Directional Aggregate Visualization of Large Scale Movement Data

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Movement Data

What is Movement Data

Naive Visualization of Movement Data and Problem

Purpose and Approach of Our Research

Movement Data

- **Movement Data**: Geospatial Location data with a time stamp
- We focus on two points of movement data such as starting point and ending point of each object

Example of Movement Data

ID	Time stamp	Latitude, Longitude
50	2014/04/05/13:00.00 + 0900 (JST)	36.110915, 140.099898
50	2014/04/05/17:00.00 + 0900 (JST)	36.094774, 140.098367
51	2014/04/05 13:00.00 + 0900 (JST)	36.098233, 140.105161
:	:	:

Naive Visualization of Movement Data

- Drawing lines that connect the positions of each object in chronological order is one naive visualization

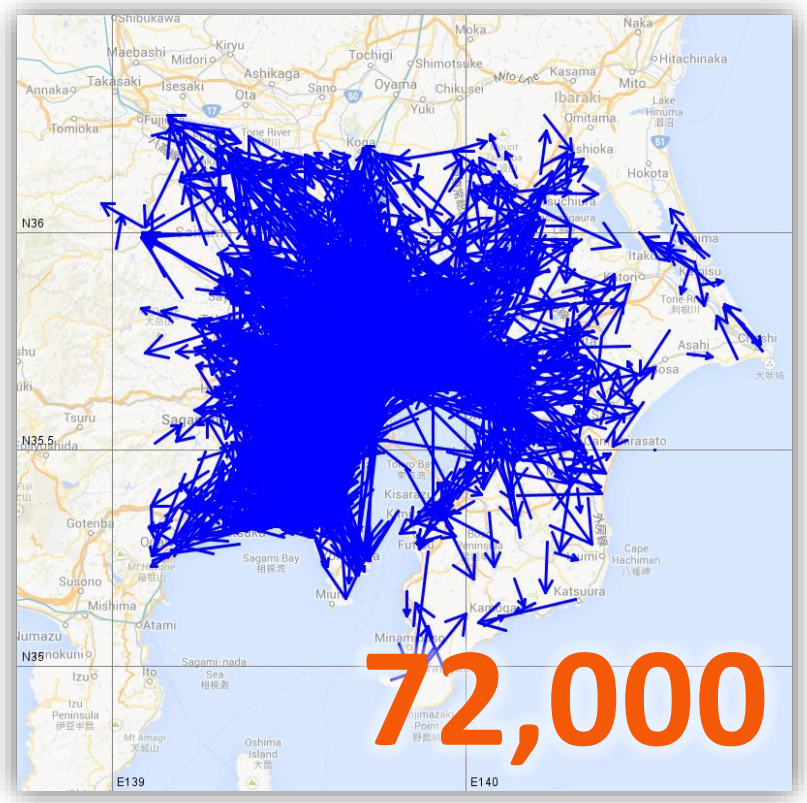
We can easily understand

- The number of objects
- Direction
- Distance

Example of Naive Visualization
Movement of 5 people(6:00 am – 9:00 am)
Line connecting the start and end points.

Problems of Naive Method

- Naive visualization causes visual clutter in large scale data



Since many lines overlap,
movement with a short distance disappear

The method of eliminating visual clutter by changing the opacity of lines

- easy to grasp the number of objects
- difficult to grasp the direction and distance of movement

Example of Naive Visualization
Movement of 72,000 people(6:00 – 9:00)
Line connecting the start and end points.

Purpose & Approach of Our Research

Purpose:

- Make it possible to grasp the number of objects, and the direction and distance of movement in large scale movement data

Approach:

- Develop an aggregate visualization method to represent large scale movement data

Related Work 1

2D Vector Field Visualization

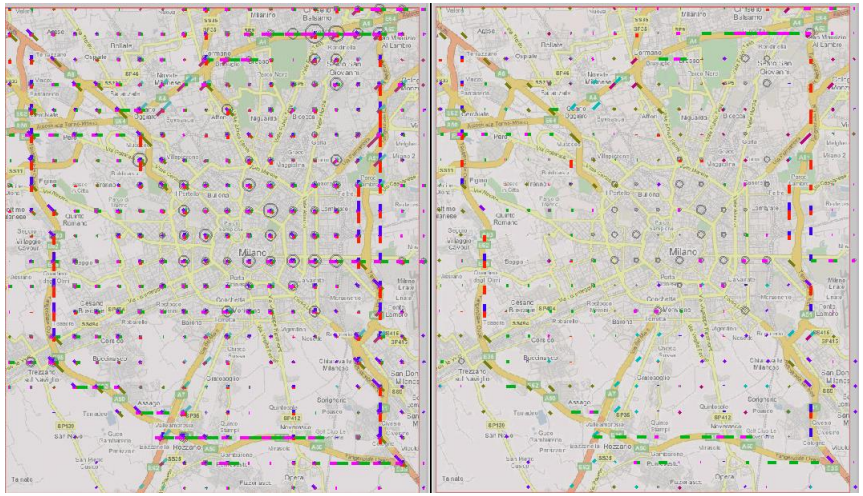
- Effective placement of the arrows [Field et al., 1993]
- Streamline placement that represents flow[Turk et al., 1996]
- It is difficult to represent a plurality of objects that move various distances and directions from one point

Geospatial Movement Visualization

- Movement visualization between predefined places [Tobler, 1987], [Phan et al., 2005]
- Movement visualization between non-predefined places [Andrienko et al., 2011]
- It is impossible to represent the distance moved for each object

Related Work 2

- Spatio-temporal aggregated visualization for movement data [Andrienko et al., 2008]
  - Aggregation facets: time (T), space (S), attributes (A)
  - We introduce S x T x T x D – aggregation (start point, start time, end time, movement direction)



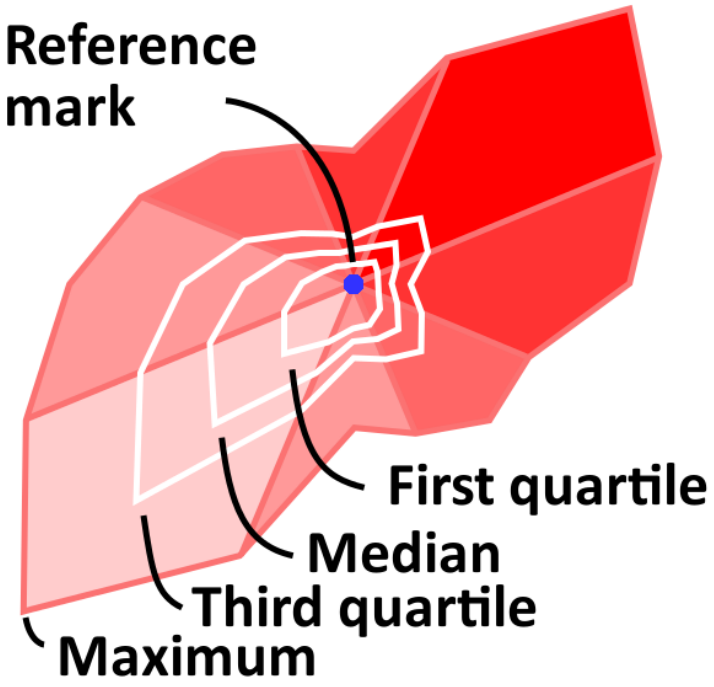
Space x Time x Direction-aggregation
The directional bar diagrams show movement data aggregated by compass directions.

Aggregate Visual Representation

Propose a New Visual Representation

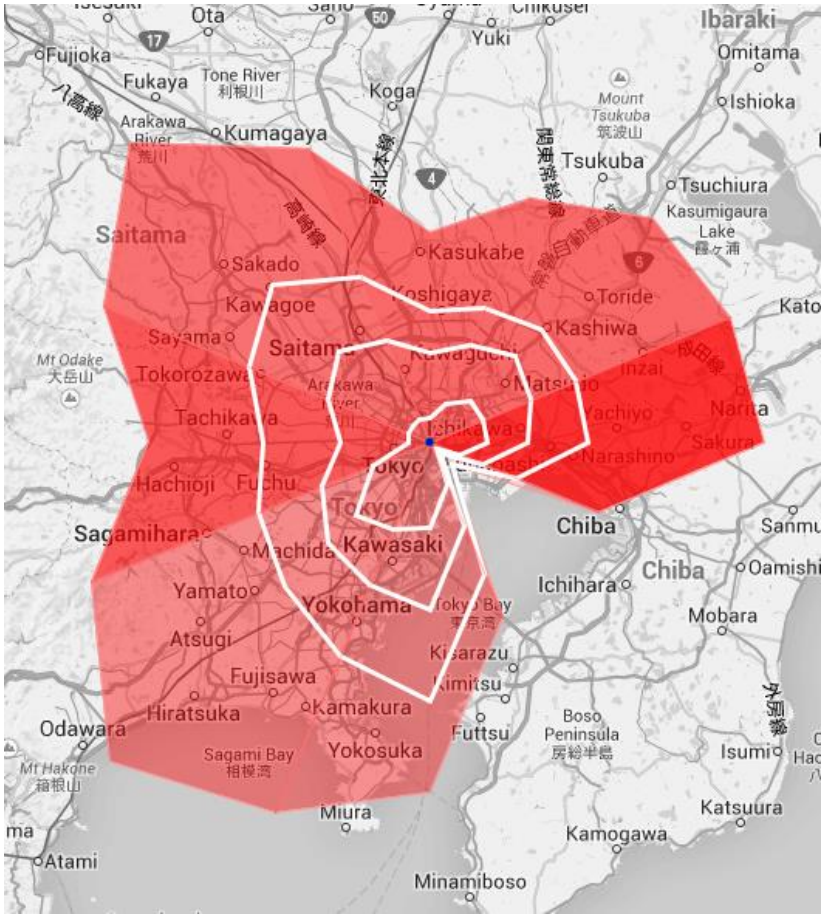
Comparison of Proposed Visualization and Naive Visualization

Amoeba Representation



- Represents the objects that start point is near the specified point
- The opacity of the surface in each direction represents the number of moving objects
- The lines represent the distribution of movement distance from reference mark

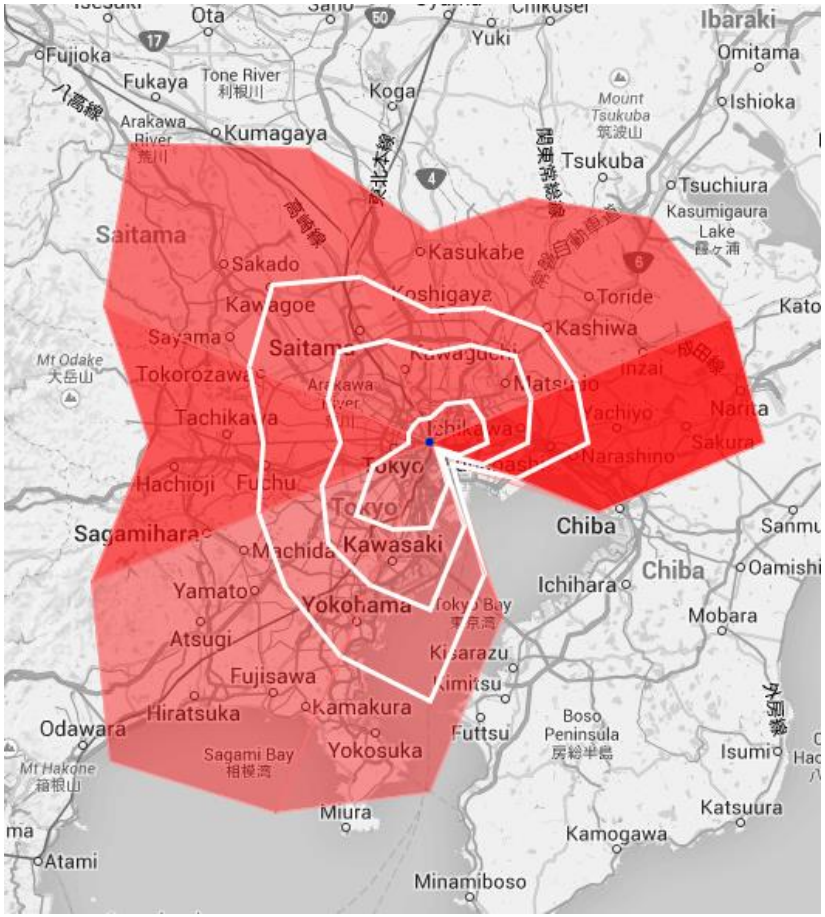
Illustration of Amoeba Representation



- Amoeba representation is draw over the map
- Distance from the reference point is displayed in accordance with the scale of the background map

Amoeba representation on actual data
302 people movement (6:00 – 9:00)
Within 3 km radius from Akihabara station.

What Amoeba Representation Represents



- movement which goes to the east is performed most frequently
- Movement distance is almost same distribution except for southeast.

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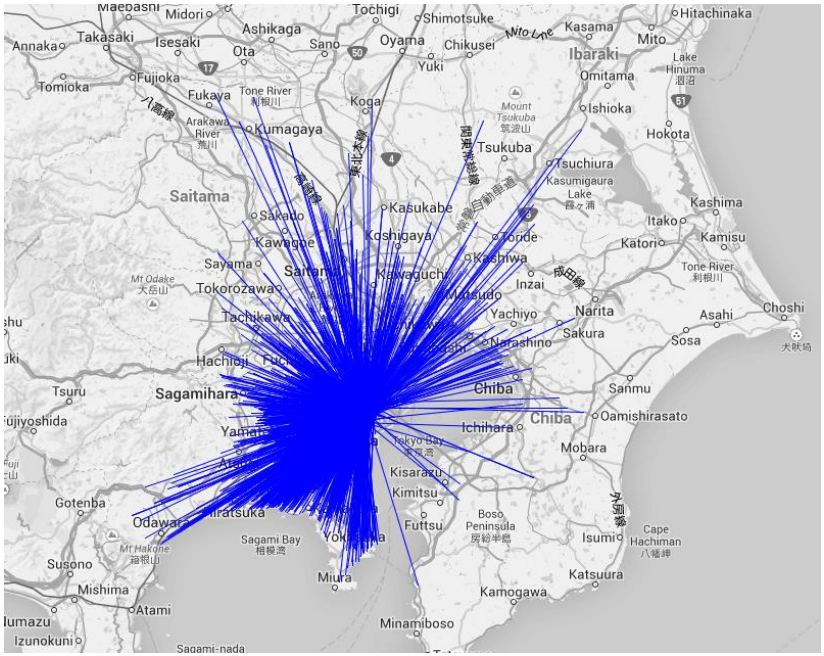
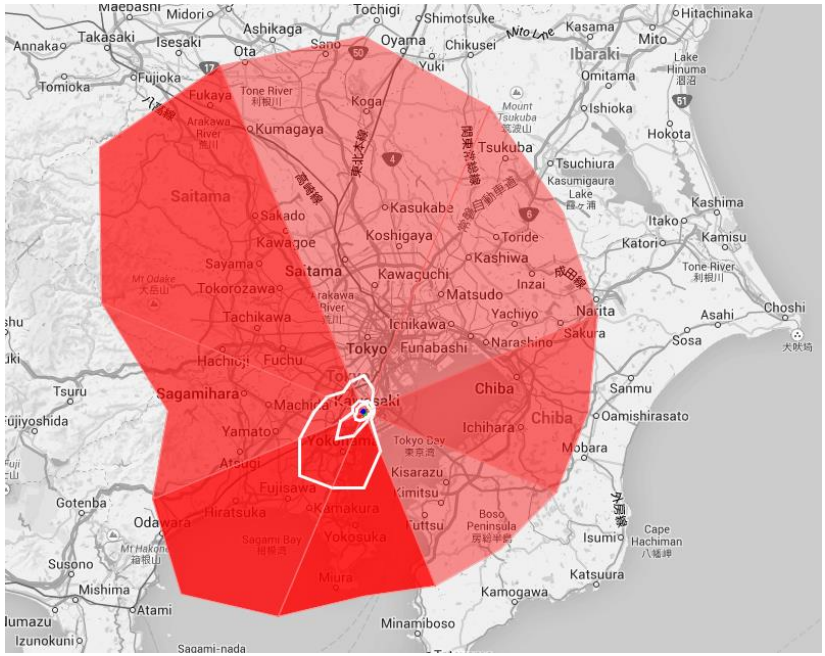
Comparison

We visualized large scale movement data with two methods



Naive visualization



Amoeba representation

Visualizing movement over three hours of 9,007 people whose starting point was within a 3 km radius of Kawasaki station

Advantage of Amoeba Representation

Comparison of two methods in large scale movement data

	Naive Visualization	Amoeba Representation
Movement path	**Depend**	**Bad**
Number of Object	**Depend**	 **Good**
Distribution of movement distance	**Bad**	 **Good**
Granularity of location information	**Fine**	**Rough**
Visual clutter	**Bad**	 **Good**

- In amoeba representation, the information which cannot be read by the naïve visualization was able to be read.

Directional Aggregation

Directional Aggregation

Visual Representation

Outline of Aggregation

We divide the movement data into a some subset
by start point, start time, end time, and movement direction.

1. Filter with Time interval
2. Aggregate with start point
3. Aggregate with movement direction
4. Calculate quartiles

Basics of Aggregation 1

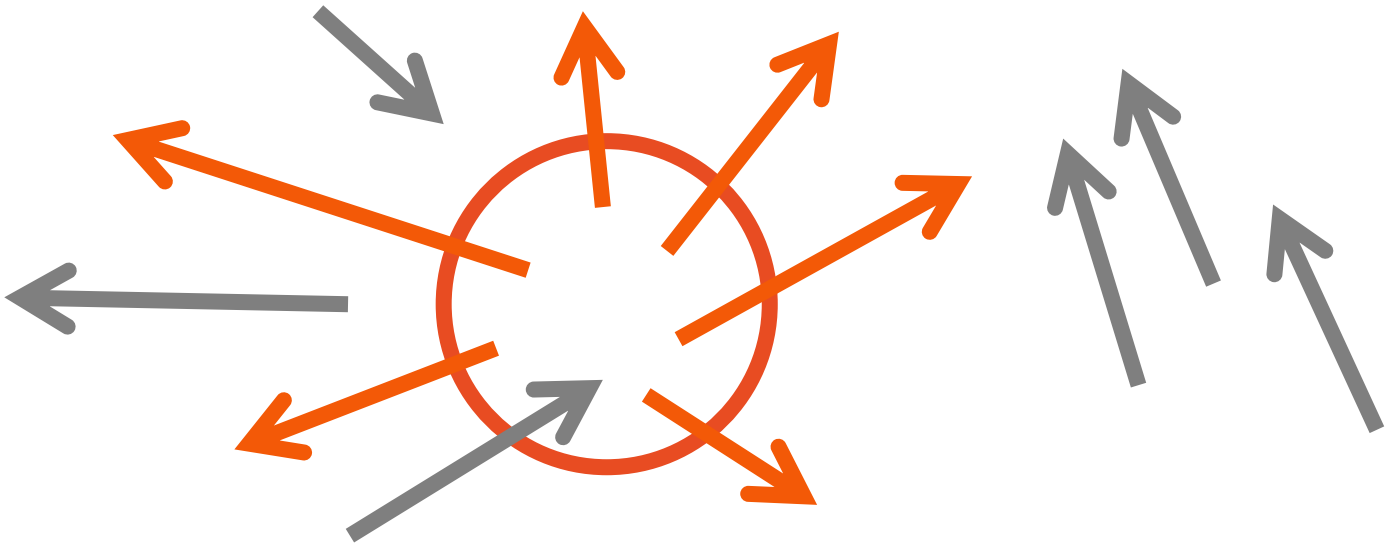
Filter with Time interval

- Filter the movement data by specified time interval
  - e.g. 6:00 am – 9:00 am

Basics of Aggregation 2

Aggregate by start point

- Extract the movement data that the start point is near the specified point
  - e.g. Within 3 km radius from Tokyo Sta.



Basics of Aggregation 3

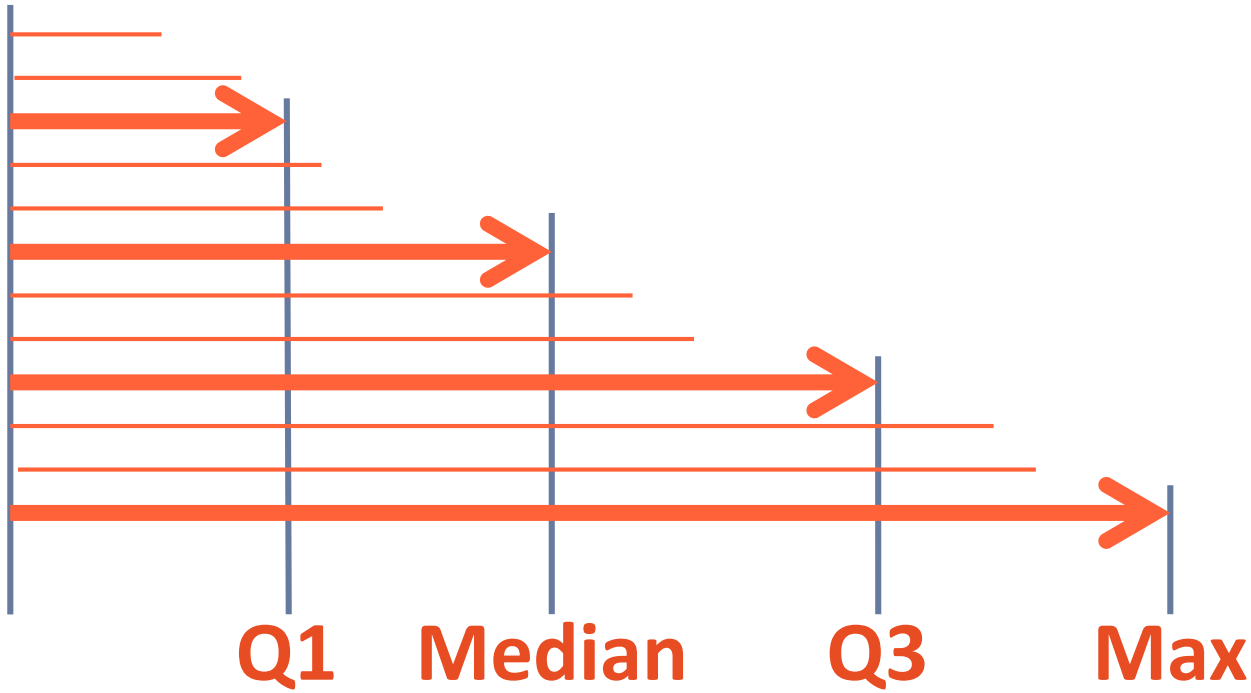
Aggregate by movement direction

- Divide into k pieces around the specified point
- Put together the objects toward the pieces of each

Basics of Aggregation 4

Calculate Quartiles and Count Up

- Calculate quartiles of movement distance
- Count up the number of objects



Improvement of Amoeba Representation

Effect of Area

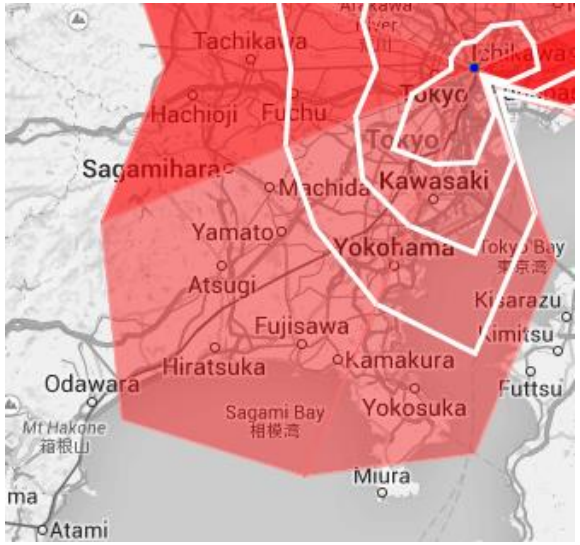
Visibility of Quartile Position

Offering the Overview

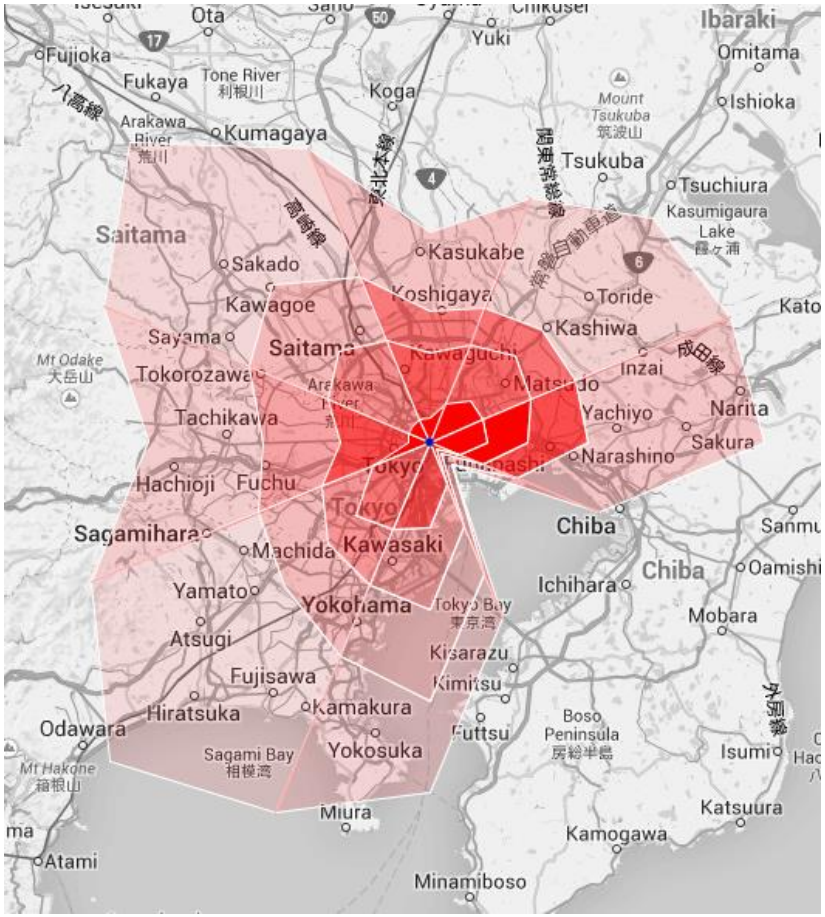
Problem about The Effect of Area

- The area of the shape in amoeba representation may affect reading of the number of objects
  - The choropleth map has same problem
- The area dose not represents the number of objects

Large areas of the outermost represents the same number as the area inside one.



Elimination of The Effect of Area

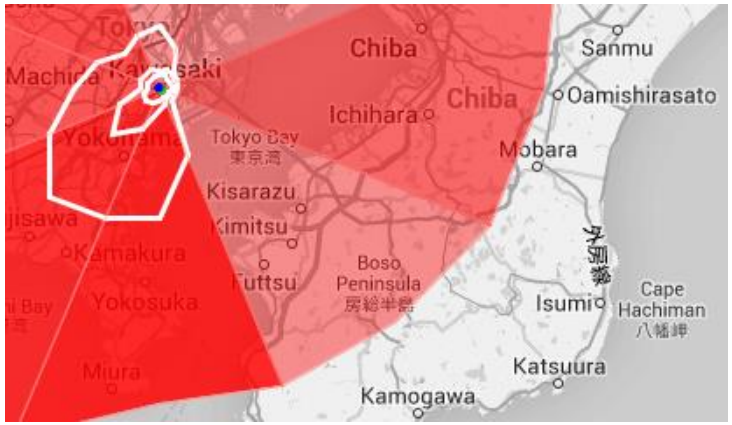


- The opacity represents the number of moving objects per unit area
- It can be seen that the point of arrival of the movement is still in the vicinity of the reference point

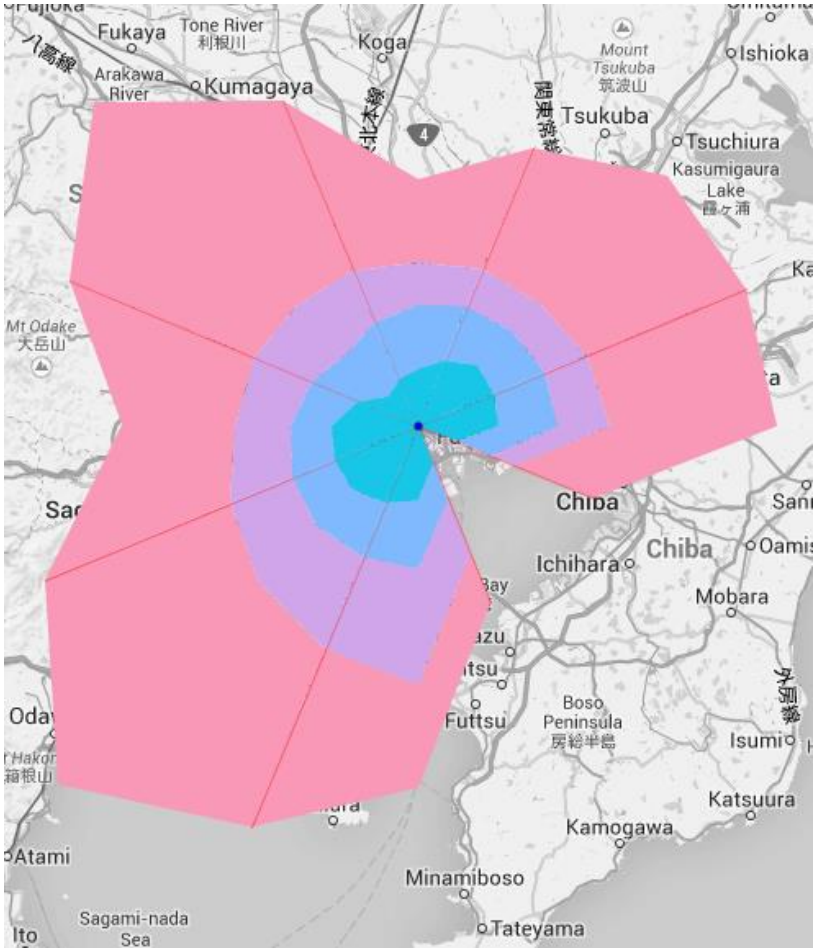
Amoeba representation on actual data
302 people movement (6:00 – 9:00)
Within 3 km radius from Akihabara station.

Problem about Visibility of Quartile Position

- It is not visible where a line is
  - The lines showing quartile position are thin to the whole figure of amoeba representation
- It is difficult to distinguish the lines
  - The lines overlap, If the number of moving objects is small



Improvement for Visibility of Quartile Position



- Using four colors of the surface for distinguish quartile positions
- The four colors of the surface is the color having the same brightness for the human perception
- The colors was chosen by reference to the L*a*b color space

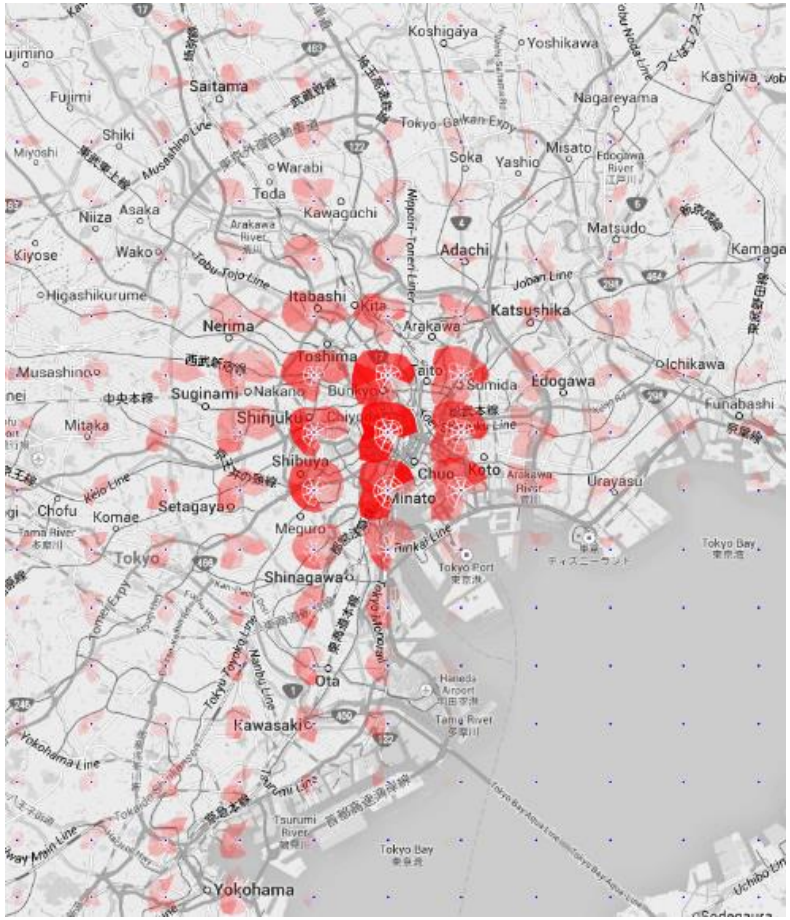
Amoeba representation on actual data
402 people movement (6:00 – 9:00)
Within 3 km radius from Tokyo station.

Offering the Overview

- Amoeba representation represents the only objects that starting point is near the one point of space
  - Knowing the overview of the movement data is difficult
  - It is difficult to read trend of moving direction and to find the point where the moving object often

- The other visualization method which offers Overview was developed.
- We call the method an “amoeba colony representation”.

Amoeba Colony Representation



- We developed an Amoeba colony representation that offers overview
- Draw amoeba representations using a small multiples technique
- Be able to grasp the movement data of many points

Data Exploration

https://www.youtube.com/watch?v=6qJWvnHvS2Y

Conclusion

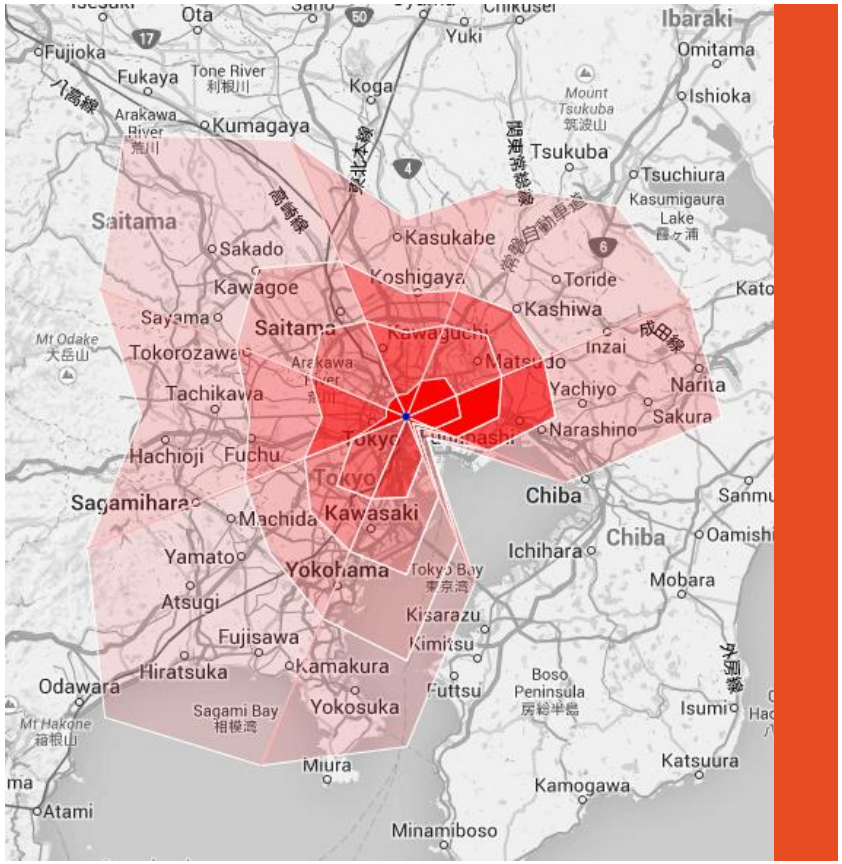
- We developed some methods that represent objects moving from arbitrary points in aggregate manner.
- These methods are overlaid on the map.

1. **Amoeba representation**
   - Represent the movement from one point by aggregate visualization
   - Represent the direction and distance of movement, and number of objects
2. **Amoeba colony representation**
   - Draw amoeba representations using a small multiples technique
   - Grasp of the movement data of many points is attained by comparing amoeba representations.

- Visualization which reduce the visual clutter was enabled by using the aggregate visualization method.

Acknowledgment

People flow data was provided by
Center for Spatial Information Science,
University of Tokyo



Directional Aggregate Visualization of Large Scale Moment Data

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Please ask questions slowly.

筑波大学

University of Tsukuba

Future work

- Evaluation of amoeba and amoeba colony representation by the user study
  - Does the visualization methods serve as a design suitable for reading the information on movement?
- More improvement for visibility of quartile position
  - When opacity is low, it is difficult to distinguish quartile positions by hue.

Future work

Evaluation

- Do the visualization methods serve as a design suitable for reading the information on movement?
- Make the task which makes a participant compare the animation, the atomic visualization and amoeba representation
  - Task that enumerate the information that can be read in each
  - Task that read instructed features
- What is the information which can be read in each?
  Isn't misunderstanding given the reader by amoeba representation?
- Whether it becomes easy to read the information which was hard to read by a atomic technique by amoeba representation.

The main point of research

Novelty

we Visualize large scale movement data in aggregate manner that paying attention to direction, distance and number of objects.

Usefulness

The statistical information of movement which arises from the arbitrary points on geography space can be read.

Technical development

In order to cancel a rise of the visual clutter degree which arises when two or more movements are visualized separately, the technique of visualizing the statistical information of movement was designed.

Contribution

Design the method of representing the large scale movement data in aggregate manner

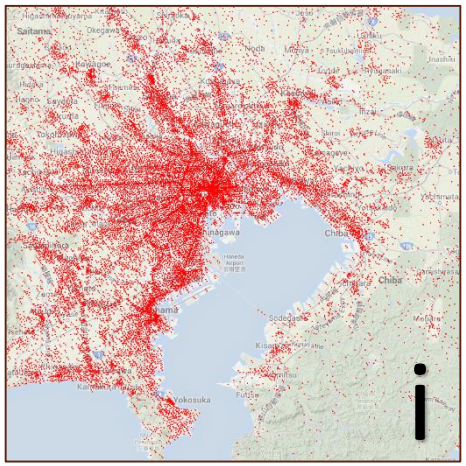
Formulation of movement data

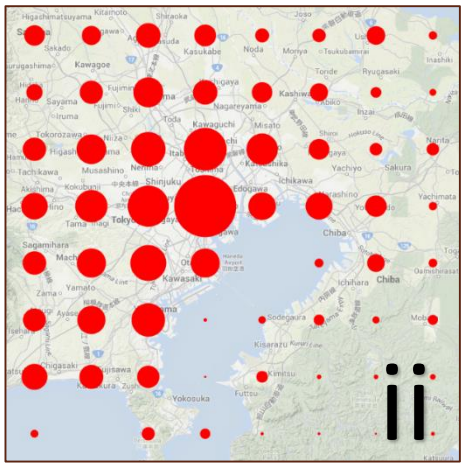
- A set of moving objects: $O = \{o_1, \ldots, o_n\}$
- Position of an object at time t: $p_o(t) \in R^2$
- We focus on the movement of the elements of O from time s to time t ($s < t$).
  - Start point: $p_o(s)$
  - End point: $p_o(t)$

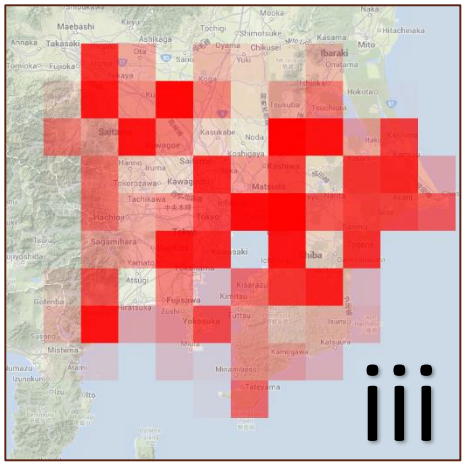
Large scale data visualization

- Shneiderman classified visualization methods of large scale data into three categories [Shneiderman, 2008].
  - i. **Atomic visualizations**
  - ii. **Aggregate visualizations**
  - iii. **Density plots visualizations**

  Our method classified ii. Aggregate visualizations.







People Flow Data

People flow data was provided by Center for Spatial Information Science, University of Tokyo

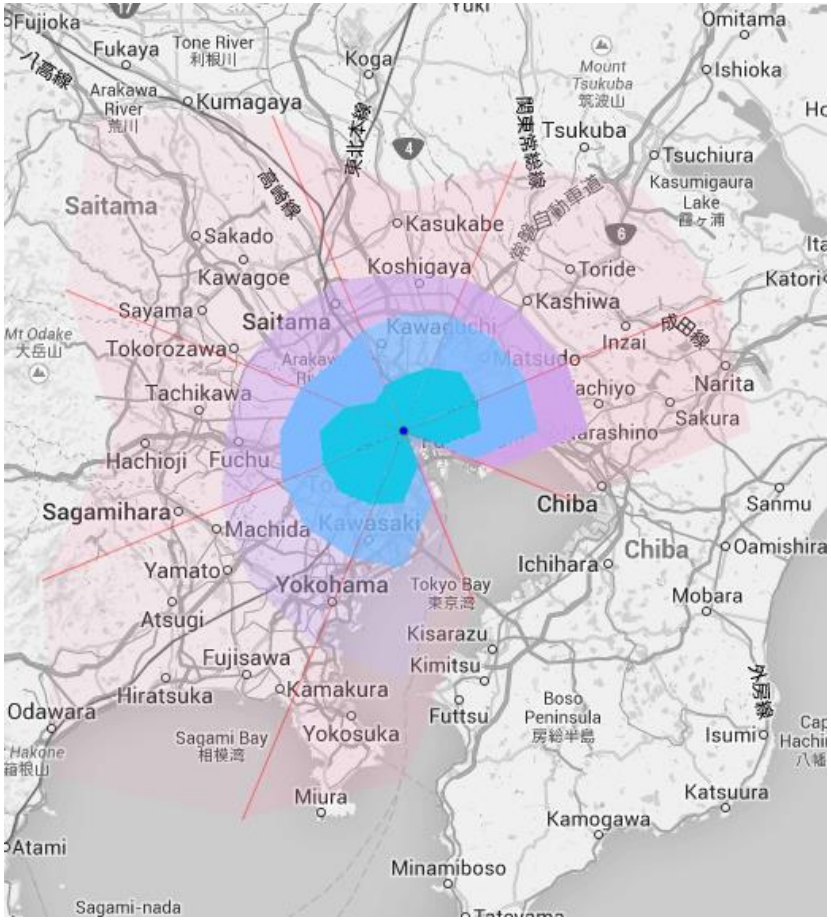
Area：	Tokyo metropolitan area
Subject number：	About 720,000 people (2% of the population of the area)
Date：	1998/10/01 00:00 am – 23:59 pm
Frequency：	Every minute
Source：	Tokyo metropolitan area transportation planning council・Kanto district maintenance office

Advantage of Amoeba Representation

- Naive visualization
  - It is difficult to observe objects that move within a short distance because of the overlapping of other lines
  - It seems to mainly indicate long distances
- Amoeba representation
  - It can be seen that movement in the south and southwest directions happens frequently because of opacity of the surface
  - The people appear to remain near the reference point

- In amoeba representation, the information which cannot be read by the atomic visualization was able to be read.

Improvement for Visibility of Quartile Position



- Changing the color of the surface for improving the visibility
- The four colors of the surface is the color having the same brightness for the human perception
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