PHYSA: 17199 Model 3Gsc pp. 1–11 (col. fig: NIL)

ARTICLE IN PRESS

Physica A xx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

Q1 Simulation study of interference of crossings pedestrian and vehicle traffic at a single lane roundabout

Q2 H. Echab, H. Ez-Zahraouy *, N. Lakouari

Laboratoire de Magnétisme et de Physique des Hautes Energies (URAC 12), Département de physique, B.P. 1014, Faculté des sciences, Université Mohammed V Rabat, Morocco

HIGHLIGHTS

- Pedestrian–vehicle interactions at a roundabout system are analyzed.
- Flux and phase diagrams for both pedestrians and vehicles are simulated.
- Rules governing crossings pedestrian, crosswalk position, and driver behavior have significant effect on phase diagrams. Q3

ARTICLE INFO

Article history:
Received 25 February 2016
Received in revised form 28 April 2016
Available online xxxx

Keywords:
Cellular automata
Roundabout
Pedestrians
Phase diagram
Maximum current
Gridlock

ABSTRACT

This paper proposes a vehicle–pedestrian cellular automata model to investigate the characteristics of the mixed traffic at a single lane roundabout. The roundabout boundary is controlled by the injecting rates α_1, α_2 and the extracting rate β whereas pedestrians are generated with arrival probability P_{cr}. The pedestrian and vehicle flux are calculated in terms of rates. Also, the phase diagrams of the system in the (α_1, P_{cr}) and (α_1, β) spaces are constructed. The results show that, the gridlock state is reached only when the pedestrians have the right of way over vehicles, while the maximum current state is reached when including a pedestrians' crossing decision rule. Likewise, we have found that the crosswalk location play a chief role in improving the dynamic characteristics of pedestrian and vehicle flux. Furthermore, it has turned out that the traffic is sensitive to the driver behavior. Q4

1. Introduction

Undoubtedly, the vehicular transportation is considered as one of the big challenges in modern societies, where the interactions between different traffic participants (e.g. cars, pedestrians, bicycles, buses) are usually complicated. Many observed traffic phenomenon have been successfully described by computer simulation with various models, e.g. car following, Fluid-dynamical method, and Cellular automaton (CA) [1–13]. This later has been adopted extremely and well received as a good tool to study the traffic and/or pedestrian dynamics [8–12,14]. Q5

Among the traffic participants, pedestrians are the most susceptible to traffic damage. For this reason, many studies have examined the pedestrian flow and its effect on vehicular traffic [15–24]. Feng et al. [15] proposed a cellular automata model to evaluate walkers' facilities before its implementation, Zhuang and Wu [16] developed a model of pedestrian crossing paths at unmarked roadways to better understand pedestrian behaviors, Yannis et al. [17] studied walkers' gap acceptance for mid-block road crossing in urban areas, Xie et al. [18] investigated the characteristics of the traffic flow on a road with a signalized crosswalk in the framework of CA model, Zhang et al. [19] proposed a cellular automata model to study the

* Corresponding author.
E-mail address: ezahamid@fsr.ac.ma (H. Ez-Zahraouy).

http://dx.doi.org/10.1016/j.physa.2016.06.006
0378-4371/© 2016 Published by Elsevier B.V.

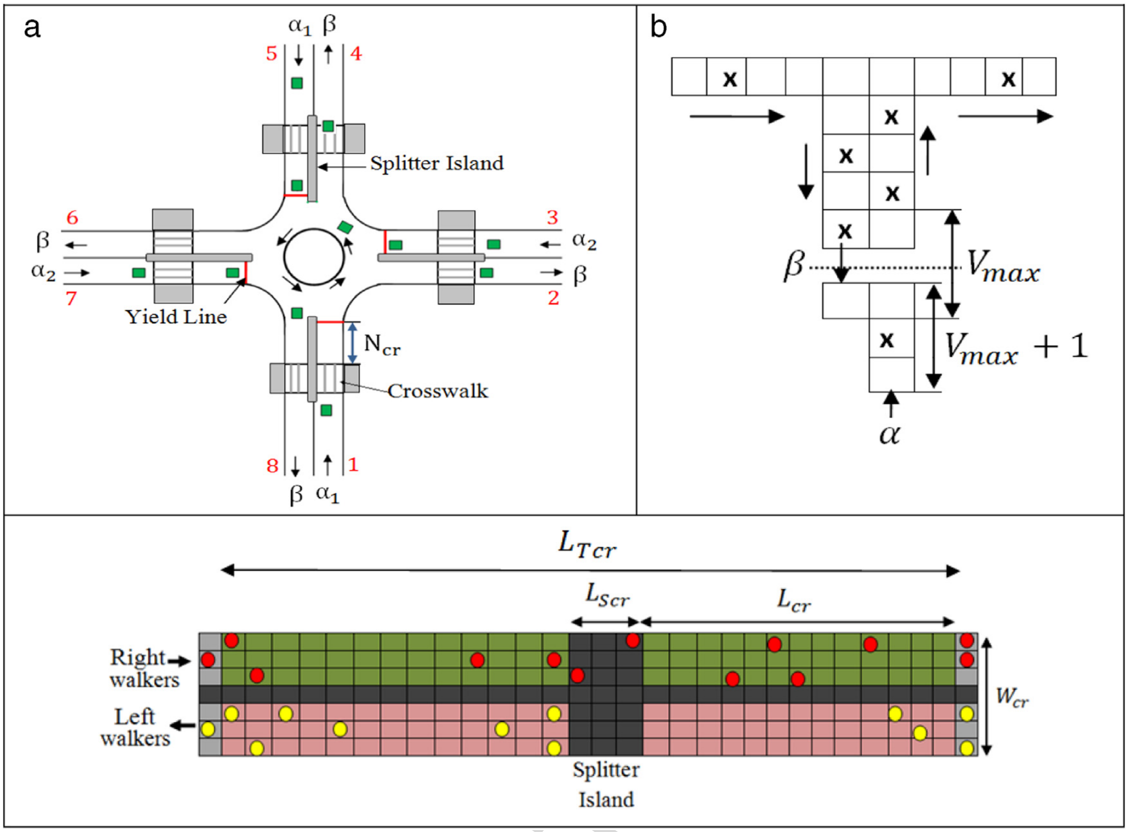

Fig. 1. (a) Sketch of the roundabout. (b) The injection rule with $V_{max} = 2$. (c) Sketch of the crosswalk.

effect of the traffic light control on the pedestrians flow. Therefore, our aim in this paper is to study the interactions between vehicles and crossings pedestrian at a roundabout system in the framework of CA model under the open boundary condition. Furthermore, we analyze how the location of the crosswalk and the driver cooperative behavior can influence the dynamic characteristics of pedestrian and vehicle flux. The paper is organized as follows. In Section 2 we explain the model. Results and discussions are presented in Section 3. The conclusion is given in Section 4.

2. Model and method

1. Roundabout model

We consider one-dimensional closed chain of L_1 cells (circulating lane) with four entry/exit lanes of L_2 cells which are equidistantly located with respect to each other. Vehicles enter from odd-numbered lanes and exit from even numbered ones. In the circulating lane vehicles move orderly and counter clockwise. Fig. 1(a) shows the sketch of the roundabout model.

2. Crosswalk

We consider that there is a crosswalk at each road direction (i.e. entry and exit lanes) to accommodate pedestrians around the roundabout. For this purpose, the crosswalk is defined on a discrete $L_{cr} * W_{cr}$ small site grid in one cell of the lane and it is located N_{cr} cells upstream of the yield lane, this situation increases the pedestrian safety and does not incur large delays to traffic. Furthermore, we use a Splitter Island between two successive exit and entry lanes to separate traffic moving in opposite directions, and provide space to pedestrians to cross only one direction of traffic at a time (i.e. pedestrians can cross the road in two stages). The part of Splitter Island used by walkers is also discretized into $L_{Scr} * W_{Scr}$ small site grid (see Fig. 1(a) and (c)).

According to HCM [25], the static thickness of a pedestrian is 0.3 m and the dynamic space (i.e. space that can accommodate only one moving pedestrian) is between 0.6 and 0.8 m. In our model we take $S = 0.6$ m as the dynamic space. So, the dimensions of the crosswalk at each road direction are: $L_{cr} = n * 0.6\ sites$ and $W_{cr} = m * 0.6\ sites$, while the dimensions of the Splitter Island are: $L_{Scr} = k * 0.6$ and $W_{Scr} = W_{cr}$. Here, n is the number of cells for one road direction, m is the number of pedestrian crossing lanes and k is the number of cells for traversing the splitter zone. We note that n,

Please cite this article in press as: H. Echab, et al., Simulation study of interference of crossings pedestrian and vehicle traffic at a single lane roundabout, Physica A (2016), http://dx.doi.org/10.1016/j.physa.2016.06.006