Pedestrian Accessibility and Mobility Environment Laboratory

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Abstract

To improve accessibility in the pedestrian environment, we need to understand better the nature of that environment and how people interact with it. We can consider anyone carrying out an activity in the pedestrian environment as creating a 'journey chain' for the activity. This chain could be as simple as 'leave house; walk to local shops; return to house'. In this case, the individual 'links' of the 'chain' could arise in streets that the person walks down, doorways into the required shops, and the layout of each shop. The journey could fail if any single link were to fail. For example, the journey would fail if there were a crossing over a busy road with no light control and the person could not walk fast enough, nor was agile enough to miss the oncoming vehicles. From this definition of a 'journey chain', a person could be classed as disabled if they encounter barriers in the environment that prevent full and active participation as a citizen. In addition, the numbers of disabled and elderly people are increasing across the developed world. It should be an aim for full accessibility for such disabled people across the pedestrian environment and to do this we need to understand more about how people interact with this environment.

We can try to improve our understanding of how people move in pedestrian environments by measuring movement in existing environments. However, it is difficult to separate the effects of the pedestrian environment from external factors, such as location, social interactions, local activities and, not least, safety constraints. Therefore we need a test environment that allows us to change elements in a repeatable controlled manner. Such a laboratory has been constructed : the Pedestrian Accessibility and Mobility Environment Laboratory (PAMELa).

This paper describes the PAMELa laboratory and explains how it can help people wishing to enhance pedestrian facilities. The laboratory consists of a modular platform; allowing control over layout (floor plan), topography (steps/gradients, street furniture, surface material and wetness); lighting; and sound systems. The lighting system allows control over luminescence from daylight to darkness, including localised lighting : for example streetlights. The surround sound system will give control over location and timing of sounds : for example, cars driving along a street, cars approaching and stopping at a crossing, pedestrian noise (talking and walking), trains going through a station whilst announcements are made.

This laboratory allows measurement of people's movement within a safe and carefully controlled environment. Existing and planned environments can be tested giving direct information on their accessibility. In addition, the results of all tests can be used to inform pedestrian simulation models. Some brief illustrative examples will be given.

Author Biography

Craig Childs is a research fellow, having obtained his PhD in Biomedical Science and Engineering. His research focus is human movement and accessibility in pedestrian environments.

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Ian Brown is a senior research fellow, with a background in Civil Engineering. His present research interest is in the design and construction of structures for experiments involving people.

Nick Tyler is Chadwick Professor of Civil Engineering at UCL. His research covers a wide range of accessibility issues of transport systems.

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Introduction

This paper presents the creation of a laboratory designed to recreate street environments for testing pedestrian movements. It gives details of the laboratory, its elements, and describes some examples of how it will be used.

Previous studies into human movement have been carried out in laboratory conditions with flat smooth floors (Sheldon RS, 2004) or with temporary obstacles (for example, Chou LS, and Draganich LF, 1997) or in real life pedestrian environments (e.g. DETR 1994). Motion laboratories are good for making detailed measurements of movement, but in an unusual, artificial environment. Outside, pedestrian environments allow measurement in real life conditions, but it is difficult to compare different conditions in a controlled manner and there are often safety issues which limit the extent to which experiments can be conducted in the 'live' street environment.

There is a resulting lack of detailed information about pedestrian movement and accessibility issues which is based on real-life experience but obtained in the context of scientifically controlled conditions. This led the Accessibility Research Group at UCL to design and construct a laboratory to test human movement for different groups of people in various environments to determine optimal layouts. These groups of people include the elderly, people with luggage/shopping, wheelchair or scooter users, and people with hearing or visual impairments. The laboratory is also a safe and unthreatening environment for examining cognitive issues relating to the pedestrian environments, especially for people with learning difficulties.

The results from tests carried out in this laboratory will inform us about the effect changes in layout may have on the accessibility of existing and proposed pedestrian environments. In addition, the results will be used to inform pedestrian simulation models. Using this laboratory we aim to understand better people's capabilities and what street environments require of people.

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[1] http://www.arup.com/
[2] http://www.weirservices.com/

Materials and Methods

The laboratory consists of a 'room', which is a covered space approximately 20m x 15m in plan and 5m high, containing a lighting system and a modular platform; allowing control over layout (floor plan) and topography (steps/gradients, street furniture, surface material and wetness) .

Lighting

The lighting system allows control over luminescence from daylight to darkness, including localised lighting, for example street lights, spot lights, or station lighting. This means that the colour and intensity of light can be accurately and repeatedly controlled. The lighting system includes ceramic discharge lamps; low pressure sodium lamps; 70W high pressure sodium lamps; 150W high pressure sodium lamps; tungsten-halogen lamps; and fluorescent lamps. This set of lamps covers those used in typical street environments : however, the laboratory was designed to allow expansion through the addition of different types of lamp. PC-based control software allows us to change easily the intensities of the lamps; which can be positioned as required.

With the walls and floor painted black, it is possible to control what people see within the laboratory, thus enabling us to test not only the conditions obtained from different lighting systems, but also the effects of different colours of obstacles, marking, surface materials, signage and so on. With the variety of lamps we can study how the characteristics of each kind of lamp affect pedestrians. For example, under some lamps it is difficult for pedestrians to distinguish colours. The laboratory also allows us to compare such characteristics with cost issues, and find better solutions for lighting in view of both pedestrian-friendliness and cost effectiveness.

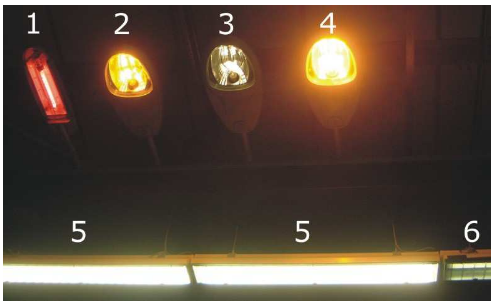

Fig. 1 Lamps : warming up

1. Low pressure sodium lamp
2. High pressure sodium lamp 70W
3. Ceramic discharge lamp
4. High pressure sodium lamp 150W
5. Fluorescent lamp
6. Fluorescent lamp with filter

Platform

The platform consists of 36 modules, stairs, a wheelchair lift, and safety barriers. Each module is 1.44m^2, giving a total surface area of over 50m^2. The modules can be arranged within the laboratory in almost any conceivable layout; for example square, rectangular, or ‘L’ shaped according to the requirements of each experiment. Once in position, the modules are connected together.

When the layout has been defined the topography can be altered. There are 20 square (Fig 2.) and 16 split-square modules (Fig 3.). The split-square modules consist of two triangles, each of which can be moved independently.

Fig 2. Square module : lowered position

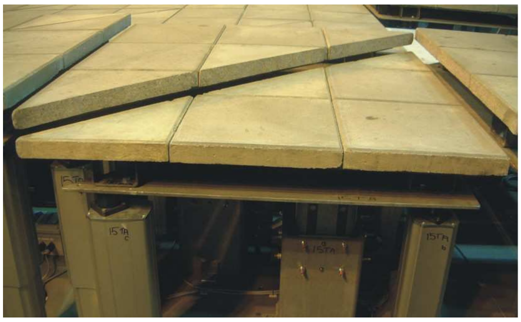

Fig 3. Split-square module : each triangle set to a different height

Actuators control the height of each corner of each module individually; allowing accurate and repeated control of the topography (the actuators can be controlled to ±0.5mm). The square modules have 4 actuators, one at each corner of the module; the split-square modules have 6 actuators, one at each corner of each triangle. The range of each actuator is 250mm, allowing a maximum step height between modules of 250mm, or a maximum gradient of approximately 1:5 from one edge of a module to the opposite edge (Fig 4.). Once the actuators are in the correct position, the power is switched off and an inbuilt mechanical brake holds the actuator in position.

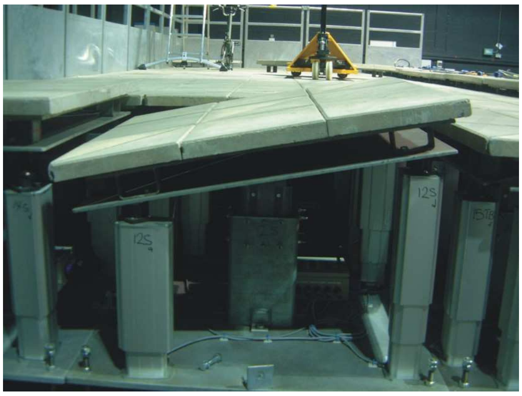

Fig. 4 Square module : set to 1:5 slope

As the laboratory is designed to represent real pedestrian environments, which do not normally stand on actuators, it is essential to ensure that the modules feel as if they represent solid ground. This means that the elements of each module have to be rigid whilst being able to be articulated and must be resistant to both vertical and lateral forces. The vertical forces (e.g. a person jumping up and down) are resisted by the actuators. The lateral forces (including those derived from the normal motion of walking and those resulting from, say, an electric scooter colliding with a step) are resisted by means of a robust sub-structure which is attached to the underside of the surface by means of a closely fitting universal joint.

Using a system of interchangeable trays, different surface materials can be used over as much of the platform as is required (for example, paving slabs, blister paving, asphalt, terrazzo tiles). It is possible to attach objects to represent street furniture and to soak the platform to recreate wet and slippery conditions.

<u>Instrumentation</u>
Digital video cameras (Figs 5a-c.) record movements on the platform from any required angle. A set of video cameras is mounted vertically above the platform at all times. The precise location of these cameras is adjustable so that the entire surface can be seen, whatever the actual shape of the layout. Other video cameras are mounted on tripods and located around the platform to provide horizontal views of the action, including particular details of interest as well as ones of a more general nature. Cameras are fitted with infrared-sensitive lenses so that recording can take place in extremely low light levels. Apart from these visual records, we have two other monitoring systems in the laboratory.

Fig. 5 Sample images from a participant performing an obstacle avoidance task, whilst wearing the eye tracker camera, in low lighting conditions (low pressure sodium lamps)

Fig. 5a Rear view from Video camera

Fig. 5b Side view from Video camera

Fig. 5c Vertical view from Video camera

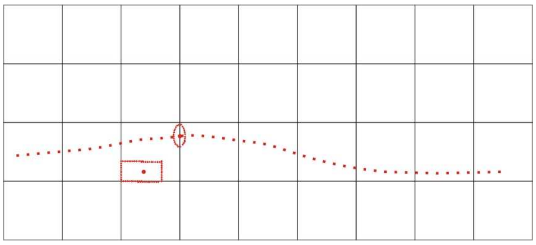

Fig. 5d Output from position tracking, showing the plan view of the 4 x 9 module layout, with the rectangular obstacle and the path taken by the participant to avoid the obstacle (moving from right to left).

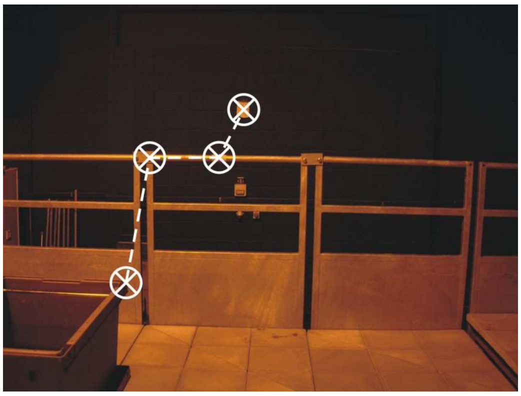

Fig. 5e View from Eye tracker camera, showing the progression of where the participant was looking : from the corner of the obstacle to a nut on the parapet surrounding the platform, to a mark on the barrier, and finally to the mark on the wall

Pedestrian location is measured using two IBEO laser scanners. These devices scan using an eye safe infrared frequency beam, recording the distance to objects in the path of the beam. Using a proximity protocol it defines individual objects and returns data on the location and velocity of those objects every 100 milliseconds. The scanners are set up to cover the required platform layout, creating a plan view of any objects (Fig 5d.).

An eye scanner can track where people are looking within the environment; as they complete tasks. This data is analysed to determine how early and how often people look at elements within their environment; either to avoid them (obstacles) or gain information (e.g. timetables).

Sound

We are currently commissioning a sound system which will enable us to provide a noise environment. This will include a static sound environment to provide an appropriate background. Onto this background noise, moving sounds will be added. We will be able to represent the sound of a vehicle moving through or past the pedestrian scene. This may be the sound of a parked vehicle which can be heard by a pedestrian as they approach and pass it, as well as the effect when such a vehicle moves off. Alternatively, positional sounds will be created which will enable us to interpose specific events, such as announcements. This will be delivered by a set of over 100 computer-controlled loudspeakers positioned around the laboratory.

The laboratory has eye testing, hearing testing and various physical monitoring equipment so that we can calibrate pedestrian’s performance with basic assessments of their capabilities – e.g. colour sensitivity, visual acuity, hearing thresholds, leg extensor power, etc.)

Examples of the use of the facility

To give an indication of the sort of experiments we can conduct in the laboratory, a few examples are given below. The laboratory is very flexible and these are just a few examples to indicate the sort of work that can be done. Where the term 'walk' is used, it includes people crossing the platform in wheelchairs and scooters.

Obstacle avoidance (Fujiyama et al, 2005)
Platform modules set flat; concrete slabs over the whole surface; surfaces kept dry; obstacle placed on platform; people asked to walk across platform avoiding obstacle; change luminance levels; measure avoidance paths; compare avoidance paths with eye tracking data.

Crossing density
Platform modules set with a raised footway section at either end; concrete slabs over the whole surface; surfaces kept dry; guard rail limiting the crossing width at either end to 2.4m; people asked to walk from one footway section to the other; keep luminance level fixed; measure time to cross for different numbers of people trying to cross in each direction; comparison of density effects for different footway-carriageway interfaces (e.g. ramps and standard kerbs).

Steps
Platform modules set with different vertical gaps; concrete slabs over the whole surface; surfaces kept dry; people asked to walk across platform; change luminance levels; measure time and effort to climb vertical gaps.

Horizontal gaps
Platform modules set flat; concrete slabs over the whole surface; surfaces kept dry; using an adjustable surface set onto the platform, create 'safe' horizontal gaps, including angled gaps (e.g. to represent the interface between the footway and a bus parked at an angle to the kerb); horizontal gaps can be combined with vertical gaps to study the effects of combinations; people asked to walk across platform; change luminance levels; measure time and effort to cross the gaps.

Longitudinal slopes
Platform modules set with different longitudinal gradients; concrete slabs over the whole surface; surfaces kept dry; people asked to walk on a prescribed route around the platform; change luminance levels; measure time to cover route and effort involved to complete sections with different gradients.

Cross-fall slopes
Platform modules set with different lateral gradients; concrete slabs over the whole surface; surfaces kept dry; people asked to walk on a prescribed route around the platform; change luminance levels; measure time to cover route and effort involved.

Manoeuvrability
Platform modules set flat; concrete slabs over the whole surface; surfaces kept dry; additional obstacles arranged with different lateral gap widths (point restrictions (e.g. bollards, lampposts) and long restrictions (e.g. walls, fences)) and turning circle areas; people asked to walk on a prescribed route around the platform; obstacles set to require different levels of ability to turn in order to avoid them; change luminance levels; measure time to cover route.

Surface material
Platform modules set at different gradients (including flat); different surface materials on the modules; surfaces dry and wet; people asked to walk on a prescribed route around the platform; change luminance levels; measure time to cover route, monitor for slips.

Bus stop
Platform modules set flat and with appropriate crossfalls; concrete slabs over the whole surface; surfaces kept dry; additional street furniture representing different kinds of bus stop, including information; people asked to use bus stop (i.e. find relevant parts; find required bus route and number); change luminance levels; measure time to get information.

Pedestrian capacity (Cepolina and Tyler, 2005)
Platform modules set flat; concrete slabs over the whole surface; surfaces kept dry; vertical restrictions placed on the flat platform so that available width changes (e.g. a bottleneck); change luminance levels; pedestrians asked to walk through the restriction; monitor inflows, outflows, congestion, delays, capacity drop effects.

Combinations
A particularly interesting feature of the laboratory is the ability to consider combinations of objects in the environment. For example, the platform could be set with a rough uneven surface changing to a smooth slippery one, with some steps and slopes. Combining this with signage which has to be read and understood, noise effects including background, specific events and instantaneous sounds such as announcements and we can model how people deal with all of these influences on their progress along a prescribed route, noting how changes in any or all of these effects alter the ability of the person to negotiate the environment. The eye scanner can indicate how they take in the visual environment in order to understand such a range of complexity.

Discussion

This laboratory has been designed and built to allow different pedestrian environments to be recreated and to measure how people move around those environments. The environment can then be altered, element by element, and the changes in pedestrian interaction noted. This allows explicit measurement of street environments to determine how many people may be excluded from an environment due to various aspects of its design and how many more people may be included after modifications. Surfaces and topographies can be changed; and obstacles can be moved in the laboratory, but not so easily in a real street. Although measurement of people moving in real life conditions is possible, it is not always possible to control the environmental conditions. In addition, there may be safety considerations testing people on real streets. Measuring people's movements in the controlled environment of this laboratory can inform pedestrian simulation models allowing artificial testing of more complex environments.

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