AUTONOMOUS NAVIGATION SYSTEM FOR PILOTLESS MANOEUVERING OF VESSELS THROUGH RESTRICTED WATERS

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ABSTRACT

An entity which supports manoeuvring of vessels through restricted water areas semi-autonomy. The proposed system has the feature of navigating through restricted areas with being less vulnerable to detection. The major features consisting of this vessel includes audio and video recording system, ultrasonic along with SONAR systems. It provides obstacle avoidance to escape from enemies and safe manoeuvring of the system. Position of the vessel and specified target reached can be periodically monitored by means of Global Positioning System. Navigation system is guided by inertial guidance system and Kalman filtering is implemented to get the precise location which also determines the position, velocity, orientation which can localize itself. The audio and video data can also be made to store in a cloud for analysis. A reference of the direction can be ensured by means of the magnetic compass connected with Arduino. Communication can be done using acoustic waves. This system has the advantage of avoiding spoofs and data leakage, monitoring water pollution and capable of spy purpose.

1. INTRODUCTION

The location tracking plays an important role in many applications such as location-based services and the radio resource management. In the Kalman filtering method, the smoothing procedure by linear regression makes the estimated location more accurate than that of the GPS method. The Kalman filtering method estimates velocity as well as location and uses them in the next estimation process. However, the estimated velocity has large error of estimation. By the recursive process of the Kalman filtering, the error of the estimated velocity induces inaccuracy of the location tracking. Moreover, the Kalman filtering method needs transient time to reach the reliable estimation, so big location error is generated at the first part of the location tracking until enough data come to the filter. An improved location tracking algorithm which uses the velocity renovation process with the Kalman filter is proposed in this paper. By the velocity renovation process, more accurately estimated velocity can be used in the Kalman filtering. The accurately estimated velocity will be able to increase the performance of the location estimation and shorten the transient time of the estimation.

2. PROPOSED SYSTEM

The proposed system uses Arduino microcontroller. All the sensors are connected to the Arduino. The acceleration and gyroscope sensor data are fused together with a help of inertial measurement unit. The data is also received and all the three data are fed into the Kalman algorithm and the more accurate location is estimated. The algorithm of the Kalman filter has several advantages. This is a statistical technique that adequately describes the random structure of experimental measurements. This filter is able to take into account quantities that are partially or completely neglected in other techniques (such as the variance of the initial estimate of the state and the variance of the model error). It provides information about the quality of the estimation by providing, in addition to the best estimate, the variance of the estimation error. The Kalman filter is well suited to the online digital processing. Its recursive structure allows its real-time execution without storing observations or past estimates.

3. EXISTING SYSTEM

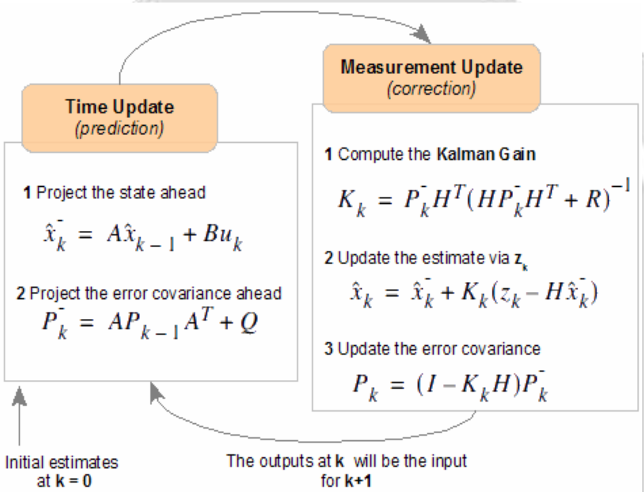
The existing system of autonomous navigation only uses the GPS data, but the GPS relies on radio signals from orbiting satellites that cannot penetrate structures generally Moreover, the fifteen-meter location accuracy of the GPS is not entirely sufficient for close area training purpose. There is also the issue of 'Canyon Effect' resulting from being surrounded by tall buildings blocking GPS signal. The signal might keep bouncing around and therefore fail to reach the GPS unit. GPS units calculate the position and time based on the time required to receive the signal

4. SYSTEM ARCHITECTURE

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output pins that may be interfaced to various expansion boards and other circuits. All the modules are connected to the Arduino, the IMU unit is responsible for the sensor fusion and the recorded data is stored in cloud (Google firebase) using a Wi-Fi module.

5.THE KALMAN FILTER

After we gathered all the information we need and started the process, now we can iterate through the estimates. Keep in mind that the previous estimates will be the input for the current state.



Here, $\hat{x}_k^-$ is the **prior estimate** which in a way, means the rough estimate before the measurement update correction. And also P_k^- is the **prior error covariance**. We use these prior values in our **Measurement Update** equations.

In Measurement Update equations, we really find $\hat{x}_k$ which is the estimate of **x** at time **k** *(the very thing we wish to find)*. Also, we find P_k which is necessary for the **k+1** *(future)* estimate, together with $\hat{x}_k$.

The Kalman Gain (K_k) we evaluate is not needed for the next iteration step, it's a hidden, mysterious and the most important part of this set of equations.

The values we evaluate at **Measurement Update** stage are also called **posterior** values. Which also makes sense.

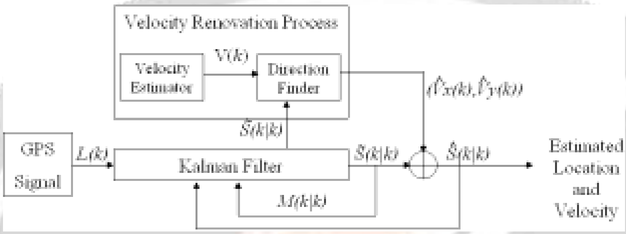
6 .KALMAN GAIN

The Kalman filter is a recursive estimator. This means that only the estimated state from the previous time step and the current measurement are needed to compute the estimate for the current state. In contrast to batch estimation techniques, no history of observations and/or estimates is required.

The Kalman filter can be written as a single equation, however it is most often conceptualized as two distinct phases: "Predict" and "Update". The predict phase uses the state estimate from the previous timestep to produce an estimate of the state at the current timestep. This predicted state estimate is also known as the *a priori* state estimate because, although it is an estimate of the state at the current timestep, it does not include observation information from the current timestep. In the update phase, the current *a priori* prediction is combined with current observation information to refine the state estimate. This improved estimate is termed the *a posteriori* state estimate.Typically, the two phases alternate, with the prediction advancing the state until the next scheduled observation, and the update incorporating the observation. However, this is not necessary; if an observation is unavailable for some reason, the update may be skipped and multiple prediction steps performed. Likewise, if multiple independent observations are available at the same time, multiple update steps may be performed

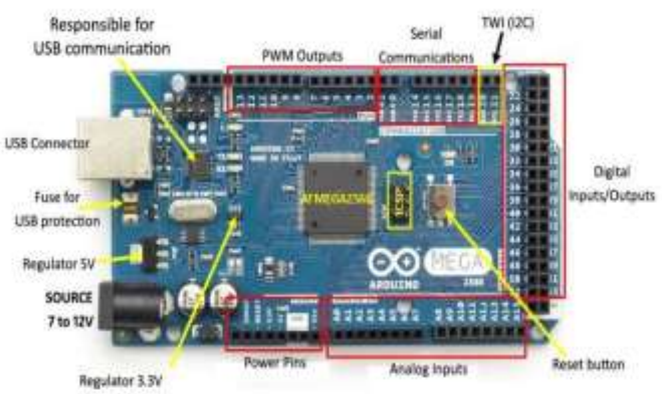
7. LOCATION TRACKING WITH VELOCITY ESTIMATION

The block diagram of the proposed location tracking algorithm which uses the velocity renovation process with the Kalman filter is shown in Fig. 1. The velocity renovation process is to use the accurately estimated velocity in the Kalman filter for increasing the accuracy of the location estimation. It consists of two parts. One is a velocity estimator and the other is a direction finder. By the estimated velocity and direction in the velocity renovation process, the x-axis and y-axis directional velocities can be estimated. The estimated velocities are passed to the Kalman filter. After that, The estimated velocities in of the Kalman filtering method replaced by the estimated velocities of the velocity renovation process.

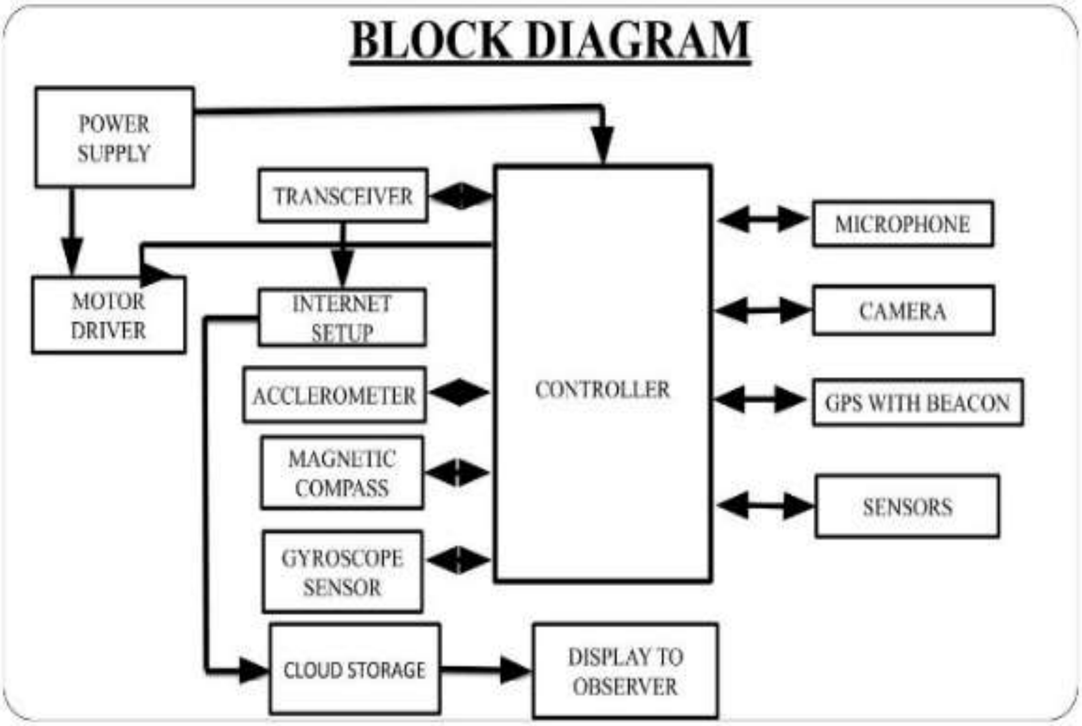


8. HARDWARE DISCRIPTION

The **ATmega328** is a single-chip microcontroller created by Atmel in the mega AVR family (later Microchip Technology acquired Atmel in 2016). It has a modified Harvard architecture 8-bit RISC processor core. The Atmel 8-bit AVR RISC-based microcontroller combines 32 KB ISP flash memory with read-while-write capabilities, 1 KB EEPROM, 2 KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte- oriented 2-wire serial interface, serial ports.



All the modules are connected to the controller with the help of wires, it normally works on 5v power diagram of the system.The modules all are separately connected to the controller .A backup power sullp is also given for the system if any problem occurs.



9. SOFTWARE DESCRIPTION

ARDUINO IDE

The **Arduino Integrated Development Environment (IDE)** is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards. The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures.

MATLAB

MATLAB (*matrix laboratory*) is a multi-paradigm numerical computing environment and proprietary programming language developed by MathWorks. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages.Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine allowing access to symbolic computing abilities. An additional package, Simulink, adds graphical multi-domain simulation and model-based design for dynamic and embedded systems.

10. WORKING MODULE

First, all raw IMU measurements are mapped onto a common frame and processed in a typical combined GPS-IMU Kalman filter. This filter construction allows for relative information between the IMU to be used as updates. The output of each local filter is shared with a master filter, which in turn, shares information back with the local filters.

MODULES

- MPU6050
- HMC588C3L
- NEO-6M GPS

MODULE DESCRIPTION

MPU-6050 (Gyro & accelerometer module)

MPU-6050 does both the work of gyro and accelerometer which is based 3-D MEMS technology. It possess onboard Digital Motion Processor capable of processing 9-axis motion fusion algorithms, it also does away with the cross-axis alignment problems that can creep up on discrete parts. This module has embedded algorithms for run-time bias and compass calibration. It also consist of sensor timing Synchronization and gesture detection.

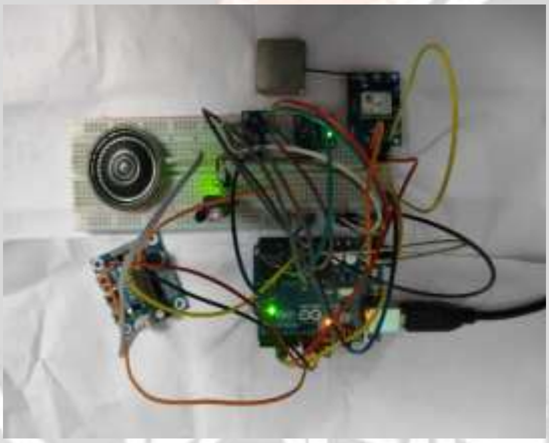
ISD1820

It is a multiple message record /playback module which can offer true single-chip voice recording, no-volatile storage and playback capability for 8 to20 seconds. The sample is 3.2k and the total 20s for the recorder. The module can directly by push button on board or by microcontroller.

HMC5883L (Magnetic compass)

GY-271 HMC5883L is a 3-axis magnetic electronic compass which is able to communicate with I2C protocol. This module is able to convert the magnetic field into a differential voltage output which can then used to sense magnetic field. It also comes along with a digital interface.

All the above modules are connected to the microcontroller and the expeiments are conducted and the observations are tabulated.

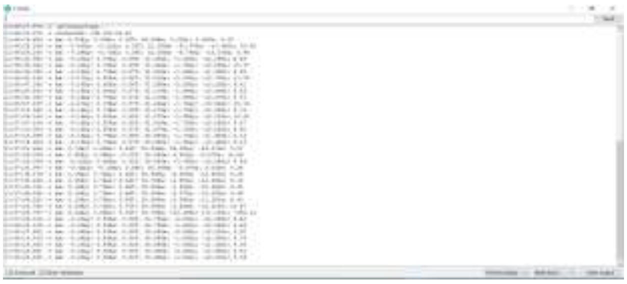


11. PRACTICAL EXPERIENCE

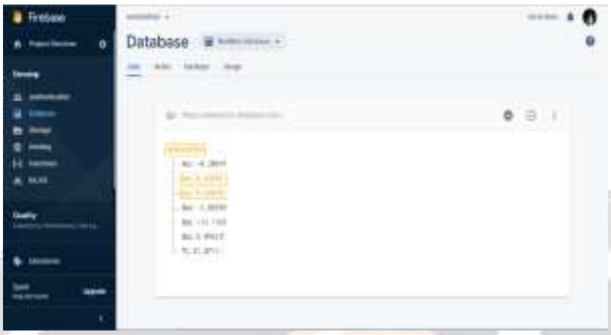
Practically we moved the GPS receiver in the six different places in Chennai city in India. In TABLE we can see the different of the GPS location tracking with the Kalman filter and velocity estimation in these three places

PLACE	GPS ACCURACY	KALMAN FILTERED POSITION
LOC 1	96.14	5.3
LOC 2	87.45	3.8
LOC 3	67.4	4.7

All the sensor readings sensed are displayed over the serial monitor as shown below and the data is uploaded to the cloud and studied later for further understanding



Serial monitor



Google firebase(cloud services)

CONCLUSION

The location tracking algorithm with the velocity renovation process has been proposed in this paper. The velocity renovation process consists of the velocity estimator and the direction finder, and it is to use more accurately estimated velocity in the Kalman filtering. The proposed algorithm reduces the location estimation error into 0.55 meter. In addition, differently from the Kalman filtering method, the proposed algorithm estimates location of a GPS receiver reliably without the transient time by the velocity renovation process which works independently of the Kalman filter. The proposed algorithm improves the ability of location tracking

REFERENCES

1. Erin Marie Fischell , Nicholas Rahardiyan Rypkema , and Henrik Schmidt, “Relative Autonomy and Navigation for Command and Control of Low-Cost Autonomous Underwater Vehicles”, IEEE ROBOTICS AND AUTOMATION LETTERS, VOL. 4, NO. 2, April 2019
2. HOWARD H. WANG, STEPHEN M. ROCK, “OTTER: The Design and Development of an Intelligent Underwater Robot”, Journal of Autonomous Robots, Kluwer Academic Publishers, Boston. Manufactured in The Netherlands.
3. Zhuoning Dong ,Wenbin Li ,Yanxing Zhou,” An autonomous navigation scheme for UAV in approach phase”, 2016 IEEE Chinese Guidance, Navigation and Control Conference (CGNCC).
4. N. Y. Ko, T. G. Kim, "Comparison of kalman filter and particle filter used for localization of an underwater vehicle", *URAI 2012 9th International Conference on. IEEE*, pp. 350-352, 2012.
5. T. M. A. Habib, "Simultaneous spacecraft orbit estimation and control based on gps measurements via extended kalman filter", *The Egyptian Journal of Remote Sensing and Space Science*, vol. 16, no. 1, pp. 11-16, 2013.
6. K., Prithviraj Arjun, A. Ashwitha, "Sensor Based Application for Smart Vehicles", *International Journal of Latest Trends in Engineering and Technology*, vol. 8, no. 1, pp. 526-532, 2017.