NIGIWAI DISCUSSION MEMO

TODO:

(1) (Done!) use synthetic data generated by Crowd Simulation (e.g., [1]: "Scenarios"[1] contains demo files.)
   (a) We want to have synthesised trajectory data. This can be used to evaluate our indicator definitions.
   (b) Also, we can use Cinema4D or other rendering software to synthesise videos to test the tracking algorithms.

(2) Make distinguishing pairs of synthetic scenarios:
   (a) to distinguish absolute and signed velocities: (1) people going in the same direction (2) opposite direction
   (b) discernible by Nigiwai score but not by a simple indicator like density: (1) one with just source and sink and people travel smoothly from source to sink (2) the other with one shop in the middle and people stop at there for some time.

(3) define "ground truth" to compare with the proposed indicators: the ultimate goal is to find correlation among different indicators.
   - inquiry, sales (for real data)
   - global and rough indicator: stay time etc. (for real and synthetic data)

(4) Find candidate journals to which we send our paper, and study the way how people publish there. (the manner of theory, experiments, writing etc.) A search "pedestrian" in Google Scholar gives several journals including Physical Review E.

1. A smoothed variant of the Nigiwai indicator*

It is highly possible that I am making silly mistakes here. Just ask if you find anything strange! Perhaps, we can use Teams chat for that?

Setting:

- $i, j \in \{0, 1, \ldots\}$: person ID
- $t \in \{0, 1, \ldots\}$: time (frame)
- $x_{i,t} \in \mathbb{R}^2$: the coordinates of people (or point-of-interest such as stores).
- $d_{i,j,t} = |x_{i,t} - x_{j,t}|$: (Euclidean) distance between i and j
- $\tilde{d}_{i,j,t}$: the moving average of $d_{i,j,t}$. For example if x_i, x_j are both present at time $t-1$,

  $$\tilde{d}_{i,j,t} = \alpha d_{i,j,t} + (1-\alpha)\tilde{d}_{i,j,t-1} \text{ (for example, } \alpha = \frac{7}{8})$$

  otherwise

  $$\tilde{d}_{i,j,t} = d_{i,j,t}.$$

  The value of α has to be chosen according to the frame rate and the strength of noise.
- $\Delta\tilde{d}_{i,j,t}$: the signed relative velocity

  $$\Delta\tilde{d}_{i,j,t} = \tilde{d}_{i,j,t} - \tilde{d}_{i,j,t-1}$$

- Nigiwai indicator for i is defined to be

  $$S_i(t) = \sum_j \frac{\exp(-\Delta\tilde{d}_{i,j,t}/W_v)}{(\tilde{d}_{i,j,t} + C)^2},$$

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[1] `https://gitlab.lrz.de/vadere/vadere/-/tree/master/`

where W_v, C are hyper-parameters. An alternative is

$$S_i(t) = \sum_j \frac{\exp(-\Delta\tilde{d}_{i,j,t}/W_v)}{\min(\tilde{d}_{i,j,t}, C)^2},$$

Remarks:

- I opted for the moving average to reduce the effect of noise. Std can be a better choice as Mohamed did.
- I guess relative velocity is better; a group of people moving together make Nigiwai!
- "Signed" relative velocity accounts for the fact that someone getting closer adds Nigiwai.
- The form of the function, e.g., exp may be altered (to e.g., cubic function y^3). We have to do trial-and-error to find the optimal one.
- We can regard a place (e.g., store) as a stationary person. For a region, we can place multiple "stationary persons" to represent the region: The region's Nigiwai can be defined as the sum of their Nigiwai.
- Taking the sum $\sum_j$ is too much computation. In practice, we can just take the sum over neighbours: $\sum_{\{j|d_{i,j,t}<\text{threshold}\}}$ or $\sum_{\{j|j \text{ runs through } k\text{-nearest neighbours of } i\}}$. k-nearest neighbours can be computed by algorithms such as *kd-tree* or *random projections*.
- Note that Nigiwai indicator $S_i(t)$ is for each person just the same as the Mohamed's version (both for region and for person).
- To define a global indicator for the whole shopping street, we need a way to aggregate local indicators. The easiest way is to take the sum:
  (1) Business Nigiwai at the moment t is $\sum_{i|i\text{runs through shops}} S_i(t)$
  (2) Visitor Nigiwai at the moment t is $\sum_{i|i\text{runs through people}} S_i(t)$
  Note that considering local indicator first has several advantages:
  (1) to break up the problem into smaller parts (modularization):
  (2) to construct different global indicators out of local ones like the above
  (3) local indicators can be used for, e.g., visualisation in the form of heatmap.

References

[1] Vedere, https://arxiv.org/pdf/1907.09520.pdf, http://www.vadere.org/getting-started/