FLOORVERSE: A Universe of Floor Plan Possibilities

Revolutionizing the way residential designs are created using AI and Quantum Computing.

GROUP 286

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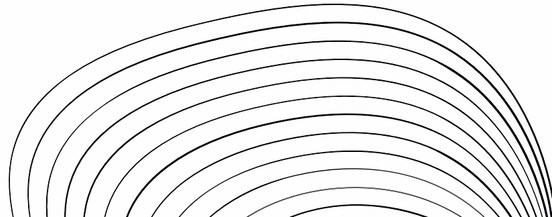
INTRODUCTION

- FLOORVERSE automates floorplan generation using a Conditional Variational Autoencoder (CVAE).
- Learns spatial relationships from a dataset of floorplan images to generate efficient layouts based on user-defined criteria.
- Reduces manual intervention while adhering to architectural standards.

MOTIVATION

- Traditional architectural design is labor-intensive.
- By leveraging machine learning, FLOORVERSE automates floorplan generation, learning spatial relationships.
- Creates realistic, functional layouts based on user-defined criteria.



OBJECTIVE

- To enable easy customization of designs for users without architectural expertise.
- Provide a user-friendly interface for exploring different design styles.
- Reduce dependency on manual architectural planning.
- Lower architectural costs by minimizing professional intervention.
- Ensure efficient space utilization with adaptive algorithms.

LITERATURE REVIEW

The existing research in AI-powered floorplan generation focuses on various methodologies, including deep learning (GANs, RNNs, CNNs, and Transformers), generative models (VAE, diffusion models), and optimization techniques (genetic algorithms). Key findings include:

- **Graph & Neural Network-Based Approaches**
  - Graph-based methods (Graph2Plan, GraphRNN) effectively capture spatial relationships and constraints for realistic floorplan generation.
  - Graph Neural Networks (GNNs) improve room classification accuracy (~81%).

- **Deep Learning & Generative Models**
  - GANs and diffusion models generate high-quality, diverse layouts (e.g., Space Layouts & GANs, HouseDiffusion).
  - Sequential models (RNNs, CVAE) generate structured layouts but need improvements in accuracy.

ROADMAP

Phase 1: Conceptualization & Requirements Gathering

- Conduct a comprehensive literature review on existing floorplan generation methods.
- Analyze the market to identify gaps in current architectural design tools.
- Define clear project objectives:
  - Automate floorplan generation.
  - Create a user-friendly platform for non-professionals.
- Establish system requirements:
  - Identify necessary data sources.
  - Specify hardware and software needs.
  - Define key performance metrics for evaluation.

Phase 2: System Design & Prototyping

- System Design ; scalable system integrating a Conditional Variational Autoencoder (CVAE).
- User Interface (UI) Development ; Intuitive ,Clean, & Responsive design.
- Backend Prototyping ; Handle user requests in real-time.

Phase 3: Model Development & Training

- CVAE Model Implementation:
  - Build the encoder, reparameterization, and decoder components.
  - Integrate the model into the project's codebase.
- Data Preprocessing Pipeline:
  - Develop the RPlanDataset class for handling input images.
  - Perform image resizing, normalization, and feature scaling.
  - Process 80,788 images from the RPlan dataset.
- Training & Optimization:
  - Train the model using binary cross-entropy and KL divergence loss functions.
  - Optimize parameters to improve generation accuracy.
  - Monitor validation performance to ensure generalization.
- Evaluation & Testing:
  - Develop evaluation scripts to compare original, reconstructed, and generated floorplans.
  - Visualize results to assess model output quality.
  - Compute efficiency metrics to measure accuracy, speed, and usability.

PROJECT TIMELINE

Project Inception & Research

1

- Automated floorplan generation identified as the primary objective.
- Comprehensive literature review on design tools,

User Interface Design

2

- Developed a responsive landing page.
- Added interactive elements for a user-friendly design experience.

Model Research

3

- Explored GNNs and quantum-powered AI for floorplan generation.
- Opted for a CVAE for efficient, constraint-based layout generation.

Model Development & Training

4

- Utilized the RPlan dataset (80,788 images) for broad coverage.
- Trained the CVAE with binary cross-entropy and KL divergence

Next Steps

5

- Investigate hybrid approaches (CVAE + GNNs/quantum methods) for further optimization.
- Enhance scalability, transitioning to cloud-based solutions

PROJECT WORKFLOW

- **Data Acquisition & Preprocessing**
- **Model Architecture & Initialization:** Implementation of a Conditional Variational Autoencoder (CVAE)
- **Training & Optimization**
- **Visualization & Evaluation**

DATASET

- RPLAN Datset
- Publicly available dataset.
- containing **80,788 residential floor plan images.**
- used for **architectural design automation.**

WORK DONE

The FLOORVERSE platform integrates front-end development and machine learning to generate customized residential floorplans.

Front-End Development

- A landing page (index.html) built with HTML, CSS, and JavaScript offers a responsive and intuitive interface.
- Users can configure unit selection, total area, and room configurations to explore floorplan generation.

WORK DONE

Machine Learning Component: ***CVAE Model***

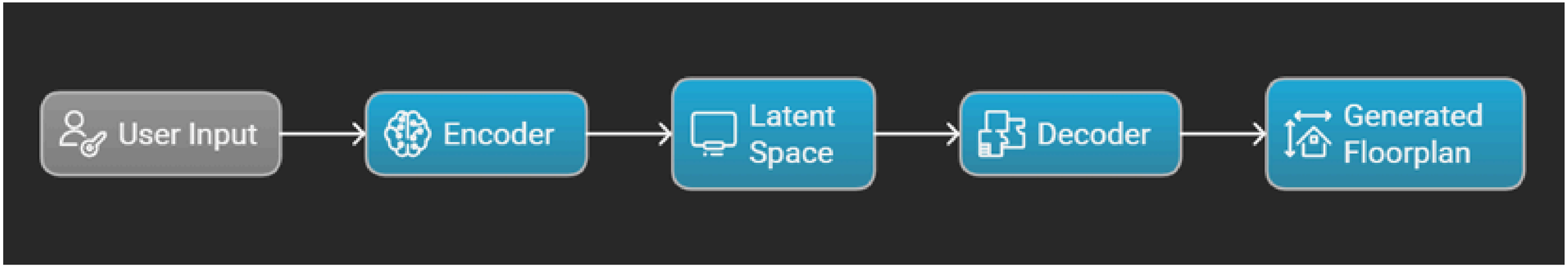
- A Conditional Variational Autoencoder (CVAE) processes grayscale floorplan images and user-defined condition features to generate floorplans.
- Encoder: Uses convolutional layers for image features and a multi-layer perceptron for condition data, transforming them into a latent space.
- Decoder: Uses transposed convolutions to reconstruct floorplans based on user input.
- The model is trained with a loss function combining binary cross-entropy (for accuracy) and KL divergence (for regularization).

WORK DONE

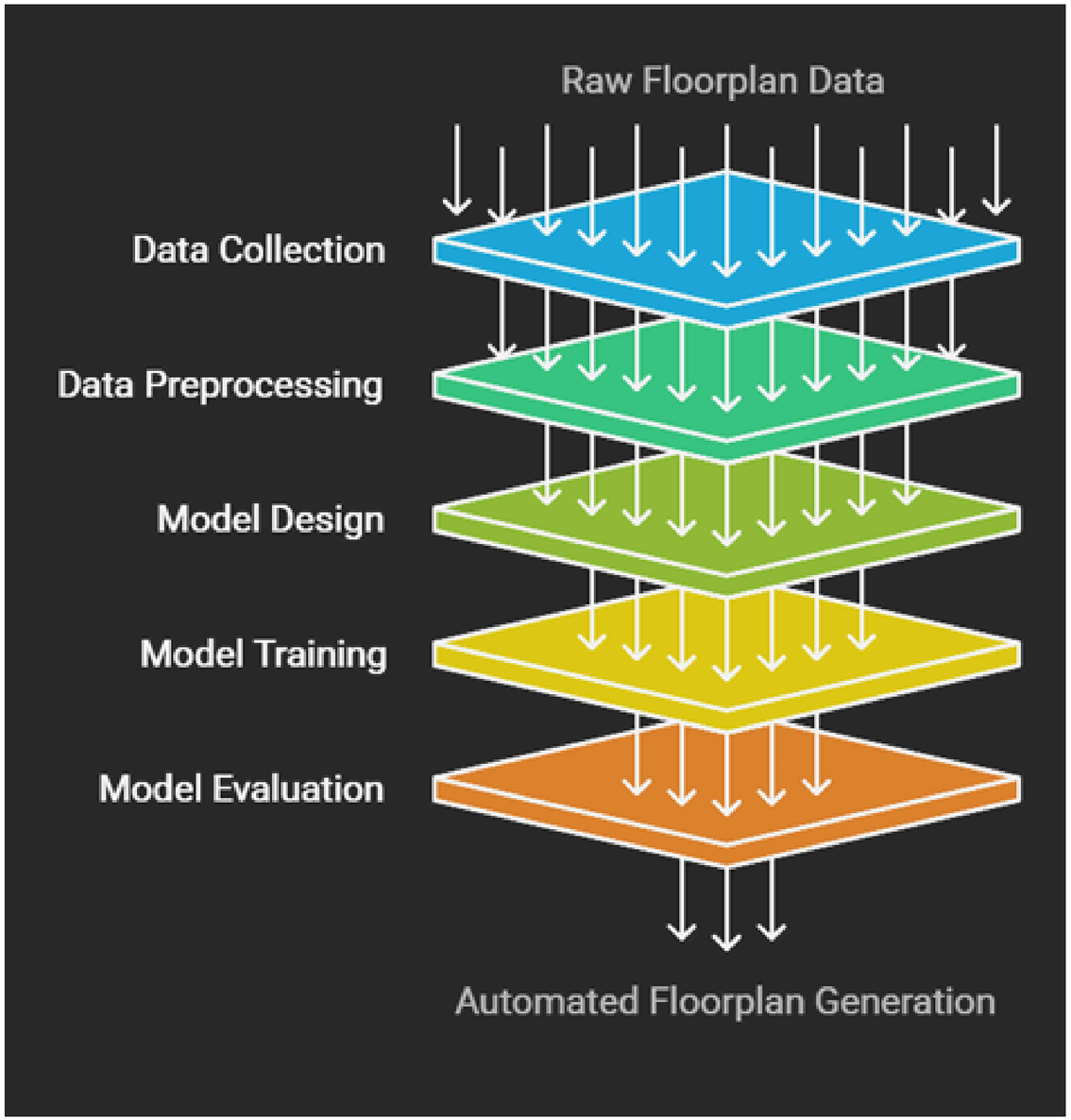
Key Features of CVAE

1. Robust Loss Function: Ensures realistic and coherent floorplans.
2. Data Normalization: Uses MinMaxScaler for condition features and pre-processes images in RPlanDataset.
3. Flexible Generation: A generate method enables diverse floorplan creation.
4. Scalability: The model integrates with a Flask backend (app.py) for real-time generation.

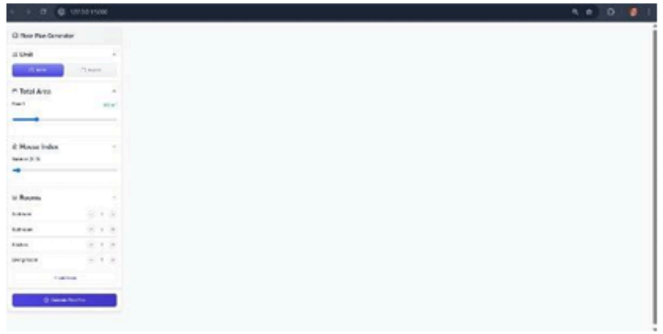
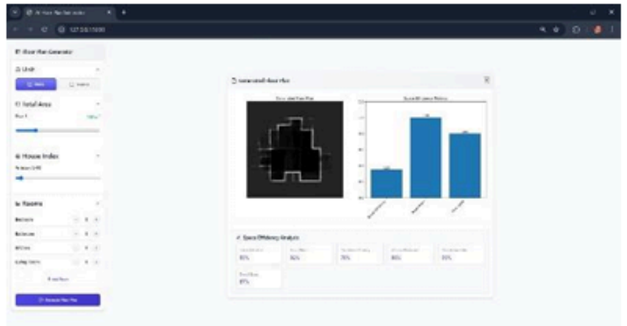
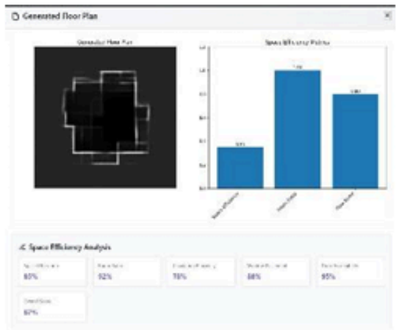
WORK DONE


User Input
Encoder
Latent Space
Decoder
Generated Floorplan

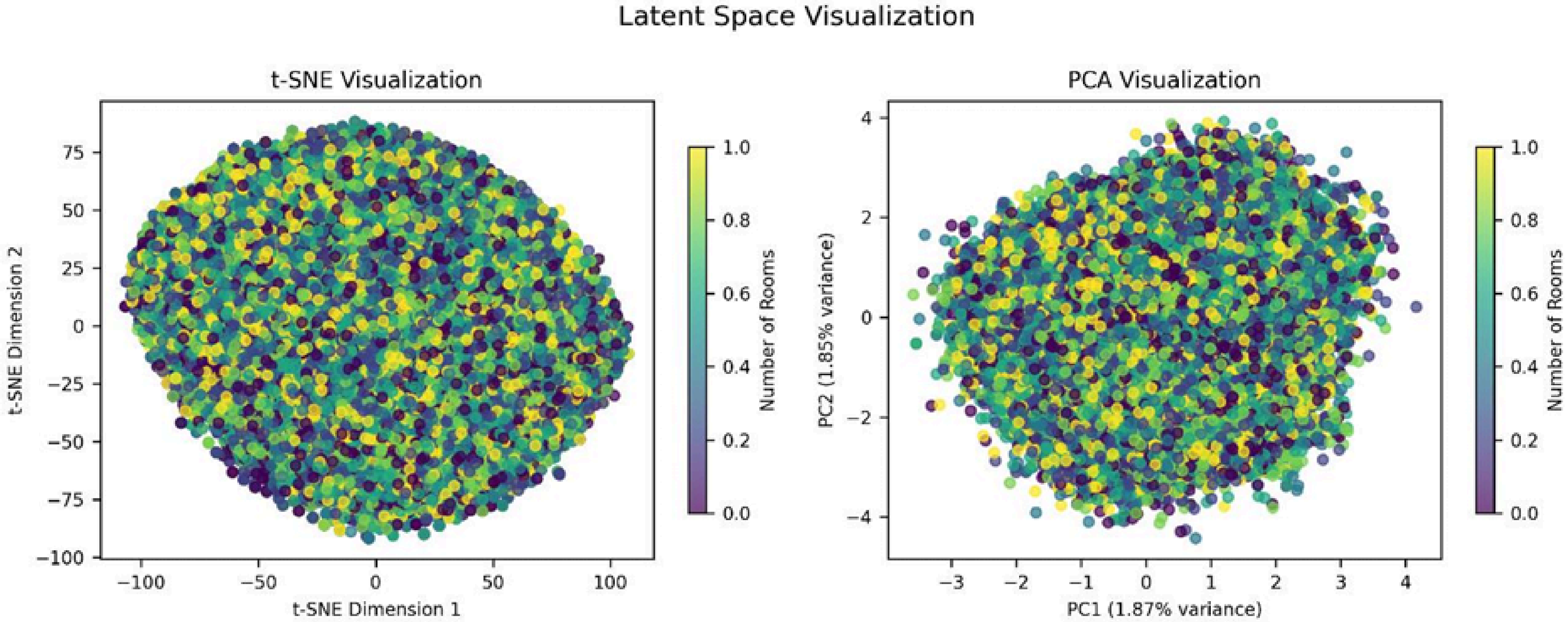
METHODOLOGY



TEST CASES

TestCase	*Result/Observation*	*Screenshot*
Landing Page:	Displays the main panel where users can set key parameters.	
Generated Floor Plan & Metrics:	Shows the system's output after users click "Generate Floor Plan." A grayscale floor plan is produced alongside a bar chart illustrating key space efficiency metrics.	
Detailed Efficiency Analysis:	Offers a closer look at the generated floor plan and its associated efficiency metrics, including space utilization, room ratio, and flow score	

VISUALIZATIONS



RESULTS

- Epochs : 50
- Batch size : 32
- Model :
  - Training Loss - **8651.1139**
  - Validation Loss - **8677.2230**

OUTCOME

- Design an advanced automated architectural design system that utilizes a Conditional Variational Autoencoder (CVAE)
- Generates customizable floorplans.
- Makes personalized home planning accessible to non-professionals.

FUTURE WORK

- Hybrid Model Integration
- Scalability and Performance Optimization
- Dataset Expansion and Augmentation
- Enhanced User Interaction

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THANK YOU!!