Ambient magnetic field-based indoor location technology

Bringing the compass to the next level
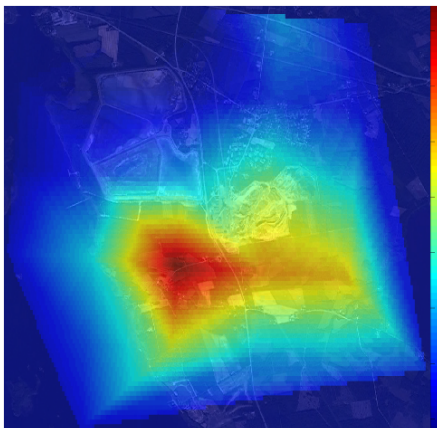
IndoorAtlas Ltd. - July 2012

BACKGROUND

IndoorAtlas' location technology is partly inspired by evidence that animals use the Earth's magnetic field not only for orientation detection but also for true navigation (Boles et al. 2003, Wlitschko et al. 1972, Maugh et al. 1982, Mouritsen et al. 2004, Mora et al. 2004). *Some animals, such as spiny lobsters, are not only able to detect the direction of the Earth's magnetic field they can even sense their true position relative to their destination. This means these particular animals are able to derive positional information from local cues that arise from the local anomalies of the Earth's magnetic field.*[1]

Modern buildings with reinforced concrete and steel structures have unique, spatially-varying ambient magnetic fields that can be used for positioning, in much the same way (albeit on a much smaller spatial scale) as animals use the Earth's magnetic field. In principle, a non-uniform ambient magnetic field produces different magnetic observations, depending on the path taken through it.

In IndoorAtlas' location technology, anomalies (fluctuations) of ambient magnetic fields are utilized in indoor positioning. This has been facilitated by modern smartphones and the rapid development of sensor technology. The image on the right shows an example of indoor magnetic fields present in modern buildings (Time Warner Center, New York, US, June 2012).

Intriguingly, IndoorAtlas' location technology has also been tested in underground environments. Experiments were conducted in tunnels located approximately 1,400 meters below the surface in the Pyhäsalmi copper and zinc mine in central Finland. The magnetic field of the mining area has a unique spatial pattern that stands out from the background magnetic field, which is a typical phenomenon in areas where magnetic minerals can be found. The image at left shows the aeromagnetic data collected from the altitude of 150 meters above the Pyhäsalmi mining area (5 km x 5 km).[2]
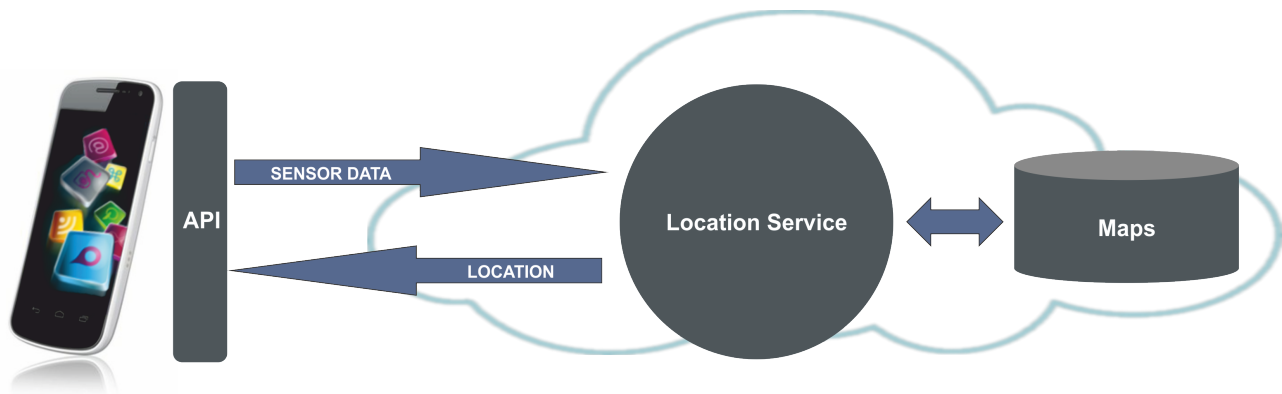

TECHNOLOGY

Overview

IndoorAtlas' cloud-based location service is illustrated on the next page. The application uses the IndoorAtlas API to communicate with the location service. The API sends processed sensor data to the location service, which computes the current location estimate and delivers the estimate back to the application's event listener method through the API.

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1 Boles, L.C. and Lohmann, K.J. True navigation and magnetic maps in spiny lobsters. Nature, 421:60–63, 2003.

2 Haverinen, J. & Kemppainen, A. A geomagnetic field based positioning technique for underground mines. International Symposium on Robotic and Sensors Environments, Sep. 17-18, 2011, Montreal, Canada

The location service connects to the map database, which hosts the magnetic field data collected from the building using the *IndoorAtlas Map Creator*™ application. The IndoorAtlas location service has been built on the top of Microsoft's Windows Azure cloud platform.[3]

The Benefits

IndoorAtlas' indoor location technology is a completely new innovation. Based on a phenomenon never-before utilized in indoor positioning and mobile computing. The technology can work accurately alone or in parallel with current indoor positioning systems for even greater detail.

IndoorAtlas' core technology is a software-only location system that requires, from the hardware point of view, only a smartphone with built-in sensors (no external hardware infrastructures, such as radio access points, are needed). The accuracy in IndoorAtlas' technology in modern buildings ranges from 0.1 meter to 2 meters.[4]
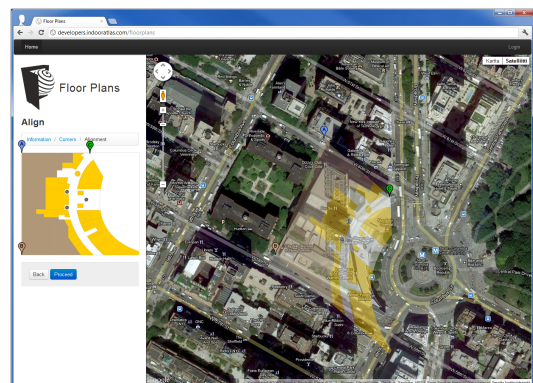
The Software

Before using the IndoorAtlas' location technology, a magnetic field map must be generated from the part of the building where the location service is going to be used. IndoorAtlas offers a complete software solution:

- Add and manage floor plans with *IndoorAtlas Floor Plans*™ web application
- Collect magnetic field data with *IndoorAtlas Map Creator*™ mobile application
- Use IndoorAtlas' API to use the location service

Floor Plans™

The process of creating location awareness inside a building starts by adding a floor plan image to *IndoorAtlas Maps*™ using the *IndoorAtlas Floor Plans*™ web application. *Floor Plans*™ makes it easy to align floor plans with corresponding geographic coordinates, enabling the use of the geographic coordinate system in application software.

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3 http://www.windowsazure.com
4   The accuracy depends on the type of the building.

Map Creator™

After adding the floor plan to *IndoorAtlas Maps*™, it can be opened with *IndoorAtlas Map Creator*™ to collect the magnetic field data and create the magnetic field map. *Map Creator*™ is an easy-to-use mobile application to map part of a floor, a complete floor or even multiple floors.

After opening the floor plan in MapCreator™, the user marks the planned route (typically a straight line or a curved path) on the smartphone screen. Next, the user walks along the path and records the magnetic field data. The *Map Creator*™ application seamlessly connects with *IndoorAtlas Maps*™, which generates the magnetic field map that will be used for indoor positioning. Next, a location aware application can begin using the *IndoorAtlas API for accurate positioning*.

API

Creating your location-awareness application is easy with the *IndoorAtlas API*. The API connects with the IndoorAtlas location service and provides regular indoor location updates to the application. The application software needs only to implement an event listener method to receive those updates, from there on it's up to your application's business logic.

The following code snippet for Android illustrates how the API is used:

```java
    try {
        // Create IndoorAtlas object
        indooratlas = new IndoorAtlas(this);
        // Login to the location service
        indooratlas.login(credentials);
        // Start the service
        indooratlas.start();
        // Start observing pose updates
        indooratlas.observe(myServiceListener);
    } catch (Exception e) {
        // Handle exception ...
    }

    class MyServiceListener implements ServiceListener {
        // Called when a new location estimate is available
        public void onServiceUpdate(ServiceState state) {
            // Get the geographical coordinates [lon, lat]
            GeoPoint geoPoint = state.getGeoPoint();
            long latitude  = geoPoint.getLatitude();
            long longitude = geoPoint.getLongitude();

            // Get the floor plan image coordinates [pixel]
            ImagePoint imagePoint = state.getImagePoint();
            float i = imagePoint.getI();
            float j = imagePoint.getJ();

            // Get the current heading of the device [rad]
            float heading = state.getHeading();
            // Use the coordinates in the application ...
    };
```

SUMMARY

Facilitated by modern smartphones and the rapid development of sensor technology, IndoorAtlas has developed a completely new innovation that utilizes the anomalies of ambient magnetic fields for indoor positioning. IndoorAtlas offers a complete software toolbox for adding and managing floor plans, collecting data to create magnetic field maps, and an API to use IndoorAtlas' location service for mobile applications. IndoorAtlas' core technology is independent of external hardware infrastructures (such as radio access points) and is able to pinpoint the location inside a building within 0.1 - 2.0 meters.

REFERENCES

Larry C. Boles and Kenneth J. Lohmann. True navigation and magnetic maps in spiny lobsters. Nature, 421:60–63, 2003.

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