EXTENDED KALMAN FILTER APPROACH FOR REDUCING TRAFFIC CONGESTION IN VANET

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ABSTRACT:

Traffic Congestion in VANET is widely researched problem in recent times. Many new techniques have been proposed in recent years and are implemented and compared with the existing techniques. In previous approach Kalman Filter algorithm is used to find the optimum route from source to the destination. This approach is well formed with the linear research problems. The problem involving in this case is a non linear problem so an extension to the Kalman Filter is used. Extended Kalman Filter considers the acceleration as a function of distance and and two previous instances are required for the same. Results shows that the proposed approach outperforms the existing approach on the basis of various performance parameters like packet delivery ratio and end to end delay. In future other Bayesian approaches must be used for solving the traffic congestion problem.

Keywords: Extended Kalman Approach, VANET

INTRODUCTION:

Vehicular networks (VANETs) are designed as a set of mobile networks (MANETs) with the distinctive property that the nodes here are vehicles [1]. So node i.e. vehicle movement is restricted by road course, encompassing traffic and traffic rules. Attributable to these restrictions, VANET is supported by some fixed infrastructure that assists with some services of the VANET and provides access to stationary networks. The fixed infrastructures are deployed at essential locations like road sides, service stations, dangerous intersections or places with unsafe weather conditions. VANET is extraordinarily sort of versatile specially appointed remote systems (MANETs) Vehicular systems are considered as a novel class of remote systems. VANET is an innovation that uses moving vehicles as hubs in a system to make a portable system [2]. In VANET, different kind of attacks can result in the loss or diminution in the accessibility. Even a robust communication channel can still suffer some attacks (such as deny of service) which can bring down the network. Therefore, availability should be also supported by alternative means. An important feature of VANET security is the digital signature as a building block. Infrastructure communications or communications inter-vehicle through, authentication (using signatures) is a fundamental security requirement. Due to the brief communication time, it is difficult to assure the reliable message reception and acknowledgement between communication vehicles on opposite directions. In vehicular ad hoc networks a majority of the messages that are transmitted will be periodic broadcast messages that announce the state of a vehicle to its neighbors. So in case of broadcast messages it needs more reliability. Some researcher proposed to use a group of vehicles carrying the messages to improve the reliability. Besides the introduction and management of trust also the security of message content is a big issue for vehicle to vehicle communication. The content of a received message has to be verified within a short time to be able to use the information as soon as possible.

Kalman Filter

Akalman filter is effective recursive filter which calculate the approximation of linear dynamic system. The kalman filter is necessarily a set of different equations and describes the state space model which implements a predictor corrector type estimator. This kalman filter is applied to both stationary and non-stationary processes. It has two significant vectors that are state vector and measurement vector. The state vector is defined as the minimal set of data to explain the behavior of the system [5].Also it can be defined as the state is the minimum amount of data about the past behavior of system which is required to predict its behavior. On theother hand, measurement vector is a measure at time t.

Kalman filter uses two equations: process equation and measurement equation. The *process equation* is used to predict the state of the system at for a given and is given as

$$X_{t+1} = A_t X_t + w_t$$

WhereAt is state transition matrix and wt is process noise.

The measurement equation is also known as observation equation and it is given as

$$Z_t = H_t X_t + u_t$$

WhereZt is measurement vector at time t and Ht is measurement matrix.

RELATED WORK:

Jayapal et al [1] presented congestion detection system which uses VANET. Traffic app is installed in each driver's smart phone that is capable of detecting location with the help of GPS system. Thisinformation is conveyed to all servers that investigate traffic congestion. When the congestion is detected, then this information is distributed to all end users mobile phone through RSUs. This traffic app sends the location information as some interval periodically and each vehicle location is traced. Through this information, the distance covered by vehicle at given time is monitored. Congestion is detected in specific area only if its value is lesser then the fixed threshold.

Liu, Zhao et al. [2] in this paper, smart traffic congestion detection has been proposed. This proposed system helps to divert the incoming vehicle and minimize the congestion without human involvement. This system may also be improved by communicating the congestion information among vehicles through IEEE 802.11p protocol. When same message is sends in similar area, and then traffic congestion is being confirmed. The information of congestion is available through mobile app installed in each vehicle. This proposed system is efficient and reliable.

Panse, Prashant et al [3] in this work, problems with traffic on highways have been discussed and novel system has been presented to investigate and prevent accidents on highway by utilizing VANET. In this paper, V2V scheme with WSA algorithm and evaluating the performance on distinct parameters of network.

Qi, Liang, MengChu et al [4] in this paper various measures are carried out to prevent traffic congestion. Traffic light scheme has been designed to reduce the traffic congestion. Two way rectangular grid networks is designed through cell transmission model. The efficiency of the presented scheme is calculated through simulations in the modeled grid network. The result detected the influence of rout-changing behaviors of drivers, the time when to operate the emergency strategy, and the inflow of the traffic network. They may be utilized to enhance the state of the art in preserving urban road traffic congestion due to incidents.

Feng, Huifang et al [5] location of vehicle has been predicted in VANET by using kalman filter. In this paper, different experiment has been employed by utilizing both real vehicle mobility and model-driven traces. Moreover performance of prediction of kalman filter is being compared with neural network based methods. The result indicates that proposed approach shows accuracy than other prediction sources.

Ghafoor, Huma et al. [6] location based routing protocol for VANET has been proposed using kalman filtering. Initially protocol chooses an idle channel from all other channel which is available to vehicle while moving in straight road. Then it detects the best node to send the packet to its destination. the relay node is selected by distributing the vehicular transmission range into five region and then it choose the one node which is in region of higher preference as compared to other regions. In two vehicles communication among two vehicles only occurs when both the vehicles are on same channel. Delay is one of the main reasons which will increase relaynode selection. in order to reduce the delay, kalman filter is being used. The result clearly demonstrated that this proposed protocol is improved in both packet delivery ratio and end to end delay.

Toutouh, Jamal, and Enrique Albaet al. [7] in this work use of smart phones has analyzed, tablets, and laptops in vehicle-to-vehicle communications by defining a test bed carried out in the city of Malaga. In our analysis we have included two different MAC/PHY specifications: the widely used IEEE 802.11g and the IEEE 802.11a. We have designed two distinct experiments: the first designed to evaluate the wireless signal strength generated by the analyzed devices, and the second, focused on characterizing the QoS of V2V communications of these devices

Dietzel, Stefanet al. [8] proposed bandwidth-efficient protection mechanism which is depending on data-consistency checking. Different techniques are combined to investigate wrong information proposed technique for forwarding paths which limits the influence of attackers on combined data. the experimental results indicates that proposed method may investigated common attacks successfully on aggregation while maintaining bandwidth efficiency.

Wongdeethai, Singha, and PeeraponSiripongwutikorn. [9] Presented a RTC protocol to collect the traffic information in vehicular ad hoc networks on roads. Moreover, the RTC (road traffic control) protocol uses the message exchange pattern in order to enhance the reliability of query delivery. The results demonstrated that proposed protocol can gather 100% of traffic information

PROPOSED METHODOLOGY:

The proposed work includes use of Extended Kalman Filter to solve the problem of congestion and to find the optimum route for the vehicle.

Route Discovery:

The design of effective vehicular communications poses a series of technical challenges. Guaranteeing a stable and reliable routing mechanism over VANETs is an important step toward the realization of effective vehicular communications. Existing routing protocols, which are traditionally designed for MANET, do not make use of the unique characteristics of VANETs and are not suitable for vehicle-to-vehicle communications over VANETs. The delay depends on whether another valid path already exists (in the case of multipath routing protocols) or whether a new route-discovery process needs to take place.

Extended Kalman Filter:

One of the main assumptions of the Kalman filter is that it is designed to estimate the states of a linear system based on measurements that are a linear function of the states. Unfortunately, in many of the situations where we would like to use a Kalman filter, we have a non-linear system model and/or a non-linear measurement equation. Specifically, the system model is a non-linear function of the states and/or the measurements are non-linear functions of the states. Usually, the non-linearities don't extend to the system disturbances and measurement noise.

Because of the attractiveness of the Kalman filter, designers have developed a set of mathematics to extend Kalman filter theory to situations where the system model and/or measurement model are non-linear functions of state. The resultant Kalman filter is referred to as the extended Kalman filter. As we will see, the extended Kalman filter uses the non-linear system model for computing the predicted state estimate, $\hat{x}(k+1|k)$, and the non-linear measurement model to form the predicted measurement, $\hat{y}(k+1|k)$.

It applies to the problem which is non-linear in nature both in terms of process dynamics and measurement dynamics. Hence, ordinary Kalman filtering cannot be applied here. An Extended Kalman Filter needs to be designed based on Taylor series expansion around a nominal value which is taken as the previous estimate in this case. The state transition matrix F is given by the Jacobian of the vector function f (x~, w~) about state x~ and the noise scaling matrix τ is given by the Jacobian of the vector function f (x~, w~) about state w~ .

Since the process dynamics are continuous while the measurements are usually discrete in nature, a hybrid continuous-discrete EKF model is to developed. The EKF equations of discrete time cannot be used directly and continuous time EKF equations has to be derived. Also, since the measurements are discrete in nature, a hybrid of both is developed and described below.

An observable, non-linear dynamical system, with continuous process dynamics and discrete measurement dynamics is described by,

$$\tilde{x}(t) = f(\tilde{x}(t)) + \tau_c \tilde{w}(t)$$

$$\tilde{y}_k = h(\tilde{x}_k) + \tilde{y}_k$$

where x~ ∈ $\Re^n$ denotes the n-dimensional state vector of the system, f (.) : Dx → $\Re^n$ is a finite non-linear mapping of system states to system inputs, z~k ∈ Dz ⊂ $\Re^p$ denotes the p-dimensional system measurement, h(.) : Dx ⊂ $\Re^n$ → $\Re^p$ is a nonlinear mapping of system states to output, τc ∈ $\Re^n$ x w denotes the continuous process noise scaling matrix, w~ ∈ Dw ⊂ $\Re^w$ denotes the w-dimensional random process noise and ~v ∈ Dv ⊂ $\Re^v$ denotes the v-dimensional random measurement noise.

Application of Extended Kalman Filter:

⟶ Moving Direction of Vehicles

⟶ Direction of Broadcast Messages

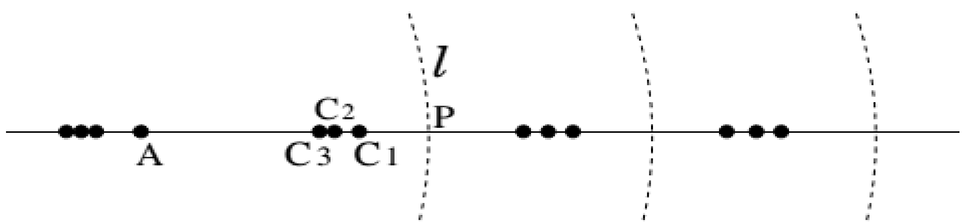

Fig1 : Simplified Broadcasting Scenario

The input maintained by vehicle C_i at time k is

x_{ik-2} , $\hat{a}_{ik-1}$ and p_{ik-1} and it measures x_{ik}.

Output by the Vehicle C_i : Potential acceleration $\hat{a}_{ik}$ of vehicle C_i and it computes a_{ik}

C_i updates $\bar{a}_{ik}$ and $\bar{p}_{ik}$ in order to predict its future position.

C_i computes Blending factor Kg_{ik}, indicates the change of acceleration from last time to current time.

At time k, C_i measures its position and then it computes a_{ik} as its measured acceleration by

$$a_{ik} = \frac{((x_{ik} - x_{ik-1}) - (x_{ik-1} - x_{ik-2}))}{\Delta t^2}$$

$$= (x_{ik} + x_{ik-2})/\Delta t^2$$

Where , x_{ik} is the position vector at time k

At this instant C_i updates

$$\hat{\bar{a}}_{ik} = \bar{a}_{ik-1}$$

$$\bar{p}_{ik} = p_{ik-1} + Q$$

Where $\hat{\bar{a}}_{ik}$ is the measured acceleration at time k evolved from time $k-1$ and $\bar{p}_{ik}$ is the measured acceleration at time k evolved from $k-1$.

C_i also computes the Blending Factor Kg_{ik}

$$Kg_{ik} = \bar{p}_{ik}\left(\bar{p}_{ik} + Q\right)^{-1}$$

C_i computes the potential acceleration $\hat{a}_{ik}$ from the measured acceleration a_{ik} and updates its variance of acceleration for future utilization.

$$\hat{a}_{ik} = \hat{\bar{a}}_{ik} + Kg_{ik}\left(a_{ik} - \hat{\bar{a}}_{ik}\right)$$

$$p_{ik} = (1 - Kg_{ik})\bar{p}_{ik}$$

Finally, the predicted position can be obtained from the distance formula

$$s_{ik+1} = (x_{ik} - x_{ik-1})\,\Delta t + \hat{a}_{ik}\,\Delta t^2/2$$

RESULTS AND DISCUSSIONS:

Average Packet Delivery Ratio: It is defined as follows:

$$Packet\ Delivery\ Ratio = \frac{Total\ received\ Packets}{Total\ generated\ Packets}$$

It is an important measure for computing the performance of the system.In the above formula the total generated packets is a combination of transmitted packets and packets lost in the network. As the Average packet delivery ratio in the above shown results increases we can conclude that the packets lost in the network decreases.

Average End-to-End Delay: It is defined as the total time taken by the packet to reach to the destination from the source from which it is generated. As the number of nodes in the network increases, the collision between packets in the network in case of base approach is greater than the proposed approach.

Figure 2 shows the graph between Average End-to-End delay and the number of vehicles in the grid. The graph clearly shows that the average delay is reduced in case of our proposed approach by a significant margin. Also in this graph it is clear that as the number of vehicles increases in the grid the average delay in sending data packets from one end to another decreases, which proves that there is a large availability of vehicles to transfer packets from one end to another. Figure 3 shows the average packet delivery ratio. This is another important parameter for evaluating the performance of the system. The graph shows the packet delivery ratio of the proposed approach with Extended Kalman Filter Algorithm shows much improvement as compared to the basic approach of linear filter.

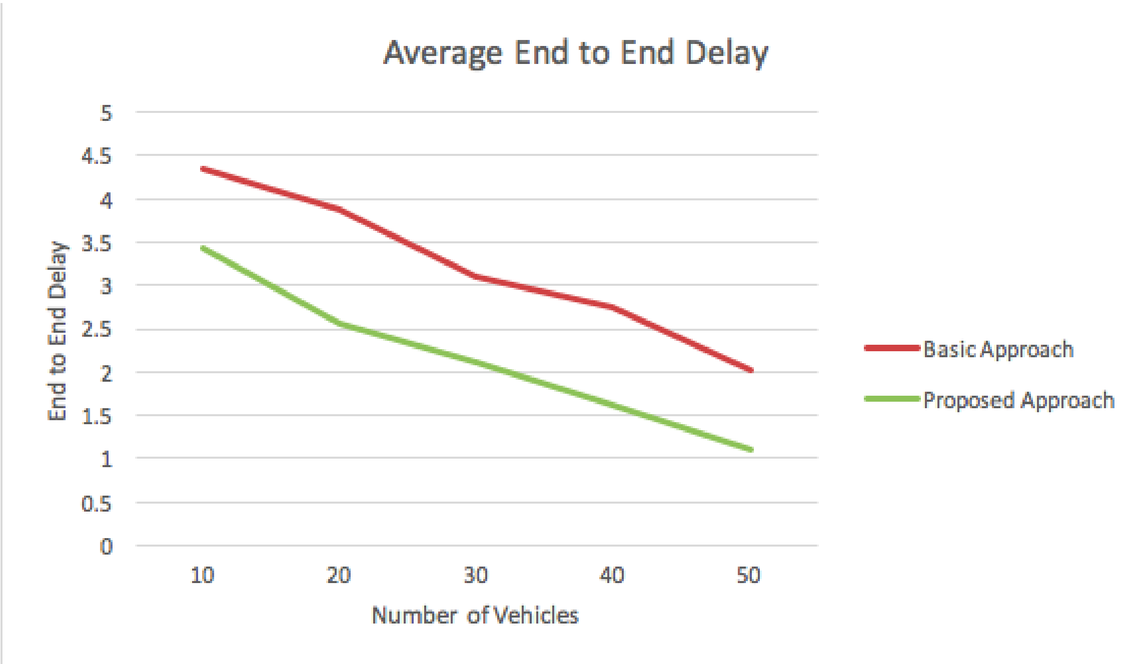

Fig 2: Graph between Average End-to-End delay and Number of Packets

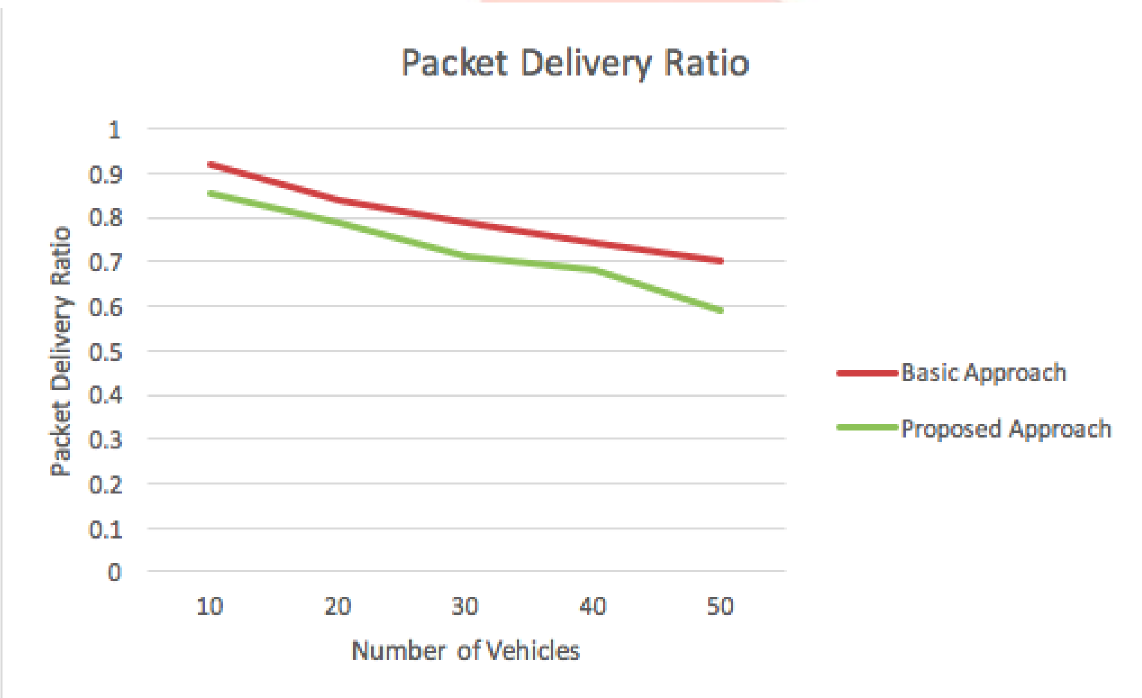

Fig 3: Graph between Average Packet Delivery Ratio and Number of Packets

Conclusion

The thesis proposes a novel Extended Kalman Filter based technique to solve the problem of traffic congestion in Vehicular Adhoc Network. Both Kalman and Extended Kalman filter has been implemented to estimate the position and velocity of the vehicles in order to correctly predict traffic congestion in every routes. Since the model is a non-linear model, the selection of EKF is justified although at the cost of extra computational power. The acceleration is calculated using the present and previous two instances of position of the vehicle which improves the accuracy of the prediction. Finally acceleration and distance relation is used to predict the future position of the vehicle. The results show that there is a significant improvement in terms of average end-to-end delay, and packet delivery ratio. These are two very important parameters when measuring the performance of any VANET system.

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