Mobile Maps Continue to Fail Pedestrians: Synthesised Reflective Auto-Aggro-Ethnographies of Walking

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We consider mobile maps, the everyday smart-device-based programs that locate the user, provide insights into local space, and support wayfinding – or do they? The authors collectively reflect on past infuriating experiences with failures of mobile maps as pedestrians. We synthesise these thick descriptions, what we call *reflective auto-aggro-ethnographies*, to identify shortcomings in mobile maps: hidden verticality, missing local detail, incorrect sensor data, and poor pathing. We turn to human-centred design to point out how these shortcomings should be (or, rather, should have been) addressed.

CCS Concepts: • **Human-centered computing → Empirical studies in ubiquitous and mobile computing**; *Mobile computing*; • **Applied computing →** *Cartography*; • **Information systems → Location based services**; *Global positioning systems.*

Additional Key Words and Phrases: Map interfaces, pedestrians, mobile, GPS, seamful design

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1 INTRODUCTION

Mobile maps are the near-ubiquitous applications on smart devices that offer the user a map (e.g., a birds-eye 2D cartographic view). In mobile maps, the device's sensors (e.g., global navigation satellite systems (GNSS) like the United States's Global Positioning System (GPS)) locate the user's position on earth and place that position on a map, sometimes with orientation. These applications include cached and/or streamed databases of places to facilitate finding points of interest (e.g., a specific sushi restaurant; game stores nearby) with directions to the destination's exterior.

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Mobile maps continue to fail pedestrians. Their situatedness within a (dystopian,) corporate, capitalist, and automobile-centric context means they are not human-centred – this should not be the case! Prior design implications raise seamful designs [9, 10, 18, 21, 36] that support humans in repairing their understanding of their location by supplying the right information [32, 35, 74, 76]. These implications have been ignored by the designers of near-ubiquitous mobile map applications that plague our existence in favour of attempting to offer "seamless" experiences through sensor fusion and predictive algorithms. These issues are exacerbated by a capitalist context in which mobile map makers are incentivised to offer un-useful points-of-interest to paying businesses over functional maps. While mobile maps work somewhat well under the assumptions of automobile-based wayfinding, they fail pedestrians.

If you, dear reader, cannot yet tell, this state of affairs infuriates us. We have spent the last year reflecting on our experiences, noting challenges and utter breakdowns in wayfinding, and generally being upset. Through this, we offer insights from a synthesis of *reflective auto-aggro-ethnography* – a new combination of positionality and approach through which we recollect our anger about past mobile map experiences to argue for change. As pedestrians, we are forced to use mobile maps that are not fit-for-purpose, while alternatives are not properly integrated into our devices.

Of course, we understand that mobile maps are a near-magical technology; after all, from analytics to the computer, each of these spaces can track itself back to the development of cartography and its application in war [53]. As such an important object with regard to technology[1], the development of accurate maps requires immense resources and is now the purview of governments and corporations [61]. It is a miracle that we even have access to such things. Yet, when on foot, we find ourselves unnecessarily lost due to the hubris of these governments and corporations – reified by hard-wired and complex policy decisions – that have failed to keep up with the ways design has shifted over time.

2 BACKGROUND

It is useful to distinguish *space* – a physical locality, an area cleared for cultivation [14] – from *place* – human-defined areas within space wherein the human experiences being (e.g., notions of "home", "work", third places [60]) [30, 44, 77, 83, 90]. A place is defined through memories, feelings, its construction as an experienced space, and/or aura [4, 57]. Places can sometimes be specified and then detected through contextual information and proxemics (e.g., being near a loved one, detecting a work device) [4, 14, 18, 41]. We are concerned with detecting and moving through space and how we (sometimes fail) to get from place-to-place, valuing the journey.

Wayfinding is a process of orientating oneself, choosing a route, and moving [12]. *Orienteering* is a related sport that centres wayfinding [67]. Wayfinding and orienteering are traditionally done with a map and compass, using landmarks (natural or built) to get around [1, 2, 12, 32, 67]. As pedestrians with mobile maps, we are engaging in processes of wayfinding using more technological means, described in this section.

Location-aware systems, of which mobile maps are a subset, are hardware-software combinations that track a user in space and supply a location-specific experience. At the advent of accurate outdoor location sensors, location-aware systems became a popular area of research in human-computer interaction (HCI) and remain important (e.g., [9–11, 17, 31, 34, 77, 78]). This work has led to a number of insights into how best to use mobile maps in wayfinding.

2.1 The Hegemony of Mobile Maps

With the growth of mobile applications, HCI researchers have studied the shift in movement and mobility practices of individuals as a consequence [45, 88]. Specifically, how the growing dependence on mobile maps affects the wayfinding

[1]For example, the composite of France or *Carte de France* took over 125 years to create and was considered, at its creation, to be the biggest leap of technological development in centuries [53]. This single object was responsible for the subsequent age of information.

and the navigation practices of individuals across a wide variety of needs [19, 42, 71, 89]. However, while these tools are often situated in accessibility design, there is a limited understanding of how the average pedestrian combats the inherent challenges and expectations associated with navigation, despite literature highlighting the wide-ranging issues and difficulties individuals face while navigating with GNSS [56]. Much HCI literature reflects how these tools are used for in-car navigation [54, 59, 75].

Yet, the role of pedestrian mobility practices as a consequence of newer in-car GNSS expectations or the limitations of GNSS due to a focus on in-car dependencies has not been introspected. While we observe researchers reflecting on the role of technology in pedestrian navigation practices like identifying landmarks [88], understanding footpath access [15, 38] (or bicycle access [68]), and last-mile connectivity needs [85], there is a limited reflection on the pedestrian experience as a consequence of car-centric navigation systems. Further, the majority of pedestrian navigation literature relates to accessibility [37] like visual impairments [52] and physical limitations [15, 16, 38]. In some ways, these implicit biases assume that a pedestrian identity is situated in a deficit lens, while vehicle use is considered normative.

However, pedestrian movement practices are one of the few universal engagements individuals can engage in across the world and across different socio-economic groups, pedestrian activities also play a significant role in creating new cultural norms and creating opportunities for third spaces in a variety of settings [28]. Despite the significance of pedestrian engagements on the cultural practices across communities, the effect of technology-mediated wayfinding practices for these shifts in cultural practices has also been limited in HCI. Pedestrian practices have the ability to create alternative movement practices that push back against dominant expectations of society and propriety, enabling alternative engagements and interactions [25, 26]. Yet, HCI has not reflected as extensively on the pedestrian experiences of GNSS as a consequence of car-centric navigation norms.

We note, too, the software ecosystems in which we find ourselves. The two major companies who develop mobile maps, Google and Apple, each prioritise their own mobile map software for their users [58]. Alternative applications are not offered the opportunity to be "first-order" mobile maps. That is, they generally cannot run in the background, make as effective use of onboard sensors, etc. The hegemony of mobile maps is secured by corporations.

2.2 Wayfinding Issues

Location-aware systems that deal in spaces are only really useful when they know the user's location, which requires sensing. We unpack the basics of sensors for wayfinding, and how they fail.

2.2.1 Location Sensing. GNSSs enable terrestrial positioning [91]; many countries contribute GNSS space vehicles (i.e., satellites), all of which are compatible and improve accuracy: Japan [20], India [49], the European Union [33], Russia [70], China [51], and the USA [91]. GNSS sensors combine signal time-of-flight data from multiple space vehicles to estimate distance to those space vehicles to perform trilateration[2]. Since each space vehicle's location above the earth is known, they act as fixed points from which to calculate location. The more space vehicles with line-of-sight, the more accurate the trilateration. GNSS is accurate, but not extremely so, and is failure-prone. Presently, using GNSS alone will provide an a user with a position that is within approximately a 4.9m radius of their actual location [6, 40, 69, 91] – not precise enough to determine where within a road a user is. This accuracy is for a clear view of the sky.

There are multiple reasons for GNSS inaccuracy and failure: dilution of precision (DOP)[3], urban canyons, and movement. DOP occurs when space vehicles are not spread out, which can only be rectified by moving to a new space. DOP

[2] *Trilateration* uses calculated lengths of the sides of a triangle to determine geometry [66]; in this case, location on the globe. Note that triangulation uses angles, which GNSS do *not* do. Explaining the maths for GNSS is out of scope; more information can be found in Zogg [91] and other references.
[3] There are many kinds of DOP, but discussing them is outside of our scope.

information is reported by a GNSS to provide accuracy. The built environment creates *urban canyons* where buildings block and/or reflect satellite signals, interfering with trilateration calculations [18, 21, 91]. For user movement, update rate matters [6, 9–11]. GNSS update rates are available for stand-alone devices, but are not clearly reported by smartphone manufacturers. Present-day update rates are typically 10Hz, after initial fix (which can take minutes). Previously, 5Hz and 1Hz were common. At a walking speed of 100cm per second (a low average [13]) and update rate of 10Hz, we can expect a recent GNSS with a good fix to be off by as much 10cm (or 20cm–100cm previously) in the best case for a moving person.

2.2.2 Orientation. Orientation is critical in wayfinding. Especially in urban areas, it can be easy to simply walk the wrong direction down a street. Determining orientation through technology is challenging – compasses are the most reliable source of direction information. Unfortunately, the tiny electronic magnetometers used in most devices are easily interfered with by nearby magnetic fields and offer only noisy, incorrect information [63]. They often require recalibration, which involves moving the device in various patterns to re-establish orientation. Many devices simplify questions of orientation by using the location movement vector as a stand-in for orientation [32, 72].

2.2.3 Technological "Solutions". Sensor and data fusion techniques are common for enhancing accuracy, reducing issues due to DOP, urban canyons, and movement [18]. Smart devices employ proprietary algorithms to combine GNSS, wireless trilateration (e.g., cellular, WiFi, Bluetooth), and additional sensors (e.g., altimeter, inertial sensors, accelerometers). Several of these sensors can be used to determine a movement vector and interpolate a user's location using dead reckoning or similar approaches [39, 73, 79]. In addition, geodesy and elevation data supply probable altitude; cartographic data can be used to make assumptions about a user's location (e.g., in a store, on the street). What is combined and how is device- and software-dependent.

3 SYNTHESISING REFLECTIVE AUTO-AGGRO-ETHNOGRAPHIES

We made up the term "*reflective auto-aggro-ethnography*" to affirm the researchers' positionality as frustrated, irritated, and generally fed up with their experiences, but unable to journal or record in-the-moment. Our ethnographies are "auto" in the same tradition of other autoethnographies (e.g., [46, 47, 82]) – deep attention to our own personal experiences with technologies. While positionality and reflection on the ethnographer's role and background are essential to any form of ethnography [5, 29, 43], we put "aggro" into the name to expressly note that this is far from an attempt to be dispassionate observers. Instead, we aim to distil our anger into change with the expectation that this sparks the reader to recognise their own frustrations with technologies and to push for change. (We also hope to delight.)

In this section, six authors share their reflective accounts of their auto-aggro-ethnography with a mobile map. We each use our own voices in sharing these stories, lightly edited by the team and put in consistent units. The ethnographies serve as a form of data and analysis by each researcher and we conclude the section with a synthesis.

3.1 Positionality

The research team consists of seven researchers hailing from well-resourced institutions around the globe (Australia, UK, USA). Many of us are not living in our home countries, which include China, India, Sri Lanka, and the USA. Most of the team are HCI researchers and include characteristics such as being well-played [3, 27] gamers, involved in emergency management, expertise in NatureHCI [86], and experience building wearable computers and/or mixed realities. The team is gender- and neuro-diverse. Our team is ethnically diverse, but we acknowledge not all ethnicity are represented and as such there is a noted absence of discussion of the racial context of maps. We all have extensive experience engaging in pedestrian wayfinding using mobile maps; many of us also have extensive experience in automobile wayfinding. Our position is that of privilege, we have ready access to mobile maps on smartphones that often have strong connectivity.

3.2 Toups Dugas [TD]: Failing to Walk the Right Direction with Apple Maps

Toups Dugas' experience with pedestrian failures in urban Australia comes after decades of automotive-centric experience in rural and urban USA. When operating an automobile with Apple Maps, sensor fusion is accurate-enough to mask seams (though they sometimes show during a missed turn and the map shows the automobile headed on the route rather than its real location).

It was December 2023 and our holidays were coming up and I needed gifts for the kids. I was visiting shops near Melbourne Central after seeing a doctor. Melbourne Central features shops all along the streets and built up on multiple floors of the shopping centre.

I was at a basic step in wayfinding – I need to orientate myself to determine what direction to walk. My present shop, MOOII (cute stuffies and jewellery) was near MeeQ (with the same types of stock) and I needed to go from one to the other. MOOII is outside on the street. MeeQ is inside the shopping centre and above ground, a fact that is unspecified on the map and unknown to me. I have a path from one to the other. The problems are: (a) discovering that MeeQ is *actually inside* the shopping centre; (b) determining how to access the centre; and (c) working out where I am and where I am facing. MOOII is near an intersection of two major streets (and an alley), I don't know *which corner* of *which intersection* it is at in order to do wayfinding.

This should be an easy task – look at the street signs and use those to determine where I am on the mobile map. Except the mobile map doesn't show me the street names – I can zoom and zoom – attempt different levels of detail to get them, but I cannot determine which street is which on the map. I realise, too, that the way MOOII shows on the map, it is unclear if it opens onto one of the two main streets, or a side street, further complicating things. This is frustrating, since it's pretty clear in the local world, directly perceived, what streets are nearby.

No matter – there are chockers shops and landmarks nearby! If I can see both my start and my end point, or even any nearby landmark, then I can orientate myself. Unfortunately for me, the map is committed to only showing the shops whose advertisers have paid the most money. I cannot find any nearby shop that I can see on my map – even the next-door 7-Eleven fails to materialise to support me.

I try a different tack; I only have the one app, so instead of giving me directions to MeeQ, I ask it to locate MOOII. I stare at this map and attempt to memorise it. Memorise the relative locations of the two streets and the other things nearby. Now! Search for MeeQ. This destroys all context – we zoom out to find all the MeeQs, rather than the one that is in the building literally across the street. As I zoom back in, I cannot reconstruct my mental map of MOOII's location and, of course, since it's not a high-paying advertiser, it doesn't show at all.

One final option – I know I cannot trust the compass, so I just start walking and hope the location-tracking error cancels out enough for me to accurately determine which street I am walking on. I then must turn 180° around and walk the correct direction toward my destination, instead of away!

3.3 Seetharaman [S]: Navigating through the Wilderness Hiking App Interface Discomforts

Hiking, like orienteering, holds a certain base expectation of movement practices, requiring navigation tools to adequately follow trails and avoid getting lost. While Apple or Google Maps might enable users to navigate a city, traffic, or public transportation, mobile maps for hiking, such as AllTrails, provide users with a simpler path to navigate a

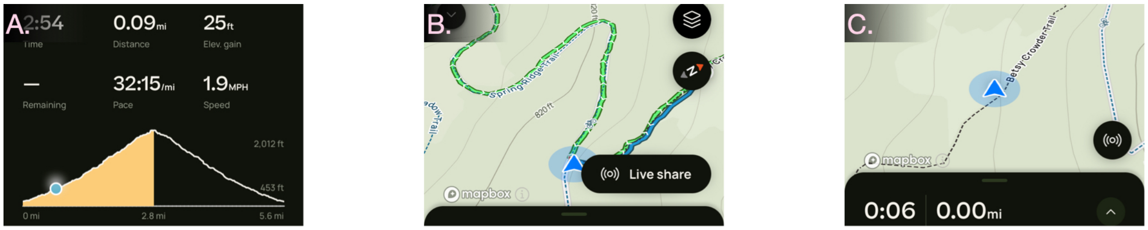

Fig. 1. A.: Bottom half of the AllTrails interface showing expected elevation for the hike. B.: Top half of the AllTrails interface showing the location for the hike. C.: A positioning glitch mid-hike where progress and trail isn't measured.

hiking trail, which is crucial for individuals to avoid getting lost. One would think that without the permutations associated with navigating urban settings, like traffic, the app can enable easier navigation experiences with other hikers or biking enthusiasts. Theoretically, this should allow for a less stressful engagement with nature while enabling awareness about elevation, difficulty, and time estimates. However, the actual experience is not a smooth interaction.

As a newer hiker without an extensive historical practice of hiking in my youth, AllTrails provides novices/amateurs with easier access to nearby trails and promotes the experience of hiking across a wider community. While this is valuable in encouraging new hikers to explore trails, the app expects the user to immediately understand how to *interpret* the trail, which often comes with experience.

The interface for AllTrails does little to support hikers meaningfully. Underneath the navigation trail is a graphic showing the expected elevation gains to prepare the hiker for these shifts during the trail (Figure 1, A.). While these graphics might appear valuable, they cause inexperienced hikers further trepidation during the trail, often not showing exact elevation gains during the hike and diminishing how much elevation has been covered. When viewing the navigation tool we have the overarching trail shown (Figure 1, A., B.); one can only begin navigation once they reach the trailhead. The app assumes driving instructions; presumably, the developers cannot envision how someone reliant on public transit can reach the site. And to be fair, most trails in California do not have accessible public transit. In the few times I was able to use public transit, I had to walk through rubble, the side of highways, and even the occasional office building to reach the trailhead. The routes on the app are often stagnant despite trail changes due to natural occurrences, such as when trees fall and undergrowth grows to cover the original trail. In these instances, the hiker will have to change routes not reflected by the app interface (Figure 1, C.). This leads to further confusion as the navigation tool does not modify itself to help the user get closer to the original trail.

In one such instance, the mobile map expected me to hike through a ravine despite two paved routes between it. Stuck at this crossroads, I chose one that appeared closest to the original trail. The map then merely pointed out the irregularity of the trail without providing clarity on how to get closer or back to the original trail. Additionally, when I continued on the paved path, the path immediately began with deep elevations, which were not reflected on the trail at all. AllTrails indicated that we had barely begun our ascent. With growing trepidation, I began to feel more discomfort as the trail continued to upwards with narrow paths and no alternative routes, while the navigation guide refused to budge on the expected elevation. Due to this, I stopped midway and returned to the start of the trail.

These instances are also optimistic as they assume the tool itself works during the hike. However, in some instances, the navigation tools might not allow you to accurately measure elevation or even the progress made on the hike because the user wasn't given the start trail option since they had begun the trail. By doing this, even though the hiker

Fig. 2. *Pokémon: GO* for wayfinding. A.: Apple Maps showing Monash University Clayton Campus; footpaths are not visible, nor are points of interest. B.: *Pokémon GO*'s mobile map interface, showing the map and points of interest (e.g., PokéStops, wild Pokémon). C.: A PokéStop that has been tapped to show the landmark name and a photo of the landmark – which is more usable than many other place representations. Screenshots A., B., and C. were taken from one location. D.: Two human-created postcards in *Pokémon GO*. Each piece of street art is easy to recognise and is linked to a location.

may be on the right trail, their inability to review how much they had walked or how high the elevation has been so far, makes it harder for amateur hikers to pace themselves and complete the hike.

I suppose the question is, why does this matter? Hiking is a physically demanding engagement, and users are expected to choose trails that are more viable to their needs. Yet, the larger question I propose is, who gets to decide what meaningful engagement is with nature? And who gets to decide what is comfortable for them? With existing ratings showing a varied expectations of what "easy" trails are (one example in the area showed a 20km hike as an easy trail), there are implicit biases about who gets to engage with nature and who gets to feel pride in these engagements. The navigation tool also sets these arguments up as it provides time estimates, distances, and elevation information to help users prepare themselves, but it also sets up expectations about how one is supposed to interact in these spaces and the exact expectations about their movements while engaging in them. It doesn't promote the slow engagement with nature, ending the trail early or parallel routes to the original trail to aid hikers in creating alternative trails and engagements with nature and allow them to make organic routes and norms while engaging in these spaces.

3.4 Fleming [F]: *Pokémon GO* as a Superior Navigation Tool

Though it uses Google Maps as a base, *Pokémon GO* also includes player-sourced, interactive points-of-interest: Gyms and PokéStops [48]. Fleming has used both Google and Apple Maps, but will often use *Pokémon GO* to find her way around instead of either of those options, even in areas with which she may be less familar. Part of this is because she is a giant nerd who plays games; spinning PokéStops helps her collect items and she can battle Pokémon that players from other teams have left in Gyms. Catching and hatching Pokémon in the game can make an otherwise boring walk more engaging and interactive, and if she takes a bit longer to get where she's going because she made a detour to hunt for an Eevee with a Christmas hat on, so be it.

However, Fleming also finds that *Pokémon GO* makes it easier for her to navigate. PokéStops and Gyms can be tapped on and viewed in the map, even if the player is not close enough to fully interact with them, which allows the player to see the landmark's name and photo without having to spend time trying to zoom in and out just the right amount without the label disappearing (a common frustration Fleming has with Google Maps). Figure 2 A. and B. show a comparison of Apple Maps and *Pokémon GO*, while Figure 2 C. shows how one gains insight into the real-world place at a PokéStop. This can make it easier to find particular places, especially if the location is not near a road; in such circumstances, the Google Street View van couldn't get close enough to get a clear photo of the venue, but the photo uploaded by another player when creating the point of interest makes it much easier to find the place in person.

Another thing Fleming enjoys about using *Pokémon GO* to navigate is that it helps her find things she would likely not otherwise see if using a regular map. While walking through the city, Apple/Google Maps tends to highlight things like retail stores, restaurants and public transport stations, but by simply travelling between these commercialised points, it is easy to miss out on the variety of interesting landmarks hidden down obscure alleys or behind dilapidated buildings, such as murals or art installations. These points of interest often get turned into PokéStops or Gyms, which give an in-game postcard when spun while the player is in range. Fleming enjoys collecting these postcards (shown in Figure 2, D.) that showcase the creativity of Melbourne's artists (as well as sharing these postcards with other players).

3.5 Liang [L]: Navigating to the Impossible and Non-existing Routes with AutoNavi Amap

Liang was born and raised in urban mainland China, and has used AutoNavi's Amap (高德地图) for ten years. It is one of the mainstream map services in mainland China, on par with Baidu Maps, and is also the map data supplier for Apple Maps. However, Amap has a very high rate of navigating the user toward impossible or even non-existent routes, and has been critiqued by users and Chinese reports for a long time (e.g., [55, 92–94]). Like many Amap users, Liang frequently experienced and adapted to Amap's navigation failures for years, and, among her countless failures, the following is one of her most impressive experiences.

Liang's friend was driving her to a restaurant near the Wuchang district of urban Wuhan city. Following Amap's navigation, they were guided to reach their destination through a route located across a city hill park. As their car entered the "route," they already sensed something was wrong – it didn't seem like a drivable route, and it looked more like a gap between the trees of the park. Then, even the gap became unrecognisable and they had to stop – they reached the top of the hill park and saw the cliffs ahead, where stone steps for tourists to walk down the mountain appeared in front of them. Meanwhile, Amap navigation was still active and showed that there was "no traffic congestion on this road section"; therefore, it suggested driving through.

Liang apologised to her friend and got out of the car to walk down the mountain to reach her destination – it shouldn't be an issue, since Amap showed it was 15min away on foot. Liang then found a wide private yard that blocked the way. Amap suggested she cross this yard, presumably by crawling through the hole in the wall in front.

3.6 Elvitigala [E]: Failing to Identify the Shortest Path for Pedestrians with Google Maps

Elvitigala is an Academic at Monash University Australia, Clayton Campus. Monash Clayton campus is one of Australia's largest campuses, with a size of 1.1km^2. Hence, many parts of the campus are unexplored. Many in the campus community (including Elvitigala) use a mobile map when they need to find a new location.

In this particular experience, I wanted to walk to Monash Heart Hospital reception to meet a friend. As usual, I wanted to get the help of Google Maps to identify the shortest path. Google suggested two paths from my office: one showed a time duration of 19min, and the other showed about 24min. I selected the path that shows the shortest time duration, about 1.4km. Although I selected the 19min route, I realised that this route did not seem optimal, looking at the other paths and lanes marked in Google Maps. I was curious as to why Maps didn't suggest that path. I was thinking maybe that path is temporarily closed, or maybe there is no such path that exists.

I started my walk along the suggested path. Before I started, I noticed that Google Maps showed me one staircase that I would have to climb *up* (I assumed). I was pretty impressed, as that is valuable information for someone with limited mobility. I didn't have such issues at that moment. I took the suggested path with a staircase without hesitation.

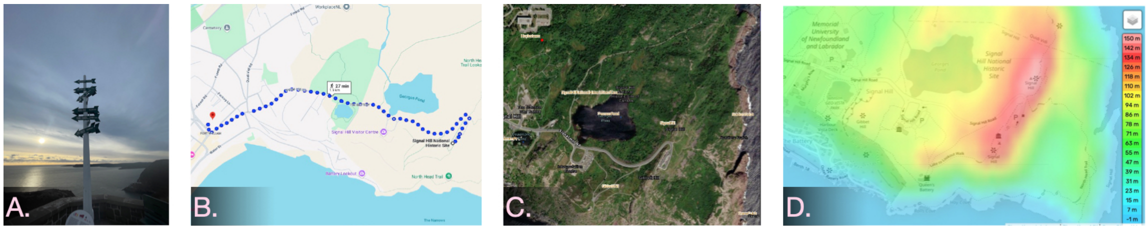

Fig. 3. Images from Signal Hill. A.: A photograph from the top. B.: The route shown in Google Maps. C.: Aerial view of Signal Hill. D.: Topographic view of Signal Hill.

I followed the exact path for about 100m, and I came to a junction. Now, I can see that the suggested path can be longer as I see a clear, straight path ahead of me in the direction I want to go for about 200m. So, I decided to take the short path in front of me. After walking about 10m, Google updated its suggested route. After reaching the next junction, I can still see the path can be shortened by looking at the map. However, I wasn't brave enough this time to take my own route. I was afraid the path would be inaccessible or non-existent as the path wasn't as intuitive to me as last time. So, I took the Google-suggested path. After I walked about another 200–300m, I had an unexpected staircase along my route to walk down. The staircase had about 8–10 stairs. I was disappointed it was not indicated on the maps. Now, I doubt whether the indicated prior staircase exists at all.

I walk down the staircase and continue on the route suggested by the map. After another 100m, I can see my route can be even shortened. However, I wasn't ready for the new route as I could not see a clear entrance to the building if I took that route. So I followed the Google suggested path, although it seemed like I was going around the bush.

I walked another 200m, and I found the staircase indicated in the Map. It's a much longer staircase than the first. Then, I had a feeling that Google could identify staircases using the phone's motion data, and the previous staircase may not long enough to identify as a staircase. I was also surprised, as I assumed the staircase was *up*, not down. Clearly, the staircase icon gave me the wrong idea about the direction of the staircase. I went down the staircase and was walking along a pedestrian path near a main road. Now, I only have 100–200m to the end destination. Suddenly, I realised Google had given me a vehicle access road instead of an easy pedestrian path for the final part of the journey.

It took me about 19min to reach the destination, which is similar to Google's suggested time. However, if Google had suggested to me the *best* possible pedestrian route, my journey would have been shortened by a good 7–10min.

So, after meeting my friend, I was brave enough to follow my gut feeling and take the shortest path I had in mind. Of course, the Google-suggested path gave me some clues about this shortest path, but It would have been much better if Google suggested that route the first time. I also realised that the pedestrian path I followed back had ramps for people with mobility impairments. It is unfortunate that current Google Maps lacks that accessibility information.

On the way back to my office, I completed the journey in about 12min, 7min less than the original time I spent at the beginning along the Google-suggested route. On the way back, I was going uphill, but it felt considerably shorter than the Google-suggested route, given it was a hot summer day in Melbourne.

3.7 Rode [R]: Getting Lost with Google Maps

Recently, I found myself atop Signal Hill in St. John's, Newfoundland, Canada and after a few minutes of looking at the beautiful panorama (Figure 3, A.) the cold wind was biting my skin. I began to plot my return to my hotel. As a disabled person, I walked with a cane and quickly realised I was atop a hill that was far too steep for me to go back down. I had been dropped off a half hour prior by a taxi, who assured me I could book one easily again. I had heard Signal Hill was a not-to-be-missed vista, and so in the morning, I plotted it carefully on Google Maps (Figure 3, B.).

It was a mere 1.9km walk. Google estimated I could walk it in 28min, and I regularly found myself walking such distances in inner-city London. So, I figured even if I could not find another taxi, I could easily walk home.

Google, though, does not share a lot of very important information. First, there was no cell phone signal atop Signal Hill, ironic given its historical prominence for sending transatlantic signals, and something you might have thought a cabbie would have known. Second, it's not flat. Other maps contain these features. So, let us look at Signal Hill, both on a satellite map (Figure 3, C.) and a topographic one (Figure 3, D.).

The satellite map quickly allows one to see it is not flat. The topographic map quickly lets one estimate that my hotel was about 23m above sea level, and the hill at 150m. That is an elevation gain of some 127m, and while one might well have expected a hilltop be a bit taller, that elevation gain was staggeringly unexpected. So, I found myself atop a 150m hill, where it was about 5°C with a 21km/h wind. I could not walk down the hill safely due to the combination of it being steep and my joints being inflexible due to the cold. I could not call a taxi as there was no cell signal. So, I found myself wondering, "how did I get here?" and "why did I keep getting myself into trouble with maps?"

I thought of the time I was at an HCI conference in Seattle, only to realise that the streets sloping to the waterfront were so steep that I had to go buy a cane to make it up and down them. Or another conference, where I managed to nearly tip my scooter over driving 5min to lunch along suburban sidewalks with a steep grade. Disabled people exist, and we go places, surely mobile maps should take this into account?

So why do mobile maps not consider disability? Why is it a mobile map not indicate when you are going somewhere, you are likely to lose cell signal? After all, if you used a map to get there, you probably will keep using it once you arrive. Similarly, why is there no indication of topography on a cell phone? Even people without disabilities might rethink steep paths in the snow. Besides this, I have been selecting "Less walking" as an accessibility option for over a decade, so Google knows I am disabled, or at least lazy! Why is there no staircase-free walking choice? Why do we not get indications of elevators and escalators that are not working on major cities' (e.g., London's) public transport? Finally, as it relates to this story, could we not also have warnings about elevation grades as well? However, there is also a question of if these features were there whether we could even trust it? There is already an option for "wheelchair accessible", and yet Google Maps still proudly tells me the route down from Signal Hill is "wheelchair accessible" despite its hair-raising 6.7% grade well exceeding the safe handling of a wheelchair.

But did I ever make it down Signal Hill? Well, I am pleased to say Newfoundlanders are just as nice as they are rumoured to be, and they found me and sorted me out, returning me to warm, level ground. This leaves me free to ruminate on why digital mapping programs are so ableist.

3.8 Synthesis

We synthesise our reflective auto-aggro-ethnographies of engaging with mobile maps. As researchers, we identified a number of issues and questions that arose from a diverse set of experiences with these ubiquitous tools. We begin by drawing out similarities from our ethnographies, which centre a lack of information about terrain and sensor data. The researchers whose ethnographies raise particular issues are identified by their initials.

Hidden Verticality [TD, S, L, E, R]: Mobile maps rarely account for the verticality of terrain (e.g., multi-floor buildings, topology). They do not provide topology data. They fail to render such data useful when making decisions about routes, which can be catestrophic in the case of disabled pedestrians. Users are unable to determine their expectations for the walking experience.

Missing Local Detail [TD, S, F, L, R]: Without insights into local names or types of cartographic objects (e.g., path types, streets, terrain, buildings), users cannot situate themselves in the physical environment and may make poor choices. When mobile maps make assumptions about what the user is doing and do not offer support in returning to a safe path, this information is needed. Insights into the characteristics of spaces (e.g., cell reception) is a safety issue.

Incorrect Sensor Data [TD, S]: We know that sensing for wayfinding is fragile, but this information is not provided to users. Determining facing is a core part of wayfinding, and being on the right path is critical.

Poor Pathing [S, L, E, R]: Determining a route is a complex, algorithmic process that relies on correct data. Pathing algorithms clearly do not take into account the combination of user ability and the characteristics of the path. Further, they may lead people directly into dangerous situations (like, off a cliff, or down a steep hill).

4 DISCUSSION OF DESIGN IMPLICATIONS: HUMAN-CENTRED COMPUTING

The synthesis of our reflective auto-aggro-ethnographies reveals concerns of hidden verticality, missing local detail, incorrect sensor data, and poor pathing in mobile maps. These issues surely arise from a number of factors, including: missing/wrong data (e.g., stale maps, lack of terrain data); insufficient development resources (e.g., planned features); legal / policy challenges (e.g., can't get data); or lack of device resources (e.g., inaccurate sensors, insufficient processing). While these factors matter, we assert that considering design implications from location-aware systems in HCI, moving away from automobile-centrality, and divorcing systems from a capitalist context lead to human-centred design [62] that could solve a number of these problems.

4.1 Human-Centred Design of Location-Aware Systems from Decades Past

Research on location-aware systems in HCI uncovered a number of design implications that remain salient to today.

We know that sensor data is a challenge to these systems and that it has not improved. This leads to issues of people being lost and confused. Yet, revealing information about sensors' fallibility is one approach to improving human experience. Seamful design calls for revealing uncertainty and making it clear when the system is failing [9, 10, 18, 21, 36]. Hiding this fact only makes living in the world harder to do.

A number of research lines have considered how to show and hide information in zoomable interfaces [7, 8]. Designs must provide context-dependent details [50, 56]. Of course, it is possible for the designer to get this wrong, but, considering prior research into the design of macro and micro readings [84] and the long history of cartography [56] and the design of orienteering courses [67], designers can make better choices about what information to provide. When people have the proper information to understand their local surroundings, they can repair their understanding of the map and successfully engage in wayfinding [32].

4.2 Human-Centred Design Instead of Automotive-Centred Design

In reconfiguring the city for the car rather than the pedestrian, we have failed to account for the eventual resurrection of people walking places. New parks, public-transit-only spaces, walkable attractions like a waterfront civic centre, and other forms of trying to get folks to walk again highlight the sheer magnitude of unintended consequences of a car-centric culture.

We have seen similar design consequences in digital spaces as well. For example, the insertion of "raid finders" in games like *World of Warcraft* have removed the need for players to traverse the world to at least touch a dungeons' entrance or to gather players nearby so the dungeon could be run [22–24]. The loss there was a loss of sociality and curiosity of the world resulting in a massive decline of user populations in the game. However, the path of development of the existing game was usurped as private servers and community-driven development of the same game but with different affordances resulted in Blizzard Entertainment essentially giving in to give players the game they used to love in the form of *World of Warcraft Classic*.

But this sort of thing cannot happen outside of a digital environment. Rebuilding cities takes enormous amounts of time, resources, and effort and around the world we see a push back toward a time when the car was all. In the middle of that struggle between the way developers have pushed and the ways large swathes of humans have rejected that development are pedestrians who just want to take a healthy walk but need a tool to help them as the loss of cartographic literacy and wayfinding requires them to use the tool they would use when driving a car.

Attention to automotive-based use cases [54, 59, 75] mean that we miss providing information that is useful to pedestrians (e.g., hiding entire streets because they are foot-traffic only [65]). A great deal of incorrect sensor data can be hidden in automotive contexts (again, making systems seem seamless). At the same time, a great deal of local minutiae are not valuable to people zipping past it in a high-speed automobile.

Hidden verticality does not matter to automobiles (which will, invisibly to their drivers, simply consume a bit more fuel), but matters substantially to pedestrians. The three-dimensional nature of the built environment demands maps that account for it [80, 81]. Verticality matters for making informed decisions about pathing, especially with regards to accessibility, as well as for successfully finding places.

Designers need to shift attention to pedestrian experiences and understand the need of pedestrians to repair. This form of human-centred computing calls back to our comments on zoomable interfaces and learning from the past.

Addressing more resources to pedestrian issues means that further cartographic data (e.g., insights into the walkability of surfaces) are needed. Such information can be crowdsourced, as is done with OpenStreetMaps [64] and prior work on geowikis [68]. With insights into walkability, safety, verticality, better choices for paths can be developed.

4.3 Human-Centred Design for Human, not Corporate, Needs

Our last point is that so much attention in mobile maps is for corporations to make money. Because of this, they block developer access so that their own products offer more (any) functionality. Further, they opt to hide needed, local data in favour of supporting the highest-paying customers (e.g., stating a nearby, desired, point-of-interest doesn't exist to provide a higher-paying advertisement [87]). This is a call to action, yet our (dystopian) capitalist environment may simply render it impossible. Finally, we call for more research is needed to ensure other positionalities needs are appropriately reflected in maps especially with regards to race and the Global South.

5 CONCLUSION: WE DESERVE BETTER

While we are a small team, we encompass a rich variety of persons in spaces and places diverse enough to capture many of the ways humans have organised themselves. We have provided hopefully useful, hopefully entertaining insights into our frustrations as pedestrians. We expect that these will resonate with readers. It is possible to address these frustrations with today's technologies; however, it requires attention to the past with ample amounts of humility on the part of large organisations. Our manifesto in thinking about human-centred design with regard to maps focuses on those places within which we walk. Rather than pushing for the re-design of cities for smart devices in the form of smart cities, what would happen if we re-arranged cities in the scope of the diverse modes of transit we use? This requires adaptive tools and in order to adapt, we must better understand the environment that these tools exist in. We call for all parties to take up these challenges and help us get to where we need, safely, by whatever means of movement possible.

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The land on which we gather is the unceded territory of the Awaswas-speaking Uypi Tribe. The Amah Mutsun Tribal Band, comprised of the descendants of indigenous people taken to missions Santa Cruz and San Juan Bautista during Spanish colonization of the Central Coast, is today working hard to restore traditional stewardship practices on these lands and heal from historical trauma.

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WPI acknowledges the painful history of genocide in the U.S. for native and indigenous peoples. As a public statement that honors the indigenous people as native inhabits on this land, WPI honors and respects the many and diverse tribal nations who were forcefully removed from their sacred lands.

WPI would like to recognize the people of the Chaubunagungamaug and Hassanamisco Nipmuc Tribe as the traditional custodians of the land on which we work. We take this moment to honor their elders, past, present, and emerging. WPI strongly advocates for higher education professionals to honor the land, the original tribal occupants, and the history of where they are located.

LAND ACKNOWLEDGEMENT (LALONE)

We gather on the traditional territory of the Onöndowa'ga:' or "the people of the Great Hill." In English, they are known as Seneca people, "the keeper of the western door." They are one of the six nations that make up the sovereign Haudenosaunee Confederacy.

We honor the land on which RIT was built and recognize the unique relationship that the Indigenous stewards have with this land. That relationship is the core of their traditions, cultures, and histories. We recognize the history of genocide, colonization, and assimilation of Indigenous people that took place on this land. Mindful of these histories, we work towards understanding, acknowledging, and ultimately reconciliation.

LAND ACKNOWLEDGEMENT (RODE)

While UCL does not have a land acknowledgement, Rode acknowledges the Indigenous traditional lands of her co-authors, and notes how these land acknowledgements are made invisible in mobile maps further erasing Indigenous peoples. She calls for preserving these Land Acknowledgements of space in digital maps.

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