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SENSOR BASED INDOOR NAVIGATION SYSTEM USING INERTIAL NAVIGATION ALGORITHM

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ABSTRACT

This paper describes the evaluation of an indoor navigation system for pedestrians based on a small Low-Cost Inertial Navigation System (INS). The focus of the paper is the transition from outdoor to indoor scenarios. The proposed scheme is the optimal integration of the sensor data from the small Indoor Navigation system with Global Positioning system (INS /GPS) with other sensors e.g. cameras and GIS with a self-programmed Kalman Filter (KF).

KEYWORDS: *navigation system, Global Positioning system, information, communication*

1. INTRODUCTION

Navigation under conditions with only insufficient or no satellite coverage is commonly known as indoor navigation. As satellite-based navigation techniques are well-researched and its navigation solutions available to the public, the need arises for equally efficient and portable solutions indoors. Examples include large public office buildings, shopping malls, or even support technology for visually impaired people or the elderly.

This introduction presents an overview of current indoor navigation techniques, highlighting the underlying principles, prerequisites and limitations. Among the most important solutions presented are the satellite-based navigation method and inertial navigation systems. Combinations are deemed successful, if the resulting positioning accuracy is higher than the individual accuracies.

Mobility and mobile information technology have become an integrated part of modern civilization and culture. The increasing capabilities of current mobile phones have turned them into portable information, communication and navigation devices, thereby putting the vast information available on the internet into a local context. Location-based services, delivering the locally relevant information to the phone just in time, are a growing part of the web-service industry.

As long as the mobile device is used in outside areas, where there is sufficient satellite coverage for GPS positioning, the location can be determined very well. However, once a building is entered, i.e. an area with insufficient satellite coverage, the position becomes either invalid, or, if positioning is achieved through the cellular network, not accurate enough for navigational purposes. The industry already provides several dedicated solutions addressing the issue of indoor navigation. However, research is still ongoing, focusing on the ideal combination of solutions, which can be considered feasible.

2.1 INDOOR NAVIGATION TECHNOLOGY

Conditions present during indoor navigation almost imply the absence of viable satellite signals, with some exceptions. Accuracies vary, depending on the particular implementation and the environmental conditions, especially distribution density of receivers and the complexity of the building to be navigated. An empty hall as compared to a cluttered, multi-storey shopping mall does significantly affect the individual systems performances.

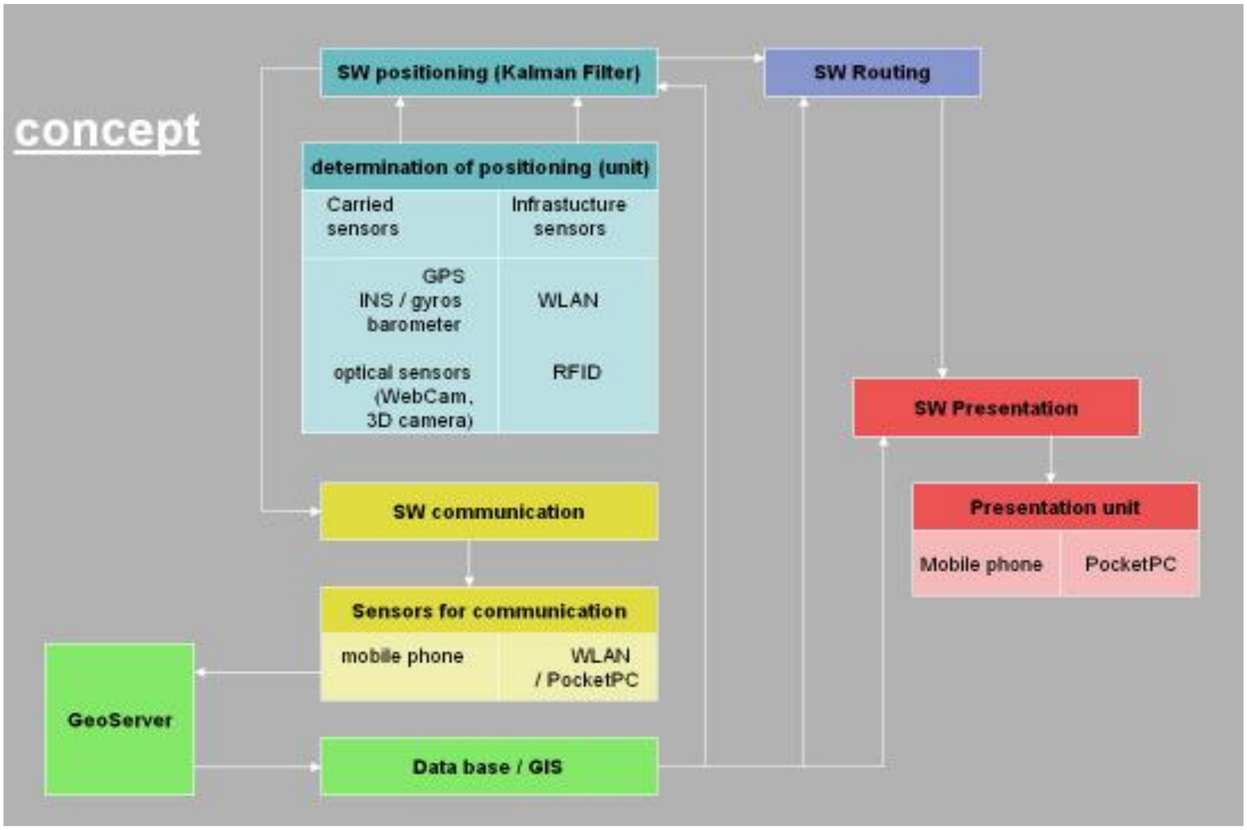
2.2 SATELLITE-BASED TECHNIQUES

Satellite-based navigation techniques are among the most prevalent solutions to date. In Global Navigation Satellite systems (GNSS), the satellites continually transmit their position and a highly accurate time-signal. The receivers measure the time of travel of the signal. This determines distance from the satellite combined with the knowledge of the satellite‟s position in space results with the calculation as a three dimensional arc section in an area of possible locations on the earth‟s surface in the shape of a circle. The receivers are not equipped with high-precision clocks to measure the time of travel. Thus a fourth signal is required to precisely determine the time. Satellite-based navigation systems require an unblocked line of sight between the satellite and the receiver to function properly. If this prerequisite is not met, satellite navigation is degraded. In those cases other methods like assisted GPS (aGPS) in combination with the cellular network or high sensitive receivers are needed. Using high sensitive GPS systems in indoor environments also requires the properties of the materials on the direct line of sight to the satellite and multipath models to correct the time of arrival of the satellite signals. However, even partial signal coverage may be used to supplement other positioning techniques. Under ideal conditions, an accuracy of a few meters or less can be achieved depending on the number of available satellites and employed aids.

2.2 INERTIAL NAVIGATION

An INS‟ core unit is the *inertial measurement unit* or IMU, which consists of linear accelerometers and angular rate sensors. The measured gravimetric information is used in an algorithm to compute first the velocity vector and then the position vector by integration of the specific forces acting on the IMU. As IMUs only measure specific forces, they cannot be perturbed by other external inputs. Also, IMUs tend to have a relatively high update rate. Highly accurate IMUs use relatively large laser-gyroscopes and pendulum accelerometers to make the gravimetric measurements. However the semiconductor-based MEMS (*micro-electro-mechanical system*) sensors make this type of navigation technique ready for hand-held and mobile device integration. For initialization, the INS requires a position fix and an initial orientation. These are usually provided by a GPS antenna and a magnetometer. A barometric pressure sensor is used in addition to stabilize the altitude measurement. The IMU always measures total acceleration, since it is technically impossible to measure the required specific forces independently from acceleration due to gravity. Hence, acceleration due to gravity is estimated using present position and an earth model, and then added to the measurement. Modeling errors and measurement noise, and the accuracy of the initial fix tend to adversely affect INS accuracies: If unsupported by external, independent position updates, the navigation solution tends to drift and become unviable after a short time, depending on sensor quality.

3.0 PROPOSED WORK



The focus in this project is on the evaluation of low-cost INS with integrated GPS sensors and its utilisation for indoor navigation. The core of the Indoor navigation system is the determination of the position. Here different positioning techniques are possible. We focus on a solution free of infrastructure sensors. A positioning unit consists of the basic sensor: IMU, GPS and barometer. Additional sensors to support the orientation in the building could be optical sensors like webcam or 3D cameras.

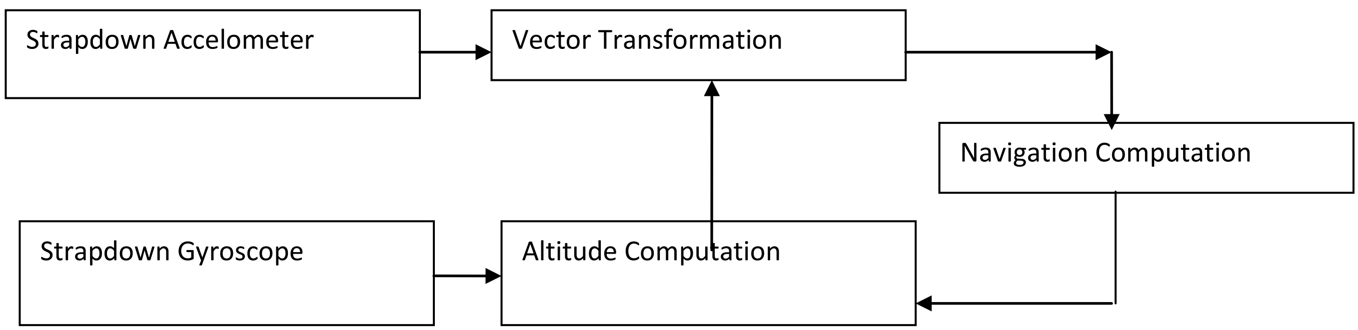
The communication and data streaming is important for the exchange of building information from and to the geoserver. This data maintain the process of the routing but also of the determination of the position. At least we need an interface to present the result of the navigation process to the user in a user friendly manner.

Positioning Algorithms:-

In the proposed concept, we use Strapdown and pedestrian dead reckoning algorithms along with the extended kalman filters are used for measured data processing and position.

3.1 Strapdown algorithm:-

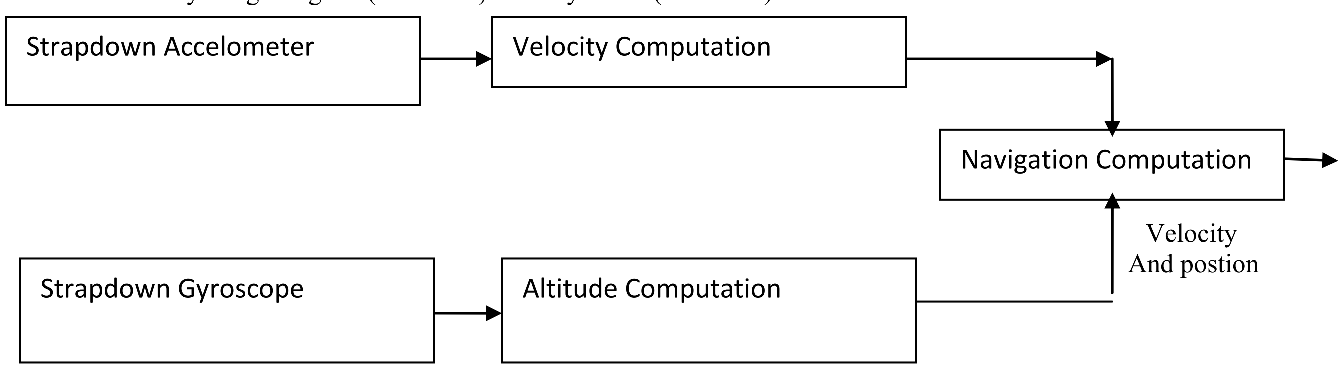
The strapdown algorithm first computes the INS orientation from the measurements provided by the angular rate sensors. Thus obtained orientation is then used to transform the measured accelerations into the navigation coordinate frame and to be able to correctly add the estimated gravity acceleration. The results are the specific forces acting on the body in the correct coordinate frame required for the double integration process which eventually yields the position update. An accurate determination of the body"s orientation is thus crucial for the quality of the calculated position.



Strapdown algorithm inside positioning unit

3.2 Pedestrian dead reckoning:-

Pedestrian dead reckoning (PDR) is a two-part algorithm, namely velocity estimation and orientation measurements, which also bases its position calculations on inertial measurements. PDR algorithms are optimized for pedestrian usage. The velocity estimation is usually based on an accelerometer reading which shows the characteristic profile of human walking, i.e. spikes in vertical acceleration, each time the foot touches the ground. A model, which maps the relationship between velocity and the user‟s characteristics such as leg-length, weight and gender, is then used to estimate the user‟s current velocity. The second component, the orientation measurements are, as with the strapdown algorithm, computed from the angular rate sensors‟ measurement. Finally, the position is calculated by integrating the (estimated) velocity in the (estimated) direction of movement.



Pedestrian dead reckoning inside positioning unit

3.3 Kalman filter & Particle filter:-

A Kalman filter is an algorithm which estimates the state of a linear system. To do this, the filter processes measurements which need to be linearly dependent of the system state. To obtain a state estimate, the kalman filter requires a model of the observed states, and a term to include process noise, taking into account model uncertainties and a term for system noise to account for measurement noise in the input data. If the observed system is a non-linear system, an *extended kalman filter (EKFis used* to overcome the restrictions of a linear model can be used.

Theoretically, there is no limit on the size of the filter‟s state vector, which is why it is the most prevalent method to use for sensor fusion. If the statistical properties and the measurement model of the particular sensor are known, they can simply be added to the filter‟s measurement equation and thus be included in the state estimation process. Kalman filters, model the system state as a Gaussian distributed random variable. Its probability density function is this completely described by mean and covariance matrix. However, Gaussian distributions only remain so if transformations performed on them are linear. Particle filters use the sum of particles to approximate the density function; each particle represents a possible realization of the state vector. The particle distribution is random, initially and the number of particles can be seen as a control for the filter performance: higher numbers of particles allow for a better approximation of the density function.

3.4 GPS / INS Integration:-

The combination of GPS and INS is a widely used method, as both techniques complement each other perfectly. The INS cannot be perturbed by external influences and guarantees a continuous and complete navigation solution. However, the solution only possesses short-term validity as the errors tend to accumulate over time. This can be overcome by the combination with a GPS receiver.

A GPS receiver provides a precise long-term navigation solution, however no orientation information can be obtained by using only a single antenna. Update rates with standard receivers are relatively low (only about one to four measurements per second). Also, the continuity cannot be guaranteed, as position determination is impossible if less than four satellites are in view.

Data fusion is almost exclusively achieved by error state kalman filters, which estimate and correct the error of the INS by using the obtained GPS fix as correction data. Depending on the information used to support the INS, literature distinguishes *loosely-coupled, tightly-coupled* and *ultra-tight/deep integration* by different levels of integration. Systems using INS as their main navigation solution always require support data to correct the long-term errors. However, under indoor navigation conditions, GPS information may not be as readily available as compared to outdoor navigation conditions. In those cases, other means of support information are required to ensure the long-term stability of INS-based navigation techniques. The most sensitive channel in an INS is the altitude, which is usually supported by barometric pressure sensors. Algorithm development needs to focus on a robust way to be able to use any support information the system may be presented with, including a means to evaluate the accuracy of said support information. Assuming a building floor plan is available, the combined information of a distance measuring technique and a particle filter can be used to find the initial (unknown) position within the building. Assuming further, that velocity and gyroscope information are available as sensor data, then the particle filter requires only a few steps to uniquely determine the position within the floor plan.

Initially, as there is no information available about the position, an even distribution of particles across the floor is assumed. However, continued measurements allow the algorithm to exclude improbable positions which would arise by the user walking through walls or outside the boundaries of the floor plan. This is only possible owing to the multi-modal density functions of particle filters. After the position has been determined, the positioning can be switch back to the uni-modal density function-based kalman filter, which requires less computational resources.

3.5 Step / Counter based velocity estimation:-

The system to be analyzed is based on the GPS/INS low-cost navigation system. The navigation system is relatively small, and connects to a computer via USB cable.

Evaluation of the system included the assessment of how well it performed under indoor conditions. Results were then improved by using the IMU data in a custom step counter algorithm and a custom kalman filter. Data processing took place in an offline fashion, with forward and backward kalman filtering. Under indoor conditions, the step counter was able to supplement the missing GPS information. However, the highly integrated nature of the system design prevents the usage of calibrated, yet otherwise unprocessed sensor data for further algorithm design. Also, long connection wires and the fact that online processing will not be achieved for indoor conditions render the solution ineffective for day-to-day pedestrian use.

3.6 Low-Cost GPS / INS systemIMU MTi-G:-

The GPS / INS is an integrated GPS and inertial measurement unit, belonging to a family of inertial motion trackers. The inertial sensors (3 axes) are based on MEMS technology; the GPS sensor is a miniature GPS receiver with external antenna. The system is also aided by additional sensors including: - 3D magnetometer - static pressure sensor, optical sensor accelometers and gyroscope. The internal signal processor runs a real-time Kalman Filter which provides inertial enhanced 3D position and velocity estimates and GPS enhanced, orientation estimates, calibrated acceleration, rate of turn and earth-magnetic field data and the static pressure (barometer). Several interface options allow for different settings regarding specific usage scenarios. The internal processor is used for the above said algorithms with input of tunable input coefficients. First tests using the inbuilt Kalman Filter carried out on the particular area different scenarios: Movable scenario, Pedestrian / good GPS conditions and Pedestrian / entering a building. For the third scenario, the transition from outdoor to indoor with two different Kalman Filter models are used. Due to the fact that the system does not compute any position if the GPS signal is lost for more than 10 seconds, no Kalman Filter output can be obtained in the building. The magnetometer signal can be used to identify the entering of the building. A good positioning during the transition from outdoor to indoor can be achieved if the GPS signal and positioning outside the building is good enough to stabilise the INS. The magnetometer cannot improve the positioning but the signals can help to detect the entering of the building. The data to be measured are Acceleration (IMU), Velocity (GPS), Position (GPS) and Pressure. Filters based on Kalman's Filter provide forward filtering and backward filtering of the data. In addition an optimal smoothing is provided to combine both filters to get an optimal result.

GIS data will be combined in the positioning process and also used for guidance. Here, not only the ground plan of the building but also the utilisation of the premises and most frequently used corridors are applied to support the navigation process. It is important to use a fast data transfer from the GIS server to the mobile measuring and visualization unit. Acquisition of cartographic and other descriptive elements are key to meaningful route guidance within buildings. Applications would be reserved in this larger version to particular demographics, who must navigate in unfamiliar buildings, e.g. for emergency services in significantly sized structures. This research aims to contribute to make smaller but still useful systems. It is necessary to control the sensors and the technology, to improve the algorithms, to use more geo-information, to build smaller units and to attach the sensors to existing mobile devices.

The above said is for case I the same procedure can be adopted for case II which is based by using map-matching for the positioning, e.g. level plans of buildings. Hereby different kinds of heights and step width on horizontal plates or stairs will be meaured.

CONCLUSION

The Proposed Algorithm will be implemented with hardware at corridors, mall places etc and to measure the above said parameters with visualization in the smart phones. The above scenario can be directly visualized in the smart phones with the accurate parameter values.

REFERENCES

1. *Retscher, G., Skolaut, G., 2003. Untersuchung von Messsensoren zum Einsatz in Navigationssystemen für Fußgänger, Zeitschrift für Geodäsie, Geoinformation und Landmanagement (zfv), 128, pp. 118-129.*
2. *Retscher, G., M. Kistenich, M., 2006. Vergleich von Systemen zur Positionsbestimmung und Navigation in Gebäuden", Zeitschrift für Geodäsie, Geoinformation und Landmanagement (zfv), 131, pp. 25-35.*
3. *Fu, Q., Retscher, G., 2008. Using RFID and INS for Indoor Positioning, Location Based Services and TeleCartography: From Sensor Fusion to Ubiquitous LBS: v. 2 (Lecture Notes in Geoinformation and Cartography) G. Gartner, K. Rehrl, Eds, Berlin: Springer Verlag, pp 421-438.*
4. *Grejner-Brzezinska, D., Toth, Ch., Moafipoor, S., Kwon, J., 2007. "Design And Calibration of a Neural Network- Based Adaptive Knowledge System For Multi-Sensor Personal Navigation", Proceedings of the 5 th International Symposium on Mobil Mapping Technology MMT'07, Padua.*
5. *Xsens, 2008. MTi-G User Manual and Technical Documentation, Document MT0137P, Revision B (April 1st, 2008)*
6. *Sternberg, H., Schwalm, Ch., 2008. Qualification Process for MEMS gyroscopes for the use in navigation systems", Proceedings of the 5th Symposium on Mobile Mapping Technology, ISSN 1682-1777, pp. 285-292.*
7. *Tanigawa, M., Luinge, H., Schipper, L., Slycke, P., 2008. Drift –Free Dynamic Height Sensor using MEMS IMU*
8. *Aided by MEMS Pressure Sensor", Proceedings of the 5 th Workshop on Positioning, Navigation and Communication 2008 (WPNC'08), ISBN 978-1-4244-1799-5 , pp. 191- 196.*
9. *Blankenbach, J., 2006, **Handbuch der mobilen Geoinformation,** Herbert Wichmann Verlag Heidelberg*
10. *Blankenbach, J.; Kasmi, Z.; Norrdine, A. & Schlemmer, H., 2008, **Indoor-Positionierung auf Basis von UWB**, Allgemeine Vermessungs-Nachrichten, 08-09, 292-300*
11. *Farrell, J. & Barth, M., Chapman, S., 1999, **The Global Positioning System & Inertial Navigation**, Mcgraw-Hill Professional*
12. *Grewal, M. S.; Weill, L. R. & Andrews, A. P., 2007, **Global Positioning Systems, Inertial Navigation And Integration,** John Wiley & Sons, Inc., Hoboken, New Jersey*
13. *Grewal, M. S. & Andrews, A. P., 2008, **Kalman Filtering: Theory and Practice Using MATLAB,** John Wiley & Sons*
14. *Hazas, M., Hopper, A., 2006, **A Novel Broadband ultrasonic location system for improved indoor positioning**, IEEE TRANSACTIONS ON MOBILE COMPUTING*
15. *Lukianto, C., Hönniger, C., Sternberg, H., 2010, **Pedestrian Smartphone Based Indoor Navigation Using Ultra Portable Sensory Equipment**, 2010 INTERNATIONAL CONFERENCE ON INDOOR POSITIONING AND INDOOR NAVIGATION (IPIN), Zurich, Switzerland*

16. *Mautz, R., 2009,* ***Overview of Current Indoor Positioning Systems****, GEODESY AND CARTOGRAPHY, 35, 18-22*
17. *Minami, M., Fukuju, Y., Hirasawa, K., Yokoyama, S., Mizumachi, M., Morikawa, H., Aoyama, T., 2004,* ***Dolphin: A practical approach for implementing a fully distributed indoor ultrasonic positioning system****, Ubicomp, 347–365*
18. *Retscher, G., M. Kistenich, M., 2006,* ***Vergleich von Systemen zur Positionsbestimmung und Navigation in Gebäuden****, Zeitschrift für Geodäsie, Geoinformation und Landmanagement (zfv), 131, 25-35.*
19. *Savage, P.G., 2007,* ***Strapdown Analytics - Second Edition****, Strapdown Associates Inc., Maple Plain, Minnesota, USA.*