Project Proposal

Automated House Planning and Visualization System for Real Estate Using Machine Learning

Group APEXA

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1. Introduction

It is almost difficult for an ordinary person to imagine a new design of a house and visualize in their mind. Architects may hire CAD (Computer Aided Drafting) programmers for this purpose. However, the cost is high and consume a considerable amount of time [1]. By utilizing our "Automated House Planning and Visualization System for Real Estate Using Machine Learning", individuals can seamlessly generate a house plan without the need for extensive architectural knowledge or costly consultations. Our system is capable of identify and generate suitable floor plans for not only flat and regular shaped lands, but also for irregular and sloped lands. The process is efficient and accessible – a person can initiate the generation of a house plan by simply inputting an image of the map of the land where they intend to build their house. In addition to the land image, users can provide essential inputs such as the desired number of rooms and other key specifications.

What sets our system apart is its ability to automatically generate a house floor plan tailored to the specific characteristics of the provided land. This automated approach significantly streamlines the planning and design process, saving both time and costs. It eliminates the time-consuming and often complicated back-and-forth interactions with architects and designers.

With this system in place, individuals no longer require a deep understanding about architecture on their housing projects. It allows accessible to a broader range of individuals. As a result, it empowers homeowners and property developers to create customized living spaces efficiently and cost-effectively, in harmony with their unique preferences and requirements. This is a step forward in the real estate industry, offering a solution that responds to the demands of our evolving urban landscape and the need for personalized and efficient house planning [2].

2. Background and Motivation

In the dynamic realms of real estate, previous research has unearthed opportunities and confronted challenges in the domain of house planning and visualization. Understanding the current landscape of related projects, and the limitations they have encountered. All the existing projects for develop floor plans and 3D (3 Dimension) visualization are manual. Below are some examples for some existing such projects.

The technical background of this endeavor is rooted in the integration of state-of-the-art technologies. Previous projects, while commendable, often grappled with the intricate requirements of a comprehensive solution. They presupposed a fundamental grasp of computer graphics, computer-aided design, procedural modeling, and proficiency in programming languages like C++ as well as familiarity with software tools such as Unity and Blender [3].

There are diffusion models for computational design at the example of floor plans. The paper explores the current state of the art in diffusion models and proposes new models with improved semantic encoding to generate valid floor plans. The authors also discuss the need to combine diffusion models with building information modeling and identify future research directions in this field. The paper provides technical details on the proposed models and their implementation, as well as experimental results and analysis

[4]. However, the limitations of this research paper include the limited evaluation of the proposed diffusion models and the absence of detailed analysis on computational resource requirements and potential ethical implications of AI-powered (Artificial-Intelligence powered) architectural design.

In present, there are automatic generation of AI-powered architectural floor plans using grid data. The proposed method involves compressing original data while preserving important information, enabling fast and effective use of floor plan models in various computing environments. The paper also discusses the use of machine learning techniques, such as Convolutional Neural Networks (CNNs) and Generative Adversarial Networks (GANs), in the automatic generation of floor plans [5]. Notably, the ethical implications of AI-powered floor plan generation in the construction industry are not addressed.

Our project distinguishes itself by harnessing image processing and machine learning algorithms, paving the way for a seamless transformation of land images into detailed house plans. Leveraging the power of cloud computing ensures both scalability and rapid processing, while the incorporation of architectural knowledge guarantees compliance with stringent regulatory standards and architectural aesthetics.

Our motivation is recognizing the technical limitations faced by earlier initiatives. The current landscape in the field calls for a transformative solution that not only integrates cutting-edge technology but also harmonizes it with architectural expertise. This synergy is the key to an accessible, efficient, and user-friendly approach to house planning and visualization, aligning with the ever-evolving needs of urbanization, customization, and the complexities inherent in real estate decision-making.

In building upon the experiences and constraints of past projects, we aim to transcend the boundaries and create a comprehensive solution that addresses the limitations identified, such as rectangular land shapes and sloped lands. Our aspiration is to extend the capabilities to lands of various shapes and angles, ushering in a new era in the real estate and architectural domains.

2.1 **Research Gap Analysis**

Table 1: Research gap analysis

Article	User Intervention	Inputs	Techniques	Limitation
1. Extraction of Structural and Semantic Data from 2D (2 Dimensional) Floor Plans for Interactive and	Manual	Vectorized Floor Plans CAD Files User Interactions	Floor Plan Interpretation 3D (3 Dimensional) Model	Complexity of floor plans: Floor plans can vary in style and level of detail,

Immersive VR (Virtual Reality) Real Estate Exploration [6]			Generation VR Experience Preparation User Preparation	making it challenging to create a generalized detection algorithm that works for all types of floor plans.
2. 3D Modelling Approach for Ancient Floor Plans' Quick Browsing [7]	Automated	2D floor plan images	Geometrical reasoning, SURF descriptors, Convolutional Neural Networks (CNNs), Fully Convolutional Neural networks (FCNs), Image processing and deep learning	Inability to handle complex floor plans with irregular shapes
3. Fast and Robust Construction of 3D Architectural Models from 2D Plans[8]	Semi-Automated	2D architectural floor plan in a CAD vector format	Vector formats Algorithmic techniques	Challenges in creating non-vertical complex structures. A semi-automated approach for generating 3D building models from architectural floor plans.

4. Generating 3D Models From 2D Floor Plan Images Using Ensemble Methods [9]	Automated	2D raster drawing of floor plan images	Image processing techniques Hierarchical recognition model	Partially automated
5. Research on 3D Visualization of Real Scene in Subway Engineering Based on 3D Model[10]	Manual	Not mentioned	Data collection techniques Data processing techniques	System cannot generate floor plans automatically Semi-automated 3D view generation. Problems in completeness and accuracy of 3D models.
6. Generating layout designs from high-level specifications [11]	Automated	Floor size Number and types of rooms	Graph Grammar Formalism, Reserved Graph Grammar (RGG), Graph Manipulation C++, Java	Limited to rectangular shapes. Limited to flat lands.
7. Automated generation of dimensioned rectangular floorplans[12]	Automated	Rectangular Arrangement (RA) Dimensional Constraints	Dimensional Constraints Linear Optimization Network Flow	Limited to rectangular shapes.
8. Customization and generation of floor plans based on graph transformations [13]	Automated	Floor plan	Graph transformation	Limited to rectangular shapes. Limited to flat lands.

3. Problem

- Existing manual home design systems are primarily limited to rectangular plots, offering limited solutions for irregular land shapes and angled lands. Furthermore, their 3D house views are not fully automated.

Current research and design tools focus mainly on rectangular and square land shapes and non-sloped flat lands, lacking fully automated 3D house views. This approach overlooks the variety of non-standard land plots. Consequently, those with uniquely shaped land parcels encounter challenges in creating house plans that maximize both space and aesthetics.

4. Aim and Objectives

Aim and objectives, serving as the foundational elements that direct and define the purpose and action plan for our project.

4.1 **Aim**

- The primary aim of this project is to develop a web application that automatically generates both house floor plans for regular and irregular land shapes as well as for angled lands with the use of user inputs and 3D house views in response to the 2D floor plan.

4.2 **Project Objectives**

- To develop an algorithm that automatically generates flat or angled floor plans other than square and rectangular shapes for homes based on user-provided inputs, including room dimensions and clear image of the survey plan.
- To implement a feature that produces 3D views of the house automatically, allowing users to visualize their designs.
- To create a web application where people can design and see their dream homes.

4.3 **Areas of Further Learning**:

- Machine Learning Techniques: Variational Auto Encoders (VAEs), Generative Adversarial Networks (GANs), Graph Neural Networks (GNNs), Implement conditional generative models, Convolutional Neural Networks (CNNs), Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), Autoencoders.

Scope: Our proposed project is to develop an automated house planning and visualization system. We are developing a website to interact with users. The system takes clear images of survey plans, desired number of rooms and the angle of the land if necessary. We hope to use Image processing and Machine Learning techniques to identify land shapes and to generate floor plan and 3D visualization.

5. Methodology

- Develop a web interface for inputting user preferences and requirements.
- Create a structured database to store user data, house plans, and other relevant information.
- Allow users to upload the image of survey plan of their land and angle of the land if necessary.
- Collect essential information from users, including number of rooms and room dimensions.
- Utilize image processing techniques to identify the shape of the land from the image of the survey plan.
- Machine Learning Techniques for Floor Plan Generation and 3D Visualization:
    - Train Variational Auto Encoders (VAEs) on existing floor plan datasets to learn common patterns and structures, facilitating the generation of new floor plans with similar patterns.
    - Apply Generative Adversarial Networks (GANs) to create realistic floor plans that are similar to existing datasets, enhancing the quality and variety of generated floor plans.
    - Utilize Graph Neural Networks (GNNs) for learning relationships between different elements of the floor plan, such as rooms, walls, and doors, to generate new floor plans based on the learned graph structure.
    - Implement conditional generative models to consider specific user requirements and constraints, ensuring the generated floor plans meet user-specified criteria.
    - Employ Convolutional Neural Networks (CNNs) for image recognition, enabling land shape recognition and enhancing image analysis throughout the process.
    - Utilize Convolutional Neural Networks (CNNs) for analyzing and processing visual data in 3D, facilitating tasks such as object recognition, segmentation, and reconstruction in 3D visualization.
    - Apply Generative Adversarial Networks (GANs) for generating 3D models or enhancing the quality of 3D visualizations.
    - Integrate Recurrent Neural Networks (RNNs) for analyzing time-series 3D data and processing sequential data in 3D animations.
    - Utilize Autoencoders for learning efficient data representations in 3D, enabling tasks such as dimensionality reduction, denoising, and data compression to facilitate 3D visualization.
- Input and output images quality will be:
    - JPEG (Joint Photographic Experts Group): JPEG is a widely used lossy image format suitable for storing photographs and 2D visual content. It's often used for less critical 2D images. (Standard Resolution 1920x1080 pixels)
    - GLTF/GLB (GL Transmission Format / Binary): GLTF and GLB are modern file formats for efficient transmission and loading of 3D models. They are suitable for storing complex 3D architectural designs. (Standard-Resolution Textures: These textures are typically in the range of 1024x1024 to 2048x2048 pixels).
- Datasets:

- Detect images: [14]
- Generating **floor plans:** [15]

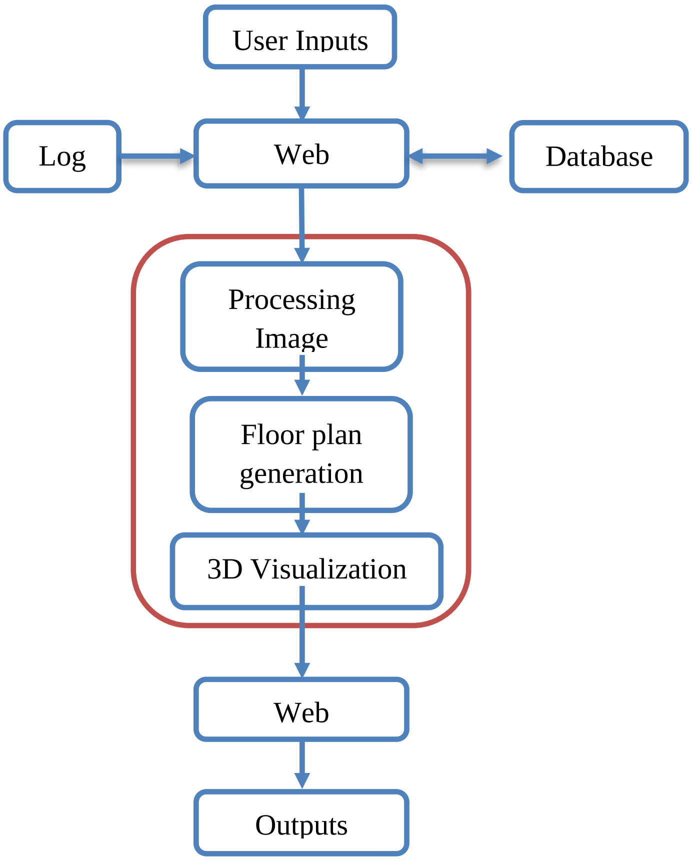

Figure 1: Process of the system

6. Project Time Plan

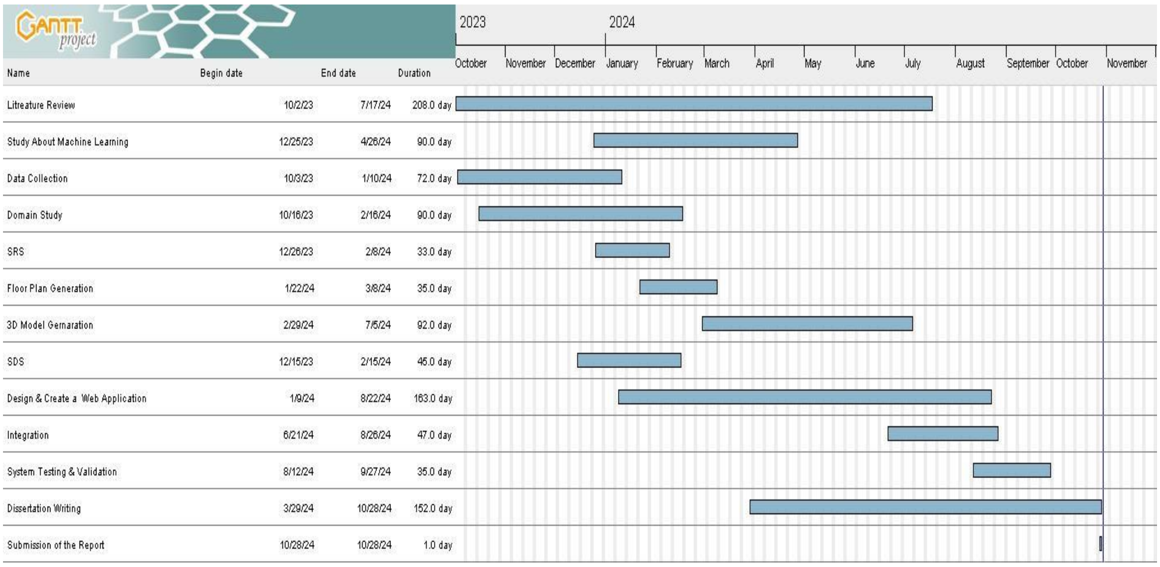

Figure 2: Project time plan

7. Resource requirements and budget

- **Resource Requirements:**

    - Computer with high performance
    - (Minimum - OS: Windows 10 or 11, Processor: Intel Core i5((2.4GHz) or equivalent, RAM: 8GB,
    - Storage: 256GB SSD, Graphics: NVIDIA GeForce GTX 1650, Display: 1920p x 1080p)
    - A web server
    - Visual Studio Code (VS Code) Software
    - Scikit Learn/Colab/TensorFlow software

8. Reference

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9. Signature of the team members:

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ICT/19/20/002	4944	T. M. M. M. B. Abeysinghe	

Date: 06.02.2024

- Recommendation of the supervisor(s)

  Name: K. H. A. Hettige

  Department/Organization: Department of Computing

  Signature: ………………………………………………………………