TED UNIVERSITY
CMPE 492
Senior Design Project II
"TEDU GuidAR"
Spatial Computing for Indoor Navigation
Test Plan Report

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Project Page URL: https://berkbelhan.github.io/ar-navigation-senior-project/

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1. Introduction

This document presents the test plan for the GuidAR system, an Augmented Reality (AR)-based indoor navigation application designed to provide real-time navigation in complex indoor environments. The system utilizes spatial mapping, tracking, and AR visualization to guide users with intuitive visual cues.

The purpose of this test plan is to define the testing scope, methodology, and environment to ensure that the system meets both functional and non-functional requirements. Testing is essential to validate the correct integration of core components such as localization, navigation, and AR rendering.

Since GuidAR operates as a local-first system on the Meta Quest 3 device, testing focuses on real-time performance, accuracy, and system responsiveness. Overall, this test plan aims to verify that the system is reliable, accurate, and user-friendly.

2. Test Objectives

The primary objective of testing the GuidAR system is to validate that all core system components meet the defined functional and non-functional requirements. This includes verifying the accuracy of user localization, correctness of navigation path generation, and proper behavior of AR visualization elements under real-time conditions.

Testing also aims to evaluate system performance on the Meta Quest 3 device by assessing criteria such as frame rate stability, response time, and latency during navigation updates. In addition, the reliability of dynamic features, such as rerouting and continuous position tracking, is examined.

Another objective is to assess the usability of the system by ensuring that users can effectively understand navigation instructions, select destinations, and interact with the interface without confusion.

Overall, testing focuses on validating the system's correctness, performance, reliability, and usability in realistic indoor environments.

3. Test Scope

The testing scope includes all major components of the GuidAR system including localization, navigation, visualization. The localization module is tested to verify that the system correctly tracks the user's position within the mapped environment. The navigation component is evaluated to ensure that pathfinding algorithms generate correct and optimal routes and update them when necessary.

The AR visualization is tested on whether correct placement and behavior of navigation elements like arrows and paths. In addition, user interface components are tested to ensure system correctly services to user actions.

3.1 Features to be Tested

- **Localization System**
  - SpatialController relocalization using anchors
- **Navigation System**
  - To verify if pathfinding algorithm works correctly.
  - ReroutingService making sure that routes are updated simultaneously as user goes through different paths.

  Mapping System
  - NavMesh: Verifying that all floors and walls are visible, obstacle handling, floor smoothing.
- **AR Visualization**
  - ARNavigationRenderer: To see if arrows, paths are rendered and working correctly.
- **User Interface**
  - Destination selection menu
  - HUD information (distance, instructions)

4. Testing Methodology

The testing methodology for the GuidAR system is designed to evaluate the system at different levels, starting from individual components and progressing to the complete system.

4.1 Unit Testing

Unit testing focuses on verifying the correctness of individual components in isolation. Each core module of the system is tested independently to ensure that it performs without errors. NavigationEngine was verified on correct path calculation using A* and UIManager checks on UI updates such as distance and messages.

4.2 Integration Testing

Integration testing evaluates how different modules interact with each other.

Key integration scenarios include:

- Localization → Navigation
- Destination selection → route generation → visualization
- User movement → rerouting mechanism

This phase ensures that combined components behave as expected when working together.

4.3 System Testing

System testing examines the complete system under realistic conditions. The goal is to validate that all components function together to provide the intended navigation experience. Test scenarios include:

- User selects a destination
- System calculates the optimal path
- AR navigation elements are displayed
- System updates navigation dynamically as the user moves

4.4 Performance Testing

Performance testing is conducted to evaluate the efficiency and responsiveness of the system on the Meta Quest 3 device. Navigation update latency and memory usage were analysed.

4.5 User Acceptance Testing (UAT)

User Acceptance Testing is performed to evaluate the system from the user's perspective. Users will use the system to determine whether it is intuitive and easy to use. The evaluation mainly focuses on clarity of navigation instructions, ease of destination selection. Overall usability of the interface.

5. Test Environment

The test environment for the GuidAR system is designed to closely match the actual deployment conditions in which the system will operate. Since the application relies on real-time spatial mapping and augmented reality rendering, testing is conducted using both development and target hardware to ensure accurate evaluation.

The primary testing device is the Meta Quest 3 headset, as the system is specifically developed to utilize its built-in sensors, spatial tracking capabilities, and passthrough AR features. All functional and performance tests are executed on this device to reflect real usage conditions.

The Unity Engine is used as the main development platform, along with the Meta SDK and MR Utility Kit for handling spatial mapping, tracking, and AR rendering. The Android SDK is used for building and deploying the application to the headset.

The test environment includes the following components:

- **Software**
  - Unity Engine (application development)
  - Meta SDK / MR Utility Kit (AR and spatial features)
  - Android SDK (deployment)
- **Operating Systems**
  - Android-based OS on Meta Quest 3 (runtime environment)

Testing is conducted in real indoor environments such as corridors and rooms to evaluate localization accuracy, navigation performance, and AR alignment under realistic conditions. This ensures that the system is tested not only in controlled setups but also in scenarios that reflect actual user usage.

6. Test Cases

The following test cases are defined:

Test ID	Description	Input	Expected Output	Result
TC-01	Destination selection	User selects a POI	System receives destination and starts navigation	Pass
TC-02	Path generation	Valid start and end nodes	Correct path is generated using A*	Pass
TC-03	AR path display	Navigation started	AR arrows and path appear correctly aligned	Pass
TC-04	User movement tracking	User walks along path	Position updates continuously and correctly	Pass
TC-05	Rerouting	User deviates from path	System recalculates a new path	Fail
TC-06	UI interaction	User presses UI elements	Correct UI response is displayed	Pass

7. Test Schedule

The testing phase follows a structured timeline, starting with code-level verification, moving on to high-stress performance optimization and concluding with real-world user validation.

Week	Phase	Focus Area Description
7	**Unit Testing**	**Core Logic & NavMesh:** Validate A* pathfinding and local storage retrieval. Ensure the NavMesh binary files load without corruption.
8	**Unit Testing**	**Perception APIs:** Test Spatial Anchor persistence and Depth API occlusion accuracy in a controlled laboratory setting.
9	**Integration Testing**	**Hardware Fusion:** Verify the interface between Meta Quest 3 sensor data and the NavigationEngine.
10	**System Testing I**	**End-to-End Navigation:** Full "Start-to-Finish" navigation tests in a single hallway. Validate rerouting logic when the user leaves the NavMesh.
11	**Performance Testing I**	**Performance Profiling:** Monitor FPS stability (target 72/90Hz) and Motion-to-Photon latency to ensure comfort during movement.
12	**Performance Testing II**	**Stress Testing:** Run the system for multiple hours continuously to monitor thermal throttling and battery drainage under heavy SLAM/Depth API load.
13	**Beta Testing I**	**Closed Beta:** Deploy the system to a small group of 5-10 students. Test multi-floor transitions (stairs/elevators) in live campus conditions.
14	**Beta Testing II**	**Open Beta:** User acceptance testing to collect qualitative UX data. Final bug fixing and documentation of the Final Report.

8. Roles, Responsibilities, and Risks

Testing responsibilities are shared among all team members to ensure efficient progress and full system coverage. Each member is responsible for testing their assigned components and reporting any issues, while all members participate in system-level testing and validation.

The main risks associated with the system are related to localization accuracy, performance, and user interaction. Since the system relies on real-time spatial tracking, inaccuracies may occur in complex environments. In addition, AR processing may affect performance, leading to latency or frame drops. There is also a risk that users may find the interface or navigation instructions difficult to follow.

To reduce these risks, testing is conducted in real environments, performance is continuously monitored, and feedback from users is considered to improve usability and system stability.