INDOOR CAMPUS NAVIGATION SYSTEM(i-Nav)

Project report submitted for the Course: Mini-Project[CS-2-14(PO)]

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Introduction:
Navigating large campus buildings with multiple floors can be a daunting task, especially for first-time visitors, new students, or individuals with accessibility requirements. Complex layouts, interconnected rooms, and limited signage often contribute to confusion and delays in reaching destinations. To address these challenges, our project introduces a Campus Navigation System specifically designed for the Pushkar building at IIT Jammu. This system leverages powerful graph algorithms to model the building's layout and helps users identify the shortest path between any two rooms. By incorporating vertical connectivity such as lifts and staircases, the system ensures efficient navigation across different floors, ultimately enhancing accessibility, reducing confusion, and saving time for all types of users.

Motivation:
The academic block of IIT Jammu, especially the Pushkar building, presents a complex layout with multiple floors, interconnected classrooms, labs, faculty cabins, staircases, and lifts. Navigating such a structure can be challenging for newcomers, visitors, and even regular occupants, particularly when moving between levels.

Static maps and signage often fail to provide clear directions, especially for users with accessibility needs or in time-sensitive situations. To address this, our project aims to develop a smart and scalable navigation system using graph algorithms and architectural data extracted from DXF floor plans. By converting these layouts into interactive pathfinding models, we aim to make indoor navigation more accessible, efficient, and user-friendly.

Literature Review :
Indoor navigation is increasingly important in large infrastructures like universities, airports, and hospitals. Graph theory is a key approach, modeling spaces as nodes and their connections as edges. **Dijkstra's Algorithm** is widely used for finding the shortest path in weighted graphs, making it ideal for indoor navigation, where paths may have varying travel costs or times.

AutoCAD DXF Parsing is a technique used to convert 2D floor plans into machine-readable formats. DXF files, containing room names, walls, and object labels, can be parsed to extract spatial data for constructing graph-based navigation models. This approach is increasingly integrated into computational models for indoor mapping.

NetworkX is a Python library that enables graph creation, manipulation, and shortest path

calculations, making it suitable for indoor navigation systems. Paired with **ezdxf**, a library for reading and writing DXF files, it allows for easy conversion of architectural layouts into navigable graph structures.

Together, Dijkstra's Algorithm, DXF parsing, NetworkX, and ezdxf provide a powerful framework for efficient indoor navigation, transforming architectural plans into usable routing models. These methods offer the potential for adaptive, real-time navigation in large-scale indoor spaces.

Methodology & Implementation Idea: The development of the

A multi-step approach combining DXF parsing, graph theory, and web integration:

1. **Floor Plan Parsing:** DXF files were parsed using ezdxf to extract rooms, lifts, stairs, etc. Text labels created nodes for navigation.

2. **Graph Construction:** Nodes represent locations; edges represent walkable paths.Vertical connections (lifts/stairs) link floors.

3. **Pathfinding:** Dijkstra's algorithm (via NetworkX) computes shortest paths using custom weights. Graph visualizations show structure and routes.

4. **Backend (Flask):** Handles queries, calculates paths, and generates route-overlaid images. Multi-floor routes are returned as ZIP files.

5. **Frontend:** Dropdown UI for selecting source/destination. JavaScript sends requests and displays/downloads results.
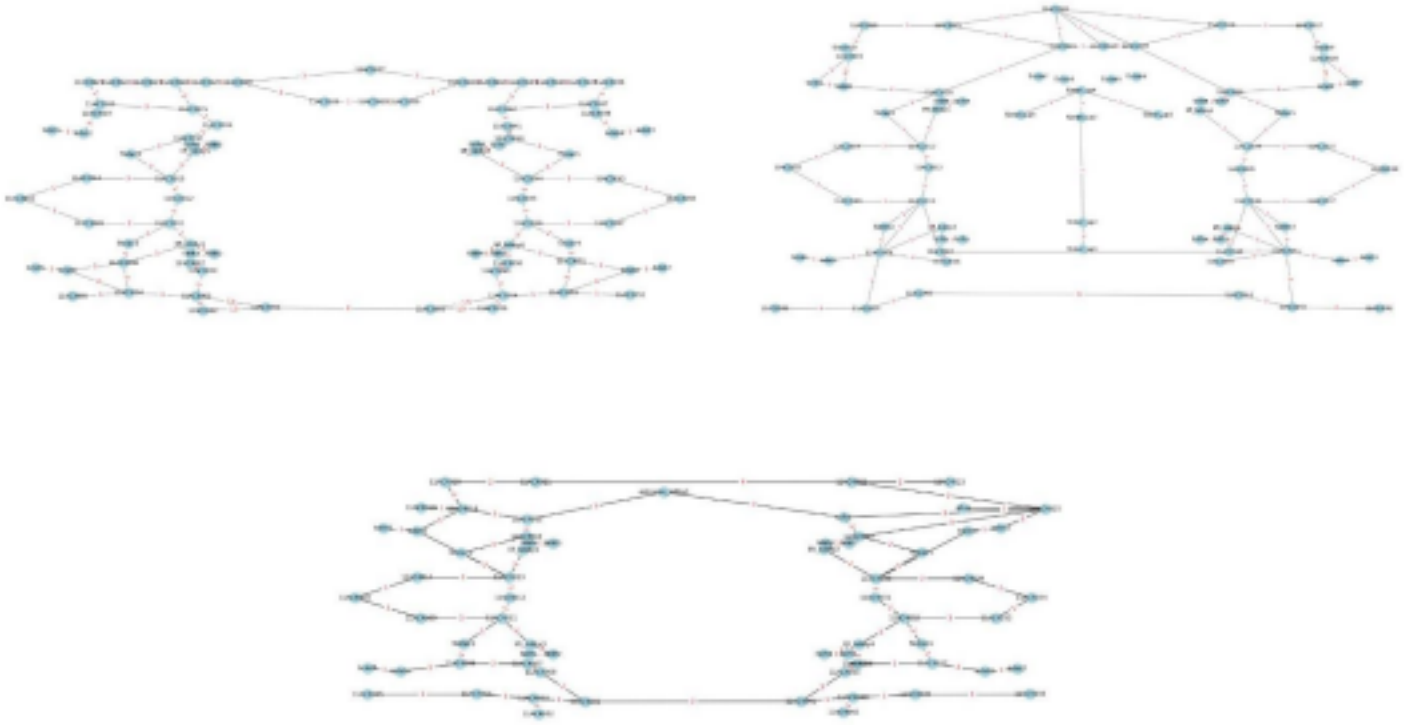
Results:
The implementation of the Campus Navigation System yielded effective results, combining graph algorithms with CAD-based data extraction for indoor navigation. Key features include:

- **Accurate Shortest Path Visualization:** The system uses Dijkstra's algorithm to compute the shortest path between rooms, with color-coded routes overlaid on architectural floor plans for easy understanding.

- **Multi-Floor Path Handling:** For multi-floor navigation, the system generates separate visualizations for each floor and compiles them into a ZIP file, ensuring users can follow the journey step-by-step.

- **Real-Time Frontend Integration:** The frontend, connected via Flask, allows users to submit source-destination queries and receive instant visual outputs, making it practical for daily use.

- **Scalability:** Using hardcoded labels and automated DXF parsing, the system can easily adapt to other buildings with similar floor plans, supporting large-scale implementations.

```
Enter start node: 11AC2022
Enter end node: 11AC3027
Shortest path: 11AC2022 -> 11AC2023 -> 11AC2016 -> f2lift6 -> lift_lobby1 -> f3lift6 -> 11AC3017 -> 11AC3016 -> 11AC3015 -> 11AC3024 -> 11AC3025 -> 11AC3026 -> 1
1AC3027
Total time taken (in seconds): 20
```

Conclusion :
This mini-project demonstrates how graph theory and CAD parsing can solve real-world indoor navigation challenges. By using Dijkstra's algorithm and parsing DXF files, we developed a tailored Campus Navigation System for the Pushkar building at IIT Jammu. The project showcases converting architectural plans into navigable graph models and highlights the practical use of computational methods. The system's backend and

dynamic frontend ensure an interactive, user-friendly experience, whether navigating within a single floor or across multiple levels. Ultimately, this project bridges theoretical algorithms with real-world applications, laying the groundwork for future advancements in smart navigation and large-scale deployment.

Achievements: The project achieved several key milestones in programming, algorithm design, and user interface development:

- **DXF Data Extraction:** Using the ezdxf library, we successfully parsed architectural floor plans in DXF format to extract room, staircase, lift, and other critical data, automating the mapping process for scalable graph generation.

- **Multi-Floor Graph Model:** A comprehensive graph model was created for the Pushkar building, with nodes representing rooms and edges indicating walkable paths, including vertical connections for cross-floor navigation.

- **Dijkstra's Algorithm Implementation:** A custom implementation of Dijkstra's algorithm was developed to calculate the shortest path, factoring in both distance and estimated travel time, optimizing the navigation route.

- **Path Visualization:** Shortest paths were visualized on floor plan images, with separate visualizations for multi-floor routes, packaged into a ZIP file, and color coded for clarity.

- **Frontend Interface:** A user-friendly web interface was developed, allowing real-time interaction for selecting source and destination rooms, with immediate visual feedback for pathfinding.

These achievements demonstrate the system's functionality and scalability, providing an effective indoor navigation solution.

Future Work: - Real-Time Indoor Navigation: Integrate QR markers or WiFi triangulation for real-time positioning and live tracking.

- Accessibility-Based Routing: Allow users to choose accessible paths such as lift-only navigation for people with disabilities.

- Interactive Assistance: Implement voice-guided navigation and turn-by-turn instructions.

- Campus Scalability: Extend the system to other campus types such as hospitals, airports, and large institutes, where shortest-time routing is crucial (e.g., emergency room access in hospitals).