Ulrich Weidmann
Uwe Kirsch
Michael Schreckenberg
Editors

Pedestrian and Evacuation Dynamics 2012

Springer

Pedestrian and Evacuation Dynamics 2012

Ulrich Weidmann • Uwe Kirsch
Michael Schreckenberg
Editors

Pedestrian and Evacuation Dynamics 2012

Springer

Editors
Ulrich Weidmann
Institut für Verkehrsplanung
und Transportsysteme (IVT)
ETH Zürich
Zürich, Switzerland

Uwe Kirsch
Pestalozzi & Stäheli
Ingenieurbüro Umwelt Mobilität Verkehr
Basel, Switzerland

Michael Schreckenberg
Physik von Transport und Verkehr
Universität Duisburg-Essen
Duisburg, Germany

ISBN 978-3-319-02446-2 ISBN 978-3-319-02447-9 (eBook)
DOI 10.1007/978-3-319-02447-9
Springer Cham Heidelberg New York Dordrecht London

Library of Congress Control Number: 2014933212

Cover illustration: By courtesy of Uwe Kirsch

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

6th International Conference on Pedestrian and Evacuation Dynamics

Editorial

Why Is Pedestrian Research Important?

People have been walking for millions of years. Humans walked out of Africa on their journey to settle the whole world. Yet, in spite of how long and how far we have walked, there is still a great deal we do not know about walking. And, more importantly, in spite of our advanced transport technologies, the demand for walking is growing since it provides the foundation for sustainable and practical transport solutions. In summary, as the following challenges show, pedestrian research is more important than ever.

First, the density of human settlement is increasing. The world population is approximately seven billion and by 2050 it will be over nine billion. Today, over 50 % of people live in cities; by 2050 it will be over 70 %. Many of these cities will be megacities with settlement densities hard for us to imagine today. Even in places with stagnant population growth, such as Europe, forecasts show that the number of people living in major cities will increase as a result of better economic opportunities and efforts to protect rural landscapes. These population increases pose a major challenge for urban infrastructure and transport systems everywhere. Not only must more people be served, but crowded transport systems pose additional risks during technical breakdowns or emergency situations. Managing these risks is becoming more complex and important to society. In short, our cities will have more pedestrians, so we need to better understand their behaviour and needs.

Second, the number of older and disabled persons is rapidly increasing. We need to design fully accessible infrastructure and transport systems to meet the needs of older and disabled people, but also recognize that they move more slowly than younger people. So we also need to reduce distances, simplify paths and reduce detours. Understanding the physical requirements of walking will be fundamental to achieving these important goals.

In addition to becoming more crowded, new social media are enabling people to quickly organize spontaneous gatherings. Whether for a celebration or a revolution, social media can bring together thousands of people in hours. Once the process has started, there is little time to evaluate a location's physical safety conditions or to establish necessary pedestrian control systems. New pedestrian assessment methods and applications are needed to help quickly evaluate and plan for these types of events.

Third, increasing land use intensity encourages the construction of underground infrastructure, especially for transport. Many cities will build or extend underground metro systems. Many existing and new railway lines will be placed underground to serve as a backbone for regional transport networks. For example, in Zurich a new underground railway line is being built between the main station and the northern part of the city. But underground transport will not be confined to cities; long distance rail lines – especially high speed lines – will include many tunnels and underground structures to both maximize speed and reduce environmental impacts. Examples include Switzerland's 35-km Loetschberg railway tunnel (operating since 2007) and 57-km Gotthard tunnel (opening in 2016). Designing underground transport systems and facilities that can efficiently and safely accommodate large numbers of people in regular operations and, especially in emergency conditions, requires a very detailed understanding of pedestrian behaviour and needs. Government authorities have very stringent requirements that must be fulfilled in order to obtain approval for these types of projects.

Fourth, walking is a fundamental element of public transport and therefore must be carefully considered as operators seek ways of reducing costs and improving productivity. One example: today it costs Zurich's public transport operator 1 million CHF annually to operate a tram and 0.5 million CHF to operate a bus! The faster the service, the fewer the vehicles needed to run the same schedule. So, a powerful means for reducing costs is accelerating service – only fast public transport can be efficient. A good way of achieving this is to reduce dwell times at stops, but doing this successfully requires careful analysis of pedestrian movements.

Similarly, a growing number of railways are adopting the principle of cyclic timetables ("Integrierter Taktfahrplan"). Achieving the required node-to-node running times needed to meet these timetables can mean spending many millions of CHF on infrastructure improvements per minute of travel time saved. The alternative, reducing station dwell times through better design of pedestrian transfer facilities, can be much less expensive and make service more attractive to passengers.

But even in a continuously changing world, there are constants: The Swiss distance measure "Schweizerstunde" ("Swiss hour") used in the nineteenth century was equal to 4.8 km = 1.33 m/s or exactly the average of today's pedestrian speed!

Answering these challenges requires new knowledge, new methods and new tools. We must understand pedestrian behaviour under different conditions as well as be able to predict and simulate these behaviours in advance. We must develop accurate simulation for use in designing pedestrian facilities, helping us avoid dangerous situations, plan adequately for emergencies, and, last but not least, to make walking more attractive and enjoyable in general. The PED 2012 conference was an excellent opportunity to showcase research focused on these important topics.

At PED 2012, over 170 people enjoyed 70 presentations and keynotes as well as 70 poster presentations. The conference included presentations on new mathematical models and improvements to existing models. Many presentations described new insights on pedestrian behaviour in normal situations and emergency cases. Exciting new fields of research based on new technologies such as sensors and advanced means of observation were opened. In short, PED 2012 highlighted the transportation research community's commitment to meeting the challenges inherent in creating the pedestrian society of the future and has served as a starting point for innovative new research ideas, building a strong foundation for future research and the next conference.

Zürich, Switzerland Ulrich Weidmann

Contents

Part III Simulation and Modeling

Part V Miscellaneous

List of Participants

Wassim Abu Abed Leibniz Universität Hannover, Germany

Tomoeda Akiyasu Meiji University/Japan Science and Technology Agency, Core Research for Evolutional Science and Technology, Japan

Bani Anvari Imperial College London, UK

Cecile Appert-Rolland Centre national de la recherché scientifique/University Paris-Sud, France

Jean-Michel Auberlet Institut français des sciences et technologies des transports, de l'aménagement et des réseaux, France

Rebekka Axthelm Zürcher Hochschule für Angewandte Wissenschaften, Switzerland

Günter Bärwolff Technische Universität Berlin, Germany

Dietmar Bauer Austrian Institute of Technology, Austria

Olivier Benz Analysis Simulation Engineering GmbH, Switzerland

Gabriele Bernardini Università Politecnica delle Marche, Italy

Christian Blättler Schweizerische Bundesbahnen, Switzerland

Maik Boltes Forschungszentrum Jülich GmbH, Germany

Stephane Bonneaud Brown University, USA

André Borrmann Technische Universität München, Germany

Thomas Brudermann University of Graz, Austria

Sebastian Burghardt Bergische Universität Wuppertal, Germany

Alain Bützberger Swisstraffic AG, Switzerland

Felix Israel Cabrera Pontificia Universidad Católica del Perú, Peru

Nese Çakici Alp Kocaeli University, Turkey

Mario Campanella Delft University of Technology, Netherlands

Ahn Chan-Sol Korea Institute of Construction Technology, South Korea

Tao Chen Technische Universität Berlin, Germany

Jaisung Choi University of Seoul, South Korea

Mohcine Chraibi Forschungszentrum Jülich GmbH, Germany

Marcin Cisek Main School of Fire Service, Poland

Julien Cividini Universite Paris-Sud 11, France

Sean Curtis University of North Carolina at Chapel Hill, USA

Helena Cybis Universidade Federal do Rio Grande do Sul, Brazil

Antonin Danalet École Polytechnique Fédérale de Lausanne, Switzerland

Maria Davidich Siemens AG, Germany

Marjolein de Jong Hasselt University, Belgium

Manuela Di Mauro Nanyang Technological University, Singapore

Jan Dijkstra Eindhoven University of Technology, Netherlands

Christoph Dobler Eidgenössische Technische Hochschule Zürich, Switzerland

Kristen Dorcey-Joyce Quadstone Paramics, UK

Dorine C. Duives Delft University of Technology, Netherlands

Dirk Durst Federal Office of Civil Protection and Disaster Assistance, Germany

Bilal Farooq École Polytechnique Fédérale de Lausanne, Switzerland

Lei Feng University of Maryland, USA

Ralf Frisch Planung Transport Verkehr AG, Germany

Taku Fujiyama University College London, UK

Ed Galea University of Greenwich, UK

Ronald John Galiza The University of Queensland, Australia

Patrick Gessler TraffGo HT GmbH, Germany

Henri Hakonen KONE Corporation, Finland

Uwe D. Hanebeck Karlsruher Institut für Technologie, Germany

Flurin Hänseler École Polytechnique Fédérale de Lausanne, Switzerland

Dirk Hartmann Siemens AG, Germany

Sven Hebben TraffGo HT GmbH, Germany

Gesine Hofinger Schutzkommission beim Bundesministerium d. Inneren, Germany

Akihiko Hokugo Kobe University, Japan

Beat Hürzeler Schweizerische Bundesbahnen, Switzerland

Frank Huth Technische Universität Berlin, Germany

Andrew Hutton Network Rail, UK

Ulrike Huwer Basler & Hofmann AG, Switzerland

Gregor Jäger BFT Cognos GmbH, Germany

Peter Jenkins Building Design Partnership, UK

Anders Johansson University of Bristol, UK

Susan Johnson Johnson Engineered Solutions Limited, Canada

Masatoshi Kaitsuji Kobe University Graduate School, Japan

Toshiyuki Kaneda Nagoya institute of Technology, Japan

Stavros Katsoulis DEMCO SA, Greece

Erich von Känel Bundesamt für Verkehr, Switzerland

Armel Ulrich Kemloh Wagoum Forschungszentrum Jülich GmbH, Germany

Chris Kemp Bucks New University, UK

Nicolas Keusen Bundesamt für Verkehr, Switzerland

Junkug Kim Korea Institute of Construction Technology, South Korea

Yongseok Kim Korea Institute of Construction Technology, South Korea

Jung Yup Kim Korea Institute of Construction Technology, South Korea

Michael Kinsey University of Greenwich, UK

Ekaterina Kirik Institute of Computational Modeling of Siberian Branch of Russian Academy of Sciences, Russia

Uwe Kirsch Eidgenössische Technische Hochschule Zürich, Switzerland

Sergey Kitov KONE, Finland

Bryan Klein Thunderhead Engineering Consultants, Inc., USA

Wolfram Klein Siemens AG, Germany

Hubert Klüpfel TraffGo HT GmbH, Germany

Angelika Kneidl Technische Universität München, Germany

Yoshiyuki Kobayashi Nagoya Institute of Tecnology, Japan

Rainer Könnecke IST GmbH, Germany

Timo Korhonen VTT Technical Research Centre of Finland, Finland

Athan Kosmopoulos Village Roadshow Group of Companies, Greece

Konstantinos Kostas Technological Educational Institute of Athens, Greece

Gerta Köster Hochschule München, Germany

Barbara Krausz Fraunhofer Institut für Intelligente Analyse- und Informationssysteme, Germany

Tobias Kretz Planung Transport Verkehr AG, Germany

Sebastian Kühn Technische Universität Kaiserslautern, Germany

Laura Künzer Friedrich-Schiller-Universität Jena, Germany

Gregor Lämmel Technische Universität Berlin, Germany

Peter Lawrence University of Greenwich, UK

Qiuping Li Wuhan University, China

S.B. Liu City University of Hong Kong, Hong Kong

Peter Luh University of Connecticut, USA

Lorenza Manenti University of Milano-Bicocca, Italy

Dinesh Manocha University of North Carolina at Chapel Hill, USA

Kerry Marsh University of Connecticut, USA

Ignacio Martínez NECO Ingeniería y Economía del Transporte, Spain

Okaya Masaru Meijo University, Japan

Thomas Matyus Austrian Institute of Technology, Austria

Hermann Mayer Siemens AG, Germany

Brian Meacham Worcester Polytechnic Institute, UK

Elise Miller-Hooks University of Maryland, USA

Michael Moos Analysis Simulation Engineering GmbH, Switzerland

Mehdi Moussaïd Max Planck Institute for Human Development, Germany

Stefan Münchow Hamburg University of Applied Sciences, Germany

Mojdeh Nasir Deakin University, Australia

Kai Nagel Technische Universität Berlin, Institut für Land- und Seeverkehr, Verkehrssystemplanung und Verkehrstelematik, Germany

Takuya Oki Tokyo Institute of Technology, Japan

Ana Olmeda INECO Ingeniería y Economía del Transporte, Spain

Toshihiro Osaragi Tokyo Institute of Technology, Japan

Christine Palmer WSP, UK

Wieger Pasman NPC – DHV, Netherlands

Thomas Pestell WSP, UK

Julien Pettré INRIA, France

Matthias Plaue Technische Universität Berlin, Germany

Carlos Pretto Universidade Federal do Rio Grande do Sul, Brazil

Verena Reuter Technische Universität Kaiserslautern, Germany

Kevin Rio Brown University, USA

Christian Rogsch RiMEA e.V., Executive Committee, Germany

Enrico Ronchi Lund University, Sweden

Marai Marlène Ruffieux Bundesamt für Verkehr, Switzerland

Daniel Sauter Urban Mobility Research, Switzerland

Michael Schreckenberg Universität Duisburg-Essen, Germany

Michael Schultz Technische Universität Dresden, Germany

Stefan Seer Austrian Institute of Technology, Austria

Michael Seitz Hochschule München, Germany

Armin Seyfried Forschungszentrum Jülich GmbH, Germany

Mubarak Shah University of Central Florida, USA

Nirajan Shiwakoti Monash University, Australia

Swen Stemmer Hochschule München, Germany

Marijn Swenne Leiden University, Netherlands

Daniel Swenson Thunderhead Engineering, USA

Tomoichi Takahashi Meijo University, Japan

Thomas Thiel-Clemen Hamburg University of Applied Sciences, Germany

Paul Townsend Crowd Dynamics International Limited, UK

Franz Treml Hochschule München, Germany

Lene Ulriksen COWI A/S, Denmark

Vaisagh Viswanathan Nanyang Technological University, Singapore

Vladimir Vukadinovic Disney Research Zurich, Switzerland

Nathalie Waldau-Drexler Ingenieurbüro WALDAU, Austria

Urs Walter City of Zürich, Switzerland

Ulrich Weidmann Eidgenössische Technische Hochschule Zürich, Switzerland

Ilan Paul Weinmann ICTS Europe, France

Marian Weltevreden NPC – DHV, Netherlands

Bruni Werberich Universidade Federal do Rio Grande do Sul, Brazil

Roland Wiederkehr Pöyry Infra AG, Switzerland

Markus Wiersch Consorcium, Germany

Andreas Winkens BPK Brandschutz Planung Klingsch GmbH, Germany

Gabriel Wurzer Technische Universität Wien, Austria

Isami Yahiro MT Security Company, Japan

Kaoru Yamada Tokyo Institute of Technology, Japan

Daichi Yanagisawa Ibaraki University, Japan

Kensuke Yasufuku Osaka Univesity, Japan

Francesco Zanlungo Advanced Telecommunications Research Institute International, Japan

Oliver Zechlin Siemens Switzerland AG, Switzerland

Jun Zhang Bergische Universität Wuppertal, Germany

Robert Zinke Friedrich-Schiller-Universität Jena, Germany

Part I
Keynotes

Automatic Detection and Tracking of Pedestrians in Videos with Various Crowd Densities

Afshin Dehghan, Haroon Idrees, Amir Roshan Zamir, and Mubarak Shah

Abstract Manual analysis of pedestrians and crowds is often impractical for massive datasets of surveillance videos. Automatic tracking of humans is one of the essential abilities for computerized analysis of such videos. In this keynote paper, we present two state of the art methods for automatic pedestrian tracking in videos with low and high crowd density. For videos with low density, first we detect each person using a part-based human detector. Then, we employ a global data association method based on Generalized Graphs for tracking each individual in the whole video. In videos with high crowd-density, we track individuals using a scene structured force model and crowd flow modeling. Additionally, we present an alternative approach which utilizes contextual information without the need to learn the structure of the scene. Performed evaluations show the presented methods outperform the currently available algorithms on several benchmarks.

Keywords Human detection • Tracking • Data association • Crowd density • Crowd analysis • Automatic surveillance

1 Introduction

The number of surveillance cameras in urban area is increasing at a significant rate which results in massive amounts of videos to be analyzed. Observing crowds and pedestrians manually in such large amount of data is cumbersome and often impractical which makes automated methods extremely favorable for this purpose.

A. Dehghan • H. Idrees • A.R. Zamir • M. Shah (✉)
Computer Vision Lab, University of Central Florida, Orlando, USA
e-mail: adehghan@cs.ucf.edu; haroon@cs.ucf.edu; aroshan@cs.ucf.edu; shah@cs.ucf.edu

U. Weidmann et al. (eds.), *Pedestrian and Evacuation Dynamics 2012*,
DOI 10.1007/978-3-319-02447-9_1,

Automatic tracking of pedestrians is one of the required abilities for computerized analysis of such videos.

The density of pedestrians significantly impacts their appearance in a video. For instance, in the videos with high density of crowds, people often occlude each other and usually few parts of the body of each individual are visible. On the other hand, the full body or a significant portion of the body of each pedestrian is visible in videos with low crowd-density. These different appearance characteristics require tracking methods which suite the density of the crowd. In this paper, we present two state of the art methods for tracking pedestrians in videos with low and high density of crowds.

For videos with low density of pedestrians (Sect. 2), first we detect individuals in each video frame using a part-based human detector which efficiently handles occlusion (Sect. 2.1). Later, we employ a global data association method based on Generalized Minimum Clique Graphs for tracking each person over the course of the whole video (Sect. 2.2).

We present two approaches to tracking for videos with high density of crowds. In the first one, the scene layout constraint which is captured by learning Dynamic Floor Field, Static Floor Field and Boundary Floor Field along with crowd flow is leveraged to track individuals in the crowd. In the second approach, no learning or crowd flow is used to track targets. Instead, the tracking is performed utilizing salient and contextual information.

2 Pedestrian Tracking in Videos with Low Crowd Density

Our framework for tracking pedestrians in videos with low density of crowds consists of two main steps: Human Detection (Sect. 2.1) and Data Association (Sect. 2.2):

2.1 Part-based Human Detection

Human detection is a fundamental problem in video surveillance. Robust human tracking is highly dependent on reliable detection in each frame. Although human detection has been well studied in computer vision, most of the existing approaches are unsuitable for detecting targets with large variance in appearance. Therefore, robust human detection remains a challenge due to the highly articulated body postures, occlusion, background clutter and viewpoint changes.

Many approaches have been proposed for human detection over the last decade. In most of them, the problem is formulated as a binary sliding window classification, i.e. an image pyramid is constructed and a fixed size window is scanned over all of its levels to localize humans using a non-maximum suppression procedure.

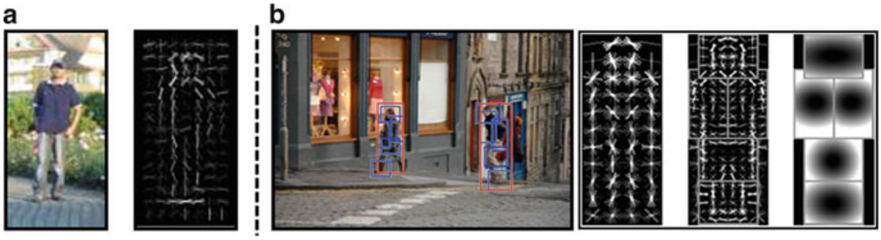

Fig. 1 (**a**) A sample positive image and its HOG descriptor. (**b**) *Left*: detections obtained using part-based human detector in [6]. *Right*: a model for root and parts and a spatial model for the location of each part relative to the root

Dalal and Triggs [5] use HOG as low a level feature which is shown to outperform other competitive features, such as wavelets, for human detection. HOG provides a robust feature set that allows the human body to be distinguished discriminatively even in cluttered background. The descriptor purposed by Dalal and Triggs computes an edge oriented histogram on a dense grid of uniformly spaced cells. Then, they use overlapping local contrast normalizations in order to improve the overall performance. A linear SVM classifier is used to learn a model for the human body using positive and negative samples. The detector is then applied to the image to localize human bodies, i.e. the detector takes an image, a position within that image and a scale as the inputs and determines if there is a person in that particular location and scale. Figure 1a shows a sample positive image and its HOG descriptor.

Using local features to learn body parts is another approach to human detection. Part-based approaches which model an object as a rigid or deformable configuration of parts are shown to be very effective for occlusion handling. Felzenszwalb et al. [6] simultaneously learn parts and an object model. Their model is an enriched version of Dalal and Triggs' which uses a star structured part-based model defined by a root filter plus a set of parts associated using a deformation model. The score associated to each star model is the summation of the scores of the root filter and parts at a given location and scale minus a deformation cost which measures the deviation of parts from their ideal location relative to the root. The scores of both parts and root are defined as the dot product of a learnt filter which belongs to that part and a set of extracted features for that specific location. The same set of features as [5], i.e. HOG, is used in [6] with the difference that principle component analysis has been applied to HOG features in order to reduce the dimensionality.

2.1.1 Human Detection with Occlusion Handling

While the deformable part-based model has recently shown excellent performance in object detection, it achieves limited success when the human is occluded. In particular, the final score in [6] is computed using the score of all the parts

Fig. 2 *Left*: human detection results using [6]. *Right*: human detection results using our approach where *red boxes* show the human detected as full bodies, *green boxes* show the humans detected as upper bodies, and *yellow boxes* show the humans detected as heads only. It is clear that [6] failed to detect occluded humans since it does not have an explicit occlusion model, while our approach detects the occluded parts and excludes them from the total detection scores, thus achieving significant improvements especially in crowded scenes

without considering that some of them can be occluded by other pedestrians or static objects in the scene. The occlusion happens especially in crowded scenes such as the example shown in Fig. 2 which signifies the drawback of this method. Considering the score of the occluded parts in the final decision score may cause the algorithm to ignore most of the partially occluded humans in the final detection results. Therefore, some methods such as [7] or [8] rely on head detection only and disregard the rest of the body.

To address this problem, we purpose in [9] to infer occlusion information from the score of the parts and utilize only the ones with high confidence in their emergence. By looking at the score of each part, we find the most reliable set of parts that maximizes the probability of detection. Let H denote the HOG feature of the image, and $p = (x,y)$ represent the location of a part. The detection score at location (x_0,y_0) defined in [6] is:

$$score\,(x_0, y_0) = b + \sum_{i=1}^{i=n} s\,(p_i)\,,$$

where b is the bias term, n is the number of parts, and $s(p_i)$ is the score of part i which is computed as:

$$s\,(p_i) = F_{p_i}.\varnothing\,(H, p_i) - d_{p_i}.\varnothing_d\left(d_x, d_y\right),$$

where F_{p_i} is the part filter, and $\varnothing\,(H,p_i)$ denotes the vector obtained by concatenating the feature vectors from H at the sub window of the part p_i (d_x,d_y) denotes the displacement of the parts with respect to the anchor position. To address the discussed issue, instead of aggregating the score of all the parts, we select the subset of parts which maximize the detection score:

$$score\,(x_0, y_0) = b + argmax_{S_m}\frac{1}{|S_m|} \times \sum_{i \in S_m} \frac{1}{1 + exp\,(A\,(p_i)\,.s\,(p_i) + B\,(p_i))}\,.$$