POSITIONING TECHNIQUES THAT CAN BE USABLE IN ENGINEERING GEODESY

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***Abstract**: The current context of development known under the technological aspect, in the most developed countries there is a tendency modernization and automation of the production and the main goal pursued is to increase work efficiency and precision work. So, in engineering geodesy applications appears the need to identify and use new systems for position determination, systems that satisfy the rigors imposed by the specific accuracy requirements to this field of work.*

***Keywords:** infrared, radio waves, ultrasound*

1. Introduction

Location sensing technology is very important for an infrastracture of an ubiquitous computing environment. Outdoor location sensing technology such as GPS is already developed and widely used. For indoor location sensing, there are a few technologies, but they are not widely used currently. Improving technology has found new positioning technologies become increasingly necessary in many areas of work including engineering geodesy. If location sensing technology which uses the wireless LAN infrastructure is developed, it will be used widely and can be a popular way. As indoor location sensing, there are techonologies based on ultrasonic sensor, radio and infrared system. Some systems have to need high installation cost and maintenance cost. In this paper presents some main characteristics of these positioning systems.

2. Location detection techniques

The main types of location detection techniques are: triangulation, scene analysis, proximity and stochastic. A location system can deploy them individually or in combination. Each technique has its own advantages and disadvantages:
1. *Triangulation* is pure mathematical technique for detecting location, and it is the most established method. It uses the geometric properties of triangles to estimate location. In this method, measurement is made from multiple reference points. Then location is computed using the measurements along with some additional measurements if they are required. Triangulation is divided into two types. They are lateration, which uses distance measurement, and angulation, which uses angle measurement. The location systems which use triangulation method are: GPS (Global Positioning System), Skyhook Wireless WiFi, Active Bat, SpotON, VOR (VHF Omnidirectional Ranging).
2. *The scene analysis location detection* technique uses a scene from a specific vantage point, called view point, along with an acceptable representation of a space under observation, to identify features of the scene so that inferences about the location of the observer or of objects

within the space can be made. Image processing techniques are applied, along with the eployment of geometric representation of the space, for simplification and feature extraction from images, obtained through vision systems. Many location systems use scene analysis technique widely used in robotics, and the main systems are: MotionStar and MSR RADAR.
3. *Proximity* is the location detection technique which involves determining the location of an object when it is close to a known reference point. A limited range of physical phenomenon is used to detect the presence of an object. Proximity location detection technique entails two types of fashion for detecting proximity. In the first fashion, physical contact is the determining factor for proximity. Various types of sensors, pressure sensor and touch sensor, are generally used to sense physical contact. In the second fashion, proximity is determined wirelessly. The space is covered by the power of the wireless access mode and the proximity of an object to the reference point is detected as containment within the space. The location systems: Active badges, Cricket, Smart Floor.
4. *Stochastic location detection* is a data driven approach. It uses statistics to detect the location of an object. In this technique, the space is divided into subspaces. Each of the subspaces has at least one point, called training point, at which the signal strength is measured from some certain points of reference. Thus, a database of signal strength information is constructed. The signal strength at an object's position from some certain points of reference is used as test data for the database constructed to infer the position of the objects. In this calculation many statistical concepts come into play, such as, probability theory, probability distribution, central tendency and dispersion. Many kinds of signals can be used, namely, RF, ultrasound and infrared, in the stochastic technique.
To be a useful source of information for positioning, a location sensor system should additionally have a number of features such as:

- Wide-area coverage: The sensor system should be able to find objects in all rooms of a large building, allowing location-aware applications to be deployed throughout that environment.
- Tracking of many objects: To ensure that the environmental model is complete as well as accurate, the locations of many objects should be monitored.
- High location rate: The high spatial accuracy of location information provided by the sensor should be matched by a high update rate.
- Software support for applications: The basic sensing technology used by the location system should be integrated with a software support structure that permits easy access to location data and convenient manipulation of that information.
- Easy integration into existing environments: Tags either active or passive placed on objects must be small, lightweight, and wireless, so that motion of the objects is not hindered.
- Low power consumption: Any components of the location system must have low power consumption to minimise the logistical task of maintaining those components.
- Low cost: The cost of installing and operating the sensor system must not be prohibitive.

3. Location technologies

Containment -based location systems determine the positions of objects by identifying spatial regions that contain those objects. The size of the spatial containers governs the resolution with which the locations of objects can be found-smaller containers correspond to higher location resolution.

Position-based location systems track objects by reporting their coordinates in a frame of reference. The actual position measurements may be made in many ways. Object locations can be sensed directly, using measurements of fields emanated or affected by them, or by contact methods. Alternatively, locations can be deduced from measurements of other hysical properties of the object. Inertial schemes determine the acceleration or velocity of objects, and integrate those measurements to obtain their positions relative to initial points. Triangulation systems use measurements of the bearings of objects from known, fixed points to find their locations. Similarly, trilateration or multilateration schemes find object positions by determining their distances from fixed points.

3.1 Optical tracking systems

The main condition of these systems is the visibility between a target which may be passive or active and a detector. This limitation may be restrictive in indoor environments that contain many opaque objects.
Outside-in videometric schemes. These systems use a set of cameras placed at static points in the environment to monitor objects within that environment. A infrared sensitive video camera is placed at a known, fixed point, and views the scene containing the object to which a number of infrared emitting LEDs are attached in a known pattern. The positions of the LEDs in the image are determined, and this information, together with knowledge of the 3-D relationship between the LEDs, allows the position and orientation of the object. The accuracy of the system is 3 mm in position, and 2^o in orientation.
Inside-out videometric schemes. These systems use a set of cameras carried by an object to determine its position and orientation in relation to a set of static targets placed around the environment. Three cameras, mounted on a helmet worn by the user, view an array of infrared-emitting LEDs affixed to the ceiling. A tracking controller individually illuminates the LEDs in turn by determining which LEDs are actually seen by the cameras the helmet can be tracked with a resolution of around 2mm in position and $0{,}1^o$ in orientation. The main disadvantage of the system is that the camera arrangement is bulky and is tethered to a control unit, and and to cover a relatively small area around 12 m^2 , takes approximately 900 LEDs.

3.2 Infrared Systems

Infrared devices are cheap and easy to get, and so are often used for indoor positioning. Two sample system are Active Badge System and the Wireless Indoor Positioning System (WIPS).

The “Active Badge” system emits a unique code for approximately a tenth of a second every 15 seconds. These periodic signals are picked up by a network of sensors placed around the host building. A master station, also connected to the network, polls the sensors for badge “sightings”, processes the data, and then makes it available to clients that may display it in a useful visual form. Pulse-width modulated infrared (IR) signals are used for signaling between the badge and sensor mainly because: IR solid-state emitters and detectors can be made very small and very cheaply; they can be made to operate with a 6m range, and the signals are reflected by partitions and therefore are not directional when used inside a small room. Moreover, the signals will not travel through walls, unlike radio signals that can penetrate the partitions found in office buildings. Infrared communication has been used in a number of commercial applications ranging from the remote control of domestic appliances to data backup links for programmable calculators and personal organizers. Because IR technology has already been exploited commercially, it is inexpensive and readily available for developing new applications such as the Active Badge.

3.3 Radiolocation systems

Radio-based positioning systems are frequently used because the signals they use can pass through solid objects. In indoor environments, signal reflections from objects are problematic. Wide-area hyperbolic navigation systems calculate the position of a receiver from observed phase differences between radio signals transmitted by synchronised beacons placed at known locations. Systems contain at least one master station for two or more secondary stations. The receiver measures the difference in arrival time signal from a pair of stations, and the difference is interpreted as the difference in distance between the receiver and two transmitter stations. Another example that use this technology is GPS system.The system cannot be used indoors, because the frequencies at which the satellites transmit signals do not penetrate buildings. As a solution was created indoor GPS environment that uses fixed transmitters called pseudolites to generate the required signals. Centimetre-level accuracy is achieved using a differential carrier phase technique, but an auxiliary optical tracker is required to resolve possible position ambiguities.

At SpotON system, tags use received radio signal strength information (RRSSI) as a distance estimator to perform ad-hoc lateration. The location sensing architecture we set out to build is conceptually simple even though the algorithm implementation is certainly nontrivial. Multiple basestations provide signal strength measurements mapping to an approximate distance. A central server then aggregates the values to triangulate the precise position of the tagged object. Finally, the computed object positions are published to client applications.

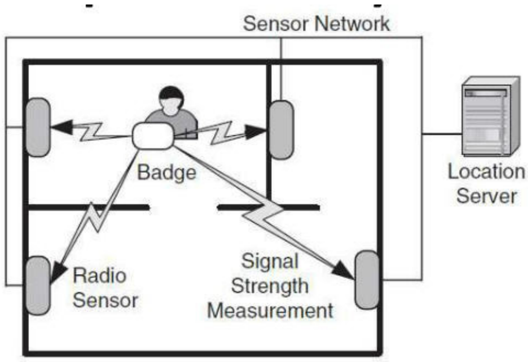

Fig. 1. The SpotON system

3.4 Ultrasonic Positioning Technologies

Ultrasonic multilateration systems determine the positions of objects by measuring distances between ultrasound sources and detectors. In some systems, a transmitter is mounted on the object, and several fixed receivers detect its signal. In others, a number of fixed transmitters generate signals that are picked up by a single receiver on the object to be tracked.

These systems rely on measurements of the time taken for ultrasound to travel between sources and detectors. Knowledge of the speed of ultrasound in air can then be used to calculate the corresponding transmitter-receiver distance. The measurement schemes can be grouped into three categories:

- *Broadband methods*, in which a pulse containing a range of ultrasonic frequencies is emitted by a transmitter, and receivers measure the time-of-flight of the pulse to determine the transmitter-receiver distance.
- *Narrowband,* in which received phase measurements of a continuous tone can be used to deduce the fractional part of the transmitter-receiver distance expressed as a multiple of the sound wavelength. The method cannot yield an unambiguous distance measurement, because the number of complete cycles made by the wave along the transmitter-receiver path is unknown. This phase ambiguity can be avoided by combining the narrowband measurement with a coarse, broadband measurement, at the expense of increased system complexity. Narrowband methods usually have lower signal-to-noise demands of the ultrasonic channel, because filtering can be used to select signals of only the measurement sound frequency.
- *Correlation methods*, in which receivers identify a known pulse shape, or pulse sequence, emitted by a transmitter. These methods combine the low signal-to-noise requirements of narrowband systems with the phase-ambiguity-free characteristics of broadband systems.

The distance measurement methods described above are based on a knowledge of the speed of ultrasound in air, which is around 340m/s at room temperature. The relatively slow speed of sound compared to say, that of light has two main effects on the characteristics of ultrasonic multilateration systems. First, timing units with microsecond resolution are sufficient to measure distances with sub-centimetre accuracy and so the electronic complexity of the systems is low. Second, the ultrasonic signals take an appreciable amount of time to travel from the transmitter to the receivers, resulting in a lag by tens of milliseconds in position readings.

Active Bat system is an indoor location system which locates an individual within a building at any given time. It locates an individual by detecting the location of their Bats. A Bat is a small device carried by an individual which deploys ultrasonic technology to send data. Each Bat features a unique identification code by which they are recognized. A Bat sends a short ultrasound pulse at a specified time interval. The sensors are set in a square grid at a distance of 1.2m. The pulses, sent by the Bats, are detected by the sensors. The time of flight of the pulse from the Bat to the sensor is computed using an accurate clock. The distance from the Bat to the receiver can be computed as the speed of ultrasound in air is known. The network contains a master station which performs the task of computing location. The Bat system is an absolute location system. It has issues with network, e.g., specialized cabling. It needs many networked sensors above the ceilings of the rooms of the building and their exact and accurate placement.

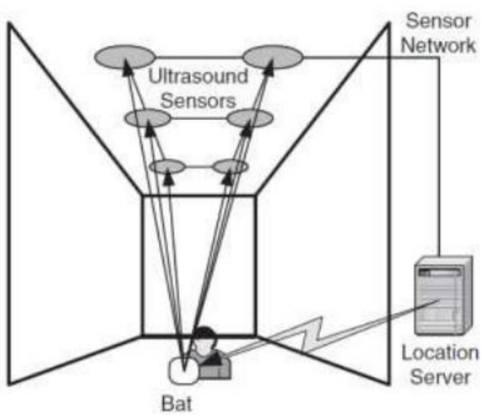

Fig. 2. The Active Bat system

All ultrasonic multilateration systems suyer from problems caused by noise interference and reflections. Noise effects can be minimised by characterising the interference sources in the environment, selecting an operating frequency at which there is little noise, and filtering around that frequency. Reflection problems are particularly severe when the trackers are used in cluttered indoor environments. Ultrasonic signals may reflect off surfaces in such a way that they reach the receiver along routes longer than the direct transmitter-receiver distance. Examples of surfaces that may generate reflected signals with significant amplitudes include walls, hard furnishings, monitor screens, and so on. Distance measurements made using a reflected signal will be longer than those made using a direct path signal and, if used unwittingly, could introduce errors into the multilateration calculation.

When dealing with reflected signals, broadband and correlation-based systems which use pulse waveforms have an advantage over narrowband systems which employ a continuous tone. Since reflected pulses travel a longer distance to a receiver than any direct pulse, they arrive at a later time, as shown in Fig. 3 and the signals are distinct. Assuming that the direct pulse reaches the receiver, the first signal detected by the receiver after the pulse emission will have travelled along the direct transmitter-receiver path. It is therefore only this first signal that is used to measure the transmitter-receiver distance, and subsequent signals can be ignored. Reflections can therefore be separated from direct signals in broadband and correlation-based systems, but reflected narrowband signals cannot be separated in this way.

Occasionally, the direct path from a transmitter to a receiver is blocked,but a reflected pulse still reaches that receiver. The first pulse detected by the receiver will then have travelled along a path that is longer than the direct transmitter-receiver distance, and the calculated distance between the two will be incorrect. If this distance is then used by the multilateration algorithm, the reported object position will be erroneous, and so efforts must be made to reject distance measurements due to reflected signals.

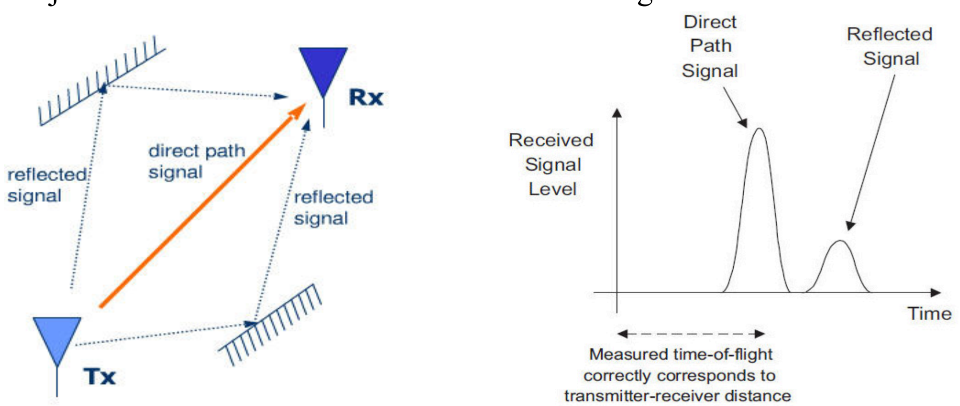

Fig. 3. Distance measurements in the presence of reflected pulses

4. Conclusions

Positioning is an important technology that is of critical importance in location based systems. A number of indoor location system have already been constructed, and several interesting applications have been developed using them. The infrared devices are cheap and easy to get, and so are often used for indoor positioning. Ultrasound devices use ultra sounds transmitters to transmit the position of a user. Sensors are placed in the building, and the transmitter sends ultra sounds signals on request. These systems utilise several different techniques for determining the positions of objects, and they found applications in many areas. Nonethereless, it seems that no existing systems has all the characteristics required of an information surce for location-aware computing.

5. References

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