Ambient BLE Sensing and Shared Gamified Displays for Encouraging Outings and Social Interaction among Older Adults

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Abstract. Rapid population aging has heightened concerns about social isolation, reduced physical activity, and cognitive decline among older adults. In Japan, the increase in nuclear households and single-person residences has led many older adults to limit daily outings, increasing risks of frailty and dementia. Encouraging regular outings while creating opportunities for casual social interaction in everyday living environments is therefore an important challenge. This paper proposes and evaluates an outing and social interaction support system for older adults in residential communities. The system integrates low-cost BLE sensing, ambient infrastructure, and gamification to promote voluntary outdoor activity without requiring continuous smartphone use. It consists of a portable BLE scanner tag, a BLE-based location estimation module, a flowerbed cultivation application, and shared digital signage installed in common spaces. The BLE scanner tag passively collects surrounding signals, enabling outing histories to be recorded with minimal user burden. User movement is estimated using a fingerprinting-based method that leverages ambient BLE signals from existing devices. Estimated movement data drives a gamified visualization in which virtual flowerbeds grow based on walking behavior and visited locations, encouraging shared viewing and interaction. Field experiments and a preliminary user study indicate that five out of six respondents thought the system "looks fun," and four out of six "want to continue using it," and many also said that "it is easy to operate," suggesting that the system is highly compatible with the elderly. This result suggests the system has the potential for promoting active and socially connected aging.

Keywords: Elderly · Outing promotion · Gamification · Bluetooth Low Energy.

1 Introduction

Japan's rapidly aging population has led to smaller household structures and increased separation between generations, resulting in a growing number of older adults living alone. This social shift has made isolation a serious concern, particularly as many older adults have lost the habit of going out. The COVID-19 pandemic further accelerated this trend, and surveys have reported a marked decline in outing frequency among older adults even after restrictions were lifted. In recent years, social withdrawal among middle-aged and older adults in Japan has also increased. Such withdrawal not only reduces opportunities for physical activity and social interaction but is also associated with higher risks of frailty and cognitive decline. National surveys indicate that participation in work, community events, hobbies, and other social activities decreases with age, highlighting the need for interventions that support continued engagement in daily life. Reduced outings and social interaction contribute to frailty, a condition characterized by age-related physical and mental decline that can significantly lower quality of life and increase the risk of dementia. Preventing frailty requires maintaining healthy lifestyles and encouraging regular physical activity and social participation. To this end, creating opportunities that motivate older adults to go out and interact with others in their daily environments is essential.

This study focuses on residents of housing complexes for older adults and aims to promote voluntary outings and activate social interaction among residents. We propose an outing support system that combines a BLE-based location estimation method with a gamified application centered on digital flowerbed cultivation. Residents carry a small BLE scanner tag that passively records surrounding BLE signals during outings. Location is estimated by comparing collected signals with pre-recorded reference data to identify visited areas and movement ranges.

Based on these data, a flowerbed cultivation application visualizes residents' activity on shared digital signage installed in common spaces. Walking and visiting locations cause virtual flowers to grow, providing motivation for outings and opportunities for shared viewing and conversation. Field experiments demonstrated that the proposed method enables coarse-grained but meaningful location estimation, while a preliminary user study suggested that the system is enjoyable, easy to use, and capable of motivating older adults to go out.

2 Related Work

This section reviews representative studies related to this work. We first summarize prior efforts to promote physical activity and reduce social withdrawal among older adults, including community-based initiatives and technology-mediated interventions. We then review gamification and mobile-application approaches for motivating outings and sustaining engagement, as well as systems that support social participation. Finally, we discuss research using BLE/IoT technologies for activity support and monitoring, and clarify the positioning of this study.

2.1 Health Promotion, Outing Motivation, and Social Participation Support

In Japan, national and local governments have promoted initiatives that encourage social participation among older adults. For example, the Cabinet Office has recognized organizations that support “ageless life” practices, which emphasize active and independent living regardless of age [2]. Community-based activities, such as local meeting spaces and gardening groups, have been reported to foster social ties, provide a sense of purpose, and contribute to participants’ physical and mental well-being [21, 28]. These initiatives highlight the importance of shared activities and community spaces in supporting healthy aging, although many rely on sustained human facilitation and are difficult to scale.

Alongside these initiatives, research has increasingly explored technology-based approaches to promote physical activity and outings. With the widespread adoption of smartphones, gamification and mobile applications have been used to motivate walking and improve adherence [6]. Prior work indicates that gamified interventions can increase walking behavior by combining digital feedback with behavioral nudges [12]. Walking games designed for older adults have also been proposed to encourage exploration and group-based activities, and evaluations suggest positive effects on physical activity and engagement [23]. Moreover, competitive gamification has been shown to significantly increase physical activity levels in large-scale randomized trials [17]. Commercial applications such as *Pikmin Bloom* similarly demonstrate how walking-based gamification can motivate daily movement by visualizing activity through virtual growth [16]. However, many of these approaches are primarily smartphone-centered and tend to support individual experiences, offering limited opportunities for face-to-face interaction in real-world settings.

Mobile applications have also been studied as a means to promote social participation among older adults. Randomized controlled trials have shown that such applications can increase the frequency of social activities, particularly participation in hobbies and cultural groups [8, 5]. At the same time, sustaining effects over time can be challenging due to reduced novelty, and many systems implicitly assume a certain level of smartphone literacy. Consequently, their applicability may be limited for older adults who are reluctant to use or carry smartphones on a daily basis.

2.2 BLE/IoT-Based Support Systems for Older Adults

BLE and IoT technologies have been applied to support physical activity and monitoring among older adults. Prior work has proposed mobile systems using BLE beacons and NFC tags to encourage exploration in public spaces [7], as well as community-based monitoring systems for people with dementia using BLE sensors and smartphones [15]. Large-scale field trials using wearable tags and ICT have also suggested that point-based mechanisms can motivate outings and create communication opportunities [24, 25]. However, many of these approaches require dedicated infrastructure, volunteer participation, or smartphone-based applications, which increases deployment cost and limits scalability. These constraints make it challenging to apply such systems in everyday residential environments.

2.3 Positioning of This Study

Existing studies often assume continuous smartphone use, provide limited opportunities for in-person social interaction, or require costly sensing infrastructure. In contrast, this study addresses these limitations by proposing a low-cost outing support system that leverages portable BLE scanner tags and ambient BLE signals without relying on smartphones. By evaluating the system in residential complexes with a high population of older adults, this work demonstrates the feasibility and generality of a practical approach to promoting outings and social interaction in real-world living environments.

3 Proposed Method

Here, we summarize the system requirements and proposes a system that satisfies them.

3.1 Outing and Social Interaction Support System

System Requirements The system requirements for deployment in a housing complex with a high proportion of older residents are as follows:

1. A system that is easy to use and imposes minimal burden, even for older adults who find it inconvenient to carry a smartphone at all times
2. Reduced cost of the devices distributed to residents
3. A design that is enjoyable and supports habit formation for regular outings
4. A mechanism that encourages social interaction among residents

Although smartphones are widely used, some older adults still perceive them as heavy or inconvenient to carry. Therefore, the system should rely on a small and lightweight device. Because the system needs to be distributed to many residents, the device should also be inexpensive and readily available.

In addition, interventions for promoting outings and social interaction often show short-term effects that are difficult to sustain. Incorporating game-like elements such as collecting and growing items can provide a concrete purpose for going out and help maintain engagement. Based on this idea, we propose a system that allows residents to share the items they obtained through outings in a common place, making the experience enjoyable and easier to continue while also facilitating interaction among residents.

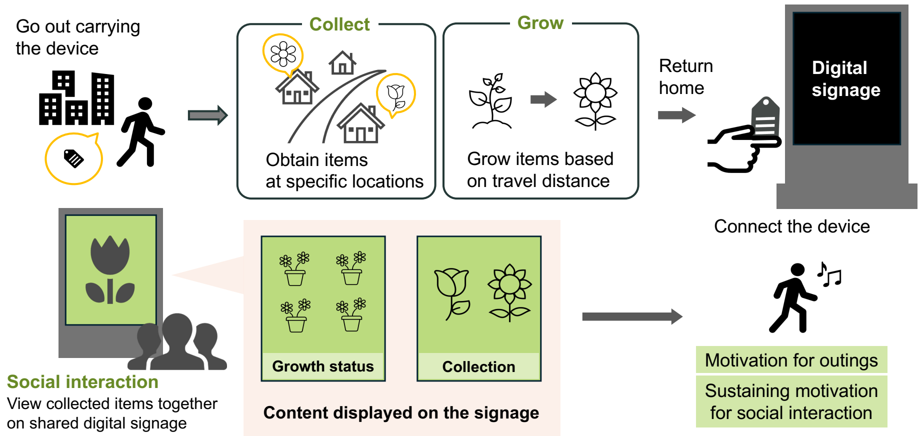

Fig. 1. Overview of the proposed system

System Overview Based on the requirements described in Section 3.1, we propose a system that promotes outings and social interaction among older adults living in a housing complex. An overview of the proposed system is shown in Fig. 1. The system uses a BLE scanner tag and shared digital signage: residents walk in the surrounding area and "collect" virtual flower seeds via the BLE scanner tag, thereby encouraging walking and outings.

The proposed system consists of (i) a location estimation method that records outing behavior by estimating visited locations and travel distance using a device distributed to residents, and (ii) an application that visualizes residents' outing records using gamification to motivate continued participation. Section 3.2 describes the location estimation method, and Section 3.3 describes the flowerbed cultivation application.

3.2 Proposed Location Estimation Method

The proposed location estimation method records residents' outing behavior. Residents are provided with a BLE receiving sensor (hereafter, the sensor) that collects data during outings. Using the data gathered by the sensor, reference data are constructed and used for location estimation. This section describes the requirements and overview of the method as well as the experiments conducted.

Related Work on Device-Based Indoor/Outdoor Localization This subsection reviews prior localization methods using short-range wireless technologies such as BLE. For outdoor localization, GPS (Global Positioning System) is commonly used [1]. As GPS is often built into smartphones, it provides an accessible way to obtain location information. There are also many small GPS-equipped devices for safety monitoring of older adults and children [9, 19]. While GPS can provide high accuracy outdoors, it consumes substantial power; therefore, this study adopts BLE as a low-power alternative.

For BLE-based localization, research has explored several approaches, including fingerprinting, proximity-based methods, and trilateration using received signal strength indicators (RSSI) [20, 4, 3]. Many systems estimate relative positions based on RSSI between fixed anchor devices and a mobile observing device. As an example of proximity-based methods, Kudou et al. [10] proposed a real-time indoor localization method that identifies the nearest beacon using statistical hypothesis testing over RSSI values collected in a time window. Because RSSI thresholds can vary across devices and fluctuate when multiple beacons are present, they used statistical testing to mitigate instability. For fingerprinting-based indoor localization, Pu et al. [18] proposed an effective location fingerprinting algorithm based on a weighted kNN method. In the training phase, RSSI patterns are recorded for each grid cell, and in the test phase, similarity is computed between an observed RSSI pattern and the stored fingerprints to estimate location. Although high accuracy was reported, the study assumed fixed receiving positions, and performance with a mobile receiver was not examined.

BLE has also been used for outdoor localization. Sun et al. [22] proposed a BLE-based outdoor localization method for small areas using a double-reflection model and formulated localization as an optimization problem that minimizes RMSE between measured and estimated RSSI. Their method achieved high accuracy without additional hardware such as AoA/ToF, and without requiring a large fingerprint database, using optimization algorithms such as MFASA. However, their results were shown only in simulation, and evaluation under real-world conditions with obstacles and radio interference was not conducted.

Requirements of the Location Estimation Method The requirements for the proposed location estimation method are as follows:

1. A system that is easy to use and imposes minimal burden on older adults
2. Reduced cost of distributed devices
3. Reduced installation cost of BLE transmitters used for localization

Because residents must carry the device whenever they go out, we designed a lightweight device that is easy to carry. To minimize burden, we also eliminated any operations required during outings, so residents can use the system simply by carrying the device.

As described in Section 3.1, we estimate residents' locations using BLE (Bluetooth Low Energy) signals. The method leverages ambient BLE signals emitted from nearby facilities. Many existing approaches install dedicated BLE transmitters and estimate location based on received signal strength; however, transmitter installation and associated administrative costs make real-world deployment difficult. Therefore, we reduce installation cost by utilizing BLE signals already present in the environment.

Overview of the Location Estimation Method Based on the system requirements in Section 3.1, an overview of the proposed method is shown in Fig. 2. We collect BLE signals emitted by devices installed in surrounding environment (e.g., shops, residences, and public facilities) and use these data for outdoor localization, demonstrating the feasibility of the approach [26]. Among RSSI-based localization approaches (e.g., fingerprinting, proximity, and trilateration), this study adopts fingerprinting due to its relatively high estimation performance. In fingerprinting, the target area is divided into grid cells, and RSSI values from nearby BLE transmitters are measured in advance for each grid. The system then finds the grid whose RSSI characteristics are most similar to the observed measurements and outputs its coordinates as the estimated location.

The localization procedure consists of two phases: a reference-data construction phase and a test phase. In the reference phase, the system collects signal strengths and transmitter addresses and constructs reference data that represent the characteristics of each grid. In the test phase, the similarity between newly observed BLE data and the reference data is computed to estimate the BLE scanner tag's location. In this study, we operated the system in outdoor environments and estimated the BLE scanner tag's location at regular intervals during outings.

In the following, we explain how the reference data are constructed and describe the BLE data-sensing device used in our experiments around NAIST.

Construction of Reference Data for Localization Fig. 3 illustrates the procedure for constructing reference data. We first collect BLE signals within the area where residents typically move. The collected information includes BLE BD address, RSSI, timestamp, and location (latitude and longitude). The area is divided into multiple grid cells with uniform spacing, and the BD addresses and RSSI values obtained in each grid are aggregated. When the same BD address is observed multiple times within a grid, the mean RSSI is used.

During data collection, dynamic BLE sources (e.g., signals emitted by pedestrians' devices or passing vehicles) may be included. Because the proposed method uses continuously observable BLE signals as the basis for localization, such dynamic data should be removed. We therefore extract BD addresses that are repeatedly detected across scans (hereafter, *common addresses*) and use them to construct the reference data. The reference data are organized with common addresses and RSSI values as columns. Common addresses are listed in alphabetical order; if an address is observed in a grid, the corresponding RSSI is stored, and if not observed, an RSSI value of 0 is assigned. We also apply a threshold to RSSI values and treat values below -90 dB as not observed due to weak signals. This preprocessing yields reference vectors for each grid. Grid size presents a trade-off: smaller grids can improve estimation accuracy but increase computational cost. Prior work on BLE-based fingerprinting commonly adopts grid sizes of approximately 2–5 m [11], whereas outdoor wide-area fingerprinting often uses grid sizes of 10 m or larger [27]. Because our system targets wide-area outdoor localization, we set the grid size to 10 m or more.

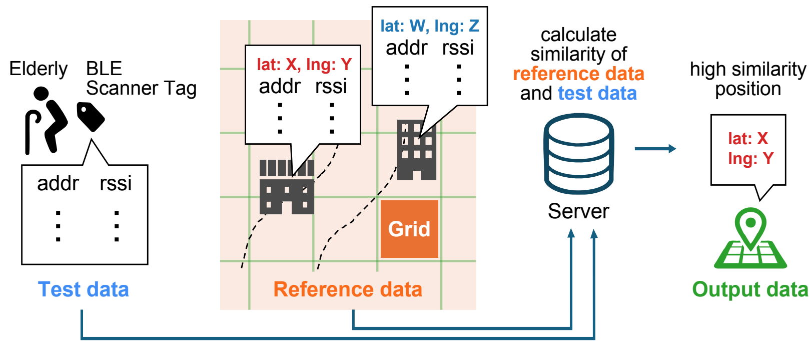

Fig. 2. Location estimation method

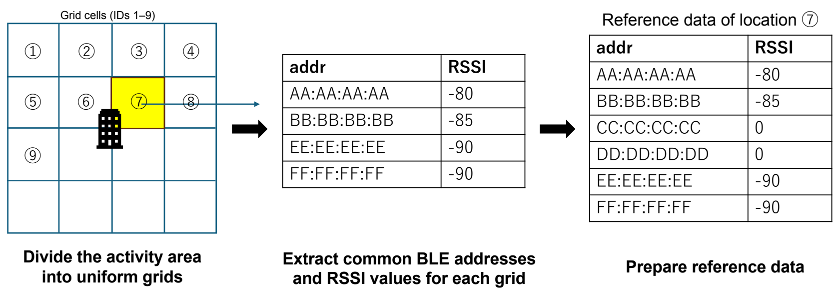

Fig. 3. Procedure for constructing reference data

Location Estimation The location estimation procedure is shown in Fig. 4. As input, we use the data excluded from the reference-data construction for the test phase. The test data are organized based on the set of common addresses, producing vectors with the same address/RSSI structure as the reference data (hereafter, *estimated data*). We then compute similarity between the reference data and the estimated data. After computing similarities for all reference grids, the location information of the most similar reference grid is output as the estimated location.

Similarity between vectors is computed using cosine similarity based on RSSI values. Let the RSSI vector of the estimated data and that of the reference data be represented by Eqs. (1) and (2); then the similarity is computed by Eq. (3):

$$\mathrm{RSSI}_{\mathrm{test}} = (\, x\,)_1\, x_2 \cdots x_n^T \tag{1}$$
$$\mathrm{RSSI}_{\mathrm{ref}} = (\, y\,)_1\, y_2 \cdots y_n^T \tag{2}$$
$$\mathrm{Similarity} = \frac{\sum_{k=1}^{n} x_k y_k}{\sqrt{\sum_{k=1}^{n} x_k^2}\sqrt{\sum_{k=1}^{n} y_k^2}} \tag{3}$$

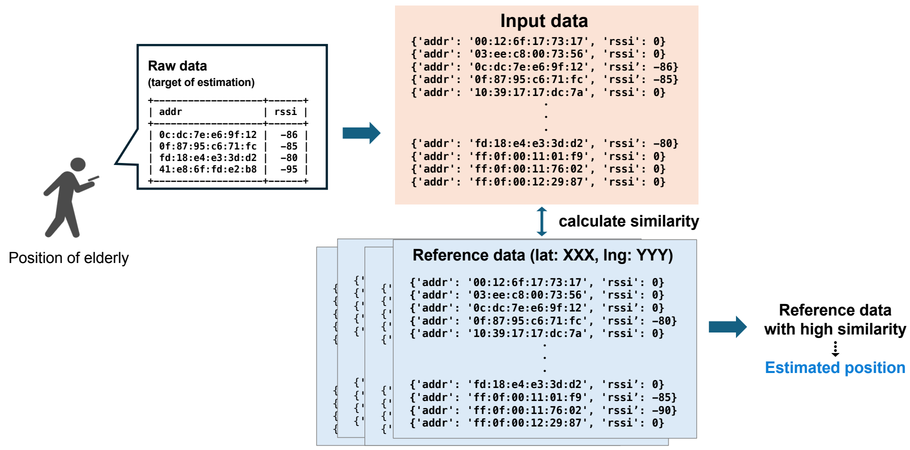

Fig. 4. Steps of the location estimation procedure

3.3 Flowerbed Cultivation Application

This section describes the implementation of a flowerbed cultivation application that uses gamification to encourage voluntary outings in an enjoyable manner. The application is a web-based system running on Windows-based digital signage and is implemented in TypeScript.

Requirements of the Flowerbed Cultivation Application The requirements of the application are as follows:

1. Residents enjoy going out
2. Motivation for outings is sustained over time
3. Social interaction among residents is encouraged

Encouraging voluntary outings requires an initial trigger, and promoting interaction among residents requires a place where residents can naturally gather and communicate. Therefore, we propose an application in which residents collect and grow items by walking with a BLE scanner tag, thereby supporting habitual outings, and share their collected items with other residents to facilitate social interaction. To allow residents to check their items, we install digital signage in a shared space of the housing complex and use it as a new place for interaction.

Fig. 5 shows the user interface of the application. The left side of Fig. 5 is the standby screen. The signage remains in this state most of the time; when a resident connects a BLE scanner tag upon returning home, the display transitions to the flowerbed screen shown on the right.

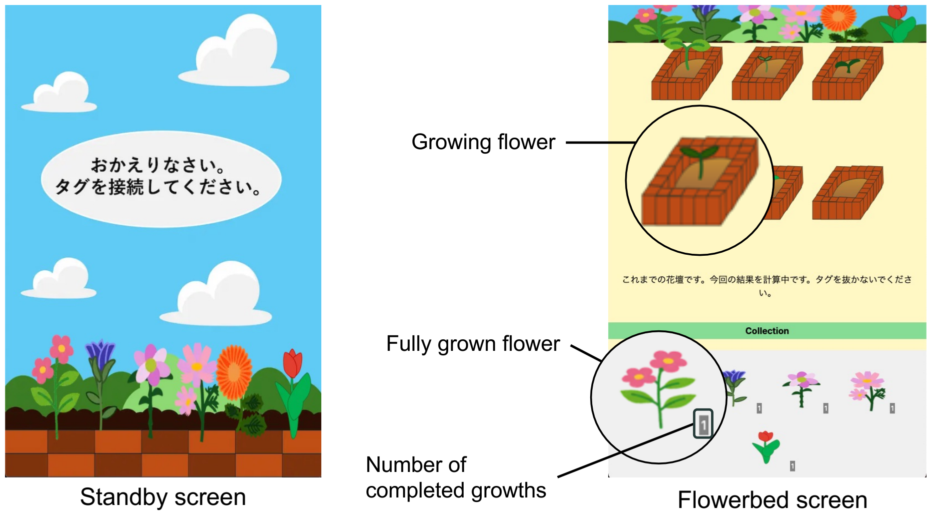

Fig. 5. Application user interface

We selected digital gardening as the theme because gardening has recently become a popular hobby among older adults[4]. In this application, residents collect flower seeds by visiting specific locations, and flowers grow according to travel distance. Residents carry the BLE scanner tag during daily outings and, after returning home, connect it to the digital signage to view the growth status of their flowerbed.

Design of the Flowerbed Cultivation Application Fig. 6 illustrates the flow from bringing the BLE scanner tag close to the signage to visualizing the resident's data. The application updates a flowerbed database (hereafter, the flowerbed DB) using the movement records computed by the location estimation method described in Section 3.2. The flowerbed DB stores the types of flowers and growth stages for each resident.

When a resident connects a BLE scanner tag to the digital signage, a JSON file containing the BLE data collected by the scanner is transferred to the signage. The location estimation method then estimates locations from the JSON file, and the results are reflected in the flowerbed DB. Once the DB is updated, the flowerbed screen is updated accordingly.

Fig. 7 illustrates how the flowerbed changes with growth. In this example, a new flower is added because the participant visited a specific spot, and existing flowers grow by one stage because the participant traveled 1 km. The predefined spots were selected by investigating residents' typical routes during the data collection described in Section 4.1, and six locations were designated. The system includes six flower types and six growth stages.

[4] `https://www.nttpub.co.jp/book/detail/9784757104051/`

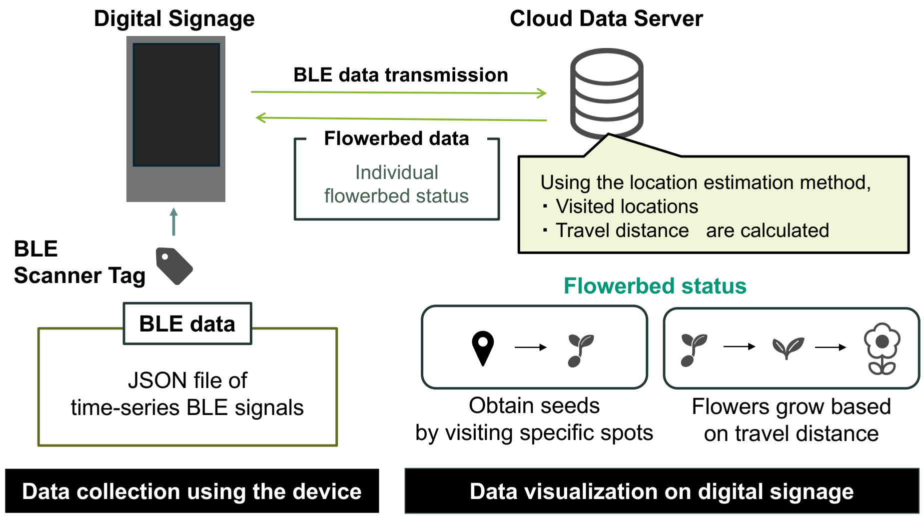

Fig. 6. Data flow and visualization process of the proposed system

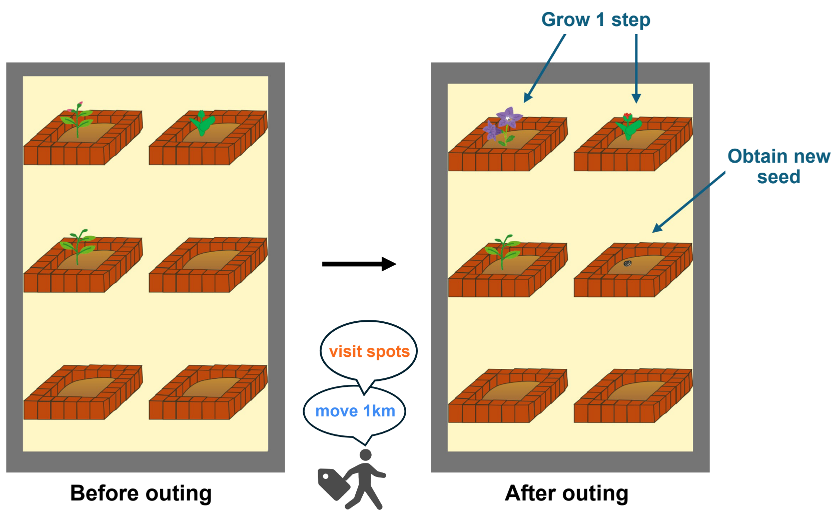

Fig. 7. Flowerbed changes with flower growth

4 Evaluation of the Proposed System

4.1 Accuracy Evaluation of the Location Estimation Method

Experiment Around NAIST To examine the feasibility of the proposed location estimation method, we conducted a preliminary experiment around NAIST.

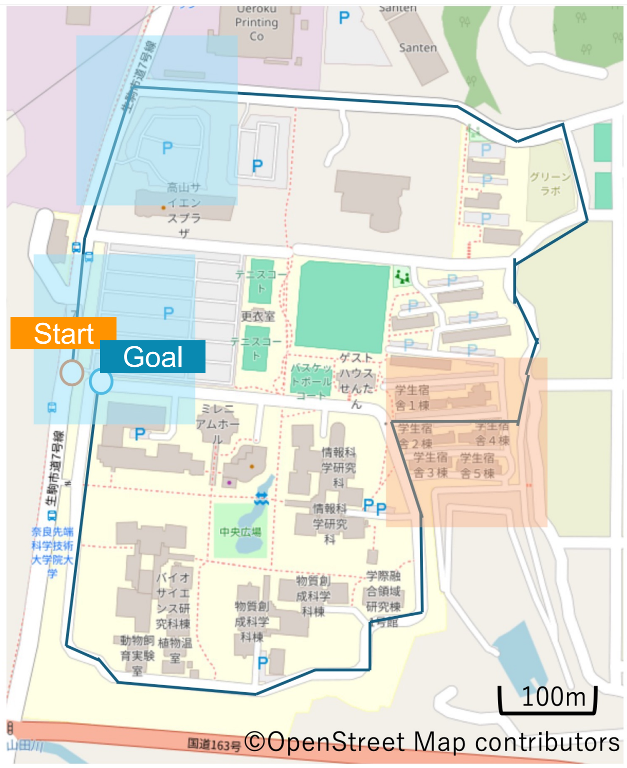

Fig. 8. Walking route used in the experiment

Assuming a walking route suitable for exercise and with limited signal infrastructure, we collected BLE signal data over several days around the campus area and evaluated localization accuracy.

The route used in the experiment is shown by the blue line in Fig. 8. We set a loop around the university campus as the experimental environment. The route is approximately 2 km and takes about 20 minutes to walk, passing several locations around the campus and returning to the main gate.

Data Collection and Reference Data Construction Fig. 9 shows the BLE data scanning device used in this experiment. We used a Raspberry Pi-based BLE scanning device equipped with a GPS module [14, 13]. The collected data were transmitted to a server via an LTE module. The device records BD address and RSSI from BLE signals, as well as GPS-based location and timestamp information. BLE scanning was performed every 15 seconds.

Data were collected six times over two days. We used four datasets after excluding two runs that contained missing data. Table 1 shows the time periods and the number of BLE scans for the four datasets. For evaluation, we used three

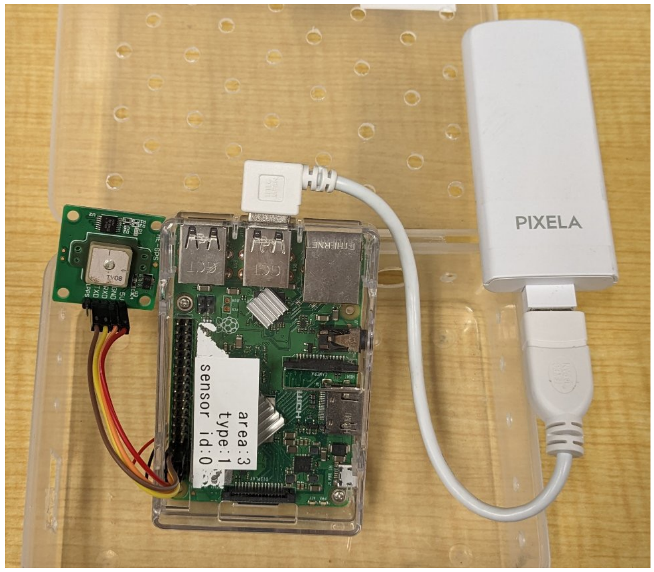

Fig. 9. Device for scanning BLE signals

Table 1. Data collection periods and number of BLE scans

Dataset	Collection period	#BLE scans
1	12/23 17:29:00–17:49:59	82
2	12/24 10:51:00–11:12:59	87
3	12/24 11:47:00–12:09:59	90
4	12/24 12:43:00–13:07:59	98

datasets to construct reference data and one dataset as test data, repeating this process four times by rotating the test dataset. The grid size for reference data construction was set to 11 m in latitude and 9.2 m in longitude.

Evaluation Procedure We evaluated accuracy by computing the error between estimated locations and ground-truth locations obtained from the GPS module. For each run, we performed location estimation at 1-minute intervals from the start to the end time and calculated the distance between the estimated and ground-truth coordinates. We repeated the evaluation four times by using each dataset as test data. The distance (error) between the estimated and true locations was computed using Hubeny's formula based on latitude and longitude, and we report the mean, standard deviation, median, and minimum error.

Results Around NAIST Using the four datasets, we computed the distance (error) between each estimated location and the corresponding ground-truth lo-

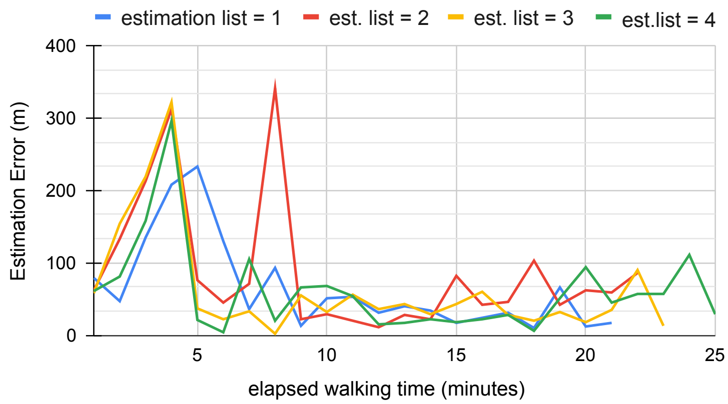

Fig. 10. Localization errors when using each dataset as test data

Table 2. Localization errors for each run

Test dataset	Mean (m)	Std. dev. (m)	Median (m)	Min (m)
1	64.76	89.19	4.35	10
2	86.68	123.24	6.05	11
3	62.47	95.62	3.60	2
4	60.24	85.41	4.50	4

cation. Fig. 11 visualizes the discrepancy between estimated and true locations on a map: blue pins indicate estimated locations, orange pins indicate true locations, and red lines indicate error magnitude. Fig. 10 shows the relationship between error and elapsed time along the route for each test dataset.

Table 2 summarizes the mean error, standard deviation, and median error for each run. The minimum and maximum errors were 2 m and 322 m, respectively. Although there were outliers, the four error curves showed similar patterns, suggesting that the method produced comparable estimation behavior across different collection times. The large variance indicates that accuracy depended strongly on local conditions. In particular, sparsely populated areas showed lower estimation accuracy, whereas areas with higher residential density (e.g., dormitory and greenhouse areas with many ambient BLE-emitting devices) tended to yield better accuracy. These results suggest that collecting device-specific address and RSSI patterns from surrounding facilities enables location estimation in the target area.

Experiment Around Houjinishi Housing Complex We evaluated localization accuracy around the Houjinishi housing complex in Higashi-Osaka, where the system is planned to be installed. The goal was to investigate how environmental differences affect accuracy. The target area covered approximately a 3 km radius centered on the housing complex, reflecting residents' daily living

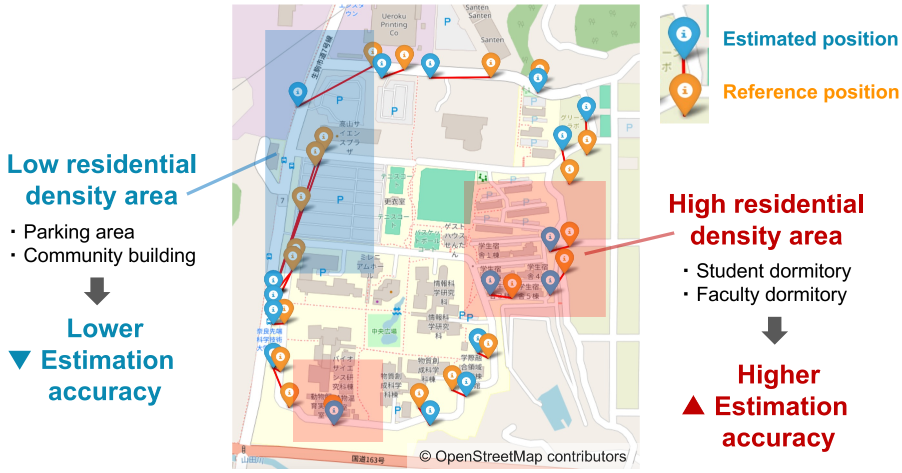

Fig. 11. Discrepancy between estimated and true locations (Dataset 1)

Fig. 12. Localization area around the Houjinishi housing complex

range and ensuring sufficient density of ambient BLE signals. Fig. 12 shows the evaluation area. Compared with the environment around NAIST, this area has more residents and shops and is expected to contain more BLE-emitting devices.

Data Collection and Reference Data Construction We distributed smartphones for data collection to three residents and asked them to carry the phones

Table 3. Collection periods after sampling to 30,000 records

Dataset	Collection period
1	10/01 00:00:00–10/20 11:57:50
2	11/01 00:00:00–11/05 11:42:39
3	11/16 00:00:00–11/18 11:21:27
4	12/01 00:00:00–12/03 10:21:16

during outings, collecting BLE data between April 14 and December 9, 2024. To ensure data reliability, we excluded periods when residents forgot to carry the phones and data outside the target area. The data were then split into four periods. To reduce imbalance and enable fair evaluation, we sampled the data so that each period included 30,000 records outside the Houjinishi area. Table 3 summarizes the collection periods. The BLE scan interval was 10 seconds.

For reference data construction, we used BD address, RSSI, location, and timestamp. For accuracy evaluation, one period was used as test data and the remaining periods were used as reference data. The grid size was set to 22.2 m in latitude and 18.4 m in longitude.

Results Around Houjinishi Using the four datasets, we computed the distance (error) between estimated and true locations. Table 4 summarizes the mean, median, and minimum errors. While maximum errors varied across periods, the median error was approximately 200 m overall, and the minimum error was 29 m. The locations with particularly high accuracy (within 100 m) were found to be places frequently visited by residents.

In the NAIST experiment, accuracy tended to improve in areas with more BLE-emitting devices. In contrast, the housing complex area did not show the same improvement despite a high device density. One plausible reason is that multiple BLE devices may be colocated, causing overlapping signals and interference. Therefore, in high-density environments, it is necessary to analyze signal characteristics and distributions in more detail.

A notable feature of our approach is that reference data were built from BLE data collected by residents' smartphones, which can reduce the data-collection cost typically required by fingerprinting methods. Moreover, the high accuracy at frequently visited locations suggests that incorporating residents' daily movement ranges into reference data construction is important for improving estimation performance. Overall, these results indicate that the proposed method is effective for estimating residents' locations and that reflecting residents' living ranges in the reference data contributes to accuracy improvements.

4.2 Evaluation of the Flowerbed Cultivation Application

This section describes a preliminary questionnaire study of the proposed flowerbed cultivation application. The purpose was to examine its potential to encourage older adults' willingness to go out, sustain motivation for continued outings, and assess usability and affinity for older users.

Table 4. Localization errors for each period

Dataset	Mean (m)	Std. dev. (m)	Median (m)	Min (m)	#Estimates
1	343	197	241	29	1263
2	151	75	140	30	486
3	181	115	162	45	329
4	154	169	101	40	327
ALL	256	189	201	29	2405

Table 5. Questionnaire items

ID	**Question**
Q1	Do you think this application is enjoyable?
Q2	If such an application were available, would you like to try it?
Q3	Would you like to keep using this application every day?
Q4	Do you think a small BLE scanner tag would be easier to carry than a smartphone?
Q5	Do you think the application is easy to use?

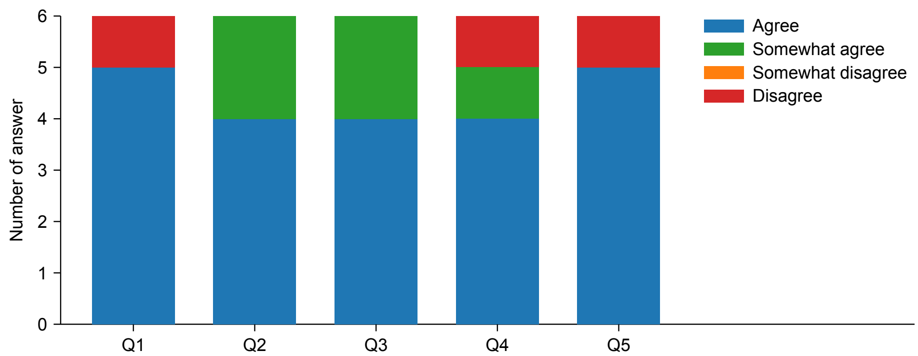

Fig. 13. Questionnaire results about the application

Evaluation Procedure We explained the concept and usage of the application to six older adults in their 70s and 80s and then conducted a questionnaire survey. After asking for basic information (e.g., age, hobbies, and outing frequency), participants answered questions about the application using a four-point Likert scale: "Agree," "Somewhat agree," "Somewhat disagree," and "Disagree." We also collected reasons for their answers.

The questionnaire items are listed in Table 5.

Results Fig. 13 shows the questionnaire results. Five out of six participants reported a positive impression of the application.

For Q1, many participants stated that the application seemed enjoyable, citing reasons such as interest in flowers and preferring visual feedback (flowers) over numerical metrics (distance or steps). This suggests the application may effectively motivate outings. For Q3, several participants indicated that they would like to continue using it daily, noting that the visual representation of walking behavior could support sustained motivation. For Q5, many participants perceived the application as easy to use, emphasizing that simply connecting the BLE scanner tag would be feasible for older adults and that older users often prefer minimal and simple operations. These responses suggest high usability and suitability for older adults who are not comfortable with smartphone operation.

On the other hand, the participant who responded negatively to Q1 cited a dislike of games and low confidence in using such applications due to difficulty with smartphones. Participants also suggested improvements, such as adding more variety beyond growing flowers, or introducing additional elements (e.g., insects gathering around flowers) to provide new goals. These comments indicate the importance of improving accessibility and designing additional mechanisms to sustain long-term engagement.

5 Conclusion

Social withdrawal among older adults reduces physical activity and social interaction, increasing the risk of serious issues such as dementia and isolation. To address this challenge, this study proposed an outing and social interaction support system that estimates visited locations and travel distance using ambient BLE signals and visualizes these data through an installed flowerbed cultivation application.

The system constructs reference data from BLE addresses and RSSI values and estimates residents' movement using similarity-based fingerprinting. The estimated results are reflected on shared digital signage, where virtual flowerbeds grow based on visited locations and walking distance, enabling residents to view and share their activity records with others by simply connecting a portable BLE scanner tag.

Localization experiments conducted around NAIST and the Houjinishi housing complex demonstrated that the proposed method enables coarse-grained but meaningful location estimation suitable for monitoring outing behavior. In addition, a preliminary questionnaire study with older adults showed positive impressions regarding enjoyment, usability, and motivation, suggesting that the system has potential to encourage outings and sustain engagement with minimal operational burden.

Future work will involve a long-term field deployment in a residential setting to evaluate changes in outing frequency, movement patterns, and sustained motivation, aiming to support voluntary and socially connected aging.

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