Canine Computer Interaction: Towards Designing a Touchscreen Interface for Working Dogs

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ABSTRACT

Touchscreens can provide a way for service dogs to relay emergency information about their handlers from a home or office environment. In this paper, we build on work exploring the ability of canines to interact with touchscreen interfaces. We observe new requirements for training and explain best practices found in training techniques. Learning from previous work, we also begin to test new dog interaction techniques such as lift-off selection and sliding gestural motions. Our goal is to understand the affordances needed to make touchscreen interfaces usable for canines and help the future design of touchscreen interfaces for assistance dogs in the home.

Author Keywords

Animal Computer Interaction; Assistance Dog Interface Design; Touchscreen Interactions

ACM Classification Keywords

H.5.2 [Information interfaces and presentation]: User Interfaces---user-centered design

INTRODUCTION

Figure 1

Jacob has epilepsy. His medical alert dog Dug is trained to sense an oncoming seizure and notify Jacob before it starts [4]. Dug is trained to nudge Jacob to a wall so he does not fall down. Dug is also trained to lick Jacob's face until he

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recovers. Dug, however, is special; he is also trained to interact with a wearable computer on his service vest [8, 9]. When Jacob has a seizure, Dug can activate a capacitive bite sensor on his vest, which notifies health services and Jacob's loved ones of his condition and where to find him.

Figure 2

By summoning help, Dug performs a potentially life-saving service for Jacob. But what if Jacob and Dug are at home and Dug is not wearing his service dog vest? Dog-computer interactions that do not require a vest or other wearables could fill a critical need for people like Jacob.

Because of the ubiquitous nature of touchscreens, we began exploring possibilities and challenges in designing virtual interfaces for dogs [24]. Our initial study demonstrated a proof of concept that a dog can use a touchscreen. In our current study, we start to examine the questions “what is the best way to train a dog to effectively use a touchscreen interface”, and “how do we design an interface best for canine computer interaction”?

RELATED WORK

Animals have been involved in research for a long time, and many research experiments have used machine interfaces to derive knowledge about animal behavior and cognition from animal interactions [5, 19, 20]. Amundin et al. [3] created an echolocation interaction based interface, using echolocation as “touch” the system acts as a type of touchscreen. Amundin's system was built to understand how a dolphin might best interact with a touchscreen, which is close in motivation to our research with canines. Work such as Mankoff's [6] has talked about HCI in the context

of animals describing a “Fitts’ Law” test for dogs using tennis balls. This work starts a conversation about canines using computer interfaces. Other animal computer interaction systems have focused around monitoring pets when the owner/handler is not at home or providing entertainment [7, 10, 12, 22, 23]. Certainly Robinson and Mancini’s work also looks at ways for dogs to interact with devices in the home, although these devices are similarly motivated the interfaces are not centered on touchscreen interactions [17, 18].

DOGS USING TOUCH SCREENS

The new lessons learned presented in this paper build on work completed previously [24] in designing a touchscreen user test for dogs modeled after Soukoreff and MacKenzie’s *multidirectional tapping task* [11, 21]. Potter, Weldon, and Shneiderman describe three main ways interfaces can be designed to accept touch interaction. [14]

Land-on, where the cursor is under the touch, and only the first impact point counts.

First-Contact, where the cursor is under the touch, but the first contact with the target counts even if its not the first impact with the surface.

Take-off, cursor is offset, and selections are made by where the touch lifts off the surface. We do not use a cursor for our dog interactions and we will call this type of interaction *Lift-off*.

The original system used *first-contact* to make tapping target selections. “Each tapping task trial consists of one press on the blue target, zero or more erroneous touches, followed by one touch on the yellow. When the dog makes a correct selection, first hitting the blue target, a lower frequency tone is played to signify to the dog he/she has made the blue selection. After selecting the blue target if the dog selects the yellow target a higher frequency tone is played, and the targets disappear from the screen upon lift off of the successful yellow target touch, signifying that the dog has completed the task. Blue and yellow targets were chosen because a dog can see the difference between yellow and blue.” [24]

We compared the results from humans performing this first-contact tapping task to dogs performing the same task with their noses. Notice in Figure 3 the human taps the screen on the blue then yellow when asked to do so. As seen in Figure 4 dogs trained to perform the same task found it easier to operate the *first-contact* interface by touching the blue and sliding their noses on the screen to the yellow. From observing these interactions we decided to try two new types of interfaces.

New Interfaces

The first new interface tested for this study (Figure 5A) mimicked the original tapping task but uses *lift-off*; in every other way the interaction is the same. The touchscreen produces a tone when the dog lifts his nose off of the screen. We chose to test *lift-off* in an effort to mold the

dogs’ interactions with the touchscreen closer to a humans interactions. If the dog participants were able to use the system with *lift-off* interactions we could closer relate the dogs interactions to what would be expected in a human-based Fitts’ Law tapping task study [11, 21].

The second new interface tested (Figure 5B) was not an effort to eliminate sliding, but instead an exploration of what a sliding or gesture type interface might look like for a canine. This interface was inspired by Accot and Zhai’s description of steering law [1, 2].

Figure 3: An existing example of a recorded human’s interaction with our touchscreen tapping task interface. Green dots are the first successful touch; red dots are the second successful touch [24].

Figure 4: This is an example of a dog interaction on the original *land-on* based tapping task touchscreen interface [24].

Figure 5: A. Screenshot of tapping task interface with *lift-off*. B. Screenshot of sliding task interface.

Unlike the tapping task, the sliding interface activates a constant tone through the duration of the touch. The dog

must touch the blue then enter the white path and follow it to the yellow without lifting off the screen or going outside the drawn path. To allow the dog to understand its progress in the task, the tone is constant while touching and changes from lower frequency on blue, to a higher tone while on the path, back to low on yellow. The tone and visual display disappear upon completion.

Interface Hardware and Software Improvements

We originally created our software in Java, but found that there was an inconsistent delay between touching the screen and hearing a tone. We switched to using Unity3D, a video game engine, because it is designed explicitly for good audio-visual performance. We also developed a testing protocol to ensure that we could get consistent timing in the recorded data. We used a solenoid powered by a function generator to generate one touch every second, and recorded the touch events. We found less than 6 milliseconds of jitter in the timing between 10 consecutive touches. Our new software also includes the ability to adjust the initial height of the interface (in our first study we worked exclusively with medium to large dogs, but we had a greater variety we needed to accommodate for in this iteration) as in Figure 6.

Figure 6: A smaller dog (Basset Hound) learning to use our new *lift-off* tapping task interface. In this training session photo only the blue selection is presented.

We also replaced our slower IR touch interface with a newer version [15], this new IR touch surface included new drivers and is easier to troubleshoot.

Dog Training Methods

Because we changed some elements of the original touchscreen interface, we felt it important to use a new set of dog participants, who were unfamiliar with the original *first-contact* tapping task interface. The new dog participants would be trained on either the *lift-off* selection system, or the swipe/gesture system, but not both. For all experiments, our research team only used positive reinforcement (R+); we did not employ any type of correction or punishment. We trained the dogs in 15-20 minute sessions with at least 30 minutes rest between each training session. We will describe the original training method and the revised method used in this study to compare.

Original “first contact” dog training method

In previous studies all of our dogs (set A) were pre-trained in targeting (touching the handler’s hand or a specified target with his nose). The dogs in our previous touchscreen

work were also trained with operant conditioning [20], specifically *shaping*, which is creating new behaviors by selectively reinforcing wanted behaviors the canine offers [16]. The dogs were classically conditioned using a food treat and a computer generated tone [13]. We used the same tone to signify completion of the touchscreen task, so that as the dogs used the interface they would hear the tone as a “reward marker”.

The touchscreen interaction, while seemingly simple, is quite complex for a canine. For training we subdivided the tasks required. The dog was rewarded for first touching the screen with his nose, then for seeking out the dot shape to touch with his nose. We began by training the dog to touch the blue dot (giving a reward only when the tone sounded) and the yellow dot separately. Each of the dot selections is marked by a different tone so the dog can understand his progress through the task. Dogs normally use a multitude of senses to find objects, part of the training was to reward the dog for only using sight to find these “virtual objects”.

Once the dog was trained to touch the dots separately our initial trainer used the *backchaining* [16] method to teach the dog to touch first the blue then yellow dot in sequence. By starting the dog on a mat, first he was rewarded for going to the screen and touching the yellow dot. When proficient with one dot, he was rewarded only after he touched the blue then yellow dot and returned to his mat. Each step was added after the dog showed mastery of the previous one. The trainer started with the last needed behavior in the sequence so the dog understood when the reward was given. Because the reward is only given at the end of the task the dogs were motivated to complete the behavior chain as correctly and as quickly as possible.

Current “lift-off” dog training method

Because we wanted to work with a new set of canine participants (set B) we reached out to a new trainer with a pool of dogs who had never used our interface. The new trainer attempted to train the dogs on our new *lift-off* tapping task interface. Before we discuss the new trainer’s techniques we believe it is important to stress that the new *lift-off* interaction style seems more difficult for canines to learn in general using either training method.

Our new trainer employed different techniques in two major areas. First, she used a style of training called *luring* [16]. Luring is when a trainer shows a reward to the dog and allows the dog to follow the reward through the task the trainer hopes to impart to the dog. In this case the trainer showed the new dog participants a food treat and enticed them to follow the treat to the screen where she wanted the dogs to touch. The luring approach was less effective than the *shaping* approach of the original study, especially with our *lift-off* system because the dog sees the treat at the screen and does not associate the completion of the task with the reward but rather the location as a place where rewards appear. Second, the new trainer did not build up the tapping task through *backchaining*. By building up the task from the beginning, the dog learned to be rewarded during each step of the sequential task along which the total task

needed to be trained. This created moments where in the middle of the tapping task sequence the dog did not comprehend that he needed to finish the entire sequence to receive a reward. This is a major problem for our research, as we need the entire sequence of the tapping task (or any other sequential task) to be completed as quickly as possible from the dog participant to be able to compare the dog interactions with human interactions.

Upon seeing the shortcomings of this new training method we began training a separate dog on the *lift-off* system using our original shaping methods. We found that the dog learned the system quicker than the (set B) dog participants, but did not learn the *lift-off* task as quickly as the original *first-contact* task.

Training for sliding/gesture interactions

Our new trainer also used *luring* to train one dog to interact with a sliding gesture based interface modeled after Accot and Zhai's description of steering law [1, 2]. *Luring* is more appropriate for beginning this training as the interface reacts to a continuous touch and slide from the dog's nose. The need for the dog to follow the path of the interface means that a trainer initially using *luring* can lead the dog through the correct motions. It is important to quickly transfer from *luring* to *shaping* so that the dog understands that the task must be completed before it receives a reward.

Figure 7: Dog participants touch interactions, green lines are successful sliding touches, and red lines are unsuccessful attempts.

RESULTS

In this ongoing research we attempted to train five dogs on the *lift-off* tapping task interface. The new trainer using her methods trained four dogs, and our original trainer using our original training protocol trained one dog. None of the dogs being trained on the *lift-off* tapping task became proficient enough to begin actual testing. Some did learn the task, but were not consistent. In general the dogs in our last study were able to learn *first-contact* much quicker and once trained, were quite proficient and consistent in their ability to activate the system. For this reason we believe that *lift-off* is not a good choice for canine touchscreen interface design.

We separately trained one dog participant on the new sliding interface. Our testing protocol has not been finalized or optimized for comparison with human interactions, but the dog was able to learn the interaction and successfully complete the sliding task. We can see from Figure 7 the dog was often successful in completing the task, sliding up from blue to yellow by staying on the visible white path. The path is vertical to allow for the dogs interaction to be visible and not occluded by the muzzle. One interface observation is that the path should be at least 3.5" inches wide to allow the dog to see the path while its nose is touching the screen.

LESSONS LEARNED: CANINE TOUCHSCREEN INTERFACE DESIGN CONSIDERATIONS

The initial results of our *lift-off* study have generated a preliminary foundation for touchscreen "best practices":

- Infrared Touchscreens with a backing non-projection monitors seem to currently be the best hardware for canine interactions [24]
- Targets for tapping should be 3.5" or larger [24]
- Target distances should be at least 3.5" apart [24]
- Sliding paths should also be 3.5" wide or larger
- *Shaping* is the most effective training method for tapping task touchscreen interactions
- *Luring* can be effectively used for initial training of sliding/gestural interactions, but should be quickly exchanged for *shaping*.
- *Backchaining* seems to be the best method for training the dog participants to complete the full sequential task with motivation to move as fast as possible through the task
- *Lift-off* touchscreen interactions are much more difficult for dogs to comprehend
- *First-contact* touchscreen interactions are easier for dogs to use and to learn

DISCUSSION AND FUTURE WORK

Through the course of attempting to update our canine touchscreen interface we learned quite a few new design considerations and also which training methods work best. One exciting area of future work we intend to pursue can be extrapolated from Figure 7. Notice that even when the dog participant did not correctly stay within the path, the dog's motion and touch gesture look the same as when it did stay within the path. If viewed from the perspective of a touch gesture these interactions would also be successful activations. We might be able to train the dogs using the onscreen visuals as a guide, and later let them make the gesture anywhere on the screen. Without having to stay within the path, but by creating more complex paths, we might be able to create a touch base gesture control system dogs to could activate relatively easily. It could be interesting to explore how complex these gestures could become.

Finally, to showcase the usefulness of what we have learned thus far, and using our canine touchscreen interface design considerations, we created a *first-contact* tapping task

system that demonstrates directly a dog's ability to call for help (Figure 8). The system has three tapping targets and once activated in sequence, sends a text message calling for help (for now just to a private phone). One of our dog participants is fully trained to activate the system when someone says to him "go get help".

Figure 8: A first-contact emergency notification canine touchscreen interface.

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