08 People flow reconstruction based on anonymous sensor data

Estimating risk of infection in a city

Abstract

We can measure the risk of infection in a city by knowing the movement routes of infected people, but collecting information of people's movements infringes privacy. We thus propose a new method for estimating multiple routes on the basis of anonymized passage information to estimate the risk of infection while preserving privacy. For a better estimation, we need to choose more appropriate path patterns of people that correctly explain the anonymized passage information. Therefore, we consider a movement model, estimate the transit probability between passage information, and find the most likely set of routes efficiently on the basis of the model. It can improve the accuracy of the estimation. Infectious disease control will be one of functions of smart cities to be realized in the future.By using our work, the risk of infection can be estimated without collecting personal movement information.

Summary

Background

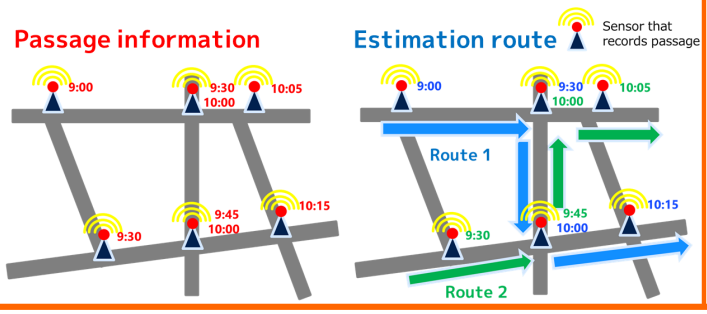
To prevent future outbreaks of infectious disease, we need to measure the risk of infection in urban areas. To do this, we want to know the movement routes of infected people. However, collecting information of personal movements infringes privacy.

Our Research

We estimate **multiple trajectories of infected people** on the basis of **anonymous passage information**.

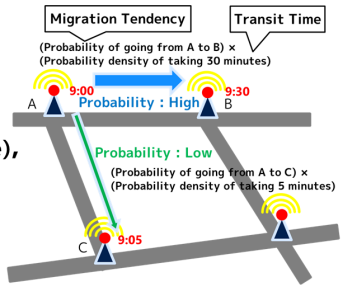
Framework

1. Deploy sensors at each intersection in a city and collect anonymous passage information (time, position, anonymous ID).
   (Anonymous IDs change regularly and people's movements can't be tracked.)
2. Determine if each passage information is from an infected person on the basis of anonymous ID, and obtain the list of infected people's passage information.
   (We don't know who correspond to each passage information.)
3. Estimate **multiple trajectories of infected people** by using the list of **anonymous passage information**.



Technical Points

Considering **movement model (migration tendency, transit time),** estimate **the transit probability** between passage information.



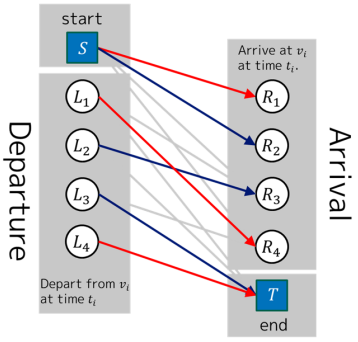
Technical Problem

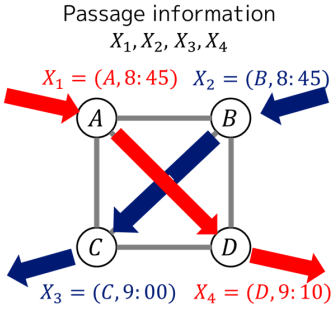
If many people are in the same place at the same time, there exists a huge number of candidates for a set of routes that explain the passage information. It is difficult to list and examine all the candidates.

Solution

The problem of finding **the most likely set of routes** can be efficiently solved by reducing it to **the minimum cost flow problem**.

By "Pass through A" = "Arrive at A"+"Depart from A ", it can be expressed as a problem of associating "Arrival" and "Departure". If we set the cost of associating "Arrival" and "Departure" as − log (transit probability), the problem of minimizing the sum of costs can be formulated as the minimum cost flow problem. The association that minimizes the sum of cost corresponds to the most likely set of routes.





References

[1] K. Matsuda, H. Ikeuchi, Y. Takahashi, T. Toyono, "People Flow Reconstruction Based on Anonymous Sensor Data toward Smart City Infrastructure for Estimating Infection Route," IEICE Technical Committee on Network Systems, 2020.

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