
# TED UNIVERSITY

## CMPE 491 Senior Project

## Analysis Report

## "GuidAR"

## Spatial Computing for Indoor Navigation

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# 1. Introduction

## 1.1 Description

This project proposes an Augmented Reality (AR) Indoor Navigation System that utilizes Simultaneous Localization and Mapping (SLAM) to provide real-time, accurate navigation inside indoor and outdoor environments such as university campuses, museums, airports, and hospitals.

The system integrates the device camera, Inertial Measurement Unit (IMU), and SLAM algorithms to generate a dynamic 3D map of the surroundings by overlaying virtual elements such as directional arrows, labels, and paths onto the real environment through AR. This allows users can easily find their way to specific destinations without relying on external GPS signals.

Using mobile devices or AR glasses, users will get to interact with a visual guide directly in their field of view. The interface will highlight important landmarks, indicate turning points, and adapt dynamically as users move or deviate from the original path.

The primary goal of the project is to enhance indoor spatial awareness, reduce cognitive load during navigation, and demonstrate the potential of AR-based interfaces in real-world, context-aware applications.

# 2. Proposed system

The proposed system, GuidAR, is an AR-based indoor navigation application designed for university environments. It uses the device's camera, IMU sensors, and SLAM algorithms to continuously track user movement and generate a real-time 3D understanding of the surrounding area. Based on the user's selected destination such as a classroom, laboratory, office, or conference hall the system computes the optimal path and overlays navigation cues directly onto the physical environment through augmented reality.

GuidAR provides intuitive visual guidance using directional arrows, labels, and floor transition indicators, ensuring that users can move confidently inside multi-floor campus buildings without needing traditional maps. The application dynamically updates the route if the user deviates and maintains local processing of camera data to protect privacy. The system architecture is modular, allowing future integration of additional campus buildings, map sources, and AR features.

# 3. Overview

## 3.1 Functional Requirements

**SLAM-Based Localization:** Real-time user tracking and environment mapping using visual and inertial sensor data.

**AR Navigation Interface:** Overlay of virtual arrows, labels, and directions aligned with the real-world view.

**Path Planning:** Automatic route generation from current position to selected destination

**Dynamic Path Updates:** Recalculate navigation path if user deviates or environment changes.

**Destination Search:** User can search and select predefined locations such as, classrooms, offices.

**Multi-Floor Support**: Handle vertical navigation through stairs or elevators.

## 3.2 Nonfunctional Requirements

**Usability:** Intuitive AR interface with clear icons and gestures.

Simple destination input and real-time feedback.

**Performance:** Real-time SLAM updates and smooth AR rendering with minimal latency. Stable frame rate 60fps for responsive visualization.

**Security:** Local data processing; no external image transmission without consent.

**Maintainability:** Modular system architecture for easy updates. Extensible for integration with additional map providers.

## 3.3 Pseudo Requirements

1-) The system should be intuitive enough for first-time users to operate without training.

2-) The application should provide smooth AR visuals that feel natural within indoor environments.

3-) Users should be able to start navigation within a few seconds after scanning the environment.

4-) The system should guide users through commonly visited university locations such as classrooms, offices, laboratories, and conference halls.

5-) The AR elements arrows, labels, indicators should be visually clear and distinguishable from the physical environment.

6-) The navigation path should adjust naturally as the user moves, without abrupt visual jumps.

7-) The scanning process should work under typical university lighting conditions.

8-) The user interface should remain uncluttered, showing only essential navigation information.

## 3.4 System Models

### 3.4.1 Scenarios

We've provided a list of scenarios for an app developed for the TED University campus.

**Scenario 1: Student Navigating to a D026**

A student opens the GuidAR application to find classroom D026. After selecting the correct campus building, the system initializes SLAM, scans the environment, and identifies the student's current position. The student searches for the classroom, views the suggested path, and starts AR navigation. GuidAR overlays directional arrows and turn indicators on the real environment. Upon reaching the room, the system displays a confirmation message.

**Scenario 2: Visitor Going to "Ahmet Ersan Conference Hall"**

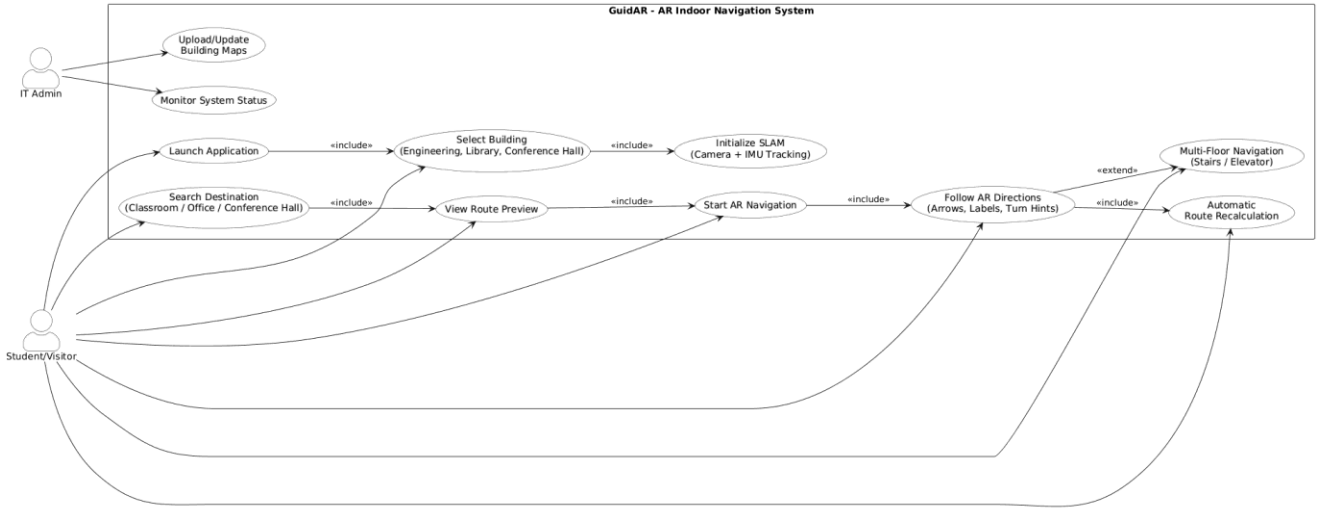
A visitor attending a seminar at TED University wants to reach Ahmet Ersan Conference Hall. They launch the app, choose the main building, and search for "Ahmet Ersan Conference Hall." GuidAR generates the optimal path and displays AR guidance. As the visitor walks, the system dynamically updates the route when they take a wrong turn. After a floor change via elevator, the system realigns the path and guides them to the correct destination.

**Scenario 3: Student Looking for an Instructor's Office**

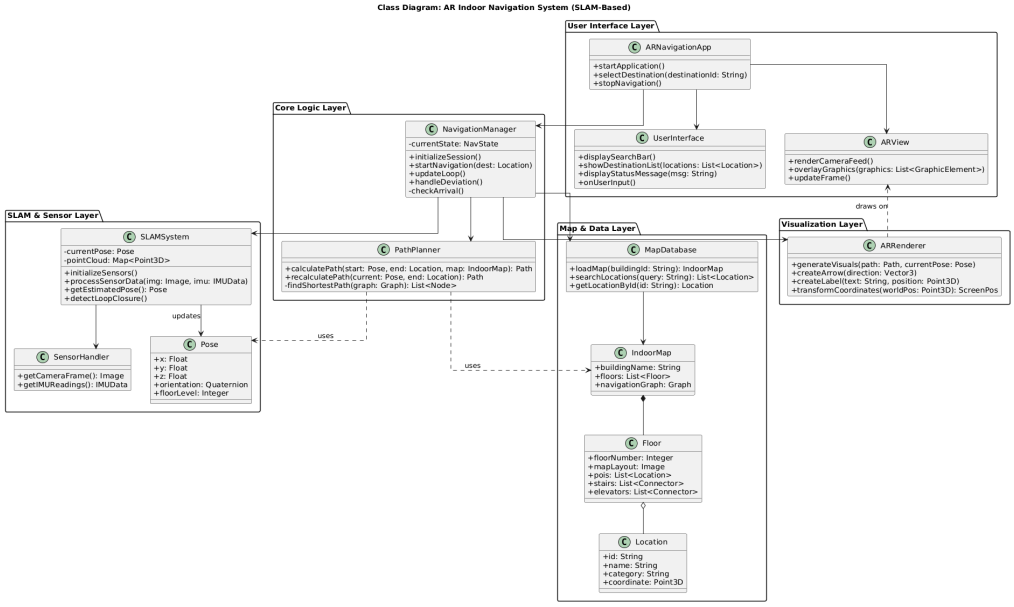
A student needs to meet an instructor during office hours. They open the app, search for the instructor's name, and GuidAR retrieves the corresponding office location. The system calculates the shortest route and begins AR navigation. The SLAM module tracks user

movement, and AR labels highlight relevant hallways and doors, helping the student reach the office without confusion.

## 3.4.2 Use Case Model

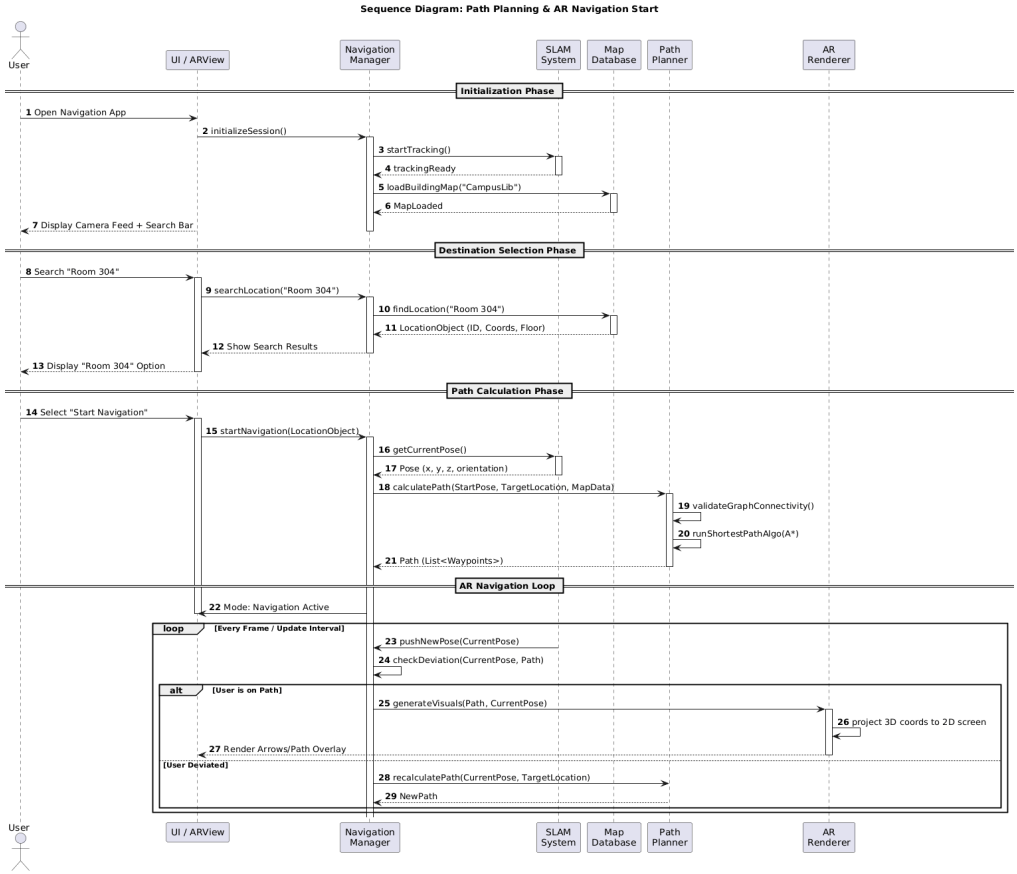



## 3.4.3 Object and Class Model

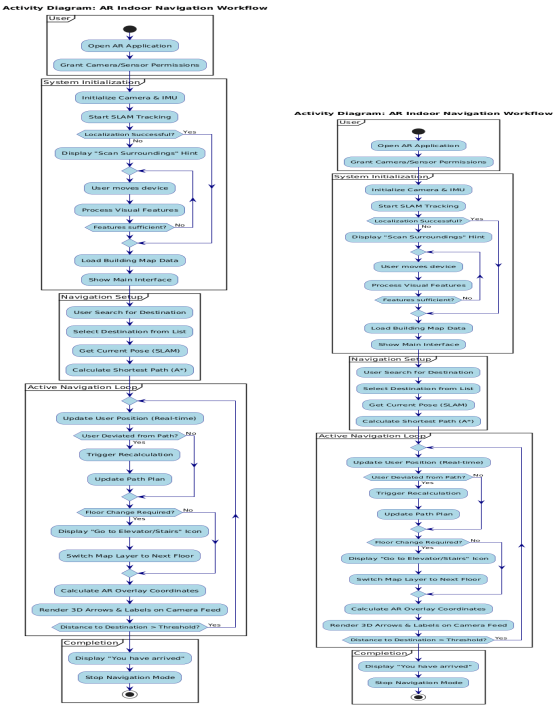


# 3.4.4 Dynamic models

## Sequence Diagram



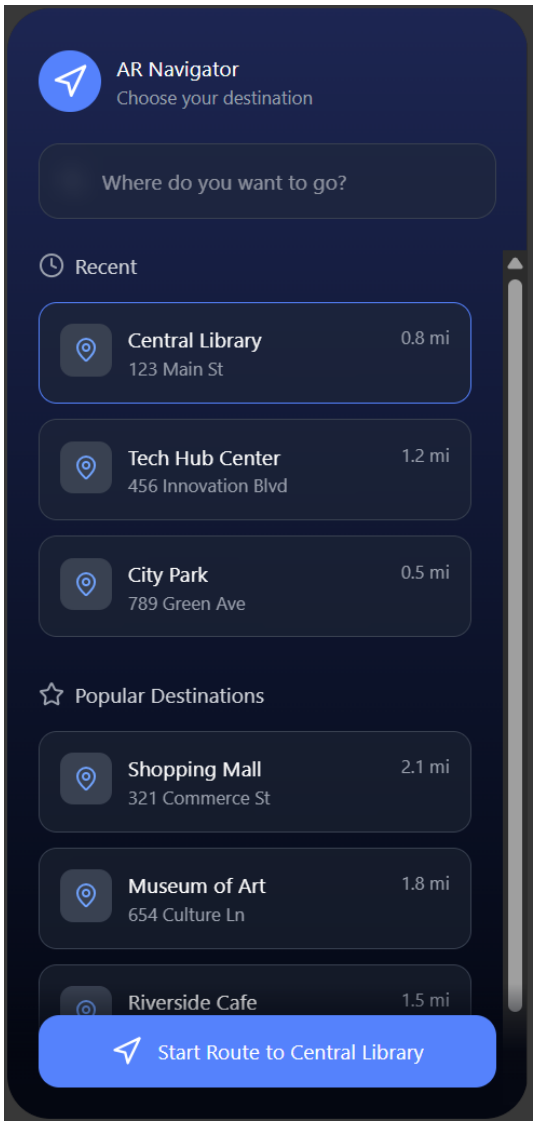

## Activity Diagram



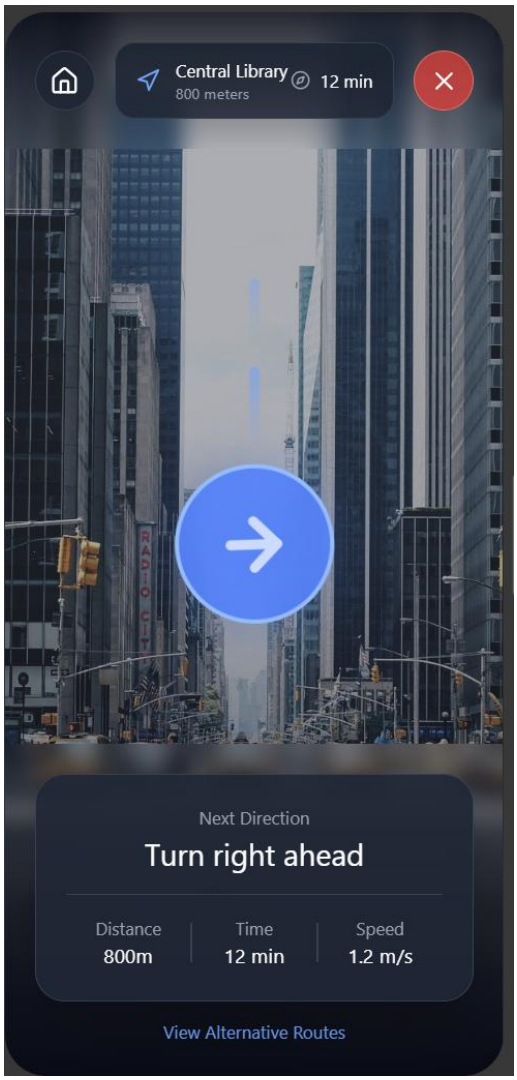

Activity Diagram: AR Indoor Navigation Workflow
User
Open AR Application
Grant Camera/Sensor Permissions
System Initialization
Initialize Camera & IMU
Start SLAM Tracking
Localization Successful?
Yes
No
Display "Scan Surroundings" Hint
User moves device
Process Visual Features
Features sufficient?
No
Load Building Map Data
Show Main Interface
Navigation Setup
User Search for Destination
Select Destination from List
Get Current Pose (SLAM)
Calculate Shortest Path (A*)
Active Navigation Loop
Update User Position (Real-time)
User Deviated from Path?
No
Yes
Trigger Recalculation
Update Path Plan
Floor Change Required?
No
Yes
Display "Go to Elevator/Stairs" Icon
Switch Map Layer to Next Floor
Calculate AR Overlay Coordinates
Render 3D Arrows & Labels on Camera Feed
Distance to Destination < Threshold?
Yes
Completion
Display "You have arrived"
Stop Navigation Mode

## 3.4.5 User Interface - Navigational Paths and Screen Mock-ups

### 3.4.5.1 User Interface - Route or Destination Selection



### 3.4.5.2 User Interface – Screen During Navigation




***picture is a reference to an active camera feed.***

## 4. Glossary

**AR:** Augmented-Reality

**SLAM:** Simultaneous localization and mapping

**GPS:** Global Positioning System

**IMU:** Inertial Measurement Unit

## 5. References


1. Volpis. (2025, October 23). A complete guide to developing augmented reality indoor navigation applications. https://volpis.com/blog/guide-to-developingaugmented-reality-indoor-navigation-applications/
2. Google ARCore Documentation, Geospatial and Indoor Mapping APIs.
3. Apple ARKit Documentation, Visual-Inertial Odometry and Room Plan APIs.
4. Sukhareva, E., Tomchinskaya, T., & Serov, I. (2021). SLAM-based indoor navigation in university buildings. https://ceur-ws.org/Vol-3027/paper63.pdf

# Project Backlog

| Task Name | User Story | Sprint Ready | Priority | Status | Effort | Assigned to Sprint |
|---|---|---|---|---|---|---|
| **SPRINT 2** | No | No | High | In Progress | 141 | Yes |
| **SLAM Algorithm Integration** | Enable real-time localization and mapping | Yes | High | In Progress | 20 | Yes |
| **Camera & IMU Sensor Fusion** | Combine camera and IMU for stability | Yes | High | In Progress | 14 | Yes |
| **AR Path Visualization** | Overlay arrows and navigation cues | Yes | High | In Progress | 16 | Yes |
| **Indoor Map Data Structure** | Define building data representation | Yes | Medium | In Progress | 10 | Yes |
| **Destination Search Module** | Search locations | Yes | High | In Progress | 12 | Yes |
| **Path Planning Algorithm** | Compute optimal route | Yes | High | In Progress | 15 | Yes |
| **Dynamic Route Update** | Recalculate route | Yes | High | In Progress | 12 | Yes |
| **Multi-Floor Navigation** | Support stairs and elevators | Yes | Medium | In Progress | 10 | Yes |
| **AR UI Design** | Simple interface | Yes | Medium | In Progress | 8 | Yes |
| **Performance Optimization** | Maintain 60 FPS | Yes | High | In Progress | 10 | Yes |
| **System Integration Testing** | Test full system | Yes | High | Not Started | 8 | Yes |
| **Error Handling** | Prevent crashes | Yes | Medium | Not Started | 6 | Yes |

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|---|---|---|---|---|---|---|
| **SPRINT 1** | No | No | High | In Progress | 24 | Yes |
| **Requirement Analysis and Use Case Definition** | Gather functional and non-functional requirements and define scope. | Yes | High | Complete | 4 | Yes |
| **Establish Contact with Potential Partner** | Reach out for feedback/sponsorship. | Yes | High | In Progress | 12 | Yes |
| **Technology Stack Selection** | Choose AR/SLAM tools and setup environment. | No | Medium | In Progress | 8 | Yes |
| **Preliminary SLAM Feasibility Test** | Initial experiments using sensors. | No | Medium | Not Started | 0 | No |