

Analysis of walking facility level of service performance for heterogeneous populations

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Motivations

- In practice, pedestrian **Level of Service (LOS)** thresholds do not account for heterogeneous pedestrian characteristics.
- There is no evidence to support that provided LOS thresholds in guidelines reflect **pedestrian groups' perceptions.**
- Existing studies didn't consider pedestrian **revealed behaviors** as a part of LOS perception analysis.



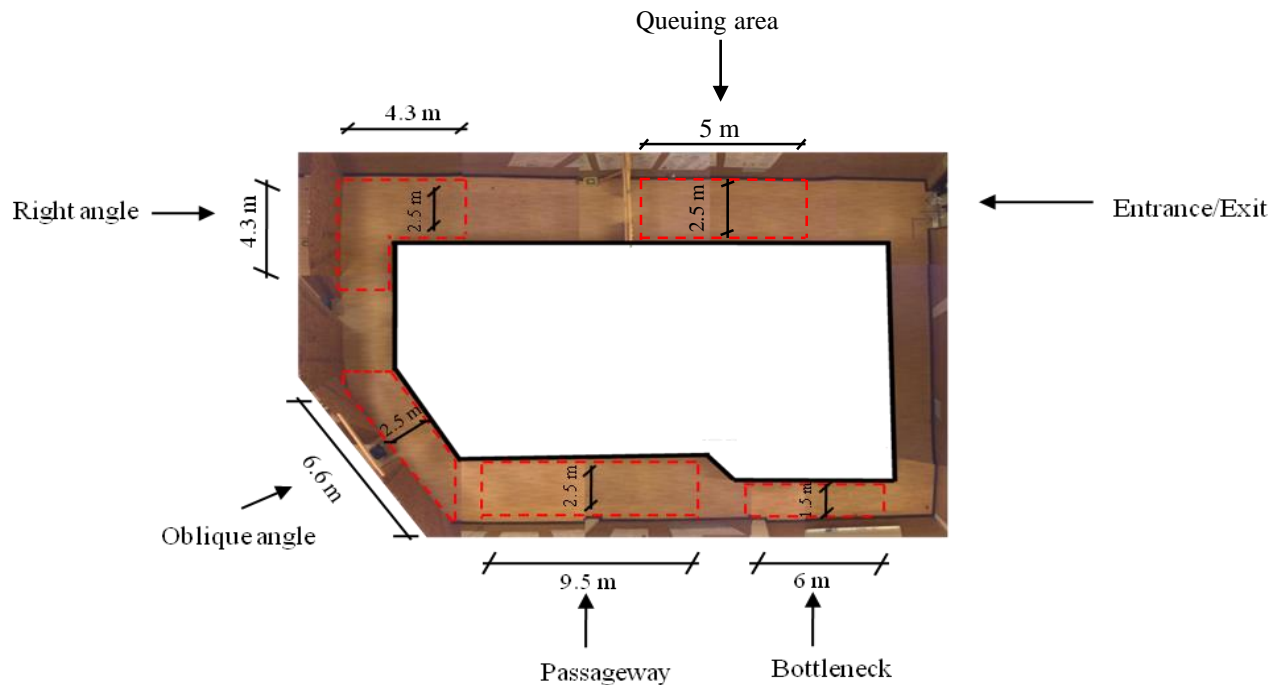
Objectives

- Developing a framework to **quantify** the effect of environmental density on walkway level of service evaluations.
- Comparing different pedestrian groups' **perceptions** on walking facility performance with existing **design guideline** recommendations.



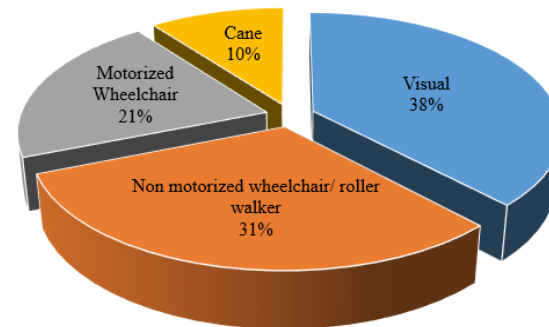
Data collection

- Walking experiment was conducted at Utah State University (USU) Motion Analysis Lab.



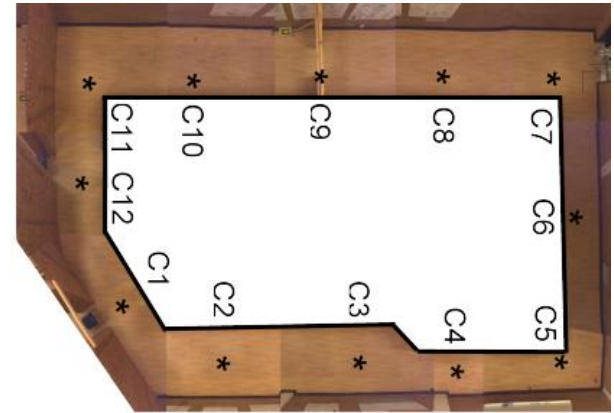
Participants

- Visual impairments
- Non-motorized devices for walking (e.g., wheelchair/roller walker)
- Individuals who use a cane
- Motorized wheelchairs.



Data collection

- 12 IDS imaging cameras
- 50 fps recording
- Tracking within 0.3 meters



Survey design

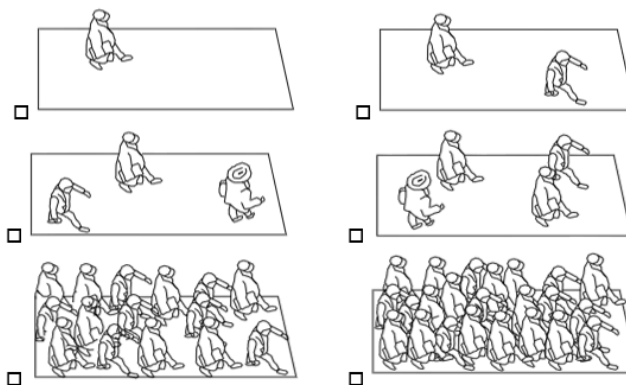
● Pre-survey

- 22 questions
- Demographic data

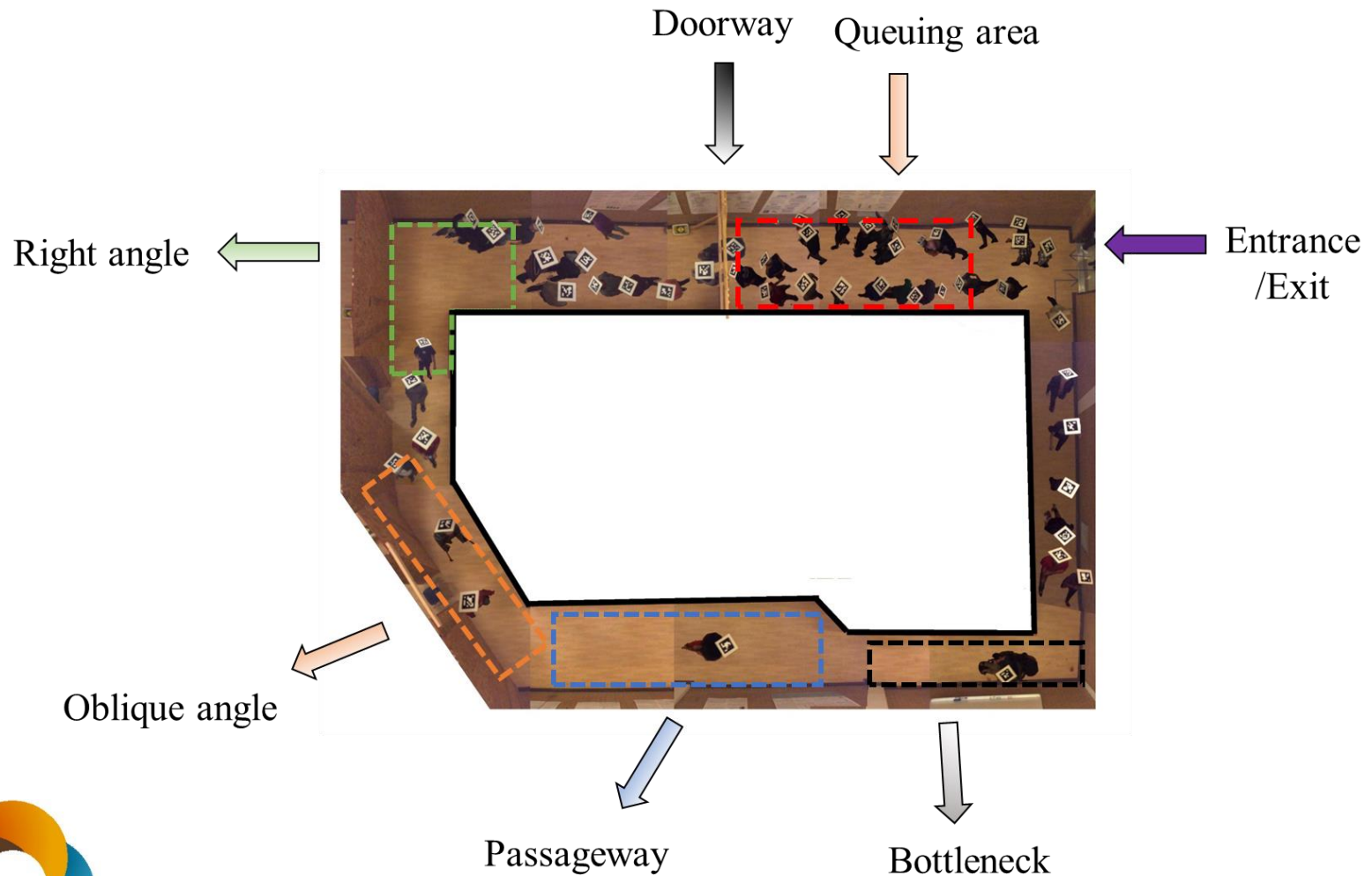
● Post-survey

- 6 ordered multiple choice
- Perception Level of Service (LOS)

1. What is your age? _____
2. What is your gender? Male Female
3. What is your height? _____
4. How would you categorize your disability/impairment?
 - Vision
 - Hearing
 - Physical/Spinal Cord Injury
 - Intellectual
 - Other _____
 - None
5. If you possess a disability/impairment, how is your pedestrian movement primarily affected? _____
6. In addition to your disability/impairment, do you have a chronic health condition or impairment? _____
7. How far do you generally walk each day?
 - less than 1/4 mile
 - 1/4 mile to 1/2 mile
 - 1/2 mile to 1 mile
 - more than 1 mile



Data collection



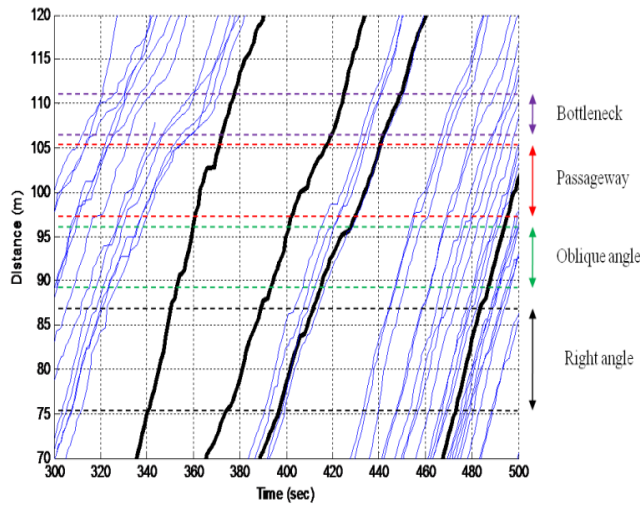
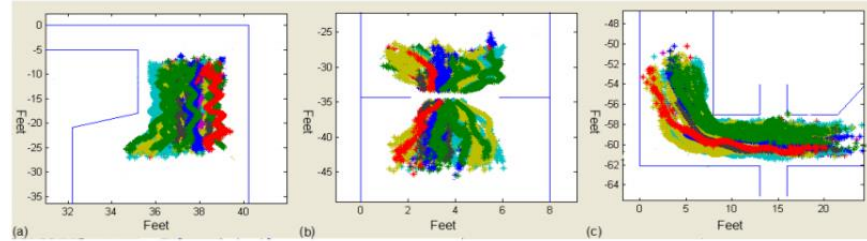
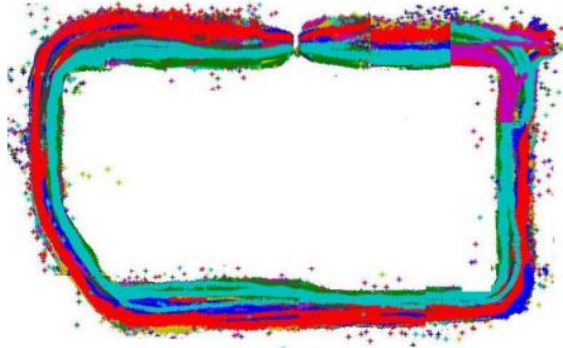
Data extraction

The screenshot shows the SingleGui software interface with several callout boxes pointing to specific features:

- Toolbar menu**: Points to the top toolbar containing icons for search, home, and other functions.
- Data loading**: Points to the Session Time (1532) and Cam Num (3) input fields.
- Region selection**: Points to the Region Draw section, including the Set region box button and the Whole Area radio button.
- Target group analysis**: Points to the Group Analysis section, which includes radio buttons for Everyone, Ex. All Groups, and Groups 1 through 5.
- Target ID analysis**: Points to the Analysis ID, Personal Space, Relative Space, and Interval Time input fields.
- Filtering methods**: Points to the Group Analysis section, which includes radio buttons for Average, Interpolate, Savitzky-Golay, and Raw.
- Time toolbar**: Points to the Current Time (196.74 Secs) display and the Time Start/End input fields.
- Map preview**: Points to the central map area showing a blue path and various data points.



Tracking results



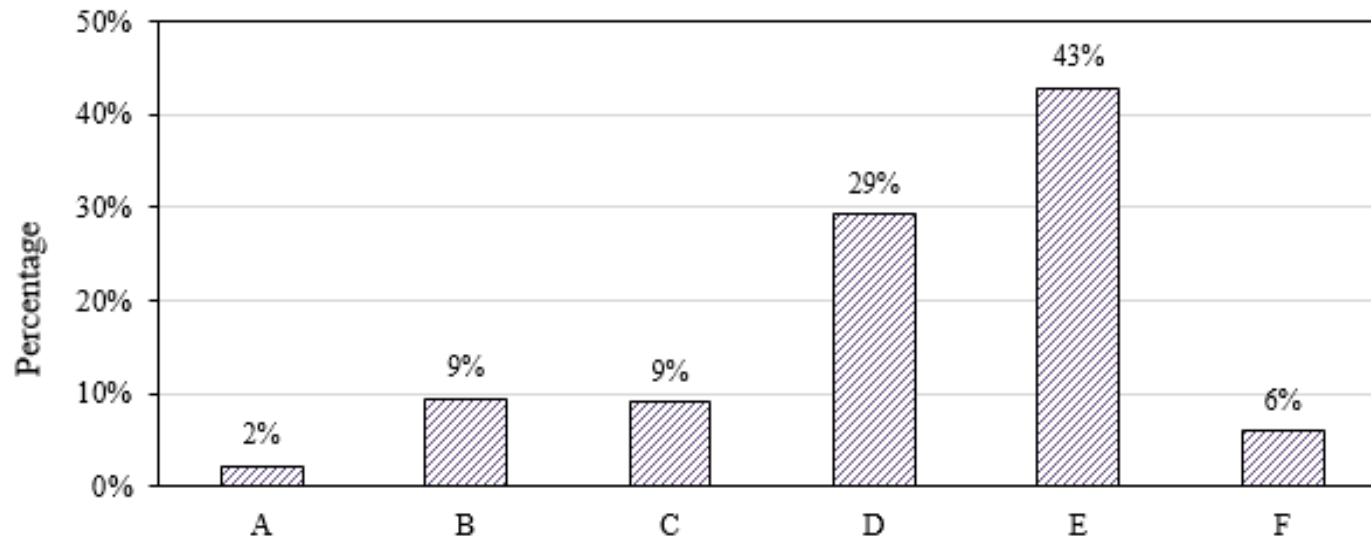
Trajectories

Time-space diagram



Analysis

- Survey response distribution from **257 surveys** (212 individuals without disabilities and 45 individuals with disabilities).



Methodology

- An **ordered probit** model can address both the discrete and ordered nature of perceived LOS data.
- **Unobserved variable** is defined as a linear function of observed variable:

$$z_n = \beta_i X_n + \varepsilon_n$$

- The perceived LOS, y_n , can be written as follows:

$$y_n = A \quad \text{if } z_n \leq \mu_1 \qquad y_n = D \quad \text{if } \mu_3 \leq z_n \leq \mu_4$$

$$y_n = B \quad \text{if } \mu_1 \leq z_n \leq \mu_2 \qquad y_n = E \quad \text{if } \mu_4 \leq z_n \leq \mu_5$$

$$y_n = C \quad \text{if } \mu_2 \leq z_n \leq \mu_3 \qquad y_n = F \quad \text{if } z_n \geq \mu_5$$

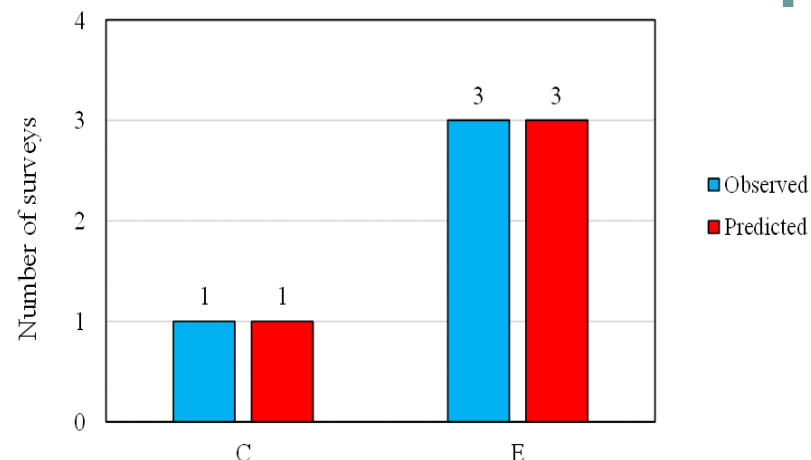
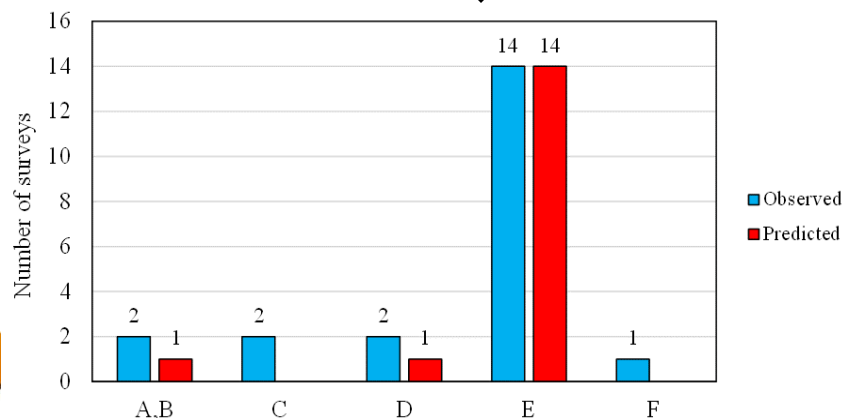


Calibration and validation

● **Calibration** results →

● **Validation** results ↓

Variables	Model					
	Individuals without disabilities			Individuals with disabilities		
	Coefficients	t-statistics	p-value	Coefficients	t-statistic	p-value
Constant	-0.78	-3.23	0.0015	-0.62	-1.35	0.1835
Density (Ped/m ²)	4.37	9.66	< 0.01	3.35	3.98	< 0.01
<i>Cut-offs</i>						
μ ₂	0.58	4.46	< 0.01	0.32	1.83	0.074
μ ₃	1.92	10.45	< 0.01	1.23	4.21	< 0.01
μ ₄	4.11	14.62	< 0.01	2.46	6.59	< 0.01
Number of observations	191			41		
Log likelihood at convergence	-197.26			-53.17		

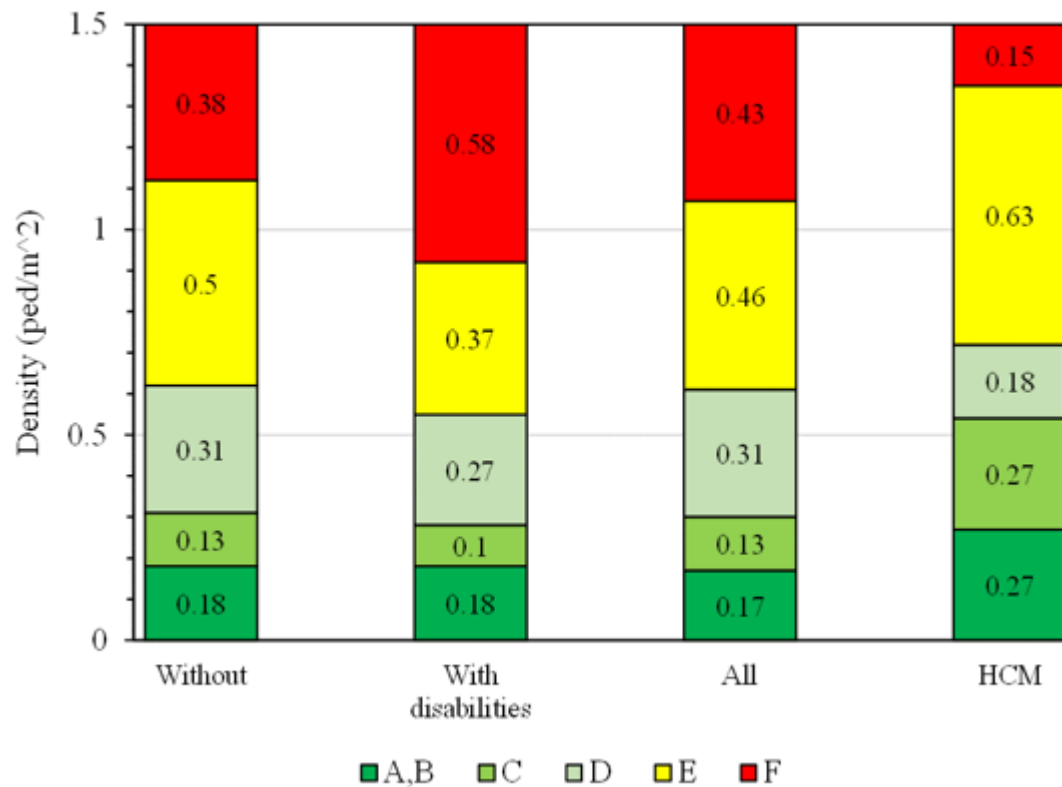


Individuals without disabilities

Individuals with disabilities

Results

- **LOS thresholds** for different pedestrian groups



Conclusions and implications

- Pedestrian LOS perception thresholds are **lower** than proposed LOS thresholds in HCM.
- considering LOS B as the target, design plan based on HCM guideline would be about **63%** of minimum width obtained from heterogeneous pedestrian perceptions.
- Minimum required width for individuals without disabilities is about **80%** of minimum width for individuals with disabilities to achieve **LOS E**.

