PetSense: Computer Animal Interaction

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ABSTRACT
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INTRODUCTION
Dogs are social animals that enjoy company and dislike being alone (Hare & Tomasello, 2005). The need of companionship can cause them stress when they are left alone. The fluctuation result of Cortisol levels from of lack of companionship and activity in their surrounding can contribute to behavioral problems (Landsberg, Hunthausen, and Ackerman, 2012). As such, the misbehavior patterns include chewing on furniture, relieving itself in the house, excessive barking, scratching at walls or doors, attempting to escape, and other destructive behaviors (Schwartz, 2003) (Figure 1). A certain of studies owe these misbehaviors to separation anxiety (Mcgrave, 1991; Flannigan & Dodman, 2001). However, anxiety is a serious disorder and most dogs don't have any anxiety when left home (Karagiannis, Burman, and Mills, 2015). They are either under-stimulated or burn their surplus energy by wrecking the furniture which means that they are just having fun and don't know that it is wrong to destroy human possessions spending their stress-free time home alone (Palestrini, Minero, Cannas, Rossi, and Frank, 2010).

Figure 1. Example photo of Dog Misbehavior; sofa and pillows are torn apart.

Many people desire to prevent their dogs from destroying their houses when they are left at home (Seksel, 2008). For example, dogs might be crated, sent to pet care, or taken care by dog baby-sitters. Some would try to teach their dogs polite house manners such as having the dogs been trained by experts to help them keep calm and get used at home alone (2008). Given these scenarios, we have seen owners' need on monitoring or training their dogs' behavior by third person or simply separate them from house property.

However, for either owners or their dogs, above-mentioned approaches are not ideal at all. For dogs, even if they are in crate, they will still bark or whine a lot (Protopopova, Kisten, and Wynne, 2016). Their "bad behavior" just comes from worrying whether they are abandoned when their owners are not at present [and in the crate] (Tuber, Hennessy, Sanders, and Miller, 1996). In other words, they are not doing bad intentionally but due to the fact that they are suffering from lacking connection with their owners. For owners, sending dogs to training center or pet day care are costly (Nast, 2006).

Several researchers proposed technical solutions such as video chat (Golbeck & Neustaedter, 2012), web based interface (Hu, Silver, and Trudel, 2007), and wearable technology (Lee et al., 2006) targeting remote connections with dogs when they are home alone. However, most of these technologies require either high level of time for input by their owners or dogs' adaptation to technology. In this paper, we are trying to investigate the potential of sense technology to enable owners to 1) monitor their dog's' performance when they are home alone, 2) correct their bad behavior in a timely manner to reduce property damage and minimal troubles, and 3) support remote communication and interaction between owners and dogs when it is necessary. All three aspects of our investigation relate to features we include in PetSense set our work apart from existing technology on the market.

In the remainder of this paper, we present our hypothesis and research questions. Then we explore potential usage of sense technology to serve our goal via designing a prototype and have it evaluated by 15 survey responses and four participants to explore to what extend our system meet their needs.

Significance and Broader Impact

There is little research that has been done that explores the potential in the interactions between dogs and technology. Currently, research has yet to fully explore how dogs can interact with a piece of technology. Our research can add to the existing research on these interactions and will be able to inform future research on this topic. Based on conducted research, there does not seem to be system or product that can track dog movement and provides dog owners the ability to correct dog behavior remotely. We attempted to create a system that can do just that and potentially improve dog behavior for the better. The remote option can meet the demands of our mobile first evolving society. By combining dual optic sensors, voice command and video monitoring capability through a smart system, PetSense covers many aspects that existing technologies cannot do by themselves.

The emotional welfare of dogs can be heavily impacted at a chemical level, specifically that of Cortisol, based on the environments that the dog is in. We envision our system being successful especially with special needs dogs, dogs who suffer from anxiety, dogs who require consistent attention and dogs that are having trouble reacting to a new environment.

During user on-boarding of PetSense where an owner selects a breed, potential behavior tendencies that the dog may exhibit can be noted beforehand for the system to recognize. Height and weight variations were specifically highlighted, in addition to facial features. For example, certain breeds in the "lap dog" category have craniofacial features that elongate their viewing plain, allowing them to have a greater sense of central vision. These dogs can detect awareness much easier, and because of this behavior, these dogs can be classified as ones who are more engaged with their owners (Stone, McGreevy, Starling, and Forkman, 2016). Learning behaviors to make our system aware is very important to its overall success. Knowing what a pet could be thinking of feeling based on its expression is very important in pet technology. Our sensor can measure height and overall physical profile, and have responses loaded for specific predictive behavior a dog breed may have to train and interact with the dog on a greater level. Physical expression is a direct link to behavior, and one must be able to measure it in the most accurate way possible. Split optic technology provides us that accuracy and can be utilized in many rooms, unlike the BARK software which is typically used in a one room setting (Barnard, 2016). This split optic sensor could be placed in multiple rooms and communicate with the system to give the pet owner the most well rounded and accurate interpretation of what is happening with their pet as possible (2016).

Dogs react significantly better to praise, positive vocal repetition, treats, and playtime. Our system supports all of these tactics over negative punishment which can hinder the relationship with the dog and its owner. This research reflects the positive effect of our work's use of vocal commands to coach the dog through the sensor system. In addition, less time spent on punishment allows the owner to have more quality time with their pet. Pets learn through repetition, and positive repetition will not only invoke a positive internal response, but accelerate the opportunity for newly learned behavior. Special needs pets and pets who suffer from anxiety can especially benefit from this type of a system because of its positive reinforcement capabilities.

The PetSense System will ultimately be receptive to a large market, as its mobile check in, monitoring and voice command capabilities are very attractive to owners who are not in their homes for long periods of time whether it be for work, school, a busy schedule, etc. This system could also be very useful for owners who will be away for extended periods of time but do not have family or friends nearby that can check in on the pet. No current technology utilizes all of our described concepts in such a customizable manner. The PetSense System allows for the user to easily

monitor a video feed from a mobile device or send a pre-recorded command as needed so the owner does not have to go home to do so. The Pet Sensor System can give positive vocal feedback following obedience, or even go to the level of dispensing a treat for the dog. Ultimately we envision this technology to be time and cost effective, and accessible to anyone with a smartphone.

LITERATURE REVIEW

Pets have a very sharp and sensitive memory (Cambridge, n.d.). In early days, dogs have been used to drive livestock since the Neolithic times, the circuses of early Rome featured trained lions, elephants and chariot horses, homing pigeons were used as early as 2350 BC in Mesopotamia, and the Vikings were training horses in the 9th century. Animals do respond to distant voice command as there were no specific techniques in past ages, but people might have shouted out loud those commands. There are several areas that the authors have looked into in order to understand the current trends in how computer technologies are incorporated with animals and their human owner.

Previous Technology for Animals

Digital technology has slowly been integrated in the interactions between humans and animals (Weilenmann & Juhlin, 2011). But we have yet to really understand the experience in these types of interactions and what are the things we can make to support this interaction further. Researchers had hunters use GPS technology with their dogs to study how technology changes relationship. The hunters had a better understanding of what the dog was doing and the interpretation of their dog.

Another paper shows different technologies trying to train animals and the emotional relation between them (Lockwood, 2004). Each dog is a different animal when it comes to nature and its temper. Thus there has to be variability in technology along those different natures. Now a days there is a certain way of training a dog which can be performed by humans alone. Technology can't do dynamic training concepts.

Research shows that even some 3D visual technology has scratched the surface in this area, such as the BARK software, but its algorithm lacks many crucial factors about the pet's environment, and only focuses on the clumping of body postures in conjunction with time to determine action (Barnard et al., 2016). Determining how to train a dog cannot simply focus on one variable, as an animal is impacted by multiple factors. The creators of the BARK software believe that they created a revolutionary product, but they failed to consider an entire home versus one room, temperature, voice recognition, and response to behavior (Barnard et al., 2016).

WagTag is an accessory that can be attached to a dog collar to track a dog's activities and the intensity of these activities (Weiss, Nathan, Kropp, and Lockhart, 2013). The activity information is visually displayed on the device, while more detailed information can be uploaded to a computer via a Bluetooth connection. Applications associated with this devices can help assess whether dogs are sufficiently active to ensure proper health, and have the potential to promote changes in behavior and a more active lifestyle. This device will track a dog's activity levels and let the dog owner know whether the dog is sufficiently active. The device uses a tri-axial accelerometer to monitor the motion (i.e., the acceleration) of the dog, and the accelerometer data are fed into an activity-level recognition model that executes on the device (2013).

Dog misbehavior can be attributed as to why some owners give up ownership of their dog. Dog behavior is difficult to track, observe, and is often a debatable topic. However, it is possible to identify some forms of behavior. Various traits and activities can be linked to the wellbeing of a dog (Hammerla et al., 2013). We have yet to fully understand the complexities of dog behavior. Researchers have gone far as even using the dog's heartbeat as ways to show an emotion of a dog (Kyu, Moon, and Park, 2016). A main attribute that many owners express is to better understand their dog and their needs, so that they can make the ideal accommodations for their dog. Various studies have studied the possibilities in doing so. A possible area of research is to consider how technology might influence the relationship between the dog and the dog owner. We do not fully realize the types of interactions that technology can have on the relationship between an owner and their dog. Technology has the potential to provide context, and enough information to better understand and interpret their dog's actions (Weilenmann & Juhlin, 2011). Dogs and pets need constant commanding system built around them as they are very prone to diverting their mind to their comfort zone. So in this paper they have made a backpack for dog full of clickers, wifi trackers, vibrational motors to alert dogs if they are doing right or wrong (Bozkurt et al., 2014).

Our research can a provide a solution into helping owners keep better track of their dog and issue commands when they are away with the use of technology. While our intention is to provide owners with means to train their dog, we think that our research can be beneficial to researchers in the area of technology integration between owners and pets.

Canine Behaviors

Dog behavior can manifest itself in a variety of negative ways, including aggression (Byrd, 2012). Obedience tests in the study of pet technology reflect that dogs can exhibit significant anxiety as a reaction to stimuli in their environment. Research showcases that dog breeds can have specific reactions or display emotions to certain stimuli (Stone, McGreevy, Starling, and Forkman, 2016). In the pet

training community, punishment is actually indicative of continuing behavior problems (Hiby, Rooney, & Bradshaw, 2004). Multiple methods can be utilized to train obedience in a dog, but it has been shown that negative feedback, punishment and the lack of vocal commands hinder a dog's progression. Considering existing research, we plan to observe and categorize dog responses based on facial expression and/or physical reaction as: 1) the dog acknowledged the command but did not obey, 2) the dog acknowledged the command and obeyed the command, and 3) the dog did not acknowledge the command and did did not obey the command. We will measure the amount of time between an issued command and the reaction (if there is one). Regardless of reaction, we will measure the amount of commands given over time and the amount of time between repetitive commands.

Ethical concerns can rise in dog training as problematic behaviors can compromise welfare substantially (Hiby, Rooney, & Bradshaw, 2004). The greater significance of that is that is that the dog could end up in a kennel if it cannot reduce its bad behavior to a level where the owner can tolerate it. This ultimately can affect the dog's mental stability and increase anxiety (Askew, n.d.). Special needs pets and pets who suffer from anxiety can especially benefit from this type of a system because of its positive reinforcement capabilities. In addition, less time spent on punishment allows the owner to have more quality time with their pet. Pets learn through repetition, and positive repetition will not only invoke a positive internal response, but accelerate the opportunity for newly learned behavior.

Affenzeller et al. have found that "The results show that engaging in playful activity for 30 min after successfully learning the task improved retraining performance" (2017). So, adding some kind of game and reward just over voice can help improve dogs with improving their memory and behavior might take the correct path.

BACKGROUND AND RELATED WORKS

Welfare of Animals

Dogs are one of the most owned types of pets in the United States. It is estimated that there are 70-80 million dogs owned in the U.S. It is also estimated that 37-47% of households in the United States have a dog. In addition, behavioral issues of dogs take up 10% of the reasons why owners give away their dogs (ASPCA, 2017). The research conducted has the potential to affect millions of dogs and dog owners. In the U.S. alone, there are an estimated 75 million owned, pet dogs, both purebred and mixed breed (Fugazza & Miklósi, 2014). These animals are but a fraction of the stray, free-ranging, and owned dogs worldwide. The ubiquity, and, to a great degree, the success of this species at living with and among humans makes them a compelling subject.

A dog's internal Cortisol levels have been studied based on a dog's location - specifically in kennels. Kennels are often the end of the road for a dog and owner's relationship, and can be absolutely devastating for both the canine and the human. When transitioned into a kennel environment, dog Cortisol levels decreased significantly enough and consistently enough to reflect that stressors such as environment change and lack of companionship can cause the dog's hormonal system to go into a state of anxiety and negative feedback (Protopopova, Kisten, and Wynne, 2016). Due to the restrictive nature of the kennel compared to the comforts or familiarity of home, a dog can go into shock. Keeping dogs in their homes can encourage stabile Cortisol levels, and overall better well being (2016). Pending the state or country's regulations, pets that are not adopted from kennels end up being euthanized. In a study of 12 different animal shelters across the USA, 40% of relinquishing owners cited behavioral problems as one of the reasons for surrendering a dog. When behavior was the only reported reason for relinquishment, aggression was the most frequently cited problem (40% of dogs). Four primary approaches have been used to investigate breed-related variation in aggressive behavior: analyses of dog bite statistics behavior clinic/consultant caseloads the opinions of dog experts and the results of behavioral testing (Duffy, Hsu, and Serpell, 2008).

The majority of dog owners consider dogs as family members. Dogs do more than just make great pets, they also assist humans in other areas such as service animals, for example: dogs assisting the blind, search and rescue for emergency, sniffer dogs that sniff out drugs and explosives, dogs in the military, and police dogs (Hammerla et al., 2013). As stated, the welfare of the dog is of high priority, especially to owners who need these dogs to assist them in arduous tasks. It is crucial for these owners to know that their pet is ok when they are away from their home. Our research can potentially provide a way for owners to keep track of their dog and make the right adjustments for their dog. So, the more information that the owner has, the more likely the owner can proceed in giving positive and correct negative reinforcement.

We would also address that there are ethical concerns we as researchers face when conducting experiments with dogs, and pets in general. Recently there has been an increase in a number of studies involving animals with most of those studies include dogs (Pesonen & Väätäjä, 2013). Ethical research is an important matter, this is especially the case with animals. The welfare of the animal should be kept in mind. It is important to note that there are guidelines when conducting experiments with animals and we as such hope that our research can perhaps reveal useful insight on the topic of conducting ethical animal research with the research community.

Research Questions

Many dog owners believe their dogs know certain behaviors are wrong: for example, chewing the sofa. Owners also report that their dogs show guilty behaviors after performing such a misdeed and that the owner is tipped off to the misdeed before they see what the dog has done purely by the dog's display of this guilty behavior. So essentially what they're saying is the dog knows it's been bad and tell the owner it's been bad by acting guilty. And these behaviors tend to be things like avoiding eye contact, slink away low body posture, putting the tail between the legs. However, the prevailing opinion among animal behavior researchers and canine behaviorists is, dogs don't actually feel guilty. They lack the cognitive sophistication to have a sense of right and wrong and instead do or don't do things based purely on consequences. Therefore, the so called guilty behaviors are actually fear behavior or a conditioned response either to the body language of an angry owner or the evidence of the misdeeds such as, a chewed up couch cushion, which the dog associates with punishment and it's also been suggested that the so called guilty look is actually a learned behavior as it reduces the punishment or avoids the punishment all together. Now there have been only four studies on this so far, and the researchers have not any conclusions about the following research questions:

RQ1: Is it possible to issue voice commands to a dog when the owner is away?
RQ2: Can the dog comprehend the voice command when the owner is not physically with the dog?
RQ3: Will the dog obey the voice command when the owner is not physically with the dog?

Petsense will address the question if whether pets can behave in the same way as the owner expects them to behave when they are not around or remotely present. It's going to depend on many factors like voice commands, detecting size, color and dimensions of the pets, sound and reward/ treat system. Owners have to program the Petsense sensor according to the different temperaments, emotions, manners, liking and disliking in pets. Considering these factors in mind resultant output from sensors may vary from pet to pet. Here we are going to also find out whether owners and human beings can comfortably rely on technology to interact with pets.

Hypotheses

From our research, we think it is not out of question that a dog can interact with a machine. Previous research shows the potential in the interactions that can occur between dogs and technology. Granted, there has yet to be research that is tackling the scope of what our research is trying to accomplish. Where in our case, our prototype will have a bigger role, in which the machine will be the one that tracks and issues orders to the dog. The question is whether the dog will be able register the owner's voice coming from the prototype which we will be testing.

H1: Voice commands can be issued to a dog when the owner is away.
H2: The dog will comprehend the voice command when the owner is not physically with the dog.
H3: The dog will obey the voice command when the owner is not physically with the dog.

Behavior is often learned in repetition. Dog behavior can be sporadic and we realize that not all dogs are the same nor will they act the same in every scenario. We have to consider breed, intelligence, environment in which they were brought up, how long the dog has been in its current environment, health and potential special needs, and its personality. We do think that the prototype has a better chance in succeeding by adding the treat dispensing component to reward dogs for their obedience. This is a form of conditioning that has been done with dogs for centuries. By issuing commands to stop misbehavior and rewarding dogs with treats we suspect dogs will comply and behave accordingly, just as a dog would through training. The challenge will be whether the dog will be compliant with the prototype that is controlled by the dog owner.

Through our research question we plan to focus on all the above problems and come up with a solution in the favor of the pets. We realize the importance of our work, and we aim to reduce euthanization of pets. Our prototype aims to provide mobile options including video feed to the dog owners who are away from home. Also, we strive to have dogs be able to comply to the prototype issuing voice commands to correct misbehavior, in which owners can be happier with their pet, thereby increasing dog welfare. The pets need a loving home and to take that away from them only because they behave in a manner deemed inappropriate by the owner while the owner is away is not just.

Methodology

This experiment required several steps to evaluate canine behavior as well as to better identify the needs and frustrations owners have with their dogs. Initial surveys were conducted to ask the participants to provide us an overview of what the dog owners define as 'bad behaviors' from their dog when they leave their dog alone in the house, as well as whether or not their dog is obedient to their commands when they are present. These surveys also served the purpose of getting a 'baseline' behavior for a dog (i.e., one dog may bark more than another, one dog may chew or destroy furniture more than another) from the dog owners.

Through the surveys we were able to deduce that the owners use voice commands to train and discipline their dogs and we would need to focus on voice commands for our prototype to be useful and effective to improve dog

behavior when the owners are not around. Also, understanding what behaviors the owners dislike allowed us to create prerecorded commands that can be used when the sensor prototype was completed (i.e., "no barking', 'off the furniture', etc.).

Before the observational study, we conducted a small interview of the dog owners and what they expect from the study. We asked the owners to talk about their thoughts and opinions about the prototype and what they thought would happen (i.e., a prediction about how their dog would react to a voice command when the owner is not physically present). Next we conducted an observational study by assigning the participants a set of tasks to test our prototype. During the study we observed the participants' behavior and reactions to our prototype. Finally, after the study we conducted a post interview of the owners. They were interviewed by asking their feedbacks and recommendations for improving future models of PetSense.

Datasets

We collected and analyzed three main sets of data via simple statistics of the mean or average response:

D1: Quantitative data collected through the pre-observation survey.
D2: The number of times the prototype detected the dog's behavior.
D3: The number of times the dog obeyed the prototype.

Participants

We chose dogs as our participants because they are the most common pet in and outside of America. Also, they are easier to train and they need to be disciplined since undisciplined dogs receive a lot of injustice from their owners.

Participants undergoing this experiment were various breeds and kinds of dogs. All dogs (in the Indianapolis area) were welcome to join for this experiment. There were not any set boundaries on a 'certain type' of dog (i.e., breed, color of fur, gender, stray, etc.) Participants were recruited via: paper flyers, email flyers, Facebook invites, and registered Indianapolis dog parks. There was no compensation given for the dogs who participated.

Dogs, like children, cannot give consent to be a part of a study, so consent was received from the dog's owners. Therefore, we conducted the surveys and interviews of the owners and not the participants.

Experimental Procedure

Research methods for this paper included survey, field study and interview which were conducted in different phases of the study. Before prototyping, an online survey was distributed on social media sites such as Facebook, Twitter, Reddit and pet dog related forums to explore respective rates and severities of different types of misbehaviors of dogs when they were left home alone. Additionally, the survey had dog owners defined what kind of misbehaviors should be corrected when they were not home with their dogs. According to the findings from survey, the authors identified that behaviors of barking at other dogs/animals/humans, as well as having separation anxiety were the most frustrating misbehavior which needed immediate remote correction and could be assisted by PetSense (Table 3).

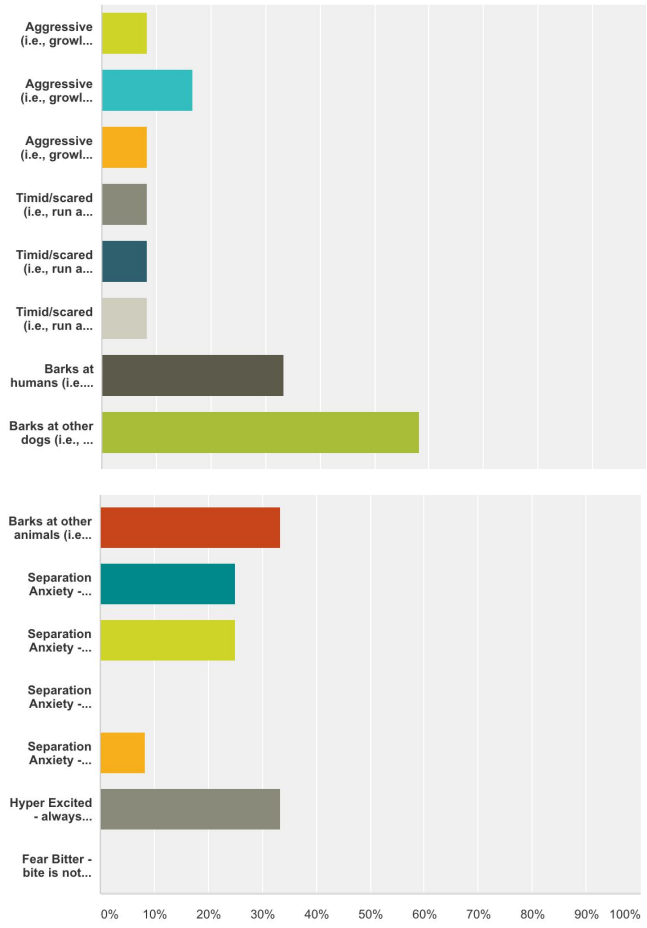

Table 3. The survey responses to the question "Does your dog have any of the following behaviors? Please select all that apply." These answers were used to make the list of five commands (said in the voice of the owner and a stranger): 'get off', 'no barking', 'no food', 'NO', and 'good boy/girl'.

The experiment consisted of a kitchen and a living room - the control room(s). The dogs were not able to wander from one control room to the other freely during the experiment for a gate will be blocking the access to other rooms. Please refer to the Appendices for pictures from the study as well as the layout of the control rooms that the dogs were in.

For the first task, the dog was left alone in the control kitchen room for 30 to 45 minutes. A large kitchen trash can (a 30 gallon container) will be left out in the open in the

kitchen. With the sensor, the dog was observed. If it jumps up to get the trashcan or otherwise tries to get into the trash can, the sensor recorded the movement of the dog and be able to detect the dog's behavior. With this information, we relayed the correct pre-recorded response of the owner's voice. In addition to not getting into the trash, the dog should not jump the gate blocking it in the kitchen. If the dog tried to jump the fence, the sensor recorded this and told the dog 'no jumping'. In addition to these verbal commands, the dog will get a treat for good behavior (i.e., not getting in the trash can or jumping over the gate).

For the second task, the dog was left alone in the control living room for 30 - 45 minutes. This control living room had a couch and TV with a wood coffee table in it. With the sensor, the dog was observed. If it tried to chew on the couch cushions, leg of the wooden coffee table, or jump at the window, the sensor recorded the movement of the dog and detected the dog's behavior. With this information, the sensor relayed the correct response (i.e., 'no chewing' or 'leave it'). These responses were pre-recorded with the owner's voice. In addition to not getting into the trash, the dog should not jump the gate blocking it in the living room. If the dog tried to jump the fence, the sensor recorded this and told the dog 'no jumping'. In addition to these verbal commands, the dog will get a treat for good behavior (i.e., not chewing on furniture or jumping over the gate).

Results

From the pre-observational study survey, there was a total of 15 participants; 12 of which were female dog owners and 3 male dog owners. Nine owners were 25 - 34 years old, two owners were 18 - 24 years old, and four owners were 45 - 54 years old. Twelve owners had one dog, and three owners had two dogs. No owners had more than two dogs.

Referring to the survey alone, the participants were confident that the dog would listen to their commands if the owner was present, but when asked if the dog would listen to commands if the owner was not present, the numbers were more spread out over the normal distribution curve. Thus, the survey responses alone were inconclusive about whether or not is it possible to issue voice commands to a dog when the owner is away (RQ1).

However, according to the study observations, it is possible to issue voice commands to a dog when the owner is away. The voice commands consisted of five simple phrases that were gathered from the data in the survey (as shown in Table 3):

(1) Get off
(2) No Barking
(3) No food
(4) NO
(5) Good boy/girl!

These phrases were spoken in both the owner's recorded voice and in a stranger's (one of the researcher's) voice.

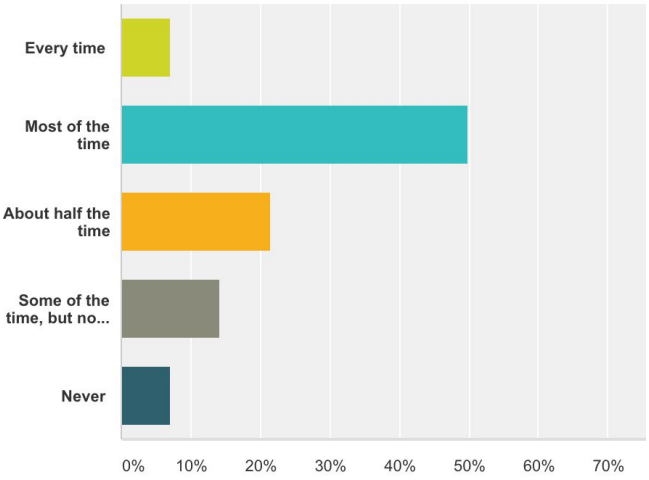

Table 1. The survey response distribution to the question: "When your dog is left with someone else, how often does it listen to other people's commands? (i.e., a dog walker, a dog sitter, etc.?)"

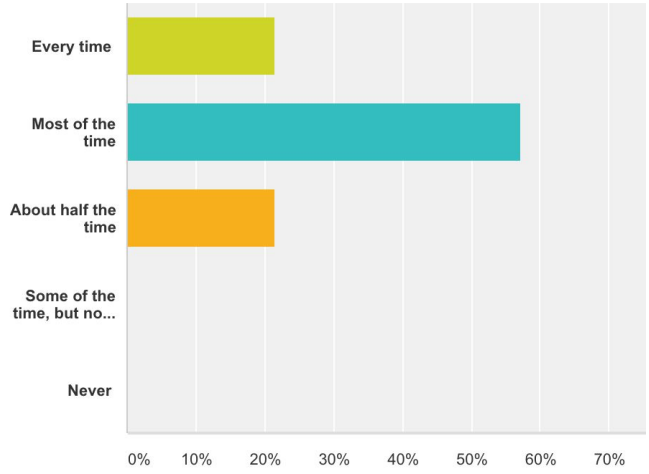

Table 2. The survey response distribution to the question: "When you are home, how often does your dog listen to your [verbal] commands?"

With respect to the other two research questions, the observational study shows support that dogs can comprehend the voice command when the owner is not physically with the dog. According to our study, all voice commands issued were obeyed by the dog. Some dogs were confused as to where the voice was coming from, but after a mean of 1.5 seconds, they listened to the command when it was made in the owner's voice. The study also shows that the dog will obey the voice command when the voice is not the owner's (i.e., a stranger's voice). All dogs listened to a stranger's voice when it was issued, understood the

command, and obeyed the command.

Discussion

Most bad dog behavior occurs when the owner is not around. From our results, we learned that dogs do respond to voice commands. Our initial hypotheses of whether or not a dog will listen and obey a voice command from the prototype a was supported. During our testing, we tested pre-recorded commands of the owner's voice, and of a stranger's voice that the dogs tested had never heard. Dogs not only listened to their owner's voice, but to a voice from stranger as well. We interchanged the stranger and owner commands at random, so there was no pattern that could be obtained from how often we would administer a command with an owner's voice versus a command with the stranger's voice. We were only able to test 4 dogs, and would have liked to have tested this concept on more dogs to further prove that the owner of the voice does not negatively affect the result of the command on the dog. In future work if we used a computer generated voice similar to Siri, we would like to test this possibility.

Another surprise we encountered is that not all dogs will exhibit bad behavior when they are left by themselves. We tested known temptations in our study. We left out bologna, one of our test dogs beloved human foods, in a very obvious location. We left several pieces of it on the counter, even let her sniff the meat, and ultimately left the package with a few slices still in it out in plain view for her to reach. In the past, this dog has been instructed to not eat food off of the counter. It took several moments for the dog once left alone, to even pay attention to the tempting bologna slices. The dog only tried to get the package after minutes had passed, and listened immediately to the command issued. The bologna remained in place on the counter. We expected the dog to exhibit negative behavior with the temptation, but we were proved wrong.

There are several design recommendations that resulted from this study. Due to time constraints, we utilized the Wizard of Oz technique during testing. We were not actually able to write sufficient code prior to testing to allow the Kinect to work as a sensor. We would advise that in future work there would be ample time for coding allowed. We cannot guarantee that the Kinect would in fact detect every height appropriately and issue an appropriate command. Testing height is essential to this type of work, as proven by the BARK software research (Barnard et al., 2016). However, based on the results of the command being issued and interpreted correctly, we can elicit that the system would work pardoning any technical difficulties. Commands were sent from a Macbook Pro to a surround sound speaker, emulating the a command sent from a mobile phone. Based on our application prototype, we feel that this type of command sent was realistic.

In addition to programming the Kinect, we would also recommend that a treat dispenser be connected into the overall system. Positive behavior reinforcement is effective in dog training (2016). Receiving a reward such as a treat can motivate the dog to continue to obey. Research supports our usage of vocal commands and treats distributed from the system as tactics that may encourage positive behavior stimulation over short and long periods of time, unlike physical punishment. One of the main goals of our system is to ultimately create a better wellbeing for both the dog and the owner, and using certain training aforementioned training tactics can definitely encourage our success rate more than that of punishment (Hiby, Rooney, & Bradshaw, 2004).

We only tested the device in two rooms, the kitchen and the living area, but ideally see this system being used in the entire home. It is not realistic to expect that the dogs will stay in one location at all times even when they are supposed to. One of our test dogs escaped over its blockade gate during testing, scratching the test. If the system spanned the entire home, it could have commanded the dog to go back to its main area it was supposed to be in versus allow the dog to roam the house freely and cause trouble. We also recommend that multiple cameras be placed at multiple angles in each room, or a single camera that can pan a 360 degree view at all times, to ensure that the dog can always be seen by the monitoring system.

We also recommend that the cameras be well hidden. We hid the Kinect in discreet locations, but the camera recording test footage was rather obvious. One of our test dogs realized she was being watched during her testing, and we had to move the tripod and camera to a discreet corner behind a chair where she would not notice it. The more realistic the environment feels, the better chance we can give the dogs to "act natural" in their habitat during test. The dog's environment greatly affects their behavior (Protopopova, Kisten, and Wynne, 2016).

We would also recommend testing over a longer period of time, such as 3 months, to ensure that the system is effective enough to use in the home full time. On a final note, we recommend that dogs that are new to their home environment be tested with this system. All of our test dogs were very comfortable in their home environment as they had all resided in that location for at least a year. Additional research proves that a dog will be affected by how comfortable they are in their environment (Barnard et al., 2016).

Conclusion & Future Work

Based on our findings, dogs do respond to voice commands when a pet owner is physically away from the dog. The owner does not need to be physically present with the dog in order for the dog to listen to a voice command. Voice

commands work when the command is coming from a familiar voice to the dog. However, unfamiliar voices seem to work just as well as familiar voices to issue voice commands based on our discovery. This leads to a possible characteristic to focus on for future studies, on how big of a role voice plays into issuing voice commands. It is an uncertainty on whether dogs cater to a particular voice; future work can address this question. Another viable question is whether or not the dog is just responding to external stimuli and not the actual voice itself - something future work can answer. Overall, the results do show the potential of the prototype being able to issue voice commands, and dogs respond and are able to comprehend a voice command when the owner is physically away.

There are multiple possible revenues to explore for the next phase of the study. The sensor developed lacks the functionality of being able to track pet movement which resulted in the manner of which the study was conducted. With enough time, we presume that the sensor would be able to track various pet movement and behavior. In addition, the accompanying application with the sensor is fairly robust however it can be utilized further by providing the end user of being able to issue commands on the go with a mobile phone. Adding this dimension will likely yield to more tests to determine whether this added functionality is useful for pet owners. Furthermore, a treat dispenser can be added to the sensor to work as a complete system, to reinforce positive behavior with a dog. Of course, further tests would be needed to determine the effective of this new proposed system.

Another area to be addressed is the number of participants gathered for the study. We realize that not all dogs are equal. There are various factors such as the breed of a dog as well as the temperament of a dog. Having more dogs participating in the future could potentially reveal areas need of work that was not present at the time due to a lack of participants. We also want to be sure of the systems effectiveness across as many dogs as possible. To address the system's effectiveness, this study would benefit from being conducted as a longitudinal study. Behavior can be difficult to measure and collect data upon, especially only over the course of a couple of weeks. By conducting the study over the course of a few months, it could reveal not only the effectiveness of our system but also the impact and longevity of our system, such as: will a dog still be compliant to the system and continue listening to voice commands or will the dog lose interest over time?

One more possible factor that could be explored is how well the system would do in tracking multiple dogs at once. It is one case where the system can track a dog within an enclosed area, but the reality is that pet owners may have more than one dog and the dogs may not be within a confined space. Conducting the study over a longer period of time will yield the best results as well as would further attest to the effectiveness of the prototype.

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APPENDICES

The following figures are photos taken of the study control rooms as well as the gate that confined the dog in a certain room (for the purposes of the study). Also shown is one step up for where the camera and sensor were positioned.

Figure 1. The gate used to block the participants in a certain control room.

Figure 2. A picture of the control kitchen room that the participants were in for their session.

Figure 3. A picture of the control living room that the participants were in for their session.

Figure 4. One of the test dogs (pre-escape from the gate) noticing the camera.

Figure 5. Picture of the sensor and where it was located in the living room.

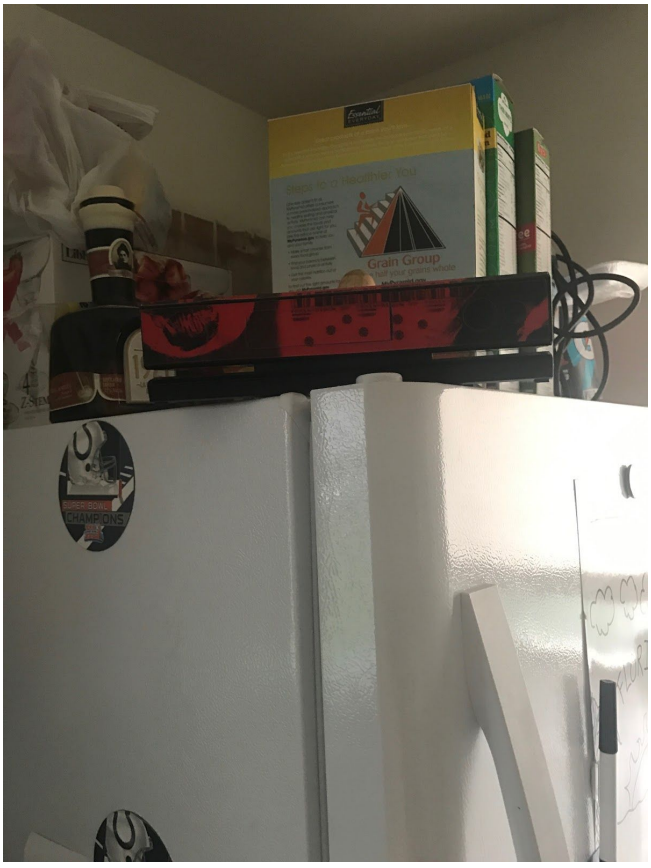

Figure 6. A close up of the Xbox Kinect sensor that served as the PetSense prototype.

Figure 7. The four dogs who participated in the study. As clearly seen from the figure, the breed, gender, weight, and age of the participants were varied for this study. From left to right, the name and some personal information of the dogs are:

Chloe: German Shepherd, Female, 5 years old, 100 lbs.

Sabine: Jack Russell Terrier Mix, Female, 4 years old, 20 lbs.

Rascal: Miniature Doberman Pinscher Mix, Male, 11 months old, 10 lbs.

Apollo: Vizsla, Male, 3 years old, 45 lbs.