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Evaluation of Layouts for Braille Guidance Blocks under Different Situations in Sports Facilities

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Abstract

This study made pedestrian models and layouts of Braille guidance blocks based on an interview with a goalball player and previous studies in order to determine appropriate arrangements in sports facilities. A simulation on walking efficiency was conducted under different conditions combining different situations of spectators' moving with different layouts. There are two types of patterns of moving objects: Pattern-A, in which only visually impaired athletes are allowed to move on the floor, and Pattern-A+B, in which both visually impaired athletes and sighted spectators are allowed to move on the floor. In addition, there are two types of layouts of Braille guidance blocks: Layout-1 is a linear arrangement of them, and Layout-2 is a rounded linear arrangement of them. The results of the simulation showed that there were no significant differences of walking efficiency between Layout-1 and Layout-2 under the conditions of Pattern-A or Pattern-A+B. Furthermore, there were no significant differences of walking efficiency between Pattern-A and Pattern-A+B under Layout-1 or Layout-2. These results show the effectiveness of the linear arrangement of Braille guidance blocks in sports facilities for visually and non-visually impaired people.

Keywords

Interview, Pedestrian Model, Braille Guidance Block, Walking Simulation

1. Introduction

We need to live together whether we are able-bodied or people with disabilities.

This is important to keep in mind while preparing for the 2020 Olympic and Paralympic Games. Although conditions for people with disabilities are getting better, there is still a need for improvement.

According to a survey on people's attitudes toward barrier-free design and universal design in 2016 (The Cabinet Office, Government of Japan, 2017) by the Cabinet Office, Government of Japan, many respondents felt progress had been made in barrier-free design in medical facilities such as hospitals and clinics (63.6%) and welfare facilities such as nursing homes (73.2%). However, only 35.5% of respondents saw progress in barrier-free design in sports facilities such as gymnasiums and pools. It can be said that the status of progress varies depending on each facility. In addition, a survey targeting the Paralympic athletes (para-athletes), coaches, and staff, conducted in 2016 by the Paralympians Association of Japan (The Paralympians Association of Japan, 2016), set goals for the development of the Paralympic sports (para-sports) such as improvement of sports facilities for people with disabilities and environments in which all people can enjoy sports together. Users actually feel the facilities are insufficient for use by people with disabilities regardless of the importance of the barrier-free design in the sports facilities.

There are studies occuring for the visually impaired. One of the results of these studies showed that, compared to healthy people, the visually impaired do not play as many sports (Kohda & Amano, 2007). The reason for this is that there is a lack of sports facilities that are friendly to the visually impaired. Visually impaired people identified problems of sports facilities. The facilities were far from their home, there are few facilities that are accessible in terms of explicitness of information, they were denied access to the facilities, and so on. These problems, that is, lack of understanding of and concern about people with disabilities in environmental design, can prevent their participation in sports activities. It is necessary to ensure safety, convey explicit information, and reduce feelings of burden and anxiety for visually impaired people.

As an example of facilities in public spaces considering visually impaired people, Braille guidance blocks are commonly accessible throughout Japan. Braille guidance blocks are blocks which are installed on road or floor in order to provide information for walking to people with disabilities and guide them safely. Some blocks are represented by dots and others are lines. People can use these blocks depending on their purpose. Dot blocks are for caution and line blocks show direction. Up until now, these Braille guidance blocks have been used, and many experiments and evaluations have been done concerning safety and comfort.

Mitani et al. (Mitani, Fujisawa, Yamada, Tauchi, Kato, & Sueda, 2007) adopted twenty-two kinds of Braille guidance blocks. These varied in width of lines, diameters of points, and heights of protuberances, and examined whether or not visually impaired people could recognize and discriminate them using white canes or the soles of their feet. The results showed that visually impaired people could recognize the Braille guidance blocks based upon Japanese Industrial

Standards sufficiently.

Previous researchers have conducted evaluation through experiments of various shapes of Braille guidance blocks in order to improve visually impaired people's recognition and identification of the blocks. There have also been studies concerning installation locations of Braille guidance blocks. For instance, Yamada and Kametani (Yamada & Kametani, 2015) examined the influence of Braille guidance blocks on visually impaired people's ascent and descent of spiral ramps. This study reported that the installation of Braille guidance blocks led to grasping the handle while going around on the spiral ramp and maintaining sense of direction during ascent and descent.

There have been many studies concerning the shape and location of the blocks, but little has been done on installation patterns of them. One of the few researchers on the topic is Arimoto et al. (Arimoto, Kondo, & Watanabe, 2005). This study evaluated various routes from Tokushima station to major buildings in the area on which Braille guidance blocks were installed from the viewpoints of effectiveness and safety for the visually impaired. As a result, evaluation indexes were proposed for quantifying the effectiveness and safety of the routes depending on moving distance, length of intersections, and so on.

The above studies were only concerned with the outdoors, but indoors also need to be accounted for. Due to the lack of studies on the topic, there is room for consideration about effective arrangements of Braille guidance blocks as indicators for visually impaired people in indoor facilities. In addition, appropriate layouts of sports facilities can vary depending on the visually impaired user and the purpose of their use. Therefore, hearing users' opinions and simulation of an actual situation are necessary when considering arrangements of Braille guidance blocks.

This study assumed the situation in which visually impaired people can use sports facilities and examined appropriate arrangements of Braille guidance blocks. The users' traits and purpose of use were clarified through an interview with a para-athlete, and a pedestrian model was made for walking simulation. The purpose of this study is to determine appropriate arrangements of Braille guidance blocks in sports facilities. The results of this study can contribute to improvement of barrier-free environment by presenting a method of arranging Braille guidance blocks properly in sports facilities.

2. Literature Reviews

The previous studies on Braille guidance block mainly focused on the shape, location, and patterns of the blocks. The results of these studies are shown as below.

2.1. Study on Shape of Braille Guidance Blocks

Yanagihara et al. (Yanagihara, Hara, & Kuwahata, 2011; Yanagihara, Kuwahata, & Hara, 2013) conducted experiments regarding recognition of protuberances on the Braille guidance blocks in order to develop blocks which have less unevenness for wheelchair users and elderly people. The results indicated that heights and arrangement of protuberances were related to the visually impaired people's confidence. Recognizing the blocks and combinations of two millimeter heights of linear or point-like protuberances was necessary for recognition using white canes.

2.2. Study on Location of Braille Guidance Blocks

Inagaki et al. (Inagaki, Fujisawa, Takahashi, Ikeda, Takeuchi, & Ogino, 2016) also proposed "Braille guidance blocks for direction determination" in order to determine precise crossing directions on crosswalks and evaluated them through experiments. The results of this study showed that visually impaired people's direction determination and sense of security was improved with the installation of the Braille guidance blocks for direction determination behind the traditional Braille guidance blocks on the start of the crosswalk.

2.3. Study on Patterns of Braille Guidance Blocks

Miyaji and Maeda (Miyaji & Maeda, 2006), utilizing the AHP (Analytic Hierarchy Process), developed the decision-making support system for travel plan of the visually impaired. This system can evaluate various routes between a starting point and a destination in terms of preference for the visually impaired. The system took into account some factors related to the preference of routes (e.g., Braille guidance blocks, sidewalks, width of a road, and so on) and proposed the most preferable route. The study can be also recognized as the one focusing on location patterns of the blocks on the routes.

3. Interview

This study conducted an interview in order to make a pedestrian model for walking simulation. A male goalball player in his twenties was chosen as an interviewee. Goalball is a para-sport in which visually impaired people participate. Therefore, the interviewee was considered to represent users of Braille guidance blocks in sports facilities. In the interview, the interviewer asked him about how he uses sports facilities and Braille guidance blocks, problems he has encountered with these facilities and blocks, and so on. This interview was conducted in a semi-structured method in August 2018. The interview lasted for 30 minutes. The interviewee's utterances were recorded by a voice recorder and transcribed after the interview. Requirements for sports facilities and Braille guidance blocks were discussed based on the transcription of the interview.

Fourteen questions were prepared for focusing on the interviewee's usual use of spots facilities and Braille guidance blocks. The questions in the interview are shown in Table 1.

3.1. Questions and Responses

1) In preparing for the Paralympic Games what type of sports facilities do you use?

Table 1. Questions in interview.

Questions about sports facilities
1) In preparing for the Paralympic Games what type of sports facilities do you use?
2) What kinds of other facilities do you typically use in your training aside from sports facilities?
3) When you first use facilities, how do you find out about them?
4) Are there any machines in this facility which might be difficult to use or areas which might be difficult to find?
5) Are there any differences between facilities you use regularly and those you use for the first time?
6) What kind of services would you like this facility to have?
Questions about Braille guidance blocks
7) Do you usually use Braille guidance blocks?
8) In what kinds of places do you use these blocks?
9) How do you find the Braille guidance blocks?
10) What are the advantages and disadvantages of the Braille guidance blocks?
11) In sports facilities which areas would benefit most from guidance blocks?
12) How would a change in the layout of the facility accommodate the visually im-paired?
13) What kind of support would be helpful to recognize Braille guidance blocks?
14) Regarding the Braille guidance blocks, did you need training about how to walk?

The subject told us that he uses his university's gym equipment, the university's gymnasium, a gymnasium unrelated to the university specially used for the Paralympic athletes, and various swimming pools.

2) What kinds of other facilities do you typically use in your training aside from sports facilities?

He told us that he uses the same facilities as other athletes, including restrooms, locker rooms, showers, vending machines and water coolers.

3) When you first use facilities, how do you find out about them?

First, a friend told him about these facilities. Later the staff helped him and he could touch a model to see how the facilities are arranged. For example, he could remember that the men's locker room is the second door. The restroom is past the locker room on the other side of the hallway on the left. He can figure this out by touching the wall as he walks.

4) Are there any machines in this facility which might be difficult to use or areas which might be difficult to find?

He said he couldn't distinguish between the men's and women's restroom, and that he feels bad when he needs to ask his friend or staff for help. There are some obstacles in the swimming pool, like things on the side of the pool which are sticking out or areas where the surface is elevated.

5) Are there any differences between facilities you use regularly and those you use for the first time?

He told us he was afraid to use facilities that he was not familiar with. He felt a little nervous when moving around an unfamiliar facility. He also didn't want to rely on friends for help. He couldn't concentrate on what he needed to do, because he was distracted by the new environment.

6) What kind of services would you like this facility to have?

He responded it would be nice to have audio guidance, and handrails with indicators which can be touched with one's fingers. It should also be easy to distinguish between the first and second floor. He said that sudden audio instructions might surprise people who are not impaired. Therefore, hand indicators might be better.

7) Do you usually use Braille guidance blocks?

He said that he uses them often.

8) In what kinds of places do you use these blocks?

He told us that he uses these blocks in dangerous places where he should be careful or places where he should stop.

9) How do you find the Braille guidance blocks?

He responded that he searched for the blocks using a white cane. If he finds the Braille guidance blocks, it can be very useful, but if there is something restricting access, it can be very difficult.

10) What are the advantages and disadvantages of the Braille guidance blocks?

The advantage is he can navigate easily with a guidance block. The disadvantages are that some guidance blocks are not in straight lines and he may bump into walls or other obstructions because of it. Also some guidance block placements are random or useless.

11) In sports facilities which areas would benefit most from guidance blocks?

He responded by suggesting that locker rooms, toilets, pool areas and places the visually impaired would utilize most would be best. He continued by saying he would also benefit from labels in Braille.

12) How would a change in the layout of the facility accommodate the visually impaired?

He would prefer straight lines, and when there is a corner he would like audio guidance or placement of a large guidance block. However, he stated that audio guidance may be distracting, especially on the court, and also for non-visually impaired people. He would also like wider walkways or two parallel walkways.

13) What kind of support would be helpful to recognize Braille guidance blocks?

He told us that he had never used the tactile maps before, as such it would be better if he had something he can touch with his hands to see where to go easily. It is important actually to go to the facility and see how everything is set up. Usually he was directly pointed where to go and what to do.

14) Regarding the Braille guidance blocks, did you need training about how to walk?

He said that he needed a lot of training and it took him about a year to became familiar with everything. He said it would be better to show someone who is not visually impaired first, before explaining how to use the facilities to him.

3.2. Summary of Interview

Our interviewee discussed using the Braille guidance blocks inside sports facilities. He explained his issues, namely the system as well as having to ask for assistance (e.g., “It is difficult to use winding lines of Braille guidance blocks”, “I usually inquire about what is thereat an information desk when I use a sports facility”). He suggested using straight lines, no handrails, and wider walkways to improve usability for the visually impaired.

He recommended against audio guidance, as it may disturb non-impaired individuals. Finally, he stated that staff should be trained to explain these facilities to the visually impaired.

4. Simulation

The variables in this simulation are as follows: how easily individuals can use Braille guidance blocks through the sports facilities, and the time taken to move from one point to another for both visually impaired and non-visually impaired people. These variables were chosen based on feedback from a goalball player during an interview, as well as on the previous studies mentioned in the introduction. The goalball venue at the gymnasium for the Kawagoe Campus of Toyo University was used for the test (**Figure 1**).

Two layout plans were proposed. For example, it is necessary to be able to stop once near the changing rooms, and some visually impaired people would prefer straight lines. In addition, there should be a distinction between the men’s restroom and the women’s. We referred to previous studies regarding the walking speed and personal space of pedestrians.

In the simulation, pedestrians moved from the court in the center of the gym to the men’s room in the upper right, in one hour. Besides, two different situations are considered. One is the situation in which spectators are allowed to move about the floor freely, and the other is the situation in which spectators are not allowed to move around the floor at all. The simulation on walking efficiency was conducted under different conditions combining different situations of spectators’ moving with different layouts. The number of pedestrians who reached the men’s or women’s restrooms within one hour in the simulation was recorded, and the layout was evaluated based on the result.

4.1. Layout

The difference between the two layouts lies in the way the corners bend. One is a linear arrangement (**Figure 2**) and the other is a rounded arrangement of Braille guidance blocks (**Figure 3**). The former is called Layout-1 and the latter is Layout-2. The red and green lines in **Figure 2** represent traffic lines of pedestrians and the blue lines are Braille guidance blocks. The simulation compared which layout would lead to more efficient walking movement. These two layout plans were compared in the simulation.

4.2. Walking Routes

Two routes of walking were prepared: a long route and a short route. It was randomly decided which route the pedestrian uses. The probability that any

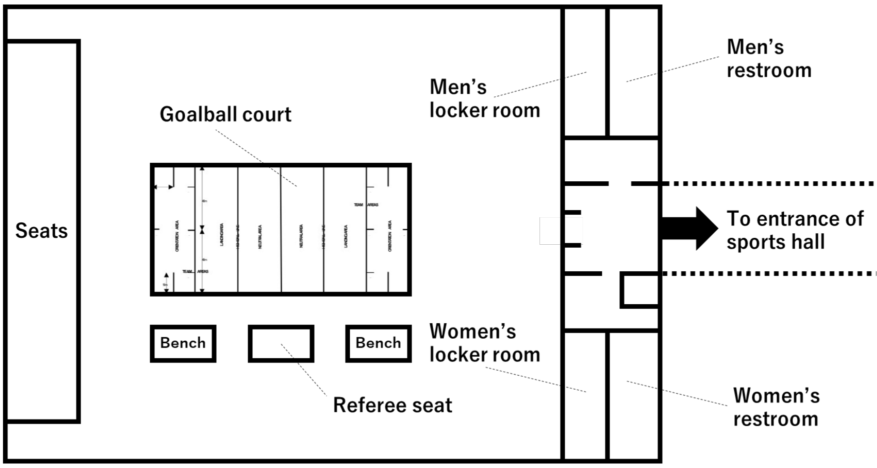

Figure 1. The floor plan of the gymnasium at the Kawagoe Campus of Toyo University.

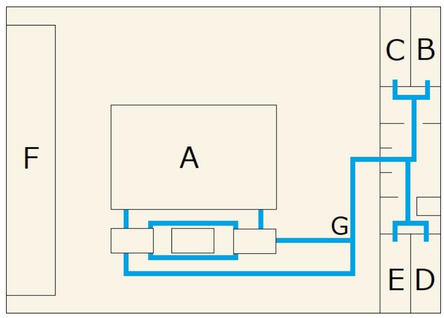

Figure 2. Layout-1.

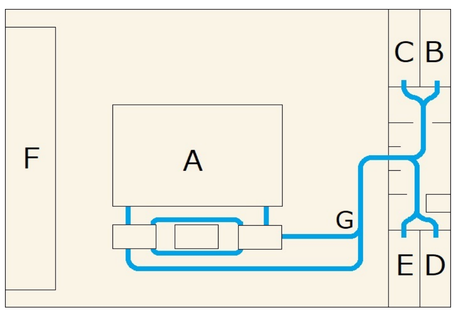

Figure 3. Layout-2.

route is chosen is 50%. Hereafter, the route having a long distance to the goal point is referred to as route 1, and the route having a short distance as route 2.

In the walking simulation, the pedestrians stopped at the branch points such as the place in front of the men's and women's restrooms and locker rooms in order to identify the rooms. This reflects the interviewee's statements about the situation of the sports facilities.

4.3. Moving Speed, Incident Rate and Personal Space of Pedestrians

Two patterns are prepared for the moving speed, incident rate and personal space of pedestrians.

(A) A visually impaired athlete having a moving speed of 0.63 m/s and a personal space with diameter 90 - 120 cm (selecting at random from this range) is generated every 10 seconds according to uniform distribution.

(B) Assume that all spectators are sighted. Each spectator has a moving speed of 0.9 - 1.2 m/s (selecting at random from this range) and a personal space with diameter 80 cm (selecting at random from this range). Three spectators are generated every 10 seconds according to uniform distribution.

These setting are based on previous studies (Noda, Matsumoto, Ogino, & Kurimoto, 1996; Nishimori & Ito, 2012). The range of pedestrians' personal space was set to 90 - 120 cm in diameter in reference to the measurements of visually impaired people's movements established in the regulations for welfare town planning of Fukuoka city (Fukuoka City, 1998). The personal space (Shibuya, 1985) is a spatial domain around an individual's body and when others enter this space one can feel unpleasant.

Hereafter, the moving speed/occurrence rate of (A) is referred to as Pattern-A, and the moving speed/occurrence rate of (B) is referred to as Pattern-B.

4.4. Simulation Software

AnyLogic was used as simulation software in this study. AnyLogic, developed by the AnyLogic Company, is a multimethod simulation modeling tool. By using AnyLogic it becomes easier to input the facility floor diagrams and the walking routes interactively (**Figure 4** and **Figure 5**). AnyLogic is superior to other software in this regard, and this is the reason why AnyLogic was used. It supports agent-based, discrete event, and system dynamics simulation methodologies.

4.5. Analysis

This study focus on the number of pedestrians reaching the goal point during the simulation in order to evaluate effectiveness of the two layouts of Braille guidance blocks. The simulation was carried out ten times on Layout-1 and Layout-2 under the condition of Pattern-A or Pattern-B. As a result, ten numbers of the pedestrians were calculated on each layout and under each condition. The numbers were statistically compared between the two layouts or the two conditions by means of the Wilcoxon signed-rank test.

5. Results

5.1. Results of Walking Simulation

The results of the simulation are shown in **Table 2**. The number of pedestrians reaching the goal point within one hour is summarized. There are two types of patterns of moving objects: Pattern-A, in which only visually impaired athletes are allowed to move on the floor, and Pattern-A+B, in which both visually impaired athletes and sighted spectators are allowed to move on the floor. In addition, there are two types of layouts of Braille guidance blocks: Layout-1 is a

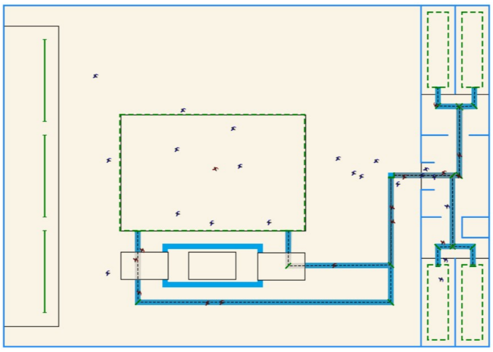

Figure 4. A screenshot of AnyLogic simulation for Layout-1 in 2D.

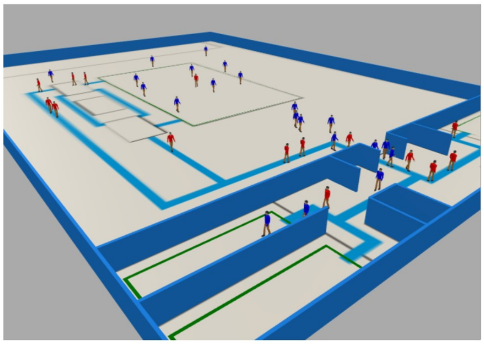

Figure 5. A screenshot of AnyLogic simulation for Layout-1 in 3D.

linear arrangement of them, and Layout-2 is a rounded linear arrangement of them.

Each simulation is performed ten times under these different combinations of patterns of moving objects.

5.2. Results of Statistical Analysis

The numbers of pedestrians reaching the goal points were compared by means of the Wilcoxon signed-rank test between Layout-1 and Layout-2 under the condition of Pattern-A or Pattern-A+B. The results of the comparison (Table 1) showed that there were no significant differences between Layout-1 and Layout-2 under the conditions of Pattern-A ($z = -1.903$, $p = 0.057$) or Pattern-A+B ($z = -1.444$, $p = 0.149$). Furthermore, there were no significant differences between Pattern-A and Pattern-A+B under Layout-1 ($z = -0.756$, $p = 0.450$) or Layout-2 ($z = -1.067$, $p = 0.285$).

6. Discussion

The results of the interview with the interviewee suggested that visually impaired people intuitively feel the ease of use of the linear arrangement of Braille guidance blocks in sports facilities. The linear routes are considered to enable visually impaired people to imagine the space structure of venues and be effective in

Table 2. Simulation results.

(a)

	Pattern-A		Pattern-A + B	
	Layout-1	Layout-2	Layout-1	Layout-2
1st	344	346	346	347
2nd	344	345	345	347
3rd	345	347	347	343
4th	345	345	345	348
5th	342	343	343	347
6th	345	347	347	345
7th	346	345	345	347
8th	346	345	345	347
9th	345	346	346	344
10th	344	345	345	345
Median	345	345	345	347

(b)

Comparison	Layout-1 vs Layout-2 (Pattern-A)	Layout-1 vs Layout-2 (Pattern-A + B)
Z-score	−1.903	−1.444
P-value	0.057$^{n.s.}$	0.149$^{n.s.}$
Comparison	Pattern-A vs Pattern-A + B (Layout-1)	Pattern-A vs Pattern-A + B (Layout-2)
Z-score	−0.756	−1.067
p-value	0.450$^{n.s.}$	0.286$^{n.s.}$

$^*p < 0.05$.

their walking to goal points. Voice guidance can be effective in sports facilities; however, it cannot be used at goalball courts. This is because the interviewee needs the sounds of the ball for his performance.

Considering the above results, the walking simulation was conducted using the linear and rounded layouts of Braille guidance blocks under the two conditions (Pattern-A and Pattern-A+B), which varied in terms of restrictions of pedestrians' movements. Comparing the numbers of pedestrians reaching the goal between the two layouts, there was no difference under the different situations. These results suggested that the linear arrangement of Braille guidance blocks (Layout-1) is effective in the pedestrians' moving as well as the rounded arrangement (Layout-2). From the above, the linear arrangement of Braille guidance blocks is considered to be appropriate for the competition venue of goalball, not only intuitively but also empirically.

7. Conclusion

This study carried out a walking simulation using the pedestrian model and the layouts of Braille guidance blocks based on the interviewee's statements and previous research in order to propose appropriate arrangements of the blocks in sports facilities for para-sports. The results of the interview and the indexes calculated with the simulation (the number of pedestrians reaching the goal points) indicated the effectiveness of the linear layout of the blocks.

As for implementation of walking simulation, there is room for improvement. For example, development of sophisticated walking models, calculation of indexes for the evaluation of effectiveness of layouts considering users' physical and mental condition, and so on. It is necessary to accumulate and install actual data into the walking simulation by conducting walking experiments, motion analysis, psychological evaluation targeting goalball players and so on.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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