A Survey on Predicting Pedestrian Safety based on Physical and Psychological factors of Pedestrians Motion

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Abstract - Walking is the special mode of transportation that comprises 60% of the World’s population. This population includes the pedestrians as the focus of sight, because they are considered as the road users. Understanding the behavior of road users is a difficult task as people have complex mindsets. When people are crossing the road, they have been subjected to various attitude issues and other psychological issues. The prediction of the pedestrian’s motion is very ridiculous, because their motions has to be predicted related to the traffic parameter. A prediction algorithm always uses the past experiences to anticipate the future events. These algorithms use the set of sample data from a sample collected over a period. This makes prediction algorithms more ideal to use within smart environments.

So as a part of this study, we have compared various algorithms, for their accurateness of the prediction on pedestrians’ movements. This paper also focuses on the various pedestrian’s data set, pedestrian behavior estimation and the various algorithms used to predict the behavior of the people. As a part of our research on pedestrian safety prediction would be done by providing an efficient prediction algorithm based on their movements, ecological factors, pedestrians’ psychological factors, other outcomes.

Keywords - Prediction algorithm, Pedestrians, Safety, SVM, KF.

1. Introduction
The Safety of the pedestrian is important to issues of world as road users are more vulnerable. About 1.24 million people lost their lives which accounts for 22% of people. These death occur when the pedestrian crossing the road and met an accident due to poor vision and fatigue driver. So the formulation of technological solution to this issue of lack of attention among the drivers and people. Further the technology has to be formulated to understand the intentions and road behavior of the users in an accurate manner.

Understanding the behavior of road users is a difficult task as people have complex mindsets. When people cross the road, they have been subjected to various attitude issues and other psychological issues. The World Health Organization has estimated that 1.22 million people are dying every year due to the bad behavior of the people.

A prediction algorithm uses the information from past experiences to anticipate the future events. These algorithms can be used in the situations where data are from a specific sample space can be collected over a period. This makes prediction algorithms more ideal for the use within smart environments. Predictive analytics is said as context of Engineering data, Big data, for example, comes from instruments, sensors and connected systems out in the world.

2. Pedestrian Psychological Behavior Estimation
According to [1], complex behavior of both road users and drivers can be determined using Variation Gaussian Mixture model (VGMM) based probabilistic trajectory prediction framework. The process of sub-categorization of VGMM resulted the performance compared to monolithic VGMM of equivalent complexity especially at the condition of longer periodic interval. In the final part of motion pattern analysis, error made by the two models is noted to demonstrate the superiority of VGMM model compared to other.

[2] used the roadside light detection and ranging (LiDAR) sensors and developed a human loop system to bring pedestrians into the connected environment. He also focused on Naive Bayes approach to provide an accurate prediction for results. It features a probabilistic approach to overcome the common deficiencies in deterministic methods and compares the feature-based data processing methods, such as artificial neural network (ANN) and model-based Naive Bayes approach.

[3] used the stereo vision mechanism to enable the autonomous cars to perform an evasive steering maneuver. [4] evaluates the pedestrians and driver’s awareness for estimated potential collision risk. [5] designed a system for concurrently to detect pedestrians and cyclists. The detection of pedestrians have been investigated in several scenario. Most of them uses 3D images, 3D point clouds or even the fusion of both sets of information. The estimation of pedestrians intention is to make even more challenging due to uncertainties regarding their impending motion (8). In fraction of a second, pedestrians can able to decide the move in one of many different possible direction.

[6], observed that the motion of the pedestrians and also the difference between an effective and a non-effective intervention can depend merely on a few centimeters or a fraction of a second. Intention of Pedestrian can be estimated jointly with path prediction. A comparative study of pedestrian path prediction provides a survey on various of interactions between autonomous vehicles and humans.

Shirazi et.al reviewed about the pedestrian motion, driver lack of attention and knowledge, vehicle behaviors at certain

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intersections. They also analyzed the features that distinguish various pedestrian behavior. According to the literature survey, research initiatives are concerned about both short-term and long-term predictions. Studies which comprises the long-term predictions usually draws the information using static cameras and aim at predicting either the pedestrians’ final destination, or the path followed. [7], modeled pedestrians’ intention using a Markov decision-process framework and pedestrian state was inferred using a Rao-Backwellized filter. [8] future actions of pedestrians are predicted by using a noisy visual data and the effects of the physical environment on pedestrians’ behavioral choices.

According to [9] information, the pedestrians head orientation and body movement is always relevant to the short-time predictions. [10] used pose recognition, lateral speed, orientation, and scene conception as input to predict actions in neural network, as walking, starting off, bending in and stopping. The approach of [11] suggested to reduce the dimensionality of the 3D coordinates of pedestrian body pose through the Gaussian Process (GP) model and predicts the motion dynamics which are related to walking, starting off, stopping and standing.

[12] also implemented the Gaussian Process Dynamical Models (GPDM) for estimating pedestrian intention regarding a pose prediction of a one-second horizon. Furuhashi predicted the motion of a pedestrian standing on the crosswalk roads which are captured by camera based on the analysis of their postural change. [13] used a Support Vector Machine (SVM) and a HOG-like descriptor for detecting motion contour pedestrian to estimate pedestrians’ intentions. Alahi et. al (2018), proposed Long Short-Term Memory (LSTM) network to learn about interactions of each pedestrian.

[14] identifying a walking activity through pedestrian localization is to understand their local intention and activity analysis. [15], used the extended Kalman Filter (EKF) and Interacting Multiple Model (IMM) algorithm to build up the single dynamic models, to determine the Constant Velocity (CV), Constant Acceleration (CA), and Constant Turn (CT). A new dataset was proposed by then which is comprised of pedestrian motion types, namely crossing, stopping and starting off.

[16] proposed a method for pedestrian path prediction and compared those analysis with other different approaches related to pedestrian path prediction, namely GP, Probabilistic Hierarchical Trajectory Matching (PHTM), KF, and IMM at various time horizons. Similar prediction performance results show the when pedestrians’ locations are precise, although, the approaches that used GPDM and PHTM performed got improved in stopping scenarios. For comparative reasons, they have also employed human subjects tasked with predictions of pedestrians possibly stopping or crossing a street.

In the pedestrian safety analysis, logistic regression and parameter statistical method are widely used to analyze pedestrian crossing behaviors. The probability of pedestrian gap acceptance was estimated to show that the gap size, number of waiting pedestrians and age significantly influence pedestrians’ crossing behaviors [17].

[18] dealt with characteristic of pedestrians, test methods, to test the advanced pedestrian detection systems. This also includes various detection algorithm approaches including pre-indicators and path prediction for a complex motion pattern. The complex motion pattern can be used for walking or a running pedestrian, including the velocity and direction changes [19].

Nevertheless, some researchers observed the uses of only dynamics would not be sufficient; because KF tracking the pedestrian walking parallel to the vehicle which predicts the pedestrian’s future positions to be set further. However, pedestrian constantly turning around her/his head towards the autonomous vehicle and road is an indication of where she/he intends to go. Therefore, this approach that merely relies on pedestrians’ dynamics will never predict their intention of crossing a street.

[20], focused basically on the trajectory prediction of pedestrians on crosswalks using their gait initiation through a piecewise linear model and a sigmoid model for calculating velocity and inferring a trajectory. Multilayer Perceptron (MLP) network that orients the network to predict a continuous trajectory and motion types.

[20], determined the intention of a pedestrian crossing / stopping, using dynamic fuzzy automations in low-light images using a thermal camera. [21] identified a Latent Dynamic Conditional Random Fields (LDCRF) system that controls an IMM using pedestrian dynamics through head orientation. [22], analyzed the different crossing surface materials, pedestrians crossing patterns on one-way streets with fewer connections with the vehicles.

[23] used datasets on pedestrians, as velocity, distance traveled, distance from the curb, and distance from the crosswalk, jointly with data on car movement and position. However, the authors evaluated these cases with the pedestrian would consistently cross a street. [24] also employed an SVM, where data can be the extracted from gait analysis. [25], predicted whether a pedestrian crossing a street can create relations between pedestrian, crosswalk, and ego vehicle.

[26], proposed a Dynamic Bayesian Network that captures some factors such as minimum distance between pedestrian and ego-vehicle. pedestrian’s head orientation, distance from the pedestrian to the curbside. [27] analyzed almost the same observable features, i.e., distance to ego-vehicle, and distance to curb, and head orientation.

3. Data Sets

Datasets created for the detection and tracking of pedestrians in images generally focuses on surveillance and inner-city circumstances. EPFL Multi-camera pedestrian videos and PETS uses static cameras in indoor and outdoor scenarios, respectively [28]. KITTI detection and tracking benchmark
datasets that significantly contributes to the autonomous vehicles field by enabling the comparisons of results of different approaches under the same input. The KITTI pedestrian detection benchmark has a greater number of methods and promotes a considerable evolution in the autonomous vehicle field by providing a rich infrastructure to test pedestrian detection and tracking [29].

Some of the currently available datasets for pedestrian path prediction are Daimler Pedestrian Path Prediction Benchmark Dataset. The problem with such datasets, contains only one pedestrian with predetermined actions. Another available dataset used for crosswalk behavior classification which provides labels with information on weather conditions, presence of traffic elements (traffic light, crosswalk) and gender [30]. However, it does not capture the coordinates of the pedestrians’ positions, but only the action associated of each pedestrian. In general, two possible categories of data sets are available, i.e. scenarios where the pedestrian is instructed to perform some predetermined actions and more realistic scenarios with real pedestrians. In both cases, the number of data collected is usually limited [31].

Two major problems has been identified in the available datasets. The pedestrian are instructed to perform some predetermined actions, i.e. subjects pretend to be pedestrians, but carry out predetermined actions (crossing, stopping, utilizing the crosswalk, etc.). Such a scenario does not comprise all information which may encourage the pedestrian to perform an action and the variability behind real pedestrians’ decisions [32]. According to report available, 80 percent of pedestrians searches for eye contact with the driver before crossing a street. Since the datasets were collected by using sensors in a car driven by a human driver, we believe the behavior of pedestrians may have been affected by such an interaction even in realistic scenarios. The communication between established between the driver and pedestrian is well established [33].

4. Performance Discussion
According to the above studies, some external factors such as street width, being alone or in a group, and presence of other cars can impudence the pedestrian’s decision-making and motion patterns. Some studies have investigated the shift of the pedestrians’ ride at a high speed, resulting in abrupt stops and the speed variation in gender and age groups [34]. Some researchers focused their experiments for discovering the parameters that most influence the pedestrians’ decision to cross a street and the factors that human drivers take into consideration when predicting movement of pedestrian [35]. The streets with narrow width, older people, young adults with a high-speed fall into these categories.

According to [36], still some algorithms could not predict the pedestrian intentions as well as their behavior. However, characteristics regarding different types of pedestrians can be used to predict their actions. For instance, drivers are usually more careful when they see a child on the curbside, since children may exhibit unpredictable behaviors and inadvertently run into the street. Likewise, when drivers spot a pedestrian with a cane, they assume he/she may be blind or have difficulties in moving.

Elderly people, walks lower than an average adult and may face difficulties due to the deterioration of their perceptual and cognitive abilities. Factors such as age, gender, number of people walking together, constraints posed by the environment [37]. A pedestrians speed evaluated the differences in crossing patterns between ordinary pedestrians and pedestrians using a mobile phone. Additionally, a mobile phone in the hands of a pedestrian may provide information regarding his/her level of awareness of the situation.

We believe that individual analysis of pedestrians would enable intelligent vehicles to make better predictions and adaptable decisions; as such information may enhance the understanding of pedestrians’ behavior patterns and speed of motion in street scenarios. The estimation of pedestrians’ intentions still requires an approach that perceive real-world scenarios, since most of the studies perform predictions using datasets in which pedestrians are actors with predetermined actions [38]. Therefore, they do not represent a real scenario where several factors can impudence a decision. A pedestrian may prefer to wait because, for instance, the street is too wide; he/she stops to answer a text message, or is pushing a stroller. We believe a further step for improvements in the state-of-the-art of predictions of pedestrians’ intentions will be the use of pedestrian-specific characteristics jointly with dynamics and contextual scene information [40-41].

Pedestrian dynamics i.e., position and velocity can be accurately assessed through stereoscopic camera images along with detection and tracking algorithms. Pedestrian awareness can be estimated through the observation of head orientation (as proposed in [39]) and also detection of possible objects that may interfere with their attention (e.g mobile phone, cane, and stroller). Information can be accessed through the identification of presence of signaling devices (traffic lights and crosswalks), curb location and number of lanes.

5. Conclusion
Age Groups of people (child, adult, and senior), the products which they are carrying while walking on the road and the group dynamics of walking (alone, pair or family) can be called as characteristics of pedestrian (child, adult, senior), detection of objects can be packing (cane, mobile phone, and stroller) and number of people walking together (alone, pair or family). These factors may interfere with the pedestrian’s awareness, mobility towards their surroundings. The identification of pedestrians’ characteristics would provide intelligent cars, information on the different pedestrians’ types, enabling cars to use adaptable systems that infer actions and understand scenarios that strongly resemble the way humans perform such tasks. Additionally, the use of the features previously discussed would improve both the development of traffic infrastructures based on reports on
most common user types and construction human/machine interfaces and advance the Assistive Intelligent Transportation System field.

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