

Examining factors of walking disutility for microscopic pedestrian model – A virtual reality approach

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supported by JSPS Grant-in-Aid #22686048

Introduction – do pedestrians *anticipate* walking disutility in future?

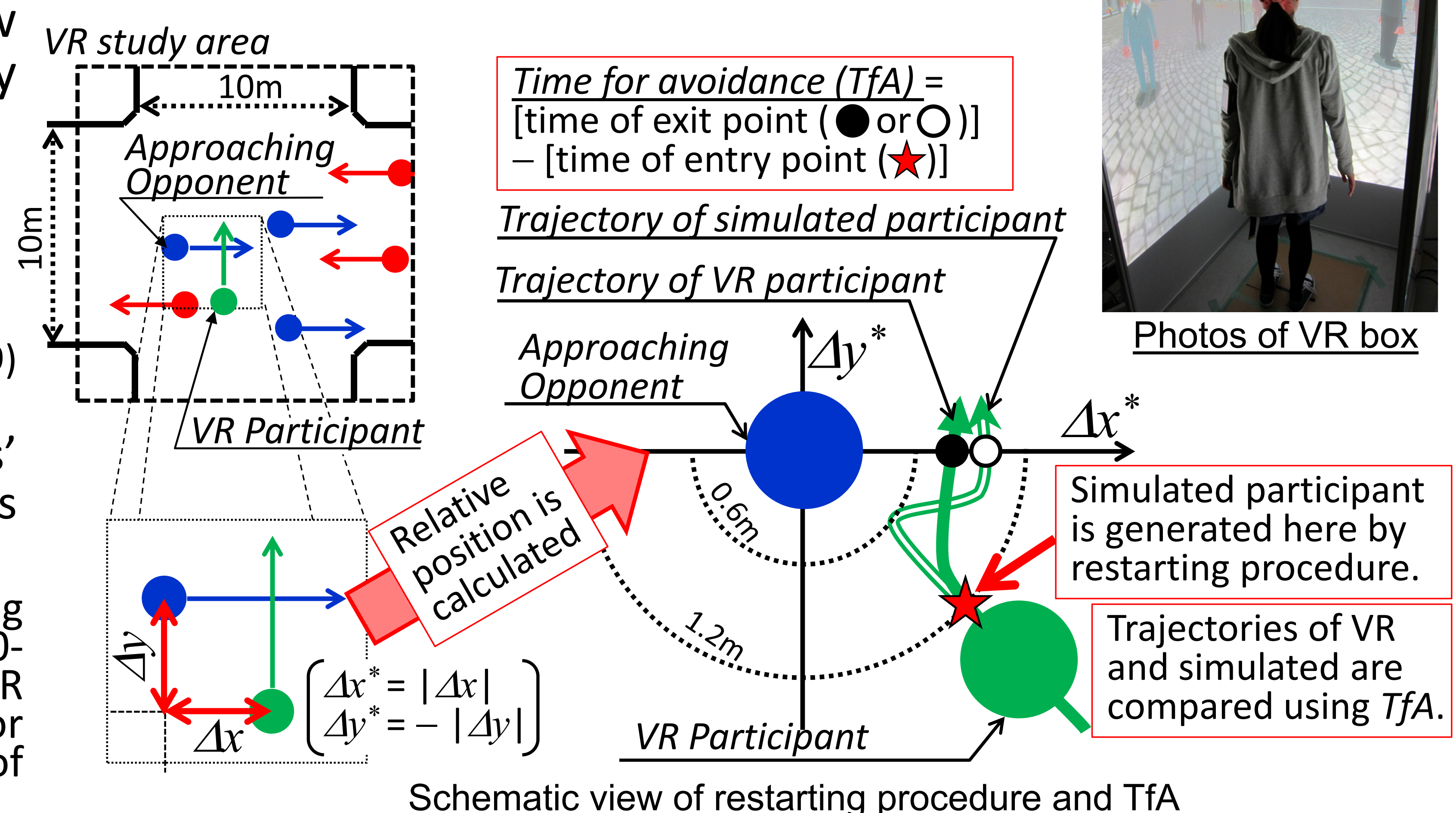
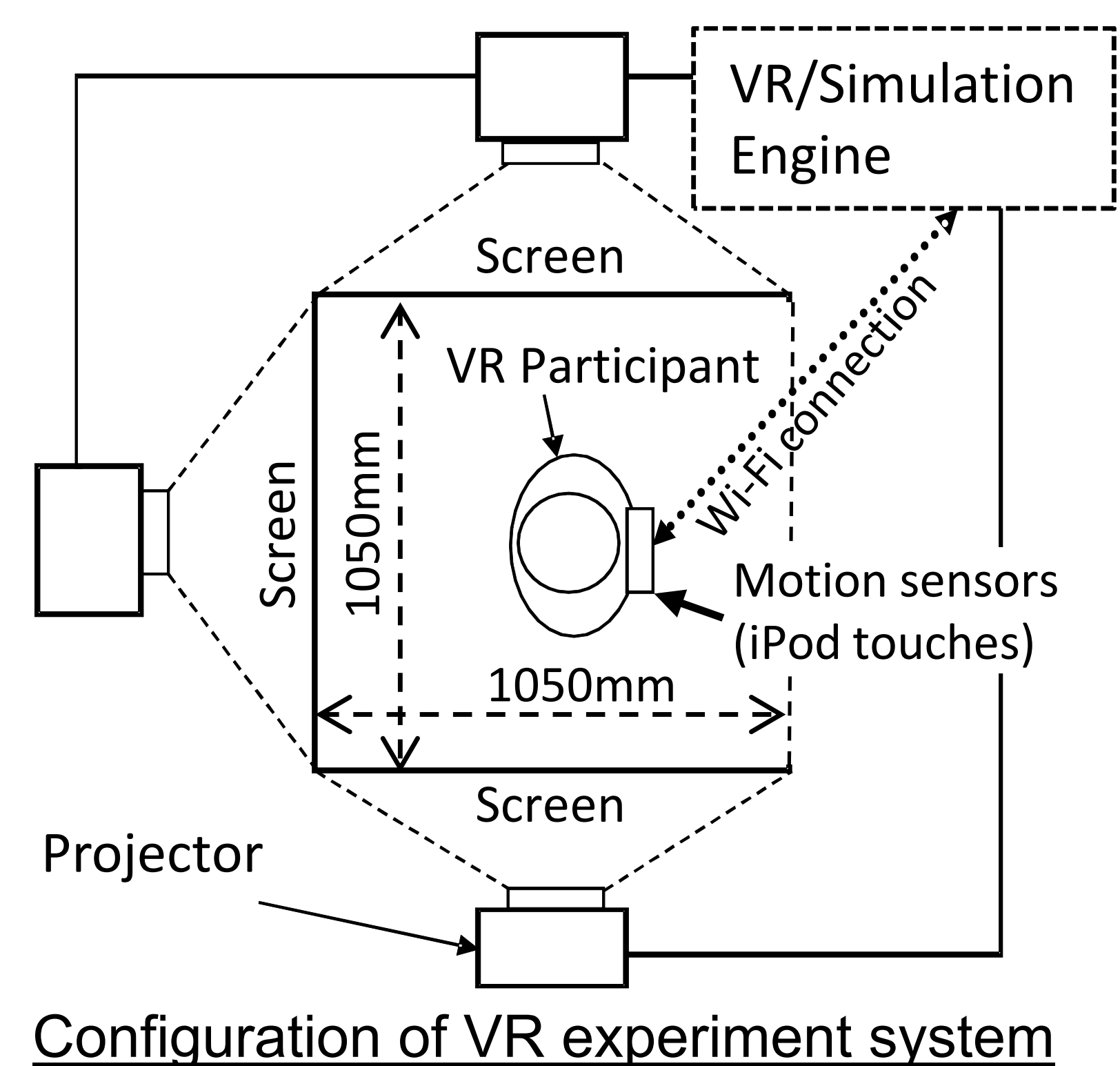
- Like other transport behaviour, pedestrian movement can be described by the *disutility minimisation principle*.
- The purpose of this study is to investigate whether pedestrians in a crowd *anticipate the disutility* to be experienced in the next few seconds, or just think of the *instantaneous disutility* at each moment to decide how they walk.
- An experiment with virtual reality (VR) system was conducted to investigate the above issue.

Disutility minimisation principle and the conventional social force model

- The conventional social force (SF) model is defined as a repulsive-force based model in which the *repulsive force does not depend on any variables excluding positions of pedestrians* (including surrounding pedestrians). (e.g. Helbing et al. (2000))
- We proved that *the conventional SF model is mathematically identical to the instantaneous-disutility-minimisation principle* by optimal control theory.

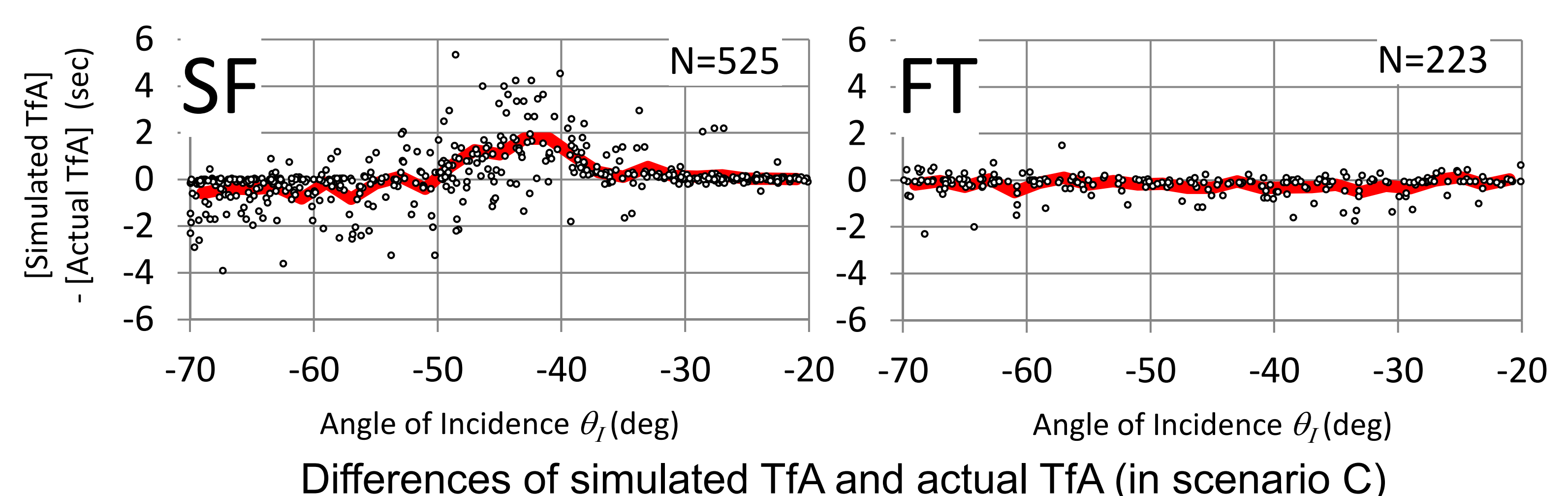
Configuration of VR system & experiment

- A *VR experiment system*, in which movements of all pedestrians except a *VR participant* are calculated by a microscopic pedestrian model, was constructed.
- Pedestrian stream(s) going through a 10mx10m intersection is simulated by the pedestrian model. *Each VR participant is asked to cross the intersection by avoiding pedestrians* in the stream(s).
- An *approach of an opponent* to the VR participant to *1.2m* invokes a *new simulation process*, in which the *VR participant is replaced by a simulated participant* whose motion is calculated by the model used for the pedestrian stream. This function is called *restarting procedure*. The reproducibility of the simulation model can be evaluated by comparing movements of VR and simulated participant.
- *Time for Avoidance (TfA)* is defined to evaluate how smooth a participant avoids an opponent when they are approaching each other.
- Two models are evaluated by the experiment:
 - *Conventional SF model* representing *instantaneous-disutility-based* model
 - *Fastest Trajectory (FT) model* (Asano et al. 2009) representing *anticipated-disutility-based model*
 - In FT model, pedestrians *explicitly anticipate* others' movements and decide a fastest path towards destinations with no collision of others.
- Conditions of experiment: Volume of peds' stream crossing intersection varies for four scenarios A-D. A:60-0, B:60-60, C: 100-20, D:120-0 (Direction 1 – Direction 2, unit: ped/min). # of VR participants = 31 (30) for SF (FT) model. Only one of either SF or FT model was experienced by each participant. Total # of crossings = 992 (960) for SF (FT) model.



Comparison of movements between human and simulation

- The difference of TfA between a VR participant and a simulated participant is calculated for each approach to evaluate how SF and FT models can reproduce avoiding behaviour of pedestrians.
- *When SF is used*, TfA of simulated participants is a few seconds *greater than* that of VR participants.
- *When FT is used*, There *is no significant difference* of TfA between VR and simulated participants.
- The above result implies that the FT can reproduce avoiding behaviour better than SF do so.



Discussions and conclusion remarks

- The result of the VR experiment implies that *considering the anticipated disutility seems necessary* in the models that determine pedestrian movements with the disutility minimisation principle. Note that this result rely on the fact that the conventional SF model is identical to the instantaneous-utility-based model.
- There would be many ways to incorporate anticipated disutility. As well as the explicit incorporations, appropriate extensions of the conventional SF model (such as Johansson et al. (2007)) should be also applicable to incorporate it.