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Experimental Study of Step Behavior in Pedestrian Movement

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Research areas including traffic flow, pedestrian dynamics, evacuation

Outline

- Background
- Experiment
- Results
- Summary

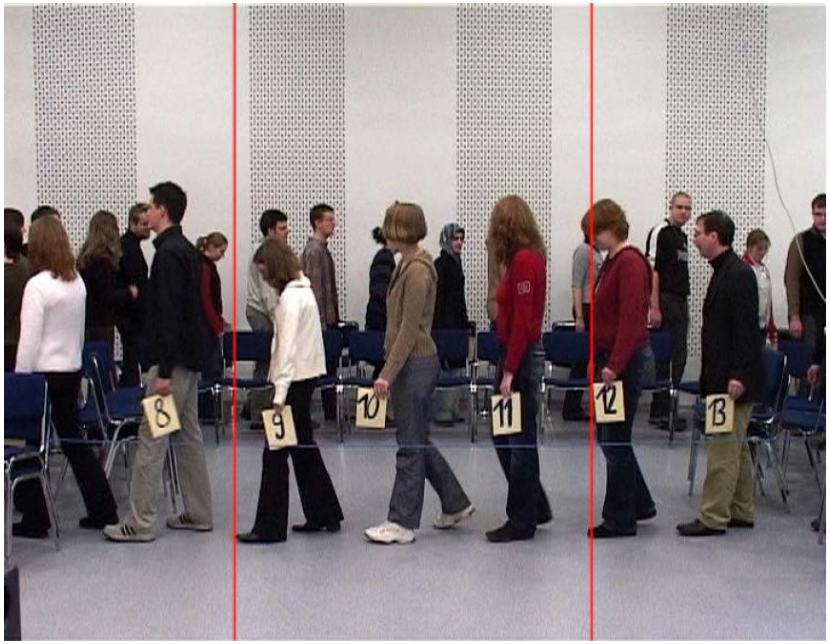
Background

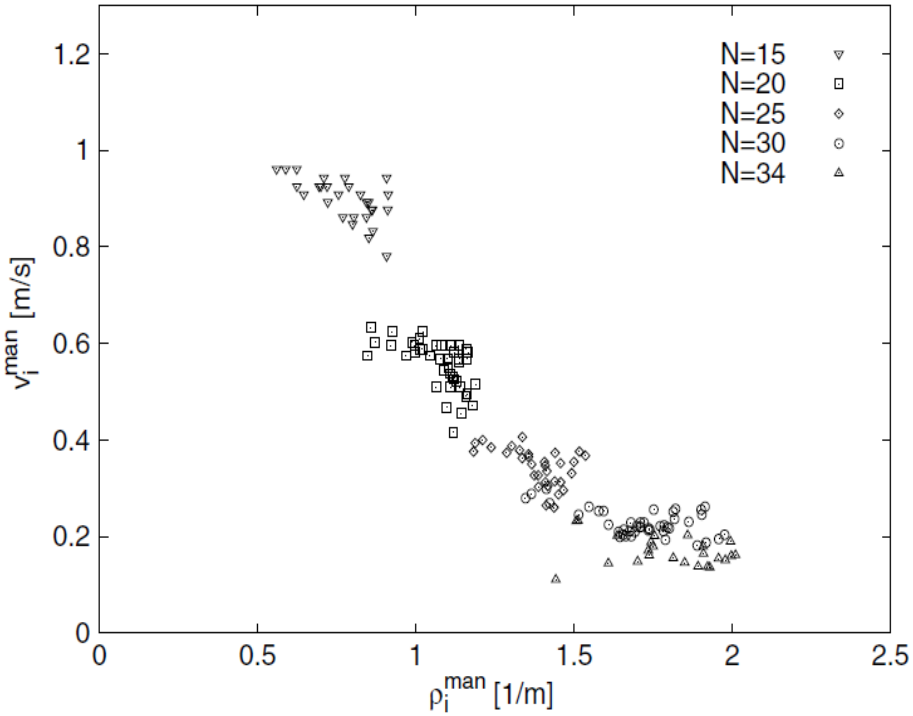
- Large crowds or high density crowds disaster

From: http://baike.baidu.com/

Stampede accident of Shanghai the Bund,2015,China

Background

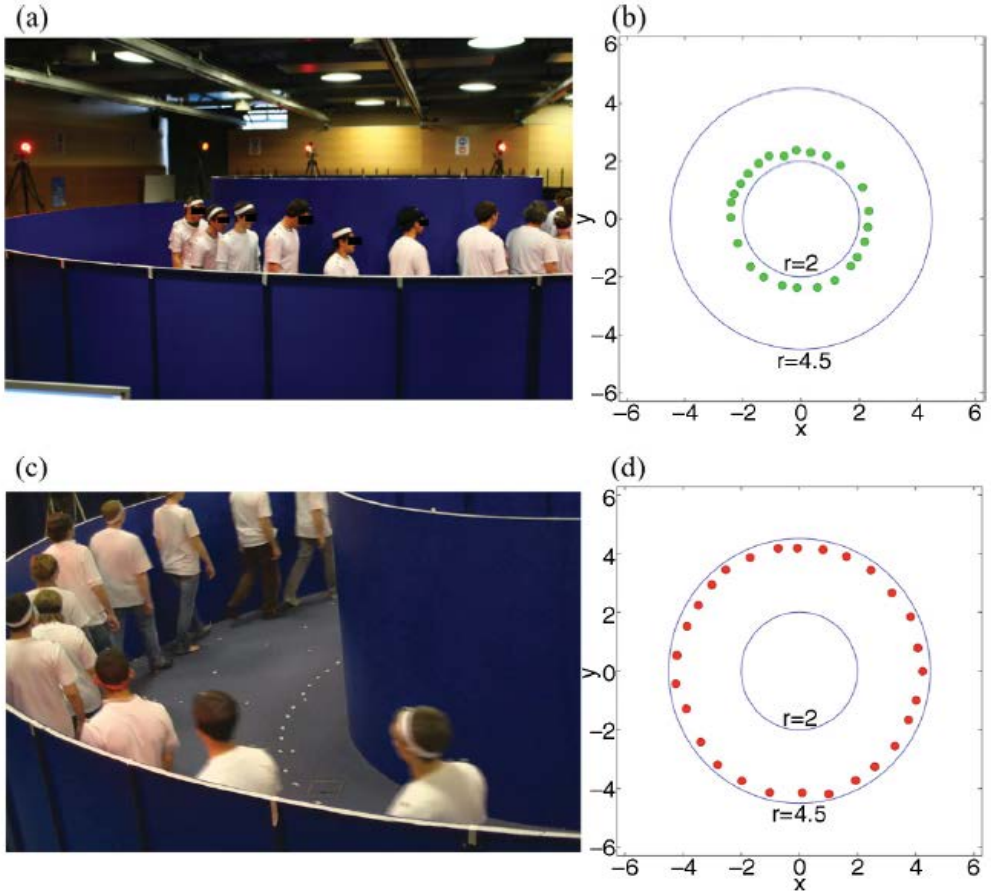




Seyfried 《The fundamental diagram of pedestrian movement revisited》 Journal of Statistical Mechanics: Theory and Experiment, Volume 2005, October 2005

Seyfried et al — The fundamental diagram
— Lockstep behavior

Background

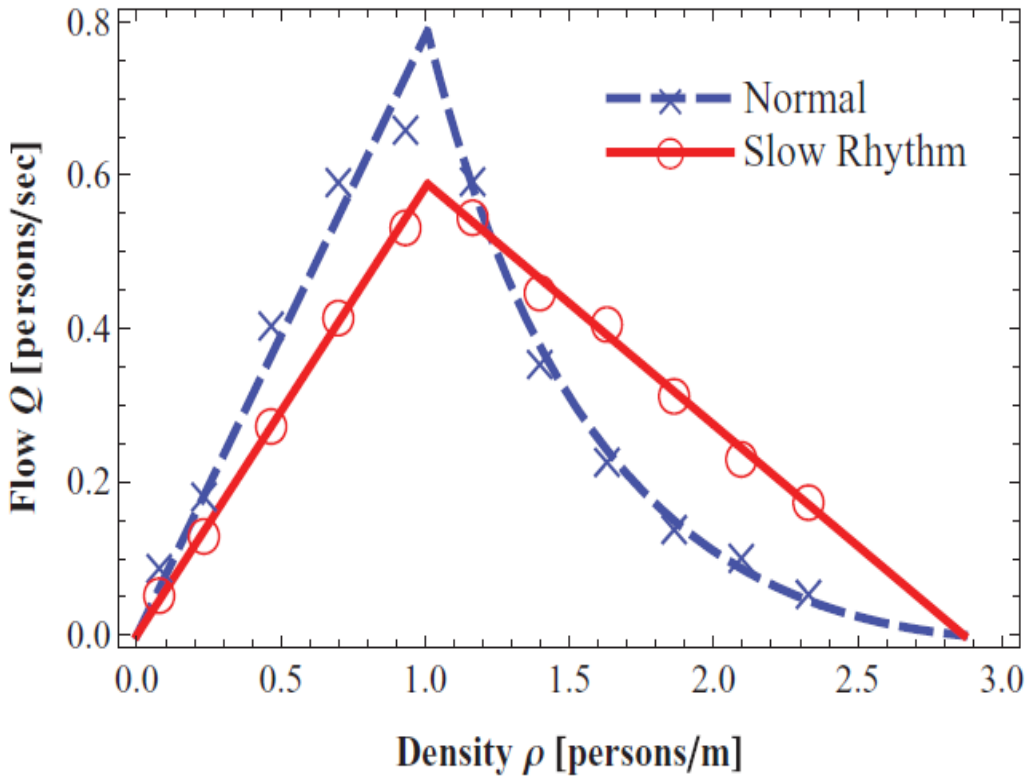


Asja Jelic et al

—Pedestrians walking in lockstep at high densities

Asja Jelic《Properties of pedestrians walking in line. II. Stepping behavior》Physical Review E, 2012, 86(4): 046111.

Background



Daichi Yanagisawa 《Improvement of pedestrian flow by slow rhythm》 Physical Review E, 2012,85, 016111

Daichi Yanagisawa et al

$$V(\rho)=S(\rho)P(\rho) \qquad \left(h=\frac{1-b\rho}{\rho}\right)$$

$$S(\rho)=\begin{cases} s & (0\le\rho\le\rho_c) \\ kh(\rho) & (\rho_c<\rho\le\rho_j) \end{cases}$$

$$P(\rho)=\begin{cases} p & (0\le\rho\le\rho_c) \\ p-a[h_c-h(\rho)] & (\rho_c<\rho\le\rho_j) \end{cases}$$

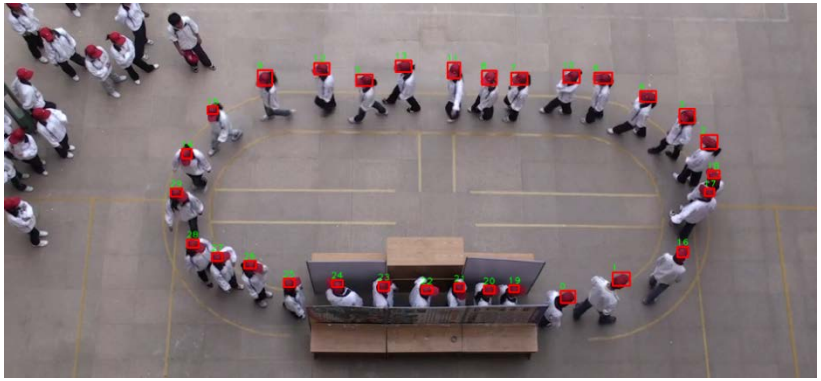
Density	*ρ (maximum ρ_j)*
Velocity	*V (ρ)*
Step size	*S (ρ)*
Pace of walking	*P (ρ)*
Headway (Distance)	*h*
Thickness of pedestrian	*b=0.35m*
Free step size	*s=0.5m*
Parameter	*k, a*

Issues need to be revealed

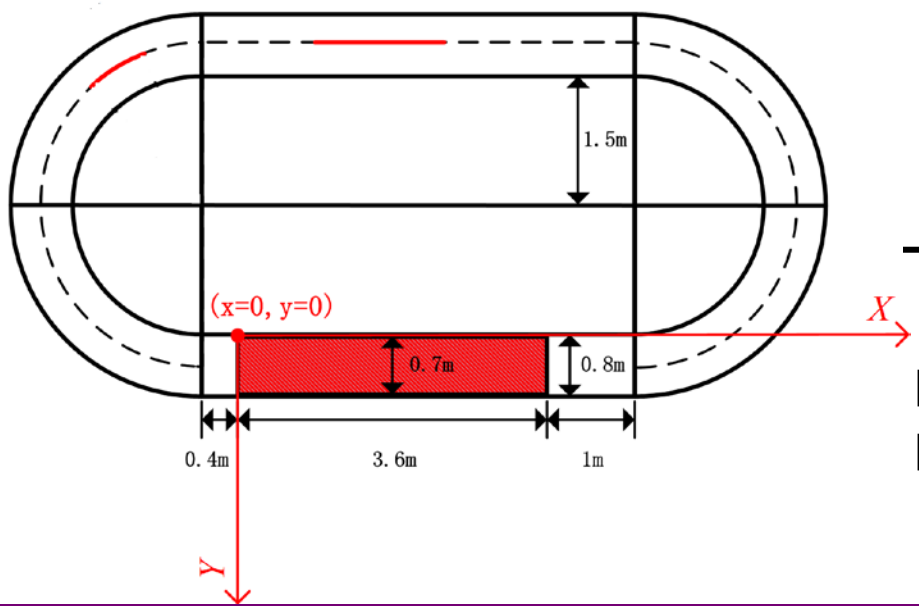
— Microcosmic Influence

— Synchronization & Antisynchronization

Experiment



Item	Detail
Time	October, 2009
Place	Baoji, China
Organizer	Weiguo Song et al
Participant	College school students
Number	5、10、15、20、25、30、40、50、60



Length: 21.94m

Density: 0.23~2.73 person/m

Experiment

Data processing

1. Position extraction

   Extracting point from each frame

2. Pedestrian trajectory

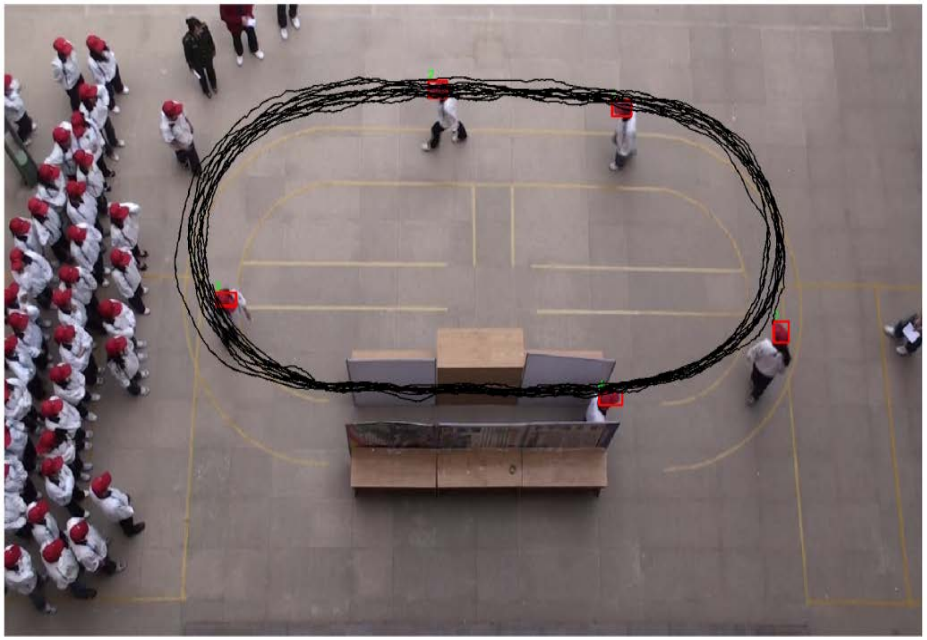
   Tracking using Matlab

3. Trajectory rectification

   Direct **L**inear **T**ransformation

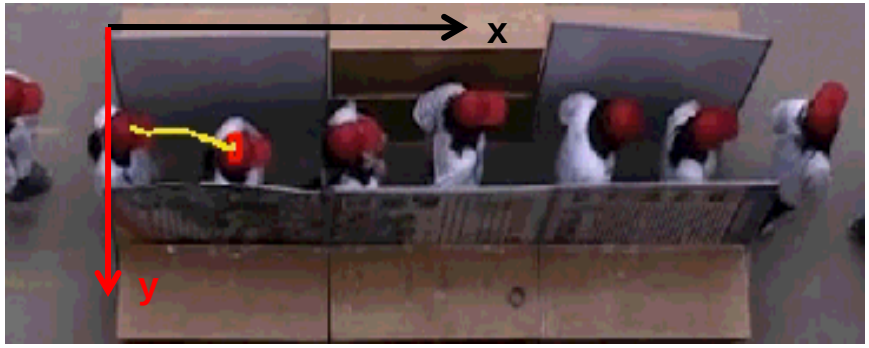
4. Movement characteristics

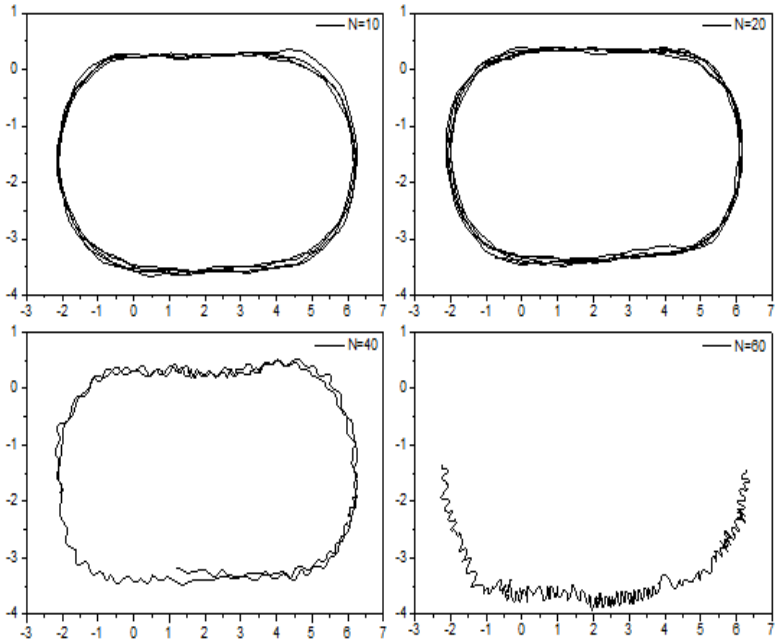
   Statistical analysis

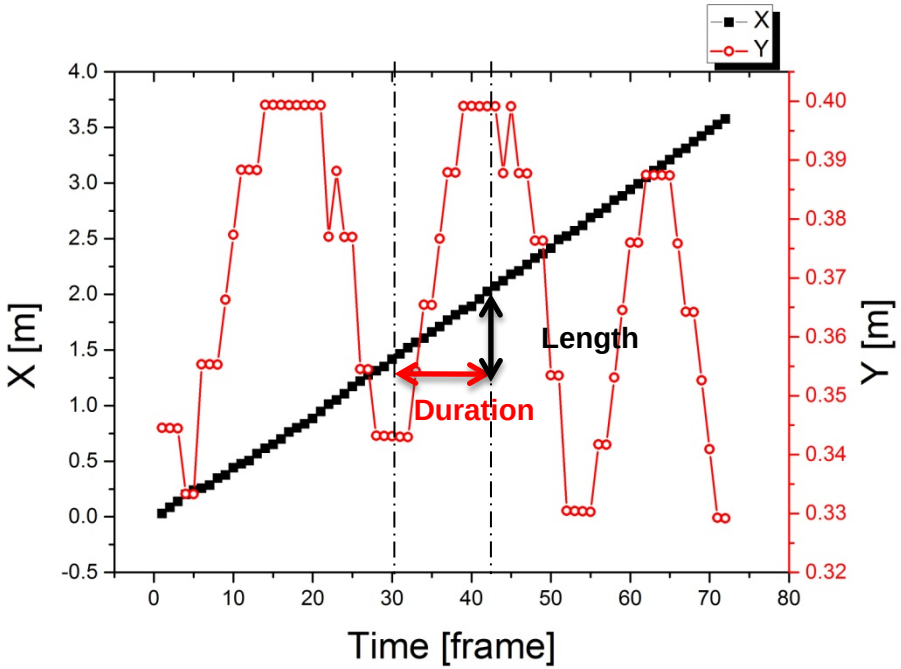


Experiment

Statistical Method

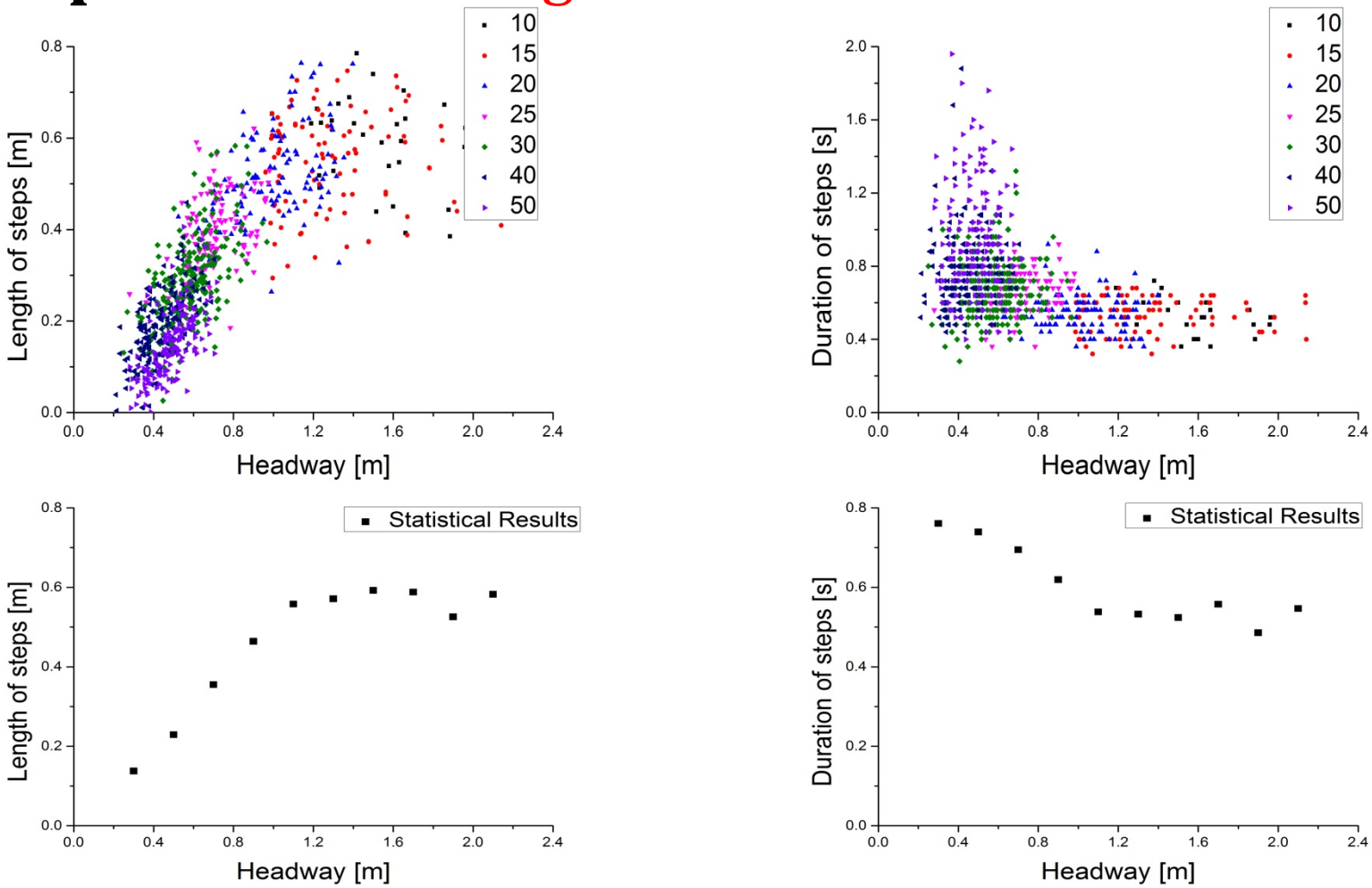






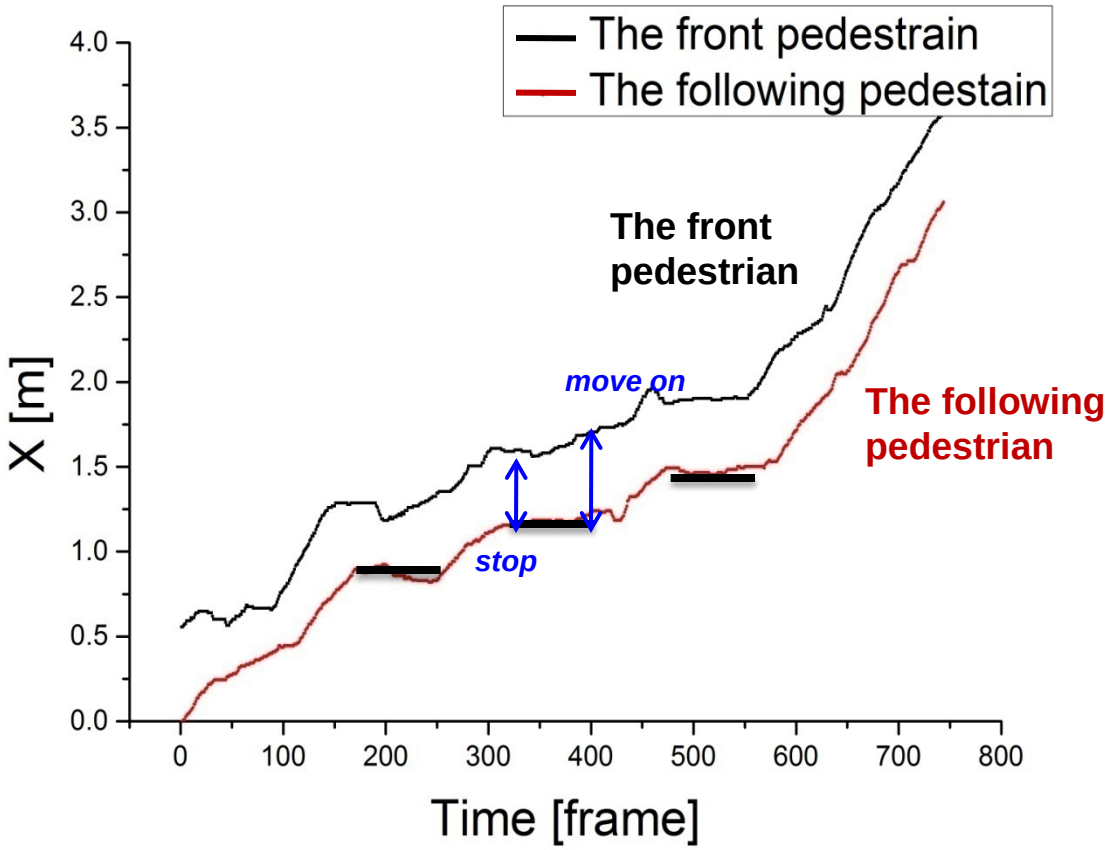
Results

- **Step Behavior:** Length & Duration



Results

- **Step Behavior:** Stop & Go

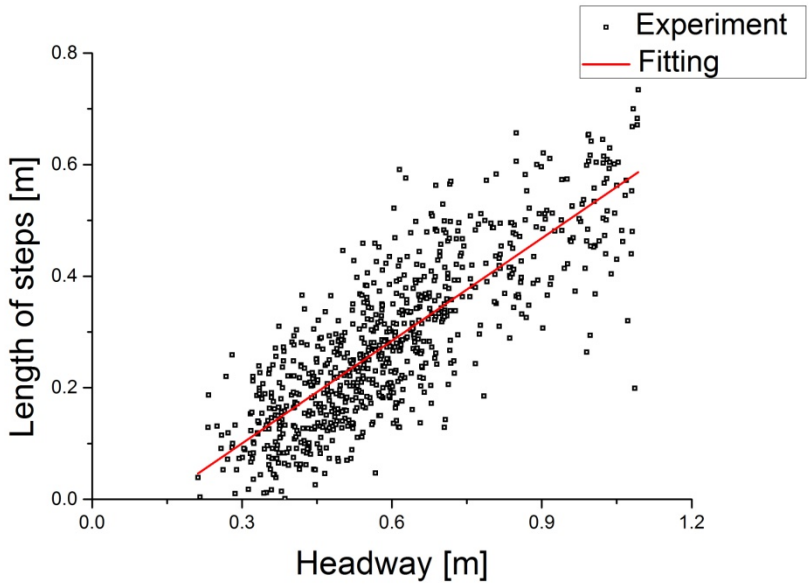


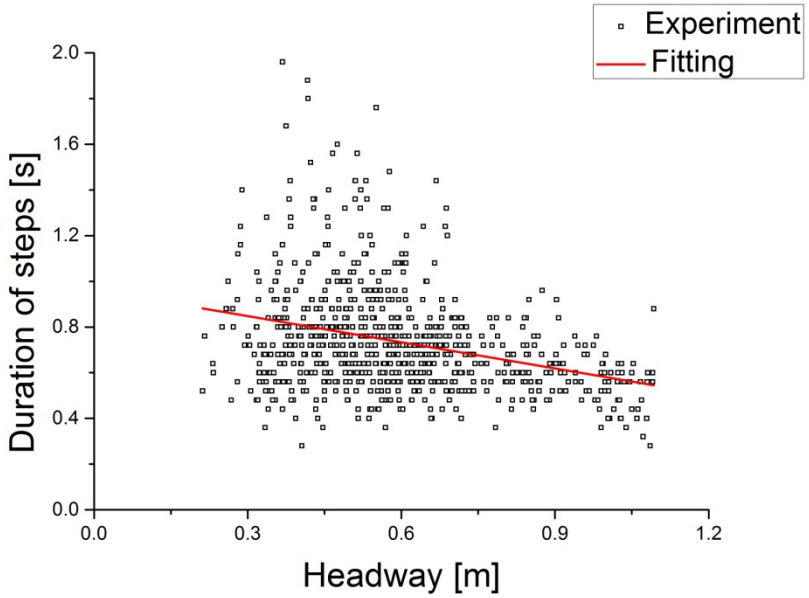
Headway<0.344m
Move->Stop

Headway>0.487m
Stop->Move on

Results

- **Step Behavior:** Fitting





$$S(h)=\begin{cases}0 \quad (stop) & h<0.344\\ 0.61h-0.08 & 0.344\le h<1.1\\ 0.59 & 1.1<h\end{cases}$$

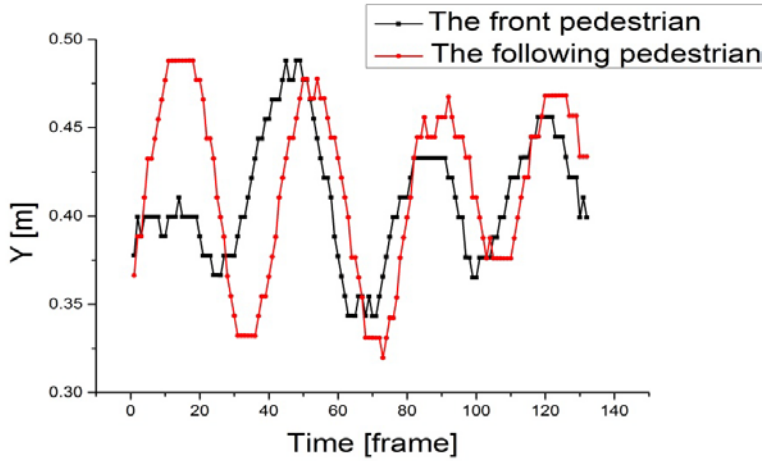
$$T(h)=\begin{cases}0.96 \quad (stop) & h<0.344\\ -0.38h+0.96 & 0.344\le h<1.1\\ 0.54 & 1.1<h\end{cases}$$

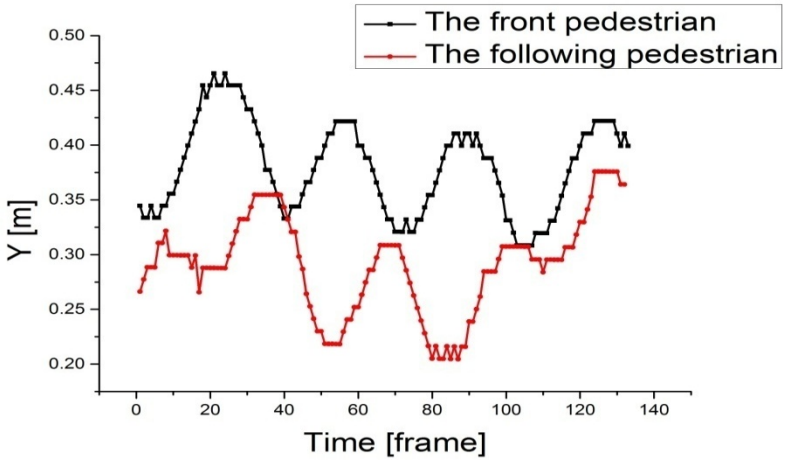
Headway h
Step Length $S(h)$
Step Duration $T(h)$

Results

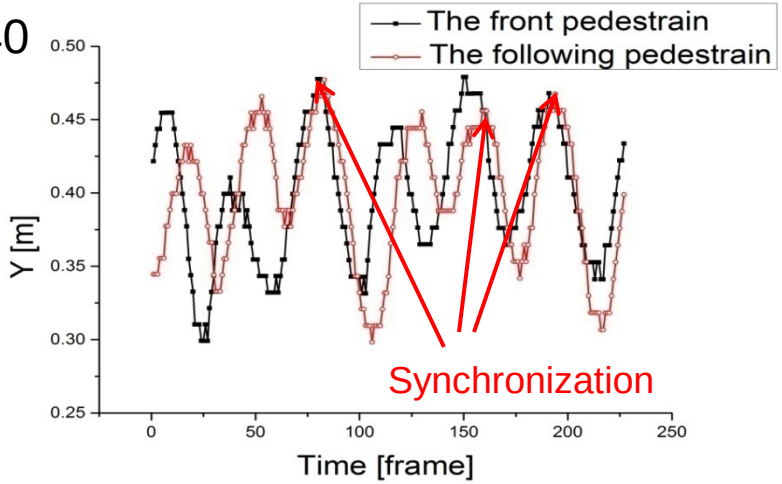
- **Synchronization & Antisynchronization**

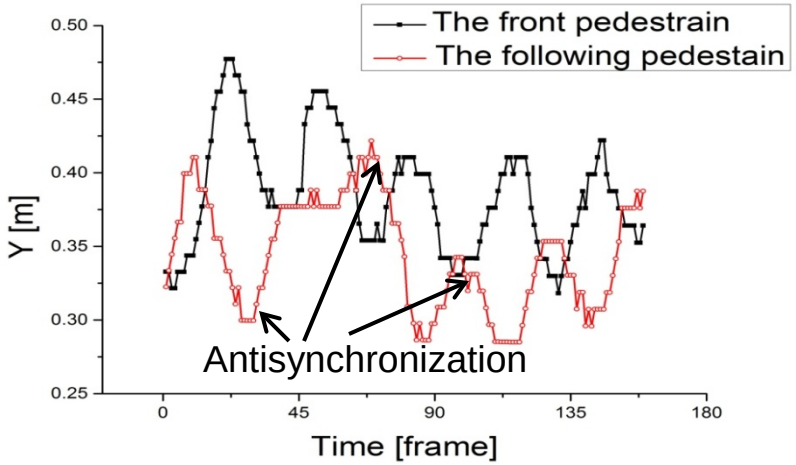
N=25





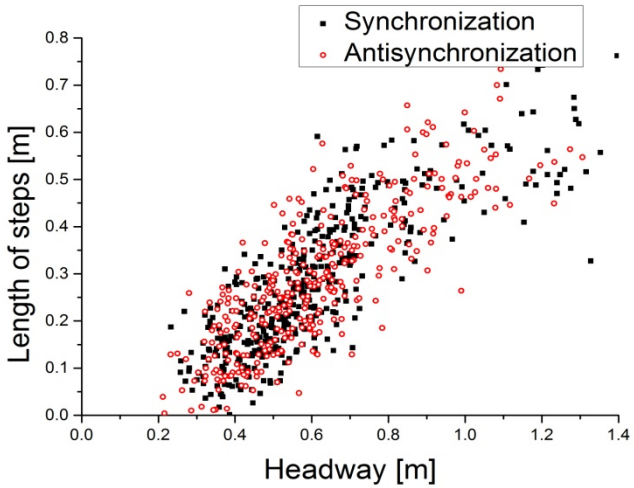
N=40

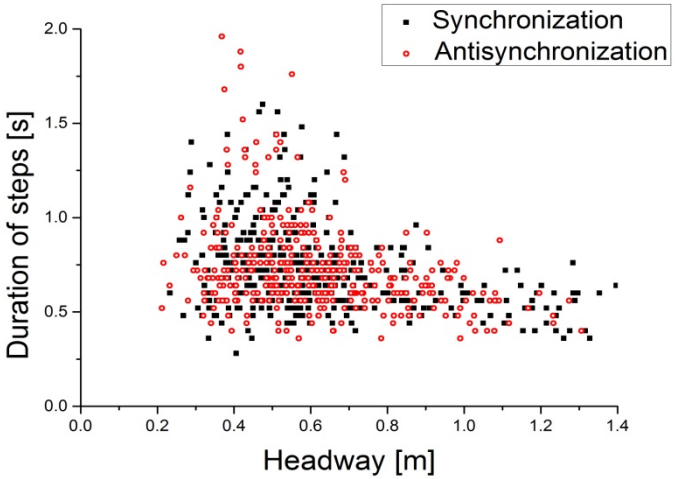


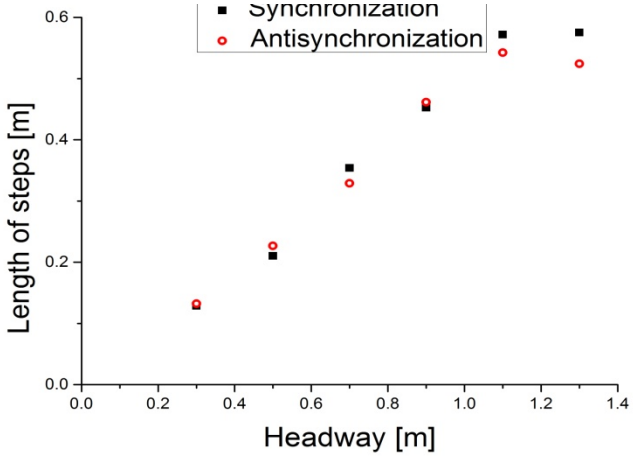


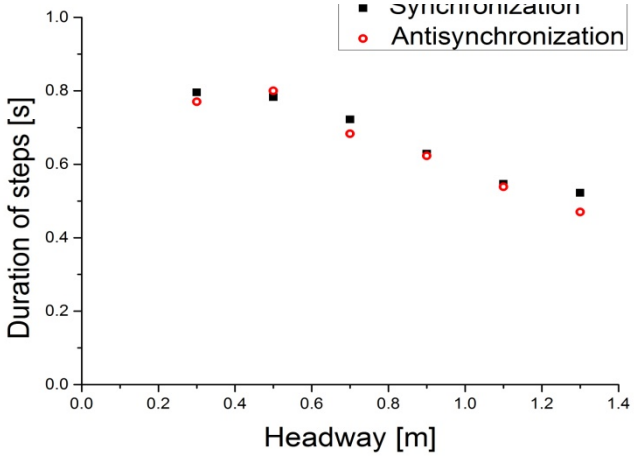
Results

- **Synchronization & Antisynchronization**



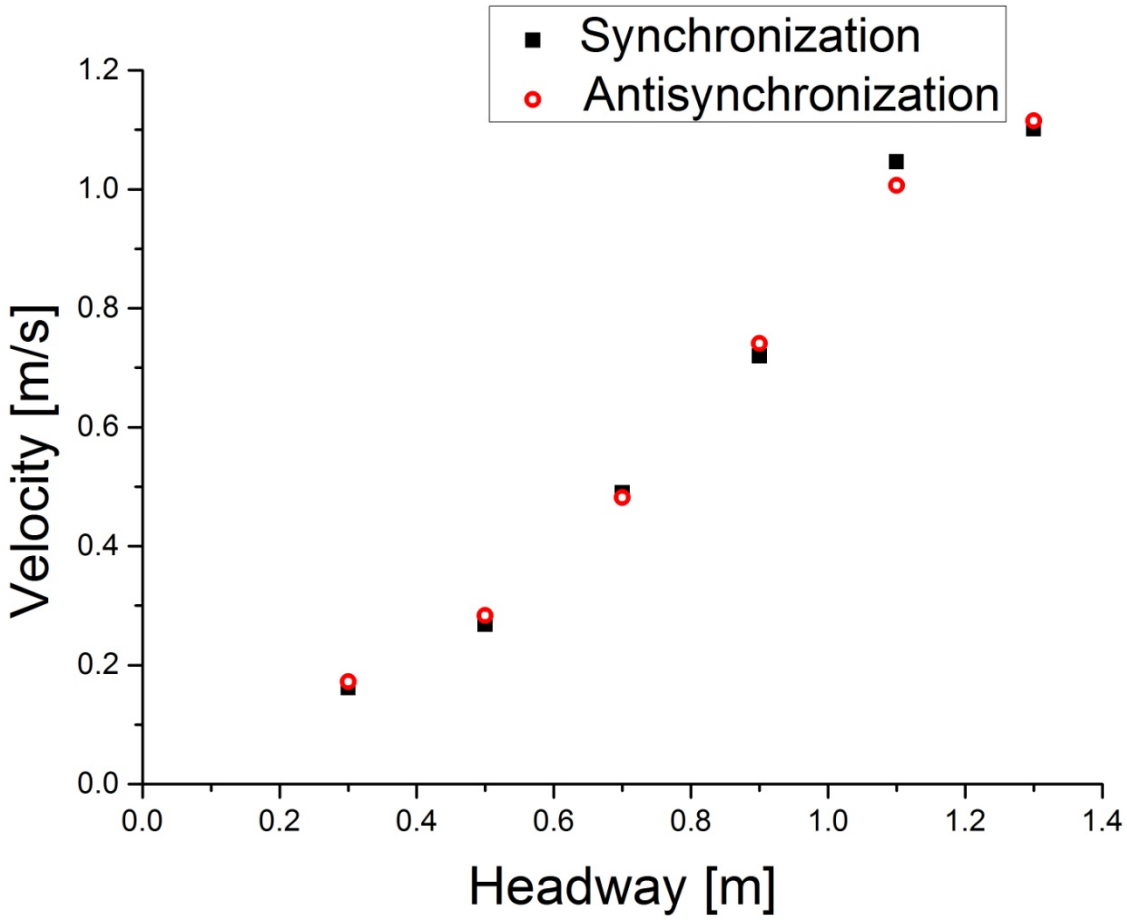






Results

- **Synchronization & Antisynchronization**



$$V(h) = \frac{S(h)}{T(h)}$$

Summary

A Single-file experiment was conducted

The relation between headway and movement characteristics is found

- Headway-Step length
- Headway-Step duration
- Headway-Stop & go

The characteristics of synchronization & antisynchronization movement are compared

- Headway-Step length
- Headway-Step duration

TGF15

Welcome to PED 2016
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