontend, backend, data source, and deployment components.

Frontend

The frontend of the application is developed using Streamlit, which provides an interactive and user-friendly web interface. It allows users to upload construction images, view analysis results, and generate landmark descriptions easily through a browser.

Backend

The backend processing is implemented using Python, which handles image processing and analysis logic. Libraries such as Pillow are used for image handling, and AI-based response functions are integrated to generate construction insights.

Data Source

The data source for the system consists of user-uploaded construction images and manually entered landmark or project names. The application processes these inputs to generate insights dynamically.

Deployment

The application is deployed locally using Streamlit, allowing the web app to run on a local server and be accessed through a web browser. The project code and documentation are maintained using GitHub for version control and sharing purposes.

4. PROJECT DESIGN

4.1 Problem–Solution Fit

The Problem

The Civil Engineering Insight Studio project effectively addresses the problem of manual construction monitoring and analysis. Traditional construction inspection methods require physical site visits and manual evaluation, which can be time-consuming and inefficient, especially when multiple construction projects need monitoring simultaneously.

The proposed solution provides an automated web-based system where users can upload construction images and receive instant engineering insights. This reduces dependency on manual inspections and helps users quickly understand construction progress and safety conditions.

The Fit

The system fits the problem by providing a simple, accessible, and efficient platform for analyzing construction activities. It ensures faster decision-making, improved monitoring, and better documentation of construction projects. Thus, the solution successfully aligns with the identified problem and meets user needs effectively.

4.2 Proposed Solution

The Civil Engineering Insight Studio solution is developed using a modular and scalable architecture consisting of the following components:

1. Image Processing Module

- Handles construction images uploaded by users.

- Performs image reading and format conversion for analysis.
- Prepares images for further processing and insight generation.
- Ensures compatibility of image formats such as JPG and PNG for analysis.

2. AI Analysis Module

- Generates construction insights based on uploaded images.
- Identifies construction project type and stage.
- Observes materials such as concrete and steel structures.
- Provides safety recommendations and improvement suggestions.
- Can be extended with advanced AI models for real-time analysis.

3. Landmark Description Module

- Allows users to input civil engineering landmark or project names.
- Generates descriptive information useful for educational or documentation purposes.
- Helps users quickly understand engineering importance and project features.

4. Streamlit-Based Web Application

- Provides an interactive web interface for users.
- Allows construction image upload and instant analysis display.
- Enables landmark description generation through user input.
- Displays insights and analysis results clearly to users.
- Offers an easy-to-use platform accessible via web browser.

5. Output & Visualization Module

- Displays analysis results including construction type, materials observed, and safety suggestions.
- Presents results in a structured and readable format.
- Allows users to interpret results easily for monitoring and documentation purposes.

System Benefits

This modular approach ensures:

- **Reusability:** Modules can be reused or extended in future projects.
- **Scalability:** System can be expanded with advanced AI models and real-time monitoring features.
- **User Friendliness:** Simple interface usable by students and professionals.
- **Flexibility:** System can support multiple construction project analysis tasks in future enhancements.

4.3 Solution Architecture

Solution Architecture Diagram (Text Representation)

The architecture of Civil Engineering Insight Studio can be represented as:

User Input
↓
Streamlit Web Interface
↓
Image Upload / Landmark Input
↓
Image Processing Module
↓
AI Analysis Module
↓
Insight Generation
↓
Result Display to User

This architecture shows how user inputs move through different modules to generate construction insights.

Data Source

The system uses user-uploaded construction images and user-provided landmark or project names as input data. Images are used for construction analysis while text input generates landmark descriptions.

Data Preprocessing

Before analysis, uploaded images are processed to ensure compatibility and quality. Image preprocessing includes reading images, converting them to standard formats, and preparing them for analysis modules. This step ensures reliable analysis output.

Train/Test Split

In the current implementation, simulated AI logic is used, so training and testing datasets are not required. However, future improvements may include training AI models using construction datasets where data can be divided into training and testing sets for model evaluation.

Algorithm Used

The system currently uses rule-based simulated AI analysis to generate construction insights. In future development, machine learning or deep learning algorithms can be integrated to automatically detect construction features and safety conditions.

Evaluation Model

The application is evaluated based on system functionality, response accuracy, and user experience. Testing ensures that image uploads and analysis results are generated correctly.

Trained Model

At present, the system uses simulated responses instead of a trained machine learning model. However, future versions may include trained AI models using construction image datasets.

User Input

Users provide input by uploading construction site images or entering landmark or project names through the web interface.

Prediction Output

The system produces outputs such as construction type, materials observed, construction stage, safety suggestions, and improvement recommendations. Landmark descriptions are also generated based on user input.

5. PROJECT PLANNING & SCHEDULING

5.1 Project Phases

Phase 1: Requirement Analysis

Objective:
To understand project goals and identify system requirements for construction analysis.

Deliverables:

- Problem statement definition
- Feature requirement list
- Selection of tools and technologies

Phase 2: System Design

Objective:
To design system architecture and workflow for smooth data processing and user interaction.

Deliverables:

- Solution architecture diagram
- Module design plan
- Application workflow structure

Phase 3: Development & Implementation

Objective:
To develop application modules including image processing, AI analysis, and web interface.

Deliverables:

- Functional Streamlit web application
- Image upload and processing module
- Insight generation functionality

Phase 4: Testing & Optimization

Objective:
To test system performance and fix errors for smooth operation.

Deliverables:

- Tested application modules
- Bug fixes and performance improvements
- Verified output results

Phase 5: Deployment & Documentation

Objective:
To deploy the project and prepare documentation for submission.

Deliverables:

- Project deployment via Streamlit
- GitHub repository with source code
- Final report, screenshots, and demo video

6. FUNCTIONAL AND PERFORMANCE TESTING

6.1 Performance Testing

Performance testing was conducted to evaluate the responsiveness and efficiency of the Civil Engineering Insight Studio application during execution. The objective was to ensure that the system operates smoothly when users upload images and request construction analysis results.

Performance Evaluation Metrics (Future Model Evaluation)

Although the current project uses simulated AI responses, future versions of the system may use trained machine learning models. In such cases, performance evaluation metrics like Mean Squared Error (MSE) and R-square (R^2) score are used to measure model accuracy.

Mean Squared Error (MSE)

Mean Squared Error measures the average squared difference between actual values and predicted values. It helps determine how close the predicted results are to actual values.

MSE Formula:

$MSE=1/n\sum_{i=1}^{n}(y_i-\hat{y}_i)^2$

Where:

- y_i = Actual value
- $\hat{y}_i$= Predicted value
- N = Number of observations

A lower MSE value indicates better prediction accuracy.

R-Square Score (R^2)

The R-square score measures how well the model predictions fit the actual data. It indicates the percentage of variation explained by the model.

R^2 Formula:

$R2=1-\sum(y_i-\hat{y}_i)2/\sum(y_i-\bar{y})$

Where:

- y_i = Actual value
- $\hat{y}_i$= Predicted value
- $\bar{y}$ = Mean of actual values

R^2 values range from 0 to 1:

- R^2 close to 1 indicates better model performance.
- R^2 close to 0 indicates weak prediction capability.

Data Used for Evaluation

In future implementations, datasets consisting of construction site images and corresponding labels or measurements can be used to train and test AI models. The dataset would typically be divided into training and testing portions to evaluate prediction performance accurately.

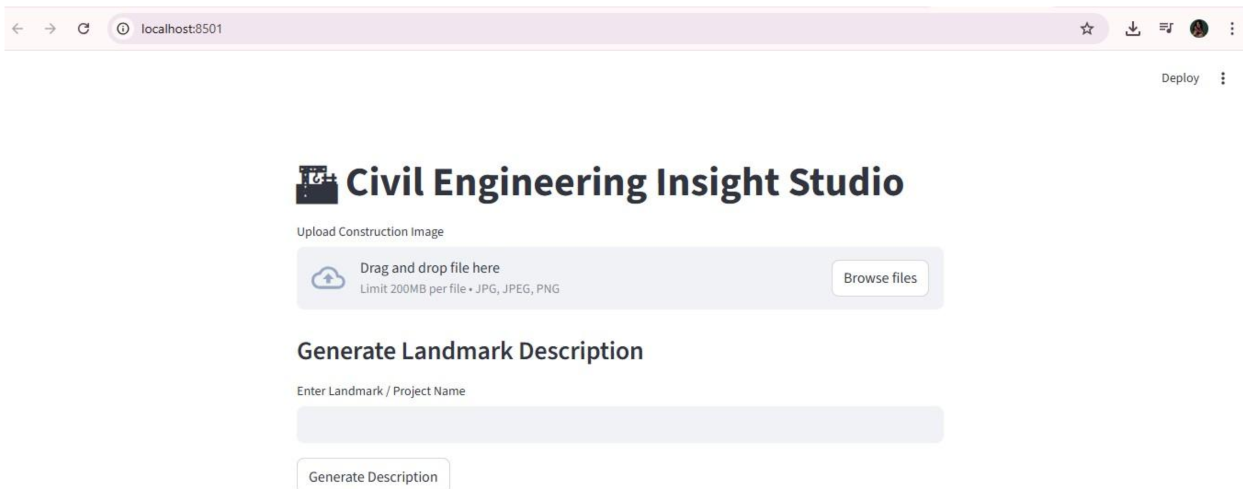
Purpose of Metrics

These metrics help developers evaluate model performance and improve prediction accuracy for construction analysis applications.

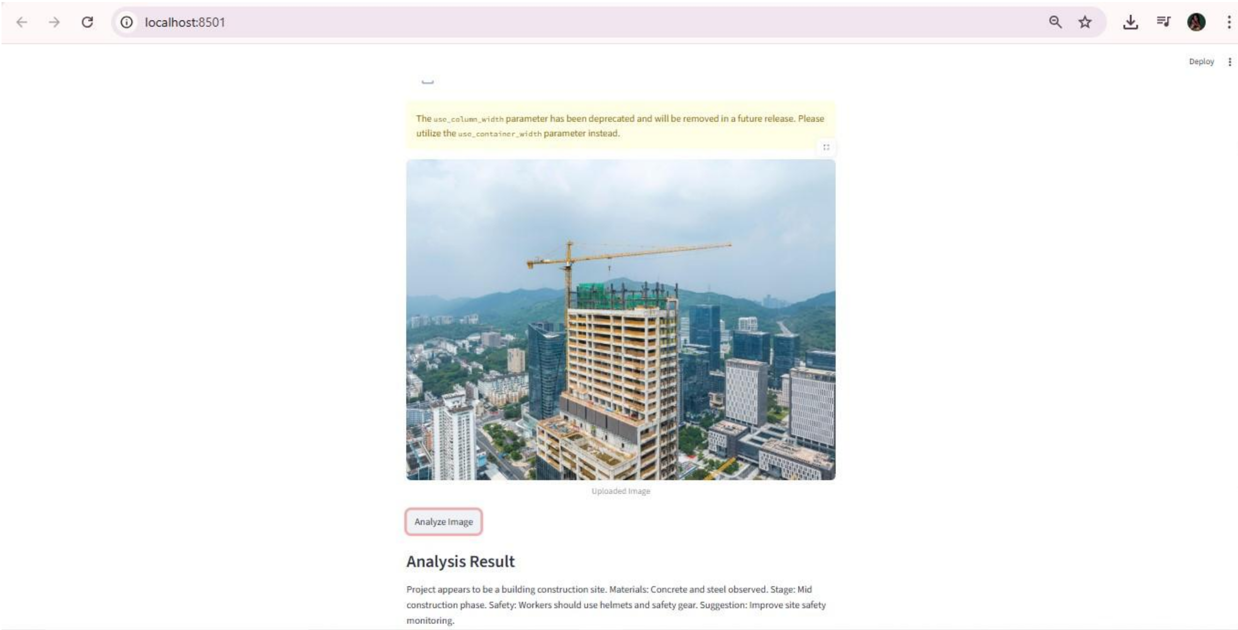
7. RESULTS

7.1 Output Screenshots

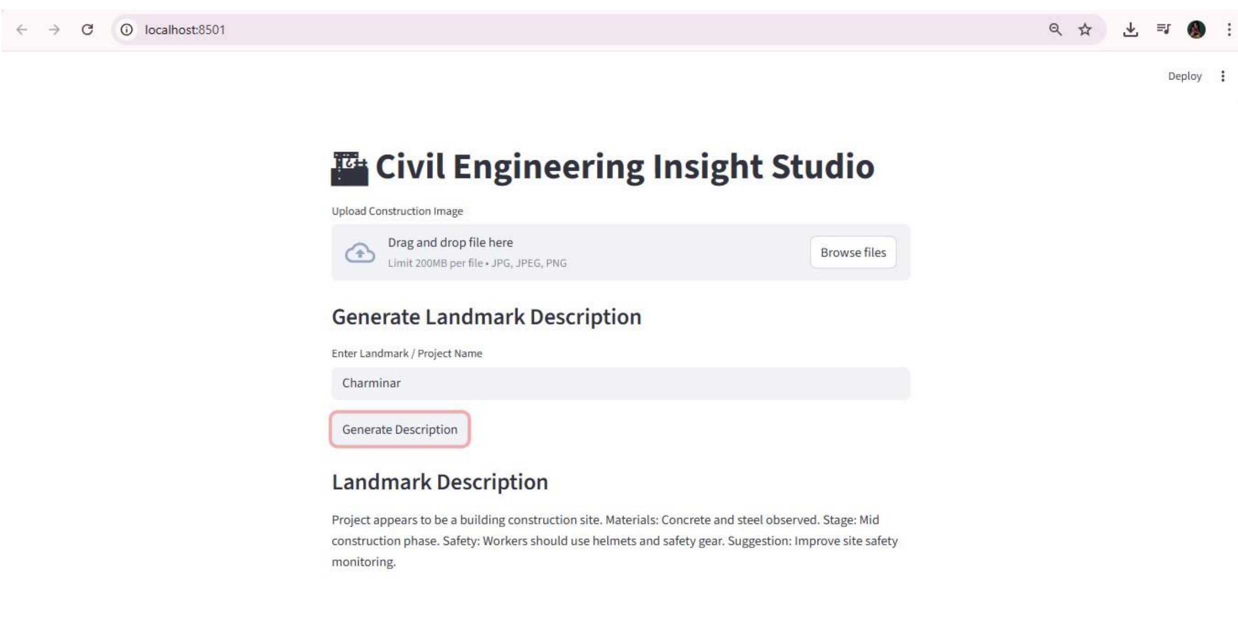
1.Home page of website:



2. Image Analysis:



3.Landmark Analysis:



8. ADVANTAGES & DISADVANTAGES

8.1 Advantages

1. The system provides quick construction analysis without requiring manual site inspection.
2. It offers an easy-to-use web interface suitable for students and professionals.
3. The application helps identify construction stage and materials used.
4. It provides safety suggestions to improve construction site conditions.
5. The system saves time and effort in monitoring construction projects.
6. It supports educational learning in civil engineering analysis.
7. The application can be extended with advanced AI models in the future.
8. The system can be accessed through a web browser without complex installation.

8.2 Disadvantages

1. The current system uses simulated AI responses instead of real AI models.
2. Analysis accuracy depends on the quality of uploaded images.
3. The application currently works only in local deployment environments.
4. It does not support real-time monitoring of construction sites.
5. Internet access may be required for future cloud-based deployment.
6. Advanced features like automated detection are not yet implemented.

9. CONCLUSION

The Civil Engineering Insight Studio project successfully demonstrates how artificial intelligence and web technologies can be applied in civil engineering to simplify construction analysis. The developed application allows users to upload construction images and receive insights regarding project type, construction stage, materials observed, and safety suggestions through an interactive web interface.

The system reduces the effort required for manual monitoring and provides quick analysis results that support decision-making in construction management. The project also shows how modern tools like Python and Streamlit can be combined to create practical engineering applications.

Overall, the project achieves its objective of providing a user-friendly platform for construction analysis and serves as a foundation for future improvements such as real-time monitoring and advanced AI-based detection systems.

10. FUTURE SCOPE

The Civil Engineering Insight Studio project can be further improved by integrating advanced artificial intelligence and real-time monitoring capabilities. Future versions of the system can include trained AI models capable of automatically detecting construction progress, structural components, and safety violations from images with higher accuracy.

The application can also be enhanced to support real-time construction monitoring using drone or CCTV camera feeds. Cloud deployment can allow multiple users to access the system remotely for large-scale project monitoring. Additional features such as automated report generation and progress tracking dashboards can also be included.

Integration with construction management systems and IoT-based site monitoring tools can further improve project supervision. With continued development, the system can become a comprehensive solution for smart construction management and engineering analysis.

11. APPENDIX

The appendix section provides additional resources and references related to the Civil Engineering Insight Studio project implementation.

A. Source Code Repository

The complete source code of the project is available on GitHub for reference and future development:

GitHub Repository Link:
https://github.com/avvaruujwal/CivilEngineeringInsightStudio

B. Dataset / Input Data

The system uses user-uploaded construction images as input data for analysis. No fixed dataset is required since images are dynamically provided by users during application usage.

C. Demo Video Link

The demonstration video showing application functionality and output results is included in the project repository or shared via a cloud link for reference.

Demo video:

https://drive.google.com/file/d/15YS8CcZa8lqeLk2vKzY-EYec2vvgpByS/view?usp=drivesdk

D. Software and Tools Used

- Python Programming Language
- Streamlit Framework
- Pillow Library for image processing
- GitHub for version control and project hosting

E. Recommended Hardware Requirements:

- Processor: Intel Core i5 or higher
- RAM: 8 GB or higher for smooth performance
- Storage: 10 GB free disk space
- Display: Full HD monitor or laptop display
- Stable internet connection for project deployment and updates

F. Screenshots and Output Samples

Screenshots of application outputs are included in the project report to demonstrate system functionality and performance.