"Sensor Technology for Global Positioning and Identification in Universal Computing System"

A project report/ thesis submitted to the department of Computer Science and Engineering of the "Royal University of Dhaka in partial fulfillment of the requirement for award of the degree of Master of Science in Computer Science & Engineering.

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May, 2020

LETTER OF TRANSMITTAL

20 May, 2020

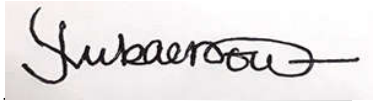
To
Mosharrof Hussain Masud,
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.

Subject: Submission of Project Report.

Dear Sir, I am pleased to submit the thesis entitled **"Sensor Technology for Global Positioning and Identification in Universal Computing System"** It was a great pleasure to work on such an important topic. The thesis is prepared according to the requirements and guidelines of the Department of Computer Science and Engineering, Royal University of Dhaka.

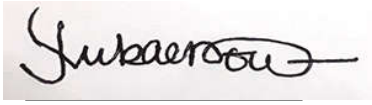
I believe that the thesis will help you in evaluating my project work. It would be a great pleasure for me to interpret any part or whole of the report whenever necessary.

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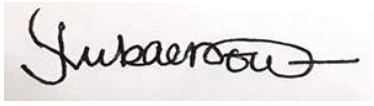
DECLARATION

I hereby solemnly declare that the project work entitled **"Sensor Technology for Global Positioning and Identification in Universal Computing System"**, has been supervised by **Mosharrof Hussain Masud,** Senior Lecturer of the department of Computer Science & Engineering, Royal University of Dhaka. I ensure that the project report has not been submitted either in whole or part for any degree or Diploma in any university previously.

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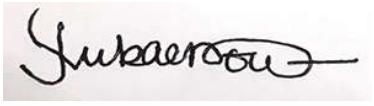
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CERTIFICATE

I hereby certify that the Project Report on **"Sensor Technology for Global Positioning and Identification in Universal computing System"** is a confide record of project work done by **Al Jubaer** for partial fulfillment of the requirements for "**Royal University of Dhaka"**.

The thesis report has been carried out under my guidance and is a record of the bona-fide work carried out successfully by the students.

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ACKNOWLEDGEMENTS

With immense pleasure, I wish to express my heartfelt gratitude to my supervisor **Mosharrof Hussain Masud,** Senior Lecturer, Department of Computer Science and Engineering**,** Royal University of Dhaka for his guidance during the course of this work. I render my appreciation to him for introducing me to the fascinating field of **Universal Computing System**. Finally, I wish to express my deep gratitude to my parents, brothers and friends in Royal University of Dhaka for their great support. Thanks go to my friend and opponent, Abdul Mannanm, Md. Nazrul, Imran, Rasel, Mehedi etc who always supported to finish my thesis.

Al Jubaer

May, 2020

ABSTRACT

Technologies for position sensing and identification are important to have in Universal computing environments. These technologies can be used to track users, devices, and artifacts in the physical milieu, for example, locating the position of a cellular phone in a physical environment. The aim of this thesis was to survey and classify available technologies for location sensing and identification. We have made a literature study on both commercial and research-oriented systems and technologies for use in indoor and outdoor environments. We compared the characteristics of the underlying sensing technologies with respect to physical size, sensing method, cost, and accuracy. We conclude the thesis with a set of recommendations to developers and discuss the requirements on future sensing technologies and their use in mobile devices and environments.

Keywords

Universal computing, Tracking, infrared (IR), Radio Frequency Identification (RFID), sensors, ultrasonic, Global Positioning Systems (GPS).

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Chapter One

Introduction

1.1 Introduction

Universal computing is a rather new area of research and has as its goal to enhance computer use by making many computers available throughout the physical environment and make them effectively invisible to the user. It can be said to be the third wave of computing after mainframe and personal computing technologies. Mark Weiser said this on Universal computing.

Work on Universal computing is still at an early phase. Currently, the research efforts are focused on new services that can be provided in the new mobile infrastructures for wireless networking. For example, if mobile devices can track their physical location in the environment applications that provide maps for can be developed. Thus, needed is knowledge of sensing technologies and their properties to allow engineers to better suit their applications to real demands. This thesis surveys available sensor systems for positioning and identification developed by commercial companies and in the research laboratories. The intended readers of this work are developers that aim to design news services and devices that make use of sensing technologies to determine and track position in the environment.

1.2 Research goal and objectives

The goal of this thesis is to survey various available sensor systems for positioning, tracking users location in the physical environment such as ultrasonic and beacon systems .

The objective of this thesis is to:

1. Survey available sensing systems for tracking positions in both outdoor and indoor environments.
2. Compare the systems with the following physical properties:
   - range, precision
   - accuracy
   - user interface
   - wireless connectivity

- size

3. Discuss important properties and emerging challenges that designers of sensor systems should address.

1.3 Conclusion

Lastly, in addition to the need for increasingly sophisticated data handling on the quantitative side of GPS-data analysis, visualisation remains in our view at the heart of the strength and relevance of using tracking technologies in urban studies. With this outlook, we see tracking studies evolving from the experimental stage to a full blown research instruments in a wide range of knowledge domains.

Chapter Two
Literature Review

This chapter introduce the area of universal computing and the underlying sensing technologies such as ultrasonic, infrared, Global Positioning Systems, and radio frequency identification.

2.1 Universal Computing

Mainframe computing in 60's-70 was characterized by massive computers that executed big data processing applications. Typically, one mainframe computer served many people. Due to developments in microelectronics e.g., integrated circuit, cost went down and made it possible to provide computing power to the masses. Desktop computing and personal computing was introduced in the 80's-90 and later connected in intranets to a massive global network. This computing can be said to be personal computing .The next predicted generation of computing is said to be Universal computing where many computing devices everywhere are connected to a person's device. This is called Universal computing or ubicomp. For example, invisible transmitters located in a room could send data to mobile phones for locating and tracking. Universal computing can be said to be – roughly - the opposite of virtual reality where people are placed inside a computer-generated world. On the contrary, Universal computing environments allow the users to live in the real world and still take advantage of the power of the computer. Characteristic of Universal computing applications is that they so to say "disappear". This means that people do not realize that they are using the devices when they perform an everyday (computer-related) task.

That is, the interface should not be "in the way" when you are using an ubicomp application. Thus, Universal computing represents profound rethinking of computer technology and its uses in real work-contexts. (Weiser, 1993).Examples of ubicomp technologies are cellular phones, tablet PCs, and digital pens.

Moreover, more advanced technologies and services are possible to develop when the appropriate sensors and computing networks are available. Examples of underlying technologies to build the envisioned ubicomp world are wireless local area networks (WLAN), bluetooth, personal area networks (PAN), RFID – technologies, Infrared based communication technologies (Ailisto & Heikki 2003).This thesis expounds on the later issue and discusses different sensor technologies for capturing user location in the real world.

2.2 Sensor technologies for identification and positioning

A sensor is a device that when exposed to a physical phenomenon such as temperature, displacement, force, etc. produces a proportional output signal (electrical, mechanical, magnetic, etc.). Sensors can be basically classified in two types such as passive and active.Active sensor systems interact with the environment and observe how signals affect the environment. Examples of active sensors are radar and sonar. Active systems work by actively controlling a probe signal in the environment and observing how interacting with the environment cause sensible changes. These changes can be compared with known observations to construct a model of the environment. Passive sensor systems measure ambient radiation of signals such as GPS, Passive motion detectors, and ambient audio.

Locations positions and shapes can be identified from sensing the environment passively.

Furthermore, sensors are classified as based on the type of output signal. analog sensors produce continuous signals that are proportional to the sensed parameter and typically require analog-to-digital conversion before feeding to the digital controller. Digital sensors on the other hand produce digital outputs that can be directly interfaced with the digital controller. Often, adding an analog-to-digital converter to the sensing unit produces the digital outputs. The term transducer is often used synonymously with sensors. A transducer is nothing but which converts one form of energy into another form of energy for example electrical energy to thermal energy and vice versa, at present

application of sensors is widely used 3- D tracking, virtual reality, accident reconstruction, crash test analysis, and helo-landing system. (John 2002).

2.1 Table : Classification of various sensors and its respective example and feature.

Sensors	Example	Features
Linear / Rotational Sensors	Hall Effect sensor	High accuracy
Acceleration Sensors	Seismic Accelerometer	Good for measuring frequencies up to 40% of its natural frequency
Force, Torque and Pressure	Ultra sonic stress sensor	Good for small force measurements
Flow Sensors	Ultra sonic type	Used for both upstream and down stream flow measurements
Temperature Sensors	Thermocouples	Cheapest, versatile sensors
Temperature Sensors	Thermostats	Very high sensitivity in medium ranges
Proximity sensors	Inductance, Photoelectric, Capacitance	Robust, non contact switching action
Light sensors	Photo Transistors, Photo diodes,	light sensity
Micro and Nano sensors	Micro CCD Image Sensor	Small size, Full field Image sensor
Smart material Sensor	Optical Fibre	Reliable and Accurate

2.3 Ultrasonic sensor

Ultrasonic is a branch of acoustics whose frequency waves are above the highest frequencies audible to the human ear. Ultrasonic vibrations (sound waves) are measured in terms of Hertz (Hz). One Hz is one wave cycle per second. The human ear is generally assumed to hear sounds with a frequency of 16 Hertz up to a limit of 20 kilohertz (20,000 cycles per second). Detection and measurement of ultrasonic waves is accomplished mainly through the use of piezoelectric receivers or by optical means. The important applications of ultrasonics are destructive Testing, Electronics, Materials Science, Oceanography, and Medical applications. Now a days there is wider use of ultrasonic technology that provides advantages for the earliest warning signs, instantaneous, more accurate at pinpointing problems, versatile and non-destructive.

2.4 Infra Red (IR)

Infrared transmissions is a means of using light to send a signal over distance. The light frequency used in infrared is above the range of visible light in the red end of the light spectrum. IR is used for transmitting a signal representing sound in many listening devices or listening systems. IR has some advantages for use in listening. It doesn't go through walls but is not affected by radio or electromagnetic signals. Its main disadvantage is only suitable for indoor applications. IR used in different applications is electrical, mechanical and building inspections, thermometer applications, photography and thermography, electro-optics, photonic devices and sensors, biological and biomedical applications, optical fibers applications.Infrared technology provides better advantages for low power requirements, low circuitry costs, simple circuitry, higher security, and portable, and disadvantages are short range, light, weather sensitive, and speed.

2.5 Global Positioning System (GPS)

The GPS is a network of satellites that continuously transmit coded Information, which makes it possible to precisely identify Locations on earth by measuring distances from the satellites. GPS is a satellite based navigation system funded and controlled by the U.S department of defence (DOD). GPS provides specially coded satellite signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity and time.

The GPS satellite system consists of the 24 satellites that make up the GPS space segment are orbiting the earth about 12,000 miles above us. They are constantly moving, making two complete orbits in less than 24 hours. These satellites are travelling at speeds of roughly 7,000 miles an hour. GPS satellites are powered by solar energy. They have backup batteries onboard to keep them running in the event of a solar eclipse, when there's no solar power. Small rocket boosters on each satellite keep them flying in the correct path. There are mainly two types of GPS, differential GPS used for Better accuracy to avoid overlapping of records, and another is server assisted GPS.GPS

satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this information and use triangulation to calculate the user's exact location. Essentially, the GPS receiver compares the time a signal was transmitted by a satellite with the time it was received.

The time difference tells the GPS receiver how far away the satellite is. Now, with distance measurements from a few more satellites, the receiver can determine the user's position and display it on the unit's electronic map. A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D position (latitude and longitude) and track movement. with four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude). Once the user's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination, sunrise and sunset time and more.

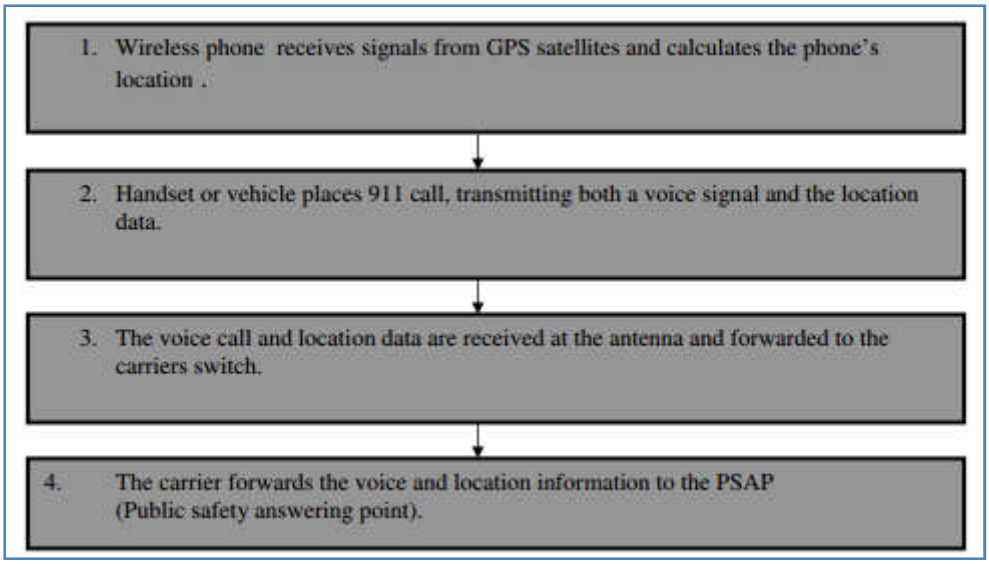


Fig 2.1 GPS Communication System

The GPS signal is provided free of charge to anyone on or near the planet with a GPS receiver and an unobstructed view of the satellites. The satellites transmit very low power radio signals allowing any one with a GPS receiver to determine their location on earth. The designers originally had a Military application in mind. The GPS allows you to

record or create locations from places on the earth and help you to navigate to and from those spots. GPS can be used everywhere except in Indoors, caves and undergrounds. (Peter 1994). The real time applications of GPS are vehicle tracking, mapping and GIS data capture, racking a species of animal using GPS, an airplane that lands itself using GPS, marine and agricultural applications, oceanography and geology, used in meteorological applications. Advantages of GPS are ease of use, reliable, accurate, efficient and absolute recording of position.

2.6 Radio Frequency identification (RFID)

A basic RFID system is an instrument consisting of three components an antenna or coil, transceiver with decoder and a transponder (RF tag) electronically programmed with unique information,that is a unique identification number.

The range of RFID systems vary depending on what they are designed for, range differs between and contact and up to20m. The difference is caused by different power usage and used frequency, because RFID systems generate and radiate electromagnetic waves, they are justifiably classified as radio systems. The function of other radio services must under no circumstances be disrupted or impaired by the operation of RFID systems. It is particularly important to ensure that RFID systems do not interfere with nearby radio and television, mobile radio services (police, security services, industry), marine and aeronautical radio services and mobile telephones. The need to exercise care with regard to other radio services significantly restricts the range of suitable operating frequencies available to an RFID system. For this reason, it is usually only possible to use frequency ranges that have been reserved specifically for industrial, scientific or medical applications or for short-range devices. These are the frequencies classified worldwide as ISM frequency ranges (IndustrialScientific-Medical) or SRD frequency ranges, and they can also be used for RFID applications.

RFID tags are categorized as either active or passive. Active RFID tags are powered by an internal battery and are typically read and write, i.e., tag data can be rewritten and

modified. An active tag's memory size varies according to application requirements; some systems operate with up to 1MB of memory. The battery-supplied power of an active tag generally gives it a longer read range. The trade off is greater size, greater cost, and a limited operational life.

Passive RFID tags operate without a separate external power source and obtain operating power generated from the reader. Passive tags are consequently much lighter than active tags, less expensive, and offer a virtually unlimited operation time, trade off is that they have shorter read ranges than active tags and require a higher-powered reader. Read-only tags are typically passive, programmed with a unique set of data and most often operate as a license plate into a database, in the same way as linear barcodes reference a database containing modifiable product-specific information (Klaus ,1998).

2.2 Table : Frequency chart for different ranges of RFIDs

Frequency Ranges	Applications and Comments
Less than 135kHz	Animal tagging, access control and track and traceability.
1.95 MHz, to 8.2MHz	Electronic article surveillance (EAS) systems used in retail stores
13 MHz to 13.56MHz	EAS systems and ISM (Industrial, Scientific and Medical)
Approx. 27 MHz	ISM applications
918 to 926 MHz	RFID in Australia for transmitters with EIRP less than 1 watt
2350 - 2450 MHz	IEEE 802.11 recognises this band as acceptable for RF communications and both spread spectrum and narrow band systems are in use.
5400 - 6800 MHz	This band is allocated for future use.

The significant advantages of all RFID systems are non-contact, on-line-of-Sight and nature of the technology, tags can be read through a variety of substances such as snow, fog, ice, paint and other visually and environmentally challenging conditions and RFID tags can also be read in challenging circumstances at remarkable speeds, less than 100

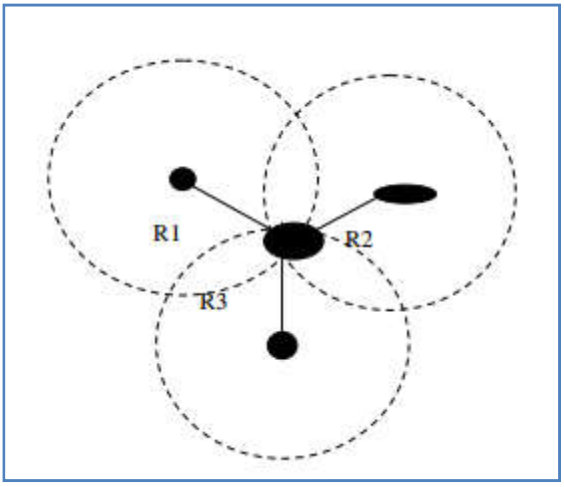
milliseconds. A disadvantage of RFID systems mainly lies withinterference, lack of security, lower speed.

2.7 Location Sensing

The three important techniques are used for automatic location sensing triangulation, scene analysis, proximity.

2.8 Triangulation

The triangulation method uses the geometric properties of triangles to compute object locations, This method is divided subcategories of lateration,distant measurements and angulations. Lateration is defined as 'to mean for distance measurements what angulation's means for angles'. It computes the position of an object by measuring its distance from multiple reference positions. Calculating an objects position in two dimensions requires distance measurements from 3 non-collinear points as shown in the below figure.



2.2 Figure: Determining 2D positions using lateration requires distance measurements between the object and 3 non-collinear points.

A bat's 3-dimensional position can be determined by using three measurements because the sensors in the ceiling are always on top of the receiver. The geometric ambiguity of only 3 distance measurements can be resolved because the bat is known to be below the sensors.

There are three general approaches to measuring the distances required by the lateration technique are direct method, Time-of-flight and attenuation. In direct measurement the distance uses a physical action or movement. These measurements are simple to understand but difficult to obtain automatically due to the complexities involved in co-ordinating autonomous physical movement. In Time-of-flight the measuring distance from an object to some Point P using Time-of-flight means measuring the time it takes travel between the object and point P at known velocity. When only one measurement is needed, as with roundtrip sound or radar reflections, “agreement" is simple because the transmitting object is also the receiver and must simply maintain its own time with sufficient precision to compute the distance. Time-of-flight location-sensing systems include GPS, the Active Bat location System, and the Cricket Location Support System (Hightower & Borriello 2001). Angulation method is almost similar to lateration. In this method angles are used the determine the position of an object, in general two-dimensional angulations requires two angle measurements and One-length measurements such as the distance between the reference points. The VHF omni directional ranging (VOR) aircraft navigation system is a different example of the angulations technique.

2.9 Scene Analysis

The scene analysis location-sensing technique uses features of a scene observed from a particular vantage point to draw conclusions about the location of the observer or of objects in the scene, usually the observed scenes are simplified to obtain features that is easy to represent and compare. In static scene analysis, observed features are looked up in a predefined dataset that maps them to object locations. In contrast, differential scene analysis tracks the difference between successive scenes to estimate location. Differences in the scenes will correspond to movements of the observer and if features in the scenes are known to be at specific positions, the observer can compute its own position relative to them. The advantage of scene analysis is that the location of objects can be inferred using passive observation and features that do not correspond to geometric angles or

distances. The disadvantage of scene analysis is that the observer needs to have access to the features of the environment against which it will compare its observed scenes.

2.10 Proximity

A location can be determined as being proximal to a known reference point, within a specific limited range. The three main approaches for sensing proximity are detecting physical contact, monitoring wireless cellular access points and observing automatic identification systems.

2.11 Properties of Location Sensing System

2.11.1 Physical Position and Symbolic Location

Location systems can be classified into physical or symbolic. Physical information provides the position of a location on a physical coordinate, for example Linköpings University is at 51 degrees 31' 17'' N by 100 degrees 7'46'' W at 4.5m elevations. Symbolic location information gives descriptions of location for example the Pc lab at Linköpings university. The distinction between physical position and symbolic location is more pronounced with some technologies than others. GPS is clearly a physical positioning technology. Point-ofsale logs, bar code scanners, and systems that monitor computer login activity are symbolic location technologies mostly based on proximity to known objects. However, some systems such as cricket can be used in either mode, depending on their specific configuration.

2.12 Absolute Vs. Relative

An absolute location system uses a shared reference grid for all located objects, while in a relative system, each object can have its own frame of reference. An absolute location can be transformed into a relative location .That is relative to a second reference point. However, a second absolute location is not always available. In reverse, we can use triangulation to determine an absolute position from multiple relative readings if we

know the absolute position of the reference points. But we often can't know these positions if the reference points are themselves mobile. Thus, the absolute versus relative distinction denotes primarily what information is available and how the system uses it rather than any other capabilities.

2.13 Accuracy and Precision

The property of the smaller distance that a system can differentiate is called the accuracy of the system. A location system should report locations accurately and consistent from measurement to measurement.Some inexpensive GPS receivers can locate positions to within 10 meters for approximately 95 percent of measurements more expensive differential units usually do much better, Reaching 1 to 3 meter accuracies 99 percent of time, these distances denote the accuracy, or grain size of the position Information .GPS can provide accuracy and precision are often the two axes of a trade-off: less accuracy may be traded for more precision. Thus, using only one of the two attributes of spatial location is not a suitable measure for comparison of location sensing systems. Rather, location systems should be assessed on the basis of the error distribution incurred when locating objects, taking into account any dependencies. Although accuracy and precision are suitable measures of the effectiveness of location sensing technologies they cannot be considered in isolation to the overall system that employs location information. It is possible to combine the position data with other information available on the system to improve the prediction of location. For example, in a IEEE 802.11b wireless local area network the position of a mobile station can be estimated from signal strength readings at the base station resulting in location estimation with accuracy of approximately 4.5 meters (Jay chaeyong 2000).

2.14 Localized Location Computation (LLC)

Sensing systems will provide a location capability and insist that the object being located its own position. Personal-badge-location systems fit into this category as bar codes and the radio frequency identification tags that prevent merchandise theft, track shipments

and help identify Livestock. The policy for manipulating location data need not be dictated where the computation is performed.

2.15 Scale

Location sensing systems may be able to locate objects worldwide within a metropolitan area ,throughout a campus in a university, or with in a single room. Further number of objects the System can locate with a certain amount of infrastructure or over a given time may be limited. To access the scale of a location sensing system we consider its coverage area per unit of infrastructure and the number of objects the system can locate per unit of infrastructure per time interval. Time is an important consideration because of the limited bandwidth available in sensing objects systems can often expand to a larger scale by increasing the Infrastructure. For e.g. a tag system that locates objects in a single building can operate on a campus by outfitting all campus Buildings and out doors areas with the necessary sensor infrastructures.

2.16 Recognition

To recognise or classify located objects and record a specific action based on their location, an automatic identification mechanism is needed. GPS satellites have no inherent mechanism for recognizing individual receivers. Systems with recognizing capability may recognize only some feature types. For example camera and vision systems can easily distinguish the colour or shape of an object but cannot automatically recognize individual people. A general technique for providing recognition capability assigns names or globally unique ids (GUID) to object the system locates. Once a tag, badge, or a label on the object reveals its GUID, the infrastructure can access an external database to look up the name type or other semantic information about the object.

2.17 Cost

The cost of a location sensing system is defined by different types. Time costs include factors such as installation processes, length and system's maintenance costs. Space costs involve the amount of installed infrastructure and the hardware's size and form factor. Capital costs include factors such as the price per mobile Unit or infrastructure element and the salaries of the support Personnel. A simple civilian GPS receiver costs around $100 and represents the incremental cost of making new object position able independently of its global location .A system that uses Infrared beacons for broad-casting room Ids requires a beacon. For every room in which users want the system to find.

2.18 Conclusion

To conclude this paper we would like to indicate a number of future developments in light of the experiments by Universal Computing system. We want to highlight the following developments: (1) the almost Universal availability of geo positioning data in a nearby future, (2) the combination of positioning sensors with other types of sensors, (3) automation of data collection and processing, (4) the evaluative capacities of tracking technologies, and (5) the increased relevance of multiple, visual environments to communicate results from tracking studies. Firstly, the above section showed that the scale of experiments is limited considerably because of logistical and data processing concerns when using the current generation of available GPS devices. If GPS would be available wider and people could just share their tracks, the only thing needed is a platform and a set of protocols to upload spatial-temporal data. This would enable open-source collection of spatial-temporal data and therefore feature GPS as a worldwide applicable sensor technique collecting spatial-temporal data, quantitative information and qualitative information. Secondly, we foresee that combining GPS with other types of sensors, such as those measuring air quality, and sensory and emotional experiences of people would enable a next generation of tracking research to offer more directly

applicable knowledge to the field of urban planning and design. This would require the development of new process architectures that combine several different data sets and the connection of data flows from stationary and mobile sensors.

Chapter Three
Research Methodology

3.1 Introduction

Information is required to prepare a research report about any selected topic. The standard of the research/thesis report will increase as much as the information and data included. Methodology involves processes and techniques of the different steps in the way of completing any project. The stages of collecting data, systematic guidelines etc. are also included in the methodology of a research or a thesis or a project. Here several data sources and methodologies are adopted for certain research/thesis work. The success of a study depends on the methodology of it. The findings of the research/thesis depend on the systematic works and critical analysis. So the systematic surveying, the plan of research/thesis, used methods for data collection and analysis are the main subject matter of discussion in this chapter.

This chapter discuss our research methodology. The chapter briefly introduces qualitative research methods for information or data collection through literature study such as reports, books, articles etc.

3.2 Qualitative research

Qualitative research methods are used to explore social and cultural phenomena. The data sources can be observation, fieldwork, documents, text, newspaper, or any material in form of books, articles that are or yet to be published etc. Whereas quantitative approaches are used for natural science such as laboratory experiments records, statistical data, mathematical modeling etc.

This report uses qualitative method of surveys i.e. a non-experimental, descriptive research method, and they are used to survey various sensor systems for position and tracking and compare their physical properties. For example, literature studies of location based sensing technology and other sensor system surveys can function as a basis for finding new features and overcoming various limitations (Michael 1997).

There is a need to compile and summarize the available knowledge in the area. We choose a qualitative approach and survey study design because we wanted to explore existing available and future sensor system.

3.3 Data Collection and Analysis

This study comprised data mainly research papers, journal articles and books. Additional information was collected from the web and other non-peer review literature.

The data was analyzed to find relevant comparable variables (i.e., properties of the systems) such as accuracy, range, and precision etc. The systems were then classified and compared according to the variables we found in the first stage. The result was two charts summarizing the properties of the different location and sensing technologies.

3.4 Conclusion

Research without method means research without guide. It should be systematic and logical. So research methodology is the most essential and significant approach leading to penetrate into the problem and solution in the entire research work. This research is mainly secondary data based. So this is the most important chapter of the research. Data sources and methods how to manipulate or arranged these are focused in this chapter. From this data and methods chapter, one can gather information of study issues and able to interpret data from selected methodology. Finally it can be concluded that adequate data and proper methodology is essential to conduct a good quality research.

Chapter Four
Project Description

4.1 Introduction

This thesis explored available sensor systems for tracking users location in the physical environment such as ultrasonic and beacon systems and it discuss the properties of location sensing systems to establish a basis on which to compare their capabilities and in terms of sensor range, precision, accuracy. It also examined common limitations of these sensor approaches.

4.2 Thesis Description

Most of the systems examined use approaches such as ultrasonic, GPS, and RFID to track and identify the user in the environment. A general limitation of these sensor approaches is that there is no location system to function appropriately in outdoor and indoor environments. Further, there are some location-tracking systems such as hybrid systems based on network domains and they are not specifically targeted for indoor or outdoor systems.For mobile applications, it is required that the sensors systems are low-wattage, especially on the receiver side. Different location systems have different accuracies, scale, cost, precision and also there are lot of limitation with every location system and thus there is a need for researcher to overcome this limitation in the areas where this technology is applied and carryout research for future sensor system. This can provide a good complement to the current interest in future sensing system.

There are some interesting sensor systems that we have omitted in this report. It is the oxygen system aims to bring an abundance of computation and communication to users through natural spoken and visual interfaces, making it easy for them to collaborate, access knowledge, and automate repetitive tasks.

Moreover, WLAN positioning is interesting. This approach can be done by setting a cellular system based on the IEEE 802.11 wireless Ethernet cells can be distinct by the range of their

WLAN 802.11 base stations and positioning sensor component on a mobile device is able to determine current location via listening beacons from cell servers. Nevertheless, ubiquitous computing will significantly improve the advantages of IT-based services. When access to the web is everywhere, and when users position in the environment can be tracked a range of the services will be possible. For example, human movement tracking technology. Even though, IT in general has achieved these advantages to certain extent, the proliferation of ubiquitous computing will drastically improve all these advantages.

Chapter Five
Analysis of results

5.1 Introduction

This chapter gives an introduction to the identified systems for positioning and tracking for use in both indoor and outdoor environments. The remainder of the chapter provides a comparison of the systems.

5.2 Indoor Sensor Systems

5.2.1 Active Badges

The active badge location system was developed at Olivetti Research Laboratory, now AT &T Cambridge. This is the first indoor badge sensing system, and it uses cellular proximity system that employ diffuse Infrared technology. Each person the system can locate wears a small infrared badge Shown in the figure. The badge emits a globally unique identifier every 10 seconds or on demand. A central server collects this data from infrared sensors around the buildings, aggregates it and provides an application-programming interface for using the data. The active badge system provides absolute location information. A badge location is symbolic.

Active badges have difficulty in locations with fluorescent lighting or direct sunlight because of the spurious Infrared emissions these light sources generate. Diffuse infrared has an Effective range of several meters, which limits cell sizes to small, or Medium sized rooms. The limitations for active badge are Indoors only, Difficulty in locations with fluorescent light or sunlight, which generates Infrared emissions, Ranges over some meters, for larger areas, uses multiple infrared beacons (Hightower, Roy & Borriello 2001).

5.2.2 Active Bat

The Active Bat location systems was also developed by AT & T researchers .This location system uses an ultra sound time-of-flight lateration technique to provide more accurate physical positioning than active badges. Users and objects carry active bat tags. It combines a 3-D ultrasonic location system with a pervasive wireless network. It sends sound waves that are picked up by three or more nodes. In a grid of receivers placed throughout a building, usually above the ceiling tiles. Receivers measure the speed of the sound waves from the active bat that calculates the distance from the wearer to the receiver and can depict the wearer in a 3-D picture of his environment. It also requires large sensor Infrastructure ultrasound-tracking technology, wireless badges to all, and privacy issues. It can also compute orientation information given predefined knowledge about the placement of bats on the rigid form of an object and Allowing for the ease with which ultrasound is obstructed. Each bat has a Globally Unique ID's (GUID) for addressing and recognition. The limitations for active bat are Indoors only and required Ceiling sensor grids. (Hightower, Roy & Borriello 2001).

5.2.3 Cricket Match

The cricket location Support system is developed by researchers at MIT and provides low cost position estimation using a network of beacons, combination of RF and Ultrasound Technologies. The system is decentralized in that each component of the system whether fixed or mobile is configured independently, no central entity is used to register or synchronize elements. User privacy is maintained by allowing mobile elements to compute their Location locally without any outside communication. Mobile elements may then use that information locally or choose to advertise it to higher level, remote services (Priyantha, Chakraborty & Hari, 2000).

Cricket computes distances using the TDOA of synchronized RF and ultrasound signals. Each beacon emits an RF pulse uniquely identifying the space it occupies. Mobile units compute the distance traveled by each Beacon signal it hears, for each beacon the mobile unit sorts the distance into ten-inch increments and counts the

number of signals it hears in each Increment. Since beacons are configured independently and do not directly Communicate, there is the potential for beacon signals to interfere with each other. Cricket avoids extensive interference by introducing randomization, beacons choose the delay from one signal broad cast to the next uniformly at random from within interval 50 to 350 smiths each beacon has an average frequency of four broadcasts per second, the broadcast times are statistically independent.

A second difficulty of the cricket design derives from the fact that the RF signals used to have greater range than ultrasound signals. The result is that it is possible when two beacons in proximate rooms broadcast nearly simultaneously that a mobile receiver will associate the RF signal Of a beacon in the adjacent room with the ultrasound signal from the Beacon collocated with the receiver. Cricket need only name the room in which a mobile element resides, cricket achieves over 95 % accuracy at this relatively low level of precision. Only one stationary beacon unit is required per room, the cost of scaling of the system geographically is quite reasonable. The advantage of cricket are privacy and decentralized scalability, while the disadvantages are lack of centralized management or monitoring and the Computational burden and consequently power burden (High & want,2001).

5.2.4 Radio Detecting and Ranging (RADAR)

RADAR was developed by Microsoft research group, and it is a building-wide tracking system based on the IEEE 802.11 WLAN.It measures signal strength and SNR of signals received to compute the 2D Position with in a building position in an area. Radar uses signal strength information gathered at multiple receiver locations to triangulate the user's coordinates in a room.Triangulation is done using both empirically determined and theoretically computed signal strength information.Radar is able to estimate a users location to with in a few meters of an actual location. Tracking a mobile user rather than locating a stationary user by reducing the problem of tracking the mobile user to a sequence of location determination problems for a user. The location uses no custom

hardware; an RF Transceiver (base station) acts as a bridge between the wireless and the wired networks. Radar location method is performed in two phases, first in an off-line phase, the system is calibrated and a model is constructed of received signal Strengths at a finite number of locations distributed about the target area. Second during online operation in the target area, mobile units report the signal strengths received from each base stations and the system determines the best match between the online observations and any point of the offline model. The radar has different design goals, it has to handle network heterogeneity and privacy concerns, low management costs (Paramvir ,Venkata & Padmanabhan,2000).

5.2.5 Pin Point

3D-iD pinpoint is a commercial location system positioned to compete with retail electronic alarm systems. Pinpoint uses RF round trip times to do ranging, like active bats it uses an installed array of antennas at known positions to perform multilateration. When a mobile tag receives a broadcast the tag immediately rebroadcasts it on a different frequency modulation with the tag's identifier cell controller.The number of broadcasts are typically kept low to extend operational lifetime. Pin points 3D –iD performs indoor positioning tracking using proprietary base stations and tag hardware.The system achieves 1 to 3 meter accuracy. The disadvantage that each antenna has a narrow cone of influence, which can make ubiquitous deployment prohibitively expensive. It is mainly used in large indoor space settings such as hospitals or houses.

5.2.6 Motion Star Magnetic Tracker

Motion star is the most cost-effective means of tracking full body motions in the world today. Tracking system such as motion star sense precise physical and relative positions. Magnetic Trackers do not have any line of sight problems they can track even if there is an obstruction between the transmitter and the receiver. Its important features are tracks multiple character simultaneously, highly portable, real-time motion capture. The

Advantages are the sensors of magnetic trackers are small and light in weight, hence the users can wear them comfortably, High precision and accuracy, High Update rates are available.The main disadvantage of magnetic trackers is that of distortion and more expensive.

5.2.7 Easy Living

Microsoft research group developed the easy living location sensing systems.It uses real time 3D cameras to provide stereo-vision positioning capability in a home environment. The easy living system keeps track of devices etc in a room, and lot of processing power is required to analyze frames captured. It is difficult to maintain accuracy since vision technology struggles with analysis accuracy. The dependence on infrastructure processing power, along with public awareness of Ubiquitous Cameras, can limit the scalability or suitability of vision location systems such as these in many applications (Tower,2001).

5.2.8 Smart Floor

Smart floor aims to identify and track a user around an instrumented space. This floor system may be used to transparently identify users in their everyday living and working environments. In the environment, Light comes on and off based on the users location and an appropriate set of audio speakers can be selected using knowledge of the location of the speaker and user. The easy living as four different sensors to measure location and identity, cameras, pressure mats, a thumbprint reader and a keyboard login system3-D Stereo camera made by point grey research measure the location of foreground people-shaped blobs and reports position measurements as a 3 coordinate tuple, The pressure mats periodically report their binary state, i.e. whether a person is sitting or standing on them.The thumbprint reader and the login system report once when ever some one uses them to identify themselves the person tracking module implements the fusion layer in easy living It combines past person track history, knowledge about where people are likely to appear in the room pressure-mat measurements and the most recent camera

measurements to produce A data base of continually update estimates of where particular people are located (Tower, 2001).

5.2.9 Enhanced 911 (E911)

E 911 is the US Federal Communications Commission (FCC) Commercial for location based services. E 911 is used to determine cellular phones location and can be use in applications that find nearest gas station, post office etc. The FCC has mandated that all mobile telephone vendors be able to locate the mobile units in case of an emergency. The FCC standard will require receiver based techniques to locate 95 % of calls with 150 m and transmitter based technique to perform the same task to a Precision of 300m, many approaches to the problem are being taken by vendors including antenna proximity, angulation, multilateration via signal strength and time of flight as well as GPS enable hand sets (Tower,2001).

5.3 Outdoor Sensing Systems

5.3.1 Global Positioning Systems

The global positioning system is probably the most widely known satellite navigation system of transmitting satellites worldwide. Anywhere a mobile receiver can obtain line of site to four of the satellites, it can locally perform a multilateration computation with average estimated error of just 35m.GPS is unique in that it uses multiple synchronized sources with known locations and a single receiver with unknown location to determine a position. The satellites use atomic clocks to maintain synchronization and precise models of satellite motion to predict satellite positions at the time of broadcast, unfortunately GPS signals do not penetrate well in all physical environments. The transmitted signals are weak and they can be blocked by walls and even trees. The measurement of position is one of the fundamental requirements Of location aware computing (Heidemann & Estrin, 2000).GPS provides physical position and absolute locations, inexpensive GPS Receivers can even determine and locate positions to with in 10 meters for approximately 95 % of measurements. One difficulty with GPS is that its receivers usually cannot detect the satellites transmission indoors. However there are commercial systems that

bridge the gap between outdoor and indoor location sensing systems such as server-assisted GPS and Differential GPS.

5.3.2 Server-Assisted GPS

Lucent has announced a system that uses a stationary server to assist Indoor mobile receivers to acquire GPS signals. The base station continuously tracks the GPS satellites via antennas. When a mobile unit needs to be located, it obtains information from the fixed server instead, which in can be said to enhance the mobile units sensitivity to the relevant GPS signals, enabling it to collect enough information with in 1 second for its position to be calculated. The system is inherently a differential GPS system. Differential GPS systems are able to eliminate some of the errors purposefully introduced into the civilian system.The signal errors that effect GPS are signal multipath, receiver clock errors, number of satellites visible, orbital errors, Satellite geometry, Ionosphere and Troposphere delays. These errors lead to intentional degradation of the satellite signal.

5..3.3 Comparison

The following section provides a comparison of the surveyed sensing systems with respect of accuracy and precision, scale, cost and limitations as defined in chapter two.

5.1 Table: Comparison of Different location sensing technologies

Technology	Accuracy and Precision	Scale	Cost	Limitations
Active badges	Room Size	One base per room, badge per base per 10 sec	In expensive	Sunlight and fluorescent interference with infrared
Active bats	9cm (95 %)	1 base per 100m,25 Computation per room	Cheap tags and sensors, inexpensive	Required Ceiling grids
Easy Living	Variable	3 cameras per small room	Processing power,Installed	Ubiquitous Public cameras

			cameras,expensive	
Smart floor	Spacing of pressure sensors (100 %)	Complete sensor grid per floor	Installation of sensor grid, expensive	May not scale upto Large populations
E 911	150m –300m (95 %)	Density of cellular infrastructure	Cell Infrastructure, Expensive	Only where cell Coverage exists
Pin point 3D-iD	1-3 m	Several bases per building	Expensive hardware and infrastructure installation	Proprietary 802.11 interference
Motion Star	1mm,1ms(nearly 100 %)	Controller per Scene,108 sensors per scene	Controlled scenes, expensive hardware	Control unit tether,precise installation
Radar	3 to 4.5 m(50 %)	3 bases per floor	802.11 network installation,expensive	Wireless NICs required
Cricket	4*4 ft region (100%)	1 beacon per 16 square feet	Expensive	No central Management, receiver computation.
GPS	1 to 5 meters (95 –99 %)	24 satellites world wide	Too expensive infrastructure	Stricted to outdoors only

5.4 Conclusion

The enhancement of GPS technology enables the use of GPS devices not only as navigation and orientation tools, but also as instruments used to capture travelled routes: as sensors that measure activity on a city scale or the regional scale. TU Delft developed a process and database architecture for collecting data on pedestrian movement in three European city centres, Norwich, Rouen and Koblenz, and in another experiment for collecting activity data of 13 families in Almere for one week. The question posed in this paper is: what is the value of GPS as 'sensor technology' measuring activities of people? The conclusion is that GPS offers a widely useable instrument to collect invaluable spatial-temporal data on different scales and in different

settings adding new layers of knowledge to urban studies, but the use of GPS-technology and deployment of GPS-devices still offers significant challenges for future research.

Chapter Six

Conclusion

6.1 Conclusion

We have studied sensor technologies for tracking users' position in physical space. First, we studied technologies and systems that are used in indoor environments like active badges and bats, the Easy living project, Easy floor, Radar, Cricket, Motion star, Smart floor and outdoor system like GPS. The properties of the underlying sensor technologies used in these systems were examined and classified according to accuracy, precision, scale, cost and additional limitation.For outdoor environments, basically, GPS is the only functional system to be used with

mobile devices. Today the GPS receivers are rather inexpensive and can locate positions to with in 10 meters for approximately 95 % of measurements, the other hand outdoors technologies GPS has 1-5 meter resolution with 24 satellite working to operate indeed too expensive technology that work only outdoors. One difficulty with GPS is that receivers usually cannot detect the satellites transmission indoors, caves and undergrounds. For indoor environments, an inexpensive choice for positioning is ultrasound solutions like the active bat system. Active badge systems can probably be used in domestic and industrial facilities like offices. Moreover, the WiFi-based (802.11) is also an inexpensive and the accuracy and precision of this technology are 3 to 4.5 meters and 50%. Next generation sensor technology should be functional in both indoor and outdoor environments and be transparent for the user (that is, the users should not be aware of the underlying sensing technology). Thus, sensor fusion and similar approaches to merge data seems to be important without for positioning and identification, example of current sension fusion research.

The comparison shows that various indoor technologies work optimally under different circumstances. However, a general issue is that trade-off between range and energy consumption. Nevertheless, then these kinds of sensing technologies emerge commercially, there will be a range of new services available in physical milieus like shopping malls, museums, airports, and restaurants. Exactly how these services should be designed is still a question.

Limitation

6.2 Limitation

A final consideration for location sensing systems is their limitations. Since the majority of them depend on the propagation properties of radio through space their effectiveness and efficiency is correlated to the environment. For example, in this section we noted that the scope of GPS is global. However, GPS receivers are unable to operate effectively in two situations: first, when they are in an urban canyon that is a artificial canyon structure created by very high buildings and second indoors where the signals are very weak. Some systems will not function in certain environments. ‘One Difficulty with GPS is that receivers usually cannot detect the Satellites transmission indoors. This limitation has implications for the kind of applications we can build using GPS.A possible solution that maintains GPS interaction yet works Indoor uses a system of GPS repeaters mounted at the edge of buildings to rebroadcast the signal inside. Some tagging systems can read tags properly only when a Single tag is present.

Chapter Seven
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