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Unidirectional Tactile Paving: Circulation for the Visually Impaired

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Abstract. The COVID-19 pandemic heightened inequalities of universal accessibility in the built environment. The visually impaired have been affected by the lack of mobility that resulted from social distancing and physical distancing. Numerous circulation networks, from small retail shops to large-scale public spaces, have been reorganized to limit the spread of COVID-19. By assigning an orientation to each lane, unidirectional circulation networks allow for physical distancing by limiting face-to-face interactions among most pedestrians. These unidirectional networks are communicated visually, by placing flat arrows on the floor, but not through the other senses and are thus inaccessible to the visually impaired. This demonstrates a lack of universally accessible design for unidirectional circulation. We propose two designs (asymmetrical blocks and cobblestone blocks) for a novel unidirectional tactile paving which allows the visually impaired to navigate through unidirectional circulation networks by feeling tiles with their feet and/or canes.

Keywords. Tactile paving, visually impaired, circulation, unidirectional circulation, universal design, physical distancing.

1. Unidirectional pedestrian circulation and the COVID-19 pandemic

The COVID-19 pandemic has changed the way in which pedestrians move through public circulation spaces. Physical distancing, defined as "the practice of staying at least 6 feet away from others to avoid catching a disease such as COVID-19" [1], has become a regular practice in diverse urban contexts. Public spaces such as parks and large pedestrianized streets allow for physical distancing when enough space is available. However, when circulation lanes are less than 6 feet in width, physical distancing is impossible. Such is the case in numerous supermarkets, retail environments, schools, and hospitals, among others. As discussed in [2], unidirectional pedestrian circulation could also be practiced in complex circulation networks, such as the public circulation networks within large informal settlements.

For physical distancing to be possible in these environments, unidirectional pedestrian circulation has become the norm. By limiting circulation in each lane, path or hallway to one direction, face-to-face interactions between pedestrians are limited. Soon after the arrival of COVID-19 to the United States and other countries, diverse preventive measures were imposed on indoor public spaces to limit the spread of the disease. While some of these measures dealt with the implementation of acrylic glass, the extensive use of hand sanitizer and the clearing of surfaces, or designated shopping hours to protect

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the most vulnerable groups of people, several measures dealt directly with pedestrian traffic. Supermarkets and stores controlled their public circulation spaces by implementing one-way aisles, which allowed pedestrians to walk around the entire building while minimizing face-to-face interactions. Kroger, the largest supermarket operator in the country, was already testing one-way aisles at certain stores by early April 2021. Other retail giants such as Walmart also implemented one-way aisles around the same time [3]. The form in which unidirectional circulation has been communicated to pedestrians raises major concerns of inclusivity. Arrows placed on the floor, which indicate the direction of one-way aisles, remain merely a two-dimensional visual means of communication. For these unidirectional circulation networks to be more inclusive, solutions which can be clearly understood by the visually impaired must be found.

Whereas these new measures have changed every pedestrian's circulation habits, people with visual impairments are disproportionately affected by them. According to Dorianne Pollack, a blind person who works at the Disability Resources Department at Northern Arizona University, people with visual impairments cannot adapt to the new COVID-19 rules of governments and business "because they are communicated in a way that is impossible for [them] to observe." [4] One example is that of unidirectional circulation. She states that "in many stores and other places, there are now directional arrows, signage and taped-off measurements to ensure distancing - but you need to be able to see them to know they're there." [4] The consequences of such measures have had profound impact on people who are visually impaired, even resulting in "food insecurity" for those who do not have family or friends to help them get groceries.

The spatial qualities of different architectural layouts might also pose a problem to unidirectional circulation. The existence of dead ends or cul-de-sacs automatically creates unavoidable face-to-face interactions. Therefore, spatial layouts that don't already have a free plan organization or corridors that tie back into the primary circulation network make total unidirectional reordering impossible. Here too, narrow lanes are at a disadvantage since they don't allow for enough width for two people to walk next to each other while practicing physical distancing. Thus, in general, the relative success of different types of programmed spaces (hospitals, airports, restaurants, etc.) in implementing unidirectional circulation depends on their specific, built-in spatial flexibility to accommodate this type of circulation. Although one-way aisles increase the amount of time that users spend in navigating through pathways and potentially raise the exposure to the virus [5], this can be balanced by carefully controlling the occupant capacity limits. Even when such rules are implemented, compliance can be difficult to achieve. In stores and similar environments, installing floor decals or arrows might not be enough to regulate traffic. Multifaceted campaigns are needed to get clients used to these new behaviours. [5]

Even as vaccination campaigns thrive in certain areas of the world, it is likely that unidirectional pedestrian circulation will continue in some urban contexts. According to the Harvard Medical School, "everyone, even those who have recovered from coronavirus infection, and those who have been vaccinated, should continue to (...) practice physical distancing" [6]. Because people infected with COVID-19 behave differently, including those who are asymptomatic or have been re-infected with the disease, it is important to implement general rules of physical distancing, which include unidirectional pedestrian circulation.

In this article, we present a brief overview of tactile paving, a revolutionary navigation aid for the visually impaired (Section 2). Subsequently, we introduce unidirectional tactile paving, a novel type of tactile paving which allows the visually impaired to navigate through unidirectional circulation networks by feeling the unidirectional tactile blocks with their feet or walking canes (Section 3). Finally, we present opportunities and challenges associated with these designs in the conclusion (Section 4).

2. Tactile paving

Japanese inventor Seiichi Miyake created a revolutionary navigation aid for the blind and the visually impaired. Tactile paving (or Tenji blocks) consists of tactile blocks on pavement which are "intended to alert visually impaired pedestrians of upcoming dangers, like sidewalk curbs and train platform edges" [7]. The textures of the blocks can be felt with the feet or with a cane; they can be perceived by the partially sighted since their colour (usually yellow) contrasts with the pavement around it. A decade after the first implementation of tactile paving near the Okayama School for the Blind, the system was popularized by Japan National Railway, since "every (...) platform was modified to include Miyake's invention" [7]. Today, Japanese law requires certain buildings and public spaces to install tactile paving, and they can be found in most public circulation spaces in major Japanese cities, like Tokyo. Other cities throughout the word have started to implement tactile paving in particular locations such as train stations and airports, as well as certain public spaces.

To create paths of any desired length, tactile blocks can be placed side by side to create paths of any desired length. According to the International Association of Traffic and Safety Sciences, there are "two types of tactile ground surface indicators: warning blocks that indicate the location of hazards or destination facilities (...) and directional blocks that indicate direction of travel." [8] Warning blocks (or warning tiles) have a blister pattern made up of small domes. (See Figure 1, top left.) These blocks usually have 25 or 36 small domes, but different variations exist. Directional blocks (or directional tiles) have long bars that are parallel to the direction of travel. (See Figure 1, top middle.) Most commonly, they have four equally spaced bars.

3. Unidirectional tactile paving

Whereas directional blocks are very functional and effective, they convey direction without conveying orientation (forward or backward). They could be called “bidirectional blocks”, since one can walk on them one way or the other. The inexistence of tactile blocks which indicate orientation in addition to direction proposes an avenue for design explorations. In this paper, we propose two designs of unidirectional tactile paving blocks which convey orientation in addition to direction. These are named asymmetrical blocks and cobblestone blocks, described below.

The first design we propose is the **asymmetrical block**. An asymmetrical block has long bars of different widths that are parallel to the direction of travel. An asymmetrical block has two standard long bars parallel to the direction of travel on the right half of the block, and four narrower long bars also parallel to the direction of travel on the left half of the block. (See Figure 1, top right and bottom.) This allows the users to feel a difference between the left and right sides of the tactile paving with their feet and cane. By informing the users that the standard long bars must always be on the right side while walking on a tactile path to respect the assigned direction, the users can internalize this convention to know which direction to follow. Asymmetrical blocks can be mass produced just like any other tactile paving block and they do not require more material than the standard directional blocks. Moreover, asymmetrical blocks can be used as standard directional blocks when unidirectional circulation is not needed or desired, without having to replace them. (See Figure 2).

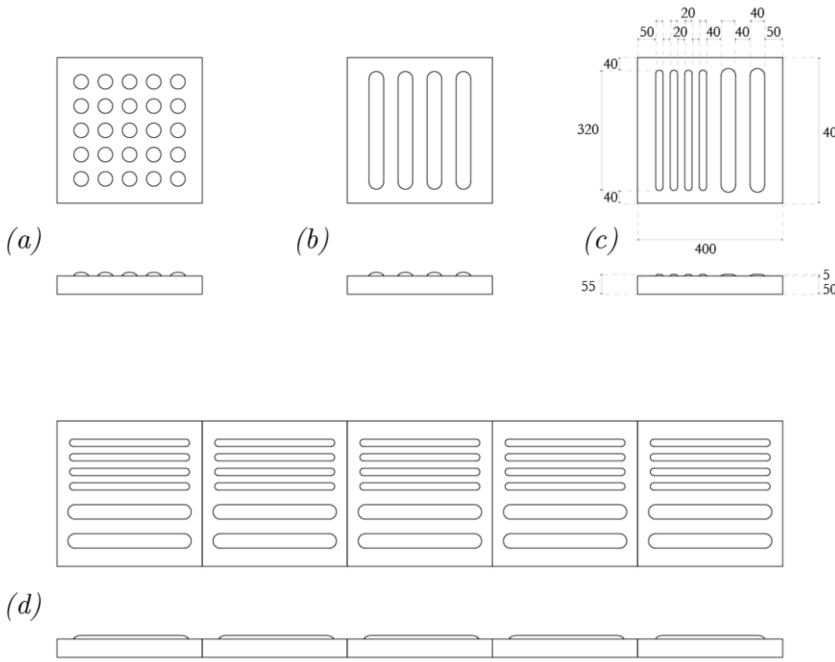

Figure 1. (a) Warning blocks with 25 small domes; top view and elevation. (b) Directional blocks with four long bars; top view and elevation. (c) Asymmetrical blocks with two standard long bars on the right side and four narrow long bars on the left side; top view and elevation. (d) An assembly of five unidirectional blocks; top view and elevation. Dimensions in millimeters.

Variations of the asymmetrical block design could allow for diverse blocks that could convey different information in addition to a sense of direction. Blocks with different arrangements and widths of bars could produce different sounds when a cane is passed over them, transforming the physical information conveyed by the blocks into audible information which could be recognized by the visually impaired pedestrian. For example, a series of long bars of alternating narrow and standard widths could indicate a construction zone.

Figure 2. A linear path made entirely of asymmetrical blocks; elevation (above) and top view (below). Human figure for scale.

The second design we propose is the **cobblestone block**. A cobblestone block has long bars like a standard directional block but, instead of being flat, it consists of two slanted planes with different inclinations sloping in opposite directions. When approaching the block while respecting the assigned direction of unidirectional travel, the pedestrian encounters the less inclined slope; when approaching it from the opposite direction, the pedestrian encounters the more inclined slope. (See Figure 3.) These slopes should be inclined enough to be felt with the feet or with a cane but not too inclined to prevent accidents by tripping somebody. Cobblestone blocks are placed between standard directional blocks at regular intervals (every 25 blocks, for example) as a reminder of the direction to follow. It is possible to place consecutive cobblestone blocks one after the other to provide additional information in addition to the direction. (See Figure 4.)

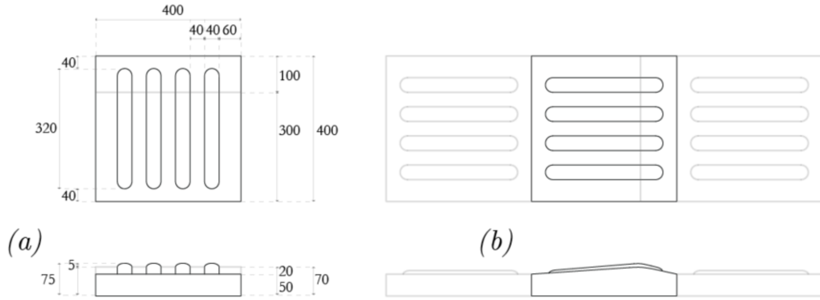

Figure 3. (a) A cobblestone block; top view and elevation. (b) A cobblestone block between two standard directional blocks (lighter lines); top view and elevation. Dimensions in millimeters.

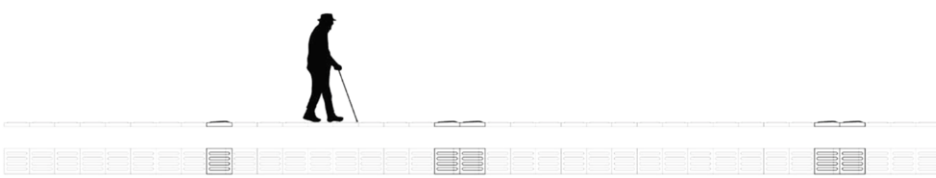

Figure 4. A linear path made of regular directional blocks (shown in grey) and five cobblestone blocks (shown in black); elevation (above) and top view (below). Human figure for scale.

In addition to asymmetrical blocks and cobblestone blocks, other unidirectional tactile blocks could be designed. These should be easy to feel with the feet or with a walking cane and should clearly communicate the orientation of the block. Additionally, they should consider the existing conventions around tactile paving design to minimize confusion among users (such as bars parallel to the direction of travel for directional blocks). Whereas possible designs could communicate resistance while walking against the assigned orientation, they should not be dangerous to the users.

4. Conclusions

In response to the COVID-19 pandemic, our spatial environment has been restructured considerably to limit the spread of the disease. Most of these recent urban interventions respond to the needs of a large part of the urban population but are rarely adapted to those with physical disabilities. The overwhelming visual barrage of new signage systems indicating unidirectional circulation in diverse contexts fails to consider the needs of the visually impaired. Unidirectional tactile paving begins to address these concerns. The designs proposed in this paper allow the visually impaired to navigate through unidirectional circulation networks by feeling the unidirectional tactile blocks with their feet or walking canes. The simplicity and intuitiveness of these designs aim to allow the users to internalize how they work in a relatively short period of time. However, unidirectional tactile paving is only a part of the solution and would benefit from a synergistic integration with other technologies.

Integrating navigation apps within spaces that deploy unidirectional circulation would create a more detailed and inclusive experience while also limiting confusion and accidents. Existing apps already provide great assistance to the visually impaired in moving through both the city and within buildings. For instance, NaviLens (navilens.com) allows its users to scan NaviLens codes placed at strategic locations on the floor and gives them important information about their surroundings. Blindsquare's GPS system (blinsquare.com) guides users to their destinations via advanced third-party tools. BlindWiki (blind.wiki) allows blind or partially sighted users to share location-based findings with others, including difficulties and barriers along paths, but also experiences and stories. Moreover, Be My Eyes (bemyeyes.com) allows volunteers to help the blind and low-vision people through live video calls. Combined with unidirectional tactile paving, these technologies could allow the visually impaired to quickly adapt to updated layouts and decrease the reliance on memorizing complex mental maps of unknown environments.

More affordable alternatives to the preliminary designs presented in this paper could facilitate their installation. Self-adhesive tactile strips can be installed on a variety of flat surfaces and, unlike tactile paving, do not have to be installed simultaneously with the pavement. For an example, see [9]. The designs presented in Section 3 could be adapted to self-adhesive tactile strips. Additionally, people with all types of visual conditions could be served if high-contrast arrows are painted on the tactile strips or blocks. By reordering or reorienting the strips, the assigned directions could be easily rearranged or inverted.

The onslaught of COVID-19 has forced us to reconsider the way in which pedestrians navigate through space and has highlighted the ways in which certain architectural layouts can accelerate a virus epidemic. However, it has also highlighted our visual bias when reshaping our environments while providing opportunities to be more inclusive when thinking of any design solutions. Unidirectional tactile paving could be an inclusive preventive measure for a future outbreak of an airborne disease, such as COVID-19.

Although this paper highlights the usefulness of unidirectional tactile paving with the goal of allowing for physical distancing, asymmetrical blocks and cobblestone blocks can be implemented in non-pandemic contexts too. Regardless of physical distancing, the use of bidirectional tactile paving (the existing type) can lead to collisions between visually impaired pedestrians who walk on it simultaneously in opposite directions. By installing two parallel paths of unidirectional tactile paving, pedestrians can walk both ways without bumping against each other. (See Figure 5.) This could require the installation of twice as many tactile paving blocks or less, but collisions would be minimized, and the tactile paving would be safer to walk on.

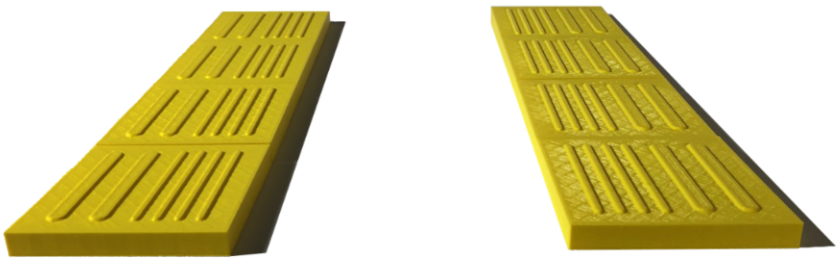

Figure 5. Two parallel paths of unidirectional tactile paving (asymmetrical tiles in this example). Since they go in opposite ways, this would minimize collisions between pedestrians. These tiles were 3D printed at the Harvard Graduate School of Design's Fabrication Lab.

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