CS449 – Human–Computer Interaction Milestone 1: QR-Based Indoor Navigation Prototype

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Abstract—**This document summarizes the current status of our CS449 project, which aims to support indoor wayfinding in our faculty building using a mobile, web-based "AR-style" interface. We describe the main idea, our study design plan, what has been implemented so far, why we switched from an iBeacon-based approach to QR markers, and the next steps toward a full prototype and user study.**

I. Project Overview

The goal of our project is to help students and visitors find classrooms on a specific floor of our faculty building with less confusion and lower cognitive load. Instead of a traditional 2D floor map, we propose a mobile web interface that shows the live camera view of the corridor and overlays simple navigation cues (a large arrow and a short text instruction) on top of it.

We treat indoor navigation as a sequence of discrete checkpoints rather than continuous positioning. Each checkpoint (for example, the main entrance, a junction, or a classroom door) is marked with a printed QR code. When the user points their phone at a marker, the app detects the QR code, interprets it as a node ID in an indoor graph, computes a shortest path to the selected classroom using breadth-first search (BFS), and displays only the next step (e.g., "Walk straight until you see the next marker" or "Turn right at the intersection").

The same set of QR markers can be reused for multiple target rooms on that floor: the QR codes only store location identifiers (N1, N2, . . .), while routes are computed dynamically from the graph.

II. Study Design Protocol

We plan a within-subjects study where each participant completes the same navigation task under two conditions:

- **2D map condition:** The participant receives a floor plan (printed or on-screen) with the starting point and target classroom marked and is asked to find the room in the real building.
- **QR-based AR web condition:** The participant uses our camera-based web interface. At each QR checkpoint, the app detects the marker, updates the current node, computes a shortest path to the chosen classroom, and shows the next directional cue on top of the live camera view.

The order of the two conditions will be counterbalanced across participants. We plan to recruit participants who are not very familiar with the chosen classroom and corridor. For each condition we will measure task completion time, number of wrong turns or backtracking events, and whether the participant overshoots the classroom door. After each run, participants will fill in a short questionnaire (Likert scales) rating how lost or confident they felt and how easy the interface was to use.

III. Design Decisions and Technology Choice

Our initial idea was to use BLE iBeacon technology for room-level indoor positioning and to render AR arrows in a mobile application. After a short feasibility analysis, we decided not to follow this path for the current course project. Reliable iBeacon-based positioning requires native access to Bluetooth APIs and careful calibration of noisy RSSI signals. This conflicts with our goal of deploying a simple browser-based prototype that can run on students' phones without installing a separate app, and it would shift our effort away from interaction design toward low-level hardware debugging.

We therefore switched to a QR-based approach. QR markers are cheap to print, easy to detect from the camera stream using standard libraries, and work well in a web context. They also fit naturally with a graph-based representation of the corridor: each marker corresponds to a node, edges encode possible movements and their directions, and BFS provides a simple shortest path in terms of node hops. This change reduces technical risk and allows us to focus on the HCI aspects of the interface and the study.

IV. Current Progress and Submitted Materials

At this milestone, we have focused on Design Thinking and a first implementation prototype:

- We defined a small graph model for one corridor: nodes for entrance, junctions, and classroom doors; directed edges annotated with high-level directions (forward, left, right, back), and a mapping from certain nodes to room IDs (e.g., FENS G023).
- We implemented a Python desktop prototype using OpenCV and the `pyzbar` library. The program reads frames from a webcam, detects QR codes, decodes their text as node IDs, runs BFS from the current node to the destination node, and overlays a large arrow symbol and a short text instruction on the camera feed.
- We wrote a Python script to generate QR code images for node IDs (N1, N2, N3, ...), so they can be printed and placed at real locations on the floor.

For the Design Thinking + Implementation phase, we will submit the Python QR navigation prototype, the QR generation script and sample QR images, and the corridor sketch/diagram illustrating the planned graph structure.

V. Next Steps

The main incomplete parts are the mobile web implementation and the actual user study. These are incomplete because we first explored several technical options (iBeacon, VR/Roblox, native AR) and needed to converge on a feasible design with a clear HCI focus.

Our next steps are to:

- Port the current logic to a mobile-friendly web application using camera access and a JavaScript QR library, maintaining the same graph and BFS navigation logic.
- Finalize the node/edge graph for one real floor, print and place QR markers, and test detection conditions (distance, lighting).
- Design and refine the mobile UI (layout of camera view, arrow overlay, and text) and run a small pilot to debug timing and instructions.
- Prepare consent forms and short questionnaires, then conduct the within-subject study comparing 2D map navigation with the QR-based AR web interface.

We expect that this QR+BFS approach will provide a realistic yet manageable interaction prototype that can be properly evaluated in the remaining time of the course.