State-of-the-Art on Neural Network Based Tourist Vehicle Behavior Analysis

Sergei Mikhailov
ITMO University
St. Petersburg, Russia
samikhailov@itmo.ru

***Abstract*—The driver behavior analysis in the tourist trip is attracting researchers and developers for a long time. The neural networks models are widely used due to the ability to discover hidden dependencies from tourist actions. The paper presents the brief related work in the field of neural network-based driver analysis and specifies the three main analysis cases.**

I. Introduction

The tourism industry has grown rapidly in recent years and is intensively integrated with modern information and communication technologies. Before the COVID-19 epidemic outbreak, according to the UNTWO World Tourism Organization international travel was expected to increase by 3.3% per year between 2010 and 2030. The COVID-19 outbreak affects and restricts tourists ways of traveling [1]. The methods used by countries to combat COVID-19, such as vaccination of the population, human contacts minimization, the use of smart tourism services for road travel, as well as the use of a smart vaccination certificate developed by the World Health Organization[1] should help rebuild the tourist area around the world.

One of the ways to secure tourists when travelling is to use personal transport while travelling. The car and tourist smartphone sensors, tourist historical data and the tourist generated content can be used for the tourist behavior analysis. The car-based tourist behavior analysis can help improve the smart tourism services performance by using the discovered dependencies between tourist driving style, trip preferences and the tourist region context situation.

The scientists use the Big Data methods and machine learning approach to construct models due to the big amount of behaviour information [2]. The neural network approach performs better than commonly used autoregressive integrated moving average models (ARIMA) in general. The neural network can be described as self-adaptive data-driven methods which can learn from examples and capture unknown or hard described functional relationships [3], which is well suited for the drivers and tourist behavior analysis, which can be used for smart tourist services for improving the travel experience.

The presented paper aimed to show neural network usage for driver tourist trip behaviour analysis. The section II presents the research of various drivers behavioral aspects during the tourist trips using neural networks and section III provides the conclusion.

[1]https://www.who.int/news-room/articles-detail/interim-position-paper-considerations-regarding-proof-of-covid-19-vaccination-for-international-travelers

II. Related work

According to the related work analysis based on the Sciencedirect platform, the neural network models can be used in the three main behavior analysis cases: driver destination and/or path prediction, critical situation detection and prediction such as drowsiness, distraction and driving style classification.

A. Driver destination and path prediction

The authors of paper [4] uses an attention-aware LSTM for real-time driving destination prediction. The neural network takes location semantics and location importance of trajectory points into the account. The POI list, day of the week and departure time slots are used as model input. The authors compare the proposed approach with hidden Markov models and random forest models and stated, that the solution demonstrates significant prediction accuracy improvements.

In the paper [5] the authors analyses sequential patterns in tourist behaviour by using a combination of Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) neural network. The proposed artificial neural network (ANN) predicts the possible location visiting. Both pedestrian- and car based-trips can be used for the proposed behaviour analysis approach. The tourist opinion and reviews were used as the main source of data.

The authors of article [6] aim to integrate multiple data sources to analyze tourists spatial–temporal behaviour patterns on micro-scale distances. Information about tourists' temporal–spatial behaviour was gathered using handheld GPS tracking devices, and questionnaires were distributed to assess tourists' socio-psychological characteristics. Three spatial–temporal behaviour clusters were identified via density center clustering, consisting of four factors: path length, tour time, coverage area, and oval circumference.

The attention-based recurrent neural network for urban vehicle trajectory prediction is presented in paper [7]. The model is evaluated by using the Bluetooth data collected in Brisbane, Australia, which contains the movement information of private vehicles. Location sequences were used as additional metrics among the route coordinates for the model input.

B. Critical situation detection and prediction

The authors of the paper [8] use a staked deep convolutional neural network classifier for driver drowsiness detection. The Viola-Jones face detection algorithm is used for the faced

and eyes region detection. A soft-max layer was used in the CNN classifier for sleepiness detection.

The driver drowsiness multi-level classification method is described in the paper [9]. The method is based on a combination of convolutional neural networks and recurrent neural networks. Five vehicle-based measures, including lateral deviation from road centerline, lateral acceleration, yaw rate, steering wheel angle, and steering wheel velocity, are used as network input. The three different classes of drowsiness were classified by the authors.

The paper [10] presents the critical event prediction approach based on neural network usage by using the driver and vehicle volatilities. The 1D-Convolutional Neural Network and Long Short-Term Memory neural networks were used for the analysis. Vehicle kinematics, driving volatility, and impaired driving were used as the input parameters for neural networks. The training process was trained on data that contains 7566 normal driving events, and 1315 severe events, vehicle kinematics, and driver behavior collected from more than 3500 drivers.

C. Driving style classification

The paper [11] proposes the neural network-based approach for driver behaviour detection and classification. The driving signals, including acceleration, gravity, throttle, speed, and Revolutions Per Minute are used for five types of driving styles recognition. The 2D convolutional neural network was used on images constructed from driving signals based on the recurrence plot technique for driving style determination.

The authors of the paper [12] presents a new methodology that combines in-vehicle telematics technology, providing measurements forming a personalised driver profile, with neural networks to identify changes in driving behavior. The Long Short-Term Memory recurrent neural networks were used for the acceleration, deceleration and exceeding the speed limit patterns detection.

The paper [13] propose a vision-based solution to recognize the driver's behavior based on convolutional neural networks. Skin-like regions are extracted from the image frame by using the Gaussian Mixture Model. The extracted regions are passed to a deep convolutional neural networks model for action labels generation. The CNN model can determine smartphone calling events, eating events, shifting the gears and normal riding events.

III. Conclusion

The convolutional and long-short term memory neural networks are mainly used and equally represented in all selected driver behavior analysis cases. The attention mechanism is widely considered for the LSTM models for the ability to overcome the limitation in the encode-decoder architecture by allowing the network to learn where to pay attention to the input for each item in the output sequence.

The two main sources of input for the critical situation detection task and driving style classification are car telemetry data and the driver images. The car telemetry data includes raw speed and acceleration, motor characteristics, etc. The driver image, captured from the cameras is used as the main source of driver visual profile and face recognition. The route/trajectory prediction mainly used the POI visitation sequences and GPS data.

The reviewed scientific articles practically do not use methods of working with drivers and the surrounding tourist region contextual information. It is possible to use not only the LSTM and CNN models for the behavior analysis, but such approaches as SGAN, Social SGAN, etc.

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