IET Intelligent Transport Systems

Research Article

IET Journals
The Institution of Engineering and Technology

Enhancement of safety and comfort of cyclists at intersections

ISSN 1751-956X
Received on 22nd August 2017
Revised 28th January 2018
Accepted on 7th February 2018
E-First on 6th March 2018
doi: 10.1049/iet-its.2017.0250
www.ietdl.org

Meng Lu[1], Robbin Blokpoel[1] ✉, Mahtab Joueiai[1]

[1]Dynniq Nederland B.V., Basicweg 16, 3821 BR Amersfoort, The Netherlands

✉ *E-mail: robbin.blokpoel@dynniq.com*

Abstract: Cyclist safety is increasingly becoming a societal problem in Europe, as shown by road safety statistics. Frequent stops for red traffic lights at intersections are experienced by cyclists as a major inconvenience. This study introduces a green wave concept for cyclists, with focus on the traffic management and control aspects under cooperative intelligent transport systems applications. It especially addresses increasing stability of the adaptive control system, to overcome the drawbacks of both actuated and traditional adaptive control (which are too unpredictable for a green wave speed advice). In addition, solutions for avoiding increased delays for other traffic are investigated, as generally result from a classic green wave approach (with only fixed-time control) and traditional adaptive control. This study introduces an adaptive control algorithm for a real-time model-predictive controller and implements a plan-deviation cost function to address stabilisation. Simulation results show that the developed method increases stability of the adaptive control system, limits extra delays for other traffic and yields a high success rate for the green wave concept.

1 Introduction

Cyclist safety is perceived as a major societal problem in European Union (EU) countries. Bicycle fatalities make up 8.1% of the total number of road accident fatalities in 2014 in the EU countries and a total of 2112 people riding bicycles were killed in road accidents in that year. Although the total number of bicycle fatalities in the EU countries decreased by 30% between 2005 and 2014, as a percentage of all road fatalities, cyclist fatalities increased from 7% in 2005 to 8% in 2014 [1].

Although the road safety records of The Netherlands (together with Sweden and the UK) are amongst the best worldwide, the accident toll is still considered unacceptably high. The Netherlands has the highest cyclist fatality rate, as percentage of the total number of road accident fatalities. In 2014, it was at 25% compared with below 16% in most other EU countries. On average, 27% of the cyclist fatalities in the EU countries occurred at junctions. In The Netherlands, this number is more than double, i.e. 55%. In general, accident data are incomplete and inaccurate, and the causality is often unknown. It was found out that 18% of the links between causes are observed to be between 'faulty diagnosis' and 'information failure' [1].

The Netherlands has the highest number of cyclists per capita in the world. Frequent stops for red traffic lights at intersections are experienced by cyclists as a major inconvenience, according to Fietsersbond [2]. Fietsersbond is the Dutch Cyclists' Union. The concept of cooperative traffic lights for vulnerable road users (VRUs) has received high attention from Dutch cities, for increasing the safety and comfort of VRUs through warranting priority or additional crossing time (i.e. extending the green-light phase or reducing the red-light phase) based on the characteristics of VRUs or on special conditions (such as weather).

From the technical perspective of traffic management and control, cooperative intelligent transport systems (C-ITSs) [3, 4] services for cyclists could help to reduce accidents at intersections, especially by mitigating 'faulty diagnosis' and 'information failure'. In addition, such service, called 'traffic light prioritisation for designated VRUs', will increase comfort for cyclists when crossing intersections.

This paper investigates the application of a green wave concept for cyclists from the traffic management and control perspective, and especially addresses increasing stability of the adaptive control system. The green wave concept was originally developed for eco-driving vehicles, and has been implemented in different countries. Eco-driving aims to reduce fuel consumption of vehicles (which consequently reduces emission), and to improve traffic efficiency (e.g. frequency of stops, accelerations and decelerations). Eco-driving can be achieved by application of in-vehicle systems and/or by use of traffic control systems. This paper targets the latter. Green wave is a result of a traffic control strategy that synchronises the green phase of consecutive traffic lights to allow the efficient flow of traffic. Providing a green wave for cyclists reduces the travel time for people who use this green mode of transport, as well as adds to the pleasure of cycling. Cycling green wave also improves the safety of cyclists by reducing the risk of red-light violation and the number of stops. Risk of red-light violation for other traffic is negligible. Owing to the balance between predictability and stability, which is the novel contribution of this paper, the other traffic does not suffer longer delay times and therefore has no reason to violate red light more often. Research questions are as follows:

(i) How to increase stability of the adaptive control system to overcome the drawback of actuated or traditional adaptive control (which is too unpredictable for a green wave speed advice).
(ii) How to ensure limited extra delay for other traffic and a high success rate for the green wave, to overcome the disadvantages of the classic green wave (only with fixed-time control) and traditional adaptive control, which both increase delays for other traffic.

In Section 2, we introduce the concept of the green wave for cyclists. Section 3 presents the adaptive control algorithm of a real-time model-predictive controller. Section 4 implements a plan-deviation cost function to address stabilisation. Section 5 describes the testing of the developed algorithm testing through simulation, and analyses the results for as input for the development and implementation of a prototype. Finally, Section 6 draws conclusions and outlines topics for further research.

2 Concept of green wave for cyclists

The green wave concept was first applied for motor vehicles, and with different purpose, i.e. for eco-driving, e.g. to reduce fuel