Shopper (GIS) - ספר פרויקט

הקדמה - אביהוא

2. indoor positioning. - אביהוא

3. שיטות לקבלה של indoor positioning - אביהוא

5. ציור על המסך - אוראל

6. אלגוריתמים מיוחדים שהשתמשנו בהם - לירון

7. Imaga אם נכניס אותו בסוף - אביהוא

8. AR - אביהוא + רון

9. Firebase - רון + אוראל

10. android sensors - לירון - תראה מה כתבתי על זה

11. android studio -

12. Beacon - אוראל

13. חברות שמתעסקות בדברים דומים - אוראל

14. GIT - לירון

Introduction

Our research project focus on indoor positioning (IPS) subject.
We want to discuss about:

- How indoor positioning work.
- Devices and method that we can use to receive individual location inside a closed facility.
- Our new ideas to receive indoor positioning.
- Companies that offers IPS services.
- success and failures that occurred along the way.

As a sub research we decided to try to solve the problem of finding the shortest route for a customer inside the supermarket.
Like the "Waze" application we read about the traveling salesman problem to first understand how to receive a solution that answer the supermarket problem:
"Given a list of products and distances between each pair of supermarket's departments \ products what is the shortest possible route that visits each department exactly once and returns to the entrance of the supermarket".
we also want to help customers by offering products on sale in their close location in the supermarket.

The purpose of the online shopping system is to ease shopping management and to create a convenient and easy-to-use application for customers, trying to buy products at the grocery store.

The system is based on both database with its products, a smart mapping system and shortest path algorithm.

Indoor positioning types

A broad comparison of the above technologies based on factors such as cost, positioning errors complexity and reuse potential of available infrastructure:

- ## IR - Infrared based indoor positioning system:

  This method uses infrared light pulses to locate signals inside the building.
  IR uses lights instead of radio waves, (which can't go through walls) .
  Radio based systems sometimes may cause trouble , as the radio waves may accidentally be picked up by other readers through walls, which make the IR type to be more accurate in room level.
  To use this method IR receivers should be installed in each room in the facility's ceiling, it should be easy to do in a new construction but can be very expensive in an acoustic, retrofitting etc.
  This type of IPS are commonly used in new hospital construction where rooms are definitely segmented.
  this type may not work in an open-space warehouse.
  we decided not to use this type of method because the supermarket's department can block the IR signal and interrupt.

- ## WIFI based system:

  WIFI based system uses "tags".
  tags are WIFI transmitters that send simple packets to a few WIFI access points in the facility, then these access points report the time and strength of that reading to a backend wich uses special algorithms to compute position and stores the answer in the cloud.
  This type of IPS gives accuracy of 3-5 meters because they use TDOA measurements with wide bandwidth.
  Achieving this level of accuracy can be very expensive if you don't have WIFI access points to support it, because you will need at least 3 access point to hear each tag transmission.

- ## Visible light communication (VLC) LED light:

Visible light spectrum is freely available and does not fall under spectrum regulations. Many advantages of VLC systems are primarily derived from recent advances and characteristics of LED technology, such as:

- Energy efficiency: LED lighting infrastructure can save up to 85% energy compared to the incandescent lamps and 60% energy compared to fluorescent lamps, while providing similar brightness and illumination
- Longer life expectancy: LED lights can last several years
- Use at restricted places: Can be used at several restricted places e.g., hospitals, airplanes etc., without any fear of electromagnetic interference.
- Security: Communication is more secure and confined as light cannot penetrate thick walls

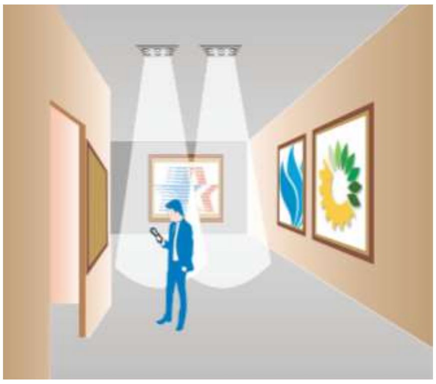


Figure 1: LED positioning

- ## GPS technology for indoor locations:

In order to use GPS technology for indoor locations, GPS repeaters are required to boost the reception of GPS signals.
The main motivation of using GPS technology for indoor localization lies in its simplicity and re-use of existing infrastructure.
In these solutions, satellite signals received by an outdoor antenna are amplified and re-radiated by indoor antenna, thereby providing live GPS signals indoors.
Various positioning algorithms are then developed to determine the location of indoor receivers with the help of these signals.
Unfortunately, indoor positioning error is never less than outdoor positioning error, which is several meters.

- **Earth magnetic filed:**

  Magnetic positioning was inspired by animal wayfinding in nature (e.g., birds, bats, bees, salmon, foxes, etc.).
  Animals rely upon the Earth's magnetic fields to locate themselves in relation to their destinations.
  Smartphones are similarly able to detect and respond to magnetic field variations inside buildings.
  Each building or structure has a unique magnetic "fingerprint," based on the way building materials affect and "distort" the otherwise persistent magnetic field generated by the Earth.
  Those patterns can be precisely assigned to a building floor plan.
  Smartphone owners (iOS and Android) can then be accurately located inside retail stores, hospitals, malls, airports and other indoor spaces
  when we tried to use certain applications that test magnetic fields inside the Cyber lab and also consult with civil engineer we discovered that it can be complicated because there are a lot of variants to consider like walls width, amount of metal inside the walls and floor etc.

Figure 2: magnetic field in building's floor

For our research we decided to implement the beacon method and combine it with android sensors.

In the following pages we will discuss about our implementation, the process and the results.

The main parts of the system are the following:

- ## Beacons – Explanation and Usage

Recent Bluetooth Low Energy (BLE) beacons provide new opportunities to explore positioning.

Beacon positioning determination using current approaches is supported by pre-calculated formulas, for generic beacons, whereas the position can be accurately estimated with a low error up to a small distance; or based on finger printing the signal for the given space. In both cases, the accuracy variate depending on hardware specifications and other conditions such as beacon brand, wrap material, temperature, wind, location, surrounding interference, battery strength, among others.

- Applications strictly based on location detection, impose challenges when the location is performed indoors, mainly because of the absence of GPS signal, and because of the challenges that positioning pinpoint based on other networks signals bring.

The main purpose of knowing such location is to offer useful information to different types of users (e.g., elevators promotions, bathroom locations, wet floor warnings) and guide instruction (e.g., emergency evacuation, or help people with special needs).

- Beacons can be spread in a city, along roads, or indoors.

Then mobile devices "sniffs" for known signals from the beacons, and measures the received signal strength.

The relative link quality between the beacon and the mobile device is used to determine the location of the mobile device using mathematical formulas.

The strongest the signal is, the closest the beacon is regarding the mobile device. Based on that beacon (or weighted average of several nearby beacons) which produces the strongest signal, the location can be estimated.

The advantage of beacon-type systems is in the simplicity and low cost of implementation. The disadvantage of beacon-type systems is that they typically provide poor quality location estimation, in most case studies location is only acceptably accurate up to 3 meters distance.

Figure 3: Beacon and smartphone communication

- ## Android sensors:

Today smartphones have a unique sensors that can be used for indoor positioning such as:

- Motion sensors -these sensors measure acceleration forces and rotational forces along three axes. This category includes accelerometers, gravity sensors, gyroscopes, and rotational vector sensors.

- Position sensors - these sensors measure the physical position of a device. This category includes orientation sensors and magnetometers.

Accelerometer sensor - Measures the acceleration force in m/s2 that is applied to a device on all three physical axes (x, y, and z), including the force of gravity.

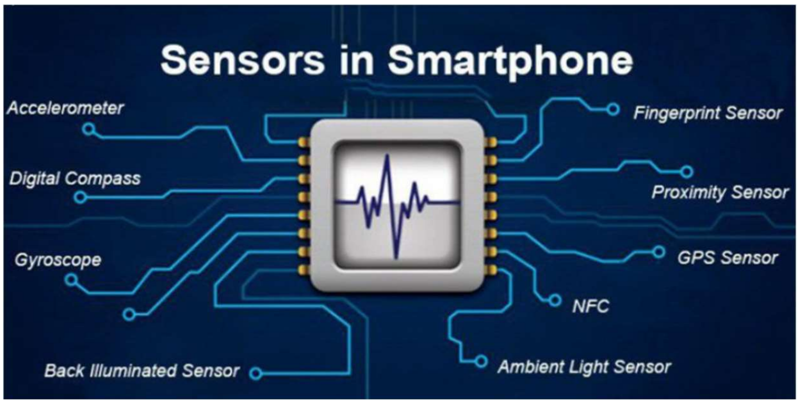


Figure 4: Android sensors

We created a simple pedometer application which counts the steps as the user walks in the supermarket.
Using the step values, we calculate the approximate distance of the shopping route.

We used the Accelerometer sensor which is found in almost all mobile devices to calculate the steps covered.
In this case the values received from the Accelerometer sensor passed through a filter to get the approximate step detection.
We created a class with an algorithm to filter out values that have close approximations to steps.
Then, we created a step detector class which accepts updates from the accelerometer sensor and deploys the filter to detect if a step has been covered by the user.

Summary: we discovered during the experiment that the accelerometer sensor is not accurate and may have some mistakes (e.g walking 10 steps but the accelerometer counts only 6).

Data structures and Algorithms

Linked list -

For shopping list management and maintenance we have created an object called PathTracker. Using this object we moved the shopping list between the different classes and screens. This object contains a linked list of sub-routes, each sub-route is a list of points on the map between product A and product B

Conversion from an angle of walking directions to a point on the map -

In order to abstract the real world to the world of algorithms, we made a parallel between the walking directions and angles at which the steps were taken and a checkerboard map that simulates the supermarket map.
Each square represents a unit of distance and has an index x and an index y on the map (to simplify one unit of distance is one meter).
Given the map of the squares facing north, it is possible to know for each movement between the squares in which direction it was made and what the new location is according to indexes in the supermarket map.

Example for our testing documentations:

The goal of the experiment was to walk in a circle route on tiles floor and end in the same position as we started (Figure 5).
We tested the conversion from degree to point algorithm using a compass (Figure 6).
We initialized the starting position to the point (1000,1000).
then, we start record the steps and angles using the cell phone sensors and tested our conversion from degree to point.

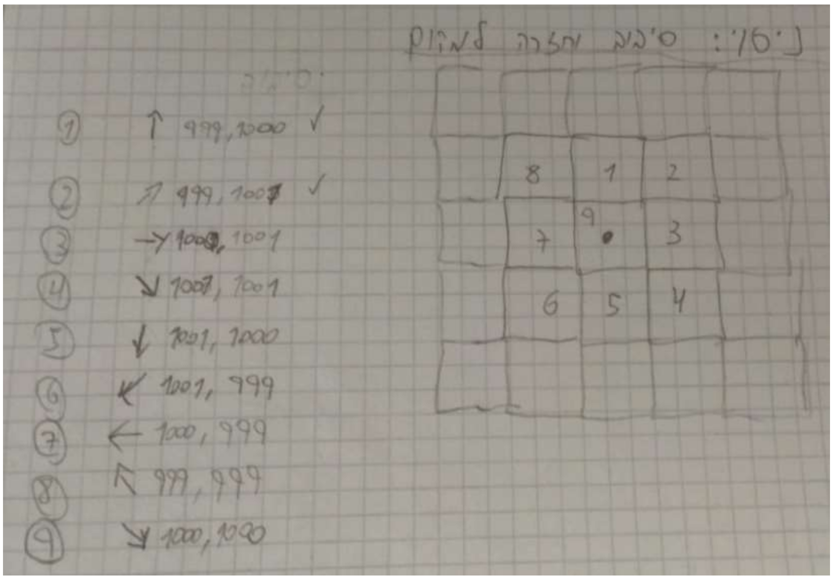


Figure 5: From degrees to pixels

Figure 6: Working with compass to validate degrees

[experiment example video clip]

Hash Maps -
To manage the customer's shopping list in an easy and smart way within the app, we used a Hashmap data structure.
Each entry on the map is a list that belongs to one department in the supermarket.
In this way, the customer enters the products in some order, not necessarily sorted, and the system knows how to sort the products according to the different departments.

Graphs -
To represent the structure of the supermarket we used a graph-type data structure.
Each node in the graph is a product or beacon and the edges are the walking route between the various products and the beacons.
The goal is to create a linked graph so that the sides of the graph do not intersect the supermarket shelves.

Dijkstra algorithm for shortest path on a graph -
To create the shortest path within the supermarket we used the Dijkstra algorithm.
To do this it was necessary to prepare in advance the supermarket graph.
Then, given two nodes in the graph (meaning two products) you can run the algorithm to find the shortest path between them.
Attached below is the process of creating the graph.

Custom drawing on Android Studio Application

The most important part of a custom view is its appearance.

Custom drawing can be easy or complex according to your application's needs.

The most important step and a very smart one in drawing a custom view is to override the onDraw () method.
The parameter to onDraw () is a Canvas object that the view can use to draw itself.
The Canvas class defines methods for drawing text, lines, bitmaps, and many other graphics primitives.
You can use these methods in onDraw () to create your custom user interface (UI).
Before you can call any drawing methods, though, it's necessary to create a Paint object. We will discuss Paint in more detail.
The android.graphics framework divides drawing into two areas:

- *What* to draw, handled by Canvas
- *How* to draw, handled by Paint.

For instance, Canvas provides a method to draw a line, while Paint provides methods to define that line's color.
Canvas has a method to draw a rectangle, while Paint defines whether to fill that rectangle with a color or leave it empty.
Simply put, Canvas defines shapes that you can draw on the screen, while Paint defines the colour, style, font, and so forth of each shape you draw.
So, before you draw anything, you need to create one or more Paint objects.
Creating objects ahead of time is an important optimization.
Views are redrawn very frequently, and many drawing objects require expensive initialization.
Creating drawing objects within your onDraw () method significantly reduces performance and can make your UI appear sluggish.

In order to properly draw your custom view, you need to know what size it is. Complex custom views often need to perform multiple layout calculations depending on the size and shape of their area on screen. You should never make assumptions about the size of your view on the screen. Even if only one app uses your view, that app needs to handle different screen sizes, multiple screen densities, and various aspect ratios in both portrait and landscape mode.

Although View has many methods for handling measurement, most of them do not need to be overridden. If your view doesn't need special control over its size, you only need to override one method: onSizeChanged ().

onSizeChanged () is called when your view is first assigned a size, and again if the size of your view changes for any reason. Calculate positions, dimensions, and any other values related to your view's size in onSizeChanged (), instead of recalculating them every time you draw. In the PieChart example, onSizeChanged () is where the PieChart view calculates the bounding rectangle of the pie chart and the relative position of the text label and other visual elements.

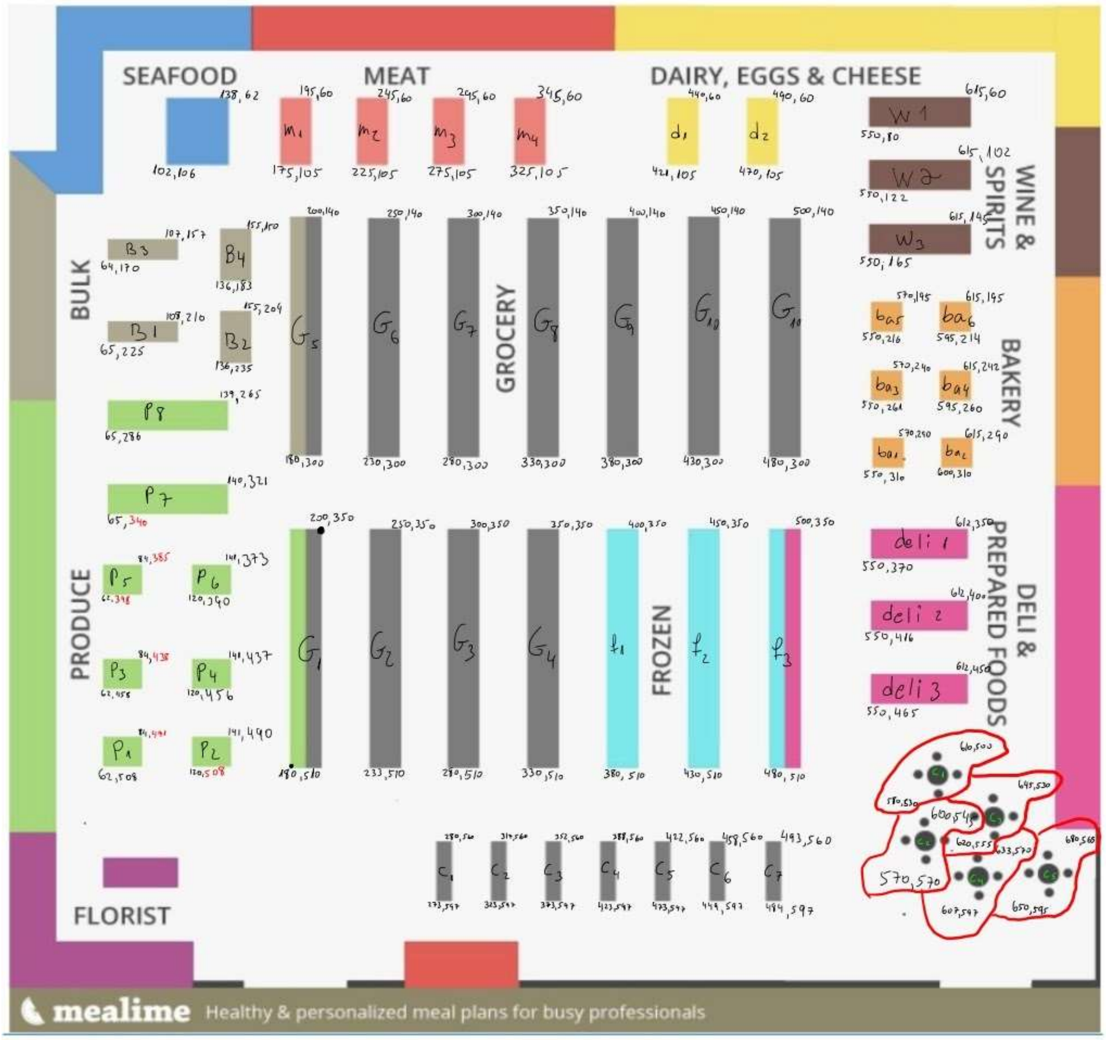


Figure 7: Determining the department positions

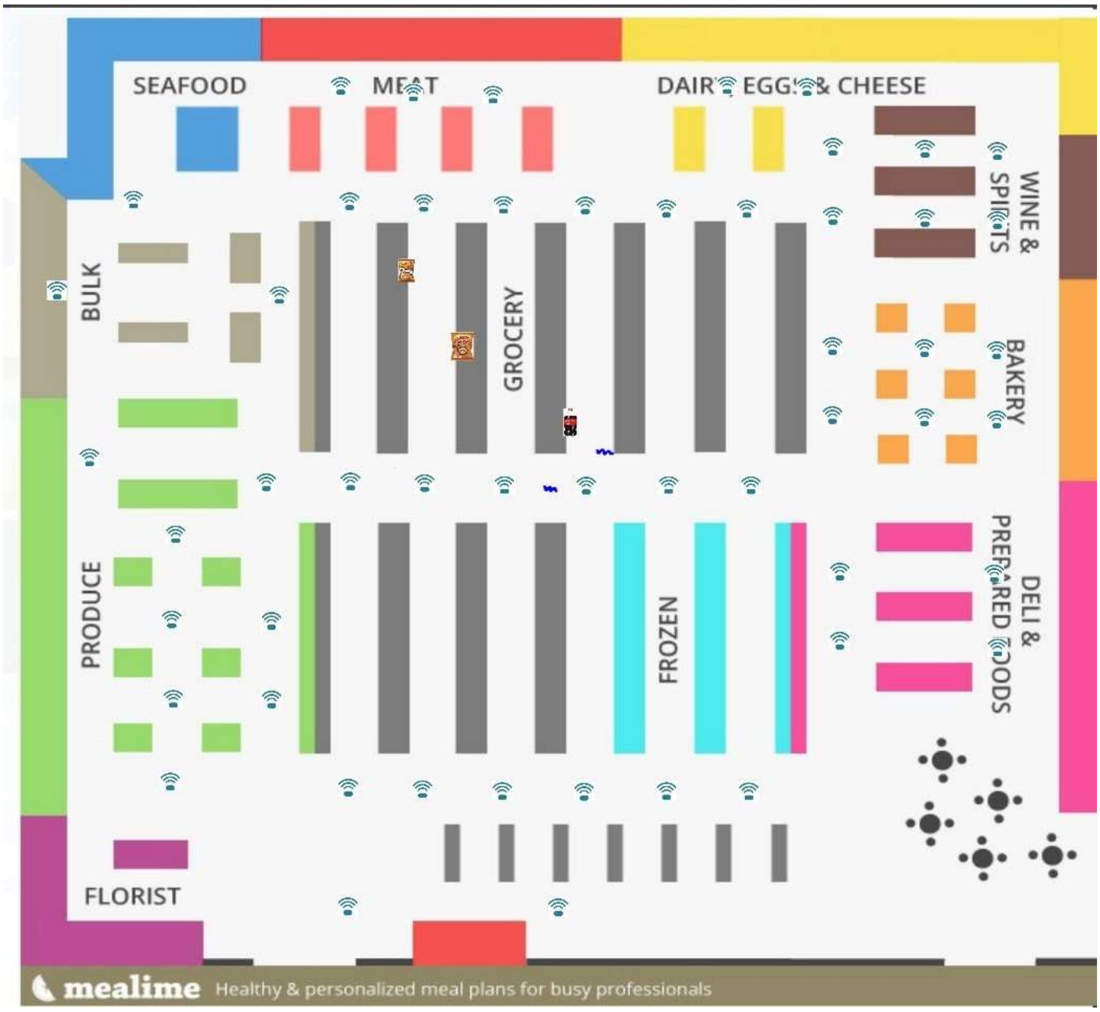


Figure 8: Determining the Beacon positions

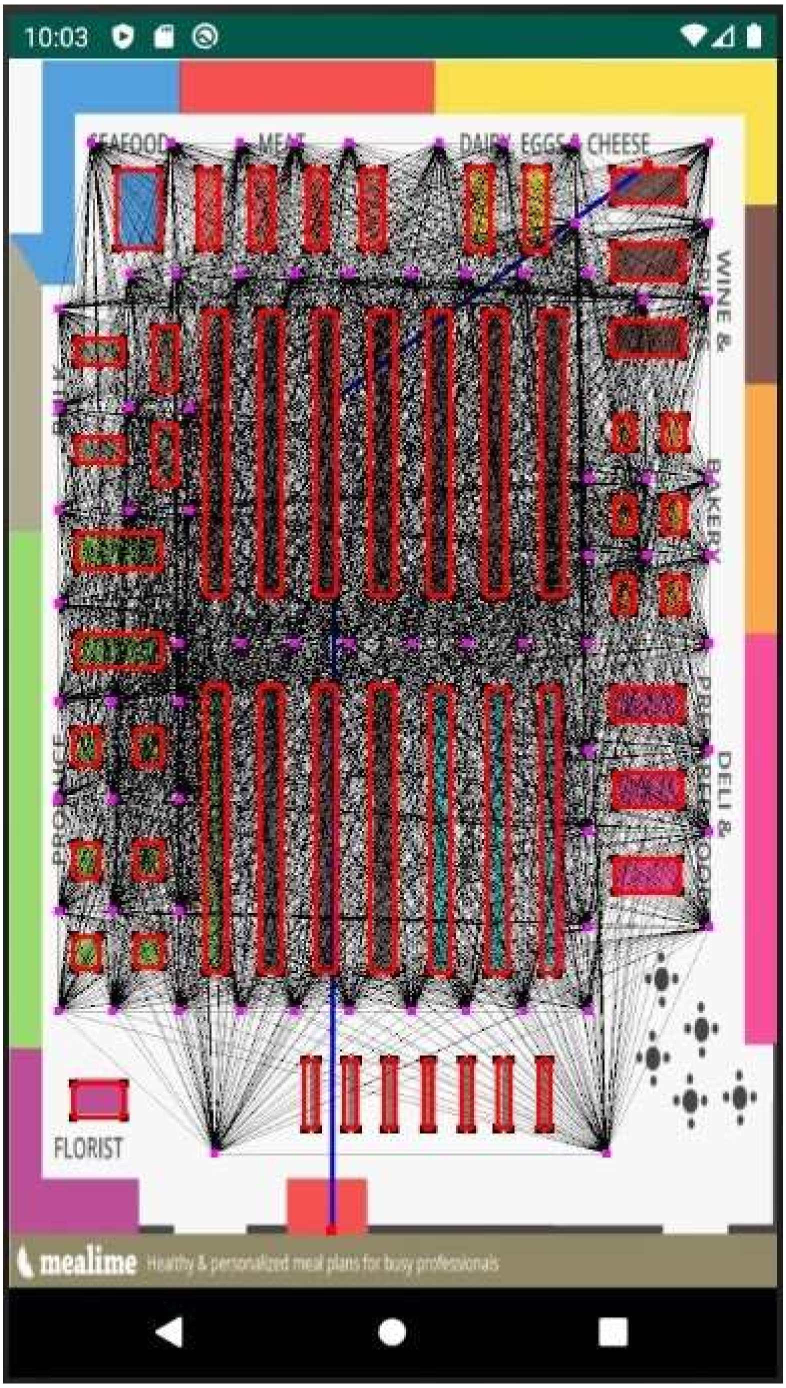


Figure 9: Connecting all nodes in the graph

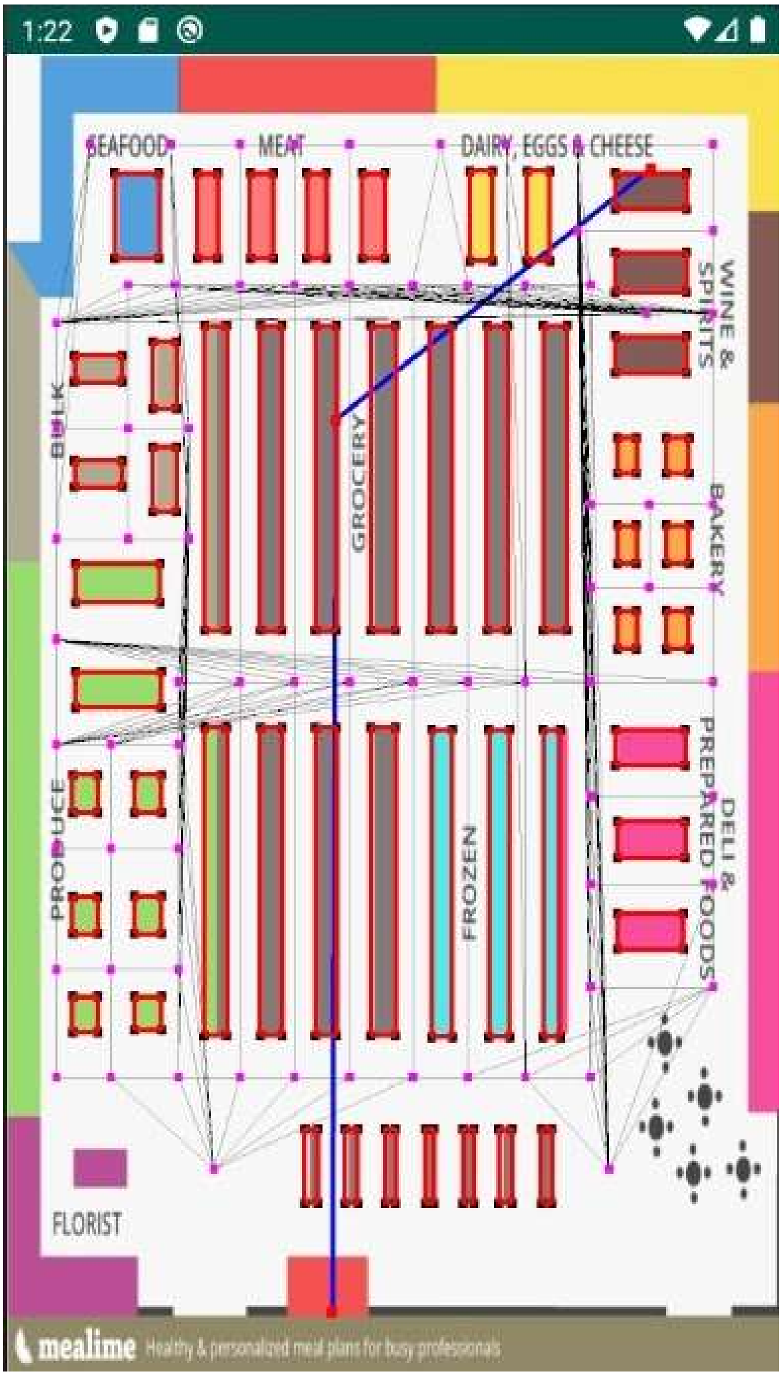


Figure 10: Delete edges that cross the

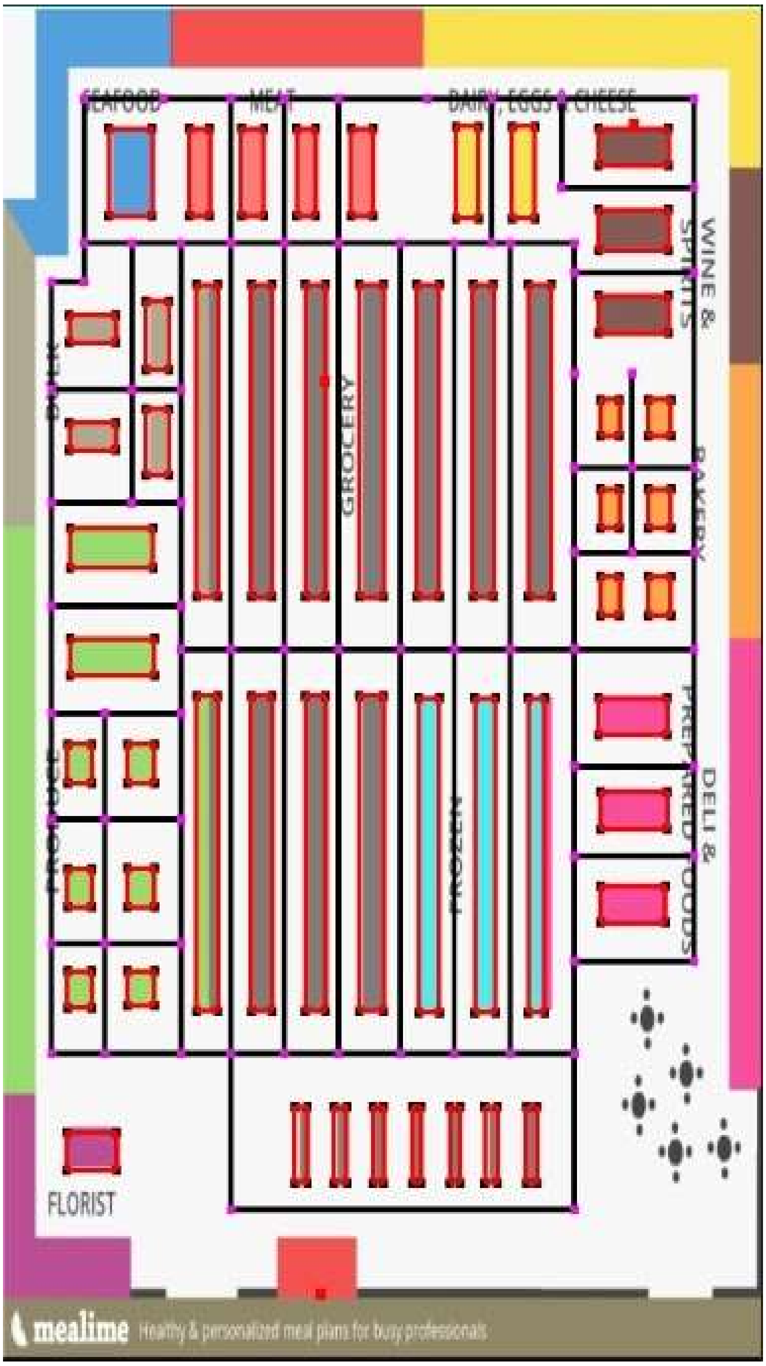


Figure 11: Deleting unnecessary routs

The augmented reality approach

Augmented reality (AR) is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory.

ARCore - is a google platform for building augmented reality experiences.
Using different API's ARCore enables a smartphone to sense its environment, understand the world and interact with information.

There are three main components to determine how the ARCore functions:

Motion Tracking

Using visual input from the camera to detect unique features in the environment.
Also, it uses the camera's position and orientation, which is understood through the input from the accelerometer and gyroscope sensors on the device.
It initially aligns the virtual content, relatively to the users actual position and orientation.
Then, it detects feature points, which are distinct features in the environment to keep track of the device's movement.
This allows the virtual content to appear as if it was "stuck" to the real world (Figure 12).

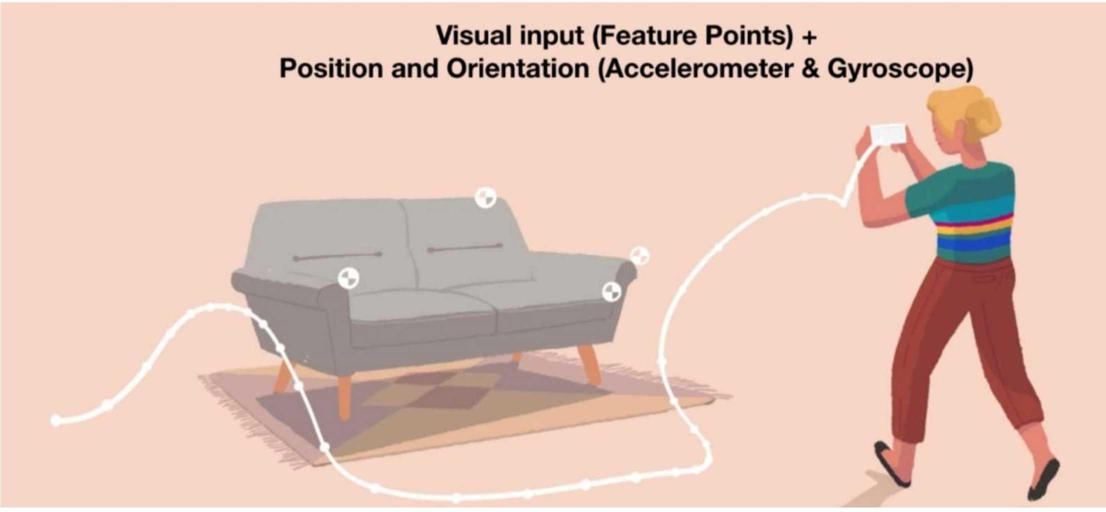


Figure 12: ARCore Motion Tracking

Environmental Understanding
ARCore is also intelligent in the sense that it can understand the environment.
For example, when it sees a lot of feature points(cluster) horizontally or vertically lined up, it understands that it is very likely that there exists a plane in that area.
This is very useful to place objects in the ARCore (Figure 13).

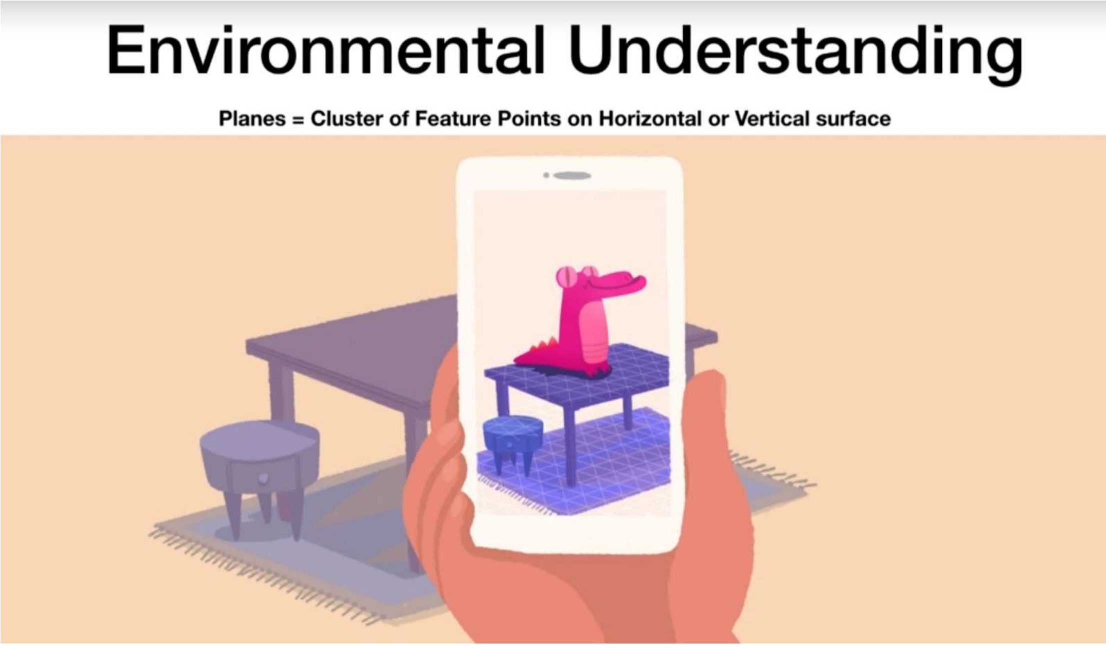


Figure 13: ARCore Environmental Understanding

Light Estimation
Estimation of light helps ARCore to create objects more realistically.
It lights objects in the exact conditions as the environmental light.

Figure 14: ARCore Light Estimation.

Sceneform

Library written on top of ARCore that makes it simpler to develop mobile applications using ARCore.
Sceneform lets us import and edit models.
We can modify our models to the most specific details before placing them in the real world.
This library provides easy handling of all UX interactions.

Evaluation and research experiments

The AR industry worth in 2019 was estimated around one hundred billion dollars and estimations are that it would keep its growth.

Unfortunately, due to the rapidly spread of the covid virus in Israel from the beginning of 2020, we did not get a chance to perform an indoor navigation experiment with this development inside of an actual supermarket store.
Therefore, we have abbondend this implementation for other approaches.
Earlier this year we have invested many resources (such as buying online courses) and a lot of time, and we believe that in the future an indoor navigation system based on the ARCore capabilities could provide an excellent solution to indoor navigation but would require some investment to map data, but scanning and placing objects within unmapped areas would be easy to do if the users will only scan the area around them with their camera, and image processing techniques will do the rest.

As described Figure 15 we managed to place a jar of milk according to our location at home

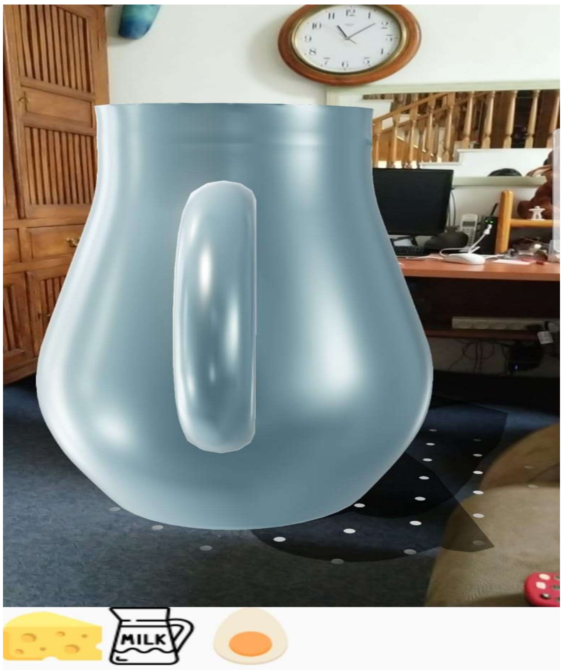


Figure 15: ARCore experiment at home.

FireBase – Brief Explanation and how we used it

The Firebase Realtime Database – the platform that we used in our project is a cloud-hosted database. Data is stored as JSON and synchronized in real-time to every connected client. When you build cross-platform apps with our iOS, Android, and JavaScript SDKs, all of your clients share one Realtime Database instance and automatically receive updates with the newest data.

The Firebase Realtime Database lets you build rich, collaborative applications by allowing secure access to the database directly from client-side code.

Data is persisted locally, and even while offline, realtime events continue to fire, giving the end user a responsive experience.

When the device regains connection, the Realtime Database synchronizes the local data changes with the remote updates that occurred while the client was offline, merging any conflicts automatically.

The Realtime Database provides a flexible, expression-based rules language, called Firebase Realtime Database Security Rules, to define how your data should be structured and when data can be read from or written to. When integrated with Firebase Authentication, developers can define who has access to what data, and how they can access it.

The Realtime Database is a NoSQL database and as such has different optimizations and functionality compared to a relational database.

The Realtime Database API is designed to only allow operations that can be executed quickly, This enables you to build a great realtime experience that can serve millions of users without compromising on responsiveness. Because of this, it is important to think about how users need to access your data and then structure it accordingly.

In our project, in order to deal with supermarket products and to store the relevant data so that we can use this data to show name of products, customers lists and other relevant details.

We had to choose a comfortable Database that we can work with, one that can be connected to our Android Studio Platform easily and with less technical problems as possible – that is the reason we chose to work with FireBase Database platform.

Screen-Shots involved FireBase from our projects:

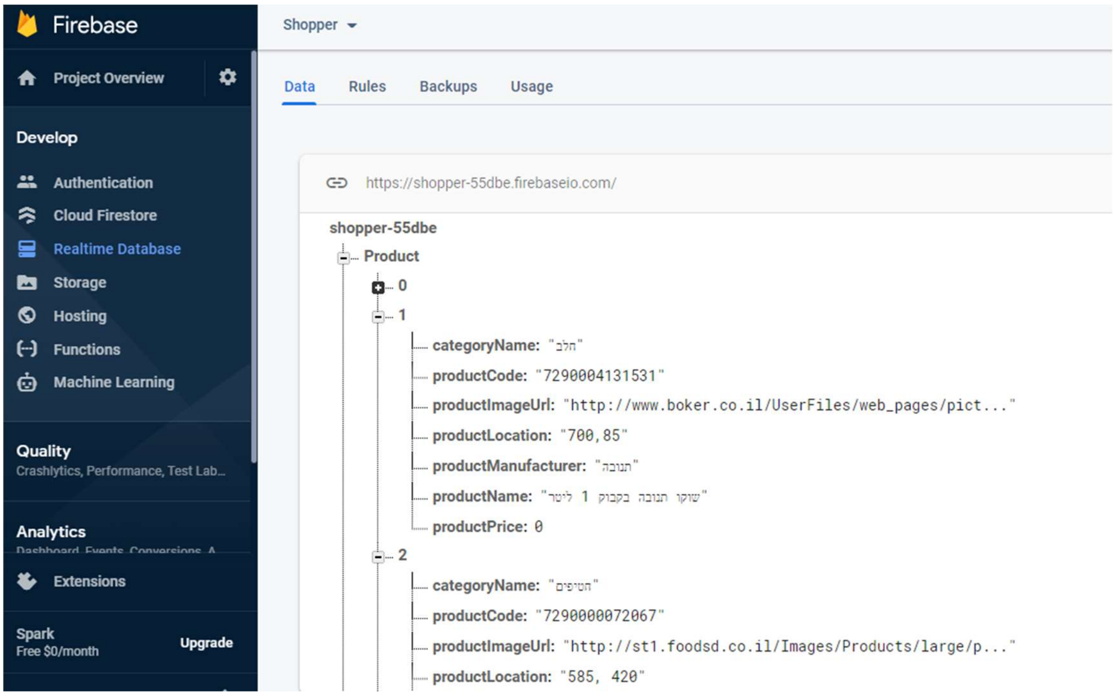


Figure 16: Products database with products locations

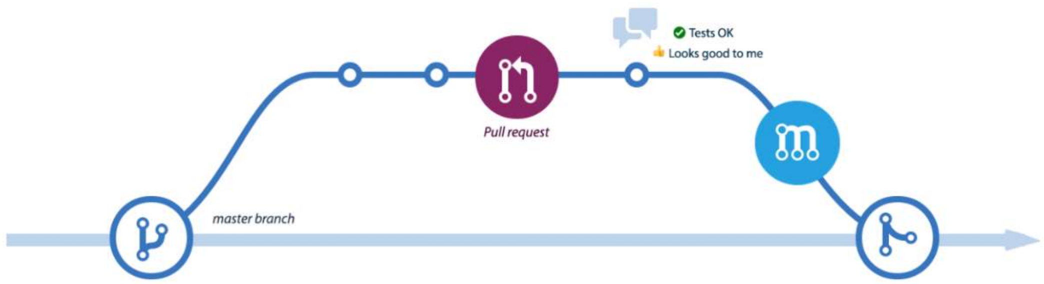
Git

Git is a free and open source distributed version control system.

GitHub.com

provides hosting for software development and version control using Git.

To work in collaboration and teamwork, the work was conducted through this system.
We created a GitHub repository for our project.
Each team member worked on a task unique to him on a separate branch.
When the task was completed, we conducted a peer review to improve the products.
We then integrated the task into the main branch using the merge branches technique that call Pull requests.



In this way, we kept a clean and tidy code project in the main branch without fear of experimenting and daring to make changes and experiments independent of each other's code and tasks.

Other Companies engaged in the same field

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LocusLabs

LocusLabs – Founded in the U.S, 2014, LocusLabs provides venue operators with a digital platform to communicate, share and manage everything about their physical spaces, In addition to Interactive maps, wayfinding and search for indoor environments — on every device.

People’s increasing reliance on mobile navigation, the push to make buildings and campuses smarter and more efficient, supply chain optimization and autonomy, and the rise of augmented reality are just a few of the factors driving the need of an accurate digital counterpart and corresponding software platform.

The company founded a smattering of custom-built applications along with monolithic GIS platforms built by engineers for engineers. They also built a geodata platform that is easy to use, making it accessible by every stakeholder regardless of where they reside in the organization.

situm
INDOOR POSITIONING

Situm - Situm provides indoor positioning and navigation technology with the minimal infrastructure.

The core technology behind Situm IPS (Indoor Positioning System) Platform and its indoor navigation and wayfinding solutions is an algorithm that merges pre-existing information in the environment (magnetic fields, Bluetooth, Wi-Fi) with data from inertial sensors of smartphones (compass, gyroscope and accelerometer) to provide an accuracy of less than 5 meters without the need of additional hardware.

Situm helps companies from different sectors to improve their services and optimize their processes by guiding visitors and monitoring their employees and mobile assets.

IndoorAtlas

IndoorAtlas Ltd - provides magnetic-field-based indoor location technology, which utilizes magnetic anomalies inside buildings and smartphones to pinpoint positions indoors. It offers a toolbox for indoor positioning that enables businesses and individuals to create indoor location-awareness applications for store promotions, mobile gaming, and logistics efficiency or to find one’s way around shopping centers and airport terminals. The company’s toolbox includes IndoorAtlas Floor Plans, a solution that enables the user to add and manage a building floor plan with the geographic coordinate system; Map Creator is a mobile application used to create magnetic maps for buildings added through Floor Plans; and Maps API is used to create indoor-location applications.

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