



Towards Improved Civil Safety: Experimental Insights into Impulse Propagation through Crowds

Sina Feldmann

IAS Series
Band / Volume 70
ISBN 978-3-95806-828-5

Forschungszentrum Jülich GmbH
Institute for Advanced Simulation (IAS)
Zivile Sicherheitsforschung (IAS-7)

Towards Improved Civil Safety: Experimental Insights into Impulse Propagation through Crowds

Sina Feldmann

Schriften des Forschungszentrums Jülich
IAS Series

Band / Volume 70

ISSN 1868-8489

ISBN 978-3-95806-828-5

Table of Contents

Abstract	.....	i
Zusammenfassung	.....	iii
Acknowledgements	.....	v
List of Publications	.....	vii
Introduction	.....	1
Bibliography	.....	9
Publication A.	Forward propagation of a push through a row of people .	17
1.	Introduction	19
2.	Methods	20
2.1	Experimental setup	20
2.2	Procedure and variations	21
2.3	Data sets	22
2.3.1	Video recordings	22
2.3.2	3-dimensional inertial motion capturing	22
2.3.3	Pressure	23
2.3.4	Accuracy	24
3.	Results	25
3.1	Pressure measurement	25
3.2	Propagation distance of a push	27
3.3	Propagation speed of a push	27
4.	Discussion	30
S.	Supplementary Information	36
S1	Pressure measurement	36
S2	Moderation analysis	37

Table of Contents

Publication B. Temporal segmentation of motion propagation	39
1. Introduction	41
2. Methods	43
2.1 Experiments	43
2.2 Analytical methods for the analysis of MoCap data	44
2.2.1 Distance between a point and a line in a 2D plane . .	44
2.2.2 Distance between a point and a line segment in a 2D	
plane	44
2.2.3 Distance between two line segments in a 2D plane .	45
2.2.4 Forward speed and acceleration	45
2.2.5 Projection of 3D position to a plane	46
3. Analysis	46
3.1 Qualitative description of phases of motion	46
3.2 3D data from MoCap	47
3.2.1 Contact	48
3.2.2 Start of motion	50
3.2.3 Perturbation and loss of standing balance	51
4. Results and Discussion	53
4.1 Detection of the phases	53
4.2 Occurrence and duration of phases	56
4.3 Applicability	59
4.4 Limitations	60
5. Conclusion and Outlook	60
S. Supplementary Information	67
S1 Analysed points of MoCap data	67
S2 Identification of the threshold values	67
S2.1 Closest distance between participants	67
S2.2 Acceleration and velocity	68
S2.3 Perturbation and loss of standing balance	69
S3 Analysis of the duration of phases relative to the intensity of	
external impulses	70
Publication C. Propagation of controlled frontward impulses	75
1. Introduction	76
2. Methods	77
2.1 Experiments	78
2.2 Data sets	79
2.3 Analysis	79
3. Results	84
3.1 Comparison to five-row experiments	84

3.1.1	Preparation	84
3.1.2	Propagation speed	84
3.1.3	Propagation distance	86
3.2	Comparison of the two detection methods	87
3.3	Extension to side	87
4.	Discussion	88
4.1	Limitations	88
4.2	Conclusion	89
S.	Supplementary Information	93
S1	Experimental Data	93
S2	Moderation analysis	93

IAS Series
Band / Volume 70
ISBN 978-3-95806-828-5

Mitglied der Helmholtz-Gemeinschaft

