Summer Internship Report

User Experience Design for Indoor Positioning and Navigation

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This Interaction Design degree project, titled 'User Experience Design for Indoor Positioning and Navigation' is done in partial fulfillment of the requirement for the degree of Master of Design in Interaction Design at Industrial Design Centre, IIT Bombay.

It was done with Sensus Technologies Pvt Ltd, Bangalore.

Duration: May to June, 2015

Declaration

We declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, We have adequately cited and referenced the original sources. We also declare that We have adhered to all the principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea / data/ fact/ source in my submission.
We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources that have thus not been properly cited or from whom proper permission has not been taken when needed.

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July 6, 2015

Abstract

People spend around 90% of their time in indoor spaces [2]. User experience in indoor spaces is comparatively less explored because of limited number of solutions for indoor navigation and positioning. While GPS helps us in navigating and locating outdoors, it cannot communicate with the satellites once we go indoors. Wifi and Bluetooth technologies are among the few options available for indoor navigation, the level of accuracy they provide is in meter level. With their custom hardware and stochastic models, Sensus has achieved centimeter level of accuracy. Currently, the technology supports B2B applications as it uses a special handheld device that communicates with beacons placed in strategic positions within the indoor space. Sensus is currently focusing on large indoor spaces mostly warehouses, museums and shopping malls. Our studies include experience prototyping, user studies, shadowing and observing people. We also contributed in their client demonstrations by designing and developing quick interfaces and worked on their concept video.

About Sensus

Sensus Labs is a company based out of Bangalore, India founded by IIT Bombay Alumni offering Indoor Positioning & Navigation solutions with an accuracy of up to 30 cm. The team is a mix of skills, from Artificial Intelligence, Machine Learning and Statistics to Design Thinking, Human Centered Design & Business Strategy. Sensus is the 1st company in India, working on indoor navigation and positioning, to get sub 30 centimeter level of accuracy.

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Literature Review

There are lot of companies around the globe offering indoor navigation and positioning solutions. An indoor positioning system is a solution to locate objects or people inside a building using radio waves, magnetic fields, acoustic signals, or other sensory information collected by mobile devices[3]. The technologies which most of the companies use for indoor navigation varies in various forms. Bluetooth, WiFi, Ultra wide band are few of the communication protocols used for communication. Various technologies like optical, radio and acoustic are also used. [3]

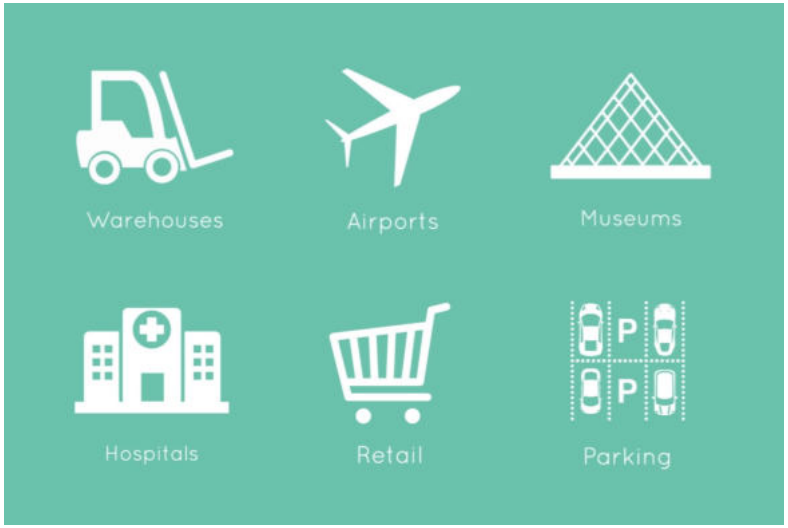
System designs must take into account that at least three independent measurements are needed to unambiguously find a location known as trilateral. Further, smoothing is required to avoid stochastic errors. [3] Trilateralization is the process of determining absolute or relative locations of points by measurement of distances, using the geometry of circles, spheres or triangles. [4] Whereas, triangulation is a process in which angles are measured. Trilateralization is not only used in indoors but also used in GPS for outdoor navigation.

There is a paper in which they do indoor navigation using camera of the smartphone. The system uses built-in cameras to determine user location in real time by detecting unobtrusive fiduciary markers. The required infrastructure is limited to paper markers and static digital maps, and common devices are used, facilitating quick deployment in new environments.[5]

A mobile application called 'inside', developed by Israeli start-up Shopcloud uses phone's internal sensors as hardware and are able to achieve accuracy of 1 meter. Inside uses internet connection of mobile phone to connect to internet, so as to download the maps of the indoor space it is within. Once the map is downloaded, it can work without the internet. The application then uses phone's camera to detect the pre defined locations and using image processing algorithms and artificial intelligence, it approximately detects your current location. There are other systems like Smartsense, UnLoc and NAVVIS which has done similar work for indoor navigation.[6]

There is a lot of work happening in the field of navigation for visually impaired people. They are the ones who needs navigation and assistance the most. Several systems have been developed for the same. There is a paper published by people from department of computer and information sciences and engineering, University of Florida called 'Drishti: An Integrated Indoor/Outdoor Blind Navigation System and Service'. Drishti uses a precise position measurement system, a wireless connection, a wearable computer, and a vocal communication interface to guide blind users and help them travel in familiar and unfamiliar environments independently and safely. Outdoors, it uses DGPS as its location system to keep the user as close as possible to the central line of sidewalks of campus and downtown areas; it provides the user with an optimal route by means of its dynamic routing and rerouting ability. The user can switch the system from an outdoor to an indoor environment

with a simple vocal command.[7]
DecaWave, a Dublin-based fabless semiconductor manufacturer that has just released a wireless-networking chip designed to provide extremely precise indoor locations. It uses very brief bursts of radio energy, and can measure the time it takes these pulses to travel between radios to a fraction of a nanosecond, allowing distances to be determined to better than 10 cm. The radio technology used for this is ultra wide band. [8]

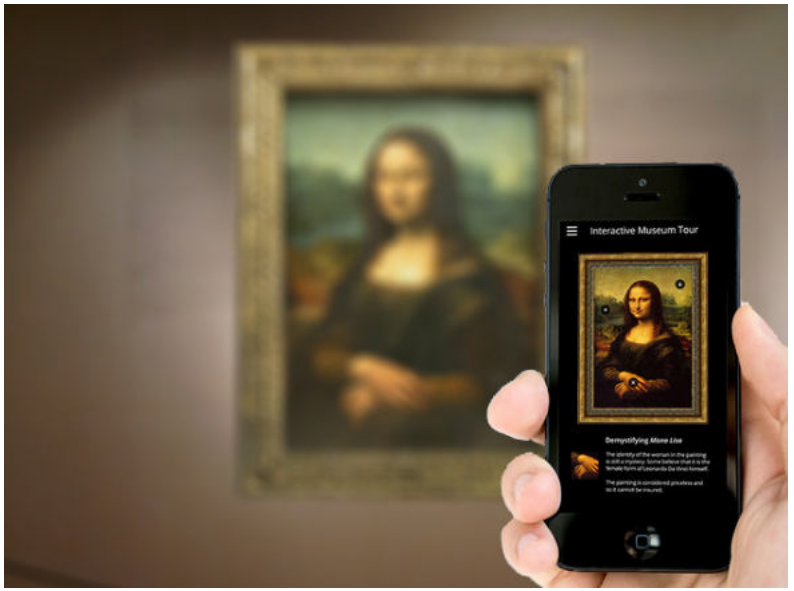


User Experience Design for Indoor Positioning and Navigation

Indoor navigation and positioning is comparatively new in India. The key application areas are Warehouses, Museums, Shopping Malls, Hospitals, Airports, Parking Spaces to name a few. It can also help people to navigate out of a building during emergency. The user experience varies widely across different types of indoor spaces. Starting from whether the users should see a two dimensional top view of a map or an indoor rendition of Google's street view, embedding elements of surprise in terms of placing contextual information to usability of the application, user experience design has to take care of all these aspects. In a warehouse scenario, the technology will be mostly used to generate an optimal route for picking items and updating the ERP system once each item is picked. It can also be used by the warehouse authorities to track its employees, generate their performance logs and warehouse analytics. On the contrary, in retail scenarios, it might open an opportunity for pushing customized advertisements into users' mobile phone depending on her location in the indoor space. This might lead to leasing out strategic positions inside an indoor space to companies interested in putting up advertisements. But, in a museum, use of mobile phones might hinder the user's museum experience. Hence, it was of utmost importance to conduct an user studies. It was very evident after multiple rounds of discussion that it would not be possible to have a standalone user experience for the mobile application and hence separate experiences were thought of for these three scenarios.

Museum

Designing user experience for museums was quite different from the rest since it depended entirely on user's personal choice. The user experience will vary vastly with respect to the type of museum and its location. Expectations of Indian users vary a lot from US or European users. By type, we mean traditional art, modern art, archeology, science. The users might want to have a seamless experience with the tangible displays when it comes to historic artefacts or monuments. Taking out the phone and looking at the digital information might cause a hindrance to that. So, displaying text on screen might not be a good solution. Hence, we decided to visit different types of museums, observe visitors and conduct an user studies.



User Studies

We carried out our user studies in three kinds of museums in Bangalore - Archeological, Art and Technical. We interviewed 10 visitors and the director of all the three museums.

The archeological museum (Government Museum, Bangalore) has a daily footfall of around 700 to 800. The visitors were mostly from different parts of India or from other countries. The artifacts ranged from Harappan civilization, artilleries, miniature paintings of Mughal Empire and sculptures of hindu deities from different eras. There were two non functional kiosks situated in different zones and the zones were divided according to the type of artifacts (sculpture, miniature paintings, archeological remains of different civilizations). The Art museum was an extension of its archeological counterpart and had both traditional and contemporary art forms and sculptures.

The technical museum (Visvesvaraya Industrial and Technological Museum, Bangalore) has an average footfall of almost 2500 to 3000 people per day and has separate zones themed Mechanics, Electricity, Space, Biotechnology, Electronics and Fun Science. It was highly interactive with working principles of materials of daily use and different laws of physics. The museum uses high end technologies like augmented reality, 3D projections and simulations.

Key Questions :

1. What was the most interesting artifact the visitors came across and why did it interest them? How much time did they spend on that artifact?

2. How much did they read from the information that was put up and whether they could relate to that? Could they visualize the timeline of incidents?

3. What kind and form of information the visitors would prefer?

4. Did they notice the kiosks in the museum? What kind of information would they like to search in the kiosks?

Top Insights

Visitors prefer interactive sections and spend more time with artifacts they can relate to.

Visitors are mostly interested in certain zones of their choice and spend very less amount of time in other zones.

They mostly come as a part of some conducted tour and have limited amount of time.

Visitors are often not aware of the historical significance of artifacts. People do not often go through the entire information and want to take pictures so that they can read it later or search about on internet. They also want to show interesting artifacts to their relatives and friends.

People want an interesting story weaved around the artifacts as stories can be remembered over plain dry artifacts.

Some visitors want to move at their own speed and hence do not take audio guides while others find it difficult to read a huge chunk of information at one go.

People generally come in a group and would want to share their experience.

User Experience Design :

Based on the insights, we started designing the experience and refrained from designing any interface for the same. Our main aim was to make an inclusive design so that it can accommodate various user groups and different types of museum. Yet we gave more weightage to archeological and historic museums more importance as it is more challenging than technical museums. The main reason behind not designing User Interface was that there were no specific museum to be considered.

Design Ideas

Displaying on phone the top attractions of the museum the moment users enter the museum.

Since it might have elements of surprise in different locations, haptic feedback should be incorporated.

The application should be as less intrusive as possible. It should learn from the user's likings and suggest artifacts accordingly.

The application should keep on pushing new cards with information pertaining to an artifact in case the user gets interested (one way to determine that is by the amount of time spent at that location). The user can save the cards for later.

Participatory design was suggested between friends and family members coming to visit museums in a group. Cards can be shared, people can be tagged by others at a particular location within the museum.

Storytelling and revealing interesting stories about artifacts.

The learning curve should be minimum for museum experiences, the application should not incorporate multiple gesture based interactions. Gestures, if included, should act as a redundant mode of doing an action.

The application should be multilingual.

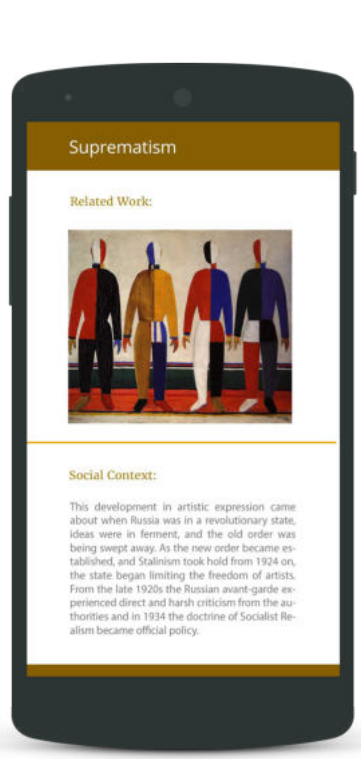
It should have an option to browse zone wise (sculptures, artillery, jewelry, eras, civilizations, paintings etc.) and navigate to the same.

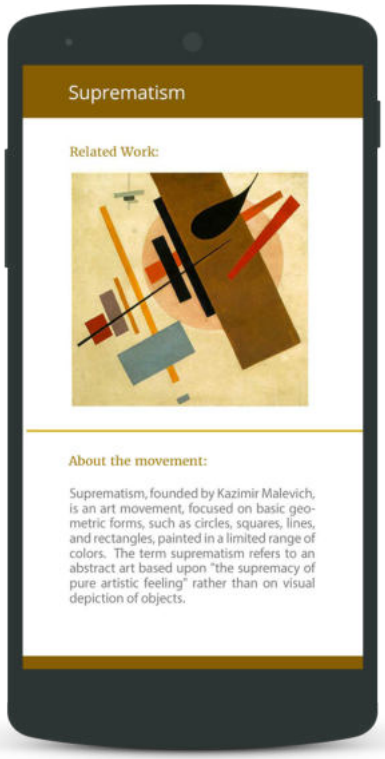
For users who have limited amount of time, the application should have the option of navigating them through the suggested top ten.

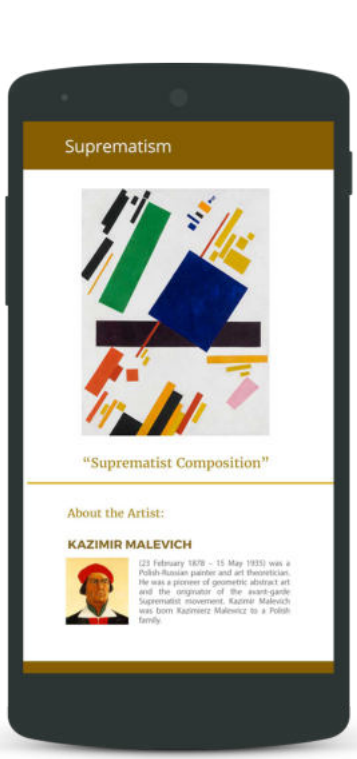
The top artifact rating can be provided by the museum authorities or crowdsourced.
For any particular artifact, there should be 'Show on Map' option so that the users can easily navigate to them.

Multiple filters can be incorporated to enhance the search experience (Type, Era, Location, Person, Importance to mention a few).

User Interface for Client Demo







For demonstration of the technology to clients, we designed the UI for the museum scenario which emphasizes on pushing of intelligent contextual data with a factor of surprise.

Warehouse

In large warehouses, where the carpet area is in thousands of square meters, navigation is very difficult. The warehouse, for which we were designing, was 2 million square feet. Around 1700 workers worked in 2 shifts there for picking activity. The picking activity being less interesting and tiresome, workers were less motivated to work. They have to navigate to the correct bin, in a shelf by decoding the code of the product printed on the pick up list. The ideal time allotted by warehouse management to complete one pick up cycle and the time taken by the workers to complete it differ a lot. There are a lot of parameters slowing down this pick up activity. They take considerable time to decode the item code, find the correct bin and navigate to that bin, marking picked up items, informing the warehouse management system about items that are missing or out of stock. A mobile application was designed that gives an optimal route to pick up items and lets the picker update the status of the item to be picked up from the device. Gamification of the application was also suggested to enhance the user experience.

Secondary Research

Warehouse Management System:

A warehouse management system (WMS) is a key part of the supply chain and primarily aims to control the movement and storage of materials within a warehouse and process the associated transactions, including shipping, receiving, putaway and picking. A WMS monitors the progress of products through the warehouse. It involves the physical warehouse infrastructure, tracking systems, and communication between product stations [1].

We studied WMSs and tried to understand the flow of goods in a warehouse. Currently, Warehouses use technologies like barcode scanners, Radio frequency Identification (RFID) to monitor flow of products. The important operations we observed in WMS were handling requests, picking, putting, packaging and shipping goods and also the necessary monitoring and updating of all these processes. The operations we were addressing were picking and putting goods, in which navigating and locating the correct bin and the correct rack in which the product is to be picked or placed in a huge warehouse was a problem.

From secondary research, we came to know about the workflow of the picking activity. The ideal work flow of the picking activity we assumed is as shown in Fig 1.

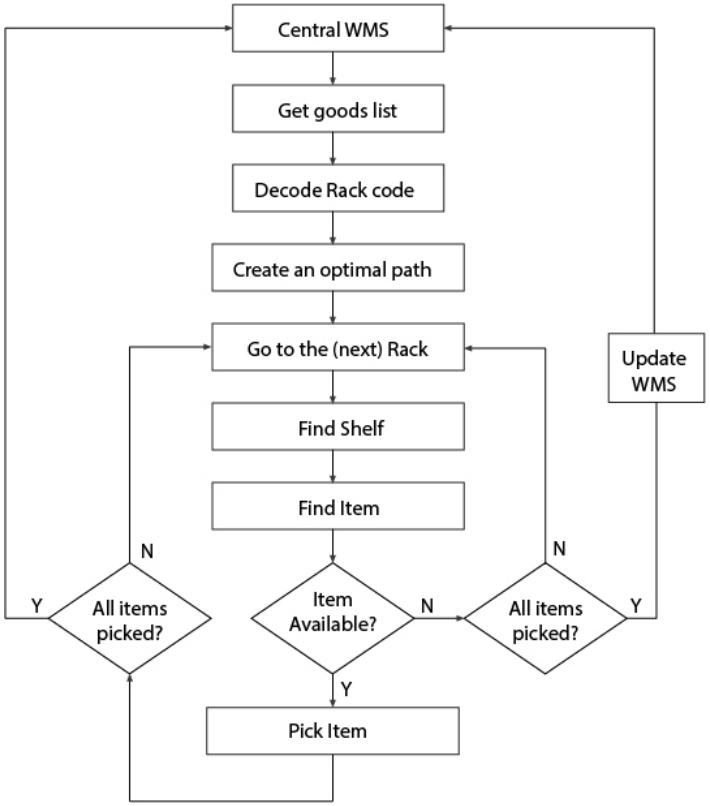


Fig 1.

Experience Prototyping

We carried out an experience prototyping of the picking activity in warehouse. We enacted the process and tried to empathize with the pickers. It helped us identify the problems he must be facing while picking through this activity. We did multiple iterations, initially taking into consideration that the picker is not experienced and still does not have a complete conceptual model of the rack sequences and numberings. The time was noted for each iteration and it was seen that once the picker is fluent with arrangement of shelves and rack sequences, the amount of time taken to pick up from a list having 12 items dropped by almost 50%. The entire process gave us a lot of insights which we used to design the experience and the interface. We could not perform user studies in the warehouse because of security reasons.

Experience Prototyping

Problems Observed :

He would not be able to remember the entire sequence of code, and will remember part by part if the sequence is long.

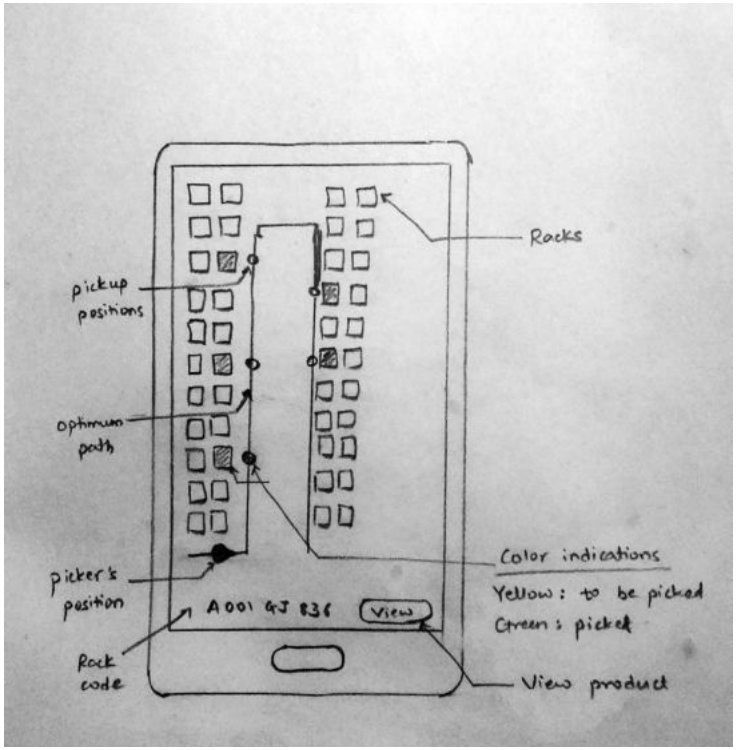
It would be difficult to create a concept model if the pattern used in code is difficult.

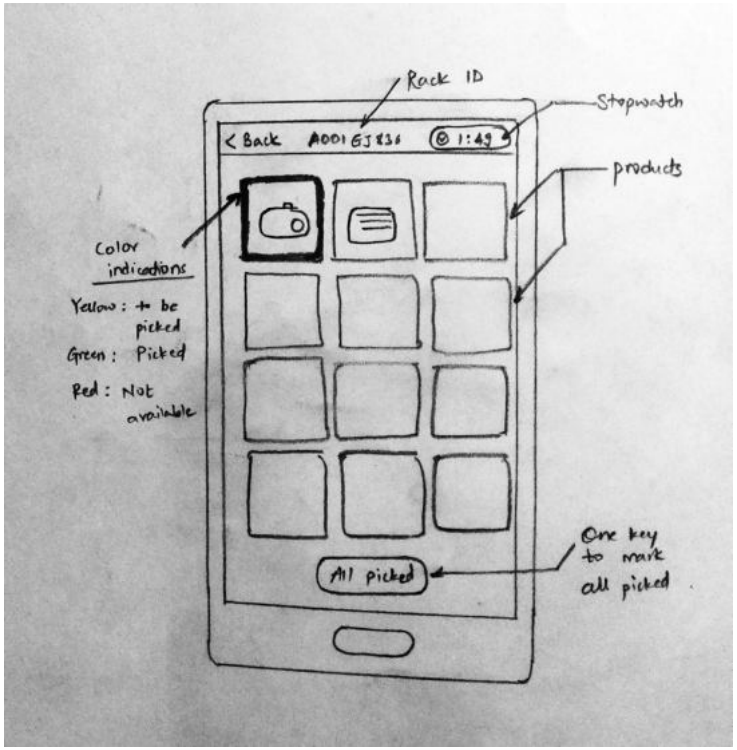
Efficiency of the picking activity will depend on the list. It should be optimized to improve efficiency.

The coding should not just be numeric or alphabetic. It should rather be alphanumeric with visual hierarchy, color coding and proper chunking.

The formation of the code should not be a jargon for the picker and he should know the way the code is formed.

Wireframes


Racks
pickup positions
optimum path
picker's position
Rack code
A001 GJ 836
View
Color indications
Yellow : to be picked
Green : picked
View product


Rack ID
Stopwatch
< Back
A001 GJ 836
1:49
products
Color indications
Yellow : to be picked
Green : Picked
Red : Not available
All picked
One key to mark all picked

High Fidelity Prototypes

Two different approaches with subtle differences were taken while designing the 1st screen. In Fig 2. the screen automatically changes and the next screen is pushed (Fig 4, 5 or 6) when the picker reaches a rack where a pickup is scheduled. While in Fig 3, the picker has to click on view to go to the next screen.

The next screen had multiple iterations from which three interfaces were shortlisted. The warehouse considered has 4 rows in each rack and 3 bins placed in a row. Fig 4. shows the bins in form of squares with images of the item to be picked from each bin. The color coding signifies whether an item is picked up (green), yet to be picked (yellow), not in stock (red). While this iteration saves an extra click by the user to review items to be picked, the entire real estate is taken up by the shelves. In yet another iteration (Fig 5 and 6), the picker can click on any shelf if he wants to view the item. While it takes an extra click (which the picker can skip), it saves enough real estate to display other information clearly. It also has a 'Confirm All' button which saves the picker from updating each item individually.

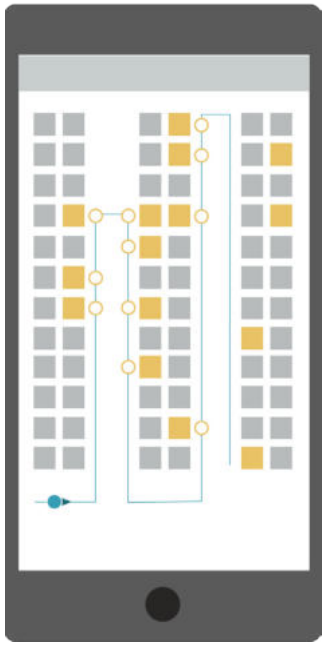


Fig 2.

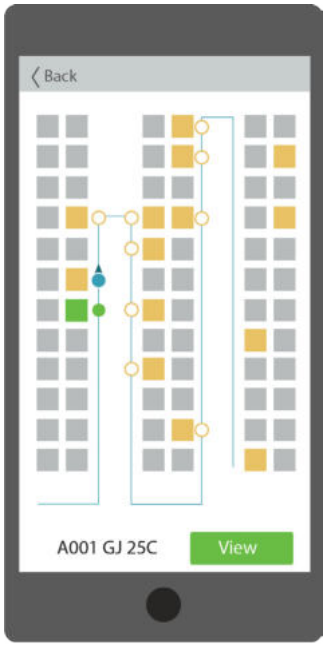


Fig 3.

High Fidelity Prototypes

Fig 4.

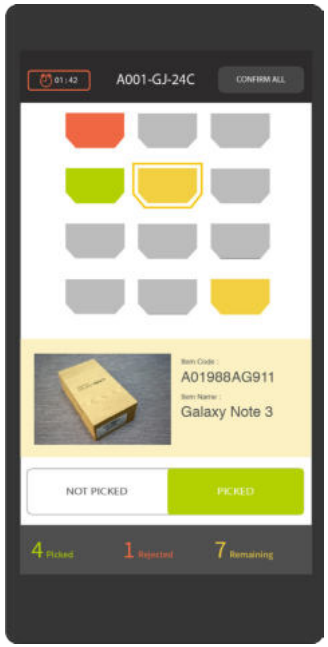
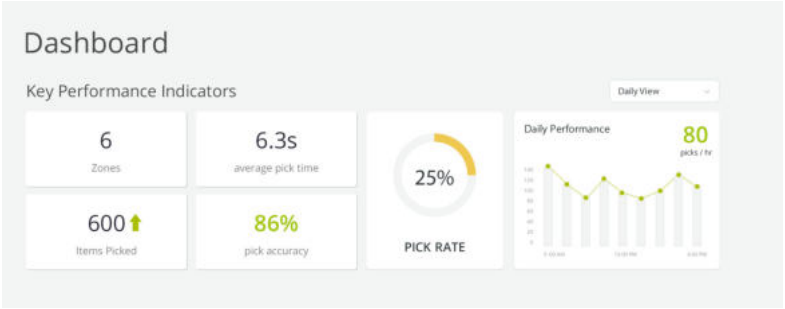


Fig 5.

Fig 6.

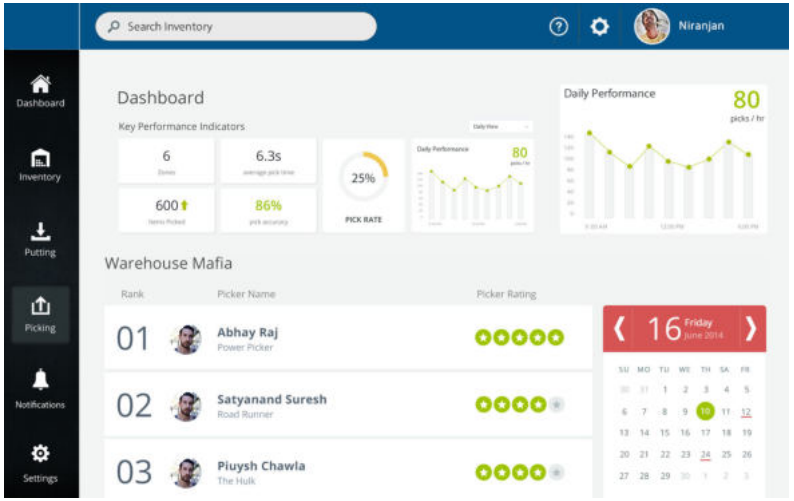
Dashboard

The central hub of the Warehouse Management System is responsible for smooth operation flow in warehouse. It supervises the pick up and put away activities, monitor and track pickers, track goods, create pick up lists and update pick up status. A web based dashboard application for central WMS was designed and developed to retrieve the performance analytics of the pickers.



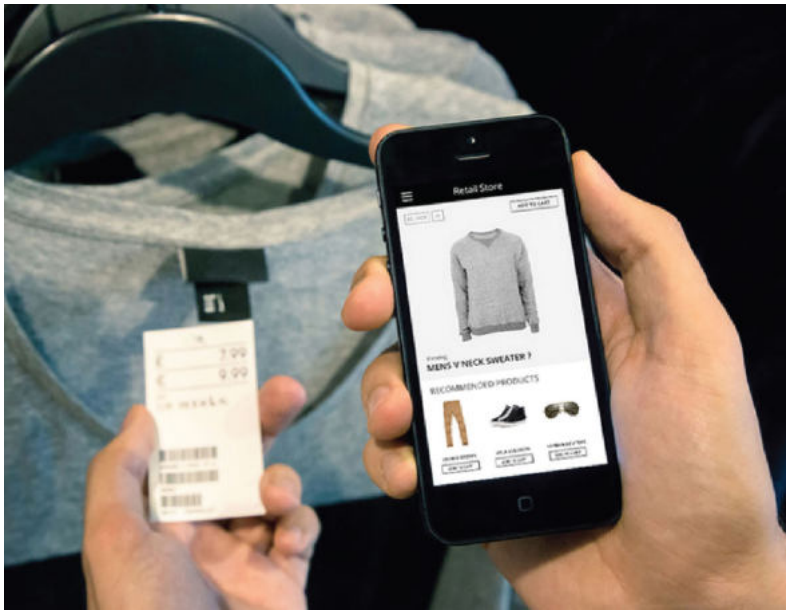
Technology :

The dashboard, a browser based application was developed using HTML5, CSS3, Bootstrap, jQuery and Morris charts for the analytics. For the communication and exchange of information between the android phone and the browser, websocket programming was used. The server side was implemented using Ruby on the rails. The server configuration and the browser client was hosted in the same machine.



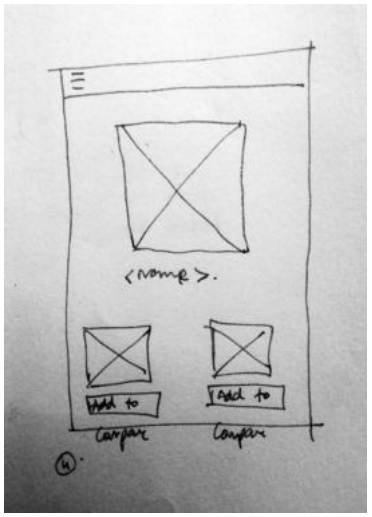
Retail

In a retail scenario, embedding advertisements strategically can benefit both B2B and B2C users. The application can pull in selective customized recommendations based on the user's previous search history or interests. Data analytics such as places frequently visited, maximum footfall might open a new way of advertising products or revealing offers and discounts. The retail outlets can use this technology to calculate popularity index of products, recommend similar products and push extra product information to customers.

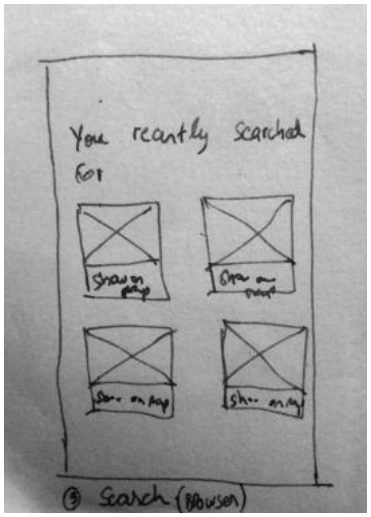


Wireframes

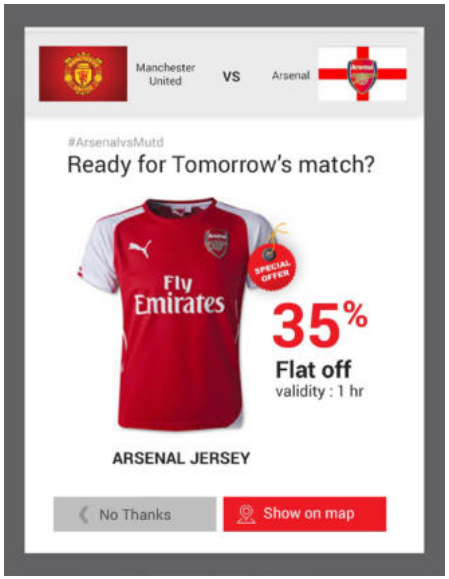

Liked Yesterday's match?
<Product Name>.
20% off
<Show on map>

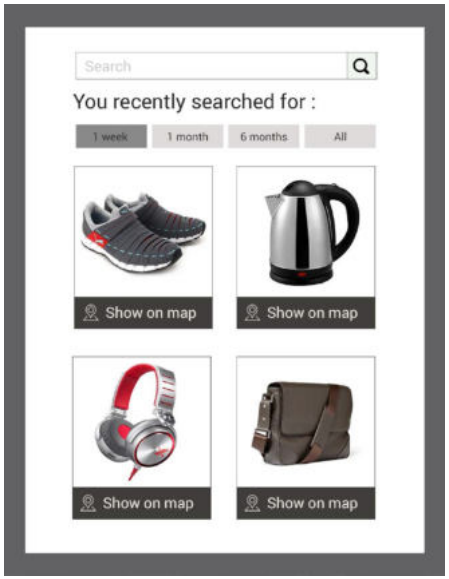

<name>.
Add to
Compare
Add to
Compare

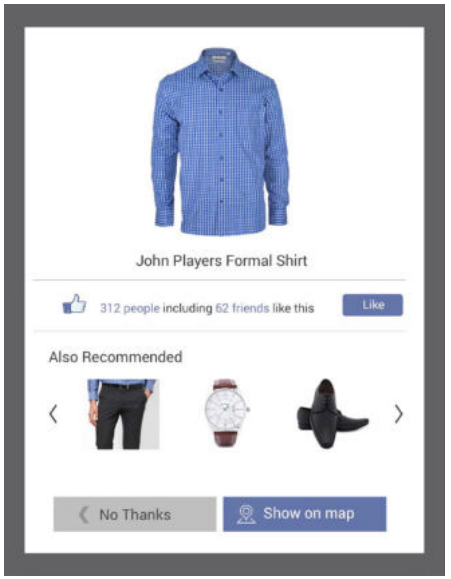

You have a new discount offer.
Back.
OK
(map)
Modal box


You recently searched for
Search (Browser)

User Interface







Interfaces for placing advertisements based on past searches and interests and searches.

Client Side Application

The client side application gives users the liberty of adding, changing or removing contextual data on different locations of the indoor space without expert help. A simple browser based desktop application was proposed which would allow the users to mark a region on the map and embed information in the form of text, images, audio or video. The target users are mostly B2B clients.

Client Side Application

Necessity :

The existing android application would have needed a separate maintenance team with sufficient coding skills to change the contextual information for the users. In a retail scenario, the necessity (frequency) to update the embedded information would be more as compared to warehouses or museums. The main idea was to enable the user to add or change contextual information and its visual representation without having to change the code.

Technology :

A working prototype was developed using HTML5, CSS3, jQuery, Bootstrap and a WYSIWYG text editor library. The application was designed and developed mainly for desktop or laptop resolution but the use of Bootstrap grids with HTML5 in the front end enabled it for tablets and mobile phones as well. The communication between the mobile application and the client was established using websocket, the information to be embedded was sent as json strings.

Design Decisions :

The entire viewport was divided into 7:3:2 ratio for large (>= 1200px) and medium (>= 992px) sized devices for the map, the display section and the option palette respectively. Initially it was decided that the entire map will have a visual representation of a grid overlay with each cell in the grid being 30cm x 30cm. Information can be added in each cell in the grid. The problem with this representation was, If the limit of the desired area in which user wants to embed information is not occupying the entire cell. So after multiple iterations, the visual representation of the grid was eliminated and it was decided that an internal algorithm will calculate the area in which the information should be embedded in the physical space and the user can select any area without the limitation of any grid.

Design Decision for different components

The display section loads the uploaded media. The text area when clicked opens a WYSIWYG text editor with basic options to format the text. The editor disappears when clicked outside the text area. The default layout is 'Tiles' and a dotted demarcation indicates the number of tiles and the information on each tile. The order of the media can be changed when the 'Reorder' button is clicked.

Used to zoom in and zoom out the map. The left-arrow on top is used to snap the widget to the left corner. The icon changes to a right arrow when it is snaps to the left. The rotate icon at the bottom toggles the orientation of the map between portrait and landscape.

An user can draw 4 kinds of shape (square, rectangle, circle, freeform) over the map. The cursor changes into a precision cursor. On selecting and drawing a shape, the cursor turns back into a standard pointer. The 'Delete', 'Copy Info' and 'Copy Area' becomes active only when an area is selected. The 'Copy Info' option when clicked turns the cursor into [] which copies the information when clicked on a newly created area.

Icon \ State	Disabled	Enabled	Hover	Active
Shape	Never	Always	Shape selection panel	Shape selected
Delete	Default	When shape is selected	Tool tip to delete	Shape deleted
Copy Info	Default	When shape is selected	Tool tip to copy info	Information copied
Copy Area	Default	When shape is selected	Tool tip to copy area	Area copied

Design Decision for different components

The user can insert text, audio, video and images and simple actions in form of buttons. Buttons can only embed an url. Different layouts and themes can be selected and previewed on a modal window.

Preview of the information with options to change or try out themes and layout. Currently, the layout options available are coverflow and tiles.

Concept Video

The concept video was to demonstrate the idea of indoor positioning and navigation, introducing viewers to the application of rich-contextual information and how it can be embedded in indoor spaces. Also, explaining the technology and its application areas to clients, investors and customers.

Concept Video

Problems with the existing video :

It was portraying the wrong concept model of the technology.

It looked like the technology was using augmented reality and made use of the camera to retrieve contextual information.

There were no standalone sequences in the video. The chronology of sequences were not arranged in a way to make their target users understand the technology and its application.

The visuals were ambiguous and there was no audio or text to support and explain the visuals.

It was almost a 5-minute long video and a lot of technical jargons were used.

The real estate of the smartphone was small and the activities performed by the users were not visible properly.

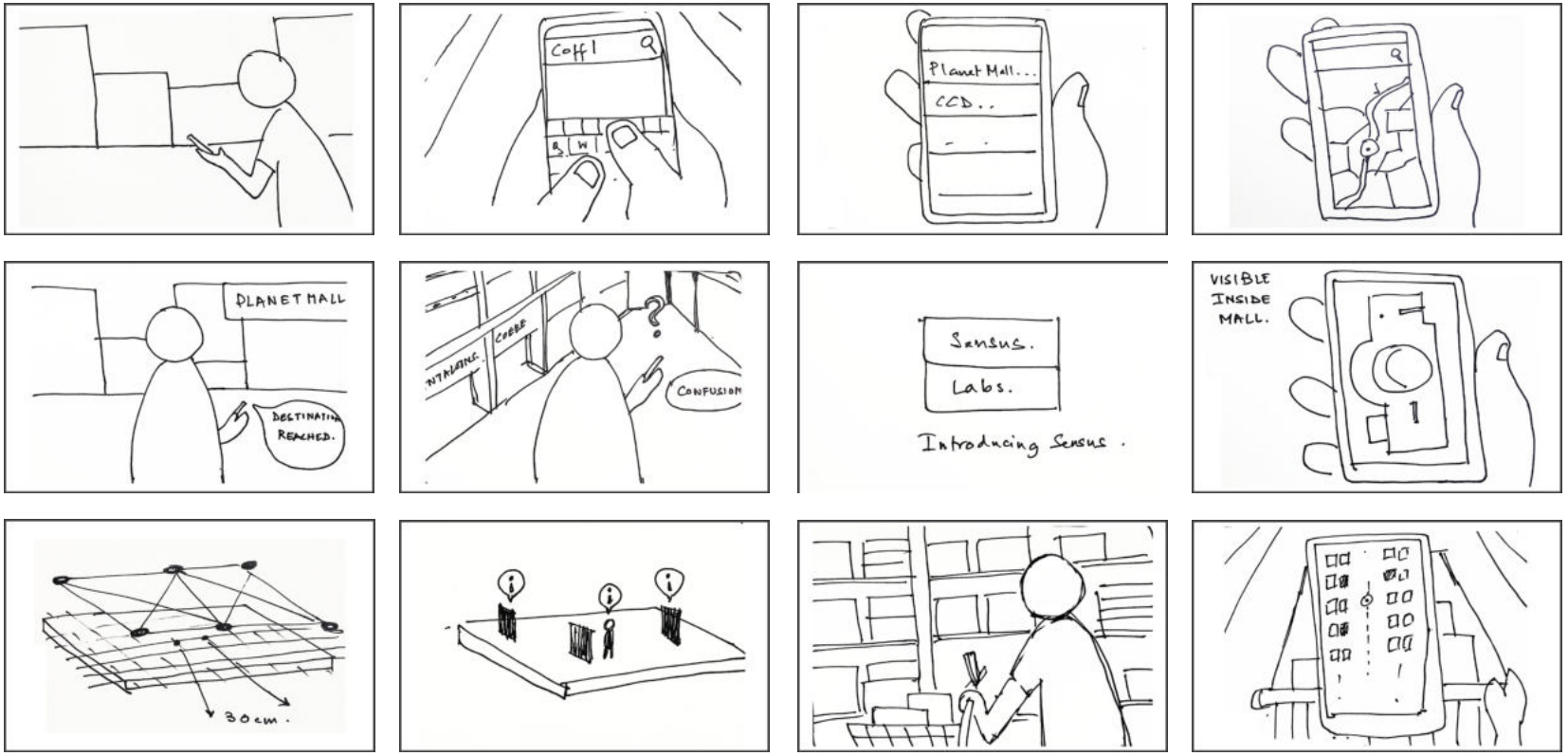
Need for a new concept video :

We chose motion graphics as a medium over live action. Live action has lot of dependencies like the acting skills of the actor, the duration of the sequence, proper lighting conditions, adding voice overs to video sequences. Motion graphics was a faster and an economical option to portray real world scenarios as well as abstract concepts in crisp and engaging way.

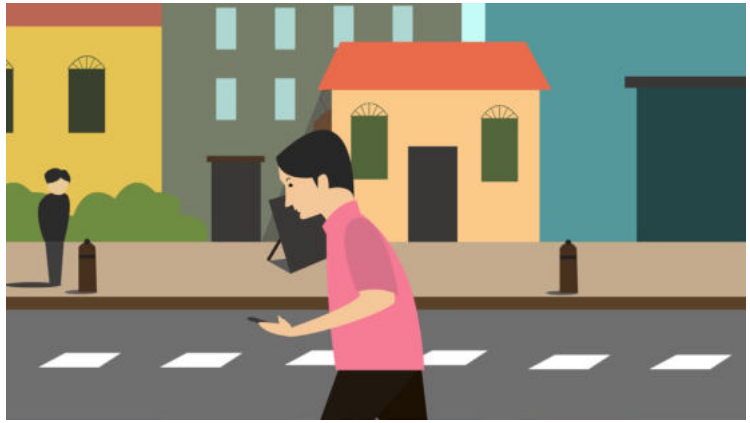
Idea and script :

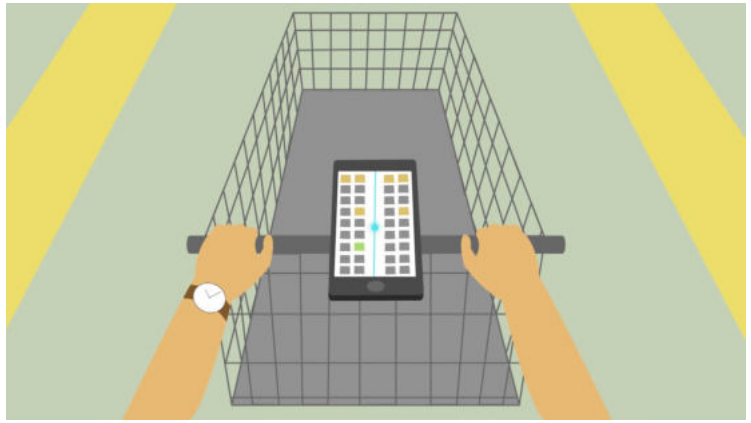
After the ideation phase, a 'problem-solution-expansion' structure was adapted to explain the technology. We decided to introduce the problem by starting the video with a person looking for a coffee shop in a new city, a scenario that viewers will be able to relate with. He searches for coffee shops on his phone and easily navigates using GPS. But, the nearest coffee shop being inside a shopping mall gives rise to confusion as GPS does not work indoors. At this point, Sensus was introduced and an explanation of how the problem of indoor navigation and positioning can be solved using their technology. The video then talks about application areas they were currently focusing on.

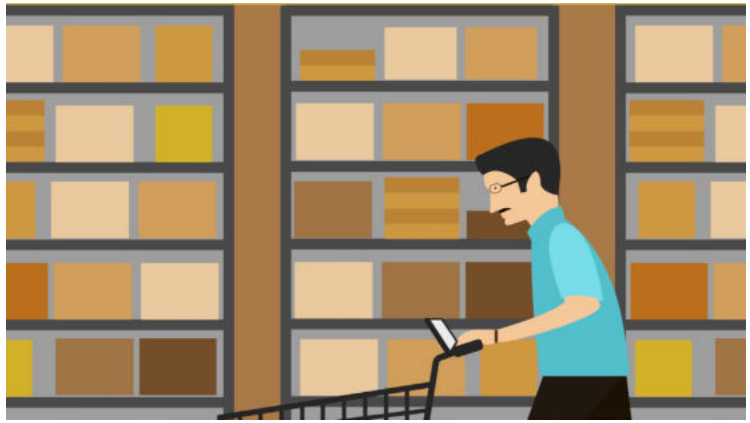
Storyboarding

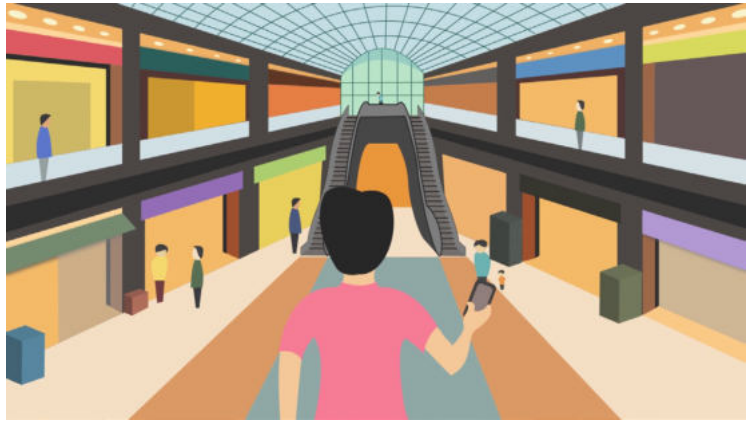


Illustrations









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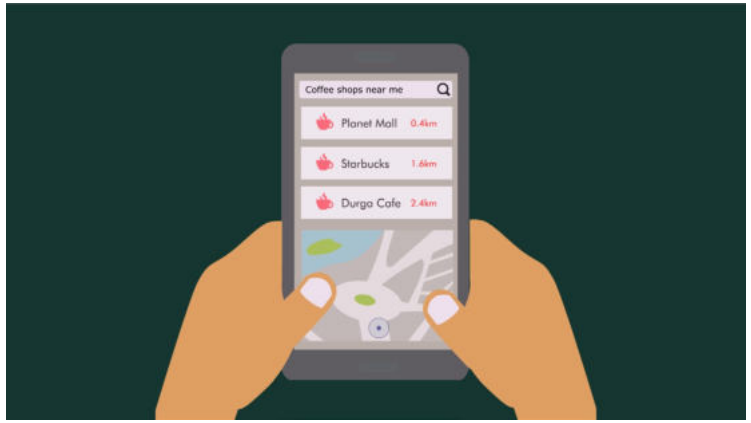
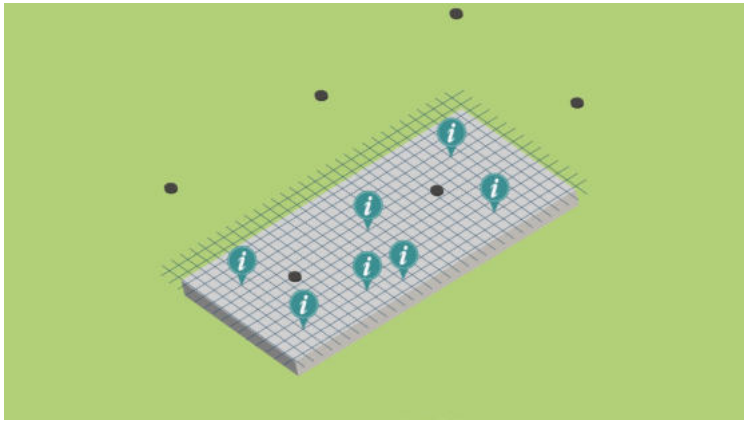
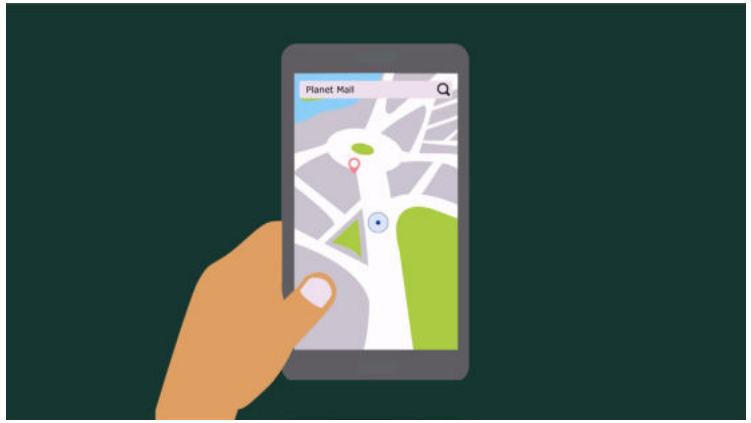
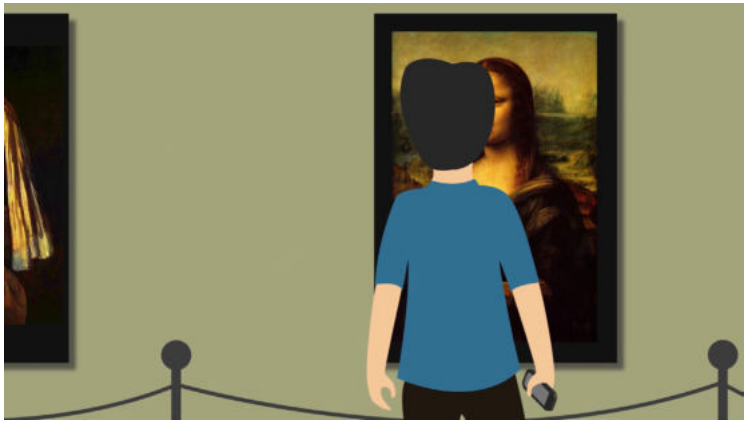








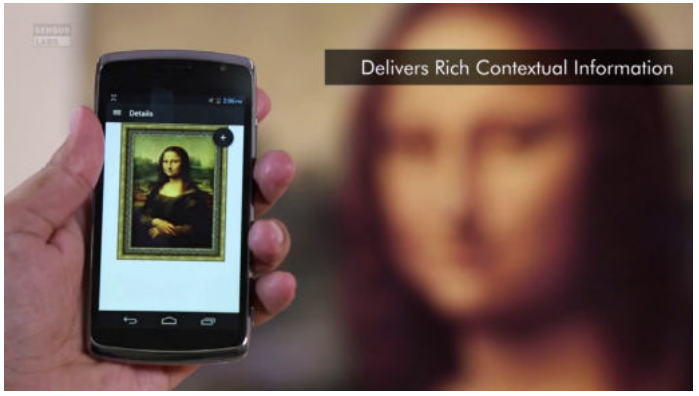
Logo Revealer & Concept Video Editing

Logo Revealer :

We made an animated logo revealer of the company's logo. According to the mentioned brief, we made a logo revealer which reflects the area company work in, which is indoor navigation. We incorporated this logo revealer in the concept video to introduce company.

Editing the Live Action Concept Video:

The existing video was also edited by trimming down redundant portions and adding textual information to compliment the video. These textual information helped in drawing a single meaning from the visuals. The chronology of the video sequences was also changed to remove ambiguity. In yet another edited version of the video, an existing audio clip explaining the technology was synchronized with the visuals of museum and warehouse scenarios and the entire duration of video was brought down to one and half minutes.



Redesigning of Website

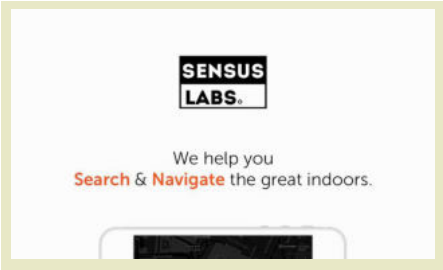


Fig. 7

Fig. 10

Fig. 8

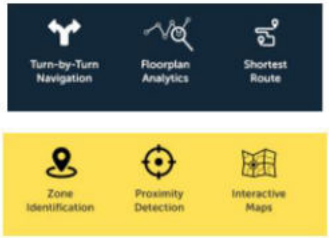


Fig. 11

Fig. 9

The website of Sensus Technologies had the following issues :

The image above the fold did not convey the company's unique selling proposition (Fig. 7).

The use of their technology in four application areas were stacked one after the other and needed a lot of scrolling from the user's end.

The infographic distinguishing their technology from existing solutions like wifi and bluetooth in terms of accuracy was not conveying the idea appropriately (Fig. 10).

The website was not mobile friendly.

It had multiple alignment issues, the set of images selected had visual errors and the icons used across the website was not consistent (Fig. 8 & Fig. 11).

The 'Request a Demo' button was not visible due to minimal color variation between figure and ground (Fig. 9).

Website Redesign

Our main objective was to fix the existing issues instead of coming up with a completely new design for the website. A new set of icons were designed to make the iconography coherent. A new infographic gif was designed instead of a static image to compare the accuracy levels of the current technology with the existing ones. The website was coded from scratch (HTML5, CSS3, Bootstrap) to make it mobile friendly.

Miscellaneous

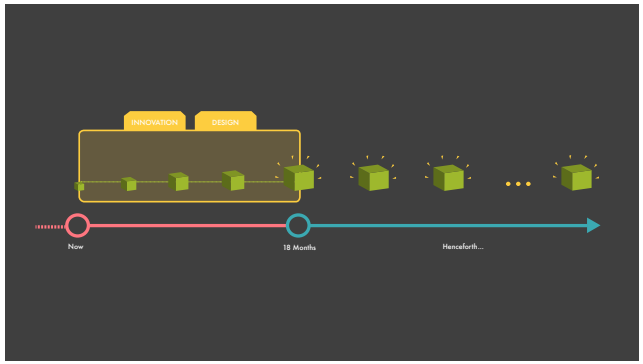


Fig. 12

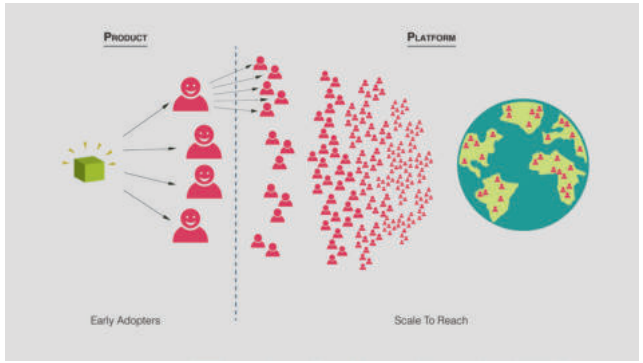


Fig. 13

Infographics :

The visuals were designed to support a business document targeted for investors. The document focused on the current strategy followed by the company and their future plan of action.

Fig. 12 depicts that the current goal of the company is to enhance the functionality of their product through design and innovation in the next 18 months and move it to mass production henceforth.

Fig 13 talks about the scalability or the mass adoption plan of the company. The early adopters of the product will test and validate the product. The product will mature and grow with their experience. These adopters will help scale the product. The product will be a finally become a platform and other applications can be built on top of it.

Micellaneous

Maps :

The android mobile application uses a scalable map designed by taking measurements of the indoor space. Initially the application had a two dimensional indoor map of the demo arena (Fig. 14). The 2D map was converted into a 3D map (Fig. 15) for better understanding of the indoor space.

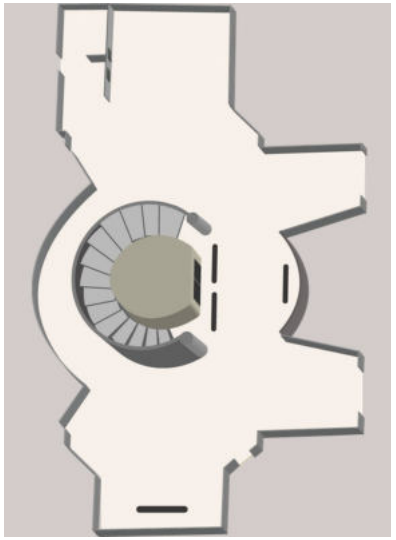


Fig. 14

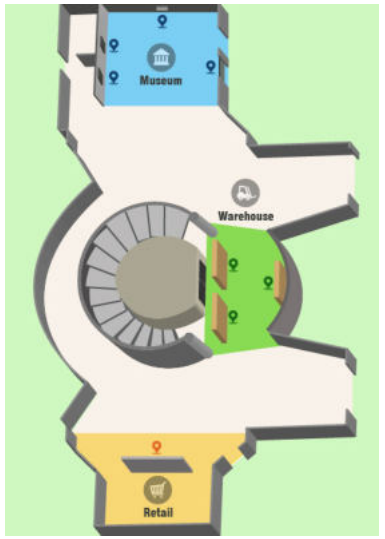


Fig. 15

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