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# Communication with Self-Growing Character to Develop Physically Growing Robot Toy Agent

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**Featured Application: Synthetic character implemented to physically self-growing robot can be utilized as a teacher assistant for childhood education with its sympathetic communication.**

**Abstract:** Robots for communication are developed extensively with emphasis on sympathy. This study deals with the growth of character and the control of its operation accordingly. The child has time to be alone with the nature of his/her robot friend. The child can interact with other people's emotional expressions through a robot. Step by step, the robot character will grow as the child grows. Through design studies, qualitative processes such as {customer experience audit, eye tracking, mental model diagrams, semantic differences} have been executed for the results. The participatory behavior research approach through user travel is mapped from the user's lead to the evidence-based design. This research considers how the synthetic characteristics can be applied to the physical growth of robot toys through the product design process. With the development of robot toy "Buddy", we tried making two variations on the robot to achieve recognizable growth. (1) An one-dimensional height scaling and (2) facial expression including the distance between two eyes on the screen. Observations represented children's reactions when "Buddy" was released to with the children. As an independent synthetic character, the robot was recognized by children who had the designed function. Robots for training may require more experimentation.

**Keywords:** motivation; children; learning; entertainment robot; interaction; synthetic character

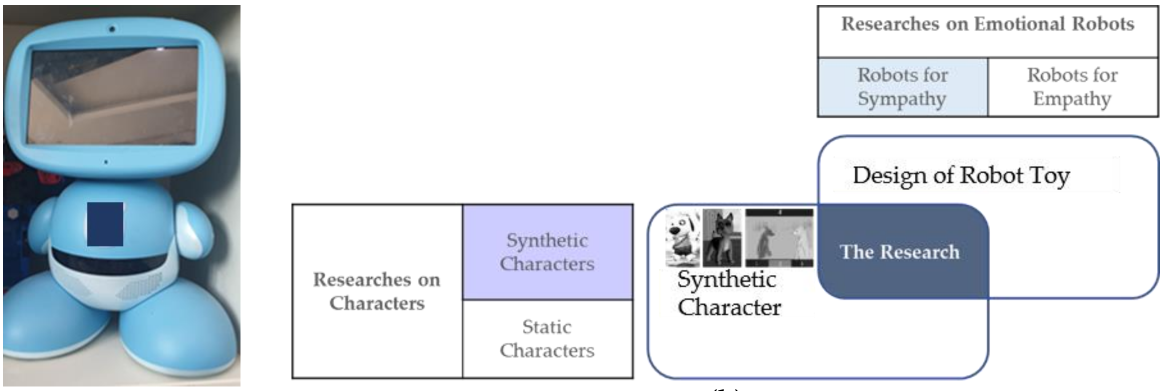
## 1. Introduction

In recent years, most of robot research has been devoted to the replacement work by the robot. On the other side, few have investigated the simulation of communication between human and robot. Children are more likely to engage in interaction with robots because they perceive robots more positively and more life-like.[1,2] Furthermore, robot design based on user research of personal service robot has become an important research issue.[2] The introduction should briefly place the study in a broad context and highlight why robot design for children is important. The introduction should briefly place the study in a broad context and highlight why it is important.

As "learning with character" or "learning with RT", a study of "PaPeRo" applied to edutainment[3] and AIBO applied as a dog friend that tells storybooks of children like story-telling robot[4]. So far, research on educational robots has focused on children's reactions and learning effects when applied to educational environments.[5]

However, in order to utilize the robot into the education field, it is not limited to simply introducing the robot to the education. It is necessary to apply various existing pedagogical theories to the interaction design of the educational robot and verify it against the children. Research on educational robots increase the focus, interest, and achievement of children's learning in comparison to other traditional media[7]. Thus teacher assistant role, suggesting that relationship as medium for inducing learning motivation of children is more important than educational contents delivery.

Children often get tired of toys they play with when they are younger. As the children grow up, they want to have new toys for their age. Unlike nature, which changes with the passage of time, dolls and existing robot toys retain their original appearance. Even when dealing with toys or serious games that have specific functions, children find another matters to play when they are consumed for a certain amount of time.




(a) (b)

**Figure 1.** Synthetic character & Robot: (a) Robot toy abandoned; (b) target area/scope of the research

The purpose of this research is motivating children in learning with the synthetic character as a matter of entertainment robot. In this paper, we design a teacher - assisted robot interaction system that can maximize empathy to operate a teacher - assisted robot that can induce children 's learning motivation and reduce the novelty effect. Based on the "Buddy" robot developed by the same researchers, the research on the character of the growing robot character and the empathic interview are used to verify that the robot can be used as an object of empathy that can serve as a teacher assistant[7] role.

## 2. Synthetic Character

Every developed robot has its own character. ex) Synthetic character is an creature that artificially have its own motivation, which can make real-time interaction with human.[5,7]

### *2.1. Former Researches on synthetic character*

2.1.1. Synthetic character resembled with animal (around year 2000)

According to the synthetic character group in MIT Media Lab, synthetic character[6] approaches:

- "Everyday common sense"
- "The ability to learn"
- "The sense of empathy"

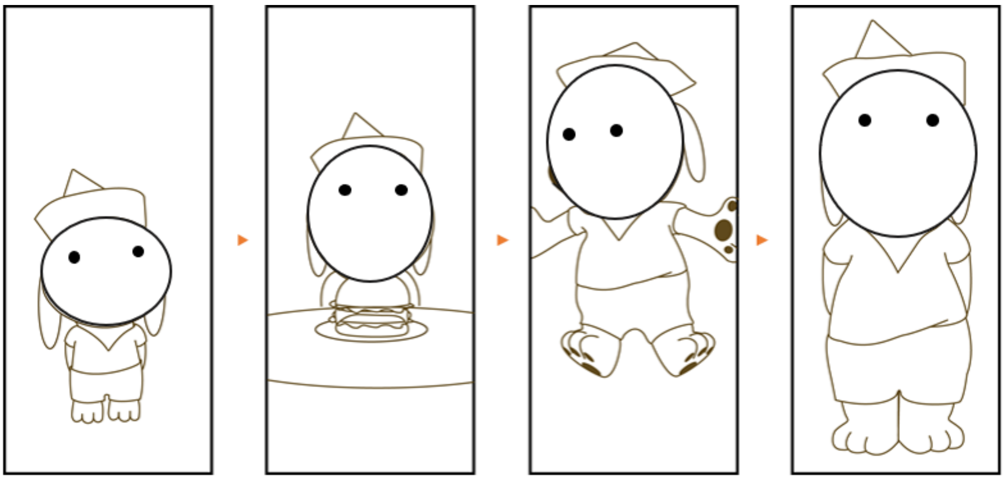
Integrated approach that implements adaptive and expressive virtual characters appeared in archive projects for synthetic animals characters such as dogs. Its result created characters that seem to have their minds in the context of the behavior - for example, multifaceted approach to designing systems that mimic biological systems as clues and design principles have used. [8,9]

2.1.2. Synthetic character in the real-world application

According to the synthetic character research of Rodrigues et al.(2009)[10], there are two common related concepts:

- Empathy
- Sympathy

Motivation from synthetic character was introduced from education industries. Plenty of user researches are ongoing while many companies are producing a lot of toys, dolls, computer games, and mobile applications associated with the use of synthetic character available to motivate users work, study and train objectives. [14] Especially for children, eating / sleeping habits were triggered to be modified with the help of synthetic character in various media like TV, book, game, and so on. For example, a variety animals in storybook is implemented to the mobile game with synthetic character growing by input of good habits.



(a) (b) (c) (d)

**Figure 2.** Growth level of the synthetic character in the mobile game be listed as: (a) Level.1 Infant; (b) Level.15 Elementary school student (c) Level.30 Teenager (d) Level. 40 Adult in animals such as dogs – grow according to the experience of food, bath, trip, and so forth from the mobile game. [11]

On the other hand, synthetic character is able to decide its own behavior upon its own internal/external information by itself within interactive learning approaches.[12] Unsupervised facial expression is available in front of a child with input from children. In this project, we decided the synthetic character by physical growth and facial expression in its own design.

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*2.2. Design Process of Robot Character in Application with Robot "Buddy"*

"Buddy" began with the need for a dynamic playground, enabling emotional interchange so that it can play with the child. This background starts with the child's lack of peer experience which is critical for his/her development. It was introduced in context of half of babies are facing the lack because their parents are too exhausted from working or childcare in South Korea.[13] For lonely children and exhausted parents, an interactive robot toy "Buddy" was designed to become a friend of babies/infants. Requirements and needs for the robot toy can be extracted from a series of design processes.

2.2.1. Dairy studies for collecting user insight

Diary studies are useful tools in exploratory research, preparing the designer for further research by contributing to an understanding of participant user groups.[14] Unlike traditional diary studies with paper and pen, digital photos uploaded on provided sites like facebook, instagram was main material in this study:

- Facebook post: message with photo
- Instagram post: digital photo with description

In the context of the burden of care, photos uploaded to the parents' site represent a special memory that parents and children can't frequently use. The specification of the robot toy includes the additional function of memory to remember the situation of specific events. As a result, the appearance of the robot toy is human-like and it communicates with the child as one's friend and teacher assistant.

2.2.2. Goal of design: position behind the uncanny valley

According to the following qualitative studies, target robot toy decided its position behind uncanny valley.[15,16] Humanoid robot. For example, BeatBo works as dancing robot toy for baby which has features of dancing with moving, learning with games, and customized sing-along gross motor.[17] The requirement for robot toy might be a humanoid robot which plays accordingly like stuffed animal in front of babies.

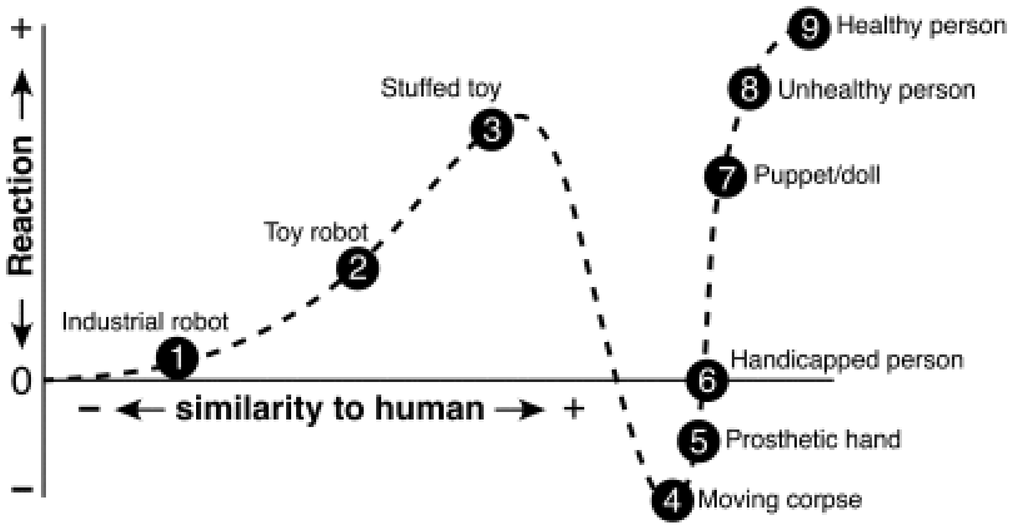
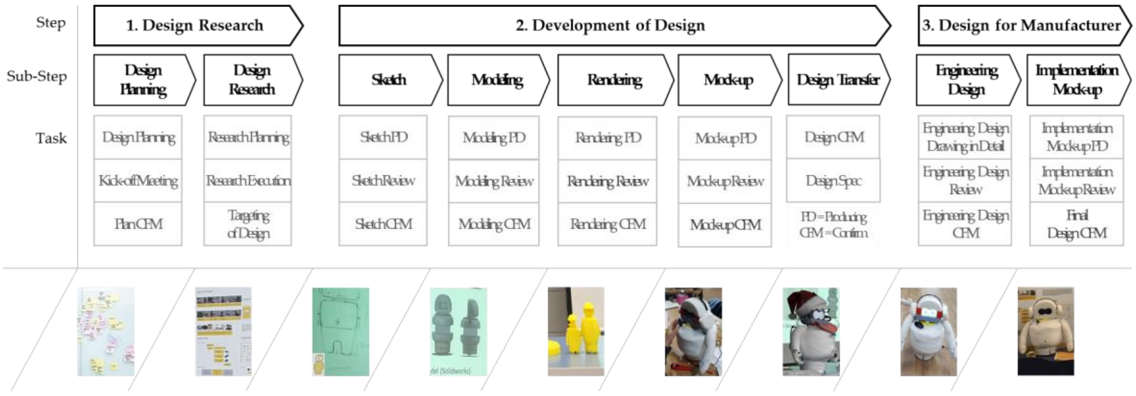



**Figure 3.** Realism of Robot[16], behind uncanny valley. [15]

2.2.3. Total Design Process: From Design Research to Development and Implementation




**Fgure 4.** Total design process of physically growing robot "Buddy"

## 3. Results

In this research, we apply growth system applied to character to human - robot interaction to observe children 's recognition and reaction to robot. This section deals with the growing robot device and method for controlling operation thereof.

### *3.1. Design Result: Function of Communication*

#### 3.1.1. Data network of the robot toy

Describing from the operation module, the control terminal is an information processing apparatus, and can be connected to a server 30 at a remote location via a network or directly to another terminal via direct or other information processing apparatuses. The control terminal can be provided with a client program for controlling the growth robot apparatus and can control the setting of the growth robot apparatus through the installed client program. The growth robot apparatus can communicate with the control terminal via the network. The control terminal 20 can be connected to the remote server 30 through the network N or to the other terminal and the server 30. Robot system is networked with control terminal for controlling the growth robot and outside server as shown on Fig.1.

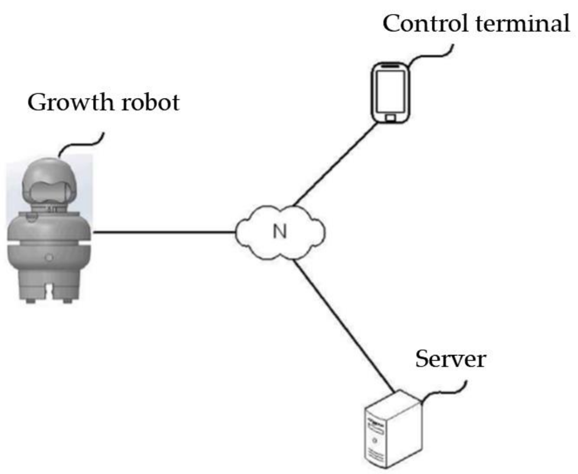



**Figure 5.** Network linked among growth robot, the control terminal, and the server.

#### 3.1.2. Communication between robot and child

Hereinafter, each component provided in the growth robot apparatus will be described in more detail. The camera provided in the growth robot apparatus senses an object located in the vicinity and photographs a person in front of the person so as to identify a facial expression of a person. The camera may include a plurality of cameras as needed. The camera can measure light intensity, such as light intensity (day, night, light, dark, etc.).

For example, the control terminal can control the software of the growth robot apparatus to be changed according to the customized character and physical growth level of a person interacting with the growth robot apparatus, It can be installed via download, or it can be updated voluntarily. For instance, the growth robot apparatus can photograph a person with a camera equipped therein and can store photographed pictures or moving pictures. Then the growth robot apparatus can provide the stored photographs or moving images to the control terminal or output it through a screen outside, and a child user can interact with pointing out the product on screen.

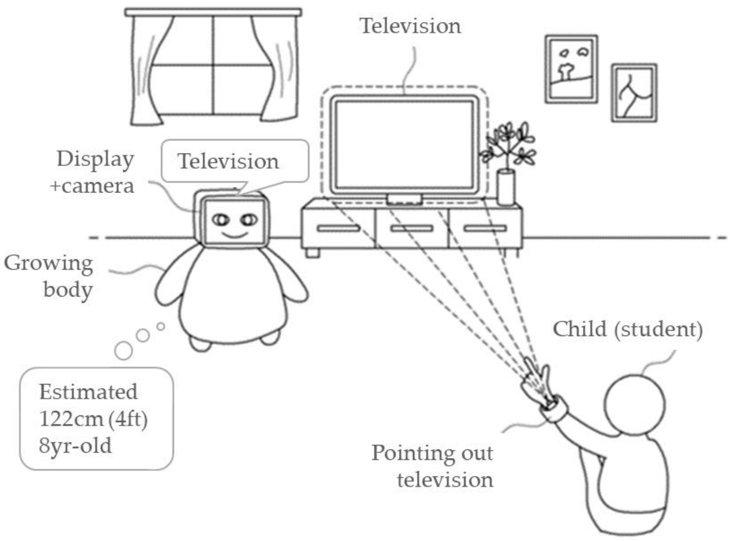
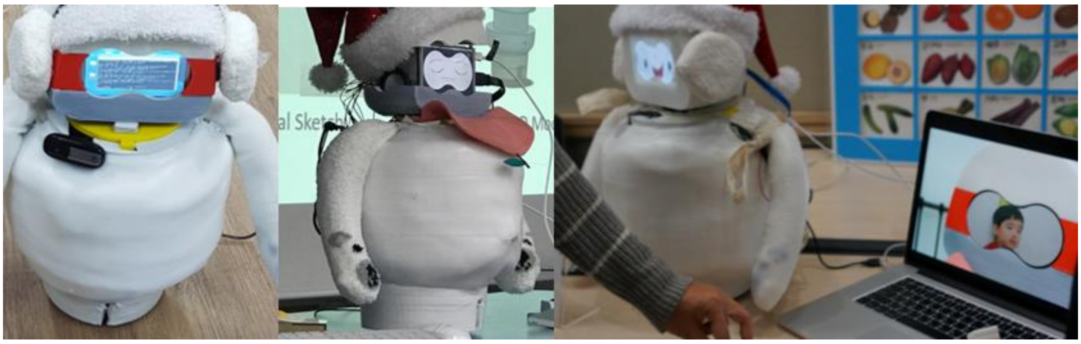



**Figure 6.** Design draft version: use of equipped camera to recognize both: 1) user height and 2) user position including the direction of user and the distance between robot apparatus and the user.

For another example, the control terminal can receive a height of a person from camera or picture of a standing person. It is able to control the hardware of the growth robot apparatus to be changed in accordance with the input of person's height. The growth robot apparatus may be divided into a head part, a body part and a leg part.



(a) (**b**) (**c**) (**d**)

**Figure 7.** Facial expression control on the LCD of robot head: (a) Console window; (b) Draft facial (c) Smile facial (d) Imagination of special memory mode that parents and children can frequently load.

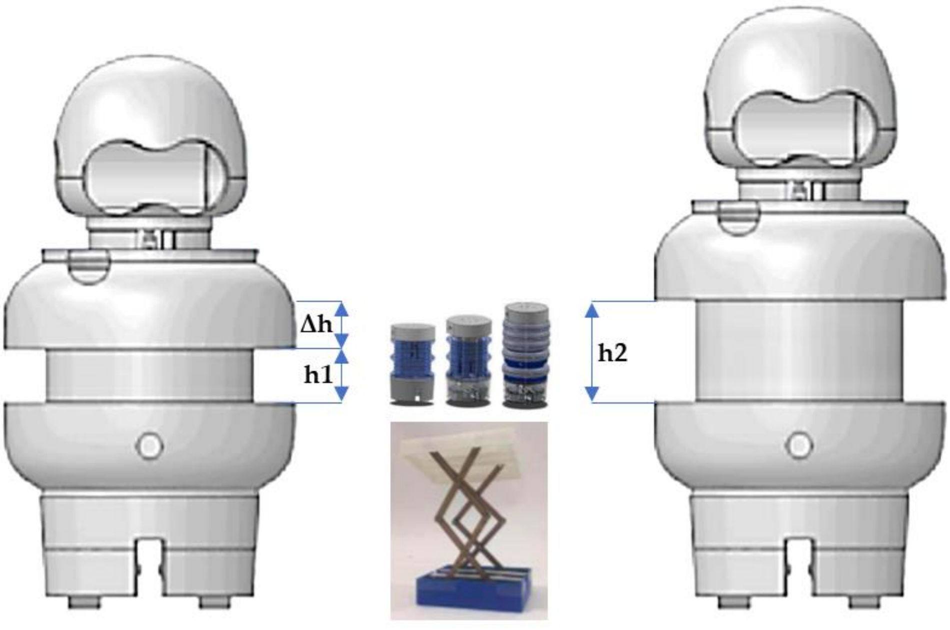
The head part of the growth robot apparatus is provided with a screen for displaying the facial expression change of the growth robot apparatus. The liquid crystal display attached on the front part of the robot apparatus displays its facial expression as well as output image for the user from the processing signal of robot as the face screen. For example, the LCD can be controlled by a single LCD control signal. A variety of reaction images can be generated internally from the robot. Control process image processor allows images input through a camera, and a facial expression to be displayed on the screen as output. With the additional ultrasonic kit assembly of sensors for sensing multiple obstacles, robot can detect a person or a product located in the vicinity of the robot apparatus. It can also detect distance to a person from the difference of distances from all available ultrasonic sensors. When a child ask a question, the robot apparatus will recognize the person and the distance with the person simultaneously with preparing the answer.

### *3.2. Design Result: Function of Self-Growing*

#### 3.2.1. Growth robot implementation

The growth robot apparatus can perform hardware growth in which the height of the growth robot apparatus is changed according to the change of the key of the interacting person. That is, the growth robot apparatus can change the length of the body portion of the growth robot apparatus according to the height of the person obtained from the control terminal. For example, the growing robot apparatus can acquire the current person's key from the control terminal 20, and is provided in the body portion of the growth robot apparatus so as to have a key similar to the acquired person's key The length of the body part can be changed by increasing or decreasing the tube as a lifting device. In its appearance, growth robot's skin is covered with a stretchable material(Dragon skin 10) according the change of body height.

The growth robot apparatus can grow in response to a change in the physical growth level and height of the interacting person, and the growth robot apparatus can perform both software growth and hardware growth. For hardware growth, there is an exemplary view showing a lifting device provided in a body portion of the growth robot apparatus. The lifting device of the growth robot apparatus may have a structure capable of varying the length, and the corrugated tube system appears like larva skin. Growth signal is implemented with wrinkled tube system including scissor jack inside as shown on Fig.2.




**(a)** **(b)** **(c)**

**Figure 8.** Robot growth implementation: (a) Height from h1 and intent of extension of Δh

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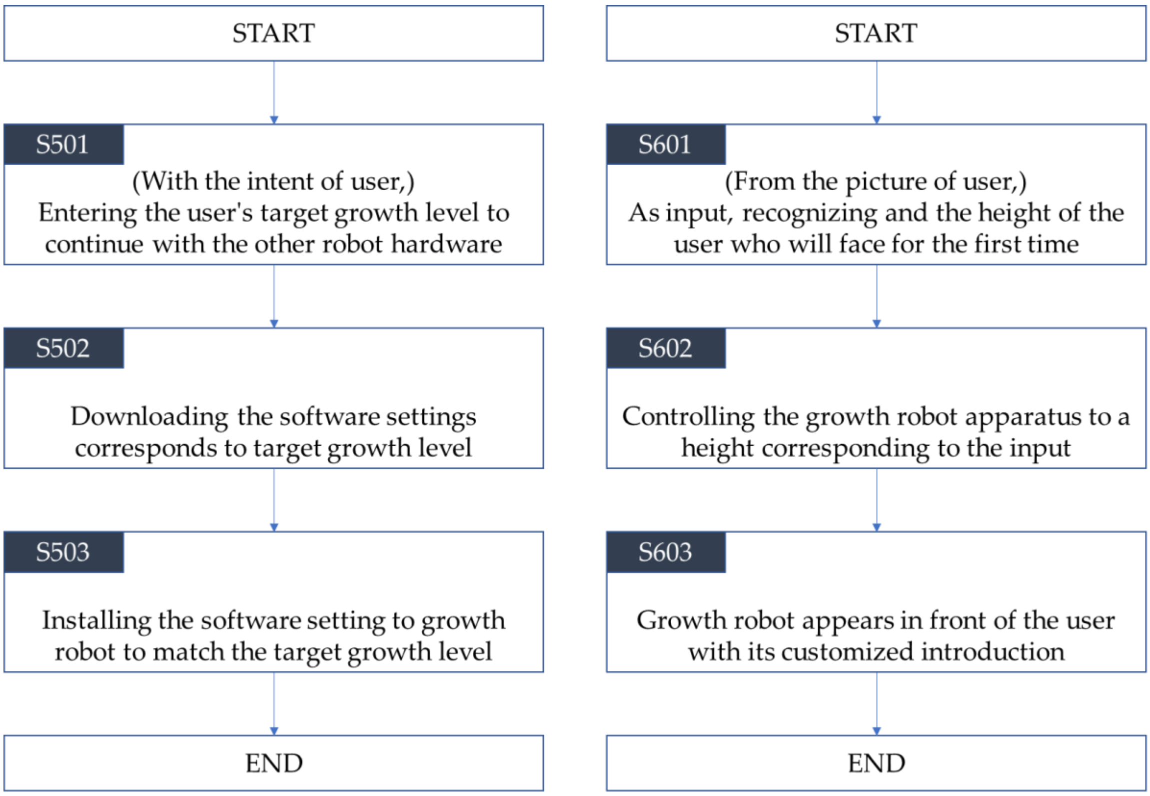
(b) implementation of Δh with wrinkled tube including scissor jack structured inside and
(c) after the physical growth of Δh up to h2

3.2.2. Growth robot operation

The body portion is coupled with the lower end of the head portion, and the length of the body portion is varied in the vertical direction so that the height of the growth robot apparatus is changed. To this end, the body portion can be separated into an upper end portion and a lower end portion, and a lifting device having a variable length is provided between the upper end portion and the lower end portion. As the length of the lifting device is changed, the length between the upper end portion and the lower end portion of the body portion is changed, so that the height of the growth robot apparatus.

Also, the leg portion may be coupled with the lower end of the body portion, and at least one wheel may be provided at the lower end of the leg portion, so that the wheel can be moved using the wheel. On the front part, a microphone for sensing a voice of a person, and a speaker for outputting a sound. A method of controlling the growth robot toys through the control terminal display will be described with reference to Figs. 5(a-b). Robot is able to be settled according to the user as Figure 10.




**(b)** (**b**)

**Figure 1.** Robot settles: (a) S500s: donor to the target user; (b) S600: reconfigure to new user in other mode. A flowchart showing a method of controlling software function of the growth robot apparatus.

Referring to the chart(a), the control terminal can receive the intelligent growth level of the person interacting with the growth robot apparatus from the user (S501). Then, the control terminal can search for software setting corresponding to the growth level on input, and download the searched software setting (S502). The control terminal can collect information about the software installed in the growth robot apparatus and determine whether or not the user is similar to the growth level of the input user. At this time, when the physical growth level of the software differs from that of the person, the control terminal can search the software of the growth robot apparatus and request the settlement of the software corresponding to the growth level of the user. Thereafter,

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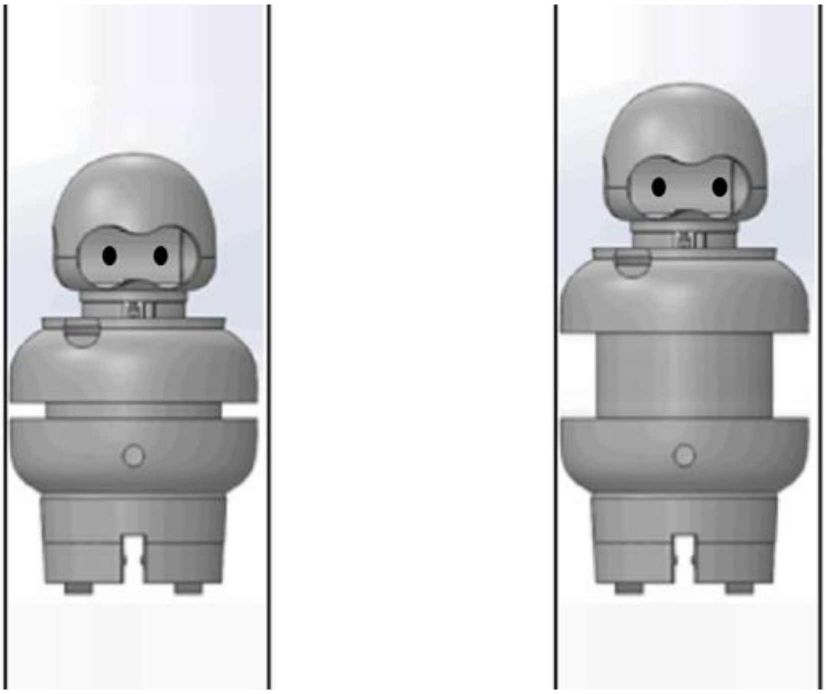
the control terminal can control the growth robot apparatus so that the settled software can be installed in the growth robot apparatus (S503).

On the other side, chart(b) is a flowchart showing a method of controlling the keys of the growth robot apparatus by the control terminal. The control terminal can recognize a height of a person from the prepared picture of the user (S601). Then, the control terminal can operate the lifting apparatus provided in the growth robot apparatus to correspond to the height input (S602). Then the growth robot can introduce itself with the customized settled height in front of the user (S603).



(a) (b)

**Figure 10.** Robot growth: (**a**) Physical appearance of robot before growth; (**b**) after growth.

**Table 1.** Degree of robot growth over age(example)..

| Growth over age | 4month | 3yr-old | 8yr-old |
| --- | --- | --- | --- |
| height(cm) | 65cm | 95cm | 122cm |
| height(ft) | 2.13ft | 3.11ft | 4.00ft |

The control method according to the embodiment described with reference to Figs. 10 (a,b) can also be implemented in the form of a recording medium comprising instructions executable by program modules. One-dimensional height scaling logs and output files would be stored in computer readable media can be any available one that can be accessed by a computer. This can include both volatile and nonvolatile or, both removable and non-removable ones those are implemented in any method or technology for storage of information such as computer readable instructions, data structures, program modules or other data. Communication media typically include any information delivery media including computer readable instructions, data structures, program modules, or other data in a modulated data signal such as a carrier wave or other transport mechanism.

## 4. Use Case Discussion

The growth robot apparatus can ask a person a question and can detect a person's behavior on a question. That is, the growth robot apparatus can ask a person about a name of an object, recognize a person's answer to a question, and recognize a person's expression or movement through a camera. The following Figure 11 describes a situation of a growth robot apparatus with the embodiment of the present invention interacting with a child user in Figure 6.

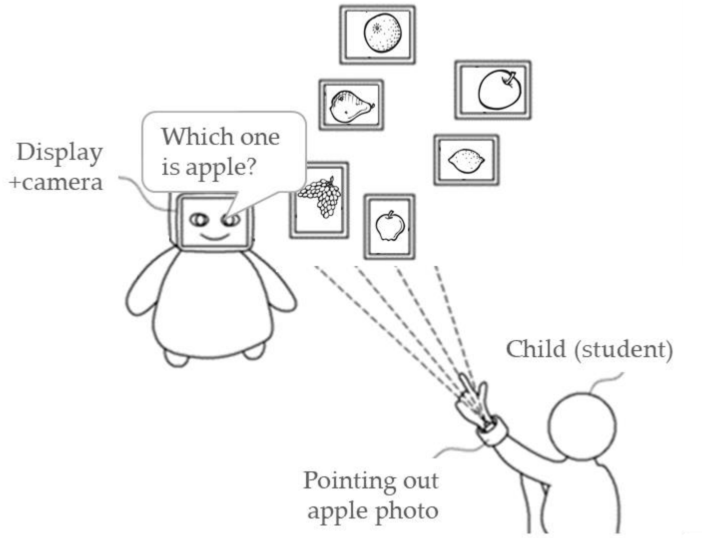



**Figure 11.** Example: robot-child interaction of fruit quiz.

## 5. Conclusions

We introduced the concept of a synthetic character applied to the robot toy. The character has a name of "Buddy" and form of humanoid robot which has physically growing function. The robot toy is able to be utilized as a teacher assistant. This robot was developed via design processes dealing with qualitative approaches which result in humanoid robot behind uncanny valley for the assistant function. To act as teacher assistant, main communication function of the robot with camera is to recognize which the user point out. Above the functionality, the robot toy also grows physically in sympathetic mind about children.

Further research is needed to compare the response of teacher assistant tasks by increasing the number of subjects in elementary school students in various settings. Also, it is necessary to search for appropriate stimulus method of teacher assistant task, and further analysis according to students' grades, personality, age, and so forth.

## 6. Patents

This research is registered in patent application: Eune, J., Lee, M., ... & Jeong, H. (2016). Growing robot device and method for controlling operation thereof. Korean patent No. 10-2016-0183090. Daejeon: Korean intellectual property office.

**Author Contributions:** Conceptualization, H. J. and A.P.; formal analysis, H.J.; investigation, M.L., A.P. and C.L.; methodology, A.P.; project administration, M.L. and J.E.; resources, M.L., J.K., C.L., T.S. and P.L.; software, J.K., C.L., T.S. and P.L.; supervision, S.K. and J.E.; visualization, H.J.; writing – original draft, M.L. and J.K.; writing – review & editing, S.K. and J.L.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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