Michelle Ho P section Literature Review

The Problem Being Addressed

Everyday Life: Losing Pets

Evidence suggests that pets have been loyal companions to humans for at least 16,000 years. (Ault, 2016). Today, Americans own approximately 89.7 million dogs in a total of 60.2 million households, 94.2 million cats in a total of 47.1 million households, and 20.3 million birds in a total of 7.9 million households (APPA, 2017). In a survey conducted by the ASPCA (American Society for the Prevention of Cruelty to Animals), 15 percent of pet owners reported a missing pet in the last five years. Approximately 93 percent of dogs and 75 percent of cats reported missing were found, but only 15 percent of them were found because of microchip tracking technology or identification tags (Moore, 2012). Most people consider their pets to be a valued member of the family. Pet owners increase their chances of finding their beloved furry friend with the use of current technology. However, existing pet-finding devices can be improved to increase the likelihood of finding lost pets.

Losing Pets during Natural Disasters

In the event of a natural disaster, pet owners can be forced to evacuate quickly, and leave their pets behind. Recently, Hurricane Harvey struck Texas, forcing emergency evacuations. Pets were left behind, and some were trapped in flood waters. Many lacked tracking devices like microchips, making them difficult to locate. Rescuers used a combination of two mobile applications to find the pets. One app was called Zello, which served as a walkie talkie between rescuers and owners, and the other was Google Maps, which helped rescuers locate the pets' reported locations (Thompson, 2017). Although this system worked, it was inefficient, and could have been improved.

Existing Tracking Technology

The emergence of human and pet tracking technology has increased within the last decade. Examples of track and trace technology available today include mobile applications and websites that use global positioning system (GPS), implanted chips, and geofencing. Many consumers are still dissatisfied with the existing technology (Von Watzdorf, 2010).

Tracking Technology with Human Studies

Before GPS was used to track pets, it was used on human subjects for a variety of field studies. However, today GPS can be used by the general public to determine a user's location, give directions, and track a user's movement. For example, the state of Wisconsin tracked sex offenders with GPS sensors to determine if they had violated their restraining orders. However, GPS often sent the police false alerts, sending law abiding ex-convicts back to jail. The system would also fail to track offenders in areas with poor weather, large buildings, and tall vegetation. Additionally, the program was incredibly expensive for its substandard performance. The state officials were displeased with this tracking technology (Hall, 2013). GPS was also used in a pedestrian tracking study which sought to use pedestrian walking patterns to determine the best layout for traffic reduction in a new city. The main reason that the researchers used GPS technology was because GPS is effective in determining orientation, collecting navigational data, and communicating that data back to the researchers. However, some of the collected data was inaccurate because the device was misused by the participant or lost signal during testing. That data was filtered out, and the remaining data was used to construct maps of traffic flows (Von Watzdorf, 2010).

Another form of location tracking technology, geofencing, uses the Global Navigation Satellite System (GNSS) to set virtual boundaries where the user pleases. When a device leaves its boundaries, a notification is sent to an app or website in order to alert the user. The same event occurs when the device reenters its boundaries, and when the device moves within the boundary. The device typically has a GNSS chip; the satellites track the position of the chip. However, geofencing has its flaws. A quality chip can be incredibly expensive. Its battery life decreases greatly when in use, and, since the satellites are in space, its notification relay time can incorrectly report the device's position and speed. Geofencing technology must be tested thoroughly to ensure its accuracy before it can be integrated into an app (Fattepur, 2016).

Tracking Technology in Pet Studies

As human tracking technology has improved, marketers have expanded the technology for use with pets. GPS collars and microchip implementation have become increasingly but, they still have some flaws. A patent from 2004 described a collar for dogs which had a GPS device that sent latitude and longitude coordinates back to the owner's remote control. The collar also had a movable video camera so that the owner could see where the pet had gone, and a recording device that could play a recorded message to the person that found the pet. However, the device provides no way for the owner to contact the finder, depends on the user's knowledge of the landscape, and has a low battery life (Edwards, 2004).

Table 1: Comparison of existing pet tracking technology*

Criteria	Home Again Micro Chip	Loc8tor Pet Finder	Tractive GPS Pet Tracker	POD 2	Pixie	Tile	Gibi	Nuzzle	Garmin Astro Radio Tracker
Tracks a pet accurately in real time	No	No	Yes	Yes	No	No	Yes	Yes (can be wrong)	Yes
Alerts others in the area of lost pet	No	No	No	No	No	No	No	No	No
Allows others to tell owner when pet is found	Yes	No	No	No	No	No	No	No	No
Battery Life	N/A	Good 10+ days	Bad 2-5 days	Bad 6 days	Good 12+ month	Good 1 year	Bad 1 day	Bad 8 hrs	Good 10+ days
Lag time	N/A	High	Low (2-3 s)	Low	High	Low	Low	Low	Low (2.5 s)
Shows a map	No	No	Yes	Yes	No	Yes	Yes	No	Yes
Uses mobile application	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No
Can be used without GPS	Yes	No	No	No	No	No	No	No	No
Size (dimensions in mm)	12 x 2 x 2	30.5 x 19.5 x 8.5	50.8 x 40.64 x 15.24	22.9 x 50.8 x 0.5	76.2 x 114.3 x 45.72	33 x 33 x 5.1	76.2 x 203.2x 152.4	15.2 x 101.6 x 22.9	160 x 35.56 x 61.0
(g)	0.029	5	35	27.2	113.4	5.7	226.8	144.6	272.2
Cost	$20/ year	$89.95	$120.28 + $5/ month	$198.5	$30	$20	$130	$190	$650
Data is user friendly	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
For different kinds of pets	Dogs	All	Cats and dogs	All	All	All	All	Dogs	Dogs
Tracking range	N/A	120 m	Where cell service is	Where cell service is	45.7 m	100 m	Where cell service is	Where cell service is	14484 m
Shows user current location	No	No	No	No	No	No	No	No	Yes
User can enter location	No	No	No	No	No	No	No	No	No
Friendly user interface	N/A	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes

****information collected from Amazon.com***

Table 1 compares nine of the top existing pet tracking technologies with twenty different criteria that customers would like to see in pet tracking technology. The devices were selected using a general internet search that provided a list of the best ranked pet tracking technologies on the market. People had ranked them the most helpful devices in 2017 for finding their lost pets. Then, a search was conducted to determine if the device was still on the market and whether customer reviews were available. This reduced the list from thirteen devices to nine. The criteria were chosen based on a study that found what people wanted in a pet tracking device. The data was collected by looking at the product summaries for each device and reading both positive and negative customer reviews. Based on the chart, it is evident that generally the devices are expensive; seven cost more than $100. The devices can also be large; four have a dimension greater than 100 mm. The devices also cannot alert others in the area of a lost pet, and have small tracking ranges. Customers were generally dissatisfied with the difficult installation process, the lag time from when the owner refreshes the device location to when the owner receives the device location, the short battery life, the long charging process, and the excessive use of cellular data (Amazon, 2017).

The devices presented in the table are a sample of the various types of tracking devices available on the consumer market. General small tracking devices can be helpful to track material items like keys, phones, or wallets. However, the alert radius for such devices is restrained, which can be unhelpful if a pet travels far from home (Perez, 2015). Microchips are inserted into a pet through an injection, so no batteries are required. Still, microchips cannot track a pet in real time and only become useful to the owner if their pet is found by another person. GPS collars are commonly used to track pets in real time, but their drawbacks include expense, occasional location inaccuracy, and low battery life (Why, 2015).

Additionally, a study conducted on existing pet tracking technology determined that marketers struggle to make pet trackers that are of a reasonable weight, are precise and accurate, and have a prolonged battery life. The study aimed to determine what the current issues with pet tracking technology are and identify the most important aspects of an optimal solution to. After deciding on two devices to test, the researchers surveyed human participants to identify the qualities best executed by the devices. According to the surveys, fast charging, long battery life, a small weight/size, water resistance, accurate localization, trace functions, chase functions, tracking duration, and connection to a mobile app were the most important features for an optimal pet tracker to have. An organized display, buttons and web access were nice add-ons and an alarm function and SMS messaging alerts were unnecessary features. Although the study determined what features would be included in an optimal solution, researchers did not design or manufacture an optimal solution (Von Watzdorf, 2010).

Programming a Solution

With the rise in mobile technology, marketers have expanded device usage to be compatible with smartphones because of their availability and easy functionality. Many tracking devices display data to a user using a mobile application (Von Watzdorf, 2010).

Android Studio

One mobile application platform used by app developers is Android Studio. Approximately 650,000 mobile applications are available on the Android market out of the over 1 million in existence (Joorabchi, 2013). Apps made with this platform can be run on devices with the Android operating system, which make up 45% of the smartphone market. Android Studio is incredibly user friendly and offers many features to help code an app such as a user interface creator, a better memory monitor, sample code for beginners to manipulate, a debugger, and a built-in translator. It utilizes Google SDKs (software development kits) and developers write code with xml and java. A developer can install emulators for various Android devices to test the app within Android Studio or the code can be downloaded to a physical Android device. With Android Studio, it is possible to integrate Google Maps and user to user communication, features essential to a pet locator application (How to Developers Android, 2015).

Map Integration

One of Android Studio's built in features is an activity for Google Maps. Google Maps is available in the Google play services SDK which must be installed. This activity has several functions for developers to integrate into their apps. Examples of these functions include allowing users to enter specific addresses and displaying them on a map or identifying their current location on a map. Several basic features are required for this activity to function in an app: a user interface to allow user interaction, buttons to trigger events, a database to store user data, and labels to display text onscreen (How to Developers: Using Google, 2016). When the developer tests the activity on a device or emulator, they can view a map of a specified location and nearby roads and landmarks (Maps, 2017).

Firebase

Android Studio is compatible with another mobile platform called Firebase. Linking a mobile application project to Firebase provides the app with more functionality. For instance, Firebase offers a real-time database for developers to integrate into their apps. The database stores user data and allows the user, and others with permission, to access that data with a login. Users can store images and audio files in the database as well. The developer can put restrictions on how that data is released. Firebase also can integrate user to user communication in an application. This platform can also provide the developer with tools to measure the app's performance. Firebase includes a test lab to run the app on many Android devices, a crash report SDK, performance SDK. All provide insight into the latencies that users experience when running the app (Developers: Let's, 2017).

Testing

Quality testing must occur before app developers can release a product to the market. The app must satisfy customers by performing the desired task accurately and efficiently. How performance is quantified varies for every unique app. Developers generally outline the goals for their app then determine metrics to measure whether those goals were met by the app. For instance, certain apps need to connect to networks quickly to run, accurately track location with GPS, or use a portion of the device's battery. Goals for these metrics would be set and tested. Developers also survey the target demographic to acquire feedback on the target's general expectations for a particular app (AppInsight, 2012). Common app metrics used by developers include versatility across multiple devices and operating systems, quick app launch and load times, minimum lag times, alert range accuracy, low battery usage, and usability, including low crash and virus instances (Joorabchi, 2013).

Typically, developers have multiple means of testing these metrics. For example, to improve user experience, the app can simply be run through a crash report and debugger to identify and target errors. The app is also run on multiple devices of varying screen sizes and operating systems. Firebase provides services with a crash report and multiple device testing (Let's, 2017). Apps can also be run on emulators, which are virtual versions of the targeted device, to see if the app works on a simple device. For the full functionality experience, developers will allow the targeted demographic to test their app and gain feedback on its strengths and weaknesses (Joorabchi, 2013).

Mobile App Performance Metrics

It can be difficult for developers to determine app performance metrics because each app has unique goals and functions. In a study conducted in 2012, a group of app developers documented how they determined their performance metrics. They identified the possible issues future customers could face from their mobile applications. Examples of problems included network connectivity problems, variances in smart phone hard ware and GPS instruments, and changes in API behavior due to battery charge and platform changes. According to the study, although there are existing support tools such as analytics frameworks, which collect data on usage, and crash reports available, these tools did not help developers trace app performance once the app was released on the market. Developers targeted their main concerns with a unique system designed to measure their specific predetermined metrics (AppInsight, 2012).

One example of these app performance metric principles in action is a study conducted in 2013 that described a mobile application which recommended apps to users based recent app usage. To determine the algorithm's effectiveness, developers needed a measurable metric. They found it necessary to test the algorithm several times and record the probability that the recommended app and the user's preferred app would be used in the same situation. Not only did they record numerical values, they judged the algorithm's accuracy to match similar apps through logic and reasoning by qualitative observations (Wang, 2013).

According to research done in 2013, some of the main challenges for app developers include a need for more effective analysis tools to determine their app metrics. Current popular methods include distributing surveys to potential users, beta testing to monitor performance, security testing to monitor the protection of user data, and emulator testing to try the app on a virtual device (Joorabchi, 2013).

Works Cited

Ault, A. (2016, September 28). Ask Smithsonian: When Did People Start Keeping Pets? Retrieved from https://www.smithsonianmag.com/smithsonian-institution/ask-smithsonian-when-did-people-start-keeping-pets-180960616/

APPA: Pet Industry Market Size & Ownership Statistics (2017). Retrieved from http://www.americanpetproducts.org/press_industrytrends.asp

Developers - Let's Try: Power Your Mobile Applications with Firebase (2017, Aug 1). *Open Source FOR you.* Retrieved from libraries.state.ma. us/login?gwurl=http://go.gale group.com/ps/i.do?p=ITOF&sw=w&u=mlin_c_worpoly&id=GALE|A499749668&v=2.1&it=r&sid=summon&password=boushuperionos&ugroup=outside

Edwards, M. (2004). US Patent No. US6720879B2.Washington DC: Google Patents.

Fattepur, M. B., S, S. G., & Huttangoudar, J. B. (2016, June 16). A Solution to Improve the Performance of Geofence Enabled GNSS Chipset. Retrieved September 18, 2017, from http://ieeexplore.ieee.org.ezproxy.wpi.edu/stamp/stamp.jsp?arnumber=7779405

Hall, D. J. (2013). *Lawmakers raise questions about GPS tracking program for sex offenders.* Retrieved from https://search-proquest- com.ezproxy.wpi.edu/docview/1323894851/abstract/628A2BB BBE36421BPQ/1?accountid=29120

How to Developers: Android Studio: A Platform for Android Development. (2015, Oct 1). *Open Source FOR You.* 1 Oct. 2015. Retrieved from libraries.state.ma.us/login?gwurl=http://go.galegroup. com/ps/i.do?p=ITOF&sw=w&u=mlin_c_worpoly&v=2.1&id=GALE%7CA430814302&it=r&asid=be6d232c7ef2f97d127c7d19f056dfd0. Accessed 8 Oct. 2017.

How to Developers: Using Google Maps in App Inventor 2. (2016, May 1). *Open Source FOR You.* Retrieved from http://libraries.state.ma.us/Login?gwurl=http://go.galegroup.com/ps/i.do

Joorabchi, M. E., Mesbah, A., & Krutchten, P. (2013, October 10-11). Real Challenges in Mobile App Development. 15-24. Retrieved from DOI: 10.1109/ESEM.2013.9.

Lau, A., Tabay, O., Yuen, I. & Tarle, M. (2005). US Patent No. US20050108692A1.Washington DC: Google Patents.

Maps Android API. (2017, July 12). Google Map APIs. Retrieved from https://developers.google.com/maps/documentation/android-api/start

Moore, A (2012, July 11). Lost Pet Statistics: Survey Looks At Likelihood Of Finding A Missing Dog Or Cat Retrieved from https://www.huffingtonpost.com/2012/07/11/lost-pet-statistics-survey-dog-cat_n_1662860.html

Perez, S. (2015). *Lost-Item Tracker Tile Rolls Out a New Renewal Service Offering Early Adopters Discounted Replacements.* Retrieved from https://techcrunch.com/2015/07/22/lost-item-tracker-tile-rolls-out-a-renewal-service/

Ravindranath, L. et al. (2012, October 8). AppInsight: Mobile App Performance Monitoring in the Wild. 108-120. Retrieved from DOI: 10.1145/347057.347416

Spek, S. V., VanSchaick, J., Bois, P. D., & Haan, R. D. (2014). Sensing Human Activity: GPS Tracking. MDPI AG, 9(4), 3033-3055. Retrieved from DOI: 10.3390/s90403033

Thompson, J. (2017, September 1). Beverly Woman Uses App to Help Animal Rescuers in Texas. Retrieved from http://whdh.com/news/beverly-woman-uses-app-to-help-animal-rescuers-in-texas/

Von Watzdorf, S., & Michahelles, F. (2010, June 7-9). Improving the Design of Track and *Trace Products: Evidence from a Field Study on Pet Tracking Devices. 2010 IEEE International Conference on Sensor Networks, Ubiquitous, and Trustworthy Computing.* 177-180. Retrieved from http://ieeexplore.ieee.org.ezproxy.wpi.edu/document/5504688/

Wang, F., Zhang, Z., & Sun, H. (2013, November 7-10). A Cooperation Based Metric for Mobile Applications Recommendation. 13-16. Retrieved from DOI: 10.1109/WI-IAT.2013.142