A Street Name-Based Summarization Method for Voice Navigation

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Information Engineering

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Background

- **Voice navigation systems have become increasingly popular.**

  ➤ Google Maps

  ➤ Turn-By-Turn style directions

  ⇒ **It has the disadvantage of a long voice navigation text if the number of left-right turns is large.**

- **Signage-type voice directions system**

  ➤ Mei-chan, Shaberu Bus Stop

  ➤ Allow users to **receive voice directions while viewing a route to the required destination on a map on a screen**
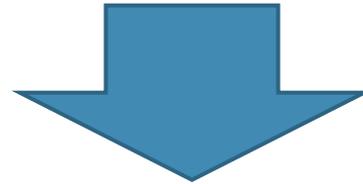
Shaberu Bus Stop

Shortest Path

Purpose of research

\<Objective>

To realize a summary of spoken directions that also provides a geographic image of the route to the destination

In order to achieve
the above objectives, …

\<Way of thinking>

➢ **Generate an easy-to-understand route that is not necessarily the shortest route, but is suitable for summarization**

➢ **Summarize the route so that the voice direction fits within the specified number of characters**
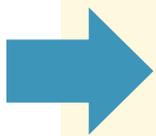
Approach

In this study, we adopt the following three approaches.

- ✓ **Using the n-Min Stroke Shortest Path(n-MSSP) algorithm**

  ⇒ **Generate multiple candidate routes with fewer right/left turns**

- ✓ **Simplify the routes based on street names, Generation of guidance text**

  ⇒ **Realization of concise guidance based on the main points of the route**

- ✓ **Based on evaluation formulas that indicate the degree of the route**

  ⇒ **Determining the best route for the user and its guidance text**

◎ **Realization of guidance text summarization**

➡ **Realization of pedestrian navigation and more advanced digital signage-based system**

The configuration of the proposed system

n-Min Stroke Shortest Path Search

input : departure point, arrival point
output : a set of the n-MSSP routes

Simplification of route candidates
1. Street-based path simplification
2. Vertex-based path simplification
   (when 1 is insufficient)

input : a set of the n-MSSP routes
output : a set of simplified routes

Generation of guidance text according to the character limit

input : a set of simplified routes
output : a set of simplified routes,
         a set of summarized guides

Determining the optimal route and guidance text based on the evaluation formula

input : a set of simplified routes,
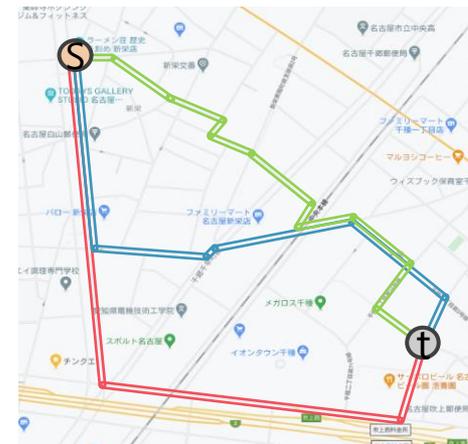   a set of summarized guides
output : the optimal path, its guide

<u>A method to search for multiple candidate routes</u>

<u>with fewer left and right turn than the shortest route</u>

- **1-MSSP**
  - **the shortest path among the paths with the fewest number of left or right turns between two points.**

- **n-MSSP**
  - **the path with the smallest amount of left or right turns among the paths shorter than the [n-1]-MSSP route**

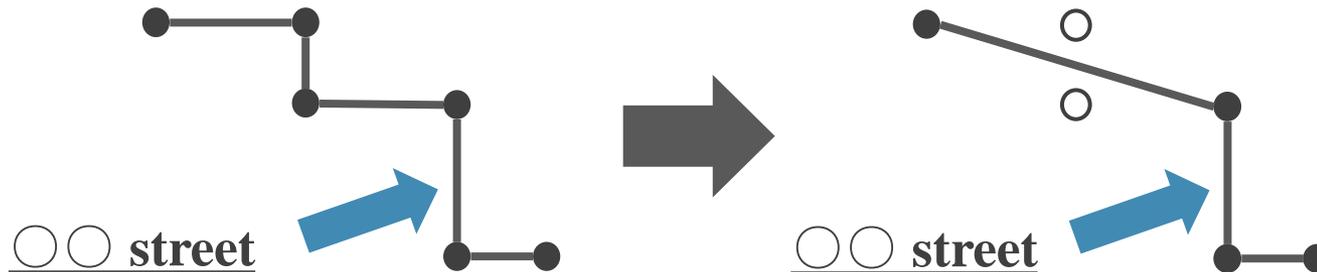| n-MSSP	distance	Number of left and right turns
1	1.3	2
2	1.2	5
3	1.1	8

Example of n-MSSP
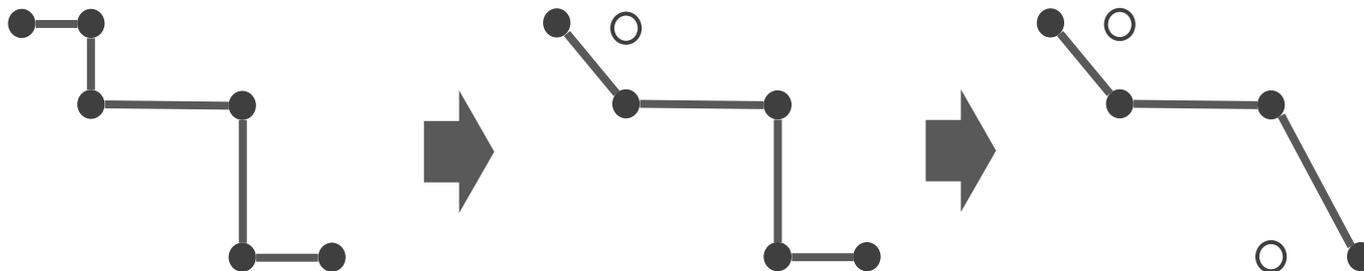
Simplification of route candidates

1. **Street-based path simplification**
   - ➤ **Simplify routes by using major roads with street names as key points**

2. **Vertex-based path simplification**
   - ➤ **Use the Visvalingam-Whyatt algorithm to simplify a path by reducing the number of vertices on the guided path one by one**

\<Preprocessing>

Create 5 sentence components and set values based on the analytic hierarchy process for each of the bottom 4

- ✓ "minimum information"
- ✓ "time required", "total distance", "distance", "turning point"

\<Basic Policy>

1. First, the guide text is composed only of "minimum information"
2. Seek a combination that maximizes the sum of values under the condition that the word limit is satisfied

   ⇒**Reduced to the 0-1 knapsack problem, where "number of characters = weight"**

Value setting using analytic hierarchy process

A is more
important than B.

A is as
important as B.

B is more
important than A.

9   7   5   3   1   1/3   1/5   1/7   1/9

B

	Total distance	Time required	Distance	Turning point	Geometric mean	Weight
A — Total distance	1	1/3	1/9	1/9	$\sqrt[4]{1 \cdot \frac{1}{3} \cdot \frac{1}{9} \cdot \frac{1}{9}} \approx 0.25$	$\frac{0.25}{6.46} \approx 0.04$
Time required	3	1	1/5	1/7	$\sqrt[4]{3 \cdot 1 \cdot \frac{1}{5} \cdot \frac{1}{7}} \approx 0.54$	$\frac{0.54}{6.46} \approx 0.08$
Distance	9	5	1	1/3	$\sqrt[4]{9 \cdot 5 \cdot 1 \cdot \frac{1}{3}} \approx 1.97$	$\frac{1.97}{6.46} \approx 0.30$
Turning point	9	7	3	1	$\sqrt[4]{9 \cdot 7 \cdot 3 \cdot 1} \approx 3.70$	$\frac{3.70}{6.46} \approx 0.57$
				Sum	6.46	1

☐ **Evaluation equation $E_i = A_i B_i + \omega \times (C_i + D_i)$**

➤ A_i : **how well the route is expressed, and it concisely captures the main points of the route**

➤ B_i : **how much of the guide text is summarized in the parts that are not related to the main parts of the route**

$\Rightarrow \underline{A_i \times B_i : \textbf{how precisely and clearly the guidance text is expressed}}$

➤ ω : **a small value**

➤ $C_i = \frac{c_i - \bar{c}}{\sigma_c}$ (**Standardization**)

  ✓ c_i : **reciprocal of the number of the left and right turns**

  ✓ $\bar{c}$: **Average** c_i

  ✓ σ_c : **Standard deviation of** c_i

➤ $D = \frac{d_i - \bar{d}}{\sigma_d}$ (**Standardization**)

  ✓ d_i : **Reciprocal of distance**

  ✓ $\bar{d}$: **Average** d_i

  ✓ σ_d : **Standard deviation of** d_i

$\Rightarrow \underline{C_i + D_i : \textbf{how well balanced the number of eight and left turns and distances are}}$

Evaluation Experiment

- **Purpose**
  - Verification of the effectiveness of the summarization method used in the proposed method
- **Subject**
  - 12 students from Nagoya Institute of Technology

- **Method**
  - Generated directions and map images were presented to the subjects.
  - The accuracy of subject route recall was analyzed.
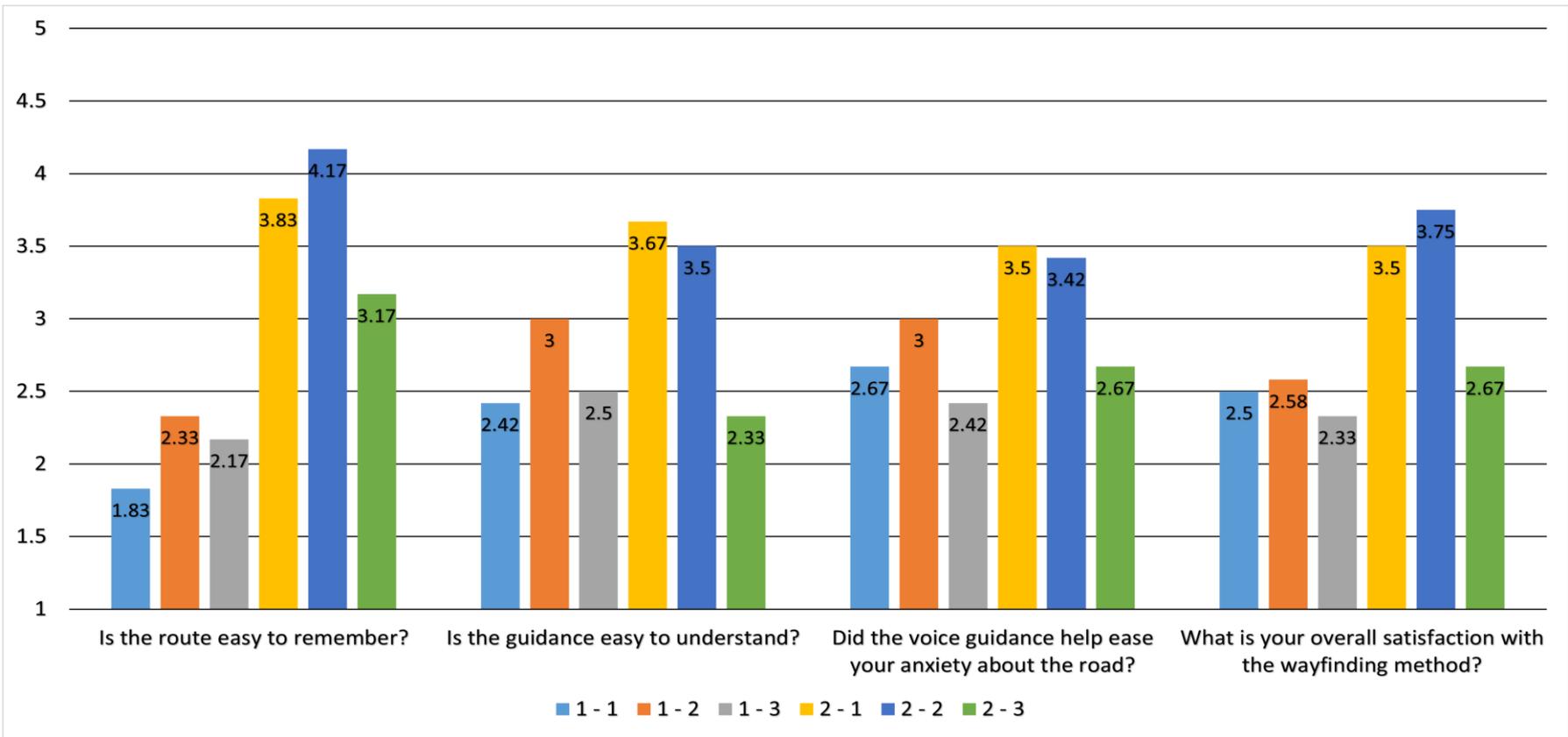 - A 5-step questionnaire survey was conducted.

Evaluation target

	Path search	Simplification method	Word count
1-1	**Shortest path**	**No summary**	**-**
1-2	**Shortest path**	**Vertex based simplifier (Proposed method 1)**	**40**
1-3	**Shortest path**	**Street based simplifier (Proposed method 2)**	**40**
2-1	$\left\lceil \frac{n}{2} \right\rceil$**-th n-MSSP**	**No summary**	**-**
2-2	$\left\lceil \frac{n}{2} \right\rceil$**-th n-MSSP**	**Vertex based simplifier (Proposed method 1)**	**40**
2-3	$\left\lceil \frac{n}{2} \right\rceil$**-th n-MSSP**	**Street based simplifier (Proposed method 2)**	**40**

- $\left\lceil \frac{n}{2} \right\rceil$**th n-MSSP**
  - The [n/2]th n-MSSP is the [n/2]th path obtained by the n-MSSP algorithm.

Questionnaire result of evaluation experiment 1

Vertex-based path simplification(1-2, 2-2) was highly evaluated compared to Street-based path simplification(1-3, 2-3).

⇒ **Route simplification that combines street names and the vertices may be a better summarization method.**

Summary and Future issues

● Summary

➢ Generation of multiple route candidates with a small number of left / right turns in stages using the n-MSSP algorithm

➢ Simplification of the guidance route based on the street name, which is the main point of the voice guidance text

➢ Evaluation of the optimum route by an evaluation formula showing the degree of summarization of the guide text and the route

● Future issues

➢ Implementation of a new summarization method that better combines vertex- and street name-based summarizations

➢ Improved map drawing that emphasizes key elements of the route