Pedestrian navigation and shortest path: Preference versus distance

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Abstract. Contemporary digital maps provide an option for pedestrian navigation, but they do not account for subjective preferences in the calculation of the shortest path, which is usually provided in terms of absolute distance. For this purpose, we performed a controlled experiment with local pedestrians, who were asked to navigate from point A to point B in a fast manner. The pedestrians' routes were recorded by means of a GPS device and then plotted on a map for comparison with suggested itinerary from a digital map. We found that the preferred shortest path is significantly different to the suggested one. Notably, the preffered paths were slightly longer than the suggested, but there was no effect in the trip duration because there were fewer obstacles, such as cars. Since many pedestrians employ GPS enabled devices, the findings of this research inform the development of mobile applications and the design of new subjective map layers for city dwellers.

Keywords. GPS, map, pedestrian, shortest path, preference, collective, experiment

1. Introduction

Contemporary digital maps are very elaborate and contain detailed information, but they lack meaningful knowledge in terms of collective habits. They might depict a technocratic instance of the real world, but their philosophy is car-driven, excluding anthropocentric features, which mainly characterize pedestrians and their behavior while walking through the city. In particular, digital maps may provide navigation functionality, but they do not account for subjective preferences in the calculation of the shortest path. It is common sense that pedestrians select shortest paths by considering multiple criteria, such as safety, traffic, weather, season, levels of noise, and accessibility, but contemporary digital maps only account for distance travelled.

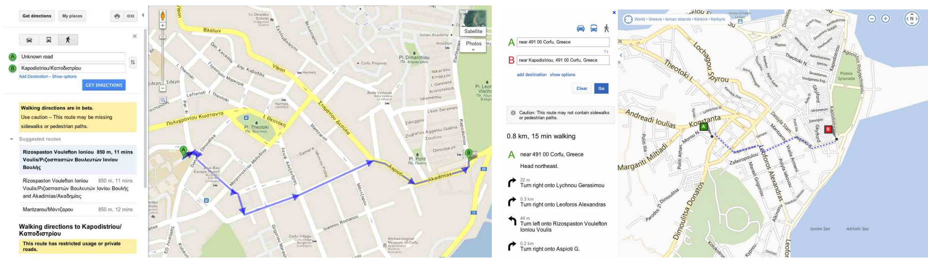

Figure 1. Digital maps provide efficient shortest path, but is it the preferred one by locals?

Moreover, we have been inspired by the following quote (Stilgoe 1998): “Outside lies unprogrammed awareness that at times becomes directed serendipity. Outside lies magic.” With that in mind, our research question gets shaped: “Could we take advantage of highly precise technology (e.g., GPS, digital mapping), in order to create a more humane cartography (e.g., subjective maps)?” In this work, we are validating the feasibility of this idea by performing a controlled experiment, which provides sufficient data to create a new type of map for city dwellers. In the future, we propose the design of digital map layers from pedestrian GPS traces, in order to provide maps that are tailored to the actual preferences of city dwellers.

2. Methodology

Since many pedestrians employ GPS enabled devices, e.g., smart phones, we propose the anonymous collection and analysis of their GPS traces, in order to explore their actual preferences and design the respective map layers. For this purpose, we performed a controlled experiment with ten local pedestrians, who were asked to navigate from point A to point B in a fast manner. The pedestrian routes were recorded by means of a GPS device and then plotted on a map for comparison with existing pedestrian navigation applications.

2.1. Subjects

Users’ compliance with certain criteria allowed the collection of a clean data-set and the minimization of incorrect assumptions regarding the selected routes. In particular, the ten participants enjoy and have a habit of walking around the city, have a good knowledge of the city’s streets, are healthy and capable of walking a medium distance, and are adult (18+) but not more than 50 years old. It was essential for the user to have lived and experienced the experiment's location area, since local knowledge is the source to derive from and depend on, in order to re-examine pedestrian navigation systems and to re-establish the pillars of their foundations.

2.2. Procedure

A specific outline of user behavior was also constructed, based on which participants made decisions according to their free-will and basic guidelines. After taking into consideration space, time, walkability and various alternatives of their combinations, points A and B (starting and finishing points of the trajectory) were decided. Main criteria of their selection were a) the variety of connecting paths able to be generated between them and b) the possibility of creating a specific scenario. The destination point is within a 750 meters radius from point A, thus pertaining to the 800 meters – 10 minutes’ walk, considered as a medium walkability radius in neighborhoods. The in-between topography is slightly steep, mainly towards point B; depending on the chosen path the inclination differentiates. The landscape is that of a provincial town’s urban context and includes a variety of sceneries; streets of high, low or no traffic, traffic lights, pavements of larger or narrower section, trees, shopping streets, pedestrian zones and promenade by the sea are possible alternatives, which combination is closely related to the participants’ choice.

For the experiment's requirements, ten subjects were asked to walk from point A to point B, according to the following guidelines: They had to follow the fastest path in a time frame of 13 minutes maximum, having in mind that they are supposed to move quickly, efficiently and do not stall. The duration of the task was defined by taking into consideration the suggestions of popular navigation applications in relation to the proposed route connecting A to B, which was reported to be eleven minutes by the Google Maps pedestrian option.

Having set the starting and finishing point of the trajectories, a plausible navigation scenario was then created. Its importance was motivated by the need to successfully control the experiment by involving participants in a common task. The scenario encouraged fast movement: "You are a student at the local University and today is your/the graduation day. The ceremony starts at 11:00 and you are supposed to be there at least 15' minutes earlier. Although it was a day you were not supposed to be late, due to several unforeseen incidents you found yourself being at the Department's Secretary on 10:30. Hence, you have approximately 13 minutes to arrive on time for the graduation ceremony."

Users were handed a GPS-enabled device and were informed about the process and their role; they were expected to complete the task in 13 min for the fast track. When back to point A, the device was returned to the organizers and participants were asked to fill out a related to their previous experience questionnaire.

2.3. Measuring instruments

The experiment's structure was determined after performing a pilot version. During that stage, time limitations, users' compliance to the dictated instructions and reasoning of preferences took place, thus forming the final layout. On the pilot's findings was the questionnaire based on; the participants' opinion of their route selection presented many similarities and on these majority points were the following questions developed on. Their purpose was to assess the choices, so as to understand the way pedestrians behave in a certain context, under specific conditions, and reach an outcome in repsect with their preferences. These results were used as the background while creating the new pedestrian-friendly layer-map.

The questionnaire measured on a 5-point Likert scale (from strongly disagree to strongly agree) the following: I chose, on purpose, a fast track: a) that would permit to walk in a quick pace, b) that a car would follow if moving from A to B, c) where less car traffic is expected, d) where less people are expected.

A final task followed by the completion of the questionnaire, which involved tracing the previously followed tracks on a printed map by the participants and answering whether they would choose to follow the same paths if asked to retake the experiment. This step was inspired by the work of Lynch (1960) and it allowed us to draw conclusions regarding the participants' perception of the city in relation to map illustration.

Last, but not least, the pedestrian routes were recorded by means of a GPS device and then plotted on a map for comparison with existing pedestrian navigation applications.

3. Results

Out of the 10 users we analyzed 7 trajectories, because the rest have performed longer durations than the required due to unforeseen cirqumastances, e.g., chance meeting with an acquintance. The acquired GPS and questionnaire data were analyzed and combined to produce results regarding to users' preferences and selections. In brief, we found that the perceived shortest path is significantly different to the one suggested by a navigation application.

Table 1 Overview of the preffered shortest paths (The suggested one by Google Maps is 11min, 850m)

User	Duration (min:sec)	Distance (km)	Avg speed (km/h)	Avg elevation (m)
11	9:23	1.15	7.36	17.24
10	13:30	1.08	4.79	16.49
9	10:50	1.01	5.60	17.74
8	9:54	1.0	6.07	23.20
7	11:00	0.97	5.29	22.27
6	11:40	0.91	4.68	22.10
5	8:40	1.02	7.09	10.95

The paths that users chose to follow while quickly moving from point A to B demonstrate variety and extended divergence from the suggested trajectory, as proposed by a popular map application. In terms of distance, participants' choices are longer by 50 or more meters, but in terms of time they achieved faster scores. The results clearly expose the computational and pure mathematical reasoning behind the suggestions of the application, in contrast to the multifactorial thinking of human beings. Distance is not the only parameter to consider; the questionnaire results show that factors such as less crowded streets or streets of less traffic are also included in the equation. Delays, as a consequence of lack of pavements or obstacles attributed to moving or parked cars, become considerably absent. Thus, computerized perception of pedestrian navigation can be out of track, since minimum distance does not always signify the fastest or safest choice. It is noteworthy that the application's suggestion goes along main roads of heavy traffic and noise, and although quite large pavement zones are provided for most of the path, it was not the primary selection of users.

The above findings are interpreted as pedestrians' behavior; their choices were based on personal experience and opinion. In an urban fabric, users evaluate conditions, preferences and circumstances and navigate accordingly. Although weather, season and time of day do not appear to play an influential role, we believe it is due to the good conditions under which the experiment took place that contradictory results were not acquired. If the experiment took place in a longer period of time, throughout the year and day, it is expected for those three factors to become essential. In addition to the answers and GPS data, the hand-drawn traces of the followed paths are of high interest, since a small amount of participants was partially mistaken, which could indicate a difficulty to link visual experience of streets to map-illustrated ones.

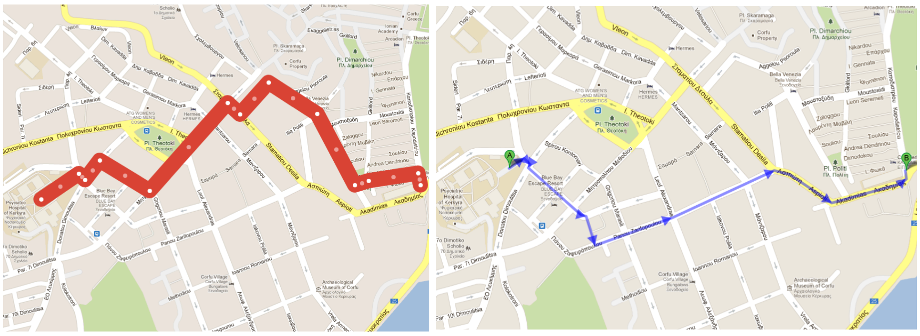

Figure 2. The collectivily perceived shortest path is signficantly different to the suggested one.

It becomes evident that a pattern emerges from these results; users tend to choose similar sub-paths not because there are not any alternative ways to move, but rather because they appraise the same urban qualities as important.

4. Discussion and Further Research

The notion of significant differences between perceived and actual use of information technology has been documented in contemporary usability research. Indeed, Nielsen and Levy (1994) have highlighted that the perceived usability might not be corelletated to the actual efficiency of an information technology, in other words, sometimes people found more usable something that is slower. Moreover, Frøkjær et al. (2000) have found that usability has a complex dependency on efficiency, effectiveness, and satisfaction. Similiarily, the main finding of this work is that the widely available shortest path functionality for pedestrians might not provide subjectively optimal results, at least in the case of urban centers with a complex set of available paths. The findings of this research inform the development of mobile applications and the design of new map layers for city dwellers. They serve as the raw data to inform the learning process for the creation of pedestrian-friendly maps.

Previous research has considered the analysis of GPS traces and the design of new types of digital maps separately. The analysis of GPS traces has been elaborated by Zheng et al. (2009), who have collected and data-mined a large data-set of trajectories, in order to find out interesting places, means of transportation, and travel habits. More recently, they have extended their research to provide social recommendations based on the itinerary habits of locals. Nevertheless, they have not examined the requirements for constructing new types of digital maps and they have not considered pedestrians. On the other hand, the design of maps has been elaborated by the MIT Senseable City group. Chen, X. (2011) created isochronic maps based on the time required to travel by public transportation. Our work is building upon those efforts by providing an integrated view of mining GPS trajectories and creating new types of digital maps.

Former subjective approaches to urban informatics have considered maps as a platform, but then have not explored how maps themselves could evolve as part of the collective local knowledge. For example, Ringas et al. (2011) have found that citizens are benefited by public sharing of personal stories in various formats (text, voice, photo, video). Moreover, Traunmueller et al. (2013) have focused on suggesting alternative leisure paths through social media voting. Nevertheless, the above works assume an extra effort on behalf of the user to share their story and they have not yet considered the potential crowdsourcing of the subjective data on a collective image of the city.

In addition to the research efforts, there have been several grass roots initiatives. For example, the biketastic community has been uploading bike routes in order to facilitate the sharing of safe and enjoyable routes for bikers (Reddy et al. 2010). Although, the biketastic system has similar motivation and approach, our work is also considering the visualization of path information in a way that is accessible to pedestrians. Moreover, the controlled experiment procedure is providing cleaner data and the opportunity to examine the subjective motives behind route preference.

In ongoing research, we are designing a dynamically crowdsourced mobile map application where the most frequently used streets will be illustrated and dynamically modified, according to users' feedback; most popular streets will appear as of larger cross-section, whereas less popular ones of narrower. Dynamics will not only be controlled by frequency, but also by personal preferences, depending on occasion: weather conditions, time of day, possible health problems, etc. will generate paths tailored to the user's specific demands and safety. These maps' priority will be the pedestrian and the biker and will be addressed to all people, either locals or visitors.

Acknowledgements

We are thankful to the participants of the study and to Iro Armeni for organizing the collection of the data and assisting in the methodology of the experiment.

References

[1] Chen, X. (2011). Seeing differently: cartography for subjective maps based on dynamic urban data (Master thesis, Massachusetts Institute of Technology).

[2] Frøkjær, E., Hertzum, M., & Hornbæk, K. (2000, April). Measuring usability: are effectiveness, efficiency, and satisfaction really correlated?. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 345-352). ACM.

[3] Lynch, K. (1960). The image of the city (Vol. 1). MIT press.

[4] Nielsen, J., & Levy, J. (1994). Measuring usability: preference vs. performance. Communications of the ACM, 37(4), 66-75.

[5] Ringas D., Christopoulou E., Stefanidakis M., "CLIO: Blending the Collective Memory with the Urban Landscape", International Conference on Mobile and Ubiquitous Multimedia 2011, 7-9 December, 2011, Beijing, China

[6] Sasank Reddy, Katie Shilton, Gleb Denisov, Christian Cenizal, Deborah Estrin, and Mani Srivastava. 2010. Biketastic: sensing and mapping for better biking. In Proceedings of the 28th international conference on Human factors in computing systems (CHI '10). ACM, New York, NY, USA, 1817-1820.

[7] Stilgoe, J. R.(1998). Outside Lies Magic: Regaining History and Awareness in Everyday Places.

[8] Martin Traunmueller, Ava Fatah gen. Schieck, Johannes Schöning, and Duncan P. Brumby. 2013. The path is the reward: considering social networks to contribute to the pleasure of urban strolling. In *CHI '13 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '13). USA, 919-924.

[9] Hyoseok Yoon, Yu Zheng, Xing Xie, Woontack Woo: Social itinerary recommendation from user-generated digital trails. Personal and Ubiquitous Computing 16(5): 469-484 (2012)

[10] Yu Zheng, Lizhu Zhang, Xing Xie, and Wei-Ying Ma. 2009. Mining interesting locations and travel sequences from GPS trajectories. In Proceedings of the 18th international conference on World wide web (WWW '09). ACM, New York, NY, USA, 791-800.