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A REVIEW ON PEDESTRIAN BEHAVIOR PREDICTION FOR INTELLIGENT TRANSPORT SYSTEMS

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Abstract - *The ability to anticipate pedestrian actions on streets may be a safety issue for intelligent cars and has increasingly drawn the eye of the automotive industry. Estimating when pedestrians will cross streets has proved a challenging task, since they will move in many various directions, suddenly change motion, be occluded by a spread of obstacles and distracted while talking to other pedestrians or typing on a mobile . There are different algorithms that aims at predicting such motion of the pedestrains around crossroads, so as to avoid the possible threat of collision with the cars.*

Key Words: Pedestrian, behavior, estimation, crossing, trajectory

1. INTRODUCTION

With recent advances in computing, the goal of fully automated driving seems to be in reach. However, for a safe travel, chances of collision must be avoided. For its own motion planning, an autonomous vehicle must predict behavior of other traffic participants. This could be especially relevant for vulnerable road users (VRUs), since collisions are likely to be fatal. Thus, accurate prediction of human motion is very important.

Each year, lakhs of pedestrians lose their lives on the world's roads. Many leave their homes as they may on any given day to highschool, work, places of worship, homes of friends-never to return. Globally, road deaths include mostly pedestrians. Millions more people are injured in traffic-related crashes while walking, variety of whom become permanently disabled. These incidents cause much suffering and grief yet as economic hardship for families and loved ones. The capacity to reply to pedestrian safety is an important component of efforts to forestall road traffic injuries. Pedestrian collisions, like other road traffic crashes, should not be accepted as inevitable because they're, in fact, both predictable and preventable. The key risks to pedestrians include: driver behaviour, particularly in relation to speeding yet as drinking and driving; infrastructure in terms of an absence of dedicated facilities for pedestrians like sidewalks, crossings and raised medians, use of phones by the pedastrians and unawareness of the traffic rules etc.

2. PEDESTRIAN BEHAVIOR PREDICTION TECHNIQUES

Different methods has been suggested by different authors for the prediction of pedestrians. In [1], it suggests the use of LSTM (Long Short Term Memory) to model the motion information of pedestrian and the use of mlp for location encoding. The positional information of the pedestrian along with its surrounding neighbors are required for accurate prediction of the pedestrian, since they influence their motion. After evaluating the motion features, weight them to predict the trajectory. The weights are then mormalized using the softmax function and then the crowd interaction vector is calculated using the extracted location features and weights.

Eike Rehder et.al. [2], proposes a goal directed planning using Deep Neural Network (DNN). The prediction network discussed in this paper consists of three sectors: Destination network, Topology network and Planning network. The destination network predicts a mixture of possible destinations form pedestrian images and positions in form of a grid map. This part consists of a Recurrent mixture density network(RMDN) and the images are processed using standard Convolutional neural network(CNN). This map is fed into the topology network, where it generates a planning topology using Fully convolutional network(FCN). The planning is executed here to get actual prediction. Finally the planning network runs the prediction as planning on these topology maps. The two planning techniques incorporated in this work were Markov Decision Processes and Forward-backward network.

F Camara et.al.[3], uses the interaction behavior of the pedestrians and the autonomous vehicles(AV) to predict the road-crossing assertiveness of the pedestrian. The region considered in this work is the unmarked intersections. That is, while in an unmarked intersection, the AV and pedestrian compete with their actions and a winner will be present. Such a game theory model interaction is considered here. In order to inform the AV in such conditions, this work collects and analyses the real-world road crossing data which would help in determining which all behavioral features of the pedestrians could be used to predict the road-crosssing assertiveness of the pedestrian. The interaction data thus collected are converted into sequences of discrete events. The probablistic methods- logistic regression and decision tree regression-and the sequence analysis are used to analyze the data events and a common behavior patterns are evaluated thus leading to selection of a winner.

The use of CNN is again considered by Alex Dominguez-Sanchez et.al.[4], for the autonomous driver assistance and surveillance system. It considers the CNN to detect the pedestrians moving in a particular direction. The CNN- based technique proposed in this work uses the current pedestrian detection techniques(histograms of oriented gradients) to maximum advantage.

Joon-Young Kwak et.al.[5], develops a system to predict the pedestrian intention especially during night-time. It proposes the use of an infrared camera which is mounted on the car for capturing the surroundings and the pedestrians at night. The sequences thus captured are used for prediction with the help of dynamic fuzzy automata(DFA) methods, which provide a systematic way to handle uncertainities.

The method of memory method using the LSTM network under an closed surrounding is considered in [6], for the purpose of trajectory detection.Physical model to determine the possible presence location of pedestrians is introduced by Peter Zechel et.al.[7], which considers the static objects and interactions with dynamic objects. It mainly focuses on occupancy area determination. Movement model based on Artificial Neural Network (ANN) is discussed in [8], which detects the trajectory of the pedestrian. Higher efficiency than Kalman filtering model is provided.

Xiaoxiao Du et.al.[9] proposes a biomechanically inspired recurrent neural network(RNN) for 3-D gait prediction. The parameters considered are: periodicity of human motion, mirror symmetry of human body and the change of ground reactions forces in human gait cycle etc. Memory (LSTM) system is the base for this work. Multiple pedestrian prediction is possible simultaneously using this system.

Probablistic prediction of pedestrian motion using Markov Chains is considered in [10]. Ivo Batkovic et.el.[11] develops a mathematical model for prediction over a finite horizon for collision avoidance in case of autonomous driving.

Prediction by considering the curbside geometry is considered [12]. In this work, a common frame called curbside coordinate frame is considered to ensure that trajectories from intersections having different geometries but representing the same behavior are spatially similar in the common frame. The Transferable Augmented Semi Non-negative Sparse Coding (TASNSC) model is used for accurate, long term prediction in corners of new, unseen intersections with similar characteristics as the ones that the model is trained on.

Another system[13] using the model based on LSTM which is able to learn human motion behavior from demonstrated data. This model incorporates both static obstacles and surrounding pedestrians for trajectory forecasting. The model architecture consists of three parameters as input per pedestrian and they are: Pedestrians current velocity, information about the static obstacles around the pedestrian and the information about surrounding pedestrian. By providing this as input to the model, it can predict the future motion in a receding horizon manner. Also, instead of forward simulation using 1-step predictions, this model forecast for the whole prediction horizon.

Prediction by analyzing the behavior of pedestrians around vehicles[14] with Variational Gaussian Mixture Model(VGMM). This was modelled for trajectory prediction at an uncontrolled intersection on a city street. This model outperforms the kalman filter baseline.

Shuai Yi et.al. [15], proposes a behavior-CNN model for prediction. The walking path prediction is considered by training the model with real-scene crowd data. Pedestrian paths in previous frames are also considered. Behavior encoding scheme is considered to encode pedestrian behavior into sparse displacement volumes which is then directly used as input.

Another model using intelligent behavioral leraning approach for it's prediction is discussed in [16]. This work focuses on the microscopic pedestrian walking behavior at each natural footstep duratio and present an artificial neural network(ANN) based behavioral learning approach for it's prediction. This approach predict the speed, direction and position adjustment behavior of an individual pedestrian efficiently.

Intentions of the pedestrians while interacting with a vehicle will follow some specific motion patterns. In [17], that work presents a conditional regenerative adversarial network based architecture. It consists of two main parts: generator and discriminator. The generator section uses a LSTM encoder-decoder (eLSTM-dLSTM) which considers the human intentions for motion prediction and discriminator is a classifier(cLSTM), which is dedicated to distinguish ground truth paths from the generated trajectories by the generator. The classifier classifies those trajectories inconsistent with intention as fake. Higher prediction accuracy is expected from this model.

Peixin Xue et.al.[18], proposes a novel architecture based on encoder-decoder LSTM network, named vehicle pedestrian LSTM(VP LSTM) to model the interaction of vehicle and pedestrian behaviors and then predict the future trajectory. The LSTM encoder uses the historical position sequences of both pedestrian and vehicle as input, to infer their fixed length hidden states respectively. The LSTM decoder then recursively exploits these state information to generate subsequent trajectory positions of pedestrians.

Model proposed in [19] focuses in the chances of a pedestrian pressing the puhbuttons at signalized mid-block Danish offset crosswalks. This considers the Bayesian netwoks(BNs), which is a graphical method that consists of nodes that represent random variables and arcs representing variables relationship. In BNs analysis, two main sequential steps are crucial: structure learning and parameter learning. The Maximum Likelihood(ML) approach is preferred for parameter learning due to it's ease of implementation. Once

both structure learning and parameter learning have been performed, the predictive inference is performed.

3. DISCUSSION

The major cause for the increased demand for pedestrian behavior prediction on raod is the hike in pedestrian accidents and death. Also it has great use in the field of intelligent transport systems, since the autonomous vehicles cannot actually respond to the sudden behavior change of the pedestrians on-road or while crossing. For the safety of the pedestrians, this prediction should be accurately handled and with less time consumption. The behavior of the pedstrians can change due to many reasons: emotional state of the individual, unawareness of the road rules, conditions of the road(unmarked crossings, width of the road which is to be traversed etc.), use of mobile phones while crossing etc. The negligence from the driver also will contribute to this scenario when the man-driven cars are considered. So whether the car is an automated one or not, the safety of pedestrians should be confirmed.

There are different methods being considered for predicting the behavior of pedestrians on road. the neural network models are the new trend in prediction. Also the memory models consisting of the LSTM models has proved to be effective in many studies as discussed in the previous section. There are mathematical models also which uses the markov chain model for prediction. There are increased research going on in making this models more accurate by experimenting with more data and advanced hybrid markov models. The data-driven models which considers the interaction information between the pedestrian and the vehicle has more practicality since the interactions also are causes for change in pedestrain behavior. The challenge in this model is the handling of such huge data and the traiining of the model with such amount of data. Since the prediction is expected to be fast and accurate, researchers has their focus on improving the models by improving the interaction parameters.

Each of the model discussed has some amount of parameters to be considered. The parameters may be the location coordinates of the pedestrian, the body pose of the pedestrian, head orientation of the pedestrian etc. While considering the decisive parameters or variables, strong care should be provided since they are used for the generation of the prediction. The datasets should be sufficient and perfect for training the different models in order to get perfect prediction of the trajectories. Information about the pedestrian characteristics will help to understand the behavior patterns which also serve as prediction data.

4. CONCLUSION

This paper presents a literature review for the pedestrian behavior detection techniques. It consists of various models through which prediction was achieved with efficiency. When intelligent transport system is considered, high accuracy and less response time is expected. The algorithms which satisfies these conditions can be considered a perfect prediction model. Since the pedestrian behavior is influenced by their surroundings and obstacles, the prediction algorithms can perform more efficiently if the surroundings and interactions are considered.

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