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Vehicular Ad-hoc Network with Adaptive Cruise Control

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Abstract: Data fusion is the process of combining data from multiple sources. To improve accuracy of the information it is necessary to collect data from multiple sensors. The intelligent transport system (ITS) is used for vehicles safety applications. It is also used to enhance the non safety applications i.e. road and vehicle efficiency. In vehicular ad-hoc network multiple sensors are available for security measures for driver, and also important for communication between V2V, V2I or I2V. To control the cruising of vehicle Adaptive Cruise Control is required. To broadcast information unscented filter based on recursive Kalman type of estimator is used..

Keyword: *Intelligent Transport System, Adaptive Cruise Control, Kalman filter, Data fusion*

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I. INTRODUCTION

Vehicular Ad-hoc Network (VANET) is wireless local area network technology to connect node to each other and is a part of Intelligent Transport System (ITS).There are few opportunity to establish the direct communication between Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), and Infrastructure-to-Vehicle (I2V) for information sharing. The ITS is used for vehicles safety applications and to enhance the non safety applications i.e. road and vehicle efficiency. The vehicle is equipped with inertial measurement units (IMU), positioning systems, and autonomous ranging sensors such as radars, laser radars, and cameras to alert the driver. Most of the accidents cases are due to carelessness or negligence of the driver. To avoid this Adaptive Cruise Control system (ACC) is used along with VANET. Adaptive Cruise Control system takes charge of controlling the throttle position from the driver and enables the cruising of the vehicle at the preset constant speed. A radar system maintains inter-car distance and warns of emergency situations.

To accurate result the system uses data fusion, process which synthesizing raw data from several sources to generate more accurate result. The data fusion is techniques to combine or fuse data are drawn from a diverse set of more traditional disciplines, including digital signal processing, statistical estimation, control theory, artificial intelligence, and classic numerical methods. Applications for multi sensor data fusion are widespread. Military applications include automated target recognition (e.g., for smart weapons), guidance for autonomous vehicles, remote sensing, battlefield surveillance, and automated threat recognition system, such as identification-friend-foe-neutral (IFFN) systems. Nonmilitary applications include monitoring of manufacturing processes, condition based maintenance of complex machinery, robotics, and medical applications, intelligent transport system (ITS) etc.

The ACC is the part of Real Time Operating System (RTOS), which contain Engine control, speed control and brake systems, safety systems, seat and pedal controls. ACC receives the Input from VANET and it takes the decision. ACC uses Unscented Kalman filter to accurate the data or control.

II. VEHICULAR AD-HOC NETWORK

VANET is a technology that uses moving vehicles as nodes in a network to create a mobile network. VANET turns every participating vehicle into a wireless router or node, allowing vehicles approximately 100 to 300 meters of each other to connect and, in turn, create a network with a wide range. As vehicles fall out of the signal range and drop out of the network, other vehicles can join in, connecting vehicles to one another so that a mobile Internet is created. VANET is a subgroup of Mobile Ad-hoc Network (MANET) where the nodes refer to vehicles. Since the movement of Vehicles is restricted by roads, traffic regulations we can deploy fixed infrastructure at critical locations.

The primary goal of VANET is to provide road safety measures where information about vehicle's current speed, location coordinates are passed with or without the deployment of Infrastructure. Apart from safety measures, VANET also provides value added services like email, audio/video sharing etc, Fig 1. describes the communication types such as Vehicle to Vehicle (V2V), Vehicle to Infrastructure (V2I), Infrastructure to Vehicle (I2V).

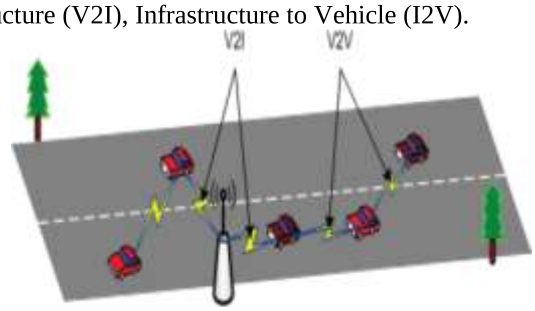

Fig 1 VANET Communication

Table 1 show various applications of VANET used in ITS.

III. STANDARD USED FOR VANET

For vehicle-to-X communication it is inevitable that all participating parties agree on a common standard. The currently foreseen standard for this specific type of communication is IEEE 802.11p (IEEE 2008). Basically it is one amendment within the family of IEEE 802.11 (IEEE 2007) standards that define the widely used technology for wireless local area networks (WLAN).IEEE 802.11p is derived from IEEE 802.11a standard, but PHY and MAC layers are modified to support low-latency communication among vehicles. IEEE 802.11p operates at a frequency band specifically allocated for road safety, such as 5.850–5.925 GHz (75 MHZ) in the US and 5.875–5.90 GHz (30 MHz) in Europe with possible future extension, defines data rates from 3 to 27 MHz for 10 MHz channels (optionally 6 to 54 MHz for 20 MHz channels), OFDM modulation and maximum power levels of 44.8dBm. The basic MAC is the same as the well known IEEE 802.11 Distributed Coordination Function (DCF). It adopts concepts from Enhanced Distributed Channel Access (EDCA) of 802.11e, like Access Category (AC) and Arbitrary Inter-Frame Space (AIFS), in order to differentiate priorities among applications. IEEE 802.11p is designed as a multi-channel scheme, where nodes can switch between channels (US) or transceive on multiple channels simultaneously (dual transceiver in Europe).For advanced networking algorithms, we use standard-compatible extensions to control radio parameters (transmit power and others) on a per-packet basis.

Iv. SENSORS USED IN VEHICLE

As evidenced with the integration of GPS and IMU sensors, future cooperative safety systems will benefit from the fusion of sensors other than just GPS and wireless communications. These sensors include autonomous ranging sensors such as radars, laser radars, and cameras, but also on-board vehicle sensors such as steering wheel angle sensors and wheel speed sensors. Besides improving vehicle positioning, on-board sensors also aid in vehicle path prediction. The combination of vehicle sensor measurements with appropriate vehicle motion models allows accurate path prediction for significant time horizons. These predictions will be the core of many cooperative collision avoidance systems. Ranging sensors such as radars, laser radars, and ultrasonic sensors will play a crucial role in detecting and tracking non-communicating vehicles or objects. computer vision sensing could supplement vehicle positioning in VANET safety systems. Similar to the goals of fusions between GPS and IMU sensors, computer vision can aid during times of satellite signal loss.

V. ADAPTIVE CRUISE CONTROL(ACC)

Vehicle collects the information from its sensor and ITS,V2V, I2V.This information is available in fused form i.e. data fusion. Important is dissemination of information using data fusion. To dissemination of information in VANET or V2V safety application. Unscented Filter is used.

Unscented Filter is recursive Kalman type of estimator. Fig.3 shows Unscented Filter Algorithm. It include following steps

1. Predict the new state of the system and its associated covariance (along with the effect of process noise).
2. Predict the expected observation and the innovation covariance (along with the effect of observation of noise).
3. Finally predict the cross correlation matrix

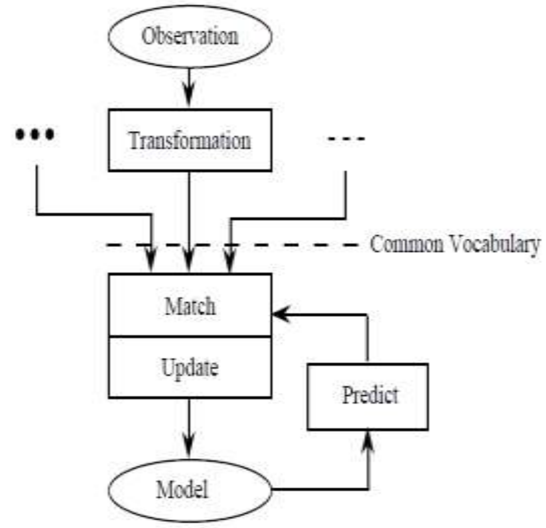

Fig. 3 Unscented Filter Algorithm

This information is the input for ACC. Cruise control(CC) is also called auto-cruise control or speed control. It automatically controls the car speed. The driver presets a speed and the system will take over the control of the throttle of the car. Generally the driver holds the vehicle steady during the accelerator pedal. Cruise control relives the driver from that duty and the driver hands over the charge to the CC when the road conditions are suitable and, if the car is cruising at high speed, when there is no heavy traffic. An ACC system car moves in cruise mode at a preset speed. A radar or laser or ultraviolet emits signals at regular intervals. These signals are reflected from the vehicle in front. when reflected signal received earlier than expected from minimum safe distance; it notifies the presence of another vehicle to the system. The ACC system then decelerates and the car slows down. Fig. 4 shows how adaptive cruise control system function.

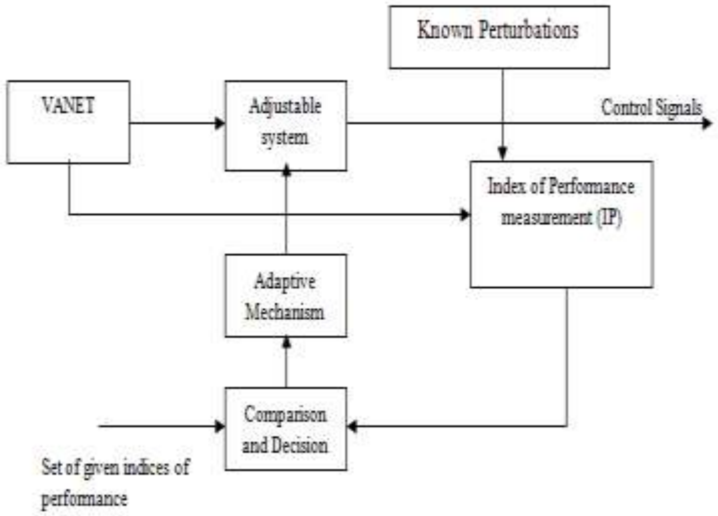

Fig 4. Model for Adaptive Cruise Control

For an ACC system, an adjustable system sub unit generates output control signals to throttle valve. The desired preset cruise velocity, desired preset distance and safe preset distance are the inputs to index of performance measurement sub-unit. Information collected from VANET is also input to index of performance measurement sub-unit. The comparison and decision sub-unit has inputs of set performance parameters and observed parameters. It sends outputs which are inputs to the adaptive mechanism sub-unit. The adaptive mechanism sub-unit sends outputs, which are inputs to the adjustable system.

VI. Conclusion

Vehicle communication widely used for vehicle safety application. To improve the result the data fusion technique is used and information is disseminating using Unscented Kalman type estimator. For safety application the disseminated information is feed to the vehicular Real Time Operating System which control the cruise and throttle. This system also alert to other vehicle using Vehicle to Vehicle (V2V), Vehicle to Infrastructure (V2I), Infrastructure to Vehicle (I2V). the data fusion and kalman filter improve the granularity of the information. The estimator works on common platform which transform the various input in common vocabulary.

VII. References

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	Feature			Requirements		
Applications	Safety App.	V2V/V2I	Multihop	Authentication	Integrity	Privacy
Intersection collision warning	√	V2V		2	2	2
Emergency vehicle warning	√	V2I	√	2	2	0
Work zone warning	√	V2I	√	1	2	0
Forward collision warning	√	V2V	√	2	2	2
Cooperative adaptive cruise control		V2V	√	2	2	2

Table 1: Sampled VC applications: features and importance of security requirements