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RESEARCH ARTICLE

AI-ACCIDENT DETECTION SYSTEM FOR FAST RESCUE ON FREEWAYS USING ON-BOARD CAR MOTION SENSORS FUSION

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Abstract

Continuous tracking and detecting position systems are significant services that can using in many applications such as detecting accident cars on Freeways. This paper introduces Artificial intelligent (AI) method to quick discover the accident and determine the position of car on Freeways that will reduce the rate of fatalities. Most tracking and detecting position systems are based on Global Navigation Satellite System (GNSS). But the GNSS signal in certain areas such as buildings and tunnel is unavailable which make a big problem for these systems. To solve this problem, most traditional methods are based on integrated GNSS with other navigation sensors such as accelerometers, gyroscopes, odometers and so on. But these integrated methods still high cost and need to long time processing. Today, most modern Vehicles are equipping with several On-board Car Motion Sensors (OVMS) such as Acceleration Sensors (AS), Wheel Velocity Sensor (WVS), Gravity Sensor (GS), Yaw Rate Sensor (YRS) and additional to GNSS that can improve the safety and also use to determine and detect the position of accident vehicle. This paper develops an approach AI-accident detection system based on integrating GNSS with On-board Vehicle Motion Sensors (OVMS) using Extended Kalman Filter (EKF) algorithm. During GPS outages, the three Acceleration Sensors (3-ASs) are processing to determine velocities and then position of vehicle on three x, y and z axes. While the YRS and GS sensors are using to determine velocities angles (ϕ, θ, ψ), on three x, y and z axes, respectively. In same time the three WVS sensors are using to correct velocities errors of three acceleration sensors (3-ASs) until GNSS signal is return again. The proposed AI-accident detection system is tested in different scenarios during GPS outage signal. The results of proposed method can actually detect accident and determine the position of vehicle with high efficiency.

Keywords: GNSS, On-board car motion sensors (OVMS), AI-method algorithm, EK filter.

1. Introduction

The rate of fatalities, in recent years, due vehicle accident has been one of the main concerns for most governments and Public Health Agency (PHA). According for the report of PHA, there are more than 2 million fatalities and 11.451 million serious injuries in every year. In addition, every year, the Car accidents will impose expenses to governments more than one hundred billion dollars for medical treatments, rehabilitation assistance, and property damages [1]. Although most Vehicle tracking and navigation services depending on Global Navigation Satellite System (GNSS), the GNSS requires perfect operating conditions for providing a valid solution. However, these conditions cannot be available in harsh environments such channels, urban canyons and indoor places due the GNSS signal needs to Line of Sight (LOS) signal propagation. So we cannot count on them as the all-environment positioning technologies [2].

Therefore , to solve problems of outage GNSS signal and provide a continuous navigation solution in harsh environments, the GNSS data is fusing with other navigation systems such as inertial navigation system (INS), odometer, Doppler velocity log (DVL) and so on [3, 4].

Today, most modern Vechiles have been equipped with On-board Vehicle Motion Sensors (OVMS) such as Acceleration Sensors (AS), Wheel Velocity Sensor (WVS), Gravity Sensor (GS), and Yaw Rate Sensor (YRS) that can improve safety in modern Vechiles and provide alternative navigation solution without need to use high-cost traditional integration methods [5]. This paper introduces proposed navigation and accident detection system based on integrated GNNS with On-board OVMS using Extended Kalman Filter (EKF) algorithm to provide continuous navigation solution during GNNS outages. The On-board OVMS sensors using in our proposed navigation and accident detection system are:

- Three Acceleration Sensors (3-ASs), that defined by a_x, a_y and a_z, to determine the velocities, that defined by v_x, v_y and v_z, on x, y, z axes, respectively.
- Three WVS sensors to correct velocities errors of 3-ASs during GNSS outages.
- Three YRS and GS sensors to determine velocity angles$(\boldsymbol{\phi}, \boldsymbol{\theta}, \boldsymbol{\psi})$ on x, y, z axes, respectively.

The EKF algorithm has been employed to the integration of GNNS and On-board OVMS sensors which can determine the optimal estimation of the system state vector with minimum mean and square errors. During GNSS outages , the position of Vehicle is determined with OVMS sensors until GNSS signal is return again [6, 7]. The paper is organized as following: Section 2 presents work background. Section 3 gives the methodology of proposed AI- navigation and accident election system process. Section 4 presents the experimental results in various scenarios. Section 5 presents the conclusions.

2. Background

It presents details on background and ideas used in this work. More specifically, two main algorithms will be considered in this study:

- Integrating GNNS with On-board OVMS, to provide a continuous navigation solution during GNNS outages .
- Implementing AI- accident detection system based on dynamic of the moving vehicle algorithms.

2.1. GNNS Navigation Equations

The GNNS System consists from three Segments: space Segment, Control Segment and User Segment) as shown in fig.1[8].

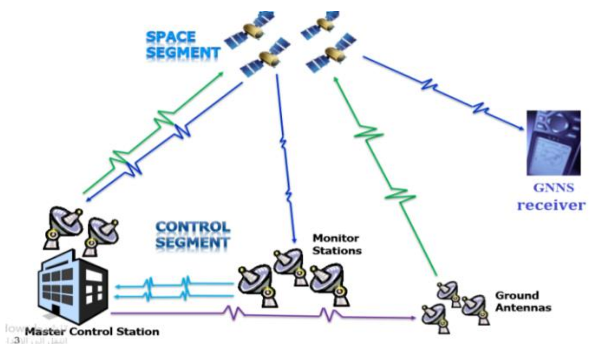


Fig. 1: Segments of GNNS System

The space segment contains from 24 satellites that altitude about 12,550 from Earth surface. These satellites arranging in six orbital planes. This arrangement allows the GNNS User Segment to receive signals from at least four GNNS satellites in same time on Earth surface. The control and monitoring system consist from several stations on earth surface whose positions are accurately known [9].The determined position ($\boldsymbol{P_{GNNS}}$) of Vechiles using GNNS System, in geodetic frame($\boldsymbol{\varphi}, \boldsymbol{\lambda}$, ɦ), is given as following equation (1) [10]:

$$\boldsymbol{P_{GNNS}} = \begin{bmatrix} \boldsymbol{\varphi} \\ \boldsymbol{\lambda} \\ \text{ɦ} \end{bmatrix}_{\boldsymbol{GNNS}} \quad (1)$$

Where $\boldsymbol{\varphi}$, $\boldsymbol{\lambda}$, and ɦ represent the Latitude, Longitude, and altitude in geodetic frame.

2.2 On-board OVMS Navigation System

The block diagram of the On-board OVMS navigation system is shown in fig.2. The three on-board Acceleration Sensors (3-ASs) are using to calculate the velocities and positions in the body frame.

Since the accuracy of 3-ASs decreases with time due the acceleration drift, the data measuring from three WVSs are using to correct velocities errors of 3-ASs during GNNS outages. In same time the YRS and GS sensors are using to determine direction cosine matrix ($\boldsymbol{C^n}$) that using to convert velocity from body frame ($\boldsymbol{v^b}$) to geodetic frame($\boldsymbol{v^g}$) [11]. The 3-ASs are used to determine the derivation of velocities ($\dot{U}$, $\dot{V}$, $\dot{W}$) which are given as following equation (2):

$$\begin{aligned} \dot{U} &= a_x + rV - qW + g\sin\theta \\ \dot{V} &= a_y - rU + pW - g\cos\theta\sin\phi \quad (2) \\ \dot{W} &= a_z + qU - pV - g\cos\theta\cos\phi \end{aligned}$$

Where a_x, a_y , and a_z are acceleration values on x, y, and z axes, respectively, and g is the gravity of earth [11]. By integration, the equation (2) gives the velocities in body frame ($\boldsymbol{v^b}$) using the initial velocities as given in following equation (3):

$$v^b{}_{3-AS} = \begin{bmatrix} v_x \\ v_y \\ v_z \end{bmatrix}_{3-AS} = \int \begin{bmatrix} \dot{v}_x \\ \dot{v}_x \\ \dot{v}_x \end{bmatrix}_{3-AS} dt \quad (3)$$

Where $v^b{}_{3-AS}$ is determined velocities of three accelerations (3_AS) in body frame.

Since navigation frame in our research is geodetic frame ($\boldsymbol{V^g}$), accelerations (3_AS) in body frame [12]. Since navigation frame in our research is geodetic frame ($\boldsymbol{V^g}$), the transformed velocities from body frame to geodetic frame is given as following equation (4):

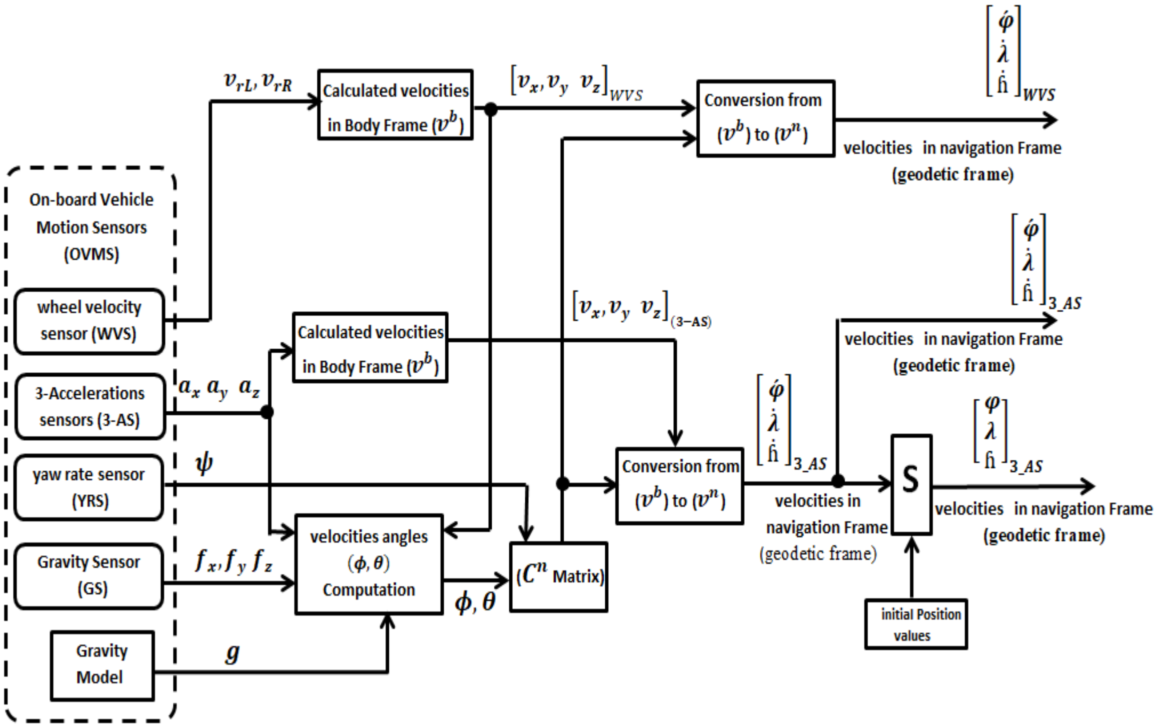


Fig. 2: OVMS Navigation System

$$v^n{}_{3\_AS} = \begin{bmatrix} \dot{\varphi} \\ \dot{\lambda} \\ \dot{h} \end{bmatrix}_{3-AS}$$

$$\begin{bmatrix} \dot{\varphi} \\ \dot{\lambda} \\ \dot{h} \end{bmatrix}_{3-AS} = \begin{bmatrix} \frac{1}{R_e} & 0 & 0 \\ 0 & \frac{1}{R_e cos\varphi} & 0 \\ 0 & 0 & 0 \end{bmatrix} [v^{ned}]_{3\_AS} \quad (4)$$

Where $v^n{}_{3-AS}$ is determined velocities of three accelerations (3_AS) in navigation frame, geodetic frame. While $\dot{\varphi}, \dot{\lambda}, \dot{h}$ are velocities in the geodetic frame, R_e is the radius of the earth. The $v^{ned}{}_{3-AS}$ is determined velocities (v_n, v_e, v_d) of three accelerations (3_AS) in North-East-Down frame. It is given as following equation (5):

$$v^{ned}{}_{3\_AS} = \begin{bmatrix} v_n \\ v_e \\ v_d \end{bmatrix}_{3\_AS} \quad C^n v^b{}_{3\_AS} \ (5)$$

$$C^n = \begin{bmatrix} cos\theta cos\psi & cos\theta sin\psi & -sin\theta \\ sin\theta sin\phi cos\psi - sin\psi cos\phi & sin\psi sin\theta sin\phi + cos\psi cos\phi & sin\phi cos\theta \\ sin\theta cos\phi cos\psi + sin\psi sin\phi & sin\phi sin\theta cos\phi - cos\psi sin\theta & cos\phi cos\theta \end{bmatrix} (6)$$

Where $\boldsymbol{C^n}$is direction cosine matrix that given in equation (6). By integration, the equation (5) gives the position of vehicle in navigation using the initial position. In same time, the calculated velocities by WVS sensor that using to correct errors of estimated velocities by 3-AS sensors during GNNS outages in the body frame ($\boldsymbol{v^b}_{\boldsymbol{WVS}}$) is defined as following equation (7):

$$v^b{}_{WVS} = \begin{bmatrix} v_x \\ v_y \\ v_z \end{bmatrix}_{WVS} = \begin{bmatrix} (v_{rL} + v_{rR})/2 \\ 0 \\ 0 \end{bmatrix}_{WVR} \quad (7)$$

Where v_x, v_y *and* v_z are velocities in the body frame, while v_{rL} *and* v_{rR} are left and right measurements velocities of WVS, respectively.

Since navigation frame in our research is geodetic frame (V^n), the transformed velocities from body frame to geodetic frame of WVR sensor is given as following equation (8):

$$v^n{}_{WVS} = \begin{bmatrix} \dot{\varphi} \\ \dot{\lambda} \\ \dot{h} \end{bmatrix}_{WVS} = \begin{bmatrix} \frac{1}{R_e} & 0 & 0 \\ 0 & \frac{1}{R_e cos\varphi} & 0 \\ 0 & 0 & 0 \end{bmatrix} [v^{ned}]_{WVS} \ (8)$$

$$v^{ned}{}_{WVS} = \begin{bmatrix} v_x \\ v_y \\ v_z \end{bmatrix}_{WVS} \quad C^n v^b{}_{WVS} \ (9)$$

Where $v^{ned}{}_{WVS}$ is determined velocities of three WVS sensor in North–East–Down (NED) frame, and $v^n{}_{WVS}$ is determined velocities of three WVS sensor in navigation frame (geodetic frame) as given in equation (9). By integration, the equation (8) gives the position of vehicle in navigation using the initial position.

The pitch angle (θ) that computed using the Earth's gravity and longitudinal GS is given as following equation (10) [13]:

$$\boldsymbol{\theta} = \sin^{-1}\left(\frac{f_x - a_x}{g}\right) \ (10)$$

Where f_x is the longitudinal GS measurement, a_x is the WVS derived forward vehicle acceleration, g is the gravity at th present location. The roll angle $(\boldsymbol{\phi})$ that computed using the lateral GS, YRS, Earth's gravity model and the value for forward velocity is defined as following equation (11) [13]:

$$\boldsymbol{\phi} = \sin^{-1}\left(\frac{f_y - v_x\dot{\psi}}{g\cos\boldsymbol{\theta}}\right) \ (11)$$

Where f_y is the lateral GS measurement, v_x is the forward velocity , $\dot{\psi}$ is the YRS measurement. The yaw angle (ψ) that computed using the YRS is defined as following equation (12) [13]:

$$\psi(t) = \psi(t-1) + \dot{\psi}\Delta t \ (12)$$

Where $f_y\psi(\boldsymbol{t})$ and $\psi(\boldsymbol{t}-\mathbf{1})$ art h yaw angle at time t and t-1, respectively, $\dot{\psi}$ is the YRS measurement, $\boldsymbol{\Delta t}$ is the sampling time interval.

3. Proposed GNSS/ OVMS -EKF Integration

The proposed GNSS/on-board OVMS sensors integrated vehicle using EKF integrated algorithm is shown in figure 3. The dynamic model of GNSS/ on-board OVMS sensors using EKF integrated algorithm is given as following equation (13) [14]:

$$\boldsymbol{\delta}\dot{x} = M\boldsymbol{\delta}x + Su \ (13)$$

Where M is the dynamic matrix, $\boldsymbol{\delta}$x is the state vector error, S is the shaping matrix, u is the white noise vector. The state vector ($\boldsymbol{\delta x}$) error is written as following equation (14):

$$\boldsymbol{\delta}x = \left[\boldsymbol{\delta\varphi}\ \boldsymbol{\delta\lambda}\ \delta\text{ĥ}\ \boldsymbol{\delta\dot{\varphi}}\ \boldsymbol{\delta\dot{\lambda}}\ \delta\dot{\text{ĥ}}\right] \ (14)$$

Where $\delta\varphi$ is latitude error, $\delta\lambda$ is longitude error, δh is altitude error, $\boldsymbol{\delta\dot{\varphi}}$ is velocity error on x axis, $\boldsymbol{\delta\dot{\lambda}}$ is velocity error on y axis, and $\delta\dot{\text{ĥ}}$ is velocity error on z axis [15]. The dynamic matrix (F) is written as following equation (15):

$$M= \begin{bmatrix} M_{11} & M_{12} & 0_{3X3} & 0_{3X4} \\ 0_{3X3} & 0_{3X3} & M_{23} & M_{24} \\ 0_{3X3} & 0_{3X3} & 0_{3X3} & M_{34} \\ 0_{3X3} & 0_{4X3} & 0_{4X3} & 0_{4X4} \end{bmatrix} \ (15)$$

Where 0_{nxm} is n x m zero matrix and $M_{11}, M_{12}, M_{23}\ , M_{24}\ and\ M_{34}$ are written as following equations (16,17,18,19 and 20):

$$\boldsymbol{M_{11}} = \begin{bmatrix} 0 & 0 & \frac{-v_n}{{R_e}^2} \\ \frac{v_e tan\boldsymbol{\varphi}}{R_e cos\boldsymbol{\varphi}} & 0 & \frac{-v_n}{{R_e}^2 cos\boldsymbol{\varphi}} \\ 0 & 0 & 0 \end{bmatrix} \ (16)$$

$$\boldsymbol{M_{12}} = \begin{bmatrix} \frac{1}{R_e} & 0 & 0 \\ 0 & \frac{1}{R_e cos\boldsymbol{\varphi}} & 0 \\ 0 & 0 & -1 \end{bmatrix} \ (17)$$

$$M_{23} = \begin{bmatrix} 0 & -v_x sin\Theta cos\psi & -v_x cos\Theta sin\psi \\ 0 & -v_x sin\Theta sin\psi & v_x cos\Theta cos\psi \\ 0 & -v_x cos\Theta & -1 \end{bmatrix} \ (18)$$

$$M_{24} =$$

(19)

$$M_{34} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \ (20)$$

The shaping matrix S is written as following equations (21,22,23,24 and 25):

$$S = \begin{bmatrix} S_{11} & 0_{3X1} & 0_{3X1} & 0_{3X1} \\ 0_{3X1} & 0_{3X1} & 0_{3X1} & 0_{3X1} \\ 0_{3X1} & S_{32} & S_{33} & S_{34} \\ 0_{4X1} & 0_{4X1} & 0_{4X1} & 0_{4X1} \end{bmatrix} \ (21)$$

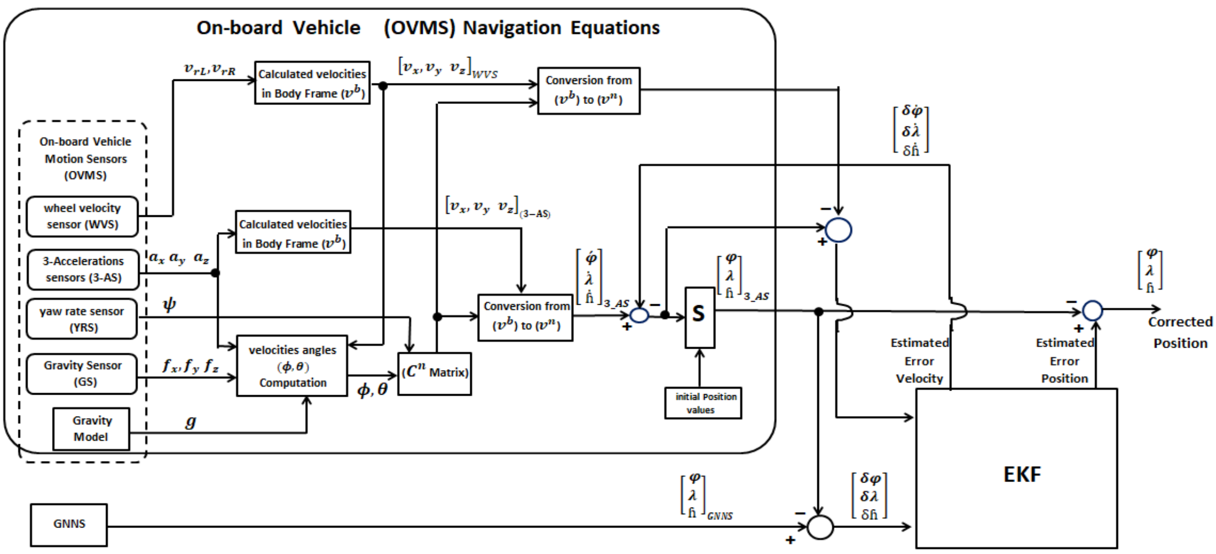


Fig. 3: Proposed GNSS/on-board OVMS -EKF Integration

where

$$S_{11} = \left[\frac{cos\Theta cos\psi}{R_e} \quad \frac{cos\Theta sin\psi}{R_e cos\boldsymbol{\varphi}} \quad -sin\Theta\right]^T \ (22)$$

$$S_{32} = [1 \quad 0 \quad 0]^T \ (23)$$

$$S_{33} = [0 \quad 0 \quad 1]^T \ (24)$$

$$S_{34} = [0 \quad 0 \quad 1]^T \ (25)$$

The white noise vector (u) is written as following equation(26) [16]:

$$u = [W_{v_{wvs}} \quad W_{\phi_{GS}} \quad W_{\theta_{GS}} \quad W_{\Psi_{YRS}}]^T \ (26)$$

Where $W_{v_{wvs}}$ is the white noise of WVS derived vehicle velocity, $W_{\boldsymbol{\phi}_{GS}}$ is the white noise of GS derived roll, $W_{\boldsymbol{\theta}_{GS}}$ is the white noise of GS derived pitch, and $W_{\Psi_{YRS}}$ is the white noise of YRS sensor [17]. The measurements of EKF model is expressed as following equation (27):

$$\boldsymbol{E} = \mathrm{D}\boldsymbol{\delta}\mathrm{x} + \mathrm{V}_m \ (27)$$

Where E is the measurement residual vector, D is the design matrix, and V_m is the measurement noise vector.

The measurement residual vector of GNNS ($\boldsymbol{E}_{GNNS}$) is the difference the position and velocity determined by on-board OVMS and the data acquired from GNNS. It is give as following equation(28) [17]:

$$\boldsymbol{E}_{GNNS} = \begin{bmatrix} \boldsymbol{\varphi} \\ \lambda \\ h \\ \dot{\boldsymbol{\varphi}} \\ \dot{\lambda} \\ \dot{h} \end{bmatrix}_{GNNS} - \begin{bmatrix} \boldsymbol{\varphi} \\ \lambda \\ h \\ \dot{\boldsymbol{\varphi}} \\ \dot{\lambda} \\ \dot{h} \end{bmatrix}_{OVMS} \quad (28)$$

Where the subscripts $OVMS$ and $GNNS$ denote the measurement values of on- boar OVMS vehicle sensors and measurement values of GNNS, respectively [17]. The design matrix for GNNS($\boldsymbol{D}_{GNNS}$) is given as following equation(29):

$$\boldsymbol{D}_{GNNS} = \begin{bmatrix} I_{3X3} & 0_{3X3} & 0_{3X3} & 0_{3X4} \\ 0_{3X3} & I_{3X3} & 0_{3X3} & 0_{3X4} \end{bmatrix} \ (29)$$

where I_{3X3} is identity matrix.

4. Accident Detection (AD) Algorithm

Accident detection (AD) algorithm ,in this paper, is using to decide if car accident is happened or not. The car accident is an accident that the average speed is 3.5 m/s and change in vehicle speed doesn't pass 6.5 m/s.

A fatal accident that may terminate to serious injury and fatality, occur when a change in vehicle speed passes 7 - 12 m/s in 1 second in any direction. In fact, the passenger airbags an on-board sensors are triggered as soon as (50 ms) the vehicle strongly collides an obstacle at δV= 20-40 Km.

The flowchart of proposed low-speed accident detection algorithm presents in fig. 4.

As this paper considers the car accident by only acceleration is not sufficient parameter to detect the accident. So, another parameter called Curvature-Of-Vehicle(COV) will aid acceleration sensor to improve the efficiency method to detect the low-speed detection. The COV parameter is based on rotation speed (β) of a vehicle is defined as following equation (30):

$\beta = A/R$ (30)

Where, A is the angular velocity of the vehicle and R is radius of the curve. So the curvature of the vehicle can be calculated by division of gyroscope value of z axis to speed of the vehicle to obtain the rotational speed.

The concept of COV parameter based on rotation speed (β) of a vehicle is shown in fig. 5.

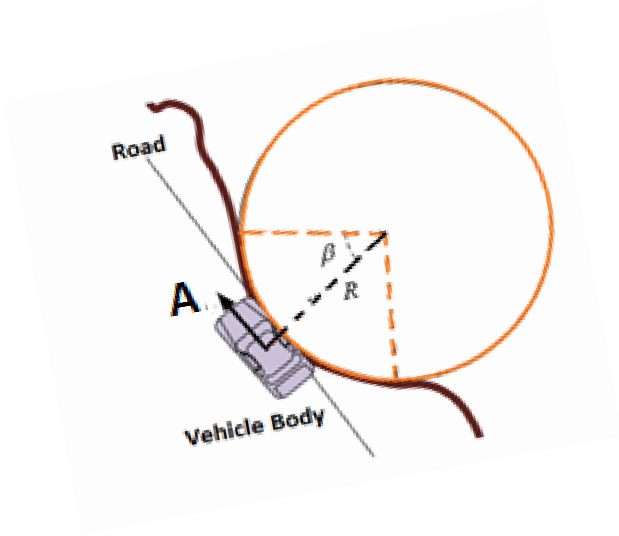


Fig. 5: Concept of COV Parameter

So in accident detection, the COV parameter can be calculated by division of yaw (ψ) value of z axis to obtain the rotational speed of the vehicle.

Therefore, the accident detection algorithm needs to two parameters, acceleration and COV, to detect the low-speed accident.

In first step considers the values of acceleration in three axes is more than 85.00 m/s2 or not, and in the second step considers also if COV parameter is more than 20 1/m or not. The threshold values are made on different tests and they performed using Matlab in various maneuvers.

After detection of accident, the Proposed GNSS/on-board OVMS-EKF navigational system automatically will send the position coordinates ($\boldsymbol{\varphi}, \lambda, h$) of the accident vehicle, via SMS message or call phone, to nearest hospital to order help.

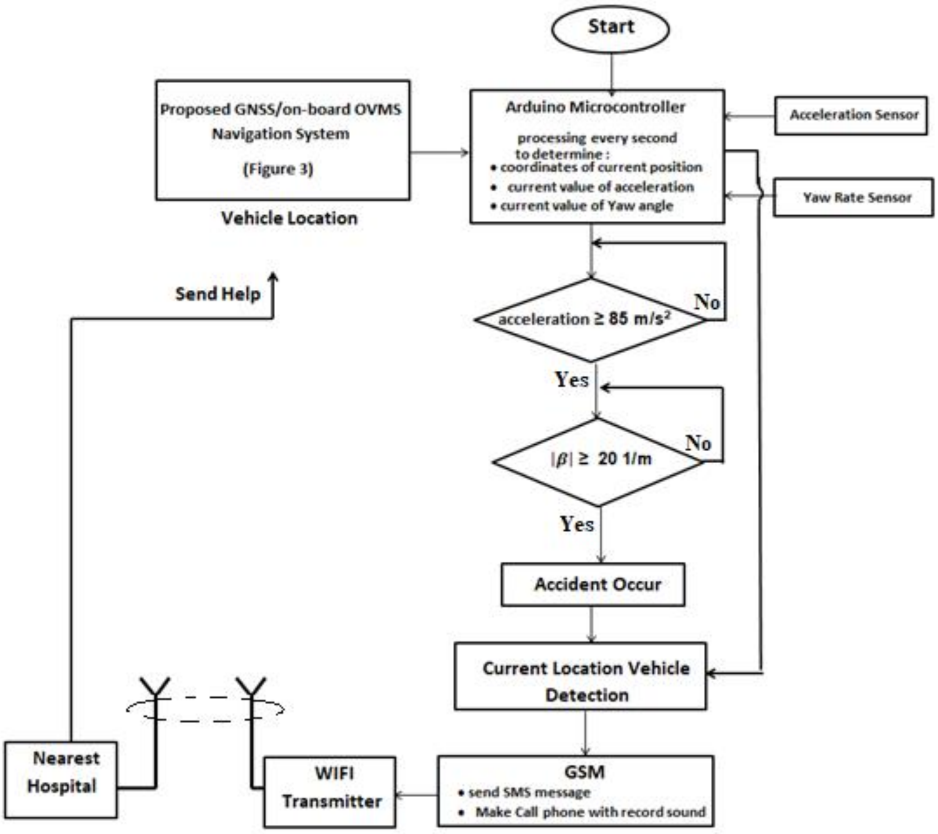


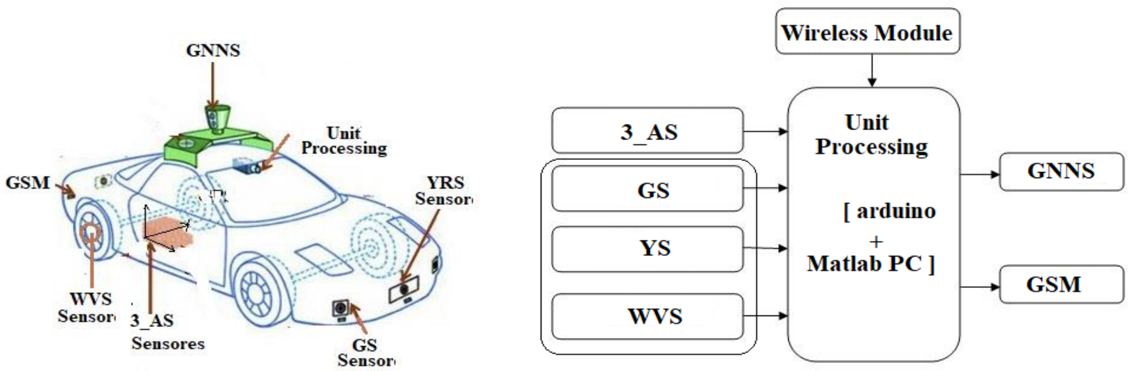
Fig.4: Flowchart of Proposed Accident Detection

5. Experimental Analysis and Results

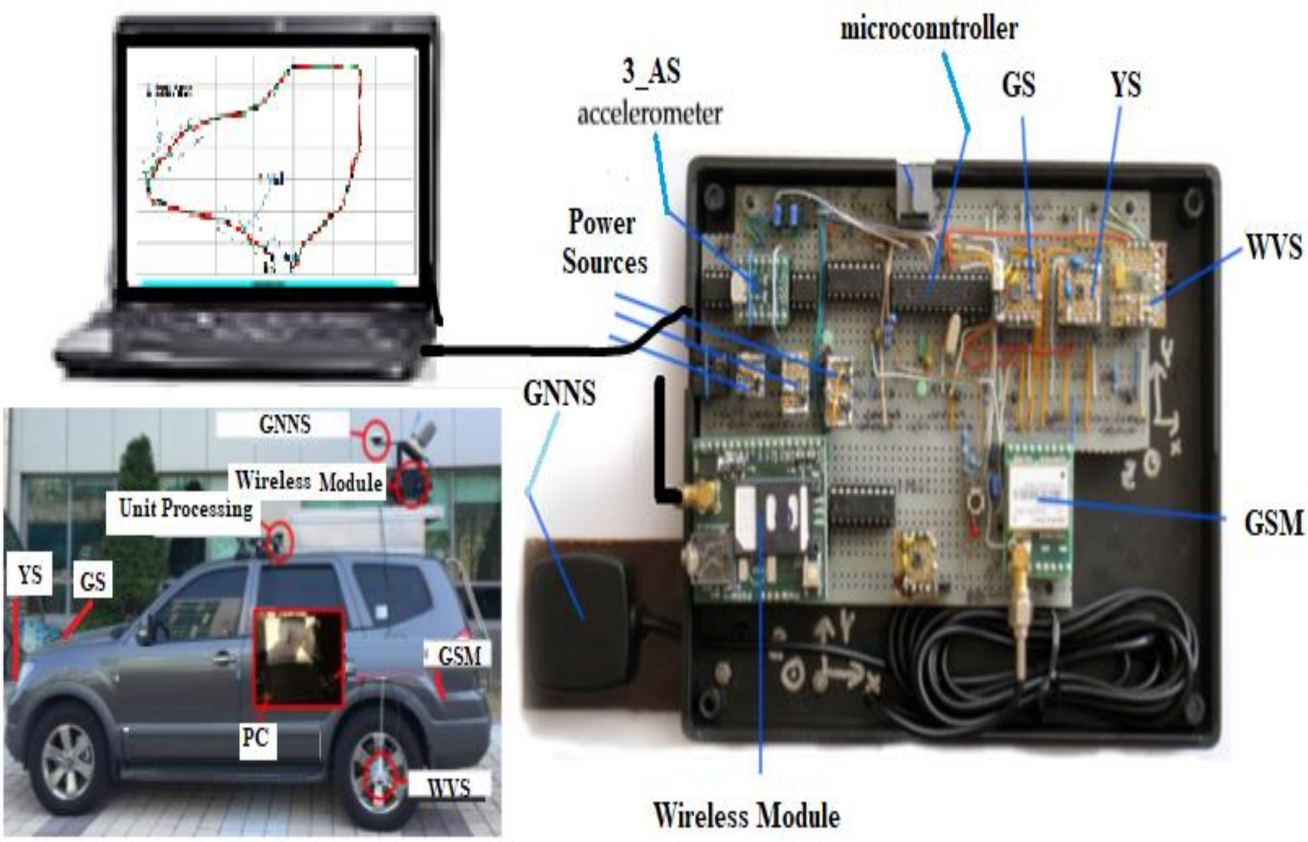
The proposed AI-accident detection system based on GNSS/on-board OVMS -EKF navigation system was tested and implemented with an experimental setup on reference trajectory about 2.2 km in Mukalla city –Yemen as shown in fig. 6.

The tests were performed via taken real measurements from GNNS and On-board Vehicle Motion Sensors (OVMS) on test trajectory and processing these measurement data with Arduino microcontroller and Matlab. The test vehicle, that equipped with on board OVMS sensors, is shown in figure 7.

Fig. 6: Reference Trajectory



a: Sensors Locations on Vehicle Body **b:** Interfacing Sensors with Unit Processing



c: Practical Components Connection

Fig7: Hardware Circuit of AI-accident detection system

The GNSS data were logged by the Novatel DL-V3GENERIC receiver. The GNSS was set to the point positioning used by automotive navigation system. According to the GNSS receiver specification, the accuracy of position and velocity are 0.489 m and 0.013m/s, respectively. The specifications of the OVMS on-board sensors are described in Table 1.

In this section, the efficiency of Proposed GNSS/OVMS -EKF Integration is tested for about 30 minutes on reference trajectory that covered with various driving circumstance encountered, urban roads with straight portions, turns, tunnel and slopes, and the speed of vehicle is about 60 km/h.

Table 1. Specification of OVMS Car Sensors

Sensor Type	Output Range	Resolution	Unit
WVS	0 – 150	0.148	m/s
YRS	-90 – +90	0.0121	Deg/s
GS	-.90 – +90	0.067	m/s^2
3_AS	-120.2 – -120.2	0.0124	m/s^2

5.1 Efficiency Test of Proposed Navigation

The raw measurements from GNNS and On-board OVMS Sensors after calibration are shown in fig. 8**.** And the estimated trajectory of proposed GNSS/OVMS -EKF Integration compared to GPS alone according to reference trajectory is shown in fig. 9.

The position error with respect to the reference trajectory is summarized in table 2.

Table 2. Estimated position error with Proposed Navigation and with GNNS Alone

		$(\delta\varphi)$ (m)	$(\delta\lambda)$ (m)
GNNS Alone	Max Value	1.924	1.825
	RMSE	1.184	1.067
Proposed Navigation	Max Value	0.821	0.429
	RMSE	0.267	0.189

From table 2 above, the position error using the proposed GNSS/OVMS -EKF algorithm is actually decreased compared to GNSS alone. The RMSE errors along latitude ($\boldsymbol{\varphi}$) and longitude ($\boldsymbol{\lambda}$) using the proposed GNSS/OVMS -EKF algorithm is reduced from 1.184 m, 1.067 to about 0.267, 0.189, respectively, compared to GNSS alone. This means, the position error is reduced to about 8% compared to GNSS alone. Via the result of this test, the proposed GNSS/OVMS -EKF algorithm can provide a accurate and stable system to determined position of accident vehicle during poor and GNSS outages.

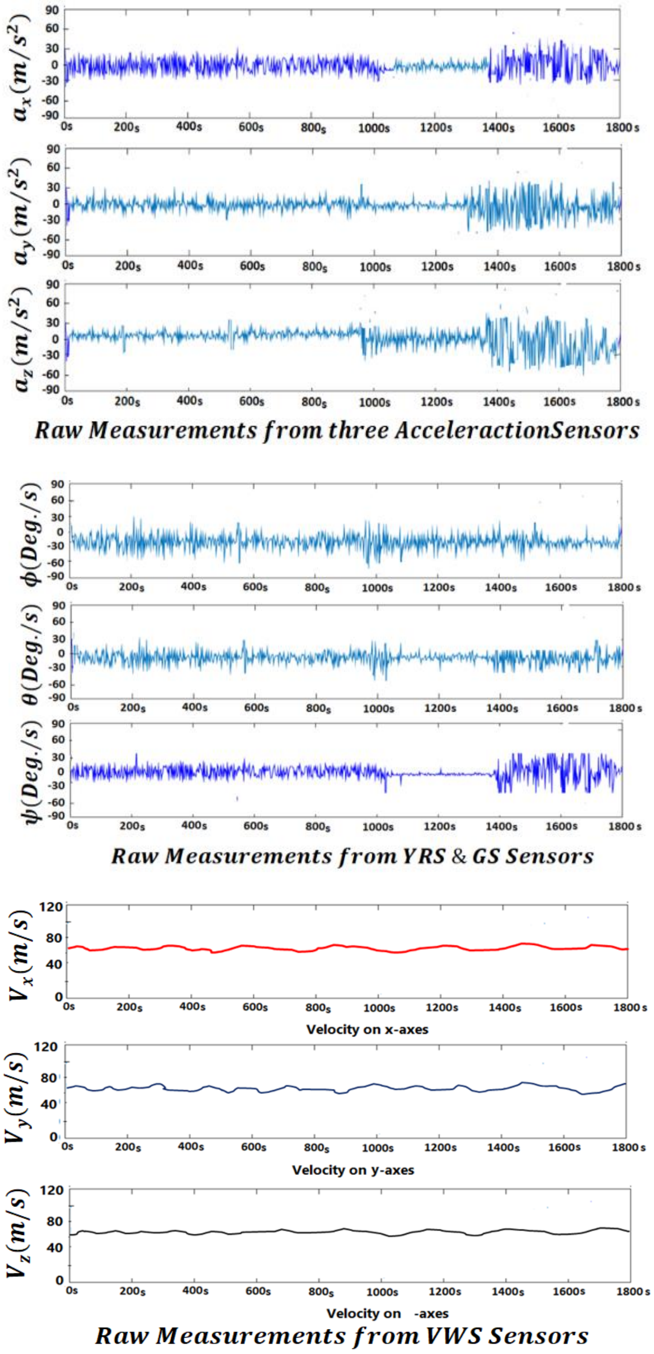


Fig. 8: Raw Measurements from GNNS and OVMS Sensors

5.2 Efficiency Test of Accident Detection System

In this scenario, The distance of reference trajectory is about 4.8 km as shown in figure 10. The reference trajectory is composed of narrow urban canyons, tunnels, and viaducts that make the GNSS signal unavailable.

According to accident detection system, if the value of acceleration is more than 85 m/s2 and the value of COV parameter is more than 20°, the accident is detected. After the accident is detected, the position of the accident vehicle will send automatically via Arduino microcontroller and GSM module to nearest hospital to order help.

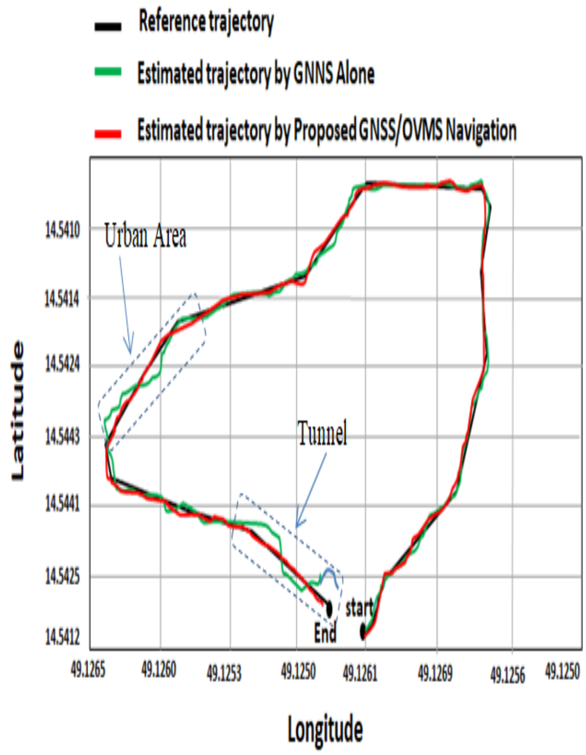


Fig. 9: Compared Results between Proposed GNSS/OVMS & GNNS Alone

Fig.10: Reference Trajectory

The speed vehicle in this scenario is about 100 m/s, as we need to detect car accident. The test takes about 15 minutes of driving considering about four times simulated accident on sharp curves paths on the reference trajectory. The accident detection algorithms based on both big acceleration and curvature of the moving vehicle is shown in fig.11.

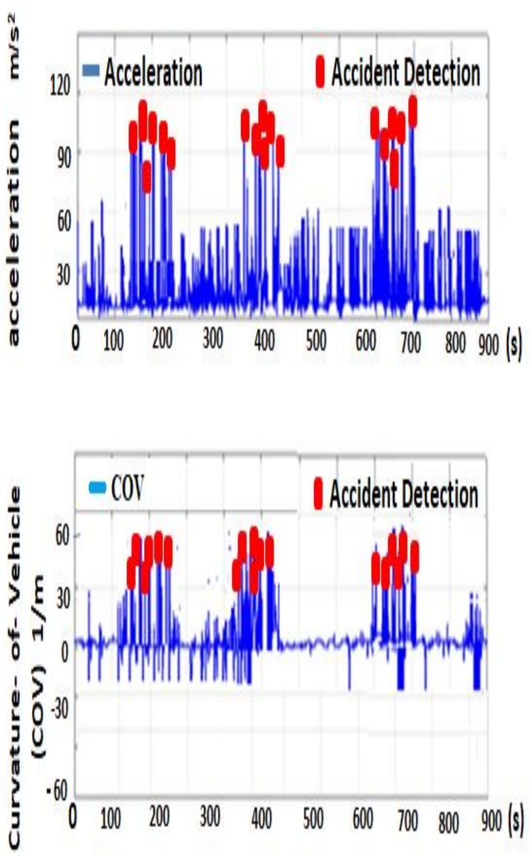


Fig.11: Accident Detection based on COV & Acceleration. Parameters.

The red paths in fig. 12 shows the position of the accident detected of vehicle on reference trajectory.

Fig. 12: Accident Detection Position

6. Conclusion

The Proposed AI-accident detection system can provide an Artificial Intelligent (AI) solution to determine the position and detect any accident of vehicle on Freeways, during available GNNS signal or not, in fast time with low cost and high efficiency.

The Proposed system is tested based on the practical functions of vehicle dynamics, presented by a set of raw measurements from On-board Vehicle Motion (OVMS)sensors, such as Acceleration Sensors (AS), Wheel Velocity Sensor (WVS), Gravity Sensor (GS), Yaw Rate Sensor (YRS) and additional to GNNS .

In first test, the proposed navigation system can provide accurate continuous navigation solution during GNNS outages and reduce 0.267, 0.189 on latitude ($\boldsymbol{\varphi}$) and longitude ($\boldsymbol{\lambda}$) respectively.

While in second test, the proposed accident detection system can detect any accident maybe occur on road with high efficiency during GNNS outages.

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مقالة بحثية

نظام ذكي لكشف وتحديد مواقع الحوادث المرورية على الطريق السريع مبني عل تقنيه مستشعرات الحركة المدمجة في السيارات

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المُلخّص

انظمة الكشف والتعقب اليوم تعتبر شيء اساسي في العديد من المجالات وعلى سبيل المثال في كشف وتحديد مواقع الحوادث المرورية كما في بحثنا هذا والذي بدورة سوف يساعد في سرعة الانقاذ وتقليل عدد الوفيات. وبما ان معظم انظمة الكشف والتعقب الحالية تعتمد على نظام تحديد المواقع والمسمى (GNSS) الا انه في بعض الاماكن وخصوصا في الاماكن الحضرية المكتظة بالبنايات والانفاق تكون إشارة هذا النظام غير موجودة مما يسبب مشكلة جوهرية في تلك الانظمة وفشلها. ولحل مشكلة انقطاع اشارة GNSS اعتمدت تلك الانظمة على عميلة دمج نظام GNSS بمجموعة من مستشعرات (Sensors) الملاحة مثل مستشعرات التعجيل (accelerometers) ومستشعرات زوايا اتجاه الحركة (gyroscopes) ومستشعرات قياس المسافة (odometers) وغيرها وذلك لتحسين كفاءة النظام خلال انقطاع اشارة GNSS. الا ان مثل هذه الطرق لاتزال تعاني الكثير من جوانب القصور مثل كبر حجمها وكلفتها واستغراقها لوقت اكبر في عمليه المعالجة واتخاذ القرار. معظم المركبات اليوم تمتلك العديد من مستشعرات الحركة المسماة (OVMS) مثل مستشعر التعجيل (AS) ومستشعر السرعة (WVS) ومستشعر الجاذبية (GS) ومستشعر زوايا الارتفاع (YRS) والتي يمكن استخدامها كما في بحثنا هذا في عملية تحسين كفاءة نظام الكشف والتعقب خلال انقطاع اشارة GNSS. الورقة البحثية المقترحة تقدم نظام ذكي لكشف وتحديد مواقع الحوادث المرورية المبني على عملية دمج نظام GNSS مع مستشعرات الحركة المدمجة في السيارات باستخدام لوغاريثمية كلمان فلتر. خلال انقطاع اشارة GNSS تستخدم مستشعرات التعجيل (AS) في تحديد سرعة السيارة ومن ثم تحديد موقعها على المحاور الثلاثة (X,Y,Z). بينما تستخدم مستشعرات الجاذبية (GS) وزويا الارتفاع (YRS) في تحديد زويا السرعة واتجاه حركة المركبة بالإضافة لاستخدام مستشعر السرعة (WVS) في تصحيح اخطاء سرعة مستشعرات التعجل حتى عودة اشارة GNSS مرة اخرى. تم فحص النظام المقترح على مجموعة من السيناريوهات (scenarios) خلال انقطاع اشارة GNSS. ومن خلال نتائج البحث استطاع النظام المقترح ان يكتشف ويحدد موقع الحادث المروري بكفاءة عالية.

الكلمات المفتاحية: نظام تحديد المواقع، مستشعرات الحركة المدمجة، الذكاء الاصطناعي، لوغاريثمية كالمان فلتر.

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