Image: GeoConnexion

Inside story

Tughrul Arslan traces the evolution of indoor navigation, reviews the state-of-play, and looks at how locational accuracy might be further improved

The evolution of the Global Navigation Satellite System (GNSS) has transformed position-fixing on land, sea and air over the last four decades. The system, which was developed in the 20th century mainly for military purposes, has since gained traction in civil applications of all types, from terrestrial surveying to vehicle navigation and from parcel tracking to precision farming to name but a few. Yet despite the several constellations of GNSS satellites now in operation (GPS, GLONASS, Galileo and BeiDou), none work well, if at all, in areas that lack a line of sight to the satellites.

To meet this need, Indoor positioning systems (IPS) have been developed specifically for the purpose. There is currently no technical standard for IPS and several technologies have been adopted by IPS providers which are widely discussed in the literature.[1] These technologies vary depending on hardware required, network availability, and so on. One way of classifying them is to consider the principal means chosen to determine position.[2]. Based on this, IPS technologies can be classified as those based on Radio Frequency, vision, magnetic field, audio and ultrasound.

Complex and frequently modified interiors, as found in hospitals, can leave visitors wondering just where to go .... once they can find the right building *Photo: GeoConnexion*

Wave power

Radio Frequency is one of the key technologies widely used for IPS. This is due to the availability of already existing networks and hardware. This category can be further divided depending on the type of the different wireless technologies employed such as cellular, Wi-Fi, ultra-wide band (UWB), Radio-frequency identification (RFID) and Bluetooth.

Cellular positioning has the advantage of widely available signals, and the hardware of customary mobile phones can be used, however, it suffers from low reliability due to varying signal propagation conditions.

Wi-Fi based positioning also has the advantage of existing communication networks which covers a large number of buildings. Furthermore, the availability of Wi-Fi in mobile devices allows Wi-Fi based positioning to be accessible to a large number of users.

However, the Wi-Fi signal also suffers from low signal reliability thus not being precise enough for certain applications. Achieving higher levels of accuracy requires a detailed calibration process and the installation of further access points.

UWB positioning can result in very high positional accuracy even in the presence of obstacles. However, it requires the installation of expensive UWB infrastructure which reduces the interest in the technology for commercial applications.

RFID tends to be cheap in term of hardware cost and deployment depending on the chosen signal frequency however it lacks the inherent capability in generally being available in mobile devices, especially smartphones. This is a major drawback in terms of user accessibility.

Bluetooth, on the other hand, has the inherent capability in mobile devices but is expensive compared to the cost of RFID hardware. With the introduction of Bluetooth 4 or Bluetooth Low Energy (BLE), which targets emerging Internet of Thing (IoT) applications, it is increasingly being adopted for indoor positioning as it can also serve as an IoT getaway. Moreover, the technology is already embedded in smartphones as well as being characterised with low energy consumption at both transmitter and receiver ends. The use of Bluetooth as a technology for indoor positioning is further reinforced by the introduction of the BLE beacon protocols, iBeacon and Eddystone, by two of the largest technology companies, Apple and Google respectively.

The latest version of its Frankfurt Airport IPS app from Fraport AG enables cross-media navigation via various devices using Wi-Fi. An online shop is also new feature of the smartphone app which Is available to some 60 million passengers who walk through the doors of Germany's largest airport every year. The heart of the app is interactive map material from indoor navigation and indoor services specialists, infsoft GmbH (https://www.infsoft.com)

The hybrid IPS approach adopted by sensewhere (www.sensewhere.com) utilises indoor RF signals including Wi-Fi and Bluetooth and exploits crowdsourcing and cloud-based algorithms to automate the calibration process and compile a global and universal database in real-time

In plain sight

Vision-based positioning uses the principle of landmarks and maps to determine location. Basic implementation of vision-based positioning is an image captured and compared with a pre-recorded database image which has a position associated with it. Some implementations capture an image of an area and, instead of comparing it to a pre-recorded image, analyse and compare the building structure to a building layout.

In the past, vision-based positioning were mainly of interest to those who worked in robotics as precise locational information is required for applications such as that described in the literature.[3]

The demand for visual positioning for consumer applications has grown with the evolution of smartphones as these now have the optical and computing capability needed to capture high resolution imagery and handle the image processing algorithms.

The introduction of Google's Tango device has further sparked the interest of researchers in visual positioning, especially those that incorporate a 3D modelling capability. In the recent years, researchers have also exploited visible light technology, using signals transmitted by LEDs.[4]

Magnetic force

The use of geomagnetic field positioning is based on work similar to that used for outdoor positioning. In 2000, Suksakulchai realised that magnetic field disturbances could be employed for indoor localisation.[5] Several papers then emerged describing positioning based on magnetic anomalies. Such methods require no pre-deployed infrastructure but are often combined with other solutions such as Wi-Fi positioning to further improve accuracy.

Other techniques requiring no additional infrastructure are those of audible and ultrasound positioning. Both are based on fingerprinting and generally employ two approaches to estimate a position: passive fingerprinting which uses ambient sound, and active fingerprinting which emits and records specific sound patterns.

Another indoor positioning approach exploits inertial navigation. As this approach uses the accelerometer and gyroscope available in most smartphones, it represents another viable technology which, when used in conjunction with other technologies, finds the initial location and then uses inertial positioning to fine tune the accuracy.

One thing Pokemon Go can't do is track gamers indoors where they spend much of their time. IndoorAtlas (https://www.indooratlas.com) wants to change that, having developed a platform that makes use of magnetic fields to map a building, the Wi-Fi environment within the building, and the compass on a user's smartphone. The company hopes to empower developers to create indoor location-based applications through its SDK that allows developers to embed IndoorAtlas in their mobile devices

Drawback

Most of the technologies reviewed above have a similar drawback; they call for a high degree of manual intervention and complex calibration. This makes them expensive and ill-suited to mass deployment on a global scale.

In most cases, further improvement in positional accuracy requires more detailed calibration. This typically entails the deployment of beacons or access points and the creation of a reference point for fingerprinting.

Follow the crowd

Automatic crowdsourcing, pioneered by sensewhere, automates the calibration process by deploying cloud-based algorithms that turn users' mobile phones and wearable devices into "automatic fingerprinting" engines. These algorithms gather specific information to compile a global and universal database in real-time.

The crowdsourced nature of the algorithms obviates manual surveying, and the database continually improves as data is acquired. The automation of the calibration process also reduces the cost of the initial setup which further increases its attractiveness and commercial potential.

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