

Using Social Media to Characterise Crowds in City Events for Crowd Management

Vincent X. GONG



The research leading to this dissertation has received funding from the European Research Council under the European Union Horizon 2020 Framework Programme for Research and Innovation. It is established by the Scientific Council of the ERC Grant Agreement no. 669792 (Allegro).

Using Social Media to Characterise Crowds in City Events for Crowd Management

Dissertation

for the purpose of obtaining the degree of doctor
at Delft University of Technology
by the authority of the Rector Magnificus
Prof.dr.ir. T.H.J.J. van den Hagen
chair of the Board for Doctorates
to be defended publicly on
Friday 18th, September 2020 at 12:30 o'clock

by

Vincent X. GONG
Master of Science in Computer Science
Delft University of Technology
born in Jiajiang, Sichuan

This dissertation has been approved by the promotor.

Composition of the doctoral committee:

Rector Magnificus

Prof. dr. ir. S. P. Hoogendoorn

Dr. ir. W. Daamen

Prof. dr. ir. A. Bozzon

Chairperson

Delft University of Technology, promotor

Technische Universiteit Delft, promotor

Technische Universiteit Delft, copromotor

Independent members:

Prof. dr. ir. G. J. P. M. Houben

Prof. dr. E. Simperl

Dr. M. Gonzalez

Prof. dr. ir. M. Van Steen

Delft University of Technology

King's College London, United Kingdom

University of California, Berkeley, United States

University of Twente

TRAIL Thesis Series no. T2020/xx, the Netherlands Research School TRAIL

TRAIL

P.O. BOX 5017

2600 GA Delft

The Netherlands

E-mail: info@rsTRAIL.nl

ISBN: your-isbn-number

Copyright © 2020 by Vincent X. GONG

All rights reserved. No part of the material protected by this copyright notice may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, recording or by any information storage and retrieval system, without written permission of the author.

Printed in the Netherlands

I have something to say.

X. Gong

Acknowledgement

Acknowledgement

Contents

Preface	vii
1 Introduction	1
2 Crowd Characterization for Crowd Management using Social Media Data in City Events	3
2.1 Introduction	4
3 Conclusions, implications and recommendations	5
Bibliography	6
Summary	9
Samenvatting (Summary in Dutch)	11
About the author	13
TRAIL Thesis Series publications	15

Chapter 1

Introduction

City-scale events are getting more popular and attract a large number of people participating in various activities. For instance, on King's Day, a national holiday in the Netherlands, a huge amount of people pour into the city and gather in the urban area, participating in various activities such as street parties, music festivals and boat parades. Event stakeholders, such as event organisers, police, municipalities, and crowd managers manage the crowd to avoid incidents. Crowd management practice consists of two phases (Martella et al., 2017), i.e. the planning phase and operational phase. In the planning phase, crowd managers require the past event data to infer guidelines, and to perform computer simulations of the crowds in the event.

Chapter 2

Crowd Characterization for Crowd Management using Social Media Data in City Events

In this chapter, we characterise city events in terms of various aspects using social media data. This answers the first research question.

20 To this end, we screen a set of factors (i.e. visitor profile, crowd size, density, mobility, location, and semantics) that characterize crowd behaviour and introduce a set of proxies (i.e. demographics, city-role, crowd temporal distribution, post position, Points of Interests, and word use) derived from social media data. Furthermore, we characterize the crowd in two city-
25 scale events, Sail 2015 and King's Day 2016, in terms of these proxies, and comparing them with information collected from events organizers and programs.

Our findings show that it is possible to characterize crowds in city-scale events using social media data, thus paving the way for new real-time and
30 planning applications on crowd monitoring and management for city-scale events.

This chapter is published as a journal article: Gong, V. X., Daamen, W., Bozzon, A., & Hoogendoorn, S. P. (2020). Crowd characterization for crowd management using social media data in city events. *Travel Behaviour and Society*, 20, 192-212.
35

2.1 Introduction

As cities compete for global importance and influence, city-scale public events are becoming an important ingredient to foster tourism and economic growth. Sports events, thematic exhibitions, and national celebrations are examples of city-scale events that take place in vast urban areas, and attract large amounts of participants within short time spans. The scale and intensity of these happenings demand technological solutions supporting stakeholders (e.g. event organizers, public and safety authorities, attendees) to monitor and manage the crowd.

Chapter 3

Conclusions, implications and recommendations

In this chapter, we present our main findings and conclusions for each re-
50 search question, followed by the overall conclusions and implications for
practice. Finally, we provide recommendations for future research.

Bibliography

- Abbott, J., M. W. Geddie (2000) Event and venue management: Minimizing liability through effective crowd management techniques, *Event Management*, 6(4), pp. 259–270.
- Li, J. (2019) *Crowds inside out: Understanding crowds from the perspective of individual crowd members' experiences*, Ph.D. thesis, Delft University of Technology.
- Martella, C., J. Li, C. Conrado, A. Vermeeren (2017) On current crowd management practices and the need for increased situation awareness, prediction, and intervention, *Safety science*, 91, pp. 381–393.
- Still, G. K. (2000) *Crowd dynamics*, Ph.D. thesis, University of Warwick.
- Tubbs, J., B. Meacham (2007) *Egress design solutions: A guide to evacuation and crowd management planning*, John Wiley & Sons.
- Zomer, L. B., W. Daamen, S. Meijer, S. P. Hoogendoorn (2015) Managing crowds: The possibilities and limitations of crowd information during urban mass events, in: *Planning Support Systems and Smart Cities*, Springer, pp. 77–97.

Summary

70 Events are getting more popular and more frequent in cities around the world. In the Netherlands in 2017, the number of festivals grew to almost 1000 ¹. These events take place in large areas of the city, they have a common topic, they include sub-events (activities), and they have start and end times and lasts from one day to several days. Examples of events are the
75 national holidays, Soul Live Festival and trade exhibitions. City events can easily attract a large number of people. Event stakeholders, such as the event organizers, police, municipalities and other authorities, and crowd managers are concerned with guaranteeing the safety, comfort and general well being of the attendees. To this end, they enforce predefined crowd manage-
80 ment measures that are adaptive to the current state of the event environment and of the participating crowd. This state is measured through information about the factors influencing event planning (Li, 2019) and pedestrian behaviour (Still, 2000; Tubbs & Meacham, 2007; Abbott & Geddie, 2000; Zomer et al., 2015) for crowd management, such as crowd size, density,
85 mobility, emotion, visitor profile, and location. Conventionally, this information is derived from data provided by stewards (operating on the ground during the event) and sometimes pre-installed sensing infrastructures, such as counting systems, Bluetooth/ Wi-Fi sensors, and video cameras. While effective, these solutions suffer from several issues: they provide little in-
90 formation about sentiments, gender and age distribution, they are expensive, they cannot provide Spatio-temporal information, and they are complex to install and maintain.

¹<https://www.eventbranche.nl/nieuws/aantal-festivals-groeit-tot-bijna-1000-per-jaar-aantal-bezoeken-daalt-mini-em-16483.html>

Samenvatting

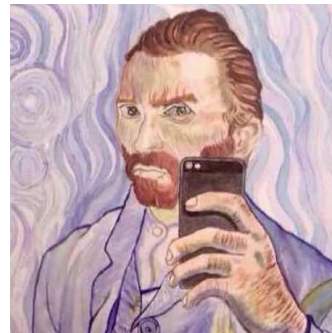
95 Social media gebruiken om menigte te karakteriseren in stadsevenementen voor crowd management

Een samenvatting in het Nederlands zal hier worden gepresenteerd.

Vincent X. Gong

About the author

¹⁰⁰ His research interests include social data analysis, crowd behaviour and crowd management in city events.



Publications

Journal papers

- 105 1. **Gong, Vincent X.**, Jie Yang, Winnie
Daamen, Alessandro Bozzon, Serge P.
Hoogendoorn, and Geert-Jan Houben.
"Using social media for attendees density
110 estimation in city-scale events." IEEE Ac-
cess 6 (2018): 36325-36340.

TRAIL Thesis Series

The following list contains the most recent dissertations in the TRAIL Thesis Series, For a complete overview of more than 250 titles see the TRAIL website: www.rsTRAIL.nl.

- 115 The TRAIL Thesis Series is a series of the Netherlands TRAIL Research School on transport, infrastructure and logistics.

Nat, C.G.J.M., van der, *A Knowledge-based Concept Exploration Model for Submarine Design*, T99/1, March 1999, TRAIL Thesis Series, Delft University Press, The Netherlands

- 120 Nuttall, A.J.G., *Design Aspects of Multiple Driven Belt Conveyors*, T2007/12, November 2007, TRAIL Thesis Series, The Netherlands

- 125 Nederveen, A.A.J., *Ruimtelijke Inpassing van Lijninfrastructuur. Een onderzoek naar de geschiktheid van inspraakreacties voor het ontwerpen van lijninfrastructuur*, T2007/13, December 2007, TRAIL Thesis Series, The Netherlands

Negenborn, R.R., *Multi-Agent Model Predictive Control with Applications to Power Networks*, T2007/14, December 2007, TRAIL Thesis Series, The Netherlands