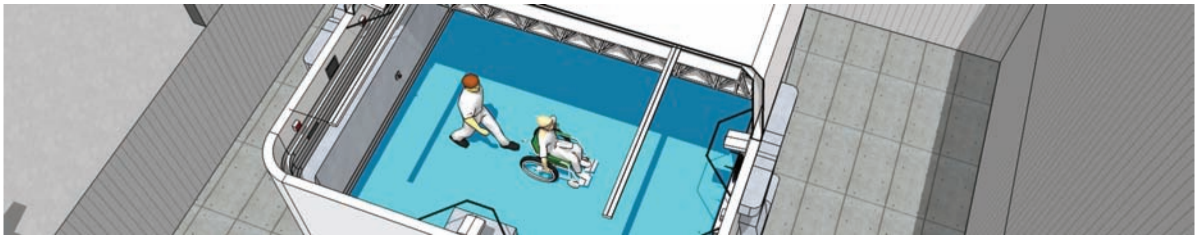

DESIGN RESOURCES

DR-10 Simulator Systems and Universal Design

Center for Inclusive Design and Environmental Access

Simulator Systems and Universal Design

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Overview

Exciting new technologies are now allowing researchers to simulate a broad range of complex environmental conditions in a safe and precisely-controlled manner (e.g. using Virtual Reality and motion simulator systems). These tools have the potential to contribute greatly to research in the field of universal design. A state-of-the-art simulation laboratory, referred to as iDAPT (Intelligent Design for Adaptation, Participation and Technology) is currently being developed at the Toronto Rehabilitation Institute that will allow this potential to be realized in extraordinary ways.

Figure 1: Photo of iDAPT facility at the Toronto Rehabilitation Institute

Issue and Its Importance to Universal Design

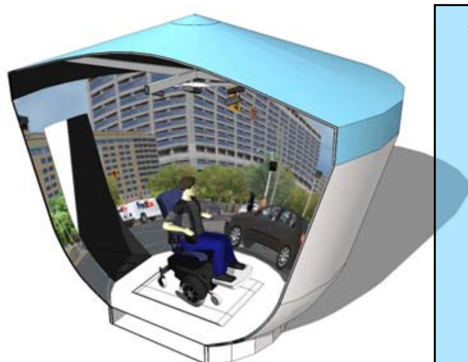
Simulation technologies are most often associated with fields such as aerospace engineering and pilot training, military applications and the gaming and entertainment industry. Such technologies are used to simulate a variety of sensory experiences including visual, auditory, proprioceptive (muscles and joints,) vestibular (acceleration detector in the inner ear), and somatosensory (touch). In doing so it is now possible to create visual and auditory experiences using customizable computer-simulated environments (i.e. Virtual Reality) to introduce specific physical motion parameters (e.g. using a car or airplane motion simulator), or to generate different climatic conditions (e.g. by manipulating environmental temperature). This allows a user to interact with these systems in real time, so that when driving a simulated vehicle for instance, the movement of the steering wheel is used to directly update the visual and auditory information in the virtual environment, as well as the movement characteristics of the motion platform.

These same technologies can also provide considerable advantages for studying the problems people face in navigating the built environment as well as for testing novel product prototypes. Specifically, iDAPT facility will have the ability to provide realistic, yet precisely controlled environmental conditions to evaluate human perception and performance under both ordinary and challenging situations. When attempting to create environments and products that are accessible to everyone (particularly individuals with disabilities and age-related conditions), tests should be administered under very safe conditions that closely mimic experiences encountered during typical interactions in the real world.

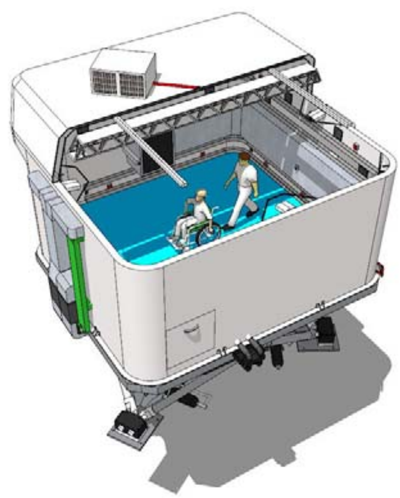
The Challenging Environments Assessment Laboratory (CEAL)

The main objectives of the iDAPT research program are to perform careful scientific assessments and to develop innovative devices and interventions that will lead to tangible solutions to real problems. The centerpiece of the new iDAPT facility is the Challenging Environments Assessment Laboratory (CEAL).

CEAL consists of a large 6m x 6m (19’6” x 19’6”), one-of-a-kind, 6-degree-of-freedom motion platform that can realistically mimic everyday environmental conditions as well as introduce challenging environmental conditions. The platform can be configured with various, interchangeable payloads (portable, self-contained, fully instrumented laboratory spaces) that can be physically lifted on to the hydraulic motion platform base using a large crane. Currently there are three payloads, each with their own unique capabilities (figure 2). Additional future payloads are also being developed.



The **Visual Dome Payload** contains a high resolution, 180 degree field-of-view visual projection system and a high-quality surround sound system that can be coupled with various movement interfaces including a linear treadmill and manual and electronic wheelchairs. An extremely high resolution, virtual rendering of downtown Toronto has been developed. This simulation includes intelligent vehicles and pedestrians and a realistic 3D soundscape.



The **Winter Payload** can be used to simulate different atmospheric conditions such as sub-zero temperatures, wind and snow and it actually contains a real ice floor.

The **General Purpose Payload** can be entirely customized for individual experimental needs. Options for interchangeable features include an instrumented staircase and a large force plate floor. Here it is shown with the staircase with force plates built into the steps and load cells built into the handrails.

CEAL Payloads

All of the payloads are outfitted with state-of-the-art motion capture systems, microphones and surround sound systems. Other measurement devices will include eye-trackers, EMG systems (to measure electrical muscle activity) and EEG systems (to measure electrical brain activity) and more.

CEAL will be open for research in February 2011 and everyone is encouraged to come and use these exciting new facilities.

Figure 2: Interior graphics of iDAPT facility and current payloads

Research Questions to be Addressed Using CEAL

Walking on slopes and different ground surfaces: Thirty thousand people in Ontario break their hip each year due to falls. Many of these individuals never fully recover from their injuries. Using CEAL we will be able to safely study several issues surrounding what leads to slips, trips and falls and find ways to prevent them. This will involve, for instance, evaluating the effectiveness of different types of footwear for walking on various ground surfaces (e.g. ice and snow, sloped surfaces, etc.). Similarly, studies might be undertaken to understand how the challenges introduced by different ground surfaces can affect individuals who have had knee replacement or knee fusion surgeries or those who require the use of a walker, wheelchair or scooter. In CEAL we will be able to systematically change the slope and traction of the ground surface, and also to create specific movement perturbations to create balance disturbances to participants to better study falls under highly controlled conditions. A similar approach might be used to test the stability and performance of mobility aids or other assistive devices on more challenging ground surfaces. And all of these tests will have the ability to precisely measure the biomechanics of the entire sequence of behaviours using sophisticated motion capture systems, force plates, etc.

Interactions with steps and stairs: 60-70% of falls causing injury happen on steps and stairs. Understanding issues related to optimal staircase and handrail designs is another important issue that will be investigated using CEAL. For instance, using an instrumented staircase in the General Purpose Payload we will be able to examine the effectiveness of different handrail designs for balance recovery while walking up or down stairs (Gorski, 2005; Lever, 2006; Maki et al., 1984; 1985; 1998; 2008). By using force plates that are mounted in the steps and also through information provided through load cells in the handrail behaviours can be characterized precisely. These characteristics might include types of recovery movements executed and their effectiveness in avoiding a fall. Similar setups can be used to help develop new design concepts for stair-climbing aids and for better evaluating the safest rise/run ratio of steps. The results of this work will eventually be used to inform building codes and policy decision making.

Contending with different atmospheric conditions: Deaths and injuries increase during the winter months due to increases in the occurrence of dangerous weather conditions such as snow, ice and slush and also due to the impact of cold exposure on physiological functions (e.g. cardiovascular and respiratory issues). Using CEAL we will be able to systematically manipulate environmental temperatures (down to sub-zero temperatures), generate snow and wind and introduce a real ice surface. This will allow us to better understand how winter conditions affect the ability to manoeuvre using mobility aids such as walkers, wheelchairs and scooters and to determine the effectiveness of different types of winter clothing on physiological responses such as a rise **blood pressure?** (Li et al., 2009). We will also be able to mimic aspects in the built environment, such as intersections and pedestrian crossings to more clearly define safety concerns and propose informed solutions (Li and Fernie, 2009).

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