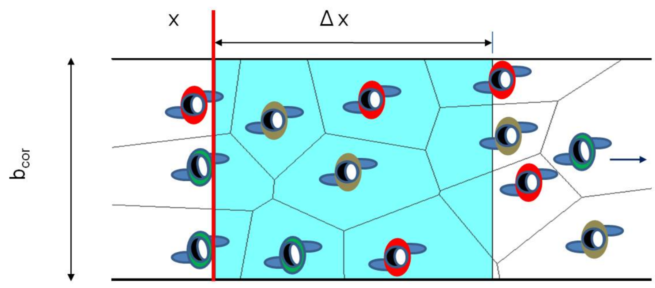


Figure 1. Illustration of different measurement methods.Note that Method A is a kind of local measurement at cross-section with position x averaged over a time interval Δt. While the Method $B \sim D$ measure at certain time and average the results over space Δx. especially for Method D, the voronoi diagram formed from these pedestrian must be calculated first in the measurement time.

Some results of experiment uo

1. Description

4 different measurement methods for calculating the basic quantities, flow, density and velocity are as following.

1.1. Method A

Method A is a measurement over time, which measures by taking a reference location x on the corridor over a fixed period of time Δt (as shown in Figure 1). We refer to this by $\langle\rangle_{\Delta t}$. Using this method, it is easy to obtain the pedestrian flow J and velocity vi of each pedestrian passing x directly. Thus, the flow over time $\langle J\rangle_{\Delta t}$ and the time mean velocity $\langle v\rangle_{\Delta t}$ can be calculate following the equation (1) as following.

$$\langle J\rangle_{\Delta t} = \frac{N_{\Delta t}}{t_{\Delta t}} \qquad and \qquad \langle v\rangle_{\Delta t} = \frac{1}{N}\sum_{i=1}^{N} v_i(t) \tag{1}$$

where $N_{\Delta t}$ is the number of persons passing the location x during a certain time interval Δt. $t_{\Delta t}$ is the time between the first and the last one of the $N_{\Delta t}$ persons passing x. That is to say, $t_{\Delta t}$ is the actual time that the $N_{\Delta t}$ used for passing the location and not always the same with Δt. The time mean velocity $\langle v\rangle_{\Delta t}$ here is the arithmetic mean value of the instantaneous velocity $v_i(t)$ of the N persons passing the location x in Δt.

$$v_i(t) = \frac{\vec{x}_i(t + \Delta t'/2) - \vec{x}_i(t - \Delta t'/2))}{\Delta t'} \tag{2}$$

1.2. Method B

The second method is an over space and time measurement in deed. The space mean velocity and density are calculated by taking a segment Δx in the corridor as measurement area. The velocity $\langle v \rangle_i$ of each person is defined as the length Δx of the measurement area divided by the time he or she cost in this area (see equation (5)).

$$\langle v \rangle_i = \frac{\Delta x}{t_{out} - t_{in}} \tag{3}$$

The density ρ_i for each person is calculated as equation (6).

$$\langle \rho \rangle_i = \frac{1}{t_{out} - t_{in}} \cdot \int_{t_{in}}^{t_{out}} \frac{N'}{b \cdot \Delta x} dt \tag{4}$$

where t_{in} and t_{out} is the time a person enter and exit the measurement area. b is the width of the measurement area while N' is the number of person in this area at a time t.

1.3. Method C

The third measurement method, the most common method, is similar with Method B. In this method, the density $\langle \rho \rangle_{\Delta x}$ is defined as the number of pedestrian divided by the area of measurement area. That is

$$\langle \rho \rangle_{\Delta x} = \frac{N}{b \cdot \Delta x} \tag{5}$$

while the space mean velocity is the average of the instantaneous velocity $v_i(t)$ for all pedestrians in the measurement area at time t.

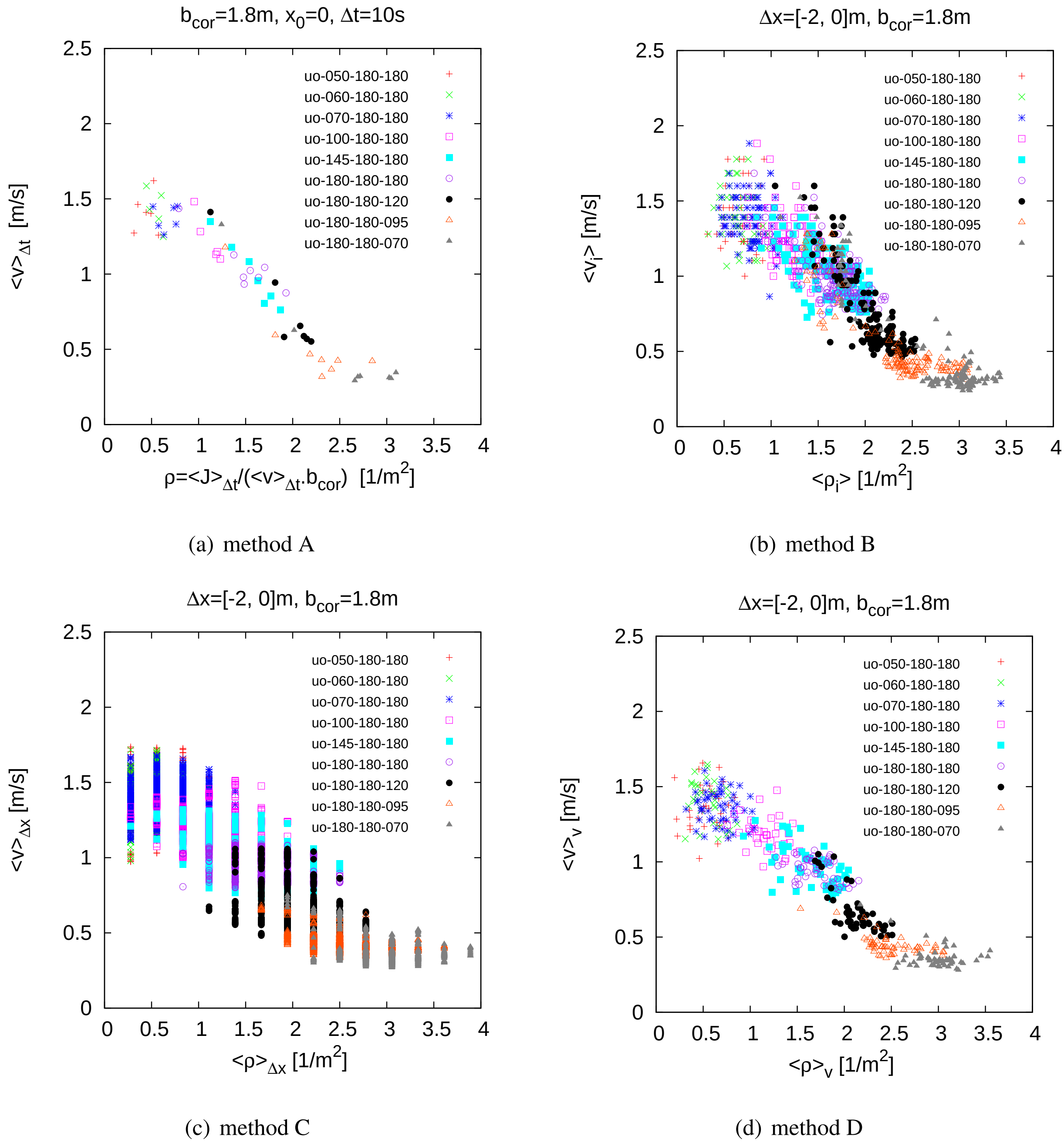
$$\langle v \rangle_{\Delta x} = \frac{1}{N} \sum_{i=1}^{N} v_i(t) \tag{6}$$

It is considered more accurate than the time mean results. The data for space calculating may be taken from time-lapse pictures, video recording, or both.

1.4. Method D

Here, a voronoi diagram based method, which is also a kind of over space measurement and we call it as voronoi method, will be introduced. Because the trajectory of each pedestrian is gotten using the *Petrak* and the position of a pedestrian is represented by a point at any time. In this case, it is easy to create the voronoi diagram (see Figure 1) from the points in the geometry each time.The voronoi cell area A_i for each person i can be obtained and the density distribution ρ_{xy} of the space can be treated as $1/A_i$. The voronoi density ρ_v for the measurement area is defined as following[**?**].

$$\langle \rho \rangle_v = \frac{\iint \rho_{xy} dxdy}{b \cdot \Delta x} \tag{7}$$



(a) method A

(b) method B

(c) method C

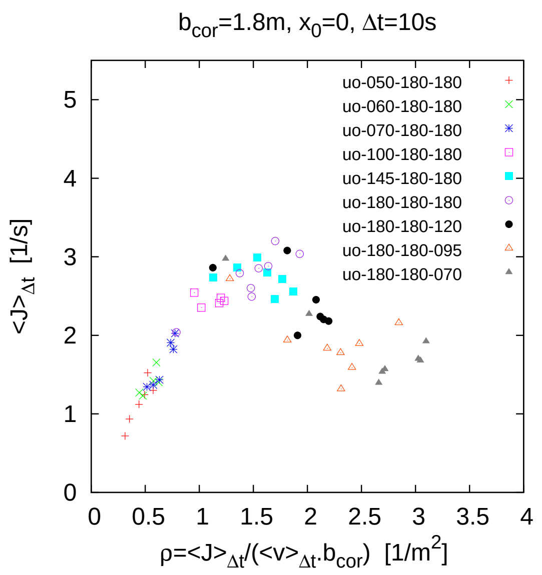
(d) method D

Figure 2. The fundamental diagrams, the relationship between density and velocity, measured at the same set of trajectory but with different methods. Except the density in (a) is calculated using $\rho = J/(b \cdot \Delta x)$, all data are measured directly.

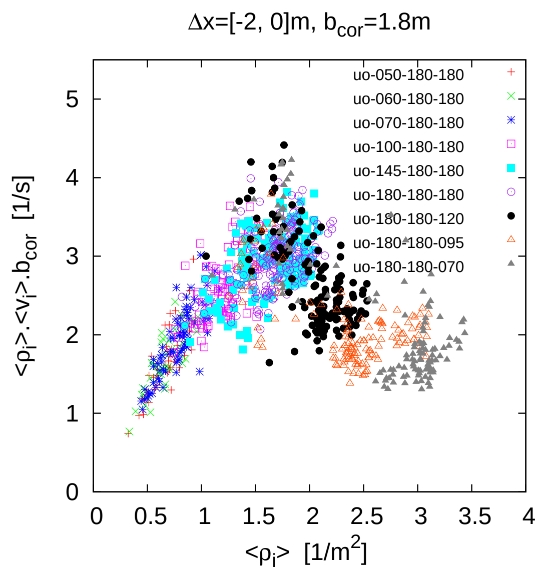
Similarly, the voronoi velocity can be defined as equation (8)

$$\langle v \rangle_v = \frac{\iint v_{xy} dxdy}{b \cdot \Delta x} \qquad with \qquad v_{xy} = \frac{v_i(t)}{A_i(t)} \tag{8}$$

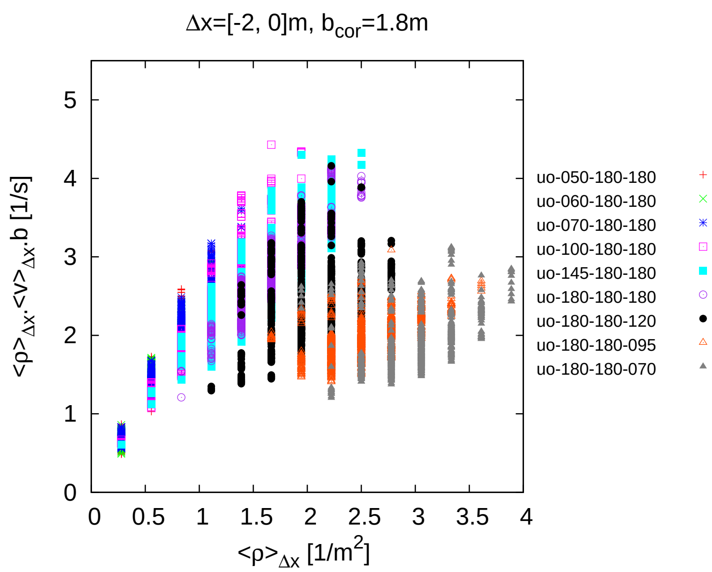
where $v_i(t)$ is the instantaneous velocity of each person and can be calculated the same with equation (2).



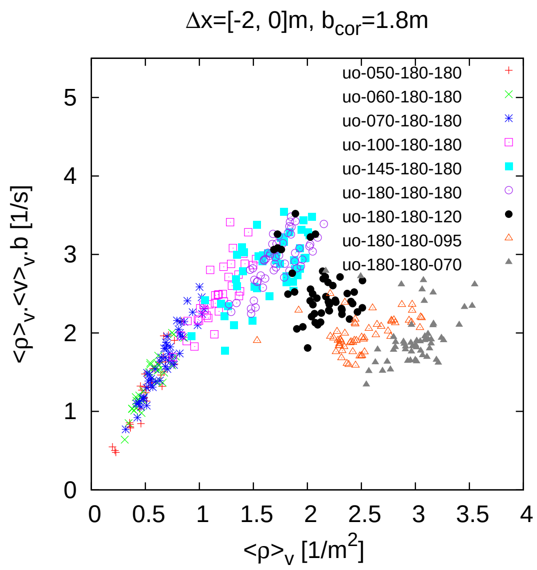
(a) method A



(b) method B

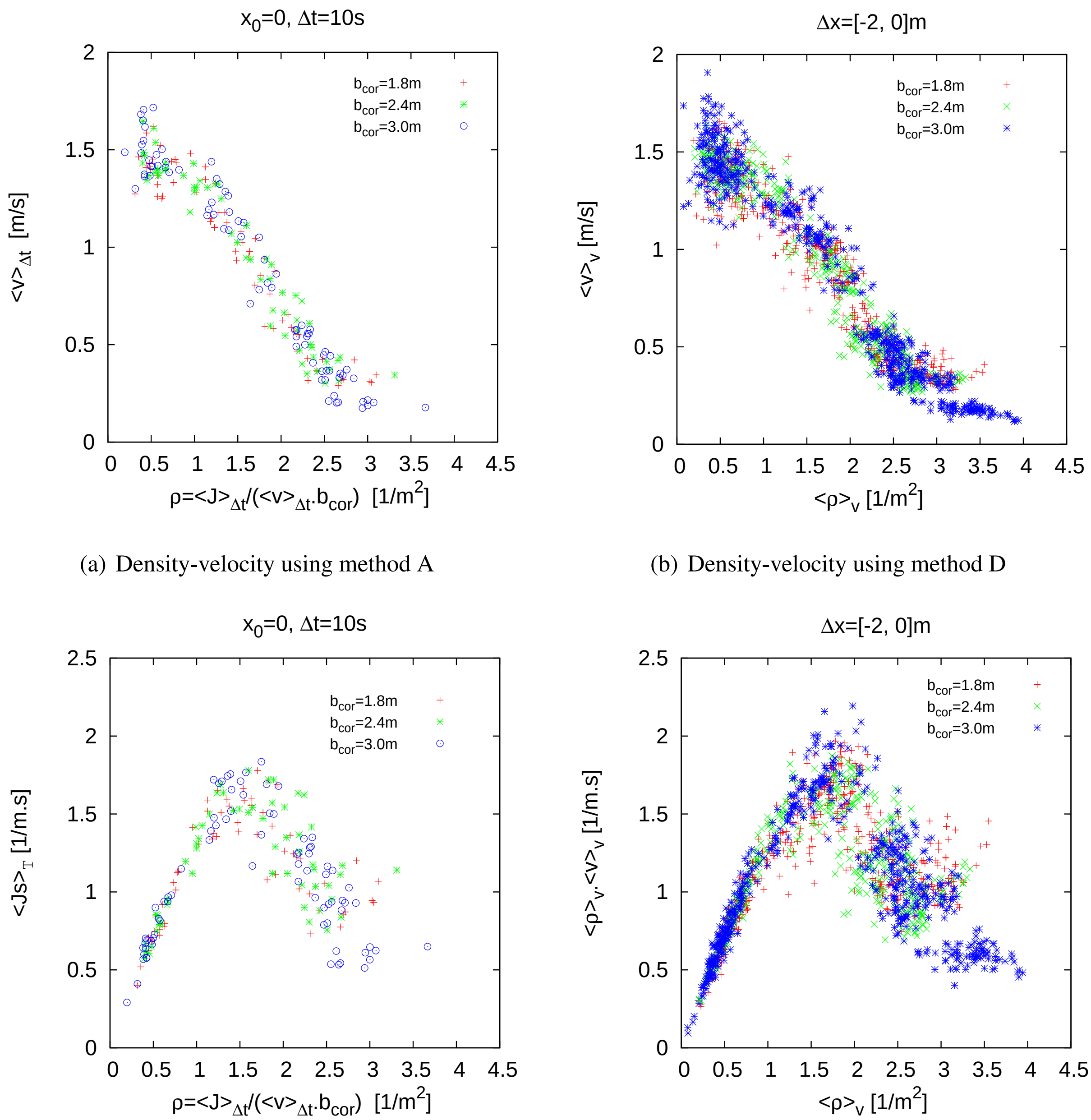


(c) method C



(d) method D

Figure 3. The fundamental diagrams, the relationship between density and flow, measured at the same set of trajectory but with different methods. The density in (a) is calculated indirectly using $\rho = J/(b \cdot \Delta x)$, while the flows in (b),(c) and (d) are obtained by adopting the equation $J = \rho v b$.



(a) Density-velocity using method A

(b) Density-velocity using method D

(c) Density-specific flow using method A

(d) Density-specific flow using method D

Figure 4. Comparison of the experimental results with different corridor width.

Table 1. The related parameters in straight corridor experiment

Experiment index	Name	$b_{entrance}$ $[m]$	b_{cor} $[m]$	b_{exit} $[m]$	N
1	uo-050-180-180	0.50	1.80	1.80	61
2	uo-060-180-180	0.60	1.80	1.80	66
3	uo-070-180-180	0.70	1.80	1.80	111
4	uo-100-180-180	1.00	1.80	1.80	121
5	uo-145-180-180	1.45	1.80	1.80	175
6	uo-180-180-180	1.80	1.80	1.80	220
7	uo-180-180-120	1.80	1.80	1.20	170
8	uo-180-180-095	1.80	1.80	0.95	159
9	uo-180-180-070	1.80	1.80	0.70	148
10	uo-065-240-240	0.65	2.40	2.40	70
11	uo-080-240-240	0.80	2.40	2.40	118
12	uo-095-240-240	0.95	2.40	2.40	108
13	uo-145-240-240	1.45	2.40	2.40	155
14	uo-190-240-240	1.90	2.40	2.40	218
15	uo-240-240-240	2.40	2.40	2.40	246
16	uo-240-240-160	2.40	2.40	1.60	276
17	uo-240-240-130	2.40	2.40	1.30	247
18	uo-240-240-100	2.40	2.40	1.00	254
19	uo-080-300-300	0.80	3.00	3.00	119
20	uo-100-300-300	1.00	3.00	3.00	100
21	uo-120-300-300	1.20	3.00	3.00	163
22	uo-180-300-300	1.80	3.00	3.00	208
23	uo-240-300-300	2.40	3.00	3.00	296
24	uo-300-300-300	3.00	3.00	3.00	349
25	uo-300-300-200	3.00	3.00	2.00	351
26	uo-300-300-160	3.00	3.00	1.60	349
27	uo-300-300-120	3.00	3.00	1.20	348
28	uo-300-300-080	3.00	3.00	0.80	270