Developing an Initial Model of Cat Robot Utilizing an Eco-friendly Materials for the Use of Early Treatment of Children with Autism Spectrum Disorder

Ja Young Kwon[1], Keum-hi Mun[2], Bo Hee Lee[3] and Jin Soun Jung[4]
[1]*Department of Social Welfare, Semyung University, Jecheon-si, R. O. Korea,*
[2]*Department of Industrial Design, Semyung University, Jecheon-si, R. O. Korea,*
[3]*Department of Electrical Engineering, Semyung University, Jecheon-si, R. O. Korea,*
[4]*Department of Fashion Design, Semyung University, Jecheon-si, R. O. Korea,*

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Abstract: The purpose of this research is to develop an initial model for the use of early treatment that will improve the social interactions of children with Autism Spectrum Disorder (ASD). Researchers from the department of social welfare, electrical engineering, industrial design, and fashion design carried out a fusion research for this purpose. The department of social welfare conducted a survey with professional therapists in order to first find out the necessary treatment components of the cat robot. The department of electrical engineering gave technical suggestions on the practical functions of the robot such as movements and emotional exchanges with humans. In addition, the department of industrial design proposed the robot's exterior, movement, and character designs. Considering that the robot will be used as a therapeutic medium for children, they also developed an eco-friendly material in order to prevent infection and other hygienic problems and also improve the therapeutic effects of the robot. A follow-up study is proposed.

1 INTRODUCTION

ASD is reportedly the fastest spreading childhood disorder (Autism Society of America, 2008). It is known that one in 150 children is diagnosed with ASD (Center for Disease Control, 2008). The main characteristics of children with ASD are that they have social interaction disabilities, communication disabilities, repetitive stereotypy behaviours, and limited attention spans.

There have been a few endeavors and some attention about using robots as a treatment medium for autistic children recently, such as KASPER, Probo. Therapeutic approaches of ASD that use robots commonly show that robots were able to draw out high levels of social interactions from the children with ASD (Robin et al., 2005; Feil-Seifer and Matric ,2008). There were several researches in Korea as well. The first one to apply robots in the treatment of developmental disorders was Cho, Kwon, and Shin (2009). This research conducted one ten-minute session per week for eight weeks where adolescents with ASD interacted with humanoid robots. It was discovered that these adolescents interacted actively with the robots. Kim, et al′s study(2010) on the response of autistic children through interactions with robots showed that robots have a positive effect on children such as increased eye contact, attention, and concentration with teachers. Therefore, these study results show that robots as a medium for treating and educating children with ASD can be effective.

Robot development is a convergence technology that is impossible with just one field of study researching it. It is important, as an early treatment medium for children with ASD, to figure out the assisting role of the robot by first analyzing the user′s disability and lifestyle. A multi-disciplinary research, ranging from robotic technology, exterior design, material design, and development of emotion-based treatment programs, is necessary for the development of a cat robot model that can be used for the early treatment of children with ASD.

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Therefore, this research is composed of researchers throughout the department of social welfare, electrical engineering, industrial design, and fashion design in order to develop an initial model for an eco-friendly cat robot for the use of early treatment of children with ASD.

2 BASIC DESIGN AND REQUIREMENT ANALYSIS

2.1 Clinical Components of a Cat Robot Required for the Early Treatment of Autism Spectrum Disorder

Cross-academic professional clinicians were focus-group interviewed twice and guardians were focus-group interviewed once to investigate the necessary clinical components of the cat robot for the use of early treatment of children with ASD. Table 1 provides personal information about the participants of the FGI. Two series of FGI records were all recorded and transcribed, and summarized and organized into common categories.

Table 1: Background for FGI participants.

	Gen-der	Age	Educ-ation	Areas of expertise	Career (Year)
Session 1	F	34	B.A	Special education	9
	M	44	B.A	Speech therapy	21
	F	45	M.A	Psychology	8.4
	F	55	M.A	Medical Doctor	28
	F	29	B.A	Occupational therapy	5.5
	M	42	M.A	Rehabilitation therapy	15
	F	46	M.A	Physical therapy	23
	F	38	M.S.W	Social Work	14.8
	F	31	B.A	Occupational therapy	6
Session 2	F	30	B.A	Occupational therapy	3
	F	35	M.A	Art Therapy	6

As a therapeutic medium, the cat robot must consist of several therapeutic components.

First, it must be able to act and express emotions appropriate to the situations in order to socially behave and interact with children with ASD. As for emotional expressions, they can be generally divided into two strands: positive and negative emotional expressions. These expressions should include joy, sadness, anger, surprise, and various other changes of emotions. Additional auditory effects, if possible, would be desirable. These functions will allow children to experience positive reactions to their own positive behaviour and negative reactions to their own negative behaviour, bringing about educational and imitational effects for the children, which will help them to become aware of other people′s positive and negative responses.

Second, it must increase social behaviours. The interactions between the cat robot and children with ASD should expedite joint attention. For example, it must be able to make movements that can draw out behaviours such as pointing at the robot or looking in the direction of the robot. It would also be desirable if it could react differently depending on how it is touched. For example, if it is touched softly, it could wag its tails or cry sweetly and if it is touched roughly, then it could raise its tail, scream sharply, or redden its face. It should increase physical contact such as hugging or touching behaviours.

Third, it should be able to move in a way to increase eye-contact or provide other visual stimulus. It should be able to motivate movements such as meeting the eye, holding eye-contact, responding “yes” when called, or turning the head in the robot’s direction.

Fourth, it needs a function where the robot can imitate the child’s actions in order to attract the child’s attention. Furthermore, it would be desirable if there was a turn-taking function where the child can wait for the robot’s reaction and they can take turns reacting to each other’s actions.

2.2 Design Research for an Initial Model

2.2.1 Appearance Design of a Cat Robot

Basically, an appearance of cat robot must be looked like one of cat. An appearance of cat is composed of the head, body, arms, legs and a tail. When designing the appearance of cat robot, it need be studied about what the desirable proportion of each part is. It must be studied for the preference and recognition as to this appearance′s proportion and shape. Also, for the cat robot to take several personified actions, there need many sensors and driven motors. Due to these environmental conditions, the proportions of cat robot could change, compared to the real.

2.2.2 Behaviour Design of a Cat Robot

For the design of a cat robot, cat′s action must be concerned first of all. A cat should have various emotions and show its emotions with whole body such as facial expressions, tail, ears, acts and etc. But, for the early treatment of children with ASD, not only behavioural act of a cat but also personified act such as ′hugging′, ′eye contact′, ′parrotry′ and ′reaction to an inappropriate act′ etc. must be applied. To hug like a man, the first pose of a cat robot must be shaped in a seating posture with its hind legs stretched forward and its forelegs upright.

2.2.3 Character Design of a Cat Robot

The character of a cat robot, for the early treatment of children with ASD, needs to be personified for looks like not a cat′s character but a human′s character (Disalvo, Gemperle, and Folizzi, 2004). Applying personification which projects a shape of an animal or a human onto the shape of a robot has a man come close to a robot better friendly, and makes the character of a robot to be delivered to a man through an appearance or movement in an easier (Disalvo, Gemperle, and Folizzi, 2004). When applying the personification of a cat robot, the character of both an animal and a human must be considered. Because, in the animal personification, non-verbal communication area such as shape of appearance, non-verbal act of a man and behaviour act of an animal are very important. The important elements that reveal the character of a cat are a direction of expressions and a handling of eyes. The expression of both an animal and a human presents an internal emotion. Lee(2003) analyzed the existing studies to abstract a fear, an anger, a sorrow, a happiness and a disgust as common emotions of a man, to develop the tool for the management of robot′s reacting motion. On this study, it would be proceed with five emotional expression of a cat robot substituting disgust with an interest. With regards to the early treatment of children with ASD, the expression with simple and basic essentials would be considered more effective than too much emotional expression.

2.2.4 Early Sketch of a Cat Robot

Early sketch has been progressed for the appearance design of a cat robot. The usual figure of a cat robot was set up as a figure of seating posture with its hind legs stretched forward and its forelegs upright. As you see, it was the easier posture to make an eye contact/hug with the children and follow the motion of children. The usual expression of a cat robot was set up as soft, friendly and tender. Because, it was studied that the warmer and tender of the robot′s appearance like a friend, the more gain the sympathy (Kwak and Kim, 2009).

′A′ ′B′ ′C′

Figure 1: 3 Sketches of a cat robot.

Among these three sketches, the most sympathetic proposal ′C′ was developed by a 3D rendering for making an early mock-up.

Figure 2: 3D Rendering of a cat robot.

2.3 Mechanical and Electrical Design of Cat Robot

Main action of the cat robot is focused on the operation that can be allowed to do eye contact and imitate human′s behaviour. All of the actions are realized by driving electrical motors at the joints as shown in Figure 3. It has a pitch and yaw joint in the neck, and a roll joint at the waist in order to turn toward the user. A pitch joint at femur is installed to raise and pay back body. It can also be able to shake a tail from side to side. In order to realize human behaviour, it is required some arm motions having a yaw and pitch joint in the shoulder, and a pitch joint at elbow. The size of the front legs and available torque of the motor are not determined because they have some dependency related with the body size and weight. The action of hind leg has little skeleton only considering the center of gravity, which was fixed at the ground surface.

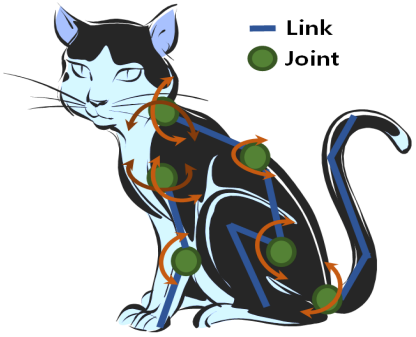

Figure 3: Joint allocation.

Figure 4: Facial expressions.

Table 2: Joint.

body part	joint motion	action
neck	pitch, yaw	look at someone and turn to the children
waist	roll	
foreleg	pitch, yaw	make simple gesture
elbow	pitch	
pelvis	pitch	tilt body
tail	yaw	wave

Table 3: Face behaviour.

face part	Action
lid	open , blind, little blind
eyebrow	change shapes
lip	up and down the lip edge
lip edge	transform up and down
ear	wave back and forth

Facial expression is to get back the result of social learning rather than expression of the fun. Autistic children has some disabilities to read subtle changes appeared in the expression of others. In this study, typical emotional expression method that is based on the presentation by Ekman(1978, 1983), is suggested and can be able to repeat emotional learning. The facial expression is created with using ears, eyes and lip of the robot as shown in Figure 4. The response action like flashing eyes and eyebrows are also deployed in the face. In addition, up and down motions of lip edge are given to express the emotional status of the robot.

Sensors system that can detect a child's response is also suggested. The reaction from the user should primarily be generated by touching and slapping of the body through some pressure sensor and capacitive sensor. They are installed in the site of the forehead and cheeks and placed at paws or tail after reviewing the circuit wiring in the future. The difficulty shown in following the behaviour of human is coming from the technology limitation of image recognition technology and this action has replaced by human control using the remote controller. The sensor measuring the distance between an obstacle and children, and the moving direction sensor are deployed in the face. To give the reaction from the voice and sound, sound sensors are used in the both side of the body and it can be able to communicate with the children using simple words. Figure 5 shows the sensor arrangement and what kinds of sensor systems are used.

Table 4: Sensor measurement.

part	position	sensing
face	head	touch and hit
	cheeks	
	beard	Touch
	ear	loud applause or voice
	forehead	human body
body	back	touch and hit
	forelegs	
	tail	
	internal	facial expression (sadness, delight and joy)
device	external	remote control

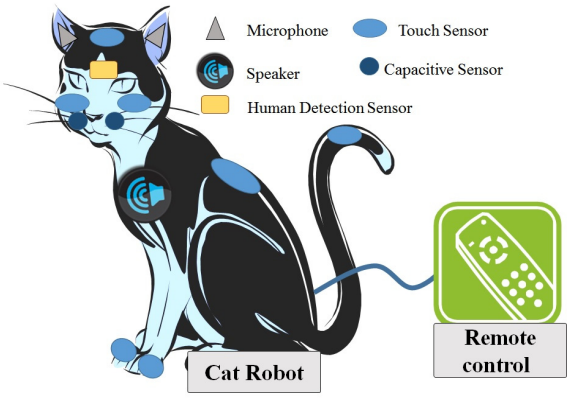

Figure 5: Sensor arrangements.

2.4 Functional Green Environment Fabric Study on Cat Robot Development Base

Essential oils in herb have been long used as fragrances and flavoring in the perfume and food industries, respectively, and more recently for aromatherapy and as herbal medicines (Bucke, 2003; Enan, 2001; Isman, 2006). Also their products are generally considered to have abroad spectrum because of the presence of several active ingredients that operate through insecticide activity(Isman, 2000). Therefore developing a functional green environment fabric that has aromaticity as well as insecticidal effects against house dust mite by using ethanol extract of three herb teas and cacao, will help the sanitation and therapy for children with ASD.

2.4.1 Materials and Methods

Plant materials and extract

Mate tea was purchased at the E-mart department store, Jecheon, Korea. Jasmine tea and jasmine petal tea were purchased via the internet, http://www.homerose.co.kr/.

Each plant material(30g) was extracted twice with 300㎖ ethanol for 24 hours at room temperature. Each plant extract was evaporated at 40±2℃ and 30mmHg by using evaporator and was obtained crude extract. Each crude extract was used as sample for insecticidal effect.

House dust mite and rearing

The mites were reared on ebioze powder mixed with mouse feed(2:1). The cultures were maintained in incubator at 25±1℃ and RH 70 ~ 75%.

Insecticidal effect test against four plant′s ethanol extract

Insecticidal effect test was applied by direct contact method. Different concentrations(1.0, 0.5, 0.25, and 0.012mg/tube) of each plant′s crude extract were prepared by dissolving with 40㎕ of ethanol in 2㎖ tube. And ethanol of each tube was volatilized. Then 25 mites were introduced into the volatilized each tube. And the tubes were maintained in incubator at 25±1℃ and RH 70~75%. Control was treated by 40㎕ of ethanol only in 2㎖ tube. Under the conditions, each tube including control was exposed for 24hours. After 24 hours, the dead mites are counted by using an electron microscope(×20). The rate of insecticidal effect of each plant′s crude extract was calculated as the ratio of died mites to total mites.

2.4.2 Result

Insecticidal effect against house dust mite, *Dermatophagoides pteronyssinus* from ethanol extracts of four plants are shown in Table 5. Insecticidal rate values between 35.46 and 100% were obtained at different concentrations of ethanol mate tea extract. The ethanolic jasmine tea extract and jasmine petal tea all showed insecticidal rate of 40~100% at different concentrations. Insecticidal rate values between 10.50 and 100% were obtained at different concentrations of ethanolic cacao extract. At 1.0mg/tube and 0.5mg/tube concentration, ethanol extracts of four plants resulted in a high mortality rate of 93.01~100%.

Table 5: Insecticidal effect of ethanol extracts of four plant species against house dust mite, *Dermatophagoides pteronyssinus.*

Plant material	Concentration (mg/tube)	Mortality(%)[a]
Mate tea	1.0	100
	0.5	98.00
	0.25	54.29
	0.125	35.46
Jasmine tea	1.0	100
	0.5	100
	0.25	100
	0.125	40
Jasmine petal tea	1.0	100
	0.5	100
	0.25	91.25
	0.125	40
Cacao	1.0	100
	0.5	93.01
	0.25	83.33
	0.125	10.50

[a] (remained mites/Total mites) × 100.

3 CONCLUSIONS

The therapeutic components required of a cat robot

for the use of early treatment of children with ASD are the ability to express various emotions, to carry out social behaviours, to hold eye contact with the children, and to imitate actions. When designing, the concept of appearance, behaviour and character are to be set up preferentially. For the design of an appearance, a proportion of head, body and tail including ears and face as well as forehead, eyes, nose, mouth and chin must be studied. For the design of behaviour, the relationship between emotional expression and an action must be grasped. Also, an effective action must be investigated and established for an early treatment of children with ASD. For the design of character, it needs a personification. A desirable method of personification must be established considered with the characters of both animal and human.

Joint movement, facial expression, and sensory system were proposed in order to realize their function including how to install and control the body. The proposed robot will have 8 joints in the body, 8 joints in the face, and be deployed over than 10 kinds of sensory system with sound management and touch detection.

The insecticidal effect against house dust mite of ethanol extracts from three herb teas and cacao was examined in the study for developing an eco-friendly material. An effort to sophisticate this early developmental model must be continued. Follow-up studies that take this early developmental cat model and evaluate its effectiveness and improve its weaknesses through actual experiments should be carried out.

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REFERENCES

Boutot, E. A., Myles, B. S., 2011. Autism Spectrum Disorders. Foundation, characteristics, and Effective Strategies. Pearson Education. Inc.

Bucke, J. (2003), Use of aromatherapy as a complementary treatment for chronic pain. Altern 5.pp 42~51.

Cho, K., Kwon, J., Shin, D.2009. Trends of cognitive robot based intervention for autism spectrum disorder, *Journal of Korean Association for person with autism,* 9(2). pp 45~60.

Disalvo, C., Gemperle, F., Folizzi, F., 2004. Imitating the human Form: Four kinds of Anthropomorphic Form. Futureground 04 Proc.

Ekman, P., Friesen, W., 1978 Facial Action Coding System: A Technique for the Measurement of Facial Movement, *Consulting Psychologists Press.*

Ekman, P., Friesen, F., 1983. EMFACS-7: Emotional Facial Action Coding System. Unpublished Manual, University of California.

Enan, E., 2001. Insecticidal activity of essential oils: octopaminergic sites of action. Comp. Biochem. Physiol.

Feil-Seifer D, Matari´c M. J. 2008. A control architecture for autonomous robot-assisted behaviour intervention for children with autism spectrum disorders. Proc. 17th IEEE Int. Symp, Aug. 1–.3, Munich, Ger., pp. 328–.33. Piscataway, NJ: IEEE.

Isman, M. B., 2000. Plant essential oils for pest and disease management. Crop prot.

Isman, M. B., 2006. Botanical Insecticide deterrents and repellents in modern agriculture and increasingly regulated world. Annu. Rev. Entomology.

Kim, K. H., Lee, H. S, Jang, S. J., Ku, H. J.2010. The Reaction of Children Labeled with Autism through Interactions with Robot*, Journal of emotional and behavioural disorder*, 26(1). pp.331~353.

Kwak, S., Kim, E., 2009. Design of the Emotional Robot for Human Empathy. *Journal of Korean Society of Design Science*. 22(5) 27-34.

Lee, D. K., 2003. A Study on the Entertainment Robot Behavioural Structure and Reactive Motion Design. KAIST. Master's thesis.

Probo project. 2010, www. probo.vub.ac.be.

Robins B, Dautenhahn K, Te Boekhorst R, Billard A. 2005. Robotic assistants in therapy and education of children with autism: Can a small humanoid robot help encourage social interaction skills? *Univers. Access Inf. Soc*. 4(2):105–120.