Automatic generation method for geographically accurate bus route maps from bus stops

Nagoya Institute of Technology

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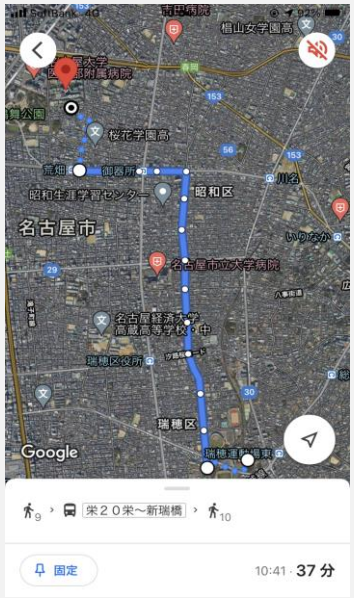
Resume of the presenter

- **Sogo Mizutani**

  - ***Career***
    - April 2017：Entered Nagoya Institute of Technology
    - April 2020：Assigned to Yamamoto Laboratory
    - April 2020： Entered graduate school at Nagoya Institute of Technology
  - ***Research***
    - Research is being conducted on the automatic generation of route maps.

Background (1/2)

- **Dissemination of web map services**
  - Such as Google Maps, OpenStreetMap.
  - Possible to draw a route map superimposed on it.

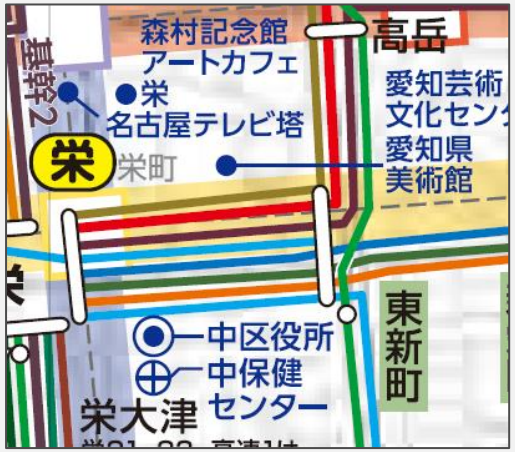


- **Dissemination of 「General Transit Feed Specification (GTFS) standard」**
  - Unified format for subways and local buses.
  - Data of timetable, coordinates of bus stops and connection relationships between routes.
  - Promoting the use of public transportation data and its multifaceted application.

Background （2/2）

- **Automatic generation of bus route maps**
  - Fewer studies on automatic generation of geographically accurate route maps compared to deformed route maps.
  - Geographically accurate route maps are drawn by hand, taking into account the order of placement that does not cause extra crossings.
  - A lot of time and effort is required to redraw every time a line is changed or discontinued.

deformed route map



geographically accurate route map

Purpose

- **Estimates route routing from stop coordinates and system data included in the GTFS.**
- **Automatic generation of highly visible and geographically accurate bus route maps from estimation results.**

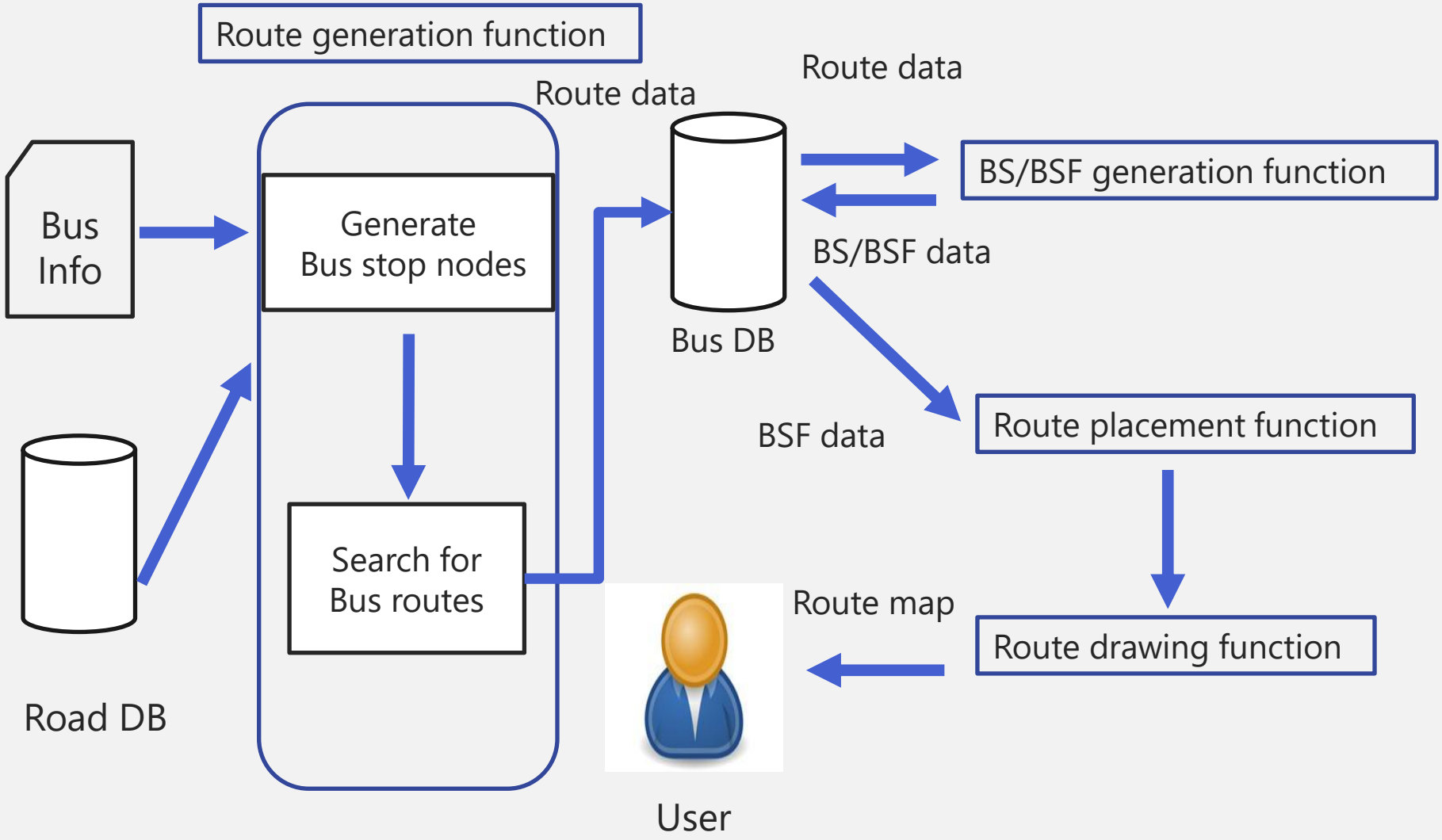
Issue

- **Route estimation requires linking stops to the road network.**
  - Latitude and longitude coordinates of bus stops in the GTFS indicate boarding and alighting points, whereas the road network consists of intersections and roads.
- **To improve the visibility of the route map, it is necessary to find the order of routes that minimizes intersections between routes.**
  - It is time consuming to do a brute force calculation for each road link.

Approach

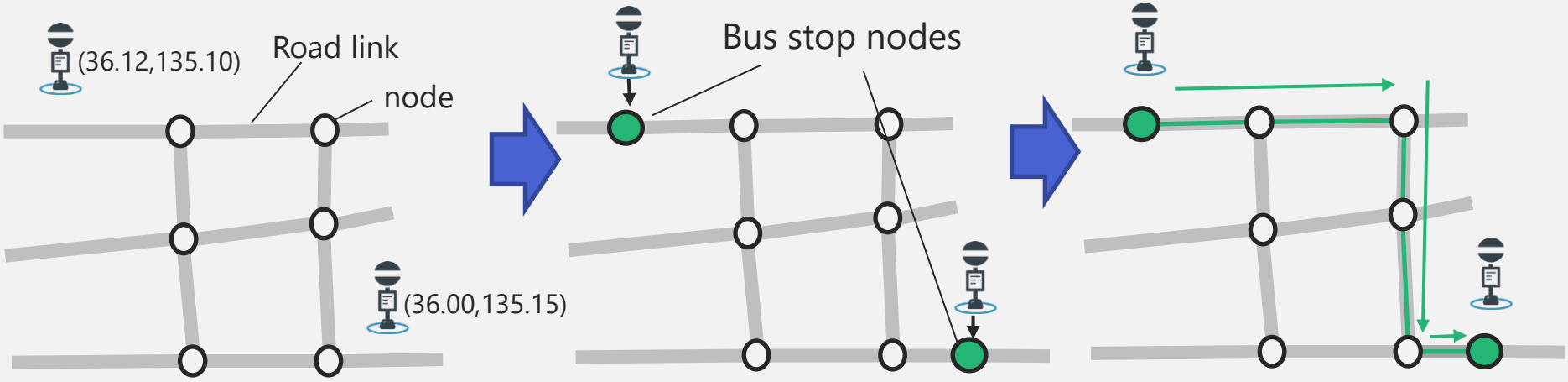
- **Route generation function**
  - Automatically estimates bus routes from the road network and the latitude and longitude coordinates of bus stops, then generates route data for bus routes.
  - At this time, routes are generated by avoiding expressways and other roads due to the characteristics of bus routes.
- **Bus stroke / Bus stroke fragment generation function**
  - Generate bus strokes that summarize the bus route in stroke (along the way) units.
  - Generate bus stroke fragments with multiple route overlap section information added to the bus stroke.
- **Route placement function / Drawing function**
  - Dynamically determine the order of placement of overlapping sections from bus stroke fragments to reduce the number of intersections between routes.
  - Shift overlapping sections based on the obtained placement order and draw them on the web map.

System configuration



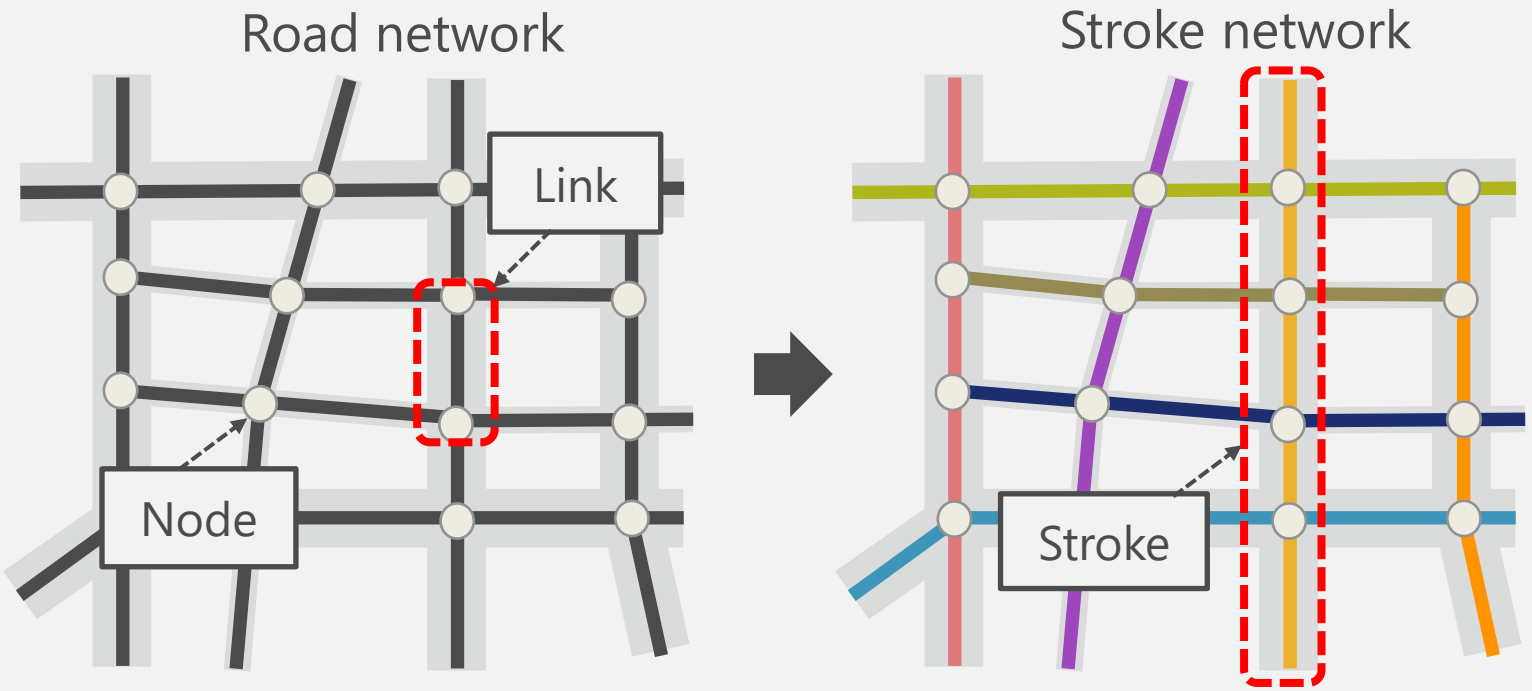
Route generation function

- **Estimates bus routes from the coordinate series of bus stops**
  - Generate a bus stop node at the point on the road closest to the coordinates of the bus stop.
    - ➢At this time, the type of road should be other than an expressway or a connecting road to an expressway.
- **Route estimation is performed between bus stop nodes by way-first search based on stop order data.**



input： Coordinates of bus stops　Generate bus stop nodes　Way-first search

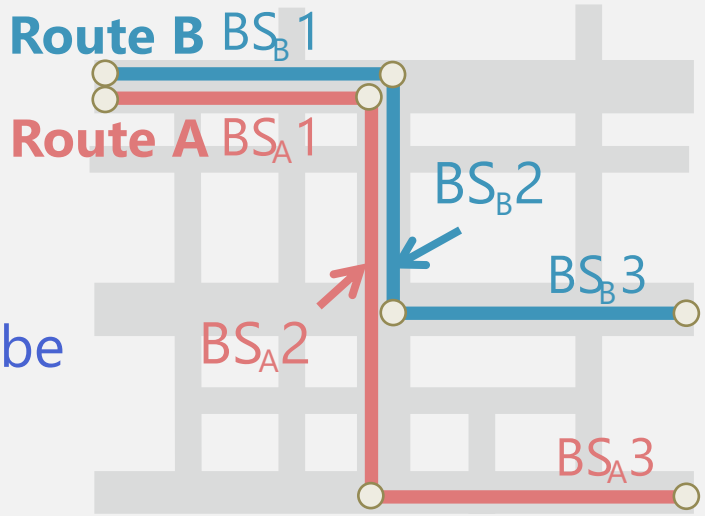
- **The stroke is a set of road networks grouped according to cognitive psychology.**
  - The stroke consists of a list of road links.



Bus Stroke（BS） ・Bus Stroke Fragment（BSF） generation function

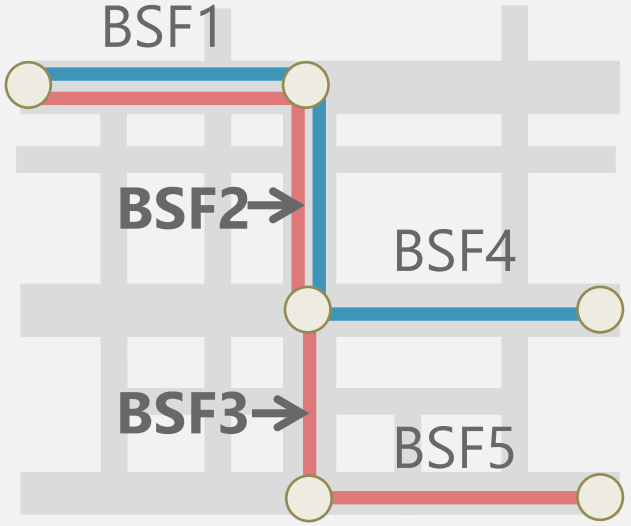
- **Bus Stroke（BS）**
  - BS indicates the section of a stroke that a route passes through on a single route.

⇒ By using strokes, fewer bus routes can be represented than by using link series.

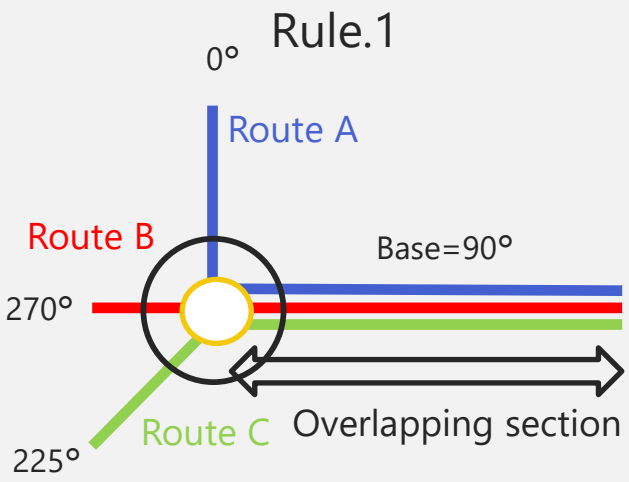


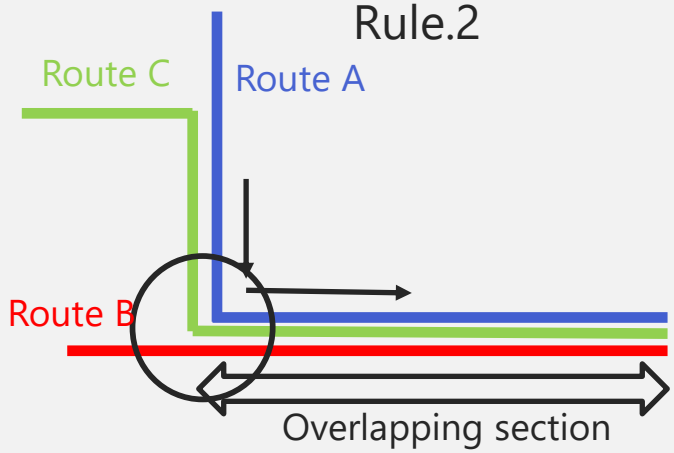
- **Bus Stroke Fragment（BSF）**
  - BSF indicates a section of a stroke that contains information on the overlap of multiple routes.
  - The BSF is generated by splitting the BS between overlapping and non-overlapping segments.

⇒ Minimize the number of combinations when determining the placement order.

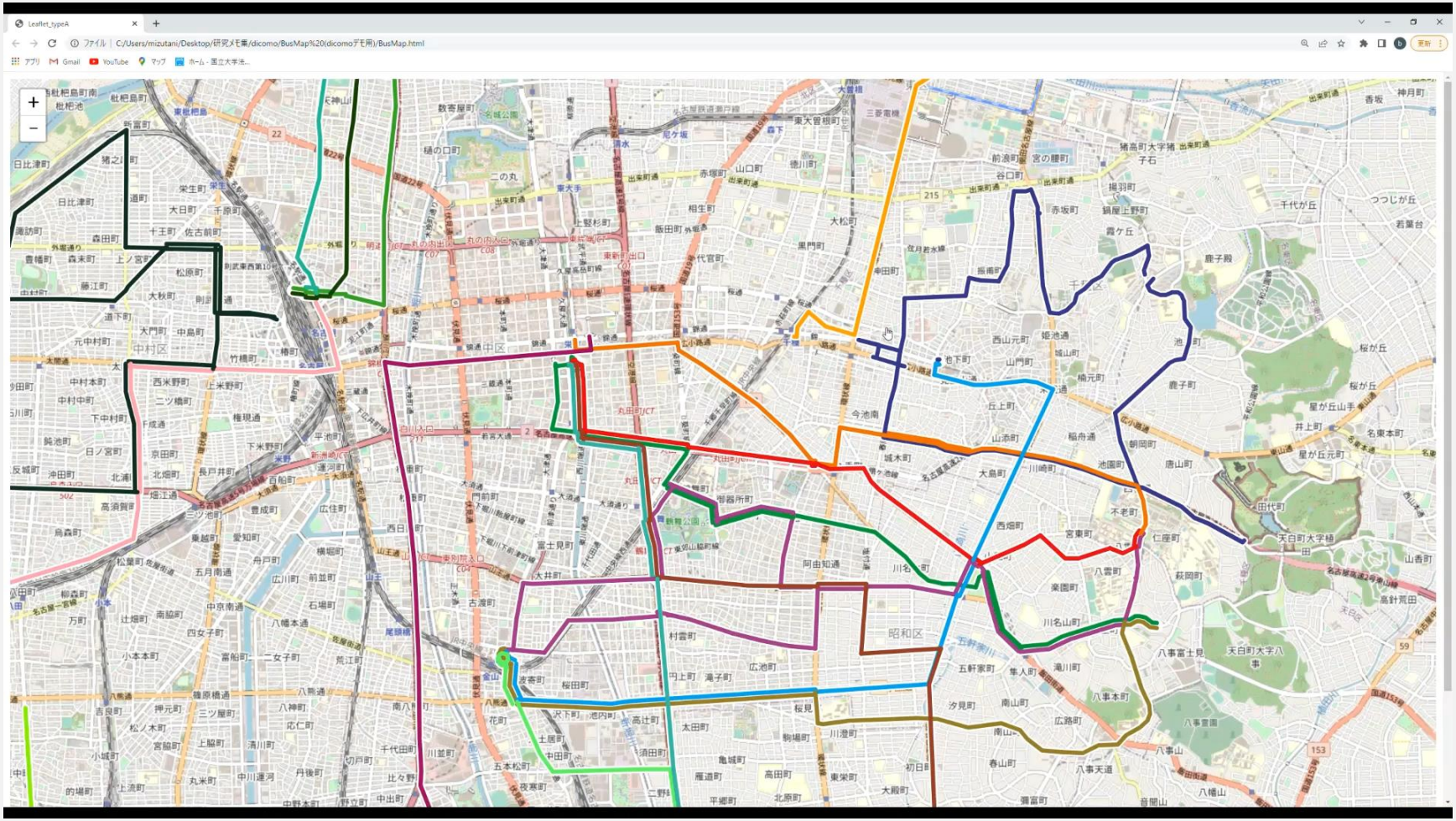


- **Two rules are applied to determine the placement order.**
  1. The placement order is determined based on the angle with the previous BSF.
  2. If the angle is the same as that of one previous BSF, go back to a BSF with a different angle.
- **Leaflet are used for drawing functions.**
  - The BSF is shifted using Leaflet Polyline Offset based on the obtained placement order, and the route map is drawn.





Demonstration

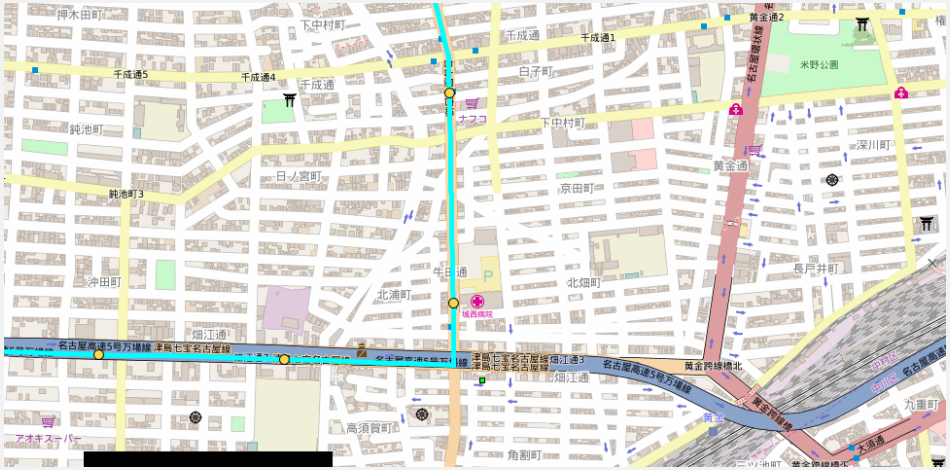


- **Purpose**
  - Verify the accuracy of route estimation using stop coordinates and road networks.
- **Method**
  - Verify the estimation accuracy of the proposed method
  - Comparison of 40 Nagoya City bus routes using Nagoya City Transportation Bureau Open Data.
- **Evaluation measure**
  - Agreement between actual route map and generated routes.

$$M = \frac{Number\ of\ muched\ routes}{Number\ of\ actual\ routes} \times 100$$

Results

- **Estimation accuracy**
  - **Estimation accuracy of the proposed method ：93.2%**



Proposed method

Actual routes

Summary

- Estimates route routing from stop coordinates and system data included in the GTFS.
- Drawing a bus route map with road strokes to account for intersections of multiple routes.
- Verified the accuracy of route estimation with the proposed method.

Future Issues

- To improve the visibility of route maps in drawing multiple routes.
- To enhance drawing of bus terminals and sections where many lines overlap.
- Acceleration algorithm for drawing all lines.