2. LITERATURE REVIEW:


This paper discusses the optimal coordination of variable speed limits and ramp metering in a freeway traffic network, where the objective of the control is to minimize the total time that vehicles spend in the network. Coordinated freeway traffic control is a new development where the control problem is to find the combination of control measures that result in the best network performance. This problem is solved by model predictive control, where the macroscopic traffic flow model METANET is used as the prediction model. He extends this model with a model for dynamic speed limits and for mainstream origins. This approach results in a predictive coordinated control approach where variable speed limits can prevent a traffic breakdown and maintain a higher outflow even when ramp metering is unable to prevent congestion (e.g., because of an on-ramp queue constraint). The use of dynamic speed limits significantly reduces congestion and results in a lower total time spent.


This paper presents an algorithm for the off-line estimation of route-level travel times for uninterrupted traffic flow facilities, such as motorway corridors, based on time-series of traffic speed observations taken from the sections that constitute a route. He proposed method is an extension of an existing and widely used method known as the trajectory method. The novelty of the new method is the fact that trajectories are constructed based on the assumption of piecewise linear (and continuous at section boundaries) vehicle speeds rather than piecewise constant (and discontinuous at section boundaries) speeds. Based on these assumptions, mathematical expressions are derived that describe the trajectories within each section. These expressions can be used to replace their existing counterparts in the traditional trajectory methods. A comparison of the accuracy of the new method and the existing method has been carried out based on simulated data. Then the comparison shows that the RMSE value for the new method is about half the RMSE value for the existing method. After decomposing this RMSE error in a bias and a residual error, it turns out that the existing method significantly overestimates the travel time. However the largest part of the reduction of the RMSE value is still due to a reduction of the residual error.
This paper investigated alternative implementations of the Adaptive Smoothing Method (ASM). The ASM is a data-driven traffic state estimator, which filters macroscopic traffic observations like speed and flow by kinematic wave theory. The conventional implementation was compared with a new implementation based on the two-dimensional cross-correlation, and a new implementation based on the Fast Fourier Transform (FFT). In these two implementations, the observations are not treated as single variables, but are gathered in a matrix representing a speed or a flow map. The cross-correlation operation and the FFT are applied to these matrices to solve the ASM. Very fast algorithms of these operations are available, which were incorporated into the ASM implementations proposed.

In this paper he has presented a new method to obtain spatio-temporal information from aggregated data of stationary traffic detectors, the adaptive smoothing method". In essential, a nonlinear spatio-temporal lowpass filter is applied to the input detector data. This filter exploits the fact that, in congested traffic, perturbations travel upstream at a near-constant speed, while in free traffic, information propagates downstream. As a result, one obtains velocity, flow, or other traffic variables as smooth functions of space and time. Applications include traffic-state visualization, reconstruction of traffic situations from incomplete information, fast identification of traffic breakdowns (e.g., in incident detection), and experimental verification of traffic models, and even a short-term traffic forecast.

He applies the adaptive smoothing method to observed congestion patterns on several German freeways. It manages to make sense out of data where conventional visualization techniques fail. By ignoring up to 65 % of the detectors and applying the method to the reduced data set, we show that the results are robust. The method works well if the distances between neighbouring detectors cross sections do not exceed 3 km.

In this paper he provides an overview of the current state-of-the-art of vehicular traffic flow modelling. To provide a structured overview of these modelling achievements, the models have been classified according to level-of-detail (submicroscopic, microscopic, mesoscopic, macroscopic). Other criteria have been considered as well, namely scale of the independent variables (continuous, semi-discrete, discrete), representation of processes (deterministic, stochastic), operationalisation (analytical, simulation), and application area (e.g. links, stretches, networks). With respect to model applicability,
microscopic simulation models are ideally suited for off-line simulations, for instance to test roadway geometry. From the viewpoint of applicability to model based estimation, prediction, and control, the absence of a closed analytical solution presents a problem that is not easily solved.


In this paper, it is shown that most recent discretizations of macroscopic first order traffic flow models are equivalent to Godunov's scheme, by analyzing the Riemann problem in the case of equilibrium flow-density relationship that are discontinuous relatively to the position. Further, it is shown that the resulting formulas lead to a unifying framework for the modeling of boundary conditions in the LWR model and correlative the modeling of intersections. A few examples of resulting intersection and network models are discussed.


In this paper further study of N-function is done by formulating the LWR model in the transformed coordinate system. These Langrangian coordinates are fixed to a given fluid particle and more with it in space-time.

The objective of this paper is as follows:

- Formulates the LWR model in Lagrangian coordinates as a conservation law and as a variational principle; it also derives relevant numerical schemes.
- Analyses the errors introduced by the Gudunov scheme in Eulerian coordinates in order to gain some insights about its nature.
- How to implement existing and novel extensions using the Langranian approach.


In this paper several filter configurations were investigated for freeway traffic state estimation, parameter estimation, and joint and dual estimation. The filters were tested with artificial data generated with the METANET traffic flow model.

The main conclusions of the simulations are:

- Although the unscented Kalman filter has advantages that it propagates the state noise distribution with higher precision, its performance was nearly equal (slightly better) to that of the extended Kalman filter.
• The performance of the joint filter is better than that of the dual filter, because the joint filter takes into account the differences of the order of magnitude between the covariances of the states and the parameters.
• Fewer detectors result in larger state estimation errors, but have no effect on the parameter estimation error.


In this paper a comparison for several filter configurations for freeway traffic state estimation is presented. Since the environmental conditions on a freeway may change over time (e.g., changing weather conditions), parameter estimation is also considered. He compares the performance of the extended Kalman filter and the unscented Kalman filter for state estimation, parameter estimation, joint estimation and dual estimation. Furthermore, the performance is evaluated for different detector configurations. The main conclusions from the simulations are that the performance of the extended Kalman filter and the unscented Kalman filter is comparable, joint filtering performs significantly better than dual filtering, and a larger number of detectors results in better state estimation, but has no significant influence on the parameter estimation error.


In this paper he presents the latest results on developing and implementing a traffic congestion mode and vehicle density estimator for a segment of Interstate 210 in Southern California. Using a mixture Kalman filtering (MKF) algorithm on the switching-mode traffic model, the estimator is able to provide estimated vehicle densities at unmeasured locations, as well as the congestion statuses (free-flow or congested), which are not directly observed. He shows that the program runs efficiently, thus making it possible to carry out estimation in real time.


In this paper a general approach to the real-time estimation of the complete traffic state in freeway stretches is developed based on the extended Kalman filter. First, a general stochastic macroscopic traffic flow model of freeway stretches is presented, while some simple formulae are proposed to model real-time traffic measurements. Second, the macroscopic traffic flow model along with the measurement model is organized in a compact state-space form, based on which a traffic state estimator is designed by use of the extended-Kalman-filtering method. While constructing the traffic state estimator, special attention is paid to the handling of the boundary conditions and unknown
parameters of the macroscopic traffic flow model. A number of simulations are conducted to test the designed traffic state estimator under various traffic situations in a freeway stretch with on/off-ramps and a long inter-detector distance. Some key issues are carefully investigated, including tracking capability of the traffic state estimator, comparison of various estimation schemes, evaluation of different detector configurations, significance of the on-line model parameter estimation, sensitivity of the traffic state estimator to the initial values of the estimated model parameters and to the related standard deviation values, and dynamic tracking of time-varying model parameters. The achieved simulation results are very promising for the subsequent development and testing work that is briefly outlined.


This paper presents a traffic state estimation and prediction model based on the cell transmission model (CTM). The nonlinear CTM is transcribed in a closed analytical state-space form for use within a general extended Kalman filtering framework. The state-space CTM switches implicitly between numerous possible linear modes. The paper provides measurement models for the traffic state and model parameters for automatically estimating traffic conditions and model parameters in an online context. The applicability of the approach is illustrated in a real and a simulated case study.


This paper presents a case study of real-time traffic state estimation. The adopted general approach to the design of universal traffic state estimators for freeway stretches is based on stochastic macroscopic traffic flow modeling and extended Kalman filtering, which are outlined in the paper. The reported investigations were conducted by use of eight-hour traffic measurement data collected from a freeway stretch of 4.1 km close to Munich, Germany. Some key issues are carefully investigated, including the tracking capability of the designed traffic state estimator, significance of the online model parameter estimation, sensitivity of the estimator to the initial values of the estimated model parameters as well as to the related noise standard deviation values, and the capability of the estimator to handle biased flow measurements.


In this paper he has presented a brief overview of traffic flow models from the point of view of a control engineer. These models can be used to develop traffic controllers using model-based control system design procedures. Also he has presented some model classifications based on the following properties: physical interpretation of the model,
level of detail, discrete or continuous models, and deterministic versus stochastic models. Since macroscopic traffic flow models are best suited for traffic control purposes, we have discussed the most important representatives of this class: the Lighthill-Whitham-Richards model, the Payne model, and an improved Payne model developed by Papageorgiou. For each of these models we have given an intuitive interpretation of the equations that describe the model. Traffic models play an important role in both today’s traffic research and in many traffic applications such as traffic flow prediction, incident detection and traffic control.


In this paper he first recalls a macroscopic model with two equations and which completely resolves the severe inconsistencies of the class of Payne-Whitham models. In this paper, he describes the effects of adding a relaxation term in the anticipation equation, and the main steps and mathematical difficulties to show rigorously the convergence to the Lighthill-Whitham model when the relaxation time tends to 0.


In this paper he presents a non-equilibrium traffic model shown to be devoid of the gas-like behavior that plagues other higher-order models. The system of partial differential equations that describes this model is hyperbolic and has two characteristic fields: one is genuinely nonlinear and the other is linearly degenerate. The first field gives rise to shock and rarefaction waves that are similar to those of the Lighthill–Whitham–Richards (LWR) model, while the second field produces contact discontinuities. All these waves travel no faster than traffic; thus the trajectory of a vehicle cannot be influenced by what happens behind it. The model is also shown to exhibit correct queue-end behavior and is able to explain some of the observed traffic phenomena that challenge old models.


In this paper he started with a discussion of the most widespread macroscopic traffic models. Each of them is suitable for the description of certain traffic situations on freeways but fails for others. Therefore, an improved fluid-dynamic model was derived from the gas-kinetic traffic equation of Paveri-Fontana [2] which is very well justified and does not show the peculiar properties of Prigogine’s Boltzmann-like approach.

For the derivation of the improved traffic model, moment equations for collective (‘macroscopic’) quantities like the spatial density, average velocity, and velocity variance had to be calculated. The system of macroscopic equations turned out to be non-closed so
that a suitable approximation was necessary. Here, the well proved Chapman-Enskog method was applied. In zeroth-order approximation the velocity distribution is assumed to be in ‘local equilibrium’. According to empirical data, the latter is characterized by a Gaussian velocity distribution. Depending on the respective kind of zeroth-order approximation one arrives at the Lighthill-Whitham model, the model of Phillips [3,71], or the Euler-like traffic equations.


In this paper a freeway traffic control problem is considered. Control is exerted by means of the variable speed signs of the Dutch Motorway Control and Signalling System. After determining an important effect of the advisory speed signals on driver behaviour, a model for traffic in one section of a freeway is presented and its stability properties are investigated. Based on this model a hysteresis type control policy is proposed that optimizes the throughput of the freeway section and succeeds in postponing congestion.


This paper shows how the evolution of multicommodity traffic flows over complex networks can be predicted over time, based on a simple macroscopic computer representation of traffic flow that is consistent with the kinematic wave theory under all traffic conditions. The method does not use ad-hoc procedures to treat special situations. After a brief review of the basic model for one link, the paper describes how three-legged junctions can be modeled. It then introduces a numerical procedure for networks, assuming that a time-varying origin-destination table is given and that the proportion of turns at every junction is known. These assumptions are reasonable for numerical analysis of disaster evacuation plans. The results are then extended to the case where, instead of the turning proportions, the best routes to each destination from every junction are known at all times. For technical reasons explained in the text, the procedure is more complicated in this case, requiring more computer memory and more time for execution. The effort is estimated to be about an order of magnitude greater than for the static traffic assignment problem on a network of the same size. The procedure is ideally suited for parallel computing.


In this paper the model equations are discretized in both space and time. Time discretization, despite its importance to numerical stability and accuracy, has not received much attention. Most current implementations apply explicit time integration methods,
which need to obey to strict stability conditions. These may result in large computing times and prevent the implementation of macroscopic traffic flow models to applications where computational efficiency is crucial, such as real time applications. The authors describe and study implicit time integration methods which have less strict stability conditions, can be used with larger time steps and reduce the computing time. The widely used root mean square error does not take into account the nature of the error. He proposes two accuracy measures which take into account errors that are important to applications in traffic flow. The phase error measures a shift of the solution over time. Numerical diffusion indicates that the solution is too 'smooth'. The authors compare explicit and implicit schemes with simple test problems for computing time and accuracy. The authors found that implicit schemes, in these cases, result in 9 to 15 times smaller computing times. However, the accuracy and the nature of the error depends on the time integration method, but can be kept at an acceptable level for computationally efficient schemes. This shows that implicit time integration methods can play a key role in applications where small computing times are crucial.


In this paper a parallelized particle filters for state tracking (estimation) of freeway traffic networks is proposed. Particle filters can accurately solve the state estimation problem for general nonlinear systems with non-Gaussian noises. However, this high accuracy may come at the cost of high computational demand. He presents two parallelized particle filtering algorithms where the calculations are divided over several processing units (PUs) which reduces the computational demand per processing unit. Existing parallelization approaches typically assign sets of particles to PUs such that each full particle resides at one PU. In contrast, he partitions each particle according to a partitioning of the network into sub networks based on the topology of the network. The centralized case and the two proposed approaches are evaluated with a benchmark problem by comparing the estimation accuracy, computational complexity and communication needs. This approach is in general applicable to systems where it is possible to partition the overall state into subsets of states, such that most of the interaction takes place within the subsets.


In this paper a advanced Kalman filter is used to assimilate pseudo color data into a three-dimensional coupled physical-biogeochemical model of the Cretan Sea. The model comprises the three-dimensional Princeton Model (POM) and the European Regional Seas Ecosystem Model (ERSEM). In this study, the Semi-Evolutive Partially Local Extended Kalman (SEPLEK) filter is introduced in order to reduce the computational burden and also to improve the performance of the standard Singular Evolutive Extended
Kalman (SEEK) filter. The novel feature of the SEPLEK filter is its correction basis which is partially local in the sense that it consists of "global (classical)" and "Local" EOFs. The global EOFs, which can be let to evolve with the model dynamics, are used to represent the long range variability between all the ecosystem variables, while the local EOFs remain invariant and are computed in such a way to separate the euphotic zone from the deep ocean. The filter is shown to be very efficient in the numerical experiments, leading to a continuous decreasing of the estimation error.


In this paper the comparision of three different Bayesian estimators are used to perform: Extended Kalman Filter (EKF), Unscented Kalman Filter (UKF) and Sampling Importance Resampling (SIR) Particle Filter. The brief explanation of each technique and describe the system implemented to perform people tracking with a mobile robot using sensor fusion is described. He reports several experiments where the three filters are compared in terms of accuracy and robustness. He showed that for this kind of applications, the UKF can perform as well as a particle filter but at a much lower computational cost.


In this paper considers the example of sensor heterogeneity arising from the fact that both acceleration and displacement are measured at various locations of the structural system. The availability of non-collocated data might often arise in the identification of systems where the displacement data may be provided through Global Positioning Systems (GPS). The well known Extended Kalman Filter (EKF) is often used to deal with nonlinear system identification. The EKF is not effective in the case of highly nonlinear problems. Instead, two techniques are examined herein, the Unscented Kalman Filter method (UKF), proposed by Julier and Uhlman, and the Particle Filter method, also known as Sequential Monte Carlo method (SMC). The two methods are compared and their efficiency is evaluated through the example of a three degree of freedom system, involving a Bouc Wen hysteretic component, where the availability of displacement and acceleration measurements for different DOFs is assumed.

In this paper the investigation of cumulative flow count-based system modeling methods that estimate macroscopic and microscopic traffic states with heterogeneous data sources on a freeway segment is done. Through a novel use of the multinomial probit model and Clark’s approximation method, he developed a stochastic three-detector model to estimate the mean and variance-covariance estimates of cumulative vehicle counts on both ends of a traffic segment, which are used as probabilistic inputs for estimating cell-based flow and density inside the space-time boundary and to construct a series of linear measurement equations within a Kalman filtering estimation framework. This paper presents an information-theoretic approach to quantify the value of heterogeneous traffic measurements for specific fixed sensor location plans and market penetration rates of Bluetooth or GPS flow car data.


This paper investigated alternative implementations of the Adaptive Smoothing Method (ASM) is done. The ASM is a data-driven traffic state estimator, which filters macroscopic traffic observations like speed and flow by kinematic wave theory. The conventional implementation was compared with a new implementation based on the two-dimensional cross correlation, and a new implementation based on the Fast Fourier Transform (FFT).

In these two implementations, the observations are not treated as single variables, but are gathered in a matrix representing a speed or a flow map. The cross-correlation operation and the FFT are applied to these matrices to solve the ASM. Very fast algorithms of these operations are available, which were incorporated into the ASM implementations proposed.


In this paper a new partial differential equation (PDE) based on the Lighthill-Whitham-Richards PDE, which serves as a flow model for velocity is proposed. He formulates a Godunov discretization scheme to cast the PDE into a Velocity Cell Transmission Model (CTM-v), which is a nonlinear dynamical system with a time varying observation matrix. The Ensemble Kalman Filtering (EnKF) technique is applied to the CTMv to estimate the velocity field on the highway using data obtained from GPS devices, and the method is illustrated in microsimulation on a fully calibrated model of I880 in California. Experimental validation is performed through the unprecedented 100-vehicle Mobile
Century experiment, which used a novel privacy-preserving traffic monitoring system to collect GPS cell phone data specifically for this research.


In this paper an examining traffic volume data is proposed. First, 3 min data from urban arterials streets near downtown Athens were used to estimate explicitly multivariate time series models. The models developed fall in the flexible family of state space approaches. Among the important advantages of this approach are both their explicit multivariate nature, which allows for data from different loop detectors to be jointly considered, and their ability to model a wide variety of univariate models, such as ARIMA, as special cases. Indeed, in some of the cases examined, the best fit was provided by ARIMA models that turn out to be quite useful especially for points of entry into the study area. The results of the models developed clearly suggest that, at least in the case of Athens, different specifications are appropriate for different time periods. Further, it also appears that the use of multivariate state space models holds promise in the urban roadway system.

Data from different detectors are not only highly correlated among themselves but are also related to prevailing traffic conditions which tend to exhibit high short-term fluctuation. In addition, during large parts of the day, traffic is highly congested, approaching unstable conditions. At such conditions the usual statistical modeling procedures may suffer from an inherent inability to describe traffic characteristics and as a result produce accurate short-term predictions. In this paper he has proposed a model to capture the traffic behavior at their boundary conditions.


In this paper he has done an experiment on a data assimilation with a complex coupled physical–biogeochemical model applying the singular evaluative interpolated Kalman filter. From the various analyzed twin experiments the SEIK filter was found to be fairly effective in assimilating nitrate, phosphate, silicate and ammonia data from 23 stations in the Cretan Sea without requiring very large computing resources and using only 10 interpolating states.

Twin experiments have demonstrated the ability of the SEIK filter to efficiently control the evolution of model state by assimilating only nutrients from a small area of the Cretan Sea. This is consistent with the multivariate character of the error sub-space, which contains the dominant modes of the model’s variability and therefore the cross correlations between different model variables. The experiments also exhibited the usefulness of the evolution of the directions of correction of the filter.

In this paper the study and implementation of implicit numerical methods for solving the flow conversation traffic model has presented. He has written an experimental code in C simulating a freeway (un) congested pipeline and freeway entry/exit traffic flow. The implicit methods shows the same (and in some cases better) accuracy as the Lax method. Then he shows that implicit methods are faster than the Lax method.


In this paper the differences of EKF and UKF for state estimation are discussed. Four rather different simulation cases are considered to compare the performance. A simple procedure to include state constraints in the UKF is discussed. It is proved that the overall impression is that the performance of the UKF is better than the EKF in terms of robustness and speed of convergence. The computational load in applying the UKF is comparable to the EKF.


In this paper a complete design of an extended Kalman filter for real-time estimation of rigid body motion attitude is presented. The use of quaternions to represent rotations, instead of Euler angles, eliminates the long-standing problem of singularities called “gimbal lock.” Two approaches to the Kalman filter design were investigated. The first approach used nine output equations: three angular rates, three components of linear acceleration, and three components of the earth magnetic field. The second approach utilized Gauss-Newton iteration algorithm to find the optimal quaternion that related the measurements of linear accelerations and earth magnetic field in the body coordinate frame to the values in the earth coordinate frame.


In this paper the Bayesian approach was proposed to find the optimal estimates of noise parameters for the Kalman filter based air quality prediction system. By optimizing the objective function with respect to the noise variances, the Bayesian methodology allows the most probable values of noise variances to be obtained and the associated uncertainties to be quantified. In this paper the Bayesian approach was demonstrated to be capable to estimate the most probable noise variances of the Kalman filter based.
TVAR (ρ) model and TVAREX model for the prediction of daily averaged PM concentrations in Macau between 2001 and 2002.


In this paper, real-time adaptive algorithms are applied to GPS data processing. Two different adaptive algorithms are discussed in the paper. A number of tests have been carried out to compare the performance of the adaptive algorithms with a conventional Kalman filter for vehicle navigation. In this paper it demonstrate that the new adaptive algorithms are much robust to the sudden changes of vehicle motion and measurement errors.


In this paper an object-tracking algorithm suitable for a network of wireless cameras is presented. It is focused on the problem of a single cluster tracking a single object. The issues of multiple clusters tracking the same object and the intercluster interactions involved in that process as well as tracking multiple objects simultaneously are subjects of future studies. Although some preliminary experimental results regarding the clustering protocol were presented, further investigation of our protocol is needed with respect to the density of cameras with common viewing areas as well as the density of single-hop neighbours since these parameters greatly influence the overhead involved in the clustering protocol and the performance of local data aggregation.