COMPUTATIONAL INTELLIGENCE FOR TRAFFIC AND MOBILITY

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ATLANTIS COMPUTATIONAL INTELLIGENCE SYSTEMS
SERIES EDITORS | JIE LU, JAVIER MONTERO

ATLANTIS PRESS

ATLANTIS COMPUTATIONAL INTELLIGENCE SYSTEMS

VOLUME 8

SERIES EDITORS: **JIE LU, JAVIER MONTERO**

Atlantis Computational Intelligence Systems

(ISSN: 1875-7650)

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Computational Intelligence for Traffic and Mobility

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AMSTERDAM – PARIS – BEIJING

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ISBNs
Print: 978-94-91216-79-4
E-Book: 978-94-91216-80-0
ISSN: 1875-7650

Preface

Advances in mobility are most clearly illustrated by the spread of motorized traffic and transport, the development of the transportation industry, including vehicle manufacturing and its associated infrastructure. These developments represent one of the main challenges for information science and intelligent technology. The discipline of Intelligent Transportation System (ITS) is widely applied to solve transportation problems including congestion, accidents and pollution emissions.

Since our daily life and work are closely related to traffic and mobility, traffic demand has increased dramatically. Following this increase, we additionally have to balance the increasing desire for mobility and efficiency with the societal concerns about traffic problems. Today's traffic demand is predominantly served by individual motorized vehicles, which are the primary means of transportation. As the traffic demand has continuously grown faster than the construction of infrastructure over the last decades, traffic congestion has become a severe problem in many countries. Meanwhile, as vehicle speed is increasing, traffic safety has also become an important and socially relevant topic, which has impact on social and economic developments. Additionally, the environmental impact and energy consumption caused by traffic systems also arouse great public concern.

The engineers and scientists in different areas are seeking solutions as to how the traffic system could be used more efficiently and how operations could be improved by using new technologies and new methodologies. Recently, computational intelligence methods have received considerable attention regarding their potential as a powerful technique for traffic and mobility problems. Computational Intelligence (CI) is the study of adaptive mechanisms enabling or facilitating intelligent behaviour in complex and changing environments. As such, CI combines artificial neural networks, evolutionary computing, swarm intelligence and fuzzy systems. The characteristic of 'intelligence' is usually attributed to humans. The concept of intelligence is directly linked to reasoning and decision-making. Nowadays, CI is widely used to develop models, algorithms and approaches for traffic and mobility operations.

This book includes the 15 final revised and extended chapters from 28 proposed chapters. Aiming at summarizing the state-of-the-art of CI in the context of modern traffic systems and the debate on the traffic problems, this book intends to introduce and discuss the developments and applications of CI in traffic and mobility from the perspective of intelligent transportation systems. The book provides the methods of CI in a manner which allows the reader to easily implement the different methodologies, and to apply these methods to solve traffic problems such as traffic congestion, traffic accident and traffic environment pollution. In the whole book, the basic concept and methodology involved with CI as well as their application in traffic and mobility are introduced by a careful and considered approach. This book is appropriate for both the first-time reader, as well as individuals already active in all embracing fields of transportation engineering, computational intelligence and intelligent transportation system.

Last but not least we feel honored that the writing and publication of this book are supported by the Programme of Introducing Talents of Discipline to Universities under grant B12022. We are heartily thankful to the late Prof. Dr. Da Ruan whose help and suggestion enabled us to publish this book. This book also represents his years of toil in scientific research, especially for CI. We would like to thank Prof. Dr. Jie Lu whose comments helped to significantly improve the overall quality of this book. Also, we wish to acknowledge the colleagues who have been involved in some of the projects that contributed to this book.

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Contents

Chapter 1

Sequential Advanced Guide Signing For Work Zone Related Rerouting On Highways: The Effect of Longitudinal Location on the Driver's Trajectory Control

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This study examined the effects of a sequenced triple (i.e., announcement, instruction, marker) sign configuration for advanced guidance in a work zone related rerouting scenario on longitudinal and lateral driver control. The longitudinal distance of only the second (instruction) sign varied (i.e., 500 m vs. 1000 m vs. 1500 m before the target exit) whereas it was held constant for the first (announcement) sign (i.e., 2000 m before the exit) and the third (marker) sign (i.e., 50 m before the exit). It was expected that the second sign would affect driver's longitudinal and lateral vehicle control and that the effect would be dependent on the sign's longitudinal location. 30 subjects completed a 14 km test-drive on a driving simulator with three exits to be taken.

Following our expectations, the second sign had an effect on longitudinal (i.e., mean speed and SD for acceleration/deceleration) as well as lateral (i.e., number of lane switches to the right) driver behavior. Furthermore, this effect depended on the longitudinal location of the second (instruction) sign. From a comparison of the three locations it was concluded that placing the second sign at 1000 meters from the exit was the most preferable option in terms of traffic safety and flow.

1.1 Background

Work zone related crashes on highways are a major issue in terms of road safety management. It has been argued that this is largely due to the interference of work zones with normal traffic flow. More specifically, work zones imply temporarily modified and complex road geometry (i.e., multiple splits, closed off driving lanes, etc.) with small warning times (Dutta *et al*., 2002), and this induces both abrupt speed alterations and last moment movement decisions, reducing the likelihood of a smooth and stable shift of traffic, which results in an increased risk for rear-end and sidesweep crashes (Mattox *et al*., 2007).

W. Wang and G. Wets, *Computational Intelligence for Traffic and Mobility*,
Atlantis Computational Intelligence Systems 8,
DOI: 10.2991/978-94-91216-80-0_1,

This explains why improving safety and operational efficiency of traffic flows at work zones still is one of the major challenges in traffic engineering. One way of dealing with safety at highway construction zones is to have road users simply navigate around them (Ullman, 2000). This particular form of incident management is referred to as rerouting and diverts drivers from the primary route onto a secondary street network and then back to the original route. The primary advantages of this system are the avoidance of a potentially direct conflict between construction zone workers and motorists as well as a lowered congestion risk with drivers being caught in upstream traffic jams on the primary route.

In a highway context, accessing the alternate route means having to take a right-lane exit while driving on a single direction multilane road with the outer right lane serving as a drive through for traffic that is not to be rerouted and therefore continues its normal trajectory (Fisher, 2004; Upchurch, 2005).

In order for drivers to optimize their decision making and actions, it is essential that they are aware of the diversion route on time (Neale, 2002). The basic theoretical assumption behind the principle of advanced warnings is that they prepare the driver and thereby maximize the chance of appropriate actions being undertaken under dangerous and/or unexpected circumstances (Crundall, and Underwood, 2001).

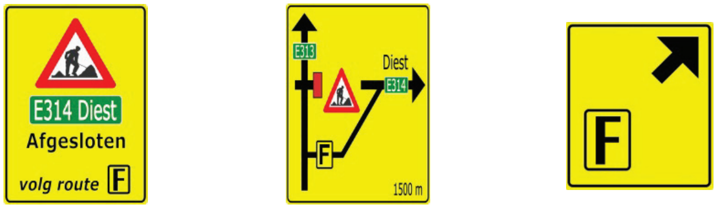
By contrast, late recognition of the exit lane makes drivers execute risky weaving maneuvers to enter the desired lane (Muttart, 2007), and motorists waiting until the last moment to change lanes may create a bottleneck and thereby reduce a smooth shift of traffic. Finally, if there isn't enough time to make a move, drivers must continue in the same travel direction until they have the opportunity to turn around which will cause an increase in both emissions and traffic volume in the opposite direction (Bullough, 2005).

For the above problems to be avoided, additional advanced guidance information is essential (Zwahlen *et al.*, 2003). The safety effects of advanced warning devices have been demonstrated before (Finley *et al.*, 2011). In general, they induce speed reduction and earlier lane change which avoids sudden stops and erratic or last-minute maneuvers.

Although rerouting has become a popular practice throughout various regions in Europe as well as the U.S., many European countries have developed their own signing system since there is no uniform set of regulations or guidelines to be followed. As a result, different signing approaches co-exist without really knowing what might be considered as best practice. The system of advanced guide signing that will be evaluated in this study is currently in use on the Flemish road network, which is among the most dense and intensively occupied networks throughout Europe.

The basic principles behind the Flemish approach have been outlined by a workgroup of specialists in traffic safety and engineering (Deknudt, 2011). The signing system they worked out is implemented more specifically for cases where highway traffic is to be rerouted due to the occurrence of a planned incident, such as road construction and maintenance works, or when highway traffic is to be guided towards big local events such as music festivals, pop concerts or sport manifestations.

More in detail, highway rerouting in Flanders is based on the principle of advanced guide signing with the exit leading to the diversion route being preceded by a sequence of three different signs. Each of these three signs serves a different purpose, i.e., announcing, instructing and marking, and the alternate route itself is represented by a predetermined code letter. Fig. 1.1 visualizes these signs more in detail.



(a) (b) (c)

Fig. 1.1 Work zone related rerouting signs: (a) first (announcement) sign, size 4 m by 4 m, (b) second (instruction) sign, size 4 m by 4 m, and (c) third (marker) sign, size 1,6 by 1,7 m.

Fig. 1.1a pictures an example of the so-called announcement sign which indicates how motorists cannot access highway E314 towards Diest by means of the usual exit, due to road works. Instead, they have to take another exit and follow an alternate route towards the E314 (represented from here on by the code letter F). This sign is located the furthest away from the exit to be taken and therefore is the sign first met by the concerned drivers. Throughout the remainder of the chapter, it will be referred to as sign 1.

Fig. 1.1b represents an example of the instruction sign. This sign follows the previous one and its message varies in function of what the precise reference situation is like. The context this example refers to is one where the exit to be taken normally in order to reach the desired destination is blocked due to construction works. Therefore, concerned drivers will have to leave the highway earlier in order to avoid they will have to turn around. As can be seen, the major difference with the previous sign is that it gives specific instructions to the drivers as to how (i.e., by means of the first upcoming right-lane exit) and when