Virtual Reality Based Scalable Framework for Travel Planning and Training

Loren Abdulezer, Jason DaSilva

Evolving Technologies Corporation, AXS Lab, Inc.

la@evolvingtech.com, jdasilvax@gmail.com

Abstract

The problem we are addressing is to provide greater travel independence through utilization of immersive technologies to navigate spaces utilizing VR and modern day mobile devices. We have focused on specific issues of travel training and fixed route services such as navigating through public transportation hubs. Immersive exploration of travel routes well in advance of attempting the travel reduces anxiety and builds confidence in wayfinding.

We explore the technology stack, working methodology, and outcomes.

Keywords

Assistive Technology, Travel Training, Travel Independence, Virtual Reality

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Introduction

A key goal in the use of assistive technology is to help level the landscape so that individuals with disabilities can partake in the benefits (whether utilitarian or optional) that other members in society regularly get to enjoy and take for granted.

Enabling travel independence addresses a big part of this goal. There may be services such as paratransit that's available. However, over reliance on such services can result in ineffective benefits; travel independence is not achieved when it becomes necessary to book such services a day or two in advance, service schedules are not reliable, and the sense of agency (the ability to spontaneously adjust travel plans due to last minute change of circumstances) is all but nonexistent. Additionally, services like paratransit are costly and generally are hard to sustain a reliable quality of service as its usage grows.

Much of this problem can be addressed using effective fixed route (“FR”) services such as subways and transportation hubs. These services already have accessibility features like elevators, wheelchair ramps and the like. Uncertainties encountered during travel can hamper FR services; most specifically, wayfinding in a complex transportation hub.

The approach introduced in this paper is to outline the framework we developed that incorporates the use of Virtual Reality (“VR”) and other immersive technologies that allow individuals with disabilities to conveniently explore environments they will need to travel ahead of attempting the route; practice the route, help eliminate uncertainties and anxieties, obtain useful information and engender a sense of confidence, before taking one step out of their home.

We explain the technology stack, key decisions for our choices, the workflow methodology for recording immersive 360 images and embedded video clips, images, voice overs, ambient sounds, text content, and other curated media elements.

We explain our approach to the user interface.

We outline the framework for cost effective and scalable deployment based on ubiquitous, readily affordable hardware, and ability to distribute content.

Discussion

Virtual Reality (“VR”) and other immersive technologies allow individuals with disabilities to conveniently explore environments and venues. We view this technology as a resource that can be harnessed to facilitate travel training and encourage travel independence. We discuss the approach we developed, key decision criteria for our implementation, preliminary results and basic next steps.

In recent years 360-degree camera technology has become a cost-effective way to record immersive images and videos. This combined with ready availability of smartphones and inexpensive VR viewing devices opens the door to achieving virtual exploration as a potent tool in travel training and travel independence.

The recording technology of 360 cameras addresses one set of needs, but does not provide a built-in solution for wayfinding or navigating a large public space such as a transportation hub. The key feature that we developed is to create a virtual map that allows an individual in VR to interactively “teleport” along line of sight through multiple 360 images as they actually would be doing in a wheelchair.

We enable simple gaze activated navigation so that dexterity and movement of hands is not an issue. Where appropriate we can embed useful information in the form of visual hot spots, informative video clips, voice overs, and instructional information. We include the use of spatial ambient sounds. We also have a framework to automatically collect and analyze user activity and patterns such as identifying hotspots the user is viewing, and establish metrics on learning improvements. These overall features are outlined in Table 1.

Table 1. Basic Features & Capabilities

Feature/Capability	**Detail**	**Comments**
Map of Venue	Accurate floorplan or map of venue is needed	This must be available ahead of 360-image capture.
Image Capture: 360-degree capture	Can be either monoscopic or stereoscopic	• Collection of images should be sufficient to enable line of sight navigation • Location on map needs to be recorded. • Orientation of images need to be consistently aligned.
Embedded Interactive Content	• Pop-up images & video clips • Voice overs • Text-to-speech • Captions	Content can be bundled into a self-contained application or can be delivered at runtime over the Internet.
Ambient Sounds	Separate audio recording of ambient sound for each 360-image	Because individual recordings are paired with the corresponding 360-image, you get spatial sound “for free”; the collection of sounds and their arrangement in the virtual environment enable this capability.
VR Hardware	Inexpensive & readily available hardware – basically: Smartphones with Gear VR or Daydream (and additionally in Tablets such as iPads)	Additionally, for travel training settings, a separate computer can be used for providing a special Coach Mode and/or collecting/analyzing user data.
Data Analytics	Smartphones can record session data	Session data can include event driven information such as actions like which hotspot was gazed at, at what time, and where the user was in the virtual scene. This collected data is available for analysis in either spreadsheets or databases.
Coach Mode	Wireless connection between smartphone & PC	• Connection is in real time so that travel trainer can see what the user is looking at as it happens. • Connection is bi-directional so that travel trainer can directly provide visual cues to the user during the session.

It is important to note subtleties in our implementation. Virtual objects like teleport icons appear with sizes corresponding to their virtual distance from the user (see Fig.1), thus, providing better information. Of course, the teleport icon size automatically changes size as the user moves through the virtual scene.

Notice that Jason is using gaze control to connect between scenes

Fig. 1. Sample VR based navigation entirely through gaze control.

Workflow

Enabling this wayfinding capability with embedded useful supplementary content involves a four-step process of planning for a given site, mapping the facility, integrating/curating the content, and deploying/publishing so the venue is explorable to a broad base audience (see Fig. 2).

Planning a site after selecting it from a list of candidate locations typically involves a physical visit, identifying specific routes, building a floor plan, noting items of interest, scheduling a date and time for the recording, and of course, securing necessary permissions/permits. It is during this planning stage/site visit that we have the opportunity to take note of things like peculiar features in the fixed route service, such as an excessive gap between the train and the station platform.

Four Step Process

PLAN	CAPTURE
CURATE	PUBLISH

Fig. 2. Workflow for each site/venue.

Capture is handled with 360 cameras, noting physical location of all photos. It is a requirement that every 360 image recorded must have coverage by line of sight so that wayfinding paths can always match actual physical path traversal with a wheelchair.

The curation process is most labor intensive. The 360 images need to be placed into a virtual map that corresponds to the real physical spaces and orientation of 360 images needs to be preserved so that “teleporting” through the various places feels natural. We create and position occlusion walls are so that teleporting only happens through direct line of sight of what is visible within each 360 image. Where appropriate, we embed visual hot spots that have interactive features, that can for instance, play an instructional video. After this there is lots of testing for verification of accuracy, completeness, and usability.

Application Structure

The application is designed to be simple and intuitive. The first step is to select a suitable train or subway station. Fig. 3 shows one of the main menus as we program it in the Unity environment. All the user needs to do is gaze at any one of these stations for a brief period to be teleported to that virtual station.

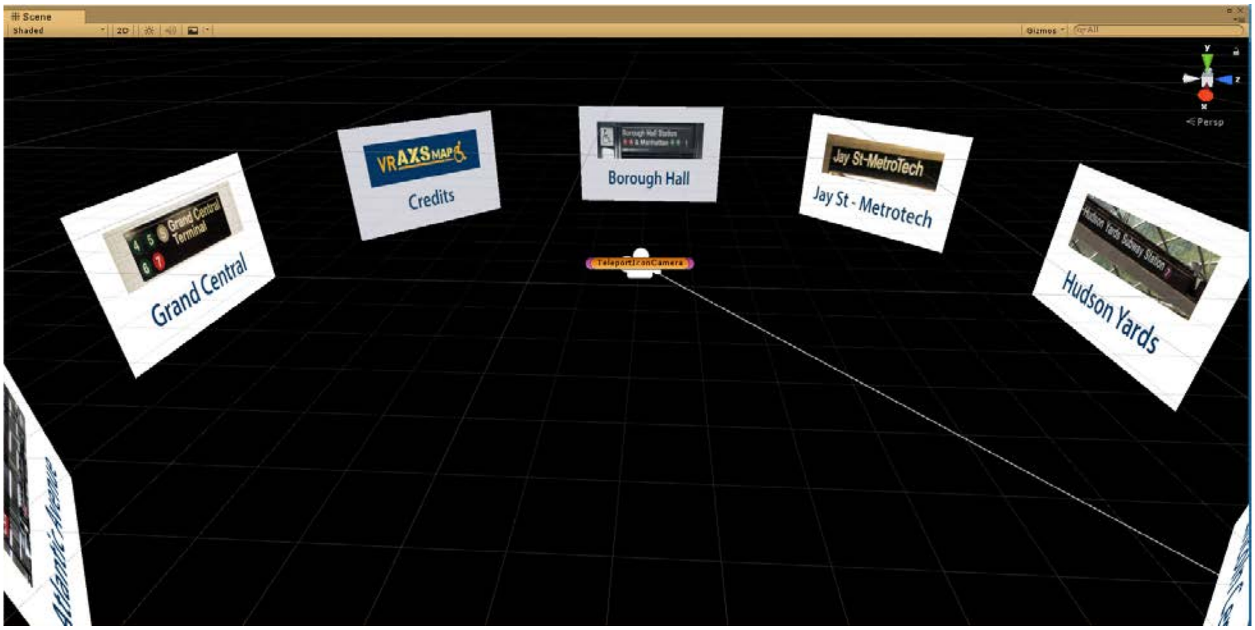


Fig. 3. 3D Menu for selecting a Station

From there the user can navigate through the virtual station (as depicted in Fig. 1) by gazing at the various icons like those shown in Fig. 4.

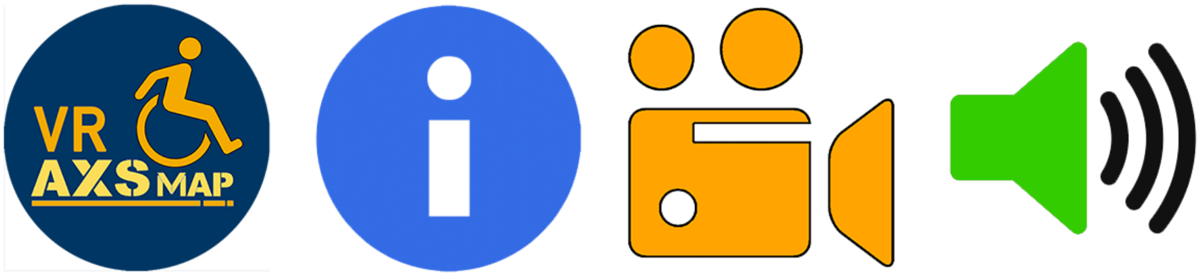
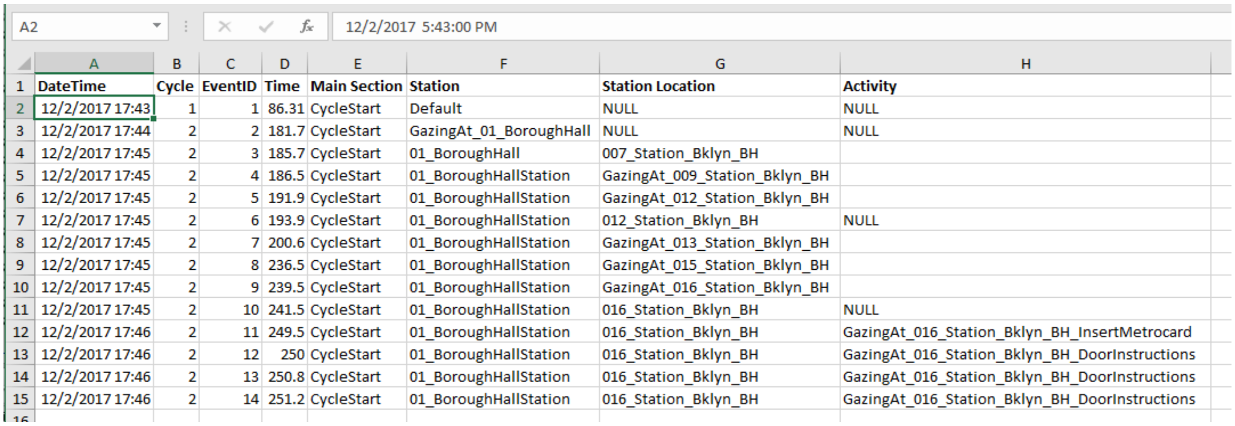


Fig. 4. Representative Interaction ICONS

Data Analytics

One of the exciting developments in our implementation is the ability to capture data on user activities to assist in facilitating user improvement using metrics. Fig. 5 shows a screenshot of data exported to Excel. We currently can only export the data in CSV format, but are exploring other options.



DateTime	Cycle	EventID	Time	Main Section	Station	Station Location	Activity
12/2/2017 17:43	1	1	86.31	CycleStart	Default	NULL	NULL
12/2/2017 17:44	2	2	181.7	CycleStart	GazingAt_01_BoroughHall	NULL	NULL
12/2/2017 17:45	2	3	185.7	CycleStart	01_BoroughHall	007_Station_Bklyn_BH	
12/2/2017 17:45	2	4	186.5	CycleStart	01_BoroughHallStation	GazingAt_009_Station_Bklyn_BH	
12/2/2017 17:45	2	5	191.9	CycleStart	01_BoroughHallStation	GazingAt_012_Station_Bklyn_BH	
12/2/2017 17:45	2	6	193.9	CycleStart	01_BoroughHallStation	012_Station_Bklyn_BH	NULL
12/2/2017 17:45	2	7	200.6	CycleStart	01_BoroughHallStation	GazingAt_013_Station_Bklyn_BH	
12/2/2017 17:45	2	8	236.5	CycleStart	01_BoroughHallStation	GazingAt_015_Station_Bklyn_BH	
12/2/2017 17:45	2	9	239.5	CycleStart	01_BoroughHallStation	GazingAt_016_Station_Bklyn_BH	
12/2/2017 17:45	2	10	241.5	CycleStart	01_BoroughHallStation	016_Station_Bklyn_BH	NULL
12/2/2017 17:46	2	11	249.5	CycleStart	01_BoroughHallStation	016_Station_Bklyn_BH	GazingAt_016_Station_Bklyn_BH_InsertMetrocard
12/2/2017 17:46	2	12	250	CycleStart	01_BoroughHallStation	016_Station_Bklyn_BH	GazingAt_016_Station_Bklyn_BH_DoorInstructions
12/2/2017 17:46	2	13	250.8	CycleStart	01_BoroughHallStation	016_Station_Bklyn_BH	GazingAt_016_Station_Bklyn_BH_DoorInstructions
12/2/2017 17:46	2	14	251.2	CycleStart	01_BoroughHallStation	016_Station_Bklyn_BH	GazingAt_016_Station_Bklyn_BH_DoorInstructions

Fig. 5. Sample Data Capture in a Session.

Deployment

All of this is built with Unity and XpressVR (a Unity based toolset developed by one of the authors), so it is relatively straight forward to deploy to a variety of standard VR, smartphone, desktop and tablet devices, which are outlined in Table 2.

Table 2. Deployment Modalities

Feature/Capability	**Detail**	**Comments**
Smartphone	• Gear VR (implemented) • Google Daydream (in development)	• Android based. • Navigation and interactivity accomplished through gaze control • Optional hand controller can be used • Suitable for data analytics (data can be captured on device and transferred after session).
Immersive Non-VR Device	iPad or smartphone	• Android or IOS. • Requires holding device in hand to face in a desired direction. • Navigation and interactivity accomplish orienting device to face “target” (effective equivalent of gaze control) and also through touch input.
PC System	Travel training & Data Analytics usage	• Tested on Windows but should work with MacOS. • Wireless connection between PC & smartphone. • In Coach Mode smartphone can be monitored in real time. • Event and monitoring data can be transferred from smartphone and analyzed on PC using standard spreadsheet of database software.

Our expectation is that the Apps will be placed onto online Stores with media content served from the cloud.

There are several important features we are bringing into this delivery platform:

- We can accommodate multiple types of disabilities from a single code base. Specifically, in addition to dealing with the wayfinding features, we can vary imagery better suited to low vision (through selective magnification). We are also devising a framework to throttle up or down to match different cognitive abilities.

- Individualized customization is a standard feature so that each individual can have the App tuned to his/her specific need.
- Cloud services facilitate passive updating of application content.

Conclusions

Travel independence is a specific kind of challenge. Technology brings in all sorts of solutions for adaptive devices. It can be as simple as a curb cut, or as elaborate as a custom-built input device. ADA and other compliance based directives can bring institutions, organizations, and companies to incorporate adaptive accommodations, but when it comes to helping individuals to achieve travel independence there remain some significant gaps. Fortunately, technologies like the kind we developed and are reporting on here rebalances this inequity. We can now harness VR and related immersive technologies to greatly enhance the utility (and freedoms) available through fixed route services.

Works Cited

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