



Fuzzy logic-based observation and evaluation of pedestrians' behavioral patterns by age and gender



Chen Chai ^{a,*}, Xiupeng Shi ^b, Yiik Diew Wong ^b, Meng Joo Er ^c, Evan Tat Meng Gwee ^d

^a School of Civil and Environmental Engineering, Nanyang Technological University, Singapore 639798, Singapore

^b Center for Infrastructure Systems, School of Civil and Environmental Engineering, Nanyang Technological University, Singapore

^c School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore

^d Research and Publication Division, Land Transport Authority, Singapore

ARTICLE INFO

Article history:

Received 12 March 2015

Received in revised form 13 October 2015

Accepted 10 April 2016

Available online 12 May 2016

Keywords:

Pedestrian behavior

Age and gender effect

Fuzzy logic

Jaywalking

Signalized crosswalk

ABSTRACT

Pedestrian behavior is affected by a multitude of factors such as age, gender, and operating conditions. However, traditional statistical analysis based on observed movements or questionnaire survey is unable to model decision-making process of each pedestrian. This study develops an innovative approach based on fuzzy logic to model the underlying cognitions and behavioral patterns of pedestrians as inferred from field observation in order to evaluate age and gender effect of pedestrians in crossing a signalized crosswalk and when jaywalking. Fuzzy sets and rules are created to model the relationship between human cognitions and decisions of an individual pedestrian. Through calibrating the membership functions of different age and gender groups, behavioral patterns of pedestrians are evaluated and compared. Different from most previous studies, both older and younger pedestrians are found to be less risk-taking than adult pedestrians. Moreover, significant gender difference is found only for cognitions of most hazardous conditions. Consistent with previous studies, it is seen that men have better cognitive skills than women at detecting hazardous situations. The findings from this study are useful to better design safe pedestrian crossing facilities. The fuzzy logic-based approach also provides an innovative way to simulate pedestrian movements in microscopic simulation models.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

Age and gender may affect pedestrians' behavioral patterns. Their effects are reflected in the accident records. In Singapore in 2014, there were 435 accidents between pedestrians and vehicles that the pedestrians were likely at fault (Singapore Police Force, 2015), and were ascribed to three major contributory factors: crossing heedless of road traffic (40%), failing to use available pedestrian crossing (8%), and crossing within pedestrian crossing but during red man pedestrian signal (11%). It is found that elderly pedestrians (above 50 years old) are disproportionately represented in accidents involving these three factors (at 33%, 26%, and 19%). This may be attributed to the elderly pedestrians being less agile, tendency to walk slower and have longer reaction time (Tarawneh, 2001; Holland & Hill, 2010). Gender differences are also evident in the accident records. Male pedestrians are involved in 60% and 64% of the accidents ascribed to crossing heedless of traffic and crossing

* Corresponding author. Tel.: +65 96544059.

E-mail address: chai0076@e.ntu.edu.sg (C. Chai).

during red lights compared to 40% and 36% for female pedestrians. This is consistent with previous observations that male pedestrians committed significantly more violations than females (Rosenbloom, Nemrodov, & Barkan, 2004).

However, in some studies, age and gender differences are not found (Diaz, 2002). This may be due to inherent limitation in the study approaches. Firstly, analysis based on crash records might be affected by the random nature of crashes as well as mobility differences between age and gender groups (Liu & Tung, 2014). Moreover, existing approaches in studying pedestrian cognitions based on questionnaire survey might be biased as the participant may not understand the survey form adequately or always reports correctly his or her attitude and intention about past scenarios. A new approach is thus desired to rigorously examine age and gender effect of pedestrians. Therefore, this study develops a novel approach based on fuzzy logic to further understand pedestrian cognitions which are inferred from field observation. Pedestrians at signalized crosswalk and when jaywalking are studied to examine whether there is difference in the cognition of pedestrians by age and gender.

The outline of this paper is as follows. Section 2, the literature review, highlights the significance of proposed fuzzy logic approach by reviewing existing studies. Section 3 introduces field observation study and the proposed fuzzy logic approach. In Section 4, age and gender effect of pedestrians are evaluated and discussed through calibration of membership functions. Findings of age and gender differences as well as advantages and limitations of the proposed innovative approach are also discussed in this section. The paper ends with conclusions and contributions of this study and suggestions for further research.

2. Background

2.1. Age and gender differences based on cognition analysis

Age and gender traits are important factors of pedestrians' risk as related to road safety, hence it is a very important issue to understand how age and gender contributes to these risks (UK Department for Transport, 2004). Some researchers ascribed the higher risk of elderly or women pedestrians to the greater amount of walking and thus being more exposed to risky situations. However, such argument is questionable given that though elderly pedestrians or women drive less, the distance walked according to age and gender groups is not compared (Carthy, Packham, Salter, & Silcock, 1995).

In recent years, cognitions, such as perception, attitude and intention, of different age and gender groups are analyzed. Younger road users are more risk-taking and less likely to perceive hazards; on the other hand, cognitive and sensory skills increase with aging (Parker, Stradling, & Manstead, 1996; Dunbar, Holland, & Maylor, 2004). Older pedestrians tend to be less agile, walk slower and have longer reaction time (Tarawneh, 2001; Holland & Hill, 2010). Experiences of being a driver also affects risk-taking behavior of pedestrians. As men usually drive more than women, they possess different perception skills (Holland & Hill, 2007). It is also found that attitude and intention affects risk-taking behavior by age and gender (Elliott, Armitage, & Baughan, 2003). Since cognitions play a very important role in age and gender differences, some researchers have applied the theory of planned behavior (TPB) model, which involves perception and intention of human, to examine pedestrians' behavioral patterns. Evans and Norman (1998) applied TPB to analyze adults' road crossing behavior for three risky situations. It is found that perceptions and attitudes accounted for 39–52% of the variance in intention to cross the road. Elderly pedestrians are also found to be more likely to make risky road crossing than other age groups, but gender differences are not found in this study. A study by Diaz (2002) compared adults under and above 26 years old. It is found that younger people are more risk-prone towards crossing the road. As in Evans and Norman's study, gender difference is not found in Diaz's study. Therefore, the key aim of the present study is to examine whether there is cognition difference of pedestrians by age and gender. Specifically, the following aims are investigated:

1. To find whether older and female pedestrians are less risk-taking than other age and gender groups.
2. To provide a mathematical approach to model, and estimate, the cognitions of pedestrians by age and gender groups.
3. To examine how age and gender traits vary under different situations, for example, jaywalking or walking-on-red at signalized pedestrian crosswalks.

2.2. Cognitions of road users

Risk-related attitude is defined as a psychological intent towards favorable/un-favorable risky behavior as well (Falk & Montgomery, 2009). A road user's attitude is found to affect his/her behavior by way of aggressive movement and involvement in traffic accidents (Parker, Lajunen, & Stradling, 1998; Iversen, 2004). Perceived risk is defined as road user's perception of a potential danger (Baron, Hershey, & Kunreuther, 2000). Some studies found that risk perception directly affects traffic safety (Nordfjærn & Rundmo, 2009). When road users are more easily seeing themselves to be in a situation of danger, he/she is more likely to not drive in a manner risky to himself or herself (Rundmo & Iversen, 2004). Another cognitive antecedent, namely perceived behavioral control (PBC), represents road user's perception of his or her ability to perform a behavior, such as stopping or changing movement direction (Ajzen & Driver, 1991; Groeger, 2002). PBC is known as a multi-dimensional construct that involves both attitude and perception aspects. It is clear that PBC also affects decision-making process. Cestac, Paran, and Delhomme (2011) conducted a questionnaire survey to understand PBC and

Download English Version:

<https://daneshyari.com/en/article/897604>

Download Persian Version:

<https://daneshyari.com/article/897604>

[Daneshyari.com](https://daneshyari.com)