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Visualizing Cat GPS Data: A Study of User Requirements

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ABSTRACT

Domestic cats are usually allowed to roam freely outside without human supervision, which creates a new market for consumer GPS tracking devices. However, current GPS devices and the supporting interfaces and visualizations are usually created with a focus on dog owners. To acquire more insight into the needs of cat owners in relation to GPS devices for domestic cats, an iterative prototype-based study was conducted. This paper presents the requirements for the visualization of GPS data of domestic cats that were determined in collaboration with cat owners during the study. Interviews and multiple prototypes were used as tools to identify and refine these requirements and were mostly based on cat owners' concerns and curiosity for their cats' location. The most important requirements for a cat owner-centered GPS visualization were being able to request the live location and being alerted if the cat might be in trouble.

KEYWORDS

human-cat interaction, visualization, gps, geospatial data, user requirements, interface design, prototype-based study

INTRODUCTION

Most domestic cats are seen as a true member of the family, a friend or even an extension of oneself [18]. Pet owners often provide their animals with similar levels of comfort, support and affection to that of other family members [15].

Tracking the movements of animals and measuring their vital parameters from a remote location, through biotelemetry tags or devices worn by them, is frequently done for research purposes [1][4] and, more recently, as a care-taking practice with companion animals [14]. In this regard, while research has been conducted into the reasons why owners use a GPS device with their dogs [14], no study focused on the reasons why cat owners use GPS devices with their animals has yet been conducted. Similarly, no studies have been conducted to investigate cat owners' requirements regarding the visualisation of tracking data. Since research has shown that there is a significant difference in attitudes and behaviours between so-called "dog people" and "cat people" [9][10], it is plausible that cat owners might have different motivations to use a GPS device compared to dog owners, partly due to significant differences in species-related care-taking practices. For example, dog owners tend to walk with their dogs, while cat owners may allow their cats to use a cat flap to let themselves out and freely roam outside.

This paper reports on a study conducted to explore cat owners' requirements for the visualization of GPS data related to domestic cats. In collaboration with cat owners, requirements were iteratively identified through the use of interviews and different prototypes employed as requirement elicitation tools. The prototypes explored a range of possible functionalities, including informing the cat owner about the location of the cat in real time or specifying zones corresponding to potentially dangerous area or safe areas for the cats to roam. Additionally, the prototypes explored the possibility of providing system capabilities such as making inferences about the wellbeing of the cat, to enable owners to decide whether to let their cats out in the first place.

BACKGROUND

Tracking cats

For a recent BBC Two's Horizon program called "The Secret Life of Cats", a study was conducted with 50 domestic cats living in Surrey, UK. This was one of the most extensive studies conducted on the behavior of domestic cats, the likes of which had previously only been conducted with big African cats. The researchers tracked the cats for multiple days using GPS devices equipped with a miniature camera. They discovered that domestic cats share their territory based on a time frame to avoid coming into contact and enter into conflict with one another. The researchers' results also showed that during their time outside often the cats explored areas that were different from the areas their owners thought they were exploring. This finding highlights how little cat owners may know about their cats' roaming habits; on the other hand, the study showed that cat owners have an interest in understanding more about the life of their cats when out of sight. However, no studies have been conducted with regards to consumer use and needs for the visualization of data from GPS tracking devices targeted to pet owners. In particular, when it comes to their care-taking role and practice, what are the experiences, reasons and requirements of cat owners?

Existing GPS devices for pets

GPS technology is currently the best option for retrieving locations outdoors [11] and its use with companion animals is becoming increasingly common. A wide range of pet GPS tracking devices are currently available, some of which are also explicitly marketed for cats. Amongst the most common GPS trackers for companion animals are Gibi [8], Pod3 [20], Tractive GPS Cat [23] and Whistle [24].

Gibi is designed specifically for dogs. The wearer's location can be tracked via a dedicated application on a google map, where it is possible to specify a safezone. The main functionality of the product is letting the user know if their pet leaves a safezone and provide on-demand location to enable the user to find a lost animal.

Pod 3 is mainly targeted to dog owners but can be used also with cats. Functionalities of the tracker include recording the route of an animal, real-time location tracking and movement monitoring, safezone specification and user alert when an animal has left a safezone.

Tractive GPS Cat is specifically intended for use with cats. Functionalities of this device include on-demand live tracking with a 2-3 second interval, virtual fencing (i.e. specification of safezones), location history, animal location sharing, and also activity monitoring.

Whistle 3 can be used with both dogs and cats. Functionalities include setting safezones and alerting the user when a pet leaves a safe area, live tracking of a pet's location, sharing information access with other users.

All these trackers applications allow the user to create safezones, see real-time information on demand and record the location history of the animal. However, all require some effort to actually see the location of the animal, by pressing a button to activate the live location. None of the applications give the user information about the animal's wellbeing or alert the users when the animal might be in danger. Instead, users have to manually retrieve the data and use it to make make their own inferences. But what is the perspective of cat owners with regards to the functionalities currently provided by GPS trackers?

Reasons to track pets

As mentioned above, cat owners consider their cats friends and family [18], and want to know how and what the cats are doing [25]. Reasons to track pets are diverse. For example, a study conducted with dog owners by Mancini et al.[14] uncovered several motivations. Some participants in the study explained that they tracked their dogs in order to protect them. For example, participants living in urban areas were concerned about traffic accidents, while participants living in rural areas were concerned about their dogs getting shot by farmers or getting injured and incapacitated while out

of sight. Additionally, multiple participants were concerned about the risk of abduction of their dogs, which was especially the case with pure-bred dogs. Another reason for tracking dogs was a desire to retrieve the dog if they went missing during a walk, whether in unfamiliar or familiar surroundings. However, safety concerns were not the only reasons for these dog owners to use a GPS device. Curiosity towards the movement patterns of their dog was also stated as a motivation for tracking dogs' location [14].

Visualizing geospatial data

Geospatial data refers to a location on Earth, as logged by a GPS device over time. Maps are commonly used to visualize geospatial data and help users understand the temporal and spatial relationships existing within the data. Through a map, distances, area sizes and directions can be illustrated and patterns can be visualized [13]. Users expect the navigation of a geospatial representation to support a set of basic tasks. These tasks include changing the map projection, its scale, its level of generalization and the field of view by moving, panning and browsing over the map [7].

Visualizations of geospatial data for consumer use exist in a large number of applications that are designed for running or cycling [3]. Applications, such as Runkeeper [21] or Runtastic [22], use a map to represent the data, where runners can track themselves during a run or check the path they took. Runners might use this kind of applicaiton to understand their spatio-temporal relation to their surroundings and perhaps to better understand their own behaviour. But how should tracking applications help users understand the spatio-temporal relations and behaviour of someone who is out of sight and may roam far for long periods? Improving our understanding of this issue was the focus of our research.

RESEARCH QUESTIONS

GPS devices that track a pet's location are increasingly of interest to ACI researchers. However, as mentioned earlier, no research has yet been conducted on the visualization requirements and needs of cat owners with regards to the use of GPS tracking devices for their cats. The goal of the work reported here was to identify a set of characteristics for the visualization of GPS data of domestic cats for consumer use, which could provide a user experience that is meaningful and relevant.

In particular, we were interested in identifying user motivations and expectations regarding GPS data visualization for cat owners, and any trade-offs that might be necessary due to CPS devices' limited battery life. Our main research question was: ***How can data, captured by a GPS device attached to a cat, be effectively and usefully shown to cat owners given current technical constraints?***

More specifically, we wanted to find out:

(1) What motivates cat owners to use a system that visualizes their cats' GPS data?
(2) What information is relevant to the user?
(3) What are the user requirements with regards to the visualization of cat GPS data?

By addressing these questions, our research aimed to lay the foundations for further investigations that could specifically focus on GPS visualization for cat owners. Our findings could enable ACI and HCI researchers alike to improve current GPS devices such that they can support user motivations and meet their expectations within the technical constraints imposed by a limited battery capacity. Thus, this work contributes towards the improvement of user experience for systems that visualize GPS data from pets, and particularly cats.

METHODS

To explore user motivations and expectations with regards to cat GPS data visualization in detail, we adopted a qualitative research approach, in the form of a case study design [6] combined with interviews and user tests with prototypes of increasing fidelity (i.e. from paper to digital form).

Participants

We conducted in-depth semi-structured interviews with ten participants, all of whom cared for one or more cats and resided either in the United Kingdom (N=5) or in the Netherlands (N=5).

Paper prototype tests were conducted with nine participants, all of whom cared for one or more cats and resided in the Netherlands. Some of these participants were newly recruited (N=6) and some had already participated in the interviews (N=3). For the first prototype test, three participants in the paper prototype test were completely new to the study. For the second prototype test, two participants had also participated in the interviews and one participant was entirely new to the study. For the third prototype test, two participants had also participated in earlier prototype tests and one was completely new to the study.

Interviews

Preliminary information regarding cat owners, their cat(s) and their motivations and expectations with respect to a GPS device for cats was collected by means of the semi-structured interviews.

The semi-structured nature of the interviews gave participants the possibility to elaborate on important topics, thus offering us insights that reflected what was relevant and important from their point of view. Interviews were conducted

in enclosed or quiet spaces (e.g. room, office) to ensure minimal environmental disruptions. Before the interview started, participants were informed about the nature of the research and data processing, they were given an information sheet providing details of the study and were asked to sign an informed consent form.

The first set of questions aimed to explore the cat owner's lifestyle, for example "How much time do you spend at home?" and "When you are outside of the house, do you have your phone close to you or is it somewhere where it is not accessible to you?" The second set of questions related to the life habits of the cat(s) and the extent to which they were able to freely explore their outdoor surroundings. A third set of questions revolved around the imaginary case in which the participants would be using a system that visualizes cat GPS data. These questions focused on the prospective users' preliminary motivations and expectations with regards to the use of the system and the data it would provide. To this end, the specifications of an imaginary tracking collar were given mentioning the limitations of the battery life, and how this might affect access to and use of the data recorded through the device. Finally, a last set of questions focused on this prospective prototype and what kind of information they would like to get from the device, for example "If you were fit your cat with a GPS device whe you let them out, what would you like to be able to see?" and "On what device would you want to be able to see the visualization?". Overall, these semi-structured interviews provided the requirements that informed the first paper prototypes.

User testing

To further specify requirements from the perspective of potential users, non-functional and semi-functional prototypes of increasing fidelity (from paper to digital) were created and user tests were iteratively conducted. The participants were asked to act as if the prototypes were actual working applications and to think outloud during every test, so everything they thought could be recorded. At every stage, it was also made clear to them that there were no right or wrong answers, and that the goal of the study was rather to find ways of improving the designs presented to them. Each test followed a plan that specified the test goals, an introduction and a number of questions for the participants, and the scenarios to whcih the questions related and which provided the context for testing the prototypes.

First prototype. Based on the requirements identified during the semi-structured interviews, a first paper prototype was developed, which was tested with the study participants to establish to what extent the envisaged application would meet the expectations of prospective users.

The first prototype (Figures 1-3) was a low-fidelity hand-drawn paper prototype, whose function was to focus on the structure of the pages and to explore whether users could find information where they expected. Four pages were drawn for this prototype: the *home page*, which showed a map with the last known location of the cats; a *cat page*, with all the cats; a *cat detail page*, with their last known location and route history; and, finally, a *settings page*. The menu items were represented by icons, including a 'map arrow' for the homepage, a 'paw' for the cats page and a 'wrench' for the settings page.

This test used the paper on which the prototype was drawn, a laptop for recording responses from the participants, a printout of the questions and scenario descriptions, and a mobile phone to audio-record the participants' comments during the test. The participants were asked to act as if the paper drawing was an actual phone, so they could pretend to tap and scroll the interface of the application.

The test began with two questions about the home (opening) 'screen' (Figure 2):
Q1: What do you think the colored circles are?
Q2: How do you think you can view more information about a cat on this screen?

Afterwards, four scenarios were presented to the user:
S1: You see you have misspelled the name of one of your cats. How do you think you could change this?
S2: Your cats are outside and you want to see who is where. How would you do this?
S3: You want to know what routes one of your cats takes. How would you do this?
S4: You want to mark a certain location as dangerous. How would you do this?

Second prototype. The second prototype (Figures 4-6) and first digital user test was conducted using the online tool Invision [12]. Invision is an online tool that can be used to craete interactive prototypes. For this prototype, users could click on elements of the prototype's interface and, if the clicked area was linked to another page, the user was redirected there.

This was the first high fidelity prototype to be used in the study and its function was to verify whether the requirements identified in the first test were met by the design. The pages were still the same, a *home page* with a map, *cat page* with the list of cats, a *cat detail page* with information about one cat, and a *settings page*. Now, on the cat detail page it was possible to request the live location had been added; and the cat page offered the option to specify a safezone. The menu icons were now a 'map' for the homepage, a 'cat face' for the cats page and a 'gear' for the settings page.

This test employed a mobile smartphone which could display the Invision prototype, a laptop for recording the participants' responses during the test and a printout with a description of the scenarios. For this test the following scenarios were given to the user:
S1: You see you have misspelled the name of one of your cats. How do you think you could change this?
S2: You want to know how much battery is left on the tracker of one of your cats. How do you think you can view this?
S3: You have the feeling something is wrong with your cat and want to find out where he is right now. How would you do this?
S4: You want to mark a certain location as dangerous. How would you do this?
S5: You get the following notification (your cat entered a dangerous area). How do you feel about the text? What would you want to do next?
S6: You get the following notification (cat has not moved for 60 minutes). How do you feel about the text? What would you want to do next?

Third prototype. The third prototype (Figures 7-9) and second digital user test, was also developed using Invision and its function was, again, to verify that the participants' requirements were met by the revised design. There were still four pages: the *home page*, the *cat page* and the *settings page*, plus the *cat detail page*. A major change was that in this prototype the home page offered more functionalities: the controls for requesting the live location and for setting safezones were both moved from the cat page to the home page.

For this test, too, a smartphone with the prototype, a laptop for recording responses and a printout of the scenarios were used. The following scenarios were given to the user:
S1: You want to know how much battery there is left on Philips tracker. How do you think you can view this?
S2: You want to view the map without seeing the zones you've set. How do you think you can do this?
S3: You want to mark a certain location as dangerous. How would you do this?
S4: You want to go out to buy groceries, but you don't feel comfortable leaving your cats out when you're away, unless they are in the garden. You will only be gone for a little while, so you decide to view the live location of your cats to see if they are around. How do you think you can do this?
S5: You have the feeling that something is wrong with Philip [Figure 10] and want to find out where he is right now. How would you do this?
Follow up question: What do you think the icon stands for?

Data Analysis

Data from the interviews and user tests was extracted by means of transcription. To uncover any emerging themes, the transcripts were imported into the analytical tool ATLAS.ti [2] and manually analyzed. Codes were created for responses

to each interview question or user test scenario. Once all the interviews or tests were coded, the number of times a code appeared was shown by the program, which made participants' topics and emerging themes easily visible.

FINDINGS

This section discusses the study findings, startig with the requirements that emerged from the interviews, followed by the requirements subsequently identified during the three, iterative rounds of user tests.

Interviews

Because of the explorative nature of the study, the interviews focused on the topics of relevant information, device type and trade-offs regarding battery life. From the interviews two motivations for using a GPS device emerged: concerns (interviewees #1,#3, #5, #6, #7, #8, #9, #10) and curiosity (interviewees #2, #4, #8). Some interviewees expressed both motivations; while others expressed one more than the other.

Motivations.

> *"I suppose the main drive would be to see whether their roaming patterns are safe or not."*
> - Interviewee #3

Owners who were largely motivated by concern were mostly worried about the safety of their cat when these were let outside. Unsurprisingly, what these participants had in common was that they all lived in cities. Interviewee #1 mentioned that "*there have been some cat related crimes in Milton Keynes and we keep them in until the suspect has moved on somewhere else*". Most interviewees in this group only let their cats out when they were around to check on them. Cars and other vehicles were a big concern for these participants. Another precaution taken, as mentioned by interviewee #8, was to let cats wear a light around their neck at night so they are more visible by traffic. Interviewee #9 mentioned she was also concerned about her cat being abducted because she looked like a pure-breed Norwegian Forest Cat. She also said *"If I was living on the ground floor, I would probably not let her outside during the day when I was gone and there was no cat flap in the door. Very selfish."* Even though she thought it was selfish to keep her cat in, her concern for the cat's safety was obviously greater. Interviewee #7's cat was also not allowed to go outside without being on a leash due to safety concerns.

In this regard, nine participants stated that using of a GPS tracker it might ease their concern as it would let them know where their cats were at all times. For example, interviewee #9 would use a GPS device *"to give me more of an ease of mind, to not stress over her safety or where she would be"*. On the other hand, other participants found that using a GPS device might actually achieve the opposite effect. For

example, interviewee #5 explained how *"I think that a GPS device can increase your anxiety. Once you have the tool, you know you can check, you are looking more often and you see all kind of things"*.

> *"I am curious where he goes, I think that it's really nice to see. Just out of curiosity."*
> - Interviewee #8

Owners who were largely motivated by curiosity lived in both rural and urban areas. They were mostly interested in what their cat did outside of the house and were not as concerned for the cats' safety. They thought they had a general idea of where their cat went but would very much like to know where they went exactly.

Functionalities. In addition to the participants' motivations for possibly using a GPS device with their cats, other themes emerged during the interviews regarding various fuctionalities:

All participants explained how they were in favor of having a GPS tracking application on a mobile device, such as a smartphone, since this was almost always with them. In this way, if something happened, they could go to retrieve the cat straight away, provided that they could be notified immediately. For example, interviewee #5 explained *"I will say my smartphone because if I am going towards him to get him definitely the smartphone will be with me"*.

Receiving notifications about a cat not moving or entering a set location, was expressed by the interviewees as an important functionality. However, different participants indicated different thresholds for when they would want to receive these notifications. One participant said that they would want to receive a notification if their cat had not moved for ten minutes *"I would say that maybe after my cat has not moved for 10 or 20 minutes there is already something going on."* - Interviewee #8, while another participant said that they would want to receive a notification only if the cat had not moved for more than three hours, *"Not too often, because he often sleeps outside. I think minimal three hours in between."* - Interviewee #5. Interviewees also mentioned that they wanted the ability to set the threshold themselves, to play around and figure out what a good time interval might be for their own cats. Interviewee #1 mentioned *"I'd want to know the cats behavior first, because it might be normal for that cat. It needs to be calibrated"*.

Interviewees also expressed differing notification preferences with regards to their cats' comings and goings in and out of the home. Nine interviewees mentioned that receiving these notifications would ease their mind and be helpful for them *"To give me more of an ease of mind to not stress over her safety or where she would be"* - Interviewee #9, while another participant said that they would find this annoying and considered it to be too much information, *"My house*

would be an exception. I think that I would prefer that when I ask the app, and not that the app gives me the notification" -Interviewee #5. Again, overall the interviewees mentioned that they would want to be able to change the frequency of such notifications themselves. "For notifications it would be nice to be able to set different channels" -Interviewee #3.

Additionally, several interviewees mentioned that they would like to see the routes their cat had taken on the current day, interviewee #7 for example *"Maybe his route mapped so I know for sure he isn't crossing any dangerous roads"*. They were also interested in being able to see the route history *"I would also like to be able to see older routes he has taken"* -Interviewee #6.

Finally, the functionality of live tracking appealed to all interviewees, mostly for reasons of safety, sometimes also due to curiosity. All participants mentioned that live tracking their cat would be optimal, *"That would be ideal, to have it in some sort of crisis mode (live location) or something"* - Interviewee #9 *"I'd like to see his live location, so that I can easily find him when I want him to be in the house"* -Interviewee #7.

Requirements. Overall, findings from the interviews highlighted the following functional requirements for the application, which were used to develop the first paper prototype:

- Live tracking of cats
- Alert when cat goes into and out of a dangerous place
- Alert when cat goes into and out of the house
- Ability to customize the notification settings
- Notify when cat might be in danger
- Route of the cat for the current day
- Route history

Paper prototype

The goal of this test was to find out to what extent the requirements that emerged from the interviews were met by the early prototype, idenitfy suitable ways of representing these functionalities as well as any required functionalities that might still be missing. All of the scenarios were created with the purpose of letting the user navigate through the application to find out whether available functionalities could be easily identified and accessed.

Findings. The use of coloured circles to represent the cats (Figure 1) was clearly recognised by participants, who explained how this was mostly due to the symbols being presented on a map. When asked to try and retrieve information about the cat, every participant clicked on the circle (Figure 2, left). When they wanted to get further information, every participant tried clicking on the tooltip that had opened (Figure 2, right). Participants felt that this was more intuitive for them than using the paw menu item, which had been
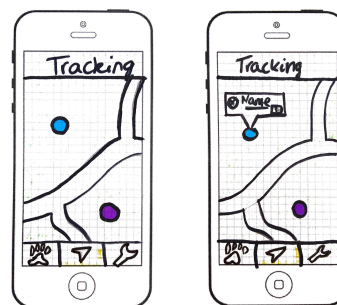

Figure 1: Left: Map view of the cats' location. Right: What happens when a user clicks on one of the circles representing the cats

designed to give them access to more detailed information about the selected cat (Figure 2). None of the participants
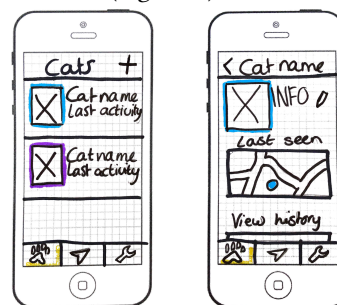

Figure 2: Left: Overview of cat data after the participant clicked on the paw icon. Right: Cat Detail page with current and historic cat data, and map.

could figure out how to change the name of a cat. All of them thought that they could do this by clicking on the name of the cat, instead of clicking on the pencil icon on the detail page, as per the prototype design.

The placement of the route history of a cat was found to be in an intuitive place (Figure 3). All the participants expected a cat's specific route information to be on the detail page of the cat. Additionally, participant #3 explained that she would like to see exactly at what time the cat was in a certain place. The way in which one could select a time period for the history of the route, by choosing between 24 hours, seven days, one week or all information, of a cat was not optimal. One participant explained that he would prefer to see some sort of calendar from which to select the desired period.

One thing that became clear during the test was that the way in which (safe or dangerous) zones could be set should be changed. In the paper prototype the option to mark a place as dangerous was accessible from the *settings page*, but this did not seem to be intuitive for the participants. Indeed, participant #2 explained that since the locations they wanted to set were relevant to individual cats, he would expect this option to be accessible from the specific cat detail page.
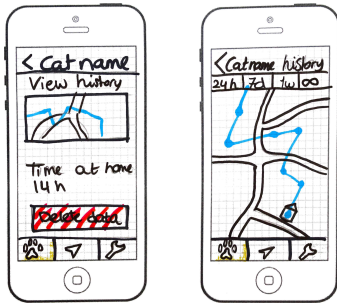
Figure 3: Left: Cat Detail page scrolled to the bottom. This reveals the View History option. Right: The route history of a cat.

Another issue that became very clear during the test was that the icons employed by the prototype were not very clear, especially the icons used for the "Map" and "Cat", displayed by a location arrow and a paw.

All of the participants explained that they would like to receive a notification when the cat did not move for a set number of hours.

Participant #1 explained battery level should also be visible somewhere in the application, *"It would also be useful to see how much battery is left"*.

Requirements. The first user test resulted in new requirements for a cat tracking application:

- Access the individual cat detail page by clicking on the tooltip of a cat
- Select dates to access historical data by using a calendar
- See the battery level of the device
- Receive notification if the cat does not move for a set period
- Use of clearer, more intuitive menu icons
- Access the function Set Zones from the Cat Detail page

First digital prototype

The main goals of this test were to determine whether the new representation and placement of functions made these easier to find, and whether this had any influence on the navigation flow in the application.

Findings. Three participants explained that they would like to see the battery level of the GPS device on the map view, rather than having to enter the "Cat Detail" page to see it (Figure 4). Since the Edit button in the paper prototype was not identifiable as a pencil, this prototype employed a clearer pencil icon to see whether the function would be clear. When the participants were asked to change the name of a cat, this time the edit button was quickly found, even though the positioning had not changed (Figure 4). Although the real time tracking of the cat was really liked by all the
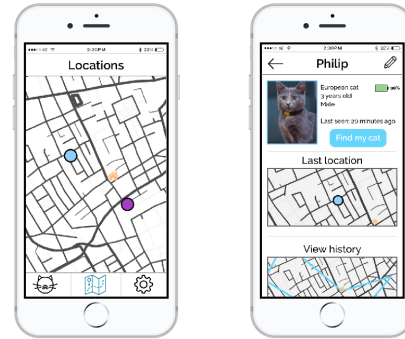

Figure 4: Left: map view of the cats. Right: Cat Detail page with information about the cat and the option to request a live location. Users can access this page two ways: by clicking on the cat icon and navigating to the cat, or by clicking on the circle and then on the tiptool.

participants, the positioning of the function turned out to be a bit confusing (Figure 4). Participant #5 pointed out that if she was really stressed (e.g. if she was worried about the safety of her cat), the steps she would have to take to get to the desired function would be too many. Also, the icon that represented the functionality to open the location in another application, such as Google Maps, was not clear (Figure 5). Participant #5 said *"I did not understand what the car meant, I thought it might mean he is near a road"*. Participants also
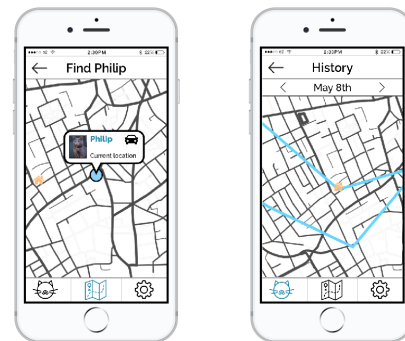

Figure 5: Left: When a user requests the live location of a cat, the live location page is shown. When the user clicks on the cat, the related tiptool is shown and allows the user to get actual directions to the cat, to physically check up on them. Right: The route history page of a cat.

commented that they would like to be able to request the live locations of all of the owned cats at one time, instead of having to request them one by one. Participant #6 mentioned that she would like to be able to share the location of her cat with friends, in case they could help find the cat.

Even though the positioning of the "Set Zones" function had been moved to the "Cat Detail" page, still the participants could not easily find it. They rather searched for it on the map and settings pages (ironically, where it was previously

located in the paper prototype). Participant #6 explained that the Cat Detail page was the last place where she expected to find it, because the zones are map related (Figure 6).

How to specify new zones was also not very intuitive for the participants. It was unclear to them that they had to press the OK button and the check icon to confirm the new zone (Figure 6). All the test participants mentioned that
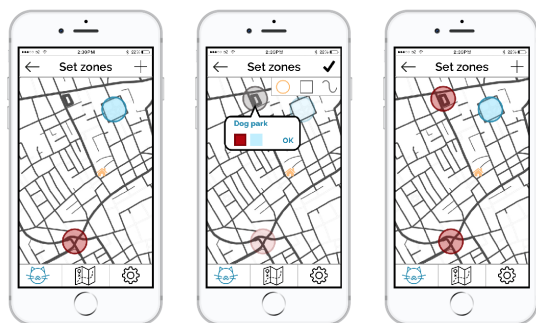

Figure 6: From left to right: 1: Overview of all zones. 2: A shape can be chosen, by clicking on the symbols in the top right corner, for the new zone and the position can be changed by dragging the shape. Releasing the shape triggers a pop-up that lets the user choose a name for the safezone and whether it is a dangerous, safe or neutral area. 3: After the user confirms the new zone, this is visible on the map overview page.

they wanted to be redirected to the live location of their cat upon receiving a notification message that the "Cat has entered a dangerous location" or that the "Cat has not moved for x amount of time". One participant mentioned how she liked to be able to see, already from the notification, for how long the cat had not moved from its position, so that she could decide for herself whether the situation required urgent intervention.

Requirements. Based on the above findings, the first digital prototype lead to the identification of new requirements:

- Show GPS battery level in the map view
- Ability to share the live location of a cat
- Ability to set the zones from the map overview page
- Ability to more quickly access the live location of a cat

Second digital prototype

The main goal of this last user test was to verify whether the revised functions of setting zones and retrieving the live location of a cat were now more easily accessible and usable. The complete prototype can be viewed using the following link: https://invis.io/XMKUC9DV2CW

Findings. During this test it became clear that the functions of requesting the live location of a cat, setting zones and checking the battery level were best placed on the map itself.

All test participants reported how it was intuitive to click on and expand the menu in the top right corner for these map-related actions (Figure 7). Participant #5, who also took part in the first digital prototype test, explained *"I like that everything that has to do with the map is accessible through the map view and that I don't have to go to the cat page every time"*. The additional battery percentage on the map view was
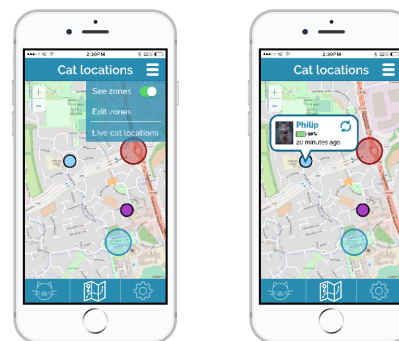

Figure 7: Left: Map overview with cat locations. Expanded menu and shows options to toggle zone visibility, edit zones or request the 'all cats' locations. Right: Tooltip appears when a user clicks on a cat. A refresh button allows the user to request the live location of this cat for five minutes, a time limit that accounts for the need to make economical use of the batteries.

also received well, especially because this was considered an essential part of using a power-hungry device such as a GPS. Participants appreciated how this was quickly visible upon opening the application (Figure 7).

If worried about their cat, the participants could open the application and easily request the live location of one or all of their cats on the map overview (Figure 7). In this regard, a participant commented that instead of the live location being active for five fixed minutes, users might prefer a toggle (Figure 9). While the participant was not opposed to the idea of the fixed five minutes of continuous live tracking, she mentioned how this might result in a waste of battery, in a scenario in which a users just quickly wants to know the live location as opposed to actually physically tracking the cat down. When asked to mark a location as dangerous, all the participants clicked on the menu and navigated to the menu item "Edit Zones" (Figure 8). By removing the OK button in the tooltip (which featured in the previous prototype) it was easier for the participants to create a new zone. Participant #6 mentioned how the process could be simplified by leaving out the verification of a newly assigned position and immediately showing the tooltip (Figure 8, second and third image). Participant #7, who did not take part in either the interview study or earlier user tests, mentioned how she would like to access a setup stage when first using the device and application. Even though she was able to find how to edit the
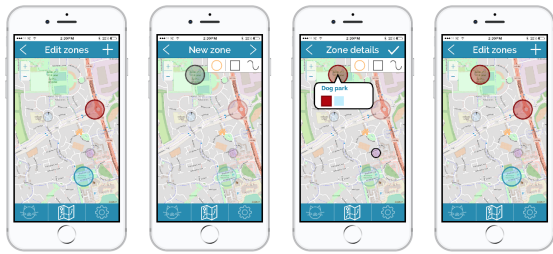
Figure 8: From left to right: 1: Edit zones main page. 2: Creating a new zone. 3: Naming and coloring a zone. 4: Map with newly created zone.

zones and add new ones, since these were not explained, she did not fully understand their purpose. The icon for sharing
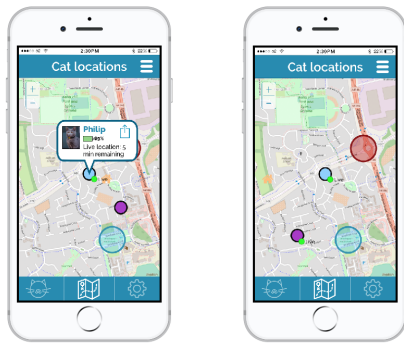

Figure 9: Live location is active for five minutes and visible from the map. Left: Map view when one cat's live location is requested. When clicked on this cat the tooltip appears, offering the option of sharing the location with another application or person. Right: Map view when all live locations are requested.

or opening the live location of the cat was also very clear (Figure 9). When asked what it meant, all of the participants immediately responded that it was for sharing the location with either an application or a person. One participant mentioned *"I know what this icon means because it is also used in other apps for the same action"*. The participants also mentioned that they knew which cat was currently showing the live location, because they understood that the green dot next to the colored circle indicated a zone.

Requirements. At the end of the testing phases, based on the above finding, the last prototype refined the existing requirements:

- Simplify the specification of new zones by combining steps
- Enable users to determine the duration of the live location (depending on battery life)
- Provide a tutorial to help users make the most of the application, with an emphasis on the use of zones

DISCUSSION & CONCLUSION

Discussion

The requirements identified during the study presented in this paper could inform the design of GPS tracking application for consumer use, especially targeted to cat owners. In particular, this research identified different areas of interest.

User motivations and expectations. The aim of this study was to identify several requirements for cat owners regarding visualization of GPS data. Analysis of interviewee answers suggests two important reasons that cat owners have to use a GPS system with their cat: safety and curiosity. The owners were concerned for the safety of their cat, especially with regards to the dangers posed byroad traffic. They were also curious to find out where their cats roamed while outdoors. Both motivations informed functions such as the ability to request the live location of one or more cats and to receive a notification when the cat might be in danger (i.e. entering a zone marked as dangerous, or appearing stationary beyond a set period of time). While the reasons for cat owners to use a GPS system seemed similar to that of dog owners, this is an important difference in usage requirements. The off-the-shelf trackers that were briefly discussed and compared earlier in the papr are all able to show the live location of a pet, but they do not alert the user when a pet might be in danger, based on thresholds set by the users.

Cat owners expressed a preference for receiving notifications about their cats' location, instead of having to manually check the application throughout the day. As discussed above, they would have liked to receive notifications if there might be something wrong with their cat (e.g. based on the amount of time they have not moved), while still being able to manually check the current location as well as historical locations of the cat at will. It was deemed important that notifications could be adjusted by the users because cats have different activity patterns while they are out of the house and the same patterns might have different meaning for different cats. Additionally, because different owners had different thresholds of concern, the required notification interval differed significantly from person to person. While these individual differences mean that set notification intervals would not be appropriate, for individual cats, the adjustment of notification occurrence could be automated through the application of machine learning algorithms, for which cat owners could set specific parameters. This level of customised automation is not currently offered by off-the-shelf trackers.

As it emerged from the study, to increase the likelihood of a cat being found quickly if something was wrong, the live location of a cat should have the option to be shared with other applications or users. Also, the function for requesting the live location of a cat should be easily accessible so users do not have to click too many times to get to an important

function. Indeed, research suggests that anxiety reduces the ability to focus on anything else other than the apparent threat; if the user was unable to find the function to locate their cat, this could worsen their anxiety and fear [16]. Only two of the trackers compared allow users to share their own data or other users to access their data.

Setting (dangerous or normal) zones should be doable at the map level. Since these zones are linked to the map, it made sense for the participants to be able to access the functionality in the same place. The user should also be in charge of the notification options regarding the zones. Setting safezones for pets is currently possible with all compared trackers. They also allow for notifications to be sent if an animal leaves a safezone. However, this is not the case for dangerous zones, the identification of which was deemed equally important by the participants.

One could also think of ways of extending the concept of zones beyond notification to human users. For example, the tracker could emit some kind of feedback audible by the cat to condition him or her to deter them from entering a dangerous area. In this case, the ethical implications would need to be considered, since such a functionality would limit the cats' ability to move freely while outdoors and would have the potential to alter their behavior and affect them in ways that are detrimental to their welfare.

Future functionalities and trade-offs. The need to keep the dimensions and weight of tracking devices to a minimum for welfare reasons means that these devices have limited battery capacity [19], while at the same time having to feed a technology that is notoriously power-hungry. Participants were aware of the need to find trade-offs between monitoring their cats as frequently as they wished and limiting their usage to extend the battery life in case of emergency. In this regard, a possibility discussed with the participants might be to monitor the cat's movement for five minutes upon request, with the option to turn live tracking off before the end of the five minutes, if all seemed well with the cat.

If battery life were to increase, other activity or physiological measures could be monitored, which would allow the system to make even better inferences about what the cat is doing. For example, if a cat was stationary and their heart rate was low, this might indicate that they are sleeping; on the other hand, if they were stationary but their heart rate was abnormally high, this might indicate that they are in distress or in danger, something which participants would have liked to be notified of. However, such a functionality might raise liability issues, for example, if a device was unable to detect that a cat is in distress or in danger, and thus failed to alert his owner.

Shortening the interval with which GPS data was captured or increasing the range of information captured might have implications not only for battery life, but also for the animal's safety. Generally, participants expressed a wish to know more precisely where their animal is, but some were concerned that their cat might be abducted. While capturing more data would be convenient for the legitimate owner, in the wrong hands such data might be used to easily track and poach cats. In this regard, encrypting [17] or obscuring [5] the data would of course be essential.

Conclusion

The qualitative study presented here explored how the data captured by a GPS device used with cats could be visualised for the cats' owners, to identify the most important requirements. Participants in the study were mostly motivated by concern for their cats' safety and by curiosity for their behavior patterns. They expected to receive notifications about the whereabouts of their cats and wished to be able to make inferences about the possible well being of their cat. They also wishes to manage their cats' movements by setting up safe and dangerous zones, and receiving notifications when a cat entered or exited either of these. Furthermore, participants wised to have the ability to request the live location of their cat for variable durations. To our knowledge, no work has so far investigated the GPS data visualisation requirements of cat owners. Our findings reveal that cat owners would like to benefit from functionalities that are not currently offered by existing products. The research presented here contributes knowledge that could help inform future, larger-scale studies on this topic to verify, revise or extend the requirements identified so far. Additionally, this work suggests a need to investigate novel designs and functionalities, such as the automation of individually tailore notifications, to improve GPS technology for cat owners and for the animals in their care.

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