KOMI: An IR-based smart robotic toy for pets

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Demonstration of the project: https://youtu.be/2lTUiRZcDG4

CCS CONCEPTS • Human-centered computing > Collaborative interaction • Computer systems organization > Robotics

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1 INTRODUCTION

Many of us choose to have a pet, as pets can bring companionship and entertainment. Research has shown that pet owners can derive not only practical and emotional support from their pets, but can also be beneficiaries of the social support network derived from friendship formation amongst other pet owners [19]. During the pandemic era, many people adopted pets to add a bit of joy in their quarantine life and to help them endure this challenging period. The challenges caused by restrictions may include mental problems like depression, insomnia, and anxiety [5,8]. Interestingly, study of human-pet interaction has shown that the emotional needs of owners during lockdown can negatively affect pets with existing behavioral problems [4]. Since the emotional states of pets then in turn affect pet owners [14], the mental and physical health of pets and the emotional state of the pet owner go hand-in-hand.

To address this issue, we created a robotic pet toy that can interact with pets (especially cats) to entertain the pet, and by extension, the pet's owner. Robotic pet toys have previously been found to alleviate loneliness in older populations [11], but we hope to design an intervention that can increase the cohesion between pets and the owner, and provide interaction, fun, and stimulation to pets themselves. Critically, unlike previous studies, we are designing not for the pet owners, but the pets themselves. We create not robotic pets, but robots *for* pets. Through the careful consideration of this design strategy, we hope to help pets to develop positive mental and physical health, and by doing so, contribute to a more positive lifestyle for both pet owners and their pets.

2 BACKGROUND

The social and emotional lives of pets directly affect their owners. Cancer diagnosis of pets lead to depression and anxiety in their owners compared to healthy controls [14], while pet ownership led to higher rates of metabolic exercise, better sleep, and more positive consideration of their community by pet owners [13]. While negative affect like allergy and heart-attack risks come with some pet ownership [18], generally positive outcomes have been associated with owning mentally and physically healthy pets, including reduced anxiety, better physical health, and improved immunity [16].

Research dedicated to robotic toys for humans include robotic toys for enhancing understanding of games and technology [10], use of affective design and playful interactions for smart toy design for children [3], and the attachment of children to dogs as robots, not robots as dogs [2]. There has been little research on designing for pets themselves, possibly due to the focus on human-centered rather than animal-centered perspectives in interaction studies [7].

Taking the perspective of designing for cats in this study, we asked what interactions lead to positive outcomes in cats, and also in the way humans and cats interact? One hint from animal behavior is the tendency for cats to chase lasers, which allows for systems that can control canine movement using noninvasive laser manipulations [15]. Cats have more rods than cones in their retina, and are thus more sensitive to slight movements as opposed to picking up visual acuity. It is thought that domestic cats chase fast-moving prey in order to express their innate desire to hunt and kill the prey [20]. Thus, we propose that **chasing a tail laser** can be a way for cats to get physical and mental exercise. In particular, we propose an infrared laser installed in the toy's tail section to let cats play with it.

Cats spend a majority of their time resting during the day, so that play generally occupy only 9% of total time [12]. Thus, for cats to have exercise to avoid being overweight, the play time should be limited in order not to over-exert the cat's low stamina. The low stamina in cats generally means they will get bored easily and lose their focus [17]. Thus, we propose a short period of play time, generally 5 to 15 minutes, for cats. The instantiation comes as an automatic **shutting down** of the movements of the toy after 15 minutes of operation so that cats can recover for its next bout of play, as opposed to exhausting themselves entirely and sleeping through the day.

House cats appear to prefer fast-moving prey like mice, rats, and birds [1]. This means that the design of robotic toy for cats should reflect the speed of the prey cats like to chase. This high speed of operation also necessitates the use of obstacle avoidance systems in the robot. The robot is expected to play with the cats on the floor. Therefore, the robot may easily hit the wall, the table's feet, or the house's clutter. If it cannot avoid obstacles automatically, the robot's shell will be damaged easily, or even the components inside will be damaged by collisions. Thus to provide the robot with speed of operation to optimally engage cats, we propose an **obstacle avoidance** system using IR sensor.

Many robot toys are designed to keep the human company in the market, but very few is designed to play with the pet. Enabot Ebo Catpal Monitoring Robot [21] is a rare project that serves as a toy to interact with your pet. However, instead of movement, it relies on voice interaction, which are not always effective with felines [6]. The weight of the Ebo is 223g with a 7.6V (1100mAh) battery which can run its automatic mode for 120 minutes. The Maximum speed of its motors are 1.6m/s. Ebo has the LED eyes to display a low battery mode and a red laser light. But in our project, the function of LED eyes is designed to change with time to facilitate downtime. We also installed the infrared laser to play with cats, but did so using a laser attached to the tail, since the cat will be chasing after the robot during her interactions.

3 METHODS

We built a robotic toy for pets designed as a device to keep company and play with cats. Inspired by the Ebo robot, we added automatic obstacle avoidance for high speed operation, a built-in LED display to indicate the robot's condition, a tail laser to engage the animal's interest, and automatic shutdown of movements to let the cat rest. These design considerations were based on the cat's innate habits of short periods of play followed by extended rest, their short attention span, and their desire for fast-moving playmates [12,20].

3.1 Automatic Obstacle Avoidance

To build the automatic obstacle avoidance system, we installed an Infrared (IR) sensor at the front of the robot to detect the obstacle. The distance of detection can be set by rotating the potentiometer on the IR sensor. When it detects something within the preset value, it will return "low" to the board . The system will then send commands to the motor driver to trigger the motor movement. There are three wheels and two motors in the inside parts that support the movement of the robotic pet. One of the wheels is a castor which can run in 360-degree rotation to help to change the direction. It acts as a supporting wheel at the front and does not require the connection to a motor.

The Infrared (IR) sensor provides an automatic obstacle avoidance feature to avoid the pet toy hitting the wall or furniture. It would return digitally "low" or "high." The sensitivity of the sensor, i.e. detecting range, can be set by rotating the potentiometer. For example, if any hindrances are blocking its way, it will return the digital data "low" and send the command to a L298N motor driver and trigger the motion of the two 360 degree DC motors connected. When two motors receive orders, it will switch the moving direction of the robotic pet toy by turning in the same direction, i.e. both clockwise, to turn away from obstacles. When the way is clear, "high" will be returned and the motor will rotate in the direction opposite to each other, i.e. one rotate clockwise and one anti-clockwise, to move forward.

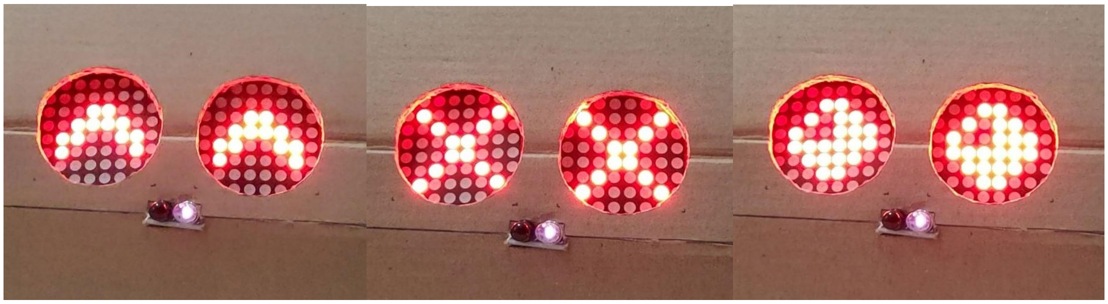

Figure 1: Facial expressions of the robotic pet toy.

3.2 LED Matrix Display

The eyes of the robot mouse were created by installing the LED matrix display. The LED display will be used to indicate the robot's condition, e.g. the duration of operation. The 8x8 LED matrix MAX7219 was set with three kinds of display: Happy face, Normal face and Cross face. As the best playtime of a cat is 5-15 minutes for each section, we assigned the operation into three stages. During the initial period, the facial expression will reveal a "Happy Face". After 10 minutes, it will turn into a "Normal face". After 15 minutes, it will eventually show a "Cross face" and all other movement related components will be turned off automatically.

A speaker is also built in the robot, to play different sound notifications along with the LED display. Thus, every time the facial expression changes, the speaker will create a sound to notify the pet owner of the time. When the robot changes the facial expression to "Cross face" and creates the sound, the pet owner will get prompt to turn off the robot.

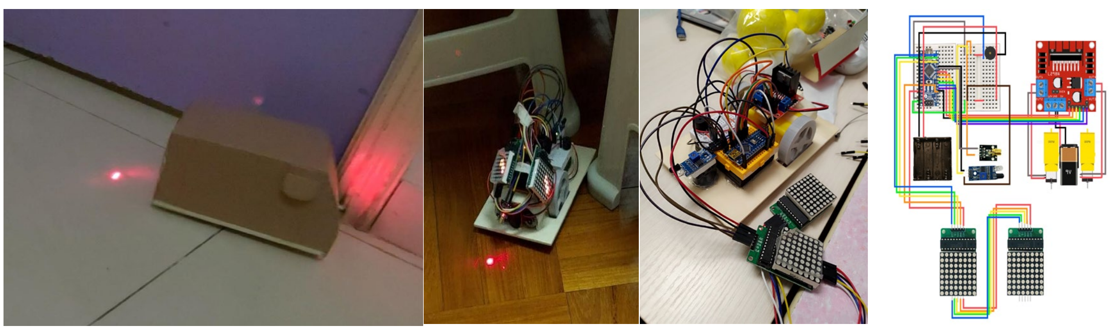

Figure 2: KOMI in action and the problem of the motor's performance (left). The circuit diagram of the system (right).

3.3 Testing and Debugging

For the obstacle avoidance function, we perform the testing with human beings as it will be more efficient compared to doing it with animals. Beside turning away from the walls and objects, it should also react to obstacles that appear suddenly in a short time. To test it, we tried to step in front of it suddenly or block the way with hands, simulating the situation where the cat jumps in and blocks its way, to test its reaction speed.

In the first iteration, we found that the robot would only turn slightly and tried to move forward again even when its way was still blocked by the obstacle. To fix that, we add a 500ms delay to the code. It therefore turns for a half second every time when the way is blocked, and it is then capable to turn away from the obstacle. However, since our prototype is shaped as a rectangular box with only one IR sensor, it sometimes get stuck in corners or on the legs of chairs.

To test the LED display, we turned the robot on and operated it for a long time until the 15 minutes passed, which the robot turned off the motors itself. It is the most straightforward way to test it. In the testing stage, we notice that the LED display keeps flickering during the operation. After checking other components, we found that the flickering issue was triggered by the IR sensor. The feature works well together with the timer and speaker's notification.

4 DISCUSSION

For the body of the robotic pet toy, we faced several problems in the production process. We decided to use 3D software like Maya to produce the robot's shape in the first stage, but it could not be made hollow on the inside to contain all the system circuits. Next, we tried to use traditional handicraft to make the shape by using cardboard as the inner container and covering it with the plaster cloth bandage to consolidate. However, the materials of plaster cloth are wet and unstable; the external form may unbalance with the circuits. Ultimately, we used a shoebox to construct the toy figure.

As for the equipment, we found out that the size of our final product is too large as cats prefer smaller plaything. The wheels we first bought online occupied a large part of the prototype that was not easy to fit on the wooden board. Thus, we used 3D printing in this section as the wheel is a solid cylinder that is easier to produce. The Arduino UNO is also too big, so we decided to change to a smaller Arduino board (Nano V3), so the width of the robot can be narrow.

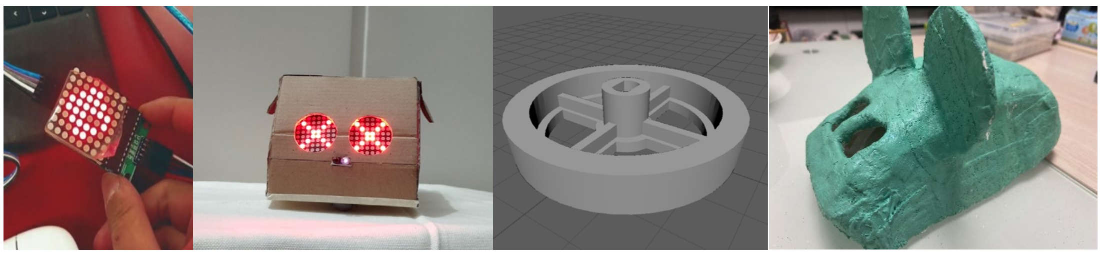

Figure 3: LED Max 2719 board and expressions generated (left), model for 3D printing of the wheel and robot frame (right).

For the LED matrix display part, we created facial expressions for the robotic pet toy by controlling each pixel. For the speed control function of the motor, the L298N motor driver we used could not perform the speed control function of the two DC motors. Thus, instead of turning the robot with the speed difference between two motors, and it was now replaced by changing the rotation direction of the wheels.

For the future development of the robotic pet, the most significant function that we want to build is a mobile application that allows pet owners to remote control the robot movement. The owner can look at their pet's behavior through the built-in camera of the robot, changing the robot's movement or direction based on their pet's reactions. It would be more user-friendly for both pets and humans. The outer figure is one of the biggest challenges for our production. We hope that the surface of the advanced version can be curvy to contain more sensors inside, so that the robot can have more entertainment functionality for pets to play with. As our robot’s shape and outlook is big and straight, it sometimes still bumps into the wall with the robot’s corners or is stuck between the chair’s legs. In the future development we would like to put more IR sensors to improve the sensitivity of the avoidance feature. The shape of the robot will be improved with a curved outer case, it will be less easy to be stuck in the corner and the situation where the robot is stuck between the chair’s legs will not happen. Finally, the speaker and motor sound are unbalanced. The motor sound is too noisy and loud, which leads to a severe problem in scared cats. As different cats have different personalities, some may be afraid of the toy because of the unnecessary noise.

5 CONCLUSIONS

Given the increased necessity for technology, we believe that even pets and animals can have systems designed for their well-being, be it a robot to keep animals company or to help owners in their relationship to their pets. The ultimate purpose is to benefit animals' mental and physical health. In this project, we chose cats as the target user by creating a robotic pet toy to entertain them. We created a laser tail light to facilitate cat vision and play, a system shut-down timer to limit bouts of play to around 12-15 minutes of intense activity, and a high speed obstacle avoidance system using IR and reversible DC motors to make the robot perform at high speeds while engaged in play without being broken.

Together, these design decisions illustrate the design of smart toys from the perspectives of pets and their interaction with their owners rather than from solely the owner’s perspective. They illustrate the practice of designing from nonhuman perspectives [9] that has become increasingly necessary in a world whose well-being depends on nonhumans.

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