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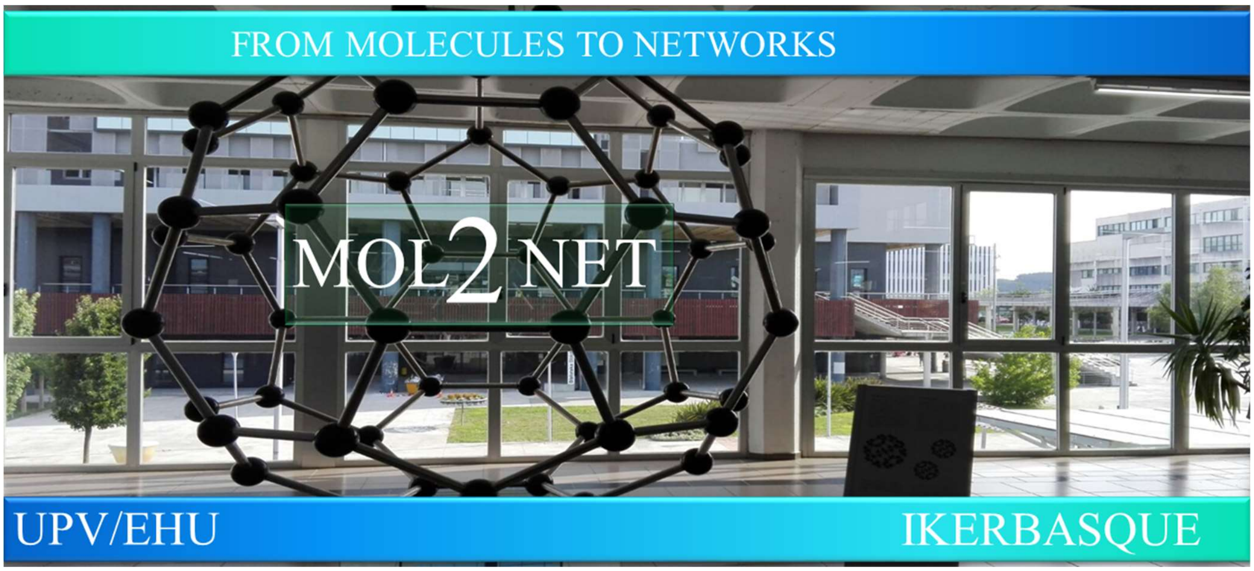
MOL2NET'22, Conference on Molecular, Biomedical & Computational Sciences and Engineering, 8th ed.



A DDDAS-Based Impact Area Simulation Study of Highway Abnormalities

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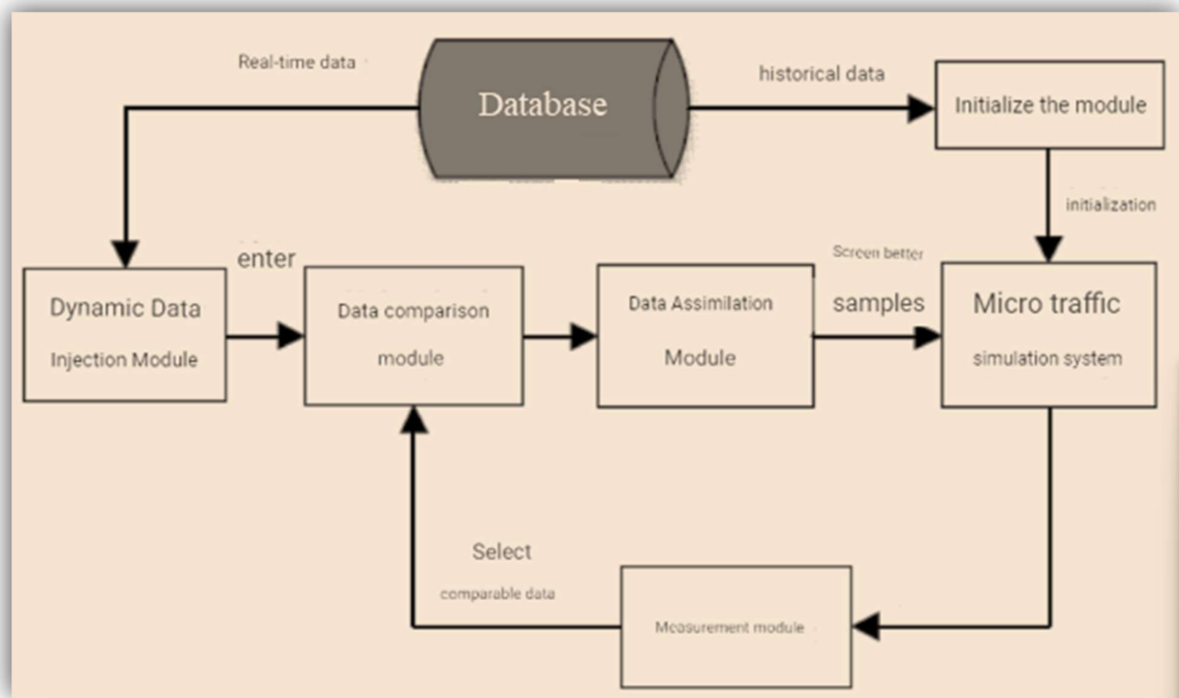
Abstract.

Roadway irregularities including vehicle failures, traffic accidents, and more may cause traffic bottlenecks. Targeted traffic management and control depend on precise evaluation of uncommon occurrences' influence range and increasing tendency. It enhances roadway service and operation. Expressway abnormal incidence estimation uses traffic flow theory. Traffic parameter detection accuracy cannot satisfy model input, making engineering application difficult. Emulation analysis was utilized to assess highway traffic flow space-time correlation and vehicle detector features, and VISSIM simulation system was used to calibrate traffic flow parameters and rectify driving behavior parameters. The authors developed a Dynamic-Data-Driven Application Systems (DDDAS)-based highway exceptional event impact area emulation analysis approach after a particle filtering investigation. Features: Traffic and driving simulation model calibration. Freeway traffic flow, analysis, and vehicle inspection data calibrated traffic flow simulation model parameters. The simulation model driving behavior parameter calibration default value is incorrect, hence weak single factor sensitivity analysis was employed to determine the core adjustment parameters. Study genetic algorithm simulation model driving behavior parameter modification. Finally, car inspection data confirmed the model. The model accurately simulates road traffic. ② Particle filter-based traffic simulation model data assimilation analysis. Traffic wave and threshold theory preprocess highway vehicle inspection data. The DDDAS-based traffic simulation analysis system uses particle filter data assimilation. Show the method using numbers. The particle filter-based traffic simulation model can continuously absorb real-time data to correctly predict event blocking road places and queue lengths. The paper concludes by detailing the traffic simulation model. Combining Beibei tunnel section vehicle detector data of G75 highway, we choose typical and actual traffic exceptional events to build similar simulation scene, verifying the DDDAS-based highway exceptional event impact area emulation analysis method.

Keywords: Highway, DDDAS, Traffic simulation, Data assimilation, Particle filtering

Graphically Abstract



Introduction

The national expressway network in my country has essentially been finished with a total distance of 108,000 kilometers, encompassing more than 90% of cities with an urban population of more than 200,000 [1]. Expressways have grown to be a need for transport and daily living. Expressways handle a significant amount of the transport capacity for those who move quickly. High traffic volume, high sealing, high driving speeds, and other features define an expressway. As the number of motor vehicles rises steadily, traffic congestion will worsen, and unusual traffic occurrences like accidents will become more frequent when the road's traffic capacity cannot keep up with the demand. Traffic congestion will be reduced, and the highway will be smooth if we can precisely assess the breadth and growth trends of abnormal occurrences and devise targeted traffic management techniques. Therefore, for expressway control and efficient operation, it is crucial to comprehend the extent of the impact of abnormal occurrences [2].

With the advancement of technology, traffic simulation is an analytical technique that reflects complicated traffic phenomena using digital computer models. The traffic simulation system combines the traffic simulation model with the specified road network structure to simulate the traffic phenomenon on the road, the characteristics and simulation data related to customs clearance, and analyze the operational guidelines and current traffic status of the traffic system. There is still more work to be done in precisely replicating dynamic traffic behavior and effectively assessing the extent of impact brought on by anomalous occurrences [3]. The US National Science Foundation (NSF) initially presented a dynamic data-driven application system in 2000. (Dynamic data-driven application system, DDDAS). Real-time system status information and related simulations are accessible via this collaborative simulation application form. The combination of components allows the simulation system to dynamically absorb real-time system state information while the simulation is taking place and appropriately alter the simulation system's state [3]. Real-time traffic status data may be precisely gathered because of the ongoing advancements in sensor and computer technology, which serves as a data foundation for creating dynamic traffic simulation systems. The traffic simulation system may dynamically integrate the real-time traffic status data throughout the simulation by merging the real-time traffic status data with the traffic simulation system. The real-time traffic state may be studied and forecasted in conjunction with the simulation system by altering the state of the traffic simulation system by the real-time traffic state's development trend [4].

Materials and Methods

Dynamic data-driven approaches' research status was introduced in the preceding section. Based on the notion of a dynamic data-driven system, this section describes its operational mechanism. The advantages of the dynamic data-driven system are analyzed compared to the traditional simulation system; According to the traffic simulation system framework driven by data introduces the operating mechanism between the framework modules in-depth and explain the key problems that need to be solved in the system realization, which lays the theoretical foundation for the follow-up research work. Dynamic data-driven systems were initially suggested by NSF in 2000. The NSF describes DDDAS as "a novel kind of research of actual systems mixed with simulation, in which the simulated system It may absorb and dynamically assimilate real-time real system data during operation" [5].

The following definition shows that DDDAS is a novel simulation application mode. The system dynamically accepts real-time measurement data from the actual system and monitors the condition of the simulated system. Adjust the simulation system to blend it with the real one. Both systems are simulations. In a novel cooperative dynamic feedback control system, real-time data makes the simulation system. It can continually alter the simulation system's model state, self-adaptively correct it, and adjust it. Prediction findings are data-driven. Dynamic data-driven systems vary from simulation-based systems. Traditional serialized sequential application execution, but the simulation system and real system are more organic and efficient. The simulation system's application area extends with ground and ground. It is both a simulation and application system. Dynamic data drives provide the following advantages over standard simulation systems [6]:

- The dynamic data-driven system brings cybernetics to simulation, and the simulation system and real system are similar. The feedback loop is dynamic. The simulation system continually assimilates actual data and dynamic data. Dynamically alter the simulation model.
- Historical data and experience constitute the foundation of traditional simulation systems. When building up the simulation model, many random aspects are neglected. dynamic mode. The data-driven simulation system's operating process is the simulation of real-time data. Precision improves with repeated adjustment.
- After the simulation process, traditional simulation systems apply simulation effects. The initialization values are tweaked after comparing the outcomes. This operating mode has altered due to the dynamic data-driven system's real-time data verification and model modification and correction.

As computer technology advances, the dynamic data-driven system will produce a new high. In simulation study of latent functions, build a new simulation application system with expanded features, modify Science and engineering bridges today will benefit many areas. recent years Computer technology, sensor technology, simulation technology, and other professional fields developed rapidly in the past. The technological and data underpinnings come from studying dynamic data-driven systems. Therefore, developing dynamic data-driven systems It's crucial to apply related research [7].

This study defines abnormal events: in the case of a specific road capacity, abnormal phenomena that should not occur under the existing road traffic load, such as traffic accidents, vehicle malfunctions, etc., create vehicle merging and traffic jams [8]. The blocking range of the aberrant event analyzed is the impacted range. Combining the micro-traffic simulation system VISSIM with the core notion of the dynamic data-driven system, various traffic simulation particles are instantiated via historical data analysis. To estimate traffic operation, all particle states are simulated. The data assimilation technique is extensively used to assimilate real-time road traffic state data and continually compare with the actual traffic state data to resample matching improved simulation particles as the beginning conditions of the next simulation process. The simulation system can watch the development trend of the actual traffic system and decrease the inaccuracy with the real traffic state by continually iterating and comparing computations to adapt its state. The space system's intricacy comes from micro-individuals. Starting at the micro-level of the simulation system, this study uses the micro-traffic simulation system VISSIM and the DDDAS paradigm to extract the complex changing trend of the simulated traffic flow and apply the assimilation method to monitor and forecast the trend direction. Data assimilation module: Data assimilation is the main challenge of the DDDAS-based simulation system. Only a strong data assimilation model can guarantee that the simulation results are always converging on the real operating state throughout the simulation framework. Therefore, the data assimilation module emphasizes research [9].

Traffic data in rich forms may be retrieved from the current micro-traffic simulation system's simulation results. Due to the growth of highway detection systems, highway detection equipment cannot deliver such a comprehensive data format. Under the vehicle detector's constrained data format, the data comparison module compares simulated particles' pros and cons. Dynamic data injection module: The expressway's fixed vehicle detector system is unreliable, according to observation and analysis of observed data. To lessen data issues on the DDDAS system, missing and anomalous data must be eliminated and repaired. The frame diagram of the dynamic data-driven traffic simulation system shows that it has modified the operating mechanism of the classic micro-traffic simulation system and can compare measurement data with the simulation process in real time. Compare, dynamically adapt, and upgrade the simulation system to estimate and forecast traffic situation. To develop a DDDAS-based traffic simulation system, the system's structure and operation mechanism must be studied to overcome the primary technological difficulties [10].

- Implement VISSIM-based highway traffic simulation. The quality of traffic simulation results depends on the correctness of traffic simulation model parameters. Only a competent simulation system that can accurately model actual traffic flow can better examine abnormal event effect. Driver, driving behavior, and traffic model characteristics are needed to set up the VISSIM micro-traffic simulation system's traffic model. Different parameter settings may affect the simulation outcome of the traffic system's simulation operation. The model's default parameter settings are based on traffic flow characteristics and road condition analyses in industrialized nations, not my country's road traffic circumstances. Calibration and adjustment of simulation model parameters is the foundation of a solid traffic simulation model, and this work addresses this subject.
- Data integration of traffic event effect range simulation The dynamic data-driven application system's data assimilation technology continuously assimilates real-time system data to compare the simulation system's state data to the real system's state data. The simulation system is adjusted and corrected accordingly to limit its error and improve its accuracy.

Data assimilation is the main challenge of DDDAS-based traffic modeling. During traffic simulation framework operation, only a strong data assimilation model can assure that simulation results are continually converging on the real operational state. Therefore, this study should concentrate on data assimilation module setup and algorithm development. In section five, the particle filter-based traffic event effect range simulation data assimilation procedure will be explained.

Results and Discussion

The establishment of traffic simulation involves the input of traffic flow parameters in the simulation environment, the correction of the driving behavior parameters of the simulation model, and other steps. The traffic simulation system based on DDDAS requires a traffic simulation environment that can represent the real road operation conditions. As a result, in-depth study on the calibration of relevant factors is required in order to create a realistic simulation environment that can accurately reflect the actual road operating circumstances. In this section, the traffic micro-simulation system VISSIM is combined to create a highway traffic simulation scheme. The simulation environment model's traffic flow parameters are calibrated by studying historical expressway traffic flow data, and the simulation model's parameters are corrected by combining the GA algorithm, all based on an analysis of the characteristics of the real traffic flow parameters of the expressway. The calibration of traffic flow parameters and the adjustment of simulation model parameters are effective, according to experimental data.

The DDDAS's core component is the data assimilation algorithm. The connection between the real system and the simulation system is established in accordance with the data assimilation algorithm, and real-time data from the real system is continuously assimilated into the simulation system's operation process, providing a mathematical foundation for the adjustment of the simulation system state. The reconstruction of traffic anomalies using a particle filter technique is presented in this study. A data assimilation framework for anomalous traffic occurrences is presented in conjunction with the notion of dynamic data-driven, and the simulation model and assimilation model in the data assimilation framework are extended. The traffic simulation model based on particle filter is shown to be able to constantly absorb real-time data to produce accurate assessment of the location of congestion events on the road and the real-time queue length via the simulation of twin experiments.

The fourth section performs in-depth study on the creation of a traffic simulation model based on particle filter algorithm. The third section covers the design of expressway traffic simulation scheme based on VISSIM. This section introduces the method of realizing a whole system from the standpoint of an entire system. It presents the platform requirements for system realization in the first place; in the second, it examines the process of realizing the whole system in conjunction with the general design of the system; and last, it introduces and implements each functional module in great detail. Finally, the application impact of the whole system is examined in conjunction with the real highway anomalous incidents. This section describes how to use a simulation analysis system to determine how abnormal occurrences would affect expressways. The platform circumstances, system implementation platform, system overall framework, introduction of the system module, and analysis of the practical application impact come first. The correctness of the system is confirmed by an investigation of the application impacts of many occurrences.

Conclusions

Abnormal occurrences on the highway will reduce traffic capacity, causing congestion and underutilization of road resources. Traffic congestion may be reduced by accurately assessing abnormal event scope and development and developing focused traffic management techniques. Traffic wave theory may be used to anticipate anomalous event affect range. The present high-speed detection system cannot precisely get its characteristics, making it difficult to utilize in engineering. When employing traffic simulation technology to examine the effect range of abnormal occurrences, most Historical traffic flow statistics cannot accurately depict expressway traffic operations. This research, based on the micro-traffic simulation system VISSIM, particle filter data assimilation technique, and DDDAS paradigm, suggested a DDDAS-based analysis approach for the impact range of anomalous expressway occurrences and created the related system to be more suitable to engineering. This article summarizes its primary work:

• Create a highway traffic simulation strategy using the traffic micro-simulation system VISSIM. The expressway simulation model's traffic flow parameters are calibrated by studying expressway traffic flow's time-varying and periodic nature and historical vehicle detection data. By examining the sensitivity of key factors to queue length and combining with genetic algorithm, certain parameters with higher sensitivity are rectified in the simulation model.

• Investigate particle filter-based traffic simulation model data assimilation. A data preprocessing approach for expressway vehicle detectors and a particle comparison method based on traffic flow parameter sensitivity analysis during abnormal occurrences are created using traffic wave theory and threshold theory. A DDDAS-based expressway anomalous event simulation model is created and tested using an example.

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