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Infrastructure-Free Indoor Navigation System

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Abstract: Large College Building, Classrooms and Labs. It is very bothersome for freshers and visitors. Satellite GPS just will not work inside of concrete buildings. Signals drop out. Estimates of position are destroyed by multipath reflections. Dedicated There are hardware solutions available such as BLE beacon grids or UWB anchors, but In fact, colleges like ours can't afford to purchase and maintain, Hundreds of battery-powered devices throughout wings. In this paper, we share our experience of designing and testing the RCPIT Navigation System. It's entirely offline mobile application, operating without external sensors and cloud servers on the user's smartphone. The app pairs Pedestrian Dead Reckoning (PDR)—using the built-in accelerometer & peak-valley state machine (with a Hand-calibrated campus with in-memory Dijkstra routing engine on hand. corridor graphs. There are many opportunities for large engineering labs to have multiple. The app assesses all entrances on different corridors and automatically selects the most suitable one. If travelling to a higher floor, Divides the route into two parts, linked by stairs and/or lifts. We also implemented an off-line text-to-speech module with 2D vector Use of cross-products to announce turns for users who are blind. In The accuracy of step detection in real corridor trials in RCPIT campus. The number of people exceeding 97% was more than 99% at normal walking pace. The 0.6ms runtime for single floor queries was less than 1ms for route calculation. and approximately 1.1 MS, for a graph of 200 nodes, between floors. Overall, using inertial sensing from smartphones in combination with a topological graph routing provides a hand on, no-cost wayfinding solution for the indoors. academic campuses.

Keywords: Pedestrian Dead Reckoning, Multi-Floor Routing and Multi-Door, Dijkstra's Algorithm, Indoor Navigation Pathfinding, Inertial Sensors, Flutter, Offline Wayfinding, Mobile Accessibility

I. INTRODUCTION

It's a story that plays out on our campus each semester. New Follow students as they walk around and fail to find any lecture rooms, external conference guests, ask peons for directions, which are given by the examiners. get lost in similar-looking corridors. Academic complexes are designed to be confusing! At R.C. Patel Institute of There are departmental wings, workshop, Technology (RCPIT) in Shirpur. The buildings include faculty cabins, bays and a twostory facility building. blocks connected by long corridors. Static wall signs help a person who is trying to get directions. bit. When not familiar with the wing shape, however, you still find yourself lost. Google maps is a magic tool when it comes to navigating outdoors. Indoors, it dies instantly. The blue dot will stop or move around in the parking lots. GPS just doesn't work in reinforced concrete.

The physics is responsible for that. A satellite is 20,200 km above the Earth broadcasting at low level of noise at microwaves. Concrete slabs Take 10-30 dB of signal power per floor [1]. Over 40 dB is achieved by heavy loadbearing columns using steel rebar. What little signal reflects off tiled floors and metal objects Lockers is able to cause severe multipath interference [2]. Receiver errors blow up to tens of meters. In a corridor 3 meters wide, that is useless.

A. Why hardware solutions don't work for us:

The commercial venues have a Bluetooth Low Energy (BLE) installed. To find users, beacons or Ultra-WideBand (UWB) grids can be used [1], [7]. They work well. However, they are entirely for a regional college. out of reach. We discussed about BLE beacons: our campus would need roughly 250 beacons. What is the replacement for a dead coin-cell? batteries every year? Who goes up ladders when ladders break? Wi-Fi fingerprinting sounds cheaper since routers exist, but requires more effort. The manual signal surveys were conducted over the days [10]. The moment a metal If the power is turned on or off in the cupboard or if IT changes the power to the router, fingerprints are broken.

We wanted something that was free of charge. No hardware. No maintenance headaches.

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B. The approach we will take is Software-Only Campus Navigation. The approach taken is Software-Only Campus Navigation.

The RCPIT Navigation System is a self-contained RCPIT application that was created to help with the navigation of and to the RCPIT website. mobile app. The entire app runs straight on the student's mobile phone. No WIFI is needed for the device to function. No cloud servers. No beacons.

There are 4 main techniques in this system: Here are some of the features that we are highlighting for your review:

- accelerometer. A peak-valley state machine with an infinite number of states is shown below. amplitudedelta filter is used to count steps with 550ms lockout While eliminating casual phone fidgeting.
- When modeling, Corridors are modeled by using MultiDoor Dijkstra Search. as coordinate graphs. Our labs are equipped with several doors, for labs with more than one door, engine is testing all the entrances and chooses the shortest walk automatically.
- This is 2 Stage Floor Routing, a method that is much simpler than the often-complicated 3D floor routing. For cross floor trips, we divide weave into 2 clean legs: walk Climb and then proceed the target, to the nearest stairs. floor.
- Offline Spoken Turns: 2D vector cross-products between In the case of corridor segments, they are able to detect upcoming corners, and trigger upon them. Audio cues for hands-free and accessible use.

This app is built using Flutter and Dart, which is then compiled into native. Android and iOS versions of ARM binaries.

C. Key Contributions

Main contributions of this work are:

The first one is Campus Topology Mapping: A handcalibrated graph. The total number of nodes on three floors of RCPIT is 200+ nodes. ground scale certified verified as 13.3 pixels per meter at ground level.

2) Multi-Door Path Optimization: A shortest-path routine that checks all entry points of large halls to select the closest door.

In 3) Two-Stage Floor Transitions: An inter-floor routing, the transition between two floors serves as an interfloor routing. Install staircases and lifts to connect floors together on pipelines. using shared IDs.

4) Strong Gait Detection: A filter based on inertial steps, which is a linear combination of 4 different filters. a 1.8 m/s2 peak threshold, a 0.4 m/s2 valley delta, and a 550ms lockout, with > 97% accuracy for all paces.

The 5th step scaling is called Resolution-Adaptive Step Scaling or Floor-specific step scaling. displacement mappings (9.3 px on ground floor, 5.0 px) Different scale blueprints (on upper floors)

6) Cross-Product Turn Cues: Geometric Classifier with Aim to get a vector cross-product to activate turn prompts for offline use: corridor bends.

7) Interactive Client Interface: Custom Flutter canvas with 350 ms animated camera smoothing and a Pause/Resume button to prevent "phantom steps" at hall stops.

II. RELATED WORK

There are two types of indoor positioning: infrastructure and infrastructure-free.Indoor positioning can be done in two ways: infrastructure and infrastructure-free. and device-only inertial tracking [1, 7].

The use of inertial tracking is not a new concept. Woodman [2] showed that double-integrating noisy is fast drifting, acceleration data. This was overcome by foot mounted IMU setups which used stride serve as a reference for the entire gait cycle.Stance phase of each stride receives a Zero-Velocity Update (ZUPT) stride [10]. However, foot units need to be fitted in shoes with strapping. Special shoes will not be worn by visitors to locate a seminar hall.

The smartphone PDR is more practical [9, 8]. The phone will detect heel strike impulses of any magnitude. and projects are located along vectors that are parallel to the corridor. Shin et al. [9] showed that thresholding the magnitudes of accelerometers Reads step count reliably even on low cost phones.

A. Systems with a similar objective

Three recent studies investigated budget navigation:

QR Codes and OSM (Patil et al., 2024) [3]: Placed QR stickers along corridors. Using camera to scan codes and view them via device. Position in an OpenStreetMap interface. It offers very low cost, but good. No continuous tracking of scans. Walk 50 meters, and the app doesn't know your location until you scan the next one.

Server-Side SVG Navigation (Patel et al., 2024) [4]: Created SVG floor plans and implemented Dijkstra on a remote cloud server. The app required maps that appeared clean. Maps were clean but the app needed continuous WiFi. In college basements and stairwells, network drops. If WiFi goes down, server routing goes out of the window.

This is a standalone Android PDR (Zhang et al., 2024) [5] build. a mobile app for Android that does not require an internet connection, and that also includes accelerometer step counting. graph routing. It was a bit of a nuisance to have

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to click on your exact starting point on an unlabeled map. Once you are lost you have no way to indicate where you are. The app didn't have anyone to hear you speak or multiple doors. support.

A summary of feature comparison is presented in Table I.

TABLE I
COMPARISONS WITH RELATED SYSTEMS ARE INCLUDED WHENEVER THEY HAVE BEEN PREPARED.

Feature	[3]	[4]	[5]	Ours
Real Time Step Tracking:	No	No	No	Yes
Species for which there is sufficient data to allow full offline operation (Part.).	No	Yes	Yes	
Multi-Floor Navigation	No	No	No	Yes
Multi-Door Room Support	No	No	No	Yes
The Device Sensor Integration	No	No	Part has been released.	Yes
Spoken Voice Guidance	No	No	No	Yes
Pause / Resume Navigation	No	No	No	Yes

Our system combines live tracking, multi-floor routing with 1995, the company launched its first nationwide railoriented audio-visual package. one mobile app (do not connect to Internet).

III. SYSTEM ARCHITECTURE

B. Design Rule: Do not import outside files.
C. Design Rule: Use a single file when inserting content.

One thing we decided early on; no cloud servers, no remote APIs, and no external databases. All are running on local. the phone. This was a move prompted by three practical considerations:

1) Corridor Dead Zones: Campus interior and basements Network connectivity in halls is at a very low level. A navigation tool The internet will be unavailable when it is required the most by dependent.
2) Privacy: following the student's footsteps on a central server creates privacy concerns. This is not necessary with local execution entirely.
3) Instant Speed: On-device graph routing takes place in 3): With less than a millisecond delay, network lag is eliminated.

A. Architecture Layers

This app is organized into three parts or modules:

Presentation Layer: Developed using Flutter widgets. It includes On the home screen, there are start and destination dropdowns, and Rendered with interactive canvas, via CustomPainter, A floating HUD card that displays turn prompts, and a modal dialog. for staircase transitions.
2. Processing Layer: Four essential routines, implemented on Dart's Multi-door Dijkstra engine, the crossfloor. The cross-product, PDR step filter and transition matcher. turn analyzer.
3. Hardware Interface Layer: Interface to phone sensors via platform channels. This consists of libraries that are streamed to the sensors. While flutter_tts interfaces with the linear acceleration, the former can also speak.The latter can also speak, but flutter_tts can be connected to linear acceleration. Offline Audio native speech synthesizer.

B. Core Modules

Adds a 9-pixel overlay of the floor blueprint onto Map Canvas. A rotating, blue route polyline, start marker, target bullseye and a green arrow showing user direction and direction of travel. When The viewport smoothly rotates into a new corridor as it turns into one. Using ease-out curve, 350ms with Matrix4Tween.

Step Tracker: Listens to the accelerometer every 200ms. It computes the magnitude of a vector, finds min and max points, and Enforces 550ms of lockout. Valid moves move the piece forward. move marker 9.3 pixels down and 5.0 pixels right on lower-level floors.

The Routing Engine stores corridor graphs in memory as Dart. The Routing Engine uses in-memory Dart graph to store corridor graphs. constants. It performs Dijkstra search on every door of the: destination room: returns the shortest path.

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Floor Transition Resolver: It routes for multi-floor trips. the user to one of the nearby stairs or lift on the initial floor, maps the identifier of the landing (such as GF_Staircase_1 to) FF_Staircase_1), and precomputes the second leg to the destination room.

IV. CAMPUS GRAPH MODELING

A. Corridors as Graphs

We consider each floor of the campus as an independent weighted, A graph Gf = (Vf , Ef) that has nodes and edges in both directions. Vertices Vf are room doors, Turns, staircases or lifts. Edges Ef are walkable paths. The f as a subscript stand for floor and is in {Ground, First, Second}.

The coordinates of a node are the location of the node in the image of the blueprint. The ground floor (2100 x 1600) is made using actual tape.The ground floor (2100 x 1600) is constructed from actual tape. A measurement was taken in a hallway 30 metres long, and found to be 13.3 pixels. equals 1.0 metre. Upper floor blueprints had different image resolutions that have to be calibrated separately using pixel displacement.

B. About the Scaling and Categories dialogue boxes

The data set comprises more than 200 nodes on three floors (80 Ground floor, 90 first floor, placeholders on second floor.

There are three types of nodes:

- This feature allows rooms to be set up in dropdown menus as destinations. the classrooms, labs (Mechanical, Civil, IT, Chemistry, Computer), library, canteen, washrooms, water coolers and main porch.
- Junctions: Points placed at hallways where the intermediate value(s) of the function is/are unknown. The other common types of elements are: bends and intersections (e.g., Cafeteria_1_Turn, To avoid route lines from cutting through the object, use the following to prevent them from doing so: (IT_Office_Turn) through walls.
- Staircase_1) and Staircase_2 to Staircase_3. Transitions: Staircase_1 to Staircase_2 and Staircase_2 to Staircase_3. Staircase_4) and lifts (Lift_1, Lift_2) connecting different floors.

C. multi-Door Rooms

In engineering colleges, rarely, there is only one large facility. door. A mechanical workshop typically has a front door leading to. One corridor and one side exit on another. Routing a user to a A single hardcoded door may require an unnecessary 60-metre run.If only one door is hardcoded, the door may need to be run 60 metres just to check this door. Go around the building.

Built a table for lookup of destination to do:

Mechanical_Lab_1 ↦ [Mechanical_Lab_1, Mechanical_Lab_1_Door_B]

The routing engine is able to process all doors in the list and automatically Chooses the shortest walk for the entrance.

D. Making Bidirectional Graphs at Boot

RJ has to be replaced by a lightning rod.Graph edges RJ has to be replaced by a lightning rod, since corridors allow for two-way walking. must be bidirectional. In order to keep data files to a manageable size, we specify Only forward neighbours for each node. The automatic function is disabled at start-up. Linker routine scans the graph and adds reciprocal links if missing (Algorithm 1).

Algorithm 1 Given a graph with two nodes, how to connect them?How to link two nodes in a graph?

Do: rawNodes for floor f
Ensure: symmetricGraph
2: Make copies of all nodes and the lists of their neighbors.3: Make copies of all nodes and copies of their neighbor lists.
2: for each node A of the graph:
3: for each neighbor B of A do
4: if A ∉ B.neighbors then
5: Append A to B.neighbors.
6: end if
7: end for
8: end for
9: return symmetricGraph

This takes milliseconds to run and ensures that paths can be walked both ways without manually editing. Identical code in our codebase.

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V. MATHEMATICAL FOUNDATIONS

A. Pedestrian Dead Reckoning

1) Accelerometer (Signal Vector Magnitude): The phone accelerator reports acceleration along x, y, and z directions in the absence of gravity. Because cell phone user holds phones with random tilt angles, we compute the rotation-invariant Signal Vector Magnitude (Smag):

$$S_{mag} = \sqrt{{a_x}^2 + {a_y}^2 + {a_z}^2} \quad (1)$$

Smag oscillates as a spike during each heel strike [9].

2b) Step Detection Rules: To avoid false steps from phone To be a candidate stride, it must meet the following three criteria:

1) Peak Threshold: Smag ≥ 1.8 m/s2, confirming walking impact.

3) Peak-to-Valley Swing: Peak – following valley ≥ 0.4 m/s2 Bipedal walking is generally distinguished from isolated bipeds by its rhythmic gait. bumps.

3) Refractory Lockout: A minimum of 550ms has passed Since the final accepted step, avoiding double counting of strides.

The user marker moves by 0.7 metres along when accepted. the active path segment (9.3 pixels on ground floor, 5.0 pixels) on first floor).

B. Shortest-Path Computation

Define the weights of the edges (weights between vertices u and v): w(u, v) between node u(xu, yu) and node v(xv, yv) are Euclidean pixel distances:

$$w(u,v) = \sqrt{(x_v - x_u)^2 + (y_v - y_u)^2} \quad (2)$$

Physical distance (m) is compensated by:

$$d_{metres} = w(u,v) / 13.3 (3)$$

2) Dijkstra Relaxation: Starting at node s, distances are set to d[s] = 0 and d[v] = ∞ for all v ≠ s. Relaxation for edge (u, v) follows:

$$if\ d[u] + w(u,v) < d[v] \Longrightarrow d[v] \leftarrow d[u] + w(u,v) \quad (4)$$

3) Multi-Door Selection: For target doors {t1, t2, . . . , tk}, the engine determines the path that has the lowest total cost:

$$P^* = arg\ min_{Pi, i \in \{1,\ldots,k\}} \sum_{j=0}^{|Pi|-2} w(Pi[j], Pi[j+1]) \quad (5)$$

The search is detailed in Algorithm 2.

Algorithm 2 Selects the shortest path from door to door to choose a door.Chooses a door by the shortest path door to door using an algorithm.

Require: graph G, start s, doors {t1, . . . , tk}
Ensure: optimal path P∗
1: P∗ ← [ ]; minCost ← ∞
2: for each door ti in {t1, . . . , tk} do
3: Pi ← Dijkstra(G, s, ti)
4: if Pi ≠ [ ] then
5: costi ← Σ|Pi|−2j=0 w(Pi[j], Pi[j + 1])
6: if costi is less than the lowest cost then
7: minCost ← costi; P∗ ← Pi
8: end if
9: end if
10: end for
11: return P∗

The following is a breakdown of the C. Cross-Floor Routing process: The navigation divides in two across floors. sequential legs:

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Current Floor: System verifies the current floor (Leg 1) Draw a graph for every transition node that has been identified as a staircase. elevators (Tstart), finding the route to the nearest one:

$$FindShortestPath(G_{start}, s, T_{start}) = Leg_1 \quad (6)$$

The selected staircase (e.g., The map (GF_Staircase_2) is defined with the partner on the target. The core identifiers are matched to identify the floor (FF_Staircase_2). The router is in the resolved landing at the beginning of Leg 2 (Target Floor). calculates the way to the destination doors:

$$Leg_2 = FindShortestPath(G_{dest}, t_{resolved}, D_{target}) \quad (7)$$

In the event of a tracking stop the user will arrive at the staircase. An alert dialog with the instructions to climb or descend. Tapping "Resume on New Floor" loads in the new floor blueprint. Starts to monitor Leg 2 from the landing of the stairs.

D. Viewport Auto-Rotation

To ensure forward motion is directed up towards the top of the handset screen, heading angle θ for segment from A(x1, y1) to B(x2, y2) is:

$$\theta = atan2(y_2 - y_1, x_2 - x_1) \quad (8)$$

The canvas transformation matrix M is:

$$M = T(c) \cdot R(-\theta - 90°) \cdot S(2.4) \cdot T(-p_{user}) \quad (9)$$

where c is the screen centre, and puser is current position. Viewport orientation animates with a 350ms duration and an easeOut. Ensures smooth turns using curve.

E. Spoken Turn Detection: Turn taking in spoken interaction.

The app determines when to remind to turn directions by calculating A signed = 2D cross-product of current vector v1 = (dx1, dy1) and upcoming vector v2 = (dx2, dy2):

$$C = dx_1 \cdot dy_2 - dy_1 \cdot dx_2 \quad (10)$$

Decision rules:

- C > 100: Speak "Turn Right"
- C < −100: Speak "Turn Left"
- C<100 - Straight corridor, no announcement.

The ±100 threshold removes minor steering wobble from the data, Accurately identifying cornered hallways.

VI. IMPLEMENTATION DETAILS

A. Technology Stack

The application has been created by us in Dart with Flutter 3.19+. Flutter supports the single codebase compilation to native ARM. Android and iOS binaries, and access to canvas at a low level through. CustomPainter.

Only a few external plugins were used:

- This is an update for the following sensors:This update provides support for the following sensors: data without gravity.
- text-to-speech engine.flutter_tts (v4.0.2): TTS via native device's built-in TTS engine Offline voice directions with text-to-speech engine.

Dart maps are used as constants to store a graph dataset Compiled into the binary, map_data.dart. Routing code is in sensor_widgets.dart.UI widgets and sensor code are in sensor_widgets.dart. The listeners are located in main.dart.

B. User Interface Highlights

There are two pairs of drop-downs on the home screen: Point (floor and room) and Destination (floor and room). A A prominent "Start Navigation" button starts routing.

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In real-time navigation, the blueprint map is shown in an interactive zoomable container. The route polyline, start circle, target marker and green position arrow are drawn. dynamically. A floating HUD card at the top displays the current turn instruction.

We had noticed that in our initial hallway trials that users would frequently pause to: look at a noticeboard or say hello to friends. These slight shifts The steps that were not registered were wrong steps. To address that, we added a prominent Pause/Resume floating button. Tap it to stop step detection Immediately and says “Navigation Paused”. Tapping resume Restores live tracking and restores the current direction.

A navigation bar is displayed at the top when using cross floor navigation. blurred modal popup with a message to swap floors. Ensuring resumes tracking on new floor map. A hidden From the home page, you can access the developer screen which displays: The tapped map points' pixel coordinate were made into blueprint. calibration very fast.

VII. EXPERIMENTAL EVALUATION

A. The accuracy of steps counted.1. Accuracy of step counting.

We tested Step detection on a volunteer student at. A track of 100 steps was measured in a corridor at RCPIT. Participants held the smartphone in hand and an observer performed counting of physical steps. We tested slow, normal and fast gaits and also the "plus" side of fast walking. An experiment in which the participants remained fixed and communicated with each other using gestures. and talking.

TABLE II
A COMPARISON OF THE ACCURACY OF STEP COUNTING ACROSS WALKING PROFILES

Profile	Actual	Detected	Error	Accuracy
Slow walking	100	97	−3	97.0%
Normal walking	100	99	−1	99.0%
Fast walking	100	102	+2	98.0%
Stationary + gestures	0	1	+1	Filtered

The accuracy achieved in the case of normal walking is 99% as indicated in Table II. pace. Slow walking resulted in an undercount due to The peaks of acceleration were sometimes very high, due to the gentler strides. Was lower than the 1.8 m/s2threshold. A product was created due to fast walking: slight overcounted (+2 steps) sometimes in the wake of rapid strides Two peaks were allowed to pass through before the 550 ms lockout timer expired.

In the stationary gesture trial, only one false step costs 10 points.In the stationary gesture trial, only one off-step will cost 10 points. Measures were taken to record the number of times was recorded over 5 minutes of talking and arm movement.

The 0.4 m/s2 valley-to-peak delta requirement was met with success. Avoided the casual handling of a telephone.

B. Forwarding Computation Latency

We tested pathfinding with a mid-range Android cell phone. In real campus graphs, on the ARM Cortex-A73 (2.0 GHz). A simulated 500 node network. Table III shows that single-floor routes are computed in less than With the cross floor queries taking about 1.08ms to complete, even 0.6ms is still quite fast.

TABLE III
THE LATENCY OF COMPUTATION FOR THE ROUTING ENGINE.

Scenario	Nodes	Edges	Latency
Ground Floor (GF)	~80	~160	0.52 ms
First Floor (FF)	~90	~180	0.61 ms
Cross-Floor (2 legs)	~170	~340	1.08 ms
Simulated Network	500	1200	7.84 ms

We had only 7.84 ms of computation time on the 500-node graph, In 60 fps rendering, with a frame budget of 16.6 ms, it comes in within the time limit.

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C. Quantitative User Feedback

We conducted informal user tests with 12 first year students. 3 visiting faculty members. The results of finding by users are confirmed. unfamiliar rooms was much faster with the app. They especially found the map to be autorotating, did not need to mentally rotate map (1 point) The camera smoothly pans between corridors and the overall speed is 350ms. The The staircase pause dialog provided users with confidence in the vertical direction. floor transitions.

VIII. DISCUSSION & LIMITATIONS

A. Design Trade-offs

PDR vs. Fingerprinting: Fingerprinting provides more absolute accuracy, but needs to be re-surveyed when Wi-Fi 6 routers change. There is no setup or maintenance for PDR. For the colleges that have a budget constraint, PDR is far more feasible.

Multi-Door vs. Single Door: Large workshops have multiple doors to go in and out. doors. If all doors are checked, the calculation time is < 0.5ms. It saves users dozens of unnecessary walking metres, but takes a little longer.

3D Super-Graph: Two legs vs. 3D Super-Graph matches the true experience of the human mind in walking, running up and down stairs and in general, Continuing on the next level. It also maintains the blueprints for each floor. The distance is scale independent and the size of the Dijkstra graphs is lowered to less than 100 nodes.

Dijkstra vs. A* Search: With fewer than 100 nodes per floor, Dijkstra is faster, with a runtime of less than 0.6ms. A* would conserve microseconds at The costs of tuning heuristic distance functions.

B. Known Limitations

Stride length drift: Assumes a constant stride of 0.7 metres. In fact, the stride length of a human is not the same for all speeds, heights and fatigue. On walks greater than 80-100 metres, set up drift. becomes noticeable. Incorporating periodic QR code anchors at major points. Errors could be reset at intersections.

Second-Floor Data: The routing architecture supports a three floors of data, but the second-floor dataset currently contains Stub coordinates for placeholders to be fully calibrated as blueprints.

The current manual option is in the form of “Resume”: which users must click on. on New Floor manually. The app will provide access to data from the smartphone's built-in barometer in the future. sensors could sense the elevation changes and activate the floors. handoffs automatically.

IX. CONCLUSION

This paper introduced the RCPIT Navigation System, Mobile navigation system for college use without need of an Internet connection campuses. By employing the accelerometer data-based Pedestrian Dead Completing Dijkstra routing with two stages of vertical multi-door, The system offers voice navigation, on-device voice directions, and more. Real-time wayfinding without the need for costly beacons, Cellular data, or cloud servers. A field trial at RCPIT was performed that showed more than 97% step detection. Leverage a global web of approximately 200 high accuracy 3D buildings.Use a global network of 200 buildings with high accuracy and route calculation times less than a millisecond. nodes. The application is entirely on normal cell phones, provide a zero-infrastructure indoor navigation, at low cost educational solution for the educational institutions. Future efforts will be directed towards: on barometer assisted floor detection, QR code drift resetting, and AR camera overlays.

X. CIVIL ENGINEERING CONTRIBUTION: AUTOCAD-BASED CAMPUS FLOOR-PLAN MAPPING

A. Abstract

Users often have to find classrooms, laboratories, faculty areas, offices and other spaces in the educational campus in an indoor navigation manner. Commonly used facilities in multi-level buildings. This study describes the contributions of Civil Engineering to an interdisciplinary Indoor-Navigation project at R. C. Patel Institute of Technology (RCPIT), Shirpur. The major sources were available institutional blueprints and college-provided plans. Used to create 2D AutoCAD layouts, and used visual information and Google Maps as references. Knows the layout of the campus and out-of-classroom setting. There were five layouts of the floor (Ground, First, Second, Third and Fourth). prepared, which refers to areas that can be identified as academic, administrative, common, open and circulation. The report does not contain any independent field measurements. were undertaken. The drawings offer a structured spatial base for further development in the field of navigation; positioning systems, This paper does not include navigation algorithms, software implementation and field-validated accuracy assessment.

This method of modelling and representation relies on the following terms: AutoCAD, campus mapping, indoor navigation, floor plan, spatial mapping, Civil Engineering, digital campus layout.

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B. Introduction

Campus for education includes classrooms, laboratories, faculty spaces, administrative spaces, common areas and circulation spaces. As These areas become more complex; visitors, students and new members of staff can become confused about destinations. Indoor navigation It is different from outdoor navigation where the use of a satellite positioning system like GPS is normally not enough. A structured Representations of rooms and their relationships are thus an essential prerequisite. Various studies have focused on indoor navigation, which has been studied previously. Although it can be used to create various maps, it is also capable of generating obstacle-aware 2D plans, navigating using vision, and presenting information for emergencies in the university campus. [11]–[18]. This paper will concentrate on the campus-specific spatial-mapping phase before the navigation at the application level.

C. Problem, Research Gap and Questions

Plans you have already prepared may have some information about buildings that is useful, but it needs to be sorted into a logical digital plan to be used for further. applications. The gap that is covered here practically is the preparation of a floor-wise CAD spatial base of a particular educational campus with respect to. The institutional planning information that is available. The study questions are: (i) What are some ways to transform the available campus plans into structured digital floor plans and (ii) How can available plans be transformed into a digital floor plan that can be structured? layouts? (ii) What are the functional and circulation spaces that can be identified in AutoCAD? (iii) How can these layouts support subsequent indoor-navigation development?

D. Aim, Objectives and Scope

Objective: To create Campus & Floor layout based on the mapped RCPIT areas in 2D AutoCAD to be used as a spatial base for an. interdisciplinary indoor-navigation project. Objectives: Make layouts of five mapped floors, use institutional blueprints and college plans. As primary sources: use visual information and Google Maps to provide additional context: identify and label classrooms, laboratories, Identify faculty areas, offices, seating areas, lawns, courtyards and other identifiable facilities, organize spatial information floor-wise for future; use.

This is 2D spatial mapping on a civil engineering based scope. It does not include indoor positioning (GPS/BLE/Wi-Fi), user tracking, or any other features. Navigation and shortest-path algorithms, mobile-app development, route calculation and navigation-accuracy testing.

E. Study Area, Materials and Method

Study area is R. C. Patel Institute of Technology, Shirpur, Dhule, Maharashtra, India. A plan that already exists or provided by the college. The primary geometry and floor organization was provided by information. To assist with interpretation, visual references were used, and Google Maps was used only. for an external context of the campus and not for exact dimensions in an interior environment. The main drafting tool was AutoCAD. Independent site No field survey accuracy percentage or independent dimensional validation is claimed due to measurements not having been taken.



Figure 1. RCPIT campus location and site reference

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Figure 2. AutoCAD-based campus mapping workflow

Drawing and visual reference: collect/review plans fi identify functional and circulation spaces fi draft floor-wise AutoCAD plans fixture: organization of drawing elements plans label: rooms/facilities plans review: plans for clarity and consistency plans prepare: final digital layouts.

F. AutoCAD-Based Campus Mapping

The main output is a set of five two-dimensional floor layouts. The drafting procedure involved reviewing source plans; setting up a consistent drawing environment; reproducing identifiable walls, room boundaries, doors, stairs, corridors and other visible physical elements; labelling functional spaces; organizing drawing elements so spatial categories could be distinguished; and reviewing readability against available source information. Final geometry and dimensions remain dependent on the supplied plans because independent field measurements were not undertaken.

1) Floor-Wise Mapping

The mapped floors and principal identifiable spaces are summarized below. The original floor-plan images from the supplied paper are retained.



Figure 3. Ground floor plan



Figure 4. First floor plan

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Figure 5. Second floor plan

- Ground Floor: workshop, classrooms, library/reading room, laboratories, offices, cafeterias, courtyards and circulation areas.
- Second Floor: classrooms, computer centre, computer laboratories, CAD centre, courtyards, faculty areas and circulation areas.
- Second Floor: classroom, laboratory, drawing/seminar spaces, tutorial spaces and courtyards.

2) Representation of Spaces and Connectivity

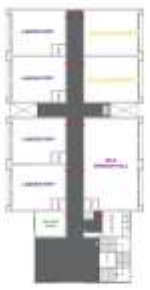
The plans break down physical spaces into the following types: Academic — classrooms, labs, tutorial/drawing areas; Faculty/administrative---faculty areas, offices and examination control office; Circulation---corridors, passages, stairs and access areas; Access structures---entrances, emergency exits, and fire doors were the elements most frequently observed.The elements observed most frequently were open spaces (courtyards, lawns and open areas), common facilities (library/reading room, seminar spaces and cafeterias), and access (entrances, emergency exits and fire doors). Elements — doors, entrances and other visible access points. Clear labels provide semantic information to the geometric layout. Doors, These corridors, stairs and entrances do not represent navigation graph or routing but are used to show physical connection. algorithm.

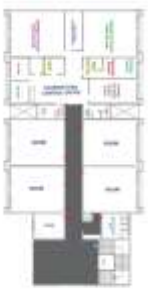
3) Results

Five 2D AutoCAD drawing plans were created for the RCPIT mapped areas on floor. Large academic areas, teaching rooms and laboratories were indicated; and faculty related, office and exam spaces were represented when they existed; courtyards, lawns, seating areas, cafeterias. Where available these were included as andrew other common/open spaces; and visible doors, passages, stairs and access elements were represented.

The resulting map is structured, digital spatial information for further processing in the field of navigation. An inventory of room counts performed quantitatively, When no independent field measurement has been performed, then no facility count, total mapped area or dimensional accuracy are reported.

G. Remaining Floor Plans and Interpretation





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- Third Floor: laboratories and MCA classrooms, seminar hall, department office, and circulation areas.
- Fourth Floor: examination control office, rooms, staff seating, storage/records areas and circulation areas.

H. Discussion

The floor wise organisation is helpful in multi level settings such as educational environments, as destinations can be identified by level. The The layout of corridors, doors, stairs, entrances and common areas are represented to indicate the physical arrangement and possible. connectivity of spaces. The work demonstrates the role of Civil Engineering in interpreting the built environment and preparing digital spatial, as well as the application of the latest technology to this field. information to be used for a wider interdisciplinary project. It doesn't contribute an algorithm, but rather a methodology and infrastructure: actual route There are no demonstrations of calculation, user position estimation and navigation performance.

I. Limitations

The drawings are based on the blueprints that are available, plans and visual aids provided by college; missing or incorrect drawings in the source. The layouts may therefore be based on information. An independent field survey and dimensional validation were not conducted. Campus Conditions may change due to renovation or space usage changes. The study is restricted to 2D AutoCAD, and does not generate a 3D BIM/virtual model. It does not include positioning technology, routing or tracking, navigation accuracy or application development.

J. Future Scope

Future work could involve field measurements for dimensioning, updates when rooms or facilities change over time, accessibility, and more. Designing accessible walkways, ramps, lifts, and mapping (2D and 3D); Converting 2D plans into BIM and 3D campus models; Emergency/evacuation mapping of exits and access routes; and integration of the structured spatial data into navigation applications.

K. Conclusion

There were five 2D AutoCAD floor plans prepared to the planning information available for the mapped areas of RCPIT. supporting references. Important academic, administrative, common, open and circulation spaces are identified on the layouts. The primary contribution is the process of turning information about the planning of a place into a structured digital spatial model that can be used to aid in the planning process. subsequent navigation-related development. Before interpreting the physical built environment, it needs to be spatially organized. be effectively used by a digital navigation system.

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