Mobile Mapmaking: A Field Study of Gamification and Cartographic Editing

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Abstract. Digital mapmaking has traditionally been a desktop computing activity with dedicated graphical (native or web) applications that strongly depend on the precision of mouse input. In addition, digital mapmaking also has a strong pillar on field observations, which have remained a separate task to the final mapmaking. In this work, we present to users a mobile application that combines the strengths of graphical mapmaking user interfaces with the actual geographical context into an integrated and collaborative user interface. In particular, the application implements three representative mobile mapmaking tasks (path recording, path editing and path reviewing) and includes gamification elements. A field experiment was conducted with thirty-six participants for two twenty-day periods during which they were asked to provide information about the pedestrian network of an urban region using the app. The results from questionnaire responses and contribution data showed that most users prefer recording their path, which is also the work with the lowest interaction. Moreover, gamification did not bring the expected results and the more difficult tasks were undertaken by few devoted users. Further research is needed to examine how interface design could better engage committed users in the aforementioned mapmaking task types.

Keywords: Mobile interaction · Mapmaking · VGI

1 Introduction

The emergence of digital maps and modern geographic tools (sensors, devices, software) that automate and abstract complex processes has made it possible for untrained people to participate in cartographic projects despite lacking the specialized knowledge and education of professional cartographers. It has come to a point where users perceive such systems differently than before. This tendency has unfolded a research space which deals with cartographic interaction mediated by computing devices [1]. Moreover, commercial smartphone devices have become capable of collecting location data and therefore offer valuable geographic information. This led to the logical consequence of mobile apps becoming a powerful tool for obtaining Volunteered Geographic Information (VGI) [2].

Human interaction with geographic applications has been studied in various contexts and largely in map use. On the other hand, mapmaking interaction research is limited as it has not been a long time since mapmaking has been widely introduced to

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non-geographers. User data analysis in VGI applications has shown the heterogeneity of the contributors in terms of usage patterns which could be exploited in HCI related decisions of resembling applications [3, 4]. Concerning pedestrian mapmaking, Kapenekakis et al. [5] confirmed the feasibility of making an abstract map by pedestrians employing common smartphone devices and an Android app. Although the app's functionality is similar with the one presented here, we additionally introduce and examine the function of map editing in the urban environment. This is considered important because many crowdsourcing map editing or VGI applications use distant editing techniques like satellite images, aerial photographs, street level images [6, 7]. In contrast, in our approach the user experiences the path network on site, as he walks. Hence, we suppose he can make more qualitative edits than in desktop applications. If this holds true, it is worth concentrating the interest on mobile variants of such systems.

Although some mapmaking mobile apps have already emerged, it is yet unclear how users operate them and generate content. There is a wide variety of functionalities from the simplistic recording of courses, to more sophisticated like applying corrections to geographic data. Since they target large numbers of users, it is expected that users will have different task preferences, cartographic skills and knowledge, and motivation in contributing. In this paper we give emphasis to selected types of functionalities typically found in such applications, which we consider to represent discrete types of map interaction tasks. We present an Android app which is utilized to explore how users interact with these tasks. The mapmaking app's main goal is to collect data and information by the users in an attempt to create a map for pedestrians based on their walking experience.

Contribution. This paper discusses lessons learnt from an experiment with a mobile mapmaking map interface. In particular, we discuss user interaction, task preference and the design considerations which arise.

2 Application Design

An Android app was developed which is based on the previous work of Kapenekakis et al. [5]. It is a crowdsourcing gamified application which generally aims at collecting location information from pedestrians. The system is complemented by a database for data storage and a server for serving requests from user devices. Its main purpose is to collect pedestrian routes resulting in an aggregated path network/map for pedestrian use.

Path Recording: The core function of the application is to collect user's location data while walking through an urban environment with minimal interaction (see Fig. 1 left). The location information collected can be considered as the basis of a new pedestrian network of paths or map, which is not identical to the vehicle roads. The task of recording paths, from a user's perspective, is analyzed as such: Tap button to start path recording ➔ Walk - passive recording of path (during walk, user can optionally select a type of path from a list) ➔ Tap button to stop path recording ➔ Confirm to save recorded path and data (includes getting informed for points gained).

Path correction: A feature that is commonly found in desktop cartographic applications is correcting street network or other geographic shapes of interest. We included an analogous functionality in the app, which allows the user to “draw” a suggestion of path correction (see Fig. 1 middle). We consider this an important addition as, inevitably, recorded paths are inaccurately recorded due to sensory limitations and environmental obstructions. The actions the user has to undergo to correct a path are: Walk checking the screen until find a recorded path that needs correcting (only near recorded paths appear) ➔ Tap to select path for correction ➔ Draw correction in straight line (Long tap to start correction ➔ Long tap to stop correction) ➔ Confirm correction (includes getting informed for points gained).

Path reviewing: Besides correcting paths, users can also review other users’ paths on walkability (see Fig. 1 right). Peer reviewing of paths has a double aim. Firstly, it is necessary to objectify paths’ walkability values and secondly to discourage and limit the effects of malicious behavior. Evaluating a path, the user must follow these actions: Walk checking the screen until find a path to evaluate (only near recorded paths appear) ➔ Tap to select path for reviewing ➔ Review path by selecting predefined choices from lists (walkability reviewing, tags reviewing, new path) ➔ Confirm upload of review (includes getting informed for points gained).

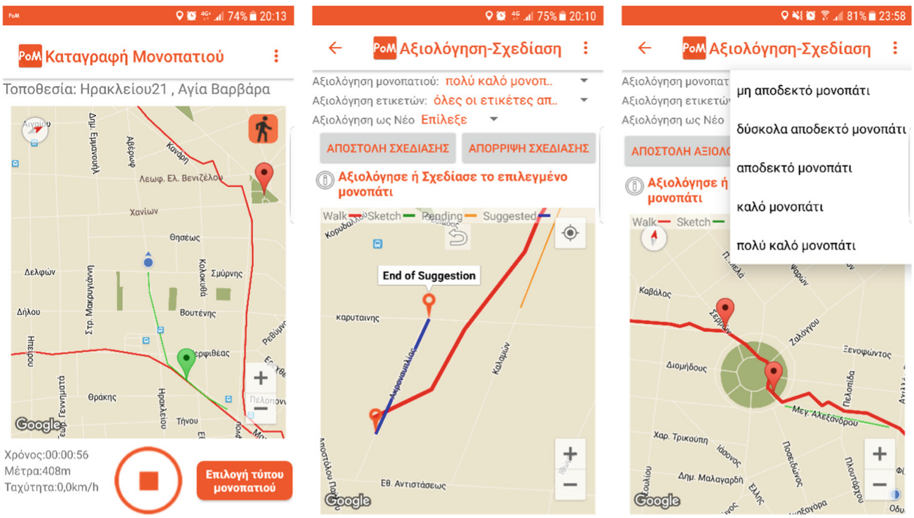

Fig. 1. **Left:** User recording a path (green line), while other paths are shown (red lines). **Middle:** User making a suggestion for correction (blue line) of a path (red line). **Right:** User reviewing a path (red line). (Color figure online)

It is noted that the above functionalities include locality as a necessary attribute for data input. For path recording this is self-explanatory. For the other two functionalities, the situated path reviewing and correcting is ensured by restricting them for paths only in the vicinity of the user.

To motivate users to provide as much information as possible, a gamification system was applied. The gamification system involved a scoring and an achievement system on Google Play for each of the actions that have already been explained. Also, a leaderboard was created to enhance competition. To explain briefly, the scoring and achievements system favor (a) recording long paths; (b) recording new paths; (c) reviewing paths; (d) reviewing unreviewed paths; (e) suggesting a path correction; (f) providing a new suggestion for path correction. It also discourages users from providing low quality, inaccurate or mischievous information. Depending on the reviews of other users, a path or a suggestion of a player may gain extra points or receive a point penalty.

The app's three core functionalities can be seen as three different interactivity functionalities usually found on VGI mobile applications. The path recording represents a minimal interaction, with fragmented engagement functionality. The user mostly interacts at the start and the end of the task, with the option of turning his attention elsewhere in the meantime. The path reviewing is a more classic interaction functionality and requires constant attention until the task is finished and a moderate interaction load. For this task to be completed the user has to find a path (both physically and on screen), to select it, to review it (from predefined choices) and to confirm the transaction. The most demanding interaction process is the path suggestion/correction. In this case the user has to find a path needing correction, to select it, to carefully apply the correction by "drawing" it on the smartphone screen and confirm the transaction.

In order to test whether the app is well implemented and free of considerable usability problems, a pilot study was conducted with six students of the Informatics Department of Ionian University in Corfu. The subjects were requested to use the app in the field for ten days, answer a short questionnaire with usability-related questions and to report any problems encountered. Generally, the subjects found the application easy to use and free of notable functional or usability issues.

3 User Activity and Evaluation

The methodological approach taken was to formulate an experiment design which would provide information about the usage and experience of the users with the different interaction functionalities. A two-part field experiment was conducted with the app. The subjects of the experiment were students of the Information Science & Informatics Department of Ionian University and were offered a bonus grade on specific courses for completing a minimum of tasks using the app. The field trial took place in the city of Corfu, a city of approximately thirty thousand inhabitants. The street layout of Corfu is variformed and hardly linearized, as it comprises of a new and an old region. The participants were invited to complete tasks, which covered all the main functionalities. More specifically, they had to record paths, review other users' paths and design corrections to recorded paths. They were also provided with an online manual (which included the details of the point system) and a link to a video demo showing the full capabilities and functions of the app.

In the first trial, the subjects were encouraged to perform all the above functionalities in the form of a game and finish with filling an online questionnaire. Short time usage was expected as the experiment was an unsupervised field experiment [8]. In order to address potential low contribution levels, we introduced both internal and external incentives. They involved bonus grades in a course of their degree and the gamification of the app with scores for each contribution and a leaderboard. Moreover, it was stated to potential participants that the ultimate goal of the game, besides player rankings, was to collect enough data to produce a new, more appropriate map for pedestrians. As in the first trial there were no pre-recorded paths, it was easier for the subjects to focus on recording paths. In the end of the first trial there were indeed a large number of recorded paths. Thus, the second trial focused only on the reviewing and designing of paths in order to draw more solid conclusions regarding these functionalities. In both of the trials of the experiment the subjects were given a twenty-day period of app usage to fulfill the tasks given.

Totally, thirty six (36) participants installed the app and twenty (20) of them made at least one valid contribution (uploading) to the database (Table 1). As valid contribution we consider a recording, or an action on a path, inside the boundaries that roughly contain the city. Also, the recorded paths had to be at least twenty (20) m long. We chose a short minimum path distance because of the short alleys that make up blocks of buildings in the old region, assuming that even a path that short could contain noteworthy information.

Table 1. User participation in each stage

Action	Participants
App installation	36
Valid contribution	20
First experiment	
Path recording	19
Path reviewing	8
Path correction	4
Questionnaire response	14
Review experiment	
Path reviewing	3
Path correction	3

3.1 Questionnaire Results

The aim of the questionnaire was to assess how the app's functionalities appeal to the user and which are the factors that motivate users to use them. The replies from the relevant questions showed that most of the respondents have never edited a map (71.4%) but where very interested in the idea of contributing in the creation of a pedestrian map. About half of the participants were motivated from the contribution in the creation of the pedestrian map, approximately the other half were motivated from the gamification features of the app and only one was participating for the extra grade.

It is impressive that while many of the participants were motivated by the score system and achievements, all of them claimed that they did not use any strategy to gain more points. Concerning the preference type of contribution among recording new paths, reviewing other users' paths, and editing existing paths, the answers dominated the recording new paths choice (92.9%).

3.2 Contribution Data Results

The participants seemed to enjoy more to record paths as nineteen (19) of them recorded 415 paths. About half of them recorded less than ten paths (52.6%), four recorded twenty to thirty paths (21%), and another four recorded more than thirty paths (21%). Although the paths are many, they considerably differ in size. In cartography, one of the most important features of contributions is coverage. From this aspect, the subjects displayed different levels of zeal as it is shown from the total path distance presented in Fig. 2. The total distance of the paths reached 254002 m. The mean path distance was 612 m, which is a reasonable walking distance according to Yang et al. [9] as trips longer than 400 m are common and the median distance of waking trips among walkers is 800 m. This may indicate that users did not put more effort than usual walks to record paths. Consequently, this could explain why users preferred this type of functionality. It is minimal, does not explicitly require the attention of the user and it can be undertaken while the user is occupied with other activities like taking a regular walk or going somewhere where he is already supposed to go. The responses from the questionnaires also support this, based on the result that not one user tried to gain more points using a strategic behavior.

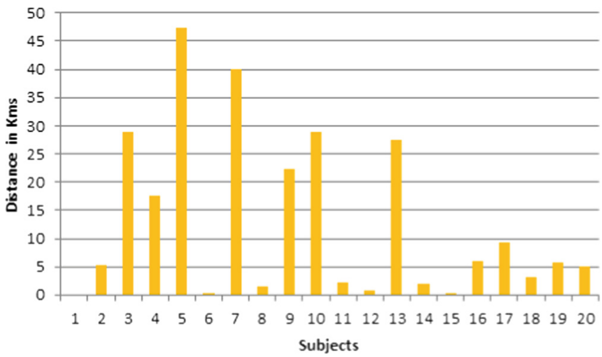

Fig. 2. Total path distance per subject

The functionalities of reviewing and correcting paths were barely used during the first experiment. At the early stage of the experiment there were only few paths to be found for reviewing and corrections. To exclude the possibility of users not fully understanding the concept of these functionalities at the early stage, we conducted a review experiment with the recorded paths from the first experiment already loaded and the recording of paths deactivated. In this way, the subjects could focus in these specific actions.

The combined results showed again little interest of the participants for these functionalities. The fact is that eight (8) subjects reviewed at least one path and five (5) suggested at least one path correction. It is interesting that of them, only three (3) contributed the vast majority of these edits (Fig. 3). Comparing path reviewing and path correcting, the total number of reviews was 152 (45.8%), little less than the total number of suggestions for path corrections which was 180 (54.2%).

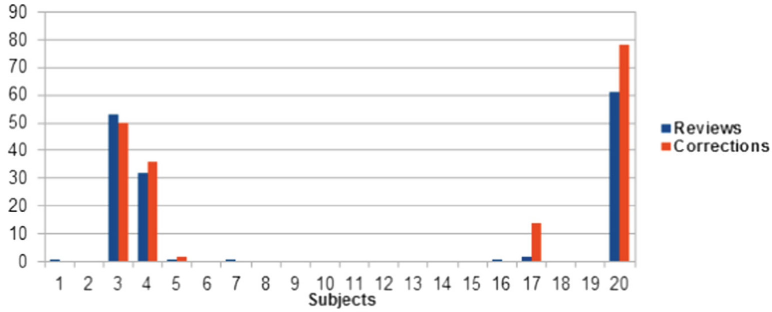

Fig. 3. Path reviews and corrections per subject

4 Discussion

The experiments revealed some behavioral aspects of users while interacting with our app, which could be generalized to relevant smartphone apps. Knowing and interpreting user behavior is important in designing interactivity.

Firstly, the majority of our subjects stated that they prefer recording paths which was also evident from the uploaded data. Thus, we assume that casual users prefer minimalistic, with lighter cognitive load interactivity for this kind of cartographic apps. In agreement with the conclusion of Poplin et al. that users find difficulties or neglect some operations due to lack of training in mapping platforms [4], our results from contribution data indicate that users' task acceptance differs highly among users. Most participants engaged more with the lightweight tasks and functionality which required less interaction, while only few users were receptive to the harder and more complex interactions. This is also in line with the research on map editing applications such as the Cyclopath geowiki and OpenStreetMap which show that a small portion of users contribute the most in mapping content [3, 10]. It is indicative that most participants did not bother at all with the more demanding tasks. This should not be understood simplistically and isolatedly, because there are also other factors involved, such as motivation, which impact avocation. However, it can be assumed that path recording may be preferred by users in similar mobile apps for interaction load or other reasons. In case of the first, similar apps should be carefully designed in order to minimize user interaction. Another solution could be to focus work on specific tasks which are less appealing. For example, in the context of a cycling geowiki, Priedhorsky et al. try to elicit volunteered work acknowledging that preference in "work types" can be correlated with personal characteristics, specifically familiarity with the region [11].

Our app serves a specific purpose. Therefore, it is understandable that not all people will be willing to participate in its goal. In anticipation of this lack of willingness to participate in the cause, we employed a gamification system. More than half of the subjects refused that the scoring system and the achievements motivated them for using the app. This is consistent with the absence of strategy for most players for gaining many points. It is also consistent with the observation that few participants offered much geographic information regardless of the scoring system. Taking the above into account, we propose that specific-purpose contributing applications such as the one studied, are better to be designed considering not the casual user, but users devoted to the goal of the app who are more likely to considerably use it. Moreover, it seems that gamification is not a panacea for increasing user engagement in every case. In contrast, Salomoni et al. reported positive results from the gamification of a mobile app which collected urban data about accessibility [12]. However, we argue that the game mechanics of our app were considerably different.

Regarding the comparison between path reviewing and path correction, we expected that users would significantly use more the path reviewing function because it is easier from an interactivity perspective and can be applied in every recorded path the user finds in his way. On the other hand, the path correction is more demanding as a task, especially when performed in a small smartphone screen, and has to be performed only on paths which can be corrected. Nevertheless, as the users who contributed more to these tasks were the few 'devoted' ones, we can assume that this kind of users are more receptive to undergo more complex and effortful interactions to fulfill tasks.

Cartographic activities play a significant role when designing user-centered cartographic interactions and interfaces should be adjusted to the corresponding users' tasks [13]. This paper analyzed the behavior of users with a serious-purpose app which included different interaction functionalities. It is evident that users contribute differently in mapmaking tasks. We believe that in some degree this is due to cognitive and interaction workload. We don't claim that there are interface shortcomings as this was not a finding from the pilot experiment, but there is a need to improve interaction in such mobile apps in order to benefit from on-site provision of geographic information. Moreover, simple forms of gamification like point gathering, leaderboard and achievement systems may not yield better results in terms of contribution in every case. When designing interactivity for similar applications, it is important to first clarify the target users for each of the functionality offered. Cartographic apps include complex tasks, which in some occasions are difficult to be performed without training. Thus, we find it logical to use different interaction functionalities and complexity per type of user, as Brock et al. also suggest in the case of bespoke map customization [14]. Further experiments and data analysis of our app might provide additional insights into building community GIS systems as mobile systems.

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