# Development of Design of Initial Cat Robot Model for the Use of Early Treatment of Children with Autism Spectrum Disorder (ASD)

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**Abstract.** According to the result of FGI's analysis, elements of function and motion have to be prepared for a cat robot was grasped. In consideration of these elements, guidelines to the construction of shape and motions for the design of the cat robot were established. By applying these guidelines, the design of outer shape of the cat robot was developed. And a cat robot's structures, electrical circuits, and driving program for the treatment of children with ASD were suggested.

**Keywords:** Autism Spectrum Disorder, Design Development of a Cat Robot

## 1    Introduction

This study conducted FGIs in order to learn the necessary or desirable motions and functionalities robots should have to be used for treating children with ASD. According to the results, elements of functions and motions should have to be prepared for the cat robot was grasped.
In order to design of the robot for the treatment of children with ASD, guidelines of design interaction should be constructed. To this end awareness and preference of the cat's face were grasped by a survey. Besides, to decide on the proportion of each of the cat's body parts, the proportions of real cats, doll cats and animated cats were researched. To assist a treatment, personified facial expressions and motions were applied to design. According to these guidelines, the design of the cat robot's outer shape was developed.
   In order to design the robot's architecture for children with ASD, a rigid support structure should be designed that can express a variety of emotions in the face and body representing various emotions and gestures. In this paper, we suggest the cat robot's structures, electrical circuits, and driving program for the treatment of children with ASD.

# 2 Need Assessment of Therapists and Parents for Initial Cat Robot Model

Initiatives that use robots to treat ASD children have consistently reported positive results in improved interactions, eye contact, and concentration (Cho, Kwon and Shin, 2009; Feil-Seifer and Mataric, 2008; Lee et al., 2010; Robin et al., 2005, Scassellati, et al., 2012). This study conducted FGIs with professional therapists and parents of children with ASD in order to learn the necessary or desirable motions and functionalities robots should have to be used for treating children with ASD.

## 2.1 Expression of Emotion

- The cat robot must be able to express various emotions      - Various emotions can be expressed with the shape of the eyes, eyebrows, and mouth      - For eye contact the robot must be able to follow the child's gaze according to the range of eye contact or be able to control the size of its pupil.

## 2.2 Stimulating the senses

- The robot must be able to easily express through the various senses depending on the situation (visual, textual, auditory, olfactory)      - Since stimulating the textual or auditory senses is especially more effective for treating children with ASD, the robot must be able to emit color or light and make sounds according to the situation, warm up when there is a lot of contact, stiffen its skin or tail, or express through other textual responses

## 2.3 Motion Ability

- Ability to emulate the motions of the child      - Ability to express closeness through motions such as approaching the child or hugging him or her      - Motioning to request to play with the child      - Ability to move around such as following the child by using wheels or other contraptions

## 2.4 Managing the robot

- Function for family members or therapists to operate the robot with a remote control - Ability to select from a various range of programs according to the child's conditions – swappable memory cards      - Function to monitor the changes in the child's behavior throughout the use of the robot      - Therapeutic program and family-use programs both included      - Produced with replaceable robot cover

## 2.5    Material component

- The material should be able to be detached and washed      - It should not shed or it should have short hair or made of texturally soft material instead      - Eco-friendly material since it is for children with ASD      - The cat robot's initial model should be developed in terms of design to realize the above components.

# 3    Development of Design of Initial Cat Robot Model

## 3.1    Guidelines for Design of Cat Robot's External Features

For the development of the design of the cat robot's external features, guideline had to be established, i.e., shape, structure of face, arms and legs, body and tail, etc. and interaction of acts. Thus, preference and awareness surveys were performed. Using computer graphics in which the cat's face size, ears, and eyes were transformed.



The result of the survey using the image board showed the most popular cat image had big ears, and centered eyes. Therefore, to design a cat robot, preferred by children, it must have big ears and centered eyes.

**Fig. 1.** Transformed cat face using computer graphics

To decide on the proportion of each of the cat's body parts, the proportions of real cats, doll cats and animated cats were researched. In real cat, in the case of kittens, the proportion of the head to the body is about 1:3, compared with that of cats, which is about 1:5. In the case of dolls or characters, for an emphasis on cuteness, kittens and cats both have a proportion of 1:1. Therefore, the cat robot must be made with a proportion of 1:2, to emphasize the kitten's cuteness but make it feel like real cat.



**Fig. 2.** Proportions of real cats          **Fig. 3.** Proportions of doll cats

The size of the ears, the shape of the eyes, the size of the mouth and the proportions between them were researched in the face of a cat. For children to recognize the face of the treatment robot as a cat, it should be designed considering the proportions of real cats. To make it like a character it should have larger ears, centered eyes, and an actual sized mouth that is emphasized to express the changes of facial expression. In the case of the treatment cat robot to improve awareness it needs to emphasize changes of facial expression and it needs to be personified. Therefore, the size of the mouth should be exaggerated, and moving the mouth up and down should direct

various facial expressions. For the treatment of ASD children happiness, sadness, anger and surprise should be expressed with the personified facial expression. According to the experts say the actions of the cat robot included eye contact, hugs, the copying of body movements, and reaction to inappropriate acts.

## 3.2　Development of Cat Robot's Outer Shape Design

To make an early working model of a cat robot for the treatment, various sketches were developed. As an emotional concern for the treatment, the cat was sketched with normal length fur to make it feel like a real cat. The proportion of the face and body was given by 1:2 to express the cuteness of a kitten. To show changes of facial expression, eye brows were emphasized, eyes were made bigger than normal size, and the eyes were centered according to the results of the preference research. Fig.4. A, B, and C show the three sketches developed to match these criteria.



**Fig. 4.** Sketches A, B, and C

**Fig. 5.** 3D rendering of sketch C

Of the three proposed sketches the most suitable sketch C was processed by rendering. This rendering was used by the department of engineering as the outer shape of the cat robot for the interior design. The cat robot's sitting height was set at 50cm to match the eye level



**Fig. 6.** Front view, Side view, and Top view of children.

In still included parts that were partially disconnected, but the positions of the inner motors for moving the eyes, eyebrows, ears, arms, and legs were drawn. To make a final proto-type model, the early 3D rendering was corrected. To make it look more



**Fig. 7.** Retouched Rendering　　**Fig. 8.**Second interior design

like a cat, the shapes of the face, ears and body were reformed and to improve the facial expression of the cat robot, the shapes of the eyes, mouth and ears were corrected. The 3D rendering for the second interior design was developed. According to this 3D rendering the second interior design was developed by the engineering department as seen in Fig.8.

To put it together using each part's holes that were prepared during the interior engineering design, the exterior design of the head was developed by dividing it into two parts, front and rear using Rhino as a tool.



**Fig. 9.** Body of cat robot



**Fig. 10.** 3D model of cat robot

## 4 Electrical system design

### 4.1 Joint system design

Cat robot for the treatment of children with ASD should be considered the action against the user's abnormal behavior. For the treatment of emotional expression to a face part, intelligent controller units related with the movement should be considered in the body portion and the tail portion. It maybe takes after real cat and be able to do similar movement. Head unit is very important to represent the emotion. It has parts of the eyes with forehead, eyebrows, mouth, and ears like a cat, which are operated with 10 motors. Furthermore the each parts of the face are arranged separately and controlled by each individual motors, so they can move independent and express the required emotions. In connecting the head and neck of the body, two degrees of freedom is implemented with the motion of shaking and nodding, so cat robot has a total of 21 degrees of freedom.
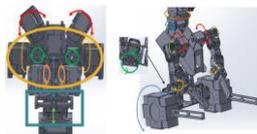


**Fig. 11.** Motor movements in body and face



**Fig. 12.** Cat robot skeleton and motor installation

### 4.2. Controller design

The operations of each part of the body and interactions between robot and ASD children are detected by wide range of internal and external sensors of the robot. Several capacitive contact sensors were installed on head, back, belly, and each arm and leg, which can detect the user's touch. In addition sound generating device was designed to generate cat voice according to various situations. The cat sound can be reproduced through audio Codec with electrical speaker. Sound effect is essential to make interaction each other, especially ASD treatment. An infrared sensor can catch the motion when somebody moves within a boundary of certain distance. It can be

able to measure the distance between user and robot and also direction of movement, so it can be used to increase intimacy with robot. In the waist, a 3-axis accelerometer was installed to measure the robot orientation if the robot was tilted, lifted, or if user try to hug according to the user's feeling.
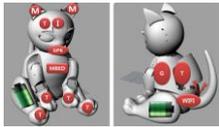


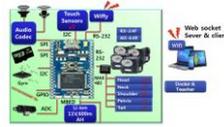**Fig. 13.** Sensor and actuator deployment    **Fig. 14.** Block diagram of the controller

All the proposed motion is determined by number of commands that ordered from operator on the web through Wireless Internet (Wifi), and robot behavior and actions is set by downloading command on the web. In this way a large number of robots operating in wide field are available to play in the response of the robot and easily collect data as a useful therapeutic effect, and the teacher or operator can control the robot remotely as a medium of treatment.

## 5    Conclusion

A cat robot for an early treatment of children with ASD should have to look like a real cat for understanding as a cat to children with ASD. On the other side it needs to be exaggerated expression by personification for better understanding of motions or facial expressions. Initial model of cat robot's outward shape, motions and facial expressions were designed, planned and produced according to these requirements. This initial model of cat robot should have to be covered with appropriate artificial furry coat. In addition the cat robot should be corrected by feedback through realistic application and experiment to children with ASD and normal children. These kinds of studies using corrected perfection model of animal robot is expected to help early treatment of children with ASD.

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