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Low-Cost Tightly Coupled GPS/INS Integration system Based On Sigma point Kalman Filter

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ABSTRACT: In this case, represents the research review for construction of a "tightly coupled GPS/INS integration system based on nonlinear Kalman filtering process". The traditional process combine linearization of the framework around a simple path, and the extended Kalman filtering (EKF) process which linearizes the framework around the past conclusion, or the affirmation, whichever is available. The recently implemented sigma-point Kalman filtering (SPKF) process uses a set of weighted samples (sigma points) to completely taking the first and second order moments of the prior random variable. The project aims to develop a universal software platform for locating and develop sensor integration. In the current development aspect, a tightly coupled GPS/INS integration system depend on a linearization around the INS solution has been designed and implemented. The framework uses the GPS pseudo range and Doppler measurements to estimate the INS errors. This paper depicts more developments of the integration filter design based on the EKF and SPKF methodologies,in order to analyze the performance of nonlinear filtering approaches.

KEYWORDS: Global positioning system (GPS), inertial navigation system (INS), Sigma point kalman filter , Computer with latest configuration, Latest version of MATLAB .

I. INTRODUCTION

Exploration is a field that concentrate on the process of checking & managing the change of craft or vehicle from one place to another. This consist four general categories:(i)Land Navigation, (ii)Marine Navigation,(iii)Aeronautics Navigation (iv)Space Navigation. It is also term of art used for the specialized awareness used by the navigators to perform exploration work. All exploration approach contain locating the navigator's location compared to aware locations or patterns. Exploration, in the broad sense, can refer to any skill that include locating the location & direction. In the sense, navigation includes orienteering & pedestrian exploration. Global Positioning System (GPS)based exploration framework have been used in Land Vehicle Navigation Systems (LVNS) due to their minimum cost, easy installation, and other beneficial things. The level of performance needed of an LVNS recently extended with the successful development of LVNS in unmanned land vehicles, with the implement of augmented reality for land vehicles & the availability of high grade LVNSs [1]. From the point of view of various indirect conditions, The Inertial Navigation System (INS) is optimal, rather than velocities. INS measures the linear acceleration and angular rates of moving vehicles through its accelerometers and gyroscope sensors.

The main activity is the location assurance. The INS error constrained increase with time, due to the unconstrained pointing errors generate by the unrewarded gyro and accelerometer errors altered the INS assessments. INS contribute high-accuracy in case of three-dimensional positioning when the GPS positioning is lower or unavailable over short periods of time. It provides much higher update positioning rates compared with the output rate conventionally available from GPS [2].The limitations of GPS are related to the loss of accuracy in the narrow-street setting, voluntary interruption of the benefit, poor geometrical-dilution-of-precision (GDOP) coefficient and the multi way reflections. GPS-based exploration framework needed four satellites, so a big defect of GPS dependence exploration framework is that their efficiency corrupt much with satellites outages. Signal blackout is more powerful for land vehicle positioning

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in urban centers, which takes place when detecting highway overpasses or tunnels due to the block signals. So it is suitable to accommodate this type of exploration framework with a various type of exploration framework in order to get a large autonomy. Both INS and GPS suffer from various error sources and defect which propel the accompaniment of the two interdependent framework. INS display relatively minimum noisy result which tend to drift over time. Contrary to INS, GPS outputs are relatively noisy but do not display long-term drift. Combining both of these systems gives a superior exploration achievements than standalone system [3]. So to get strong performance, GPS/INS integrated system widely used. But maximum defect of GPS/INS integrated framework is that some time GPS lost its signals in critical conditions for example in tunnel, hilly areas etc. So at that time it is needed to some type of mechanism should be accept to train the INS data during GPS outage. For this ambition Support Vector Machine (SVM) is used to train the INS information during GPS blackout & the assumed annealing is applied to realize the optimization of the parameters of the kernel function& the penalty function in the SVM algorithm. Therefore the integrated exploration could retail almost as precise as the GPS when GPS is off-line.

II. RELATED WORK

Extended Kalman Filter (EKF) is mostly used for GPS/INS integration. It has main limitation that the filter may radiate when the initial state assessment error is large, because in EKF, Mean and covariance matrix of the state vector are multiply through the linearized nonlinear framework miniature. Large linearization errors can be developed in the mean and covariance of the later distribution dominant to suboptimal performance and even divergence of the filter [4].

Tightly-Coupled integration removes the usage of cascaded filters unlike loosely coupled integration. Therefore, correlation of the analysis in GPS exploration filter is blocked. Instead of exploration result of GPS, pseudo ranges and pseudo range rates obtained from Doppler information are used as the analyze so for the INS/GPS integrated Kalman filter. Choice of these analyze brings nonlinearity to the analysis model of the integrated filter. Even when less than four satellites are available, integration filter will keep on operating since this framework does not require a full GPS solution to aid the INS[5]. There is only INS available during GPS outage; therefore it is compulsory to build a well-trained model to predict the positioning data. Artificial neural network (ANN) can be used for this aim. I comparison with ANN, Support Vector Machine (SVM) can give better genetic ability, thus it takes less time for training to obtain better training performance [1].

Different literature works are carried out on integrated exploration framework. Eric A. Wan et al. presented an supplement method to EKF for nonlinear assessment. This changes EKF by UKF which regularly achieves a best level of centanity than the EKF at a equal level of complexity.[6]

Zhen Guo, etal.developed a new access for tightly coupled GPS/INS integrated framework which based on Sigma Point Kalman filter. They got that for various inertial sensor grades SPKF based tightly-coupled GPS/INS system shows good achievement concerning the accuracy of the exploration result and the ability to calibrate the INS[7] HaoWuet al. introduced different process to remove the linearization error. The Unscented Particle Filter (UPF) was developed by them for states assessment. According to simulation, it shows that UPF algorithm represents high exploration accuracy in the GPS/INS integrated exploration. [8]

Gannan Yuanet al. proposed UKF design strategy for the ultra-tightly coupled GPS/INS integrated framework. INS error models are consider, which was used to assess the I/Q signals. The UKF based ultra-tight integration framework is stable and accurate, which make it profitable to work at some strict scenarios, i.e. high dynamics or greater conflict. [9] Alex Garcia et al. developed a loosely couple GPS/INS integrated exploration framework which is based on field programmable gate array (FPGA). Along with FPGA, they also introduced PDA and web server in the kalman filter. This improves the work and bring out access to map data from Google Maps [10].Myeong- Jong Yu has develop an adaptive filter for a nonlinear framework that assessment measurement noise variance in real time using analysis continuing values to consider the noise caused by large analyze errors. A scalar analysis updating U/D rule factorization filter was used to develop the planned filter and to calculate the analyze noise deviation effectively. [11]

III.PROPOSED ALGORITHM

Proposed work can be accomplished using following 2 steps. The first step is used for to estimate the velocity, position and attitude and next is SVM training model for integrated navigation. This finds the exact navigation of object with respective altitude and latitude.

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Step 1: State estimation using UKF

As shown in Fig the proposed system shows the GPS and INS as coupled with there respective characteristics performances and prediction filter used here is unscented kalman filter which is the family of sigma point kalman filter. Using this system we can estimate the position , velocity and altitude values to improve and getting the adequate performance.

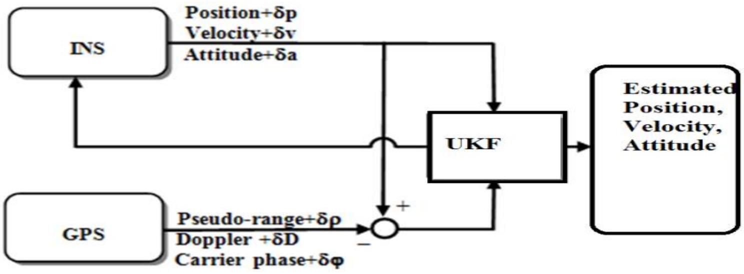

Fig.1:-Tightly Coupled GPS/INS Integration Using UKF.

Step 2 : Implementation of training model:

As following fig of SVM shows the part in the coupled GPS/INS system that shows the performance while gps/ins system at out of coverage and support the system when GPS range not adequate for some period of time. this algorithm is useful for the system as mentioned above for problem and provide benefit to the system. There is only INS available during GPS outage; therefore it is necessary to establish the well-trained model to predict the positioning information. the Artificial neural network can be used for this purpose. In comparison with ANN, Support Vector Machine can provide the better genetic ability, thus it takes shorter time for the training to obtain the better training performance. The final output results after performing the GPS/INS Integration for tightly coupled sigma point filtering are as shown in figure bellow.

State Vector Machine (SVM) can be implementing using simulated annealing.

Fig.2:-The SVM training model for integrated navigation.

IV.FLOWCHART

In the performance of Tightly coupled GPS/INS based navigation system based on Sigma point kalman Filter works on UKF filter and the SVM training model for integrated navigation. Basically the filter uses the prediction performances that's why we are using with the prediction filter as shown in fig. 3 GPS/INS both coupled as shown for getting adequare performance for proposed system. This system also shows one block that is optimum value. This optimum value is the value used in the prediction performance.

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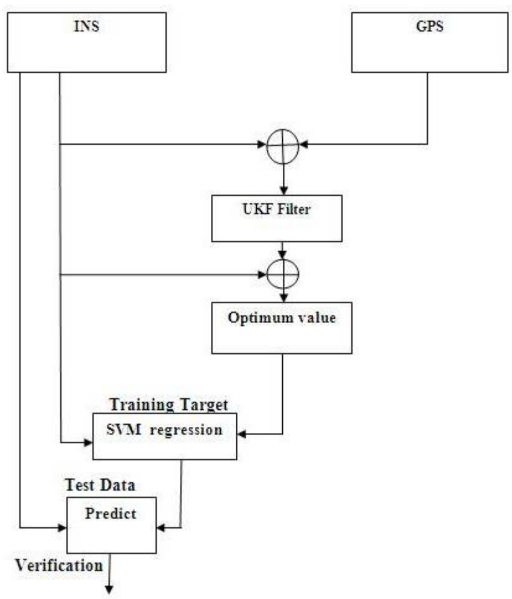

Fig. 3:-. Flow chart of proposed system

V. EXPERIMENT AND ANALYSIS

The design of a tightly coupled GPS/INS integration system based on Sigma point Kalman filtering methods. The recently proposed sigma-point Kalman filtering method uses the set of weighted samples to completely capture the first and second order moments of the perticular prior random variable.

A) Extended Kalman Filter

The EKF applies the Kalman filter to nonlinear systems by simply linearizing all the nonlinear models so that the traditional linear Kalman filter equations can be applied. then The extended Kalman filter (EKF) gives the estimate and the covariance as

x^(k +1k +1) = x^(k +1k) +K(k +1)[z(k+1)−z^(k+1k)]............................ ....(1)

P(k +1k +1) = [I −K(k +1)H(k +1)]P(k +1k)... ....(2)

The prediction of the state and its covariance are

x^(k +1k) = f[x^(k k),k]…..............……………..... ....(3)

P(K+1lK)= (K+1,K)P(Klk)FT(K+1.K)+G(K+1,K)Q(K)GT(K+1.K)…................. (4)

The prediction of measurement is

z^(k +1k) = h[x^(k +1k), k +1]…………………………….............................. ....(5)

The Kalman gain matrix is

[K (k +1)= P(K+1lK)HT(K+1)H(K+1)P(K+1lK)HT(K+1)+R(K+1)-1]………………....(6)

where F(k+1,k) and H(k+1) are Jacobian matrices associated with f and h.

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B) SIGMA POINT KALMAN FILTER

The sigma point Kalman filter updates the predication after the measurements arrive:

$\mathbf{x}\hat{}(k+1k+1) = \mathbf{x}\hat{}(k+1k) + \mathbf{S}(k+1)[\mathbf{z}(k+1) - \mathbf{z}\hat{}(k+1k)]$…………………………………........(7)

Comparing Eq. (7) with Eq.(1), one can find that the sigma point filter has the same prediction-correction structure as the normal Kalman filter. The gain matrix S in Eq. (9) can be referred to as the SPKF gain matrix, in similar way to the Kalman filter's gain matrix K in Eq.(3). The estimate covariance is as

$[P(k+1lK)= P(k+1lk-S(K+1)R(K+1)P_{ZZ}(k+1)l(k+1)S^{T}(K+1)]$………….................................(8)

The SPKF gain matrix **S** is

$k+1)P\ xz\ (k+1lk)[\ R(k+1)P\ zz\ (k+1lk\ 1)^{-1}$…………………………………………………..(9)

The SPKF calculates first and second moments of the priori random variables by utilization of the sigma points. then As opposed to the particle filtering methodologies, the sigma points are deterministically calculated from current estimate of its covariance. The sigma points can be mapped into the state space or the measurement space through the nonlinear functions of the system.

VI. SIMULATION RESULTS

There is only INS available during GPS outage; therefore it is necessary to establish the well-trained model to predict the positioning information. the Artificial neural network can be used for this purpose. In comparison with ANN, Support Vector Machine can provide the better genetic ability, thus it takes shorter time for the training to obtain the better training performance. The final output results after performing the GPS/INS Integration for tightly coupled sigma point filtering are as shown in figure bellow.

The following figure.4, shows the estimation error in co-ordination system such as in X,Y and Z axis.. Velocity error changes with respective time and this is represented in co ordinate system shown as in above plot after using the performance of EKF and SPKF.

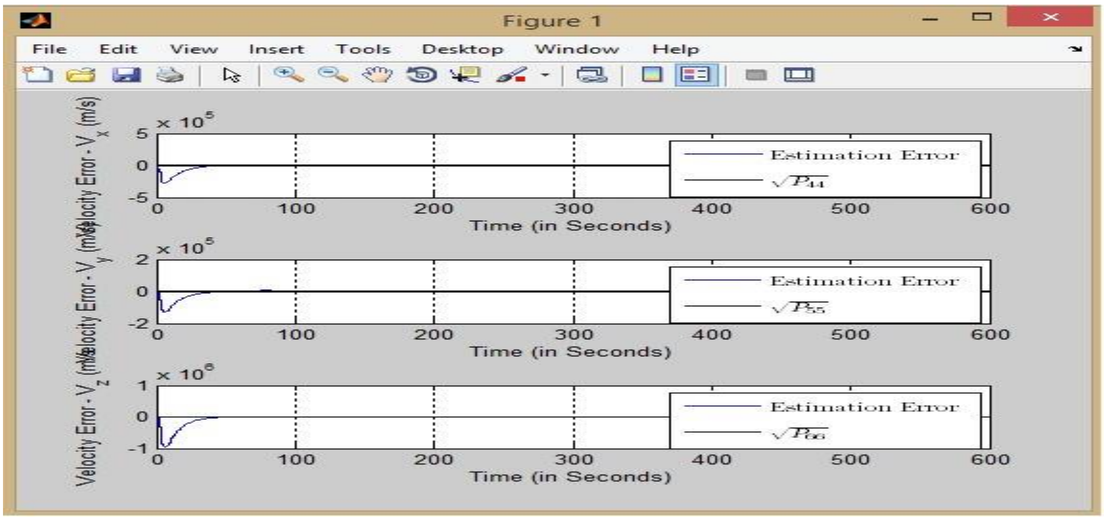

Fig.4:- Velocity Error in m/s with respective time in seconds.

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Also the following figure.5 shows the result of tilting error in navigation system by using co-ordinate system. The Tilt error is represented in X,Y and Z axis with respective time in second.

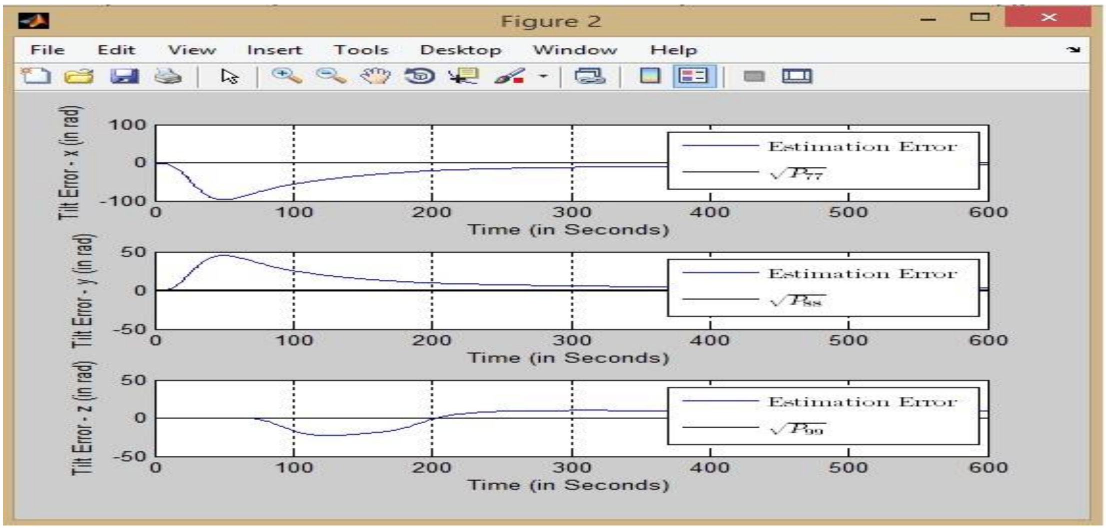

Fig.5:-Tilt Error in Rad. with respective time in Seconds

The following figure.6 shows the Latitude and Longitude after the performance output of SVM model . Then to take final navigation this longitude and latitude in degrees are useful. Represents this with respect to time as shown in fig. bellow:

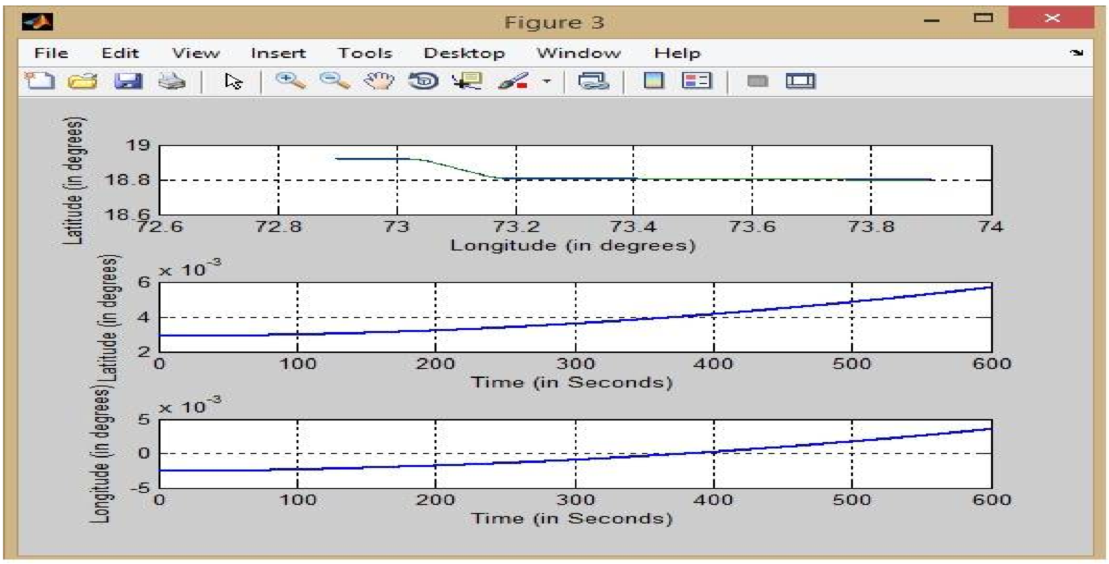

Fig.6:- Longitude and Latitude in degrees with Respective time in Seconds.

The following Figure.7 shows the final output of the Tightly coupled GPS/INS Integration after performance of the system. After implementing the above system we get the following result for output navigation position that is latitude and longitude.

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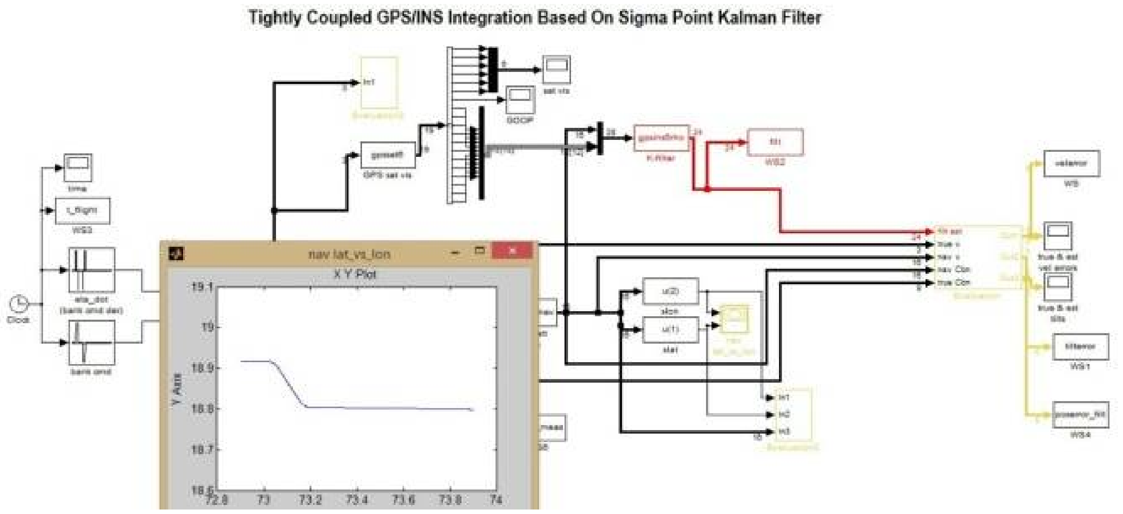

Fig.7:- Final output navigation position latitude vs. longitude

VII .CONCLUSION

A tightly coupled GPS/INS integration framework has been describe and develop on the basis of nonlinear filtering process. The new nonlinear filter, the sigma point Kalman filter (SPKF), was compared with classical process such as the linearization access and the continued Kalman filter (EKF). In contrast to the EKF, the SPKF is easier to develop because it does not need the computation of Jacobian matrices. Static and kinematic tests have determine that the SPKF can generate result of similar accuracy to those of the EKF. However the SPKF has a faster convergence speed.

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