RAIS: Towards A Robotic Mapping and Assessment Tool for Indoor Accessibility Using Commodity Hardware


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We introduce ***RAIS (Robotic Accessibility Indoor Scanner)***, a robotic-based indoor mapping and accessibility assessment system. RAIS is constructed with off-the-shelf components including a vacuum robot, smartphone, and phone gimbal along with a modified version of our previous LiDAR-based accessibility scannar RASSAR. In a preliminary evaluation of three indoor spaces, we demonstrate RAIS's ability to autonomously scan spaces, produce detailed 3D reconstructions, and find and highlight accessibility issues.

Hardware & Software

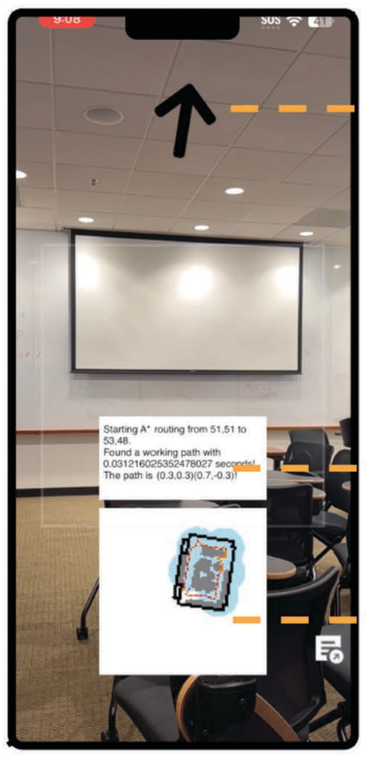
LiDAR-equipped smartphone:
To scan and reconstruct 3D environments, we use a LiDAR-equipped smartphone (iPhone 13 Pro Max). The real-time reconstructed map also guides the robot path control.

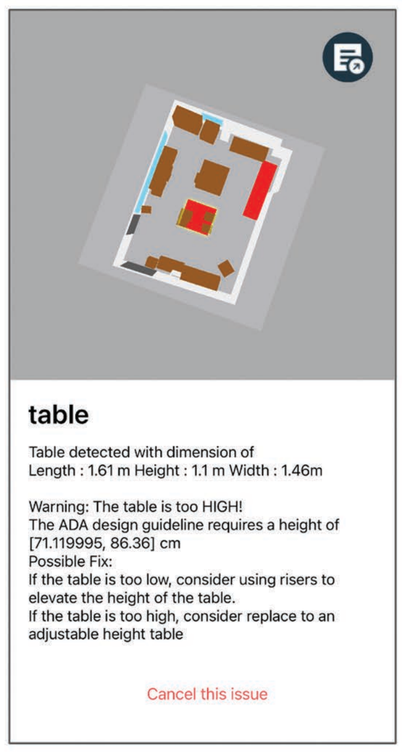
Motorized phone gimbal:
To control the capture angles of the smartphone and ensure maximum coverage, the phone is mounted on a motorized gimbal (DJI Osmo Mobile 6) which is controlled to rotate left, right, up, and down during scan

Tripod: We elevate the gimbal and phone with a tripod to improve capture of indoor objects.

Robot: To autonomously navigate and map indoor environments, we use a wheeled vaccum robot (iRobot Create 3).

Software and interface:
The 3D reconstruction and real-time accessibility barrier scanning is conducted by our previously published system RASSAR , a custom iPhone application that identifies, localizes, and visualizes indoor accessibility and safety issues.
The scan result is shown as a 3D the layout of the room, including walls, doors, as well as the indoor objects (e.g., tables, chairs) .

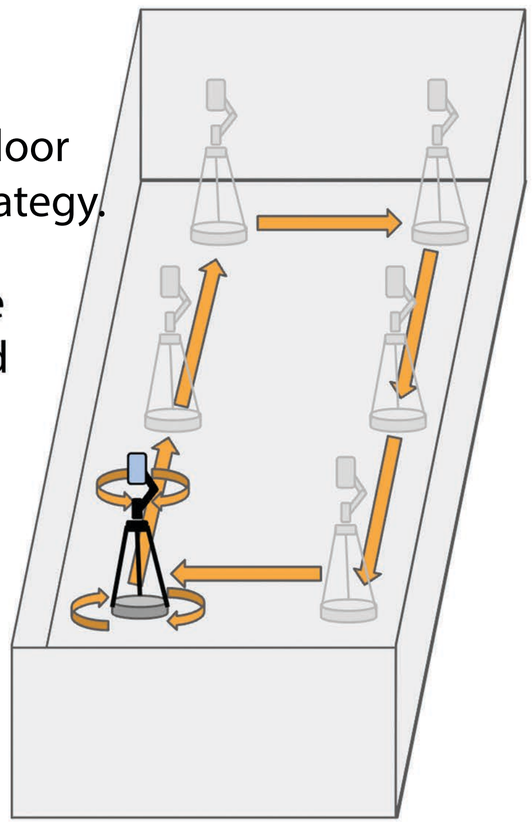




Scanning Process

To enable RAIS to explore and scan unknown indoor spaces, we implemented SLAM and a routing strategy.

SLAM: We use *ARKit* and *Roomplan API* to create real-time 3D reconstruction of indoor spaces and locate the 3D coordinates of the robot.
Routing: we implemented two methods: (1) a wall-following strategy to guide the robot exploring unknown spaces, (2) and an A* pathfinding algorithm that use the real-time output of RoomPlan API to route the robot and avoid obstacles.



Algorithm 1 RAIS Wall Following Strategy

while not back at initial position **do**
  if further than 2.5m from already scanned positions **then**
    Rotate robot and gimbal to perform scan at current position
  end if
  if not following any wall **then**
    Find nearest wall and start following it
  end if
  Move along the following wall
  if new wall detected within 1.2m **then**
    Follow the new wall
  else if left-side wall ends **then**
    Turn left, move forward until a new wall to follow is found. Follow this new wall.
  end if
end while
end algorithm

Evaluation

We tested RAIS in three indoor spaces: a makerspace, a classroom, and an office. For each space, we deployed RAIS for an automatic scan. The RAIS robot then maneuvered within the space, generated a 3D reconstruction and 2D map, and conducted an accessibility evaluation.

Space	Space Size (Sqm)	Scan Time (Min)	Time Per Sqm (Sec/Sqm)	Issues in Space	Issues Detected
S1: Makerspace	40	10	15	i2, i2, i2, i3	i2, i2
S2: Office	32	6.5	9.75	i2, i2, i4	i2, i2, i4
S3: Classroom	48	9	11.25	i4	i4