Stimulating Companionship With Rolling Robot Through Gestural Animation

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Abstract
We explore the use of animation as seen in moving pictures in the likes of Disney and Pixar to simulate the sense of companionship with rolling robots. Interacting with robots in this way provide similar benefits to owning a pet. This paper will discuss the evolution of our design and the implementation of the high-fidelity prototype of our interface. An evaluation of our implementation will also be done to determine the effectiveness of the implementation.

Author Keywords
robots; pets; benefits; disadvantages; interaction; programmable; maintenance; ownership; functionality; design; animation

CCS Concepts
•Human-centered computing → HCI theory, concepts and models;

Introduction
Problem
While pets offer companionship to people managing their daily lives, there are a variety of potential problems that come with pet ownership. For instance, the time and cost for care and attention may be excessive. Dust and fur allergies can also be an obstacle to pet ownership. Untrained pets could lack situational awareness and may bother you when you don't want to be, and they may even cause dam-

Figure 1: The Sony Aibo robot with dog like appearance and vision and voice recognition. Photo: https://www.sony.net /SonyInfo/News/Press /201711/17-105E /ithc980000002c9g-img/img01$_0$2.jpg

age to property [4]. Lastly, pets have short lifespans relative to humans and losing them can be emotionally taxing. It should be noted, these are broad representations of problems that may come with pet ownership and each type of animal comes with its own specific set of benefits and drawbacks. For example, dogs offers more opportunities for interactions with its owners than fish, but they require more care. Robotics have been used to tackle this problem, but the commercially available solution often comes with an extreme price tag, and the cheaper alternatives often comes with an inability to express themselves.

Motivation

There are numerous benefits that come with pet ownership such as reduced anxiety and healthier lifestyles through increased exercise. Physical contact with pets can also offer comfort to their owners, which may help reduce loneliness and depression[5, 4]. A robotic pet can provide the same benefits as a living one, and more. Particularly, it gives its owner more freedom by requiring significantly less care and attention. For example, an owner would have to find a caretaker to feed and walk their dog if they were to leave their home for an extended period of time. This is a non-issue for robotic pets. What is an issue however, is their exorbitant cost - which may prove as a barrier of entry for some. Thus, we aim to create a similar sense of companionship with more affordable machines. To this end we are inspired by moving pictures such as Disney and Pixar to breath life into these machines.

Related Works

The idea of creating and utilizing animal-like robots to encourage beneficial interaction with humans is not new. There are several related works in the field currently. Paro is a robot aesthetically designed to look like a cute seal cub and it acknowledges human interactions. Paro can track human motion and voice, therefore it can respond to actions such as petting and conversation[3]. Paro is currently being used within social settings in elderly care facilities to decrease stress, enhance mood, and encourage beneficial social conduct[1]. Their work is heavily focused on companionship robots in healthcare, whereas we are interested in more general design space. Aibo is another interesting case to explore, it is a robot with the physical appearance of a dog and functions as a pet. It has been marketed as a robot dog and is used within domestic households. Aibo has voice recognition and vision capabilities. In 2017, Sony announced a new version of Aibo which will have the capability to form emotional connections with its users[7]. We aim to create similar user experience to Aibo, but with a robot that was not originally designed for companionship.

To achieve that, we draw inspirations from Disney and Pixar animations to give life-like quality to an inanimate object. Particularly, we took note from the twelve principles of animation as detailed by Nataha Lightfoot [6]. Our reason for implementing interactions with Disney's 12 basic principles in mind, is to make the interaction a user has with Ollie feel more powerful, lively, and realistic. A.J.N van Breemen discussed the idea of bringing robots to life, displaying behaviour that could be inherited understood and anticipated by humans through application of these principles [2]. He mentioned that traditional movements in robots utilize feedback control loops, that exhibit stiff, dull, and mechanical behavior making it difficult for humans to perceive the robot's thought process and actions. He also mentions how historically, before the industry aligned under Disney's 12 general principles, animators faced similar issues trying to bring life into their drawings in a way that audiences could understand. He then goes on to describe each principle of animation, such as timing, appeal, staging and exaggeration, before applying it to an iCat robot. By applying these

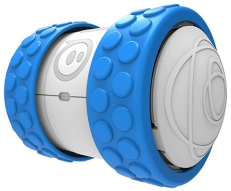

Figure 2: Ollie, the two wheeled re-programmable robot that is being used for the research proposal. Photo: https://www.jrtoycanada.ca /images/detailed/27/Ollie1.png

same principles of animation to our interactions, we hope to give users interacting with the Ollie the ability to anticipate and understand it's thought process and actions, thus creating a sense of comprehensibility and liveliness.

Design Evolution

Our design plan originally focused on the idea of a robot functioning as a domestic pet alternative. However, our design process evolved during the planning process. This is because as we designed the interactions, we noticed many of them felt mechanical and difficult to interpret. We then realized that we should place more emphasis into ensuring every interaction between robot and user seemed expressive and comprehensible from the user's standpoint. Before we can discuss potential benefits of interactions, we must first ensure the user understood what interaction had occurred.

This led us to discuss how we could attempt to bring life into our interactions. We examined videos and research papers about how this is achieved in the animation industry, because they are well documented examples of bringing life into non living mediums. Eventually, emphasis was placed upon integrating Disney's 12 Basic Principles of Animation into our robot companion interactions. This is to help promote characteristic appeal of Ollie by making the interaction more understandable and lively.

Interface Strength and Limitations

The Ollie pet robot interface offers several strengths. The exterior of Ollie is quite durable and rigid, this durability allow for a sense of comfort in doing interactions with a pet that may require slightly more force. Ollie is also water resistant and has been marketed as a toy for kids with an age rating of 8+. Pets have the potential to interact with children, so its beneficial that the Ollie is designed with that demographic in consideration. Ollie is a more affordable compared to similar market options. For example, Aibo is currently priced around $1900 USD in comparison to the Ollie which is priced around $100 USD as of this writing. The Ollie pet robot can be powered off, this is beneficial in situations where the user may have to leave for extended periods or become incapable of maintaining the pet.

However, there are a number of limitations surrounding development with Ollie. For instance, the web IDE provided by The Sphero Company does not allow for third party library integration, preventing us from implementing interaction that relies on outside technologies like voice input and position or motion tracking. Our second solution was to use the Cylon library, which didn't work with our devices since it uses Bluetooth 4 and is incompatible with Bluetooth 5 devices. Therefore, we weren't able to fully implement voice triggers and instead pivoted to using Wizard of Oz voice triggers. The Ollie still has a gyroscope and accelerometer which we used to trigger physical interactions.

High-fidelity Interactions

We implemented nine interactions with Ollie with four types of triggers: proximity, voice, time, and touch. Of these four, proximity and voice were implemented with time trigger and achieved using the Wizard of Oz method. Touch triggers are detected through reinterpretations of gyroscope and accelerometer values. These interactions are as follow.

Calculating: Voice trigger when the phrase "Yo Ollie!" is said. Ollie will enter into a listening phase where it will listen to a a sentence that the user will say out loud. Ollie will then loop in a square as it waits for a verbal input. Ollie is animated *pose to pose* in this interaction. *Timing* is considered in this design to help show that Ollie is mildly excited when you call its name.

Figure 3: The user pets Ollie which triggers the petting interaction. Ollie then changes its color to green and moves towards the user for more pets.

Angry: Voice trigger when the user says something that Ollie will extremely dislike (e.g. someone says that the Sphero is better), it will slowly turn red and lunge itself towards the user as if to attack them. In this design, the *timing* for the change in color is fine tuned using *straight action* animation to build up *anticipation*. The same method is used for creating the *exaggerated* lunge.

Disappointment: Voice trigger when the user does something that would disappoint Ollie, e.g. if someone told a very bad joke to Ollie. Ollie will then respond to the user by stopping and dimming it's lights. *Timing* is used here with *straight action* animation to as closely match the dimming of lights to an *exaggerated* sigh.

Petting: Touch trigger when the user gently stroke the center of Ollie's body, detecting via gyroscope. Ollie will change its color to green to indicate happiness. After the user stops petting it, Ollie will move closer to the user as if to request more pets. *Timing* is used here to have just enough pause between petting and requesting for more pets. *Slow in slow out* came naturally with Ollie's acceleration when he moves and helped enhanced the interaction. This is animated using *pose to pose*, varying between "being pet" and "asking for pet". Petting may promote positive emotions in the human interacting with the pet.

Happy Wiggle: Currently only touch trigger, this occurs after the user pets Ollie. It will do a "happy dance" where it will wiggle left and right for a few seconds, similarly like a dog would with its tail. *Arc* is used for the side to side rotation, resulting in an *exaggerated* wiggle dance that enhances Ollie's *appeal*. This is animated using *straight action* to control Ollie's rotational speed frame by frame.

Hit: Touch trigger when the user gently poke or hit Ollie playfully. This is detected through the accelerometer. Ollie will be startled and suddenly move back before rushing forward in a gentle retaliation. *Timing* is key to this interaction and the whole sequence was fine tuned with *straight action* animation.

Sad: Voice trigger when the user says something that will ruins Ollie's day. It will turn around, roll away for a little bit before looking back in disbelief, then turn back around and proceed on with the cruelty of reality. *Timing* is used to naturally space the actions throughout the sequence. The speed of the rotation and the *arc* of the motion is adjusted to best convey the intention. *Pose to pose* animation is used in this interaction to interpolate between key frames.

Excitement: Proximity trigger when Ollie first detect the user within its space after an extended absence. Ollie will jump and roll around joyously similarly to how a dog would welcome its owner home. *Exaggerated* movements are used to enhance Ollie's *appeal*. This is animated by setting the raw motor power to high and let it run on its own, thus it is neither *pose to pose* nor *straight action*.

Bored: Time trigger when the user has not interact with Ollie for an extended period of time. Ollie will start rotating in place. *timing* is used to determined when Ollie will be bored. It is used more so for the activation and not the narrative. This interaction help builds Ollie's *appeal* as a companion or a character rather than being just a toy. This is animated using *straight action* to control Ollie's rotational speed.

Evaluation of the Interface

The evaluation of our Ollie interface was conducted through a user survey. The user survey displays a video of each interaction performed with the Ollie and a human, and asks the participant filling out the survey to identify what action they thought Ollie was preforming and what emotion they

believed Ollie was trying to convey. This was shown in the structure of a google form and was sent out to users who have not yet seen our interface or interactions to attempt to minimize bias. The users were given an emotion chart to use as reference when describing the emotions. The results of the survey were then distributed amongst the team members who analyzed and interpreted the results individually before a group discussion where consensus was reached on the results.

Overall, Ollie's emotions and action conveyed through animation theory were well understood by participants. However 2 of the designs need improvement.

For the hitting interaction, participants fell under 3 general areas of consensus. The first grouping felt Ollie was annoyed or responded aggressively to the human's hit. There was another grouping that described Ollie as being surprised and shocked by the human's actions. There was a third smaller grouping that just interpreted Ollie's actions as rolling and were not able to effectively tell what emotion Ollie was trying to convey. Potentially, we could have emphasized more on principles of exaggeration, timing and secondary action to make it more inherently clear what action the Ollie was preforming and what emotion it was trying to convey. For example, when Ollie responds by bumping into the user we could have made Ollie roll at a higher speed, to portray more aggression. This may help to distinguish the emotion from shock or excitement. We also could've given Ollie more time to pause before responding with its retaliation, this would potentially give users more time to process that Ollie understood it just got hit and is deciding its next action/response. Secondary action, maybe in the form of winding up/rolling back slightly or changing its color to red before hitting the human back, might help as well to specify the interaction as being negative or aggressive.

The interaction for Sad was generally understood by a majority of participants but could see room for improvement. There were 3 directions of consensus for this interaction as well. The general majority of participants felt the Ollie was rolling away sadly. Another segment only noticed that Ollie was rolling away. The last smaller segment is where the participant could not understand what the Ollie was doing or what emotion it was trying to convey. I think the principle of secondary action could be used to help improve this interaction. Perhaps if we showed the Ollie first from a state where its visibly happy before becoming upset, this would make the emotion more understandable. In addition, we could have the Ollie change its color from green or yellow originally to blue, I think it was kind of difficult for users to equate the dimming of its light to sadness.

The Angry and Petting interactions were the ones that were most well understood by participants of our survey.

For the angry interaction, participants generally understood that Ollie was angry and then attacking the user. The participants don't particularly mention what helped understand this interaction, however, timing and exaggeration principles used in Ollie's angry interaction, may have helped. Timing in the sense that, as Ollie turns red the user is processing that Ollie is upset and anticipating a response and exaggeration, in the sense that as the Ollie attacks the human, the action is quite quick and aggressive in terms of movement.

For the petting interaction users generally understood that this was a happy interaction. Overall, this is a complex interaction, most participants are able to distinguish that Ollie seems happy in response to the petting, some are able to then gather that the Ollie moves closer as a sign of wanting more pets. For the Ollie's wiggle, the general consensus from the participants is that Ollie is happy, however, several participants, even make the comparison to a biological dog

Figure 4: The excitement interaction being triggered by Ollie detecting that a user has entered its space. Ollie then rolls over excitedly to the user.

wagging its tail excitedly. The use of exaggeration to further Ollie's appeal in this interaction seemed to help users connect and understand the interaction because many responses made mention of the wiggle. The use of timing also seems to be effective because many users were able to distinguish that after getting petted the first time, Ollie then approaches the user slowly for more pets.

The excitement interaction had emotion that was generally well understood as well. Excitement and Joy were the consensus amongst participants in the survey for how the Ollie felt. As for the interaction users were able to make the connection that Ollie was approaching the human with a sense of optimism similar to a dog welcoming its owner home. Exaggeration as a principle of animation may have helped in this context, because users were able to distinguish clearly that the Ollie was energetic and excited as it approached its owner.

Conclusion

The design of our solution has changed over the course of the implementation, putting the focus on conveying emotion through animation theory. We found that using animation theory is generally effective as displayed from the usage of techniques such as *Timing* which makes the difference between Ollie illustrating happiness or sadness. However, some emotions can be misinterpreted to be something else, such as excitement. We also came across difficulties in the implementation since Ollie has technological limitations which we overcame through the use of Wizard of Oz implementation. There needs to be further evaluation done in order to better determine how successful our implementation of Ollie's interface is and act according to the results.

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