SAKSHAM
~~dis~~ability

'ROSHNI' FOR THE VISUALLY IMPAIRED: Design and user study of an affordable indoor navigation system

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Overview

- **Introduction to the problem**
  - Importance of an indoor navigation system
- **Aim of the project**
- **Features**
  - System description
  - User interface
  - Plan
- **Installations and user study**
  - System installations in a university building
  - Experimentation
  - Results
- **Conclusion**
  - Comparison with existing systems

Measures adopted by the visually challenged for navigating in unknown indoor environments

Behaviour	**Problems**
Arrange for a sighted person to accompany for the trip.	Creates dependence. Lowers self-esteem.
Find a sighted person like guard in the building and ask for help.	Very unreliable. Person may unintentionally give confused directions.
Ask strangers in the building frequently for directions until the destination is reached	Very unreliable. There may not be enough people in the building.
Try to find signs by hit and trial approach	Very unreliable. There may not be sufficient cues in the building.

Importance of an Indoor Navigation System

1. **Independent Mobility: Primary Challenge for the visually impaired**

2. **Difficulty in navigation especially in GPS denied environment**

3. **Low cost solution required**

4. **Current systems have limitations:**
   - ⇒ Unaffordable cost
   - ⇒ Non availability of sales, marketing or servicing in developing countries
   - ⇒ Highly inaccurate and thus unsuitable for public use
   - ⇒ Cumbersome to carry or difficult to operate.

“ Presently, there is no system available in developing countries that allows a blind person to navigate freely in an indoor environment ”

Aims of this Project

- To design and implement an affordable user-enabled system for convenient indoor navigation.
- To assist the user in reaching the desired destination of the building through active acoustic messages.
- The system operation must be controlled entirely by the user with no dependence on sighted assistance, require minimal modifications and should be easily retrofitted to existing building infrastructure.
- To install the system on multiple floors of a university building and conduct experiments with potential users under normal conditions and collect user feedback.

Design Methodology

Needfinding

Exploratory study with 6 visually impaired individuals

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Exploration of Design Space

Technologies for indoor navigation	Existing solutions and their limitations

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Design of the system

satisfying the unmet user needs

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System implementation

Hardware development	Software development	Mechanical prototypes

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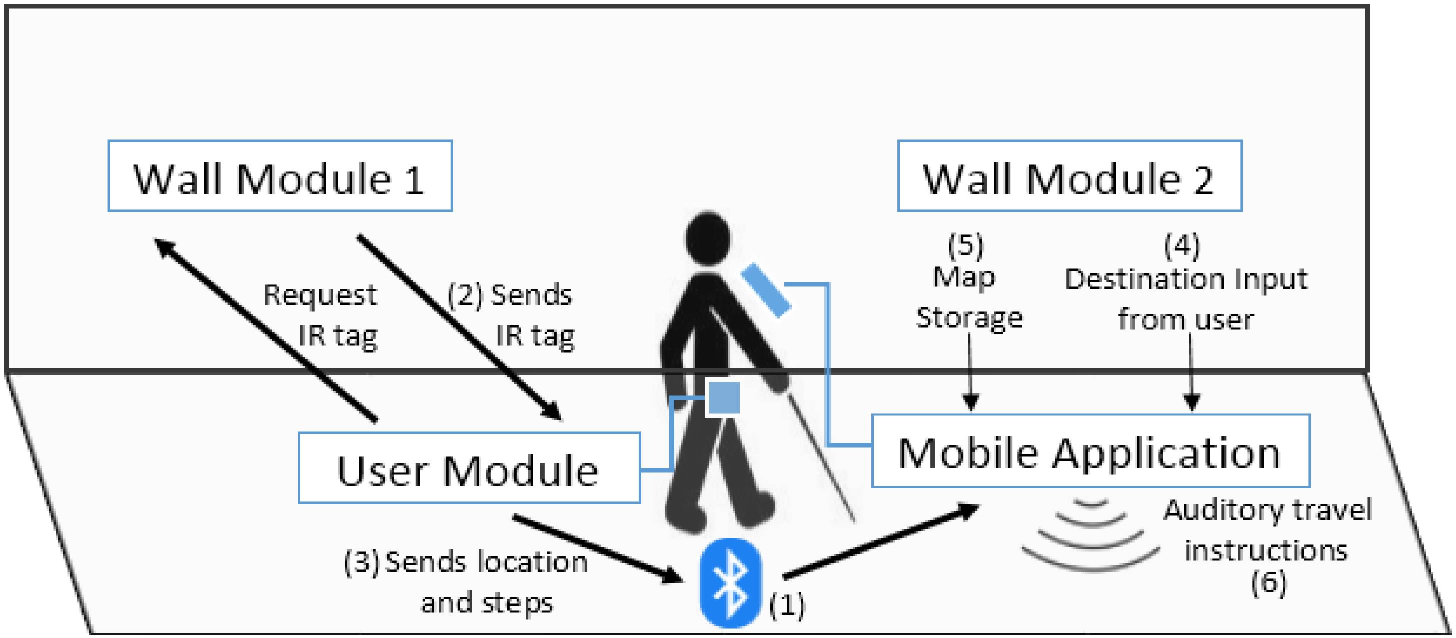
Evaluation in real-life settings

Before-and-after study with 10 users	Testing for range and accuracy

System Description



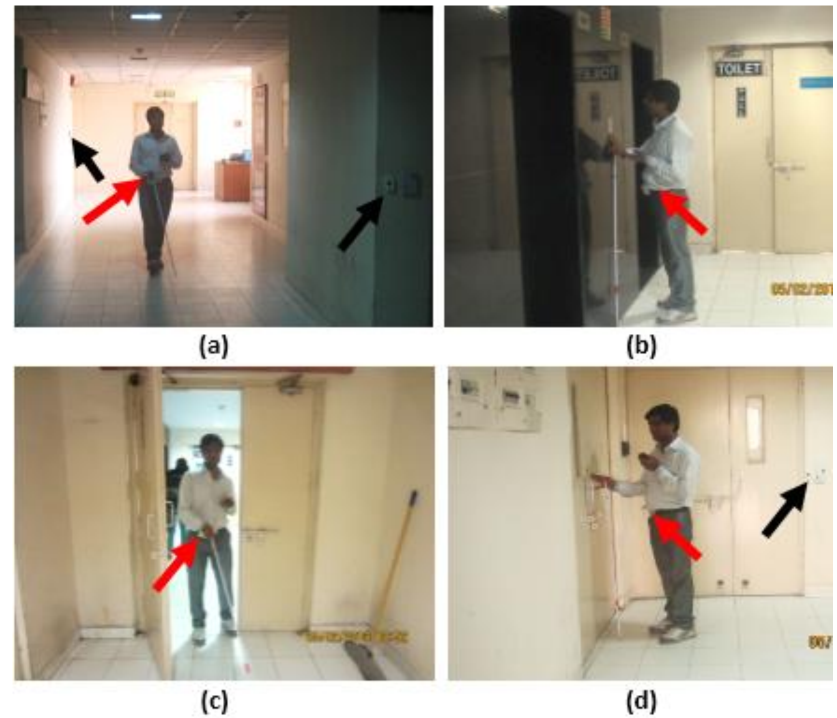
- Use of infrared sensor and inertial unit to identify the position.
- Providing a … ne application storing the map of the building.
- Buzzer to beep on reaching the destination.

Please standby for a short concept video

System Prototypes

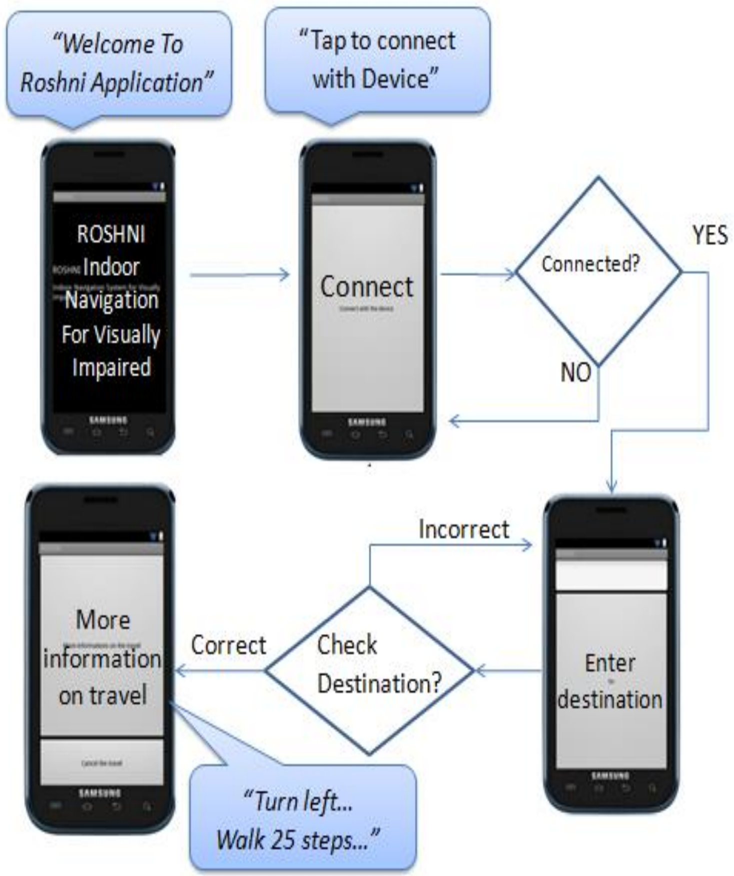
Present user and wall module

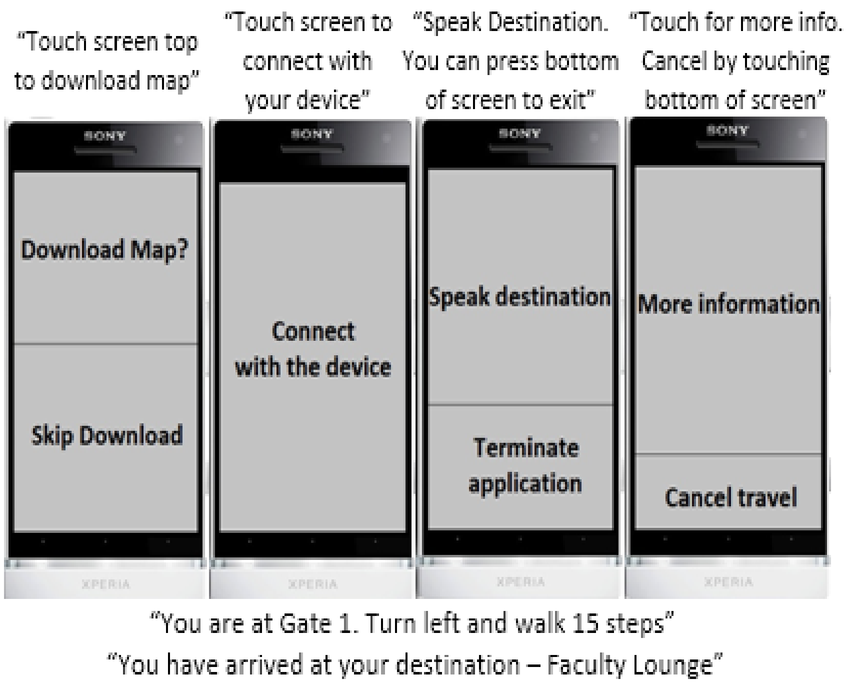
Users navigating with Roshni



User reaching the destination with the aid of the system. User module(red arrow) and wall module(black-arrow). (a)Start position on floor 4, (b)waiting for lift, (c)entering floor 3, (d)final position.

Mobile application Interface



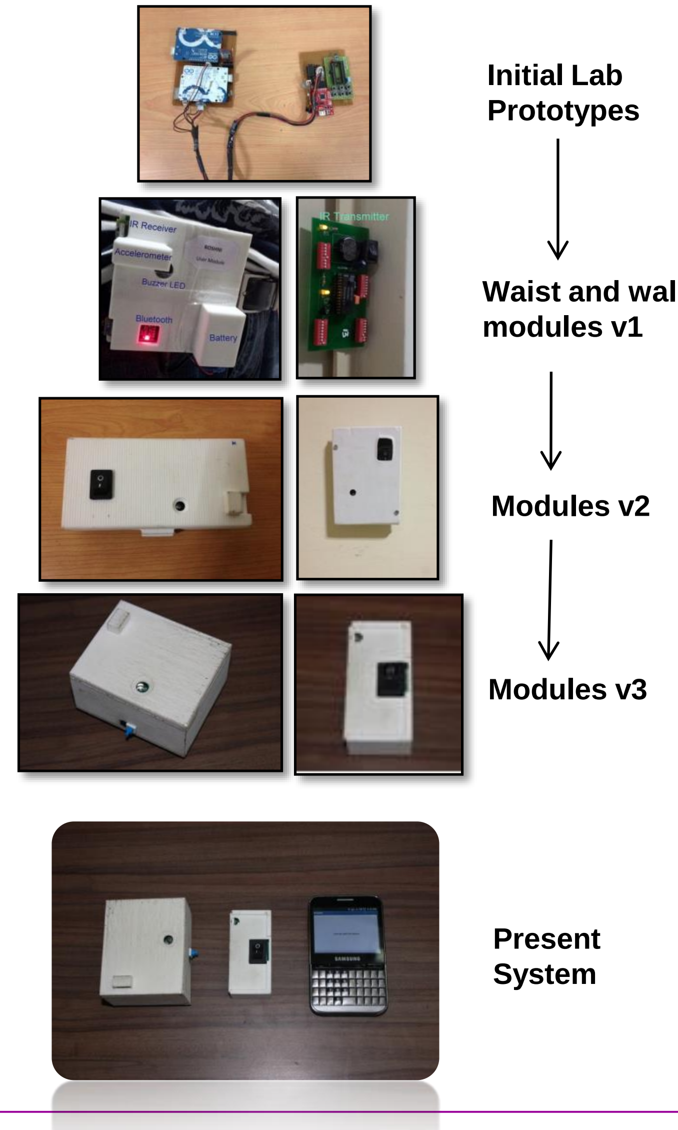


Plan

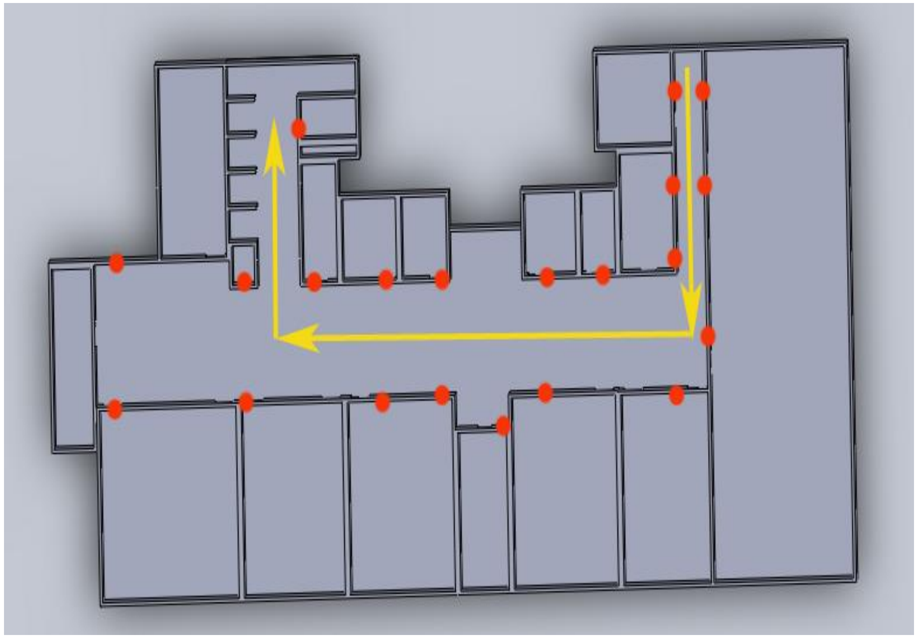
3 phase approach

- Phase 1: Concept demonstration
  - ⇒ Lab prototype demonstration showing the basic feasibility of the device.
- Phase 2: Pilot stage development
  - ⇒ Full deployment of the system in institute buildings for regular trials.
- Phase3: Industrial Production
  - ⇒ Pairing up with a company for large scale production of devices.

Currently in Phase2: Pilot stage development
Installed and tested in an institute building!



System Installation in an institute building



Track used for user trials. Red dots represent position of infrared units, yellow arrows shows the traversed path (left) University building where the system was installed (right).

Study Design

1. Need-finding study
   - ⇒ Users mentioned that most buildings rarely have accessible signage.
   - ⇒ Random exploration: find signs, ask for help, hit and trial approach.
   - ⇒ Emphasized their high degree of anxiety, hesitation to ask for help.
   - ⇒ Reported frequently getting lost and injured.

Baseline Study
- Questionnaire
- Navigate on path 1 without indoor wayfinding system

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Training

On a seperate track

→

Device Testing
- Navigate on path 1 with system
- Questionnaire
- Focussed Group Discussion

2. Experimental setup:
   - ⇒ The system was installed in 3rd and 4th floors of institute building
   - ⇒ Total 22 wall modules were installed

3. Participants
   - ⇒ 5 males and 5 females
   - ⇒ Basic English literacy
   - ⇒ Adequate knowledge of mobile phone
   - ⇒ No other disability other than visual

Reporting user feedback

Quantitative Results

- ✓ Minimal deviation
- ✓ Reduction in help seeking events

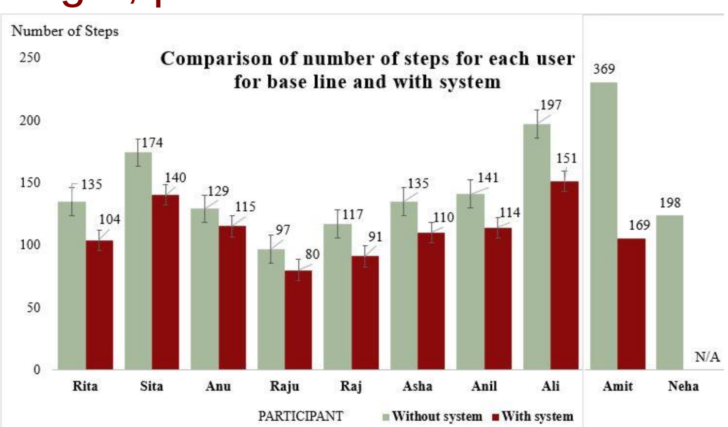
Comparison of 'major deviation from the path' for baseline and with device trial

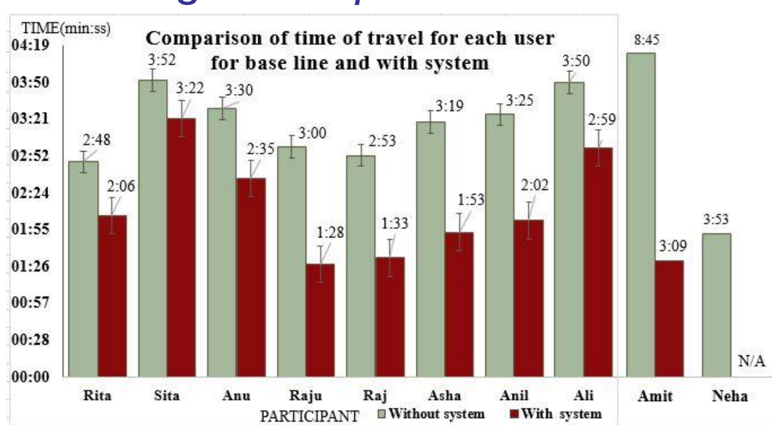
	Rita	Sita	Anu	Raju	Raj	Asha	Anil	Ali	Amit	Neha
Without system	1	2	2	3	3	2	2	3	4	3
With system	0	0	0	0	0	0	0	0	0	-

Comparison of 'number of help seeking events' for baseline and with device trial

	Rita	Sita	Anu	Raju	Raj	Asha	Anil	Ali	Amit	Neha
Without system	3	3	4	6	4	3	2	5	3	4
With system	0	1	0	1	0	0	0	0	0	-

- ✓ Optimal time of travel: Pairwise test sig. value *p=0.0003*
- ✓ Straight, path directed motion: Pairwise test sig. value *p<0.0001*





Qualitative Results

- System was found to be effective
  - ⇒ All 10 users believed it is useful for a day to day living and will be willing to use the device as a future product.
  - ⇒ Mentioned that they were able to reach their destination comfortably.

Amit: *"The device conveys the navigational instructions accurately and warns me even when I do not follow the instructions and take a wrong turn. Initially, I got lost and took a long time to reach the destination. When introduced to the device, I was very optimistic. I gained confidence with the system during training and was able to easily reach the destination."*

- Users were comfortable with the user interface

Neha: *"Audible Indicator (buzzer on destinations) is a great feature. This helps me not to enter the wrong room or collide with obstacles. Also, pinpointing the location of doors is easier"*
Raj: *"Since the literacy rate is quite low in developing countries, the speech input can make the device universal to work with. The mobile application is user-friendly and the touch input is easy to learn."*

- Average Confidence level of the users increased from 2.6 to 4 on a scale of 5

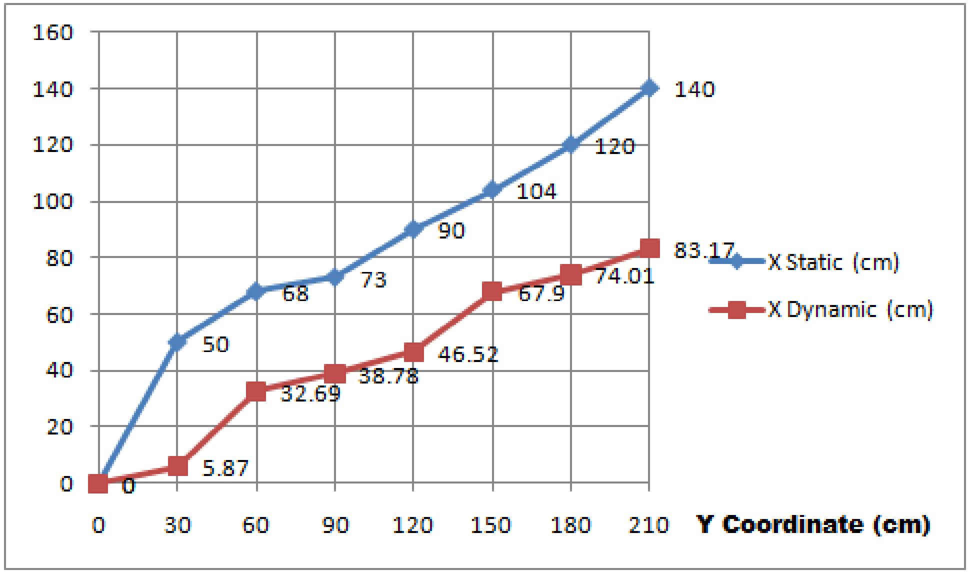
Total learning time(min) and comparison of the confidence level for baseline and with device trial

Parameter	Rita	Sita	Anu	Raju	Raj	Asha	Anil	Ali	Amit	Neha
Confidence w/o system	3	1	2	4	3	3	2	1	2	2
Approx. learning time	155	225	150	90	90	130	150	170	170	130
Confidence with system	4	3	5	5	5	5	3	4	4	-

Rita: *"I feel aware of the surroundings just like someone is speaking to me."*

Range and accuracy experiments

- Experiment setup
  - ⇒ User module was mounted on a robot and it was allowed to move in the corridor at a constant speed of 30.5cm/s. Both the static and the dynamic receiving range (beam angle) was noted
  - ⇒ Accuracy in steps was noted via user experiments.
    - ⇒ 5 users were randomly selected and ask to navigate on track



- Results
  - ⇒ Static beam angle = 36.5 deg.
  - ⇒ Dynamic beam angle = 10.2 deg.
  - ⇒ Avg. distance per step traversed by user = 52.43cm
  - ⇒ Avg. accuracy of accelerometer reading = 90%

“Optimal distance between wall modules 8m (localization accuracy = 88%)

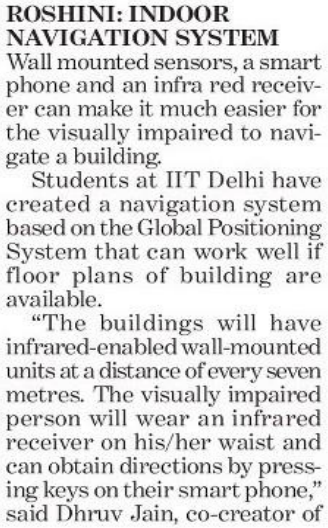
Recognition

- ✓ Emerged as winners in Eureka Paper presentation, Techkriti IIT Kanpur's Technical Festival 2013
- ✓ Selected as National Finalist in India Innovation Initiative (i3 2013)
- ✓ Received Best Paper Award at 13th International Conference on "Mobility and Transport for Elderly and Disabled People" (TRANSED 2012)
- ✓ Awarded Best Poster, in the Poster Presentation at 4th IBM Collaborative Academia Research Exchange (I-CARE 2012) held in Indian Institute of Sciences, Bangalore, India
- ✓ Received IIT Delhi Alumni Award with a cash prize of Rs. 2 lakh
- ✓ Received Media Recognition in Deccan Herald, Hindustan Times etc.
- ✓ Patent approved for filing Indian Patent Office by FIIT, IIT Delhi


INNOVATOR

Working to beat disability

"In the past, we used to invite the visually impaired to our campus, to test our innovations. But everytime someone had to escort them to the lab. This inspired me to create technology which could enable visually impaired individuals to navigate independently in any indoor area."
DHRUV JAIN


ROSHINI: INDOOR NAVIGATION SYSTEM

Wall mounted sensors, a smart phone and an infra red receiver can make it much easier for the visually impaired to navigate a building.

Students at IIT Delhi have created a navigation system based on the Global Positioning System that can work well if floor plans of building are available.

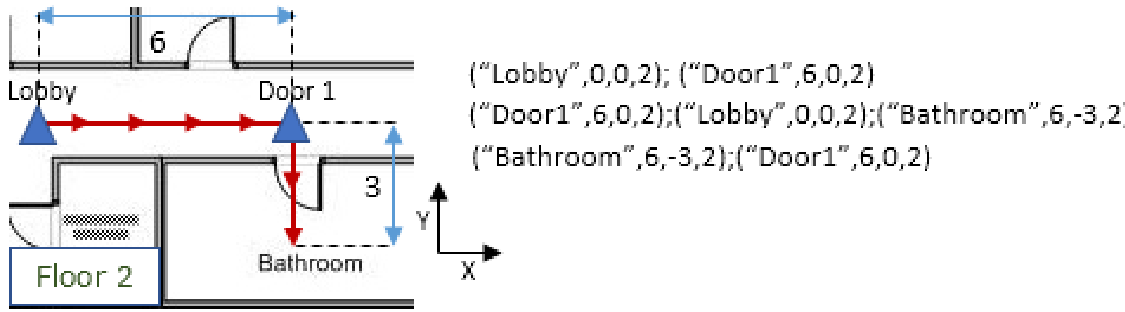
"The buildings will have infrared-enabled wall-mounted units at a distance of every seven metres. The visually impaired person will wear an infrared receiver on his/her waist and can obtain directions by pressing keys on their smart phone," said Dhruv Jain, co-creator of

IMPLICATIONS

- ✓ Affordable system.
- ✓ Can be integrated into the existing infrastructure.
- ✓ Facilitates independent indoor navigation in an unfamiliar environment.
- ✓ Small, easy and convenient for individuals with low vision.

Annexure 1: Maps

- Topological map
- Metric information between the critical sections
- Annotated with additional information about the path like obstacles etc.



An example map file converted from floor plan of a building. Red arrowed path is the navigational track. In each line, the first block represent the landmark and the other blocks represent its neighbours. Within each block, the string is the name of the landmark followed by x-coord, then y-coord and finally the floor number.

- ✓ Converted from Architectural map of the building
- ✓ Advances in technology for creating 3D models from programs like Sketchup would make the system further scalable
- ✓ The anticipation is that it will be possible to have community-based efforts for the annotation of large scale module creation for public spaces such as railway stations, airports, museums etc.

Annexure 2: Comparison with Existing Systems

Device	Concept	Limitations	Benefits of Roshni
Talking Signs	• Network of infrared transmitters installed on the walls (or poles) at strategic locations.	• The user must point a directional IR beam towards the transmitter • Large number of transmitter units have to be installed adding to a high setup cost	• User doesn't need to point leading to successful navigation • Only required to be installed at a distance of 5-7 m or at destinations
Building Navigator	• Building is fitted with retro-reflective bar-coded signs • Handheld device transmits the beam which is reflected and decoded by computer software	• User has to carry a bag pack which is heavy and inconvenient	• User carries a relatively small waist worn unit

Annexure 2: Comparison with Existing Systems

Device	Concept	Limitations	Benefits of Roshni
PERCEPT	• RFID embedded in kiosks located at specific points like entrance, elevators etc. • Information communicated to the mobile on touching the tags via glove.	• Doesn't convey the position of the user in between sparsely placed kiosks • Location of kiosks has to be known beforehand	• Position conveyed to the user at all times using IR/ inertial unit • Building is entirely transparent to the user. Only the map has to be stored in the mobile phone.
Cricket Sensors	• Ultrasound modules mounted on ceiling at regular intervals • Use of Sonar technology to identify the position	• Although very efficient, it is very highly priced	• Affordable to a moderate user in a developing country

Annexure 2: Comparison with Existing Systems

Device	Concept	Limitations	Benefits of Roshni
Devices using gyroscopic, compasses and sensors	• Use of compasses and gyroscopes and sensors to determine and position and orientation of the user.	• Less accurate • Affected by changes in environmental temperature, magnetic fields • Expensive	• Considerable accuracy • Not affected by environmental changes • Affordable
Devices using RF/Wifi or other wireless technology	• Use of signal strength of wall mounted RF/Wifi to localise the user	• Signal strength in such systems is subjected to change due to obstacles, environmental conditions and thus is inaccurate	• Doesn't use signal strength so is immune to such defects.

☺ **Thank You** ☺