16th Urban Mobility India Conference & Expo 2023

Urban Mobility India Research Symposium 2023

Paper ID: 17

Modelling the natural “pause-and-go” walking behaviour of pedestrians in bidirectional flow

Authors: Karthika PS, Ashish Verma

Presented by:

Karthika P S
PhD Student
Department of Civil Engineering
IISc Bangalore

IISc Sustainable Transportation Lab (IST Lab)

भारतीय विज्ञान संस्थान

Contents

Modeling Walking behaviour

- Very few studies which have considered the natural walk dynamics of stopping motion in a crowd explicitly
- Proposes a bi-level pedestrian modelling framework which can account for the “pause-and-go” behaviour of people
- Focus:
  - modelling the intermittent walking pattern
  - testing alternate model specifications
  - developing model for the choice of stopping and direction choice considering the panel effect of data

Pedestrian choices

- Destination choice
- Activity choice

Strategic

- Order of activity
- Route choice

Tactical

- Walking speed
- Direction

Operational

Of interest to pilgrims

Safe and comfortable journey

Display of information on activities, timings, and their locations

Entry and exit points

Access to basic facilities

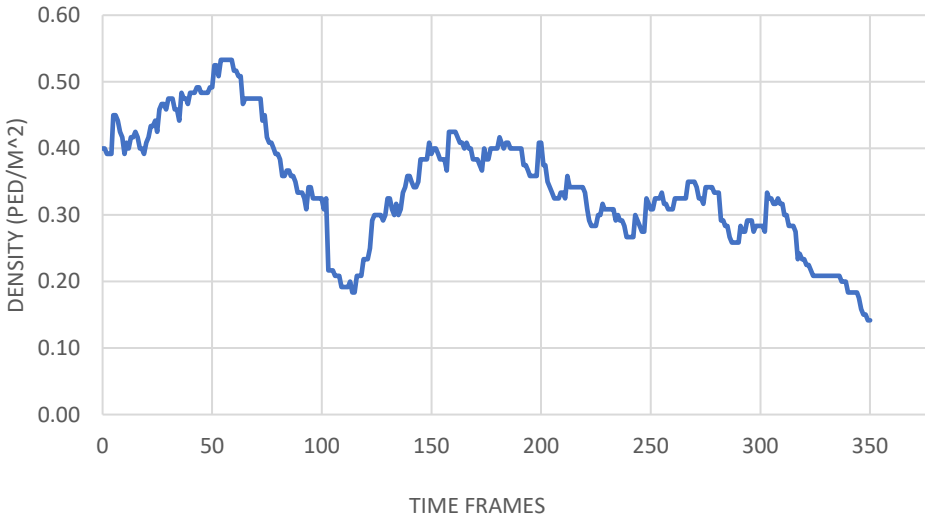
Levels of pedestrian choices
(Hoogendoorn, S. P., & Bovy, P. H. L.,2004)

Research gaps

- Inconsistency in decision making mechanism - pedestrian walking behaviour
- Ignoring non-navigational personally motivated behaviour (Leggett, 2004; Shao & Terzopoulos, 2007)
- Treating pedestrian interactions as binary
- Incorporating the heterogeneity of walking behaviour - individual characteristics and perceptions
- Lack of studies using real field data for pedestrian model calibration and validation

Data

Bada Ganesh Mandir, Ujjain

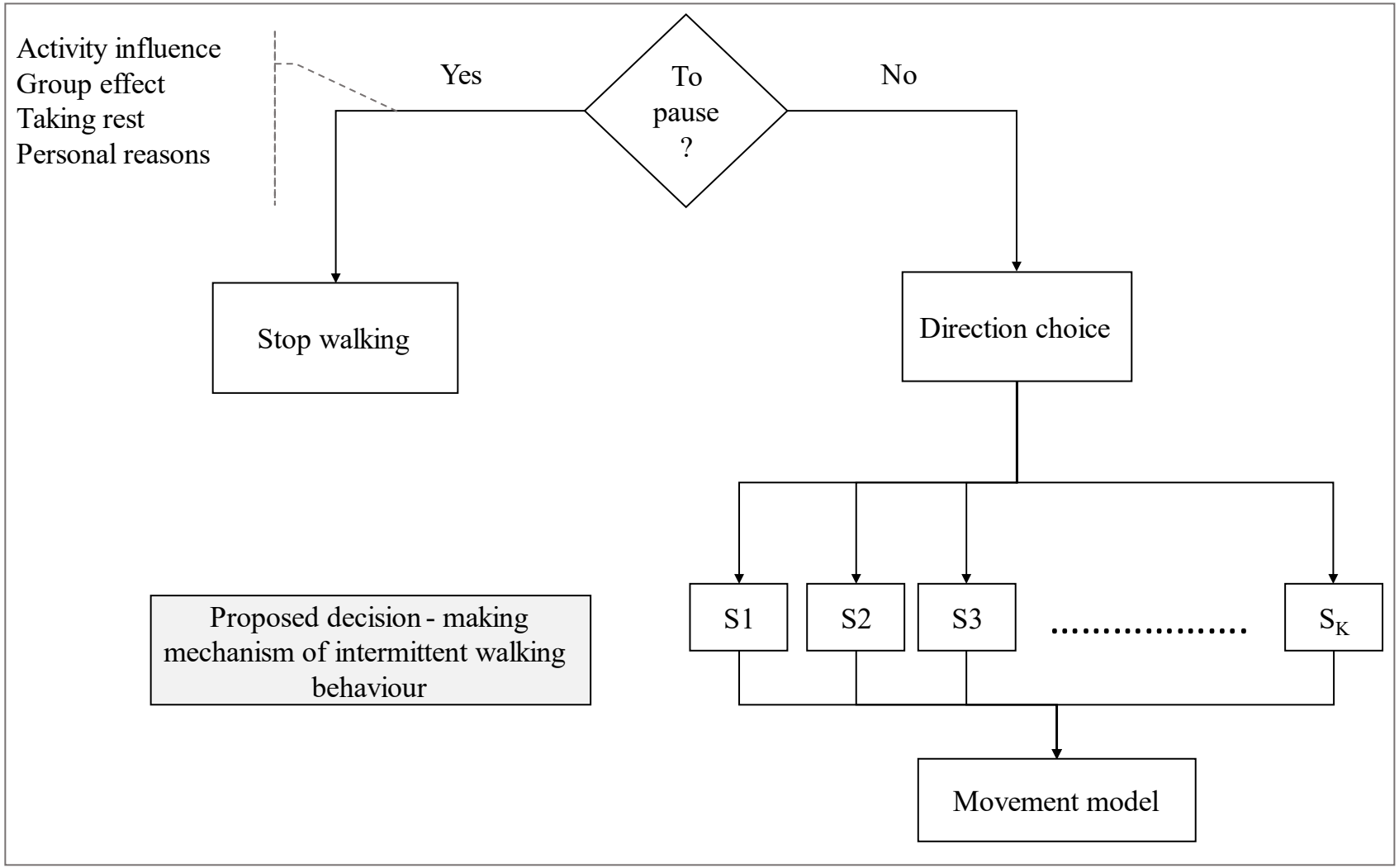


Variables and their description		
Personal attributes	Number of stationary observations	800
	Number of females (%)	35.1
	Number of males (%)	64.9
	Pedestrians with luggage (%)	19.6
	Pedestrians without luggage (%)	80.4
Number of groups (%)	Number of single pedestrians (%)	37.3
	Number of pedestrians in groups of two (%)	32.8
	Number of pedestrians in groups of three (%)	6.6
	Number of pedestrians in groups of four (%)	15.9
	Number of pedestrians in groups of five and more (%)	7.4
The average speed of pedestrians	Single pedestrians (m/s)	1.19
	Pedestrians in speeds of groups of two (m/s)	0.97
	Pedestrians in speeds of groups of three (m/s)	0.94
	Pedestrians in speeds of groups of four (m/s)	1.07
	Pedestrians in speeds of groups of five and more (m/s)	1.10
Pedestrian interactions	The average deviation from a straight direction (degrees)	2.97
	The average relative velocity between two pedestrians in the influence zone (m/s)	1.02
Surrounding pedestrian environment	The average number of people surrounding a pedestrian in IR0 (m)	5
	Average distance between two pedestrians in IR0 (m)	0.95
	Average distance between two pedestrians in IR1(m)	2.61
Total	Number of pedestrians tracked	266
	Total number of observations	6807

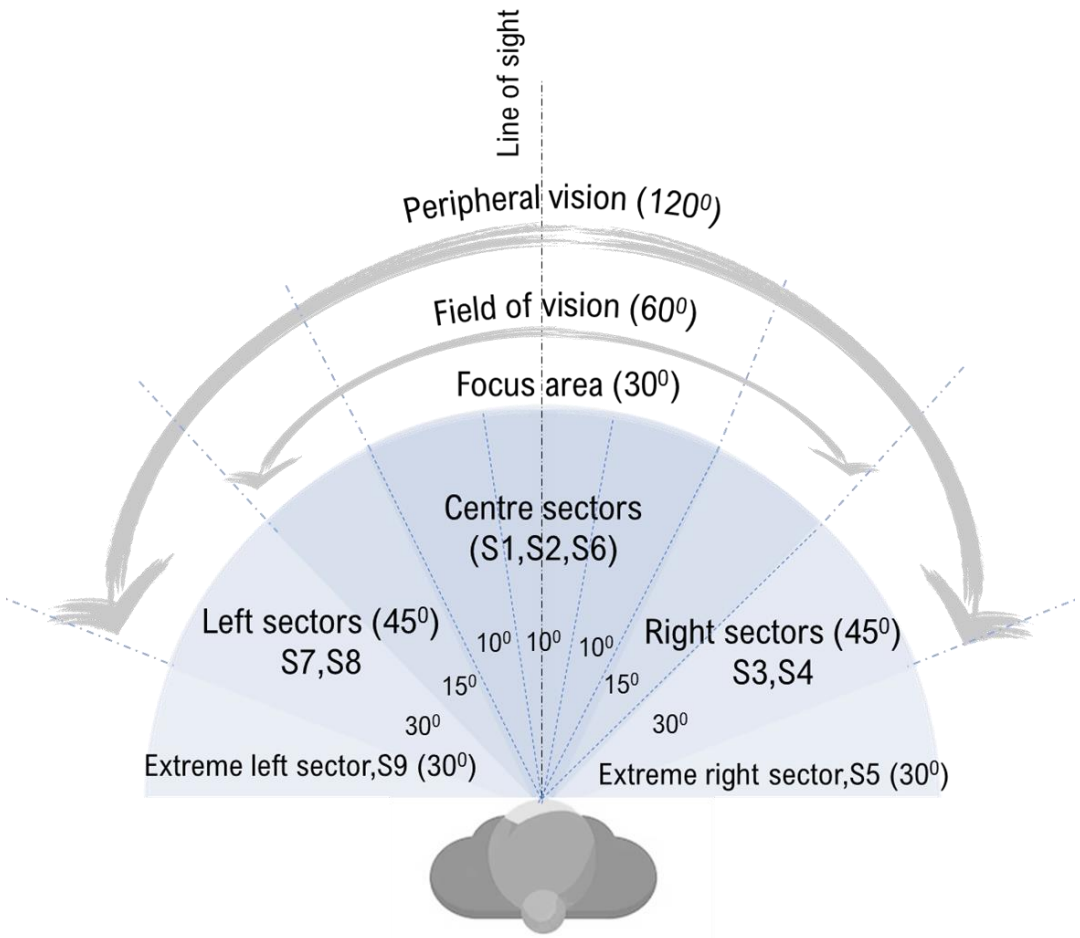
Proposed modelling framework

- Inspired by the works of Antonini et al., (2006) and Robin et al., (2009)

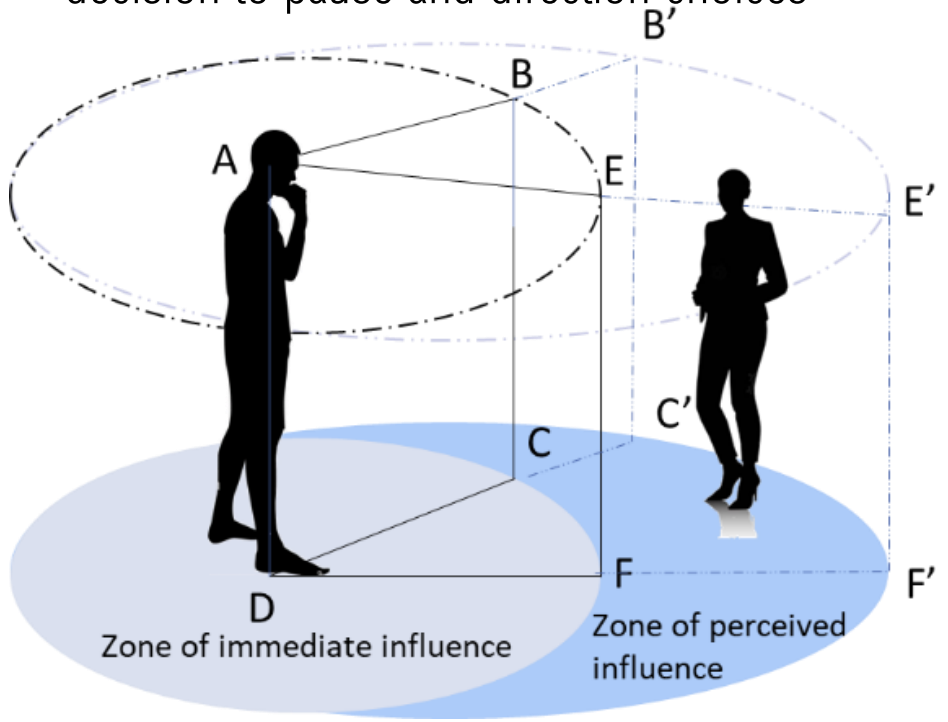
- Decision-making behaviour:
  - directional component
  - movement component



Modelling direction choice



- Partition of space into K sectors, with wider sectors angles along the sides and smaller sectors towards the centre
- Hypothesis tested:
  - People generally might not prefer to deviate significantly from their direction of motion
  - Group membership plays a significant role in the decision to pause and direction choices



Modeling ‘pause-and-go’

- Pause/Go modelling

$$P_{nt}^{pause} = \frac{1}{1 + e^{-V_{pause,nt}}}$$

$$P_{nt}^{go} = 1 - P_{nt}^{pause}$$

- Modelling the choice of direction

  Conditional probability that pedestrian *n* chooses sector k at time *t*, $p_{nt}^{k} = \frac{e^{-V_{k,nt}}}{\sum_{j=1}^{K} e^{-V_{j,nt}}}$

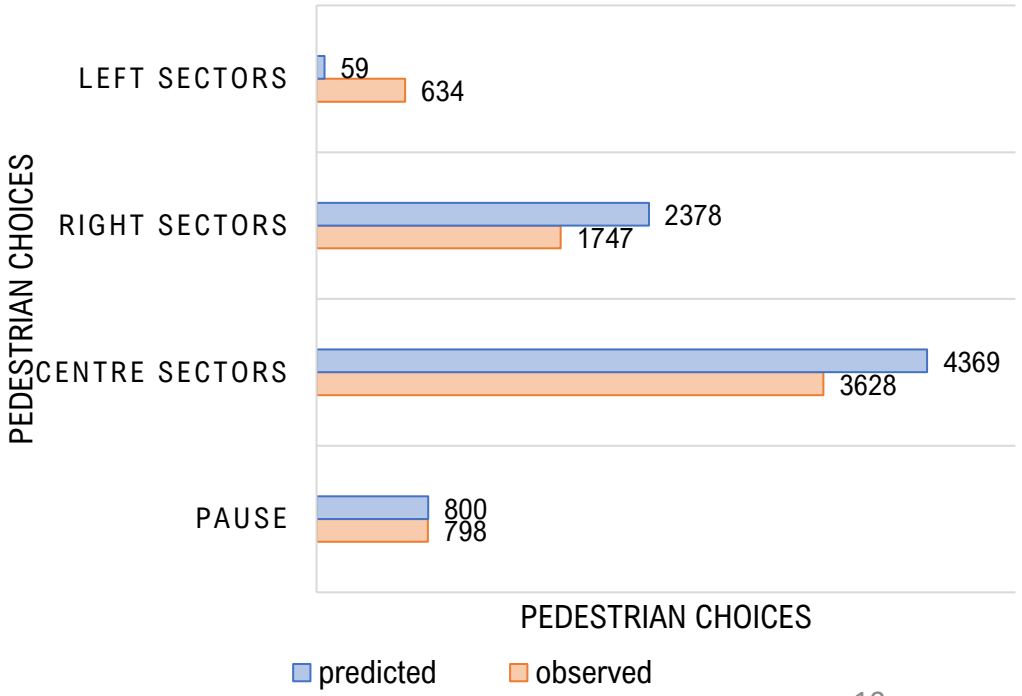
  Unconditional probability that pedestrian n chooses a sector k, $P_{nt}^{k} = P_{nt}^{go} p_{nt}^{k}$

- Likelihood expression, $L(\alpha, \beta) = \prod_{n}^{N} \prod_{t=1}^{T} \prod_{j=1}^{K} \left(P_{nt}^{pause}\right)^{y_{pause,nt}} \left(\left(P_{nt}^{k}\right)^{\delta_{nt}^{k}}\right)^{1-y_{pause,nt}}$

$$\delta_{nt}^{k} = \begin{cases} 1, if\ sector\ k\ is\ chosen\ by\ pedestrian\ n\ at\ time\ t. \\ 0, otherwise \end{cases}; y_{pause,nt} = \begin{cases} 1, if\ pedestrian\ n\ pause\ at\ time\ t \\ 0, otherwise \end{cases}$$

Variable category	Description	Estimates	t-value
	Binary logit model		
Alternative specific constant	ASC_Pause	-0.35**	-4.98
Personal Characteristics	Dummy variable for female person	-0.72**	-8.38
	Dummy variable for enforcement officer	4.30**	5.90
Direction based effect	Towards attraction point -Mahakal temple	-2.42**	-27.25
Group effect	Group Size of individual	0.04	1.21
	Multinomial logit model		
Alternative specific constants	ASC_S2	0.16**	4.25
	ASC_S3	-0.59**	-11.67
	ASC_S4	-2.52**	-22.69
	ASC_S5	0.23**	4.63
	ASC_S6	-0.64**	-13.53
	ASC_S7	-0.94**	-16.21
	ASC_S8	-2.35**	-21.41
	ASC_S9	-4.40**	-15.18
Density-based	Number of people in sector (central)	0.11*	2.07
	Number of people in sector (right)	-0.05	-1.60
	Number of people in sector (left)	-0.41**	-4.12
	Number of females in sector	-0.25**	-3.53
	Minimum distance in IR0	0.02	0.68
Collision avoidance Group effect	Group size of pedestrian in sector	0.03	0.77
	Luggage in IR0	-0.28**	-3.69
Random parameter	Variance of individual heterogeneity	4.74	0.47

Goodness of fit measures	
Initial Log-likelihood	-15673.69
Log-likelihood at convergence	-12727.90
Rho-square	
AIC	25495.80
Number of parameters	19
Number of observations	6807



Summary

- Proposes a pedestrian walking behaviour model that can account for a more naturalistic behaviour of people
- Performance of the model on the calibrated data shows that the model predicts center sector and right sector choices better than the left sectors
- Used two datasets from the same location at different times - applicability of the proposed model

Limitations & Future Scope

- Modeling the influence of group behaviour on gap choice decisions
- Further calibration of the model with a larger dataset containing information of side attractions – natural walking behaviour
- Accounting for the correlation of decisions in the upper and lower-level choices in the bi-level framework

Thank you