Shelly, a Tortoise-Like Robot for One-to-Many Interaction with Children

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ABSTRACT

We designed "Shelly", a robot interacting with children while restraining children's robot abusing behaviors. Shelly has a tortoise-like friendly appearance and touch based simple and versatile interface, which encourages children to interact with the robot spontaneously in environments such as amusement park or kindergarten. We have developed two prototypes and proved validity of Shelly's social concepts - one-to-many interaction and restraining robot abusing - through field tests. Ultimately, Shelly's novel interface and interaction model targeted for multiple-children interaction would effectively attribute to various social goods.

1 INTRODUCTION

Nowadays, several social robots such as Jibo and Cozmo are released, but most of them are interacting mainly with one person. However, in the real world, robots frequently face situations where they should deal with multiple people. Also, it is observed that service robots are frequently abused by people, especially children, which hampers the robot's mission and frustrates its social acceptance. Although it is inadequate for most robots to escape from people's abusing, at least it is required to refrain people's habitual abuse for their long-term sustainability. Thus, our robot "Shelly" is designed to interact with children while achieving an educational purpose in terms of refraining robot abusing. In addition, multiple children can interact with the robot more easily and spontaneously through its simple and versatile touch-based interface.

2 DESIGN GOALS

2.1 One-to-Many Children Robot Interaction

As we intended to make our robot suitable for interaction with 3-6 children under 12, the robot must be responsive to multiple users simultaneously and the interaction should be appealing to children. To satisfy these criteria, we set direct touch towards the robot as a key interaction feature in our interaction design. The touch interface, which is the shell of the robot in our case, is an effective tool for concurrent responses and satisfies the children's desire to touch the robot directly. Children's various touch behaviors on the shell will be the interaction inputs to Shelly. Then the robot can respond with its LED interface on the shell and physical motions through its head and legs.

2.2 Restraining Robot Abusing

We propose hiding-in-shell function in order to restrain children's robot abusing. When the robot gets a negative input such as hitting, the robot suspends all interactions for a certain period of time by hiding its head and legs inside the shell. By doing so, we anticipate a preventing effect of robot abusing as children would prefer to continue the interaction which involves various LED and physical responses.

2.3 Shelly for Social Goods

Shelly can interact with children in numerous environments such as kids club, amusement park, and kindergarten where children gather together. Shelly's vivid interaction based on the touch interface and LEDs will excite the children. We anticipate children to treat robots in a good manner through interaction with Shelly. It enables robots to perform their tasks successfully and thus can contribute to enhancement of social goods. Moreover, collaborative games based on Shelly's interface can be designed to improve children's social adaptive skills while interacting with Shelly and other children.

3 DESIGN PROCESS

The following process was pursued when designing our social robot. For an one-to-many interaction targeted robot, a personalized interaction strategy plays a key role. Accordingly, we have identified four steps: 1)recognizing interaction pattern, 2)distinguishing users, 3)profiling users' characteristics, and 4)performing personalized interaction strategy. So far, the first step has been achieved. In addition to the described interaction process, applying appropriate social concepts, in our case mentioned in Section 2, completes an ideal social robot.

4 FUNCTIONALITY

To achieve the aforementioned design goals, we implemented specific functions of Shelly. First, Shelly recognizes children's touch patterns - touching, petting, patting, hitting, and pressing - from its sensory data. Depending on children's action on Shelly, it reacts differently with LEDs and physical motions. Basically, when children touch a face of the shell, the color of LED attached to the face changes, which increases children's interests and motivates

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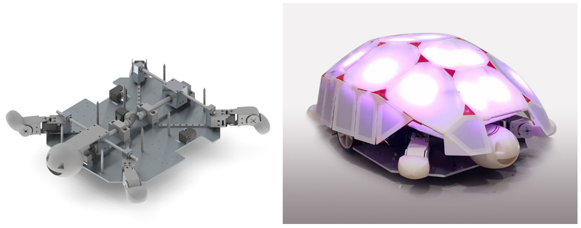

Figure 1: Rendering and picture of prototype 1

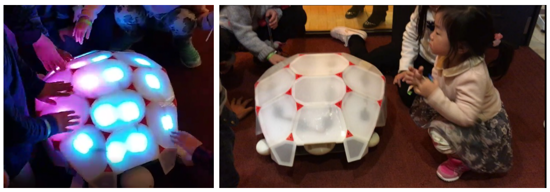

Figure 2: Field test of Shelly's prototype 1

them to interact with Shelly. When they pet the robot, 'friendliness' - an indication of the number of positive actions that Shelly has received from children - increases. When friendliness reaches its maximum, Shelly expresses happiness by blinking LEDs and shaking head and legs. We have implemented eight motions - happy, angry, frightened, sulky, looking around, refusing, greeting, and asking for stepping aside. However, if children hit or press the robot, hiding-in-shell function is activated, which acts as a penalty for the abusive behavior.

5 PROJECT DEVELOPMENT

Based on the design goals and the functionality, we have developed two prototypes. They are both composed of two modules: a shell and a stomach module. The shell module includes multiple sensors to detect what children do to Shelly, and LEDs for a graphical output according to the sensors' input. The stomach module comprises of head, legs, and wheels, functioning as the robot's physical interface. While the two prototypes are similar in functional aspects, several features have significantly changed in the second prototype in systematical aspects.

5.1 Prototype 1 - System Configuration

In the first prototype, main frame of the shell module is composed of chopsticks, 3D printed holders and acrylic panels. Proximity and vibration sensors are embedded in vertices and interior of the shell module respectively. They successfully measured children's patting and hitting. Hiding-in-shell function is materialized by ball-screw mechanism, which makes head and legs move simultaneously. With two motors embedded, each leg and head could express various motions. Arduino Mega is used as the main processor in the first prototype. It receives all sensory and actuation data and sends output signal to the LEDs and OpenCM board which controls the motors.

5.2 Prototype 1 - Field test

The usage of the first prototype has been evaluated through field tests twice. The tests were conducted as one of the programs for a monthly local recreational children event in Seongnam, Korea. The number of participants were 51, 90 children respectively. (Figure2)

We first evaluated Shelly's behavior whether it conveys its states properly. The second prototype's behavior was determined based on the result. We then evaluated the eligibility of hiding-in-shell function for restraining children's robot abusing behavior. The result shows that when hiding-in-shell function is performed for an appropriate time, the robot effectively reduces children's robot abusing behaviors. Through these field tests, we validated the social concepts of Shelly.

Figure 3: LED interface of prototype 1(left) and prototype 2(right)

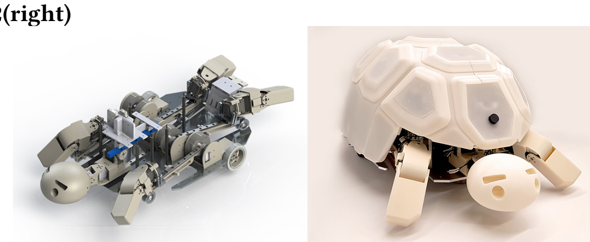

Figure 4: Rendering and picture of prototype 2

5.3 Prototype 2- System Configuration

We redesigned the shell module to substantiate our design goal - a more responsive and attractive tortoise-like robot. Flat face of the shell with light emitting from points is changed into the convex face with surface-emitted lights, and the edges of the shell were illuminated as well for a richer graphical effect.(Figure 3) We used pressure and touch sensors instead of proximity sensors, and allocated them with vibration sensors beneath the middle of the faces so that touching and abusing motions could be detected more accurately. The stomach module is also redesigned to increase liveliness. Instead of ball-screw mechanism, we used pulley-belt mechanism for legs and rack-pinion mechanism for head. Four BLDC gimbal motors and a Dynamixel motor are used in legs and head respectively for their separate retraction motion. Finally, the main processor Intel NUC communicates the sensory data with Arduino Mega. Also, by using 3D CNN, we have successfully classified users' touch patterns.

6 CONCLUSION

We designed a social robot capable of one-to-many interaction with children while restraining children's abusive behaviors towards robots. We have accomplished the first step of our design process - classifying children's touch gestures. By working through the remaining steps, a social robot that can serve personalized strategies to each child user can be fulfilled.

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