Going the Distance: Human Computing to Find Accessible Routes in Real-Time

Dianna Hu
Harvard University
dhu@college.harvard.edu

Joy Ming
Harvard University
jming@college.harvard.edu

ABSTRACT

In this paper we describe a human computation approach for solving the problem of finding an accessible route between two given locations. The system will take as input a user question, ask workers on Amazon Mechanical Turk (MTurk) to verify the accessibility of the routes returned by Google Maps using Google Street View (GSV), and re-route the user until an accessible route is found. Within each step we present a section, verify, select, and fix paradigm to assign tasks to workers in a collaborative manner. In this paper, we show that our paradigm and specifically designed quality control methods allow remote workers to properly verify and create accessible routes.

INTRODUCTION

Motivation

Locally traveling from A to B, for most, is as simple as looking up and following a pre-computed route using technology such as Google Maps. However, to others, poorly maintained sidewalks, missing curb ramps, and other obstacles present accessibility challenges. The Google Maps route presents no indication of whether its suggested routes are obstacle-free. Often the answer to this question would be solved by a "greedy" algorithm of simply traveling along the suggested route and, if necessary, re-routing when an obstacle is encountered. However, this approach is costly for the traveler. Even if there exist repositories of accessibility information, it is uncommon for such information to be easily visualized or sufficiently updated. We believe we can do better.

We present a system that will proxy the user's physical investigation of the obstacles that may appear in a given route. The system will reveal potential obstacles, evaluate the severity of these obstacles, and re-route to avoid the obstacles. To do this, we present these problems in sections to workers on Amazon Mechanical Turk (MTurk) to get feedback on the accessibility of a given route and change the route if obstacles are encountered using Google Maps and Google Street View (GSV).

However, this problem of finding accessible routes is difficult. It needs to be done in *reasonable time and cost*. Additionally, the data will be *noisy* because road conditions are constantly changing due to weather, construction, and traffic. Another challenge is the *coordination* of many workers both working in parallel at each stage or working cumulatively on other workers' results. Furthermore, this approach combines two different problems: verification and re-routing.

Every submission will be assigned their own unique DOI string to be included here.

Approach

We present a human computation based solution to this problem. The user will start with a routing question such as "How do I get from Quincy House to the Harvard Innovation Lab?"

Then the system will send a request to the server. The system first checks the top three routes given by Google Maps to see if they are accessible. Workers will *section* each of the routes by intersection, *verify* the accessibility of these sections by identifying features on Google Street View, and attempt to *select* a route with the least number of inaccessible sections. If there are no inaccessible sections, the route is returned to the user. Otherwise, workers will attempt the *fix* the sections by suggesting alternative ways to avoid these inaccessible sections and repeat the process, feeding in these fixes to the *section*, *verify*, and *select* step until a fully accessible route is found.

Contributions

This project presents the following contributions:

- A novel, simple-to-use system that solves the problem of finding accessible routes.
- The Section-Verify-Select-Fix workflow for crowdsourcing that can be applied to other complicated tasks that require re-routing.
- The use of the human strength of visually solving map-based questions from a global perspective.
- The iterative process of design and pilot study of this system.

Assumptions and Limitations

To facilitate our progress in this research, we abstract away certain technical difficulties by operating within a framework of assumptions in order to focus our efforts on the conceptual and therefore interesting difficulties instead. This paradigm of abstraction borrows from "buying a time machine," "Wizard of Oz," and "simulation" techniques [10] as we strive to create novel and innovative knowledge that may depend on a level of technology beyond what currently exists. Below we describe several of the assumptions and limitations that we accept in order to focus on core conceptual components:

Scope of Google Street View

Inevitably, the scope of possible accessible paths explored in this project is necessarily limited to the scope of the possible paths that can be confirmed or denied from GSV. Similar to the Tohme system that relies on GSV for curb ramp data [9], we assume that the views of the routes can be found reliably by both human and machine sources and that the GSV route views accurately reflect the state of the world. It may be possible to incorporate their auditing methodology for the purpose of verifying the feasibility of detecting accessible paths. From preliminary visual inspection of the GSV scope, it appears that these paths we explore may be inherently limited in the following measures:

- *Locality.* Certain walking routes suggested by Google Maps involve traversing local paths that are not currently captured in GSV data (e.g., traversing Harvard Yard in the walking route between Quincy House and Maxwell Dworkin), so alternate paths must be considered.
- *Temporality.* GSV data provides users with a timestamp tag for each view examined. It appears that some views are more recent than others, and it may be possible that portions of routes are incorrectly identified as accessible or inaccessible because they are out-of-sync with present conditions.

Connectivity
We assume a fundamental stability in the internet connectivity both between the user and the MTurk workers as well as within the MTurk workers as they collaborate to determine an optimal accessible route for the user. This assumption may limit the demographic domains of participant pools for users and MTurk workers in addition to limiting the routes (or source/destination locations) that the user or workers may specify.

It is important to note that although these assumptions currently constrain the system that we will present, it is hoped that an increase in the relevant technological capabilities, particularly those concerned with the scope of GSV data, are both realistic as well as empowering with respect to increasing the descriptive accuracy, route coverage, and user agency when using the system.

RELATED WORK

Crowdsourcing
Human computation has gained popularity in its potential to engage a geographically distributed workforce to complete complex tasks on demand and at scale [11]. However, this project focuses specifically on two main aspects of crowdsourcing: workflow and collaboration.

Workflow
Crowd workflows are most successful at highly targeted tasks [11]. There have been many ways to approach splitting up a larger problem into specific tasks each individual worker could approach. Soylent, a word processing interface that enables writers to call on Mechanical Turk workers to shorten, proofread, and otherwise edit parts of their document on demand, presents the crowd programming pattern of Find-Fix-Verify [3]. Another example is PlateMate, a system that allows users to take photos of their meals and receive estimates of food intake and composition, which presents the workflow with the stages of Tag-Identify-Measure [14]. However, these approaches have been generally linear to some extent and have not fully introduced the concepts of loops.

Collaboration
Generally, crowdsourcing has focused on small, focused tasks that can be performed independently [11]. However, many complex tasks require a certain level of coordination and interdependence between various components that interact. Therefore, allowing MTurk workers to interact and collaborate with each other can broaden the range and complexity of tasks that can be accomplished through crowdsourcing. For instance, collaborative crowdsourcing mechanisms have made significant strides in text translation, including rapid-time translation of texts from Creole to English to facilitate emergency responses after the Haiti earthquake [1]. Corresponding workflows for collaborative text translation have proposed a structure that layers the levels of linguistic expertise involved [13].

Our work proposes to create a collaborative environment in which the results of one task depends upon the results of its predecessor in a cascade of potential route sections to evaluate. In this research, we replace the spontaneous collaboration exhibited in Ambati et. al. 2012 with a more structured setting that depends not on expertise level (as all crowdsourcing participants are assumed to be novices in the accessibility domain) but rather on iterative separation and aggregation steps of accessibility mapping in small sections with endpoints ultimately aligning to produce a single, unified accessible route [1].

Crowdsourcing for accessibility
Bigham & Ladner 2011 argue that because people with disabilities have always solicited the assistance of others to make accessible what their own senses could not, they are early adopters of interactive crowdsourcing strategies [5]. Entire organizations have been formed around volunteer or paid workers for tasks such as sign language interpretation, real-time captioning, personal assistance, or reading support services [5].

With the popularization and advancement of mobile technology and online crowdsourcing communities, technologies have been designed with this idea of "information translation" in mind. One example is VizWiz, which allows individuals who are blind to take a picture, speak a question, and have it answered by workers on Amazon Mechanical Turk quickly and cheaply [4]. Instead of translating from visual to audio, there are projects that translate from audio to visual through remote sign language interpretation [15].

These technologies have effectively applied crowdsourcing technology in a real-world setting by making the answers relevant in real-time, as per the Legion system of tools [12, 2]. However, these technologies are still limited in their scope, assuming problems that are in the *abstract* space of information. For example, VizWiz is translating from visual inputs to audio outputs. However, these examples of technology are not able to impact the *physical* space.

Mapping

Human Sensors

There is movement of extending the crowdsourcing to disabilities into the physical space. One approach is using "human sensors" to determine the conditions on the ground. An example is Tiramisu, which is a transit application that focuses on crowd-sourcing acquisition of information about bus locations and fullness, predicting the arrival time of buses, and providing a convenient platform for reporting problems with specific information and reporting needs for riders with disabilities [16]. The IBM Citizen Sensing and IBM Breadcrumb application extend this idea by using the mobile devices to collect information specifically about accessibility in order to collaboratively generate accessibility maps [6].

However, such systems that require "human sensors" also require adequate intrinsic incentivization of individuals to participate in the information collection process, which may result in sparse data as accessibility involves on a highly specialized domain of the population. We instead employ extrinsic incentivization using the Amazon Mechanical Turk (MTurk) framework for producing a complete dataset required for a given user to traverse an accessible path between desired starting and ending points.

Google Street View

In fact, previous studies have successfully utilized MTurk in combination with Google Street View (GSV) imagery to crowdsource the determination and evaluation of a variety of accessibility features involved in street-level commute, including landmark locations at bus stops for individuals with visual impairments and curb ramp data for individuals who use wheelchairs [7, 9]. Furthermore, it has been shown that general accessibility issues can be identified with high fidelity between MTurk workers and first-hand accessibility experts (i.e., wheelchair-users) using static, cached GSV images [8].

Our work shifts the examination of street images to a more *interactive* level by allowing MTurk workers to make full use of GSV image manipulation functionality (e.g., panning and zooming) in order to optimize the captured accessibility information. Furthermore, we plan to extend these existing methods of identifying accessibility features to the space of dynamically generating accessible routes based on these features. Our work also presents a more *global* approach in allowing workers to see the full route as well as the section they are evaluating [17].

SYSTEM DESCRIPTION

Technology stack

Paradigm for crowdsourcing

Design challenges/iterations

EVALUATION

DISCUSSION

CONCLUSION AND FUTURE WORK

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