GPS-tracking Method for Understating Human Behaviours during Navigation

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Abstract

Many innovative tools have been introduced that can benefit human navigation. The introduction of the Global Positioning System (GPS) provides real time access to positioning and navigation information. Furthermore, with the widespread adoption of smartphones, we can access GPS-based positioning and navigation tools even more easily. Even if GPS-based tools help users find destinations efficiently, it is still important to examine the implications of a transition from relying on our cognitive map (or traditional analog tools) to an always available mapping system that simultaneously shows our position and the surrounding geography. For this research, we used GPS-tracking method to record users' navigating behaviour based on different levels of availability of a GPS-based navigation system (not available, partially available, or full availability). We also employed a manual tracking method for recording users' navigating behaviour due to some GPS limitations in urban canyons. As a result, GPS-tracking method were an efficient way of collecting human navigation data but some issues should be considered to ensure the quality of data.

Background and Relevance

As society grows, we exert considerable effort ensuring the advancement and increasing efficiency of our physical and social lives. Lately, many innovative tools have been introduced; these tools help us accomplish many of the things we have historically accomplished but with less physical or intellectual effort. Interestingly, the popularity of smartphones and location awareness technologies have altered how we obtain geographic information (Abdalla & Frank, 2012; Hirtle & Raubal, 2013; Montello & Raubal, 2012). Even if we are traveling in a novel environment, we can receive reliable route and navigation information while we are traveling with GPS-based tools. Such real time information could result in not needing to establish and remember a path before traveling; however, if we are highly depending our navigation on GPS-based tools, our knowledge and familiarity on GPS-based tools would become very vital requirement for successful navigation. We may not have an answer yet about how the familiarity and knowledge about the GPS-based tools impact our navigation and how navigation efficiency is connected with previous experience (Jung & Bell, 2014). Our past research suggests that reliability (or perceived reliability) can affect trust of a handheld positioning system (Bell, Wei, Jung, & Scott, 2011; Wei & Bell, 2012). For example, what happens when a person starts with a GPS-based tool but during travel suddenly loses access to that tool. The original research was designed to examine the impact of navigating with or without the navigation system as well as the impact of varying the levels of availability of such tools (not available, partially available, or full availability). However, in this paper we want to address how can we keep the quality assurance of the raw GPS-tracking data and how GPS-tracking data benefits to understand humans behaviour while they are navigating.

Methods and Data

This research was conducted at the University of Saskatchewan where many campus buildings were densely located (Figure 1). All research participants had an additional GPS device which sets for tracking individual participants' accurate trajectory (Table 1). A GPS-tracking method was able to deliver very rich data including the series of X-Y coordinate by 5-6 seconds intervals. However, some GPS-tracking trajectories were passed at invalid locations such as the top of the campus building and where a pedestrian path did not exist (Figure 2). However, some participants often navigate outside of the pedestrian path, so true invalid location (GPS-tracking error) and false invalid location (intended travel location) could not be easily distinguished. A manual trace was drawn to support the raw GPS-tracking data; individual participants were closely followed from behind by the researcher. Nevertheless, GPS-tracking data provided very interesting outcome which could not be observed by the naked eye.

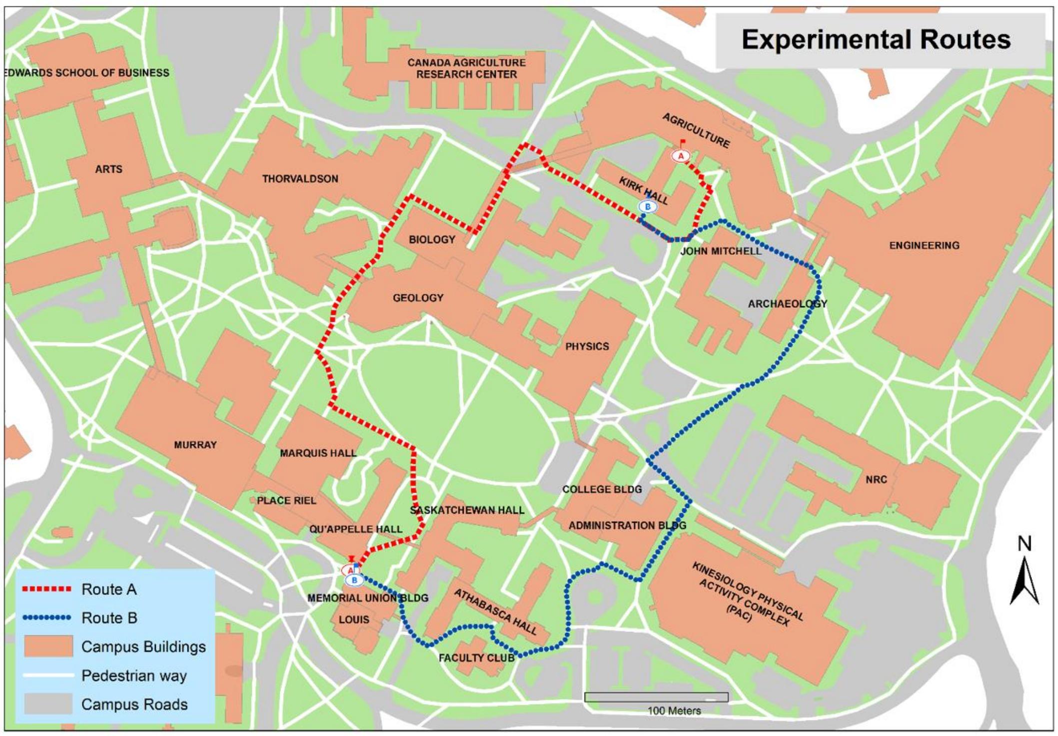

Figure 1. Experimental paths in the University of Saskatchewan

Table 1. Experimental design

Name	Condition in the first path	Status change in the transitional point	Condition in the second path
NE1	No GPS	No	No GPS
NE2	No GPS	Yes – Gain GPS	GPS
NE3	GPS	Yes- Lose GPS	No GPS
NE4	GPS	No	GPS

The experimental full path in which a gain or loss of the GPS-based tool transpired as such: a preliminary 700m path was traversed, followed by a second 740m path, each consisting of 10 turns. All conditions were equal to participants expect the availability of the GPS-based tool in the selective path. In addition, no navigation trial performed under incremental weather condition. At the mid-point (a transitional point) between the paths the participant either continued with the GPS, were given a GPS, or had the GPS taken away.

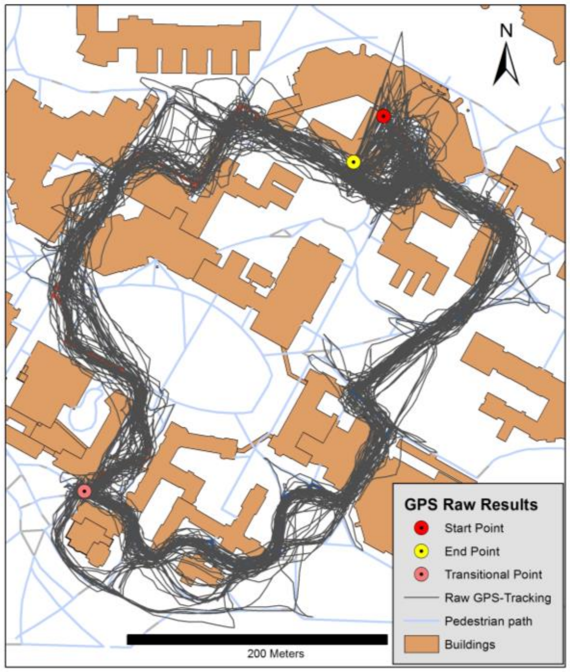

Figure 2. Raw GPS-tracking results

Results

The raw GPS-tracking data was not reliable or of similar accuracy across the full path traversed, but once data was validated, GPS-track data can be used for various analysis for understanding human navigation based on the availability of a GPS-based tool. Initially, all invalid tracking result were fixed for the further analysis (Figure 3). Figure 4 shows the arrangement of GPS points collected during participants' travel along the experimental full path. It shows that when participants did hold the GPS-based tool, their path selection was highly concentrated on the designated experimental path than participants who did not hold the GPS-based tool. Even if, participants carried the GPS for the entire experiment (NE 4), their travel was more precise (stayed on the designated experimental path) on the second path than the first path, which showed wider path "thickness." Second, GPS-tracking points were stored every 5-6 seconds, so individual travel speed could also be calculated; however, individual participants different speed of travel, so all travel speed was normalized with mean speed of travel. Once participants' travel speed was established, the specific location where participants traveled faster or slower could be mapped (Figure 5). An interesting finding is that when participants were traveling between buildings where no alternative paths exist, their travel speed is higher. Additionally, when participants had the GPS, their travel speed was slower when they were leaving from the origin or were approaching the destination.

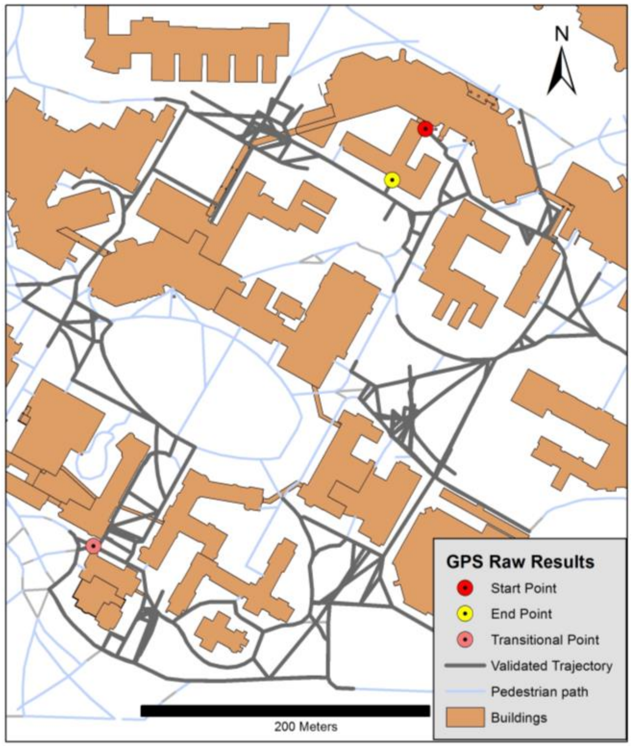

Figure 3. Validated GPS-tracking results

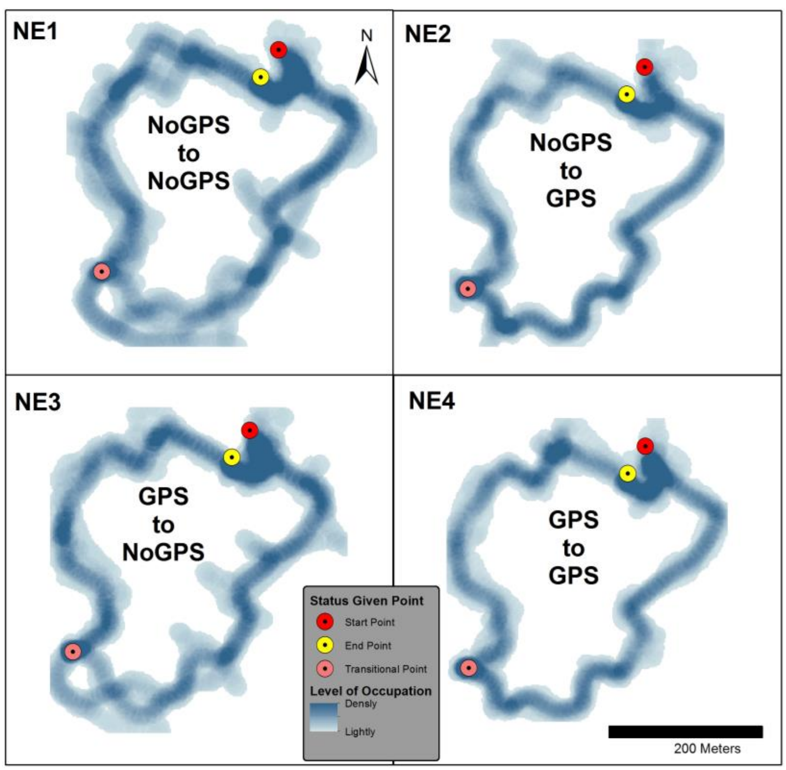

Figure 4. Path selection efficiency by tube width

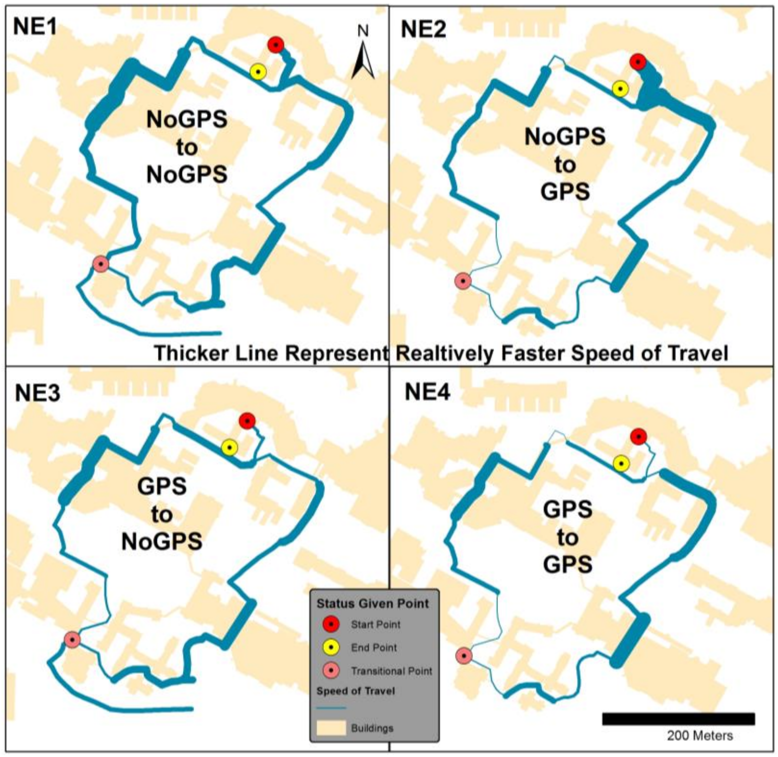

Figure 5. Tube Thickness based on speed of travel

Conclusions

Recent advances in location finding and mobile technology trigger increased demand for enriched geographic information in the palm of our hand. Global Positioning System (GPS), mobile, and other radio technologies allow us to obtain real-time location and geographic information; however, when GPS becomes unreliable, real-time location information can become misleading due to its positioning error (Bell, Jung, & Krishnakumar, 2010; Hightower & Borriello, 2001; Steiniger, Neun, Edwardes, & Lenz, 2008). Fortunately, interrupted GPS signals could be fixed through the use of other additional sensors or hardware in outdoor environments (Huang, Tsai, & Huang, 2012; Li, Tan, & Dempster, 2010; Mok, Retscher, & Chen, 2012). In addition, GPS data can be validate with the use of manual interpretation. If we more could closely research on human navigation, it will be directly beneficial to us, due to the intrinsic relationship between humans and the phenomenon of navigation.

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