SHAUN—A Companion Robot for Children Based on Artificial Intelligence

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Abstract. This article is aimed at providing a design principle for companion robot based on Artificial Intelligence. Taking children at 0–6 years old as target users and their parents as target customers, the author applied methods of investigation and observation to understand their income level, life routine, habit, pain points, consumption capacity and aesthetic level. With these previous researches and some utilization of ergonomics, this paper defined the function, size, material of Companion Robot for children. This paper explores and summarizes the user orientation of Companion Robot for children, its functional definition, material definition and man-machine definition, and shows the design practice under its guidance. This study will provide guidance for future design of companion robots and make the design location clearer by putting forward design concepts and guidelines.

Keywords: Companion Robot · Artificial Intelligence · User experience design

1 Introduction

1.1 Research Background

With the rapid development of Big Data and the Cloud, Artificial Intelligence technology has entered the third development peak. As the solid foundation of the development of many other novel technologies, AI will become the most important technology in the world in the coming decades. The concept of Artificial Intelligence was first presented at a conference held by The Dartmouth Society in 1956. The most important topic is how to imitate human brain with computer and realize some intelligent functions. And AI has now become a subdiscipline of Computer Science. At present, the development of many technologies is related to AI. Today, AI is mainly applied in 7 fields: AI Assistant, Intelligent Security, Unmanned Driving, Healthcare, E-commerce, Finance and Education.

From 2014 to 2017, the scale of Chinese AI market rose from 4.86 billion yuan to 13.52 billion yuan, with an average compound annual growth rate of more than 40%. Among them, the scale of Chinese AI industry reached 9.560 billion yuan in 16 years, an increase of 37.9% over the same period last year. In 2017, it was 13.52 billion yuan, an increase of 41% over the same period last year.

AI currently plays the following functions in the field of education: 1. Helping children learn individually in accordance with their aptitude. 2. Counseling on daily

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questions. It has become a supplement to teachers' face-to-face instruction. 3. Intelligent assessment. Reduce the pressure on teachers to correct homework, and achieve large-scale and personalized homework feedback. 4. Teaching with pleasure. AI can establish an entertaining teaching platform. Therefore, Companion Robot for children based on AI becomes a bridge between parents and children and provides a medium for their interaction [1]. In modern time, parents pay more and more attention to the education of children from preschool period, hoping to cultivate children comprehensively, so that children can grow up happily and excellently. Companion robots have gradually become a part of life, relying on the progress of artificial intelligence technology. Companion Robot is a bridge and medium for parents and children to communicate and interact emotionally. With the introduction of second-child policy in China, the market for children has quickly become active. Every year, tens of millions of newborns are born, and the number of children aged between 0 and 8 is about 120 million. Parents are post-80s and post-90s, the main consumers in the current market. They are advanced enough to adapt to globalization. They attach great importance to children's education, especially in early stage and are more willing to invest more in children's development.

1.2 Research Significance

Preschool education is the initial education for children and is especially important for them. Nowadays, the whole society is paying more and more attention to education, various new education methods and tools are emerging. At the same time, according to the survey, nowadays, many young parents are at the peak of their career and they can only spend less than an hour with their children every day. More or less, 60% of parents miss the representative moment when their children grow up. 70% young fathers miss their children's first word because of their business [2]. Only by accompanying the children and giving them optimal education can the children grow up healthily and excellently, and leave a good memory in their childhood life.

Therefore, based on the development of AI technology, Companion Robot is designed to integrate the round and lovely image into children's life. It is easy to be regarded as a close and easy-to-communicate friend by children. Implicitly, it can help children develop good habits, good mentality and make education more interesting, more diverse. Robots are not only partners, but also good teachers. They relieve the parents' burden of education, make up for the deficiencies, and enable children to acquire knowledge and grow up in a happy life.

Taking into consideration the development of AI technology and the psychophysiological characteristics of children aged 0–6 years, this study provides concepts and guidelines for the design of Companion Robot for children.

2 Review of Previous Research

2.1 Academic Research on Companion Robot

In recent years, research on Companion Robot has been under heated discussion. The research scope of companion robots is also quite wide. Meghdari et al. designed a

mobile social Companion Robot "A rash" for the education and treatment of children with chronic diseases. It is mainly aimed at children with cancer who suffer from physical pain caused by disease and its treatment. Using robotic partners to interact with sick children in hospital environments can reduce their pain and thus improve the efficiency of cancer treatment [3]. Billard et al. constructed robots with physical characteristics similar to human babies. It has been used as an assistant technology in behavioral research of autistic children [4]. Michaelis et al. designed learning partner robots to increase reading activity and observe the impact of robots on family reading experience [5]. Cavallo proposed a novel method based on reliability and acceptability assessment. This method is used to design, develop and test a personal robot system consisting of a mobile robot platform and an intelligent environment to assist people at home. The viewpoint that robots need to cooperate closely with human beings, so novel interactive engineering design methods are needed to develop service robots [6] that meet the needs of end users and can be used quickly in daily life.

On the AI side, Alpha GO Zero, released by Google, can learn from self-matching and millions of pieces of chess data. Boston Dynamics released SpotMini robots that can quickly adjust leg gait, keep standing, and eventually resume standing to complete tasks. SpotMini is also equipped with a large number of sensors, such as RGBD camera, attitude sensors, and body sensor of the limbs. These sensors can help Spot-Mini perform complex actions and cruise. The goal of Boston Dynamics is to build a robot that is more mobile, agile and perceptive than humans and other animals. At present, their research results show us the breakthrough of AI technology, which will have infinite possibilities and broad application prospects in the future.

2.2 Design Application on Companion Robot

The International Federation of Robots (IFR) released its latest global service robots statistics report in March 2016. Global sales of dedicated service robots in 2014 were 24 207, 11.5% higher than 21712 in 2013, and increased by 3% to $3.77 billion from 2013. However, research on the global service robot market is still in its infancy. The compound annual growth rate of service robot market will reach 17.4% in 2017, and the market scale is expected to reach 46.18 billion US dollars in 2017. It is expected that the annual composite growth rate of service robotics industry in China will reach 40% in the next 5 years, and the market penetration will gradually increase.

In today's robot market, Krund robot-WOW is a new-emerging force of service robot. It can do various interaction with family members through face recognition, sound source localization and voiceprint recognition. At the same time, it can learn independently through the Internet and improve its performance. It also has detection function. Sensors such as temperature, humidity and PM2.5 in the body of the robot can monitor the environment at home in real time, detect whether the elderly fall down and the children are safe, and monitor the situation at home in all aspects. Users can use simple voice passwords to control existing domestic appliances.

ZIB-1S is a dark horse in the field of Companion Robot. It is the first smart robot in China to categorize children's company market. It is especially for children's growth and companionship that each function is subdivided. In order to protect children's

hearing, a volume adjustment test was conducted. Radiation is prevented to protect children's health through screen-less design and touch dialogue details.

Buddy is positioned as a family emotional social robot, mainly for young people and the elderly. It is equipped with cameras, voice recognition and face recognition to handle daily household affairs and monitor home security. Drug reminder and drop detection functions are designed for elderly users while nursery rhyme player is designed for children.

AIBO ERS-1000 has advanced and special learning and growth capabilities. Equipped with SONY self-developed ultra-small 1-axis and 2-axis actuators. AIBO has 22 degrees of freedom on its body. At the same time, through fisheye cameras and different sensors, AIBO can recognize and analyze images and sounds, and can respond to the host's voice, and recognize the host's smile and praise. Remember the actions that can make the host happy, etc.

From the point of view of the current application situation, a comprehensive comparison of these representative companion robots is completed (Table 1).

Table 1. Characteristics of present Companion Robots.

Name	Type	Use scenario	Characteristics	Disadvantages
Krund robot-WOW	Service robots	At home, banks, kindergartens, restaurants, supermarkets	Face recognition, sound source localization and voiceprint recognition, interaction, self-learning. Temperature, humidity, PM2.5 sensor in it. Monitoring the family environment. Voice control	Large and tall
ZIB-1S	Companion Robot	At home	Online education, Human-computer interaction and Special features. In order to protect children's hearing, a volume adjustment test was conducted. Radiation is prevented to protect children's health through screen-less design and touch dialogue details	Static and Not vivid
Buddy	Family emotional social robot	At home	It is equipped with cameras, voice recognition and face recognition to handle daily household affairs and monitor home security	Less content for children
AIBO ERS-1000	Pet robot	At home	Equipped with SONY self-developed ultra-small 1-axis and 2-axis actuators. AIBO has 22 degrees of freedom on its body. At the same time, through fisheye cameras and different sensors, AIBO can recognize and analyze images and sounds, and can respond to the host's voice, and recognize the host's smile and praise. Remember the actions that can make the host happy, etc	Realistic image makes people lack imagination. No screen

Summarize their advantages and disadvantages, learn from their strengths and make up for their weaknesses. Companion Robot for children should be considered in such aspects as appropriate size, interesting, functional design for children, modelling that can meet contemporary aesthetics and stimulate purchase.

3 Research Method and Procedure

Firstly, by using literature research method, through reading and referring to many literatures of high quality from international conferences and journals, the research status of Companion Robot is comprehensively understood, which lays a foundation for the research of the design concept of Companion Robot.

Secondly, the qualitative analysis method is used target the user group through investigation and observation. And do in-depth research around the target group of products. Because the target group of this study is children aged between 0–6 years old, and the target consumer group is parents of post-80s and post-90s. Through careful observation of their behavior, life style, habits, pain points, income level, consumption ability, aesthetic needs and so on, the follow-up construction of design concepts is gradually established.

Subsequently, using morphological analysis method, in the definition of shape, a large number of existing children's products and consumer goods with high sales on the market are collected, their main elements and characteristics are analyzed and summarized, these products are divided into several categories by morphological analysis method, and then through in-depth interviews, questionnaires and other methods to summarize the shape suitable for the target group.

Then, by collecting a large amount of data, the performance characteristics of each material are compared, and the human-machine dimensions of the target group are collected, and the materials and sizes corresponding to the target group are defined.

Finally, the design concept and criteria of Companion Robot for children are summarized, and the design practice of this study is guided by the previous research results and methods.

4 Research Outcome and Practical Design

4.1 Research Process

This study first understands the current situation and application fields and scope of AI technology which is becoming more and more mature nowadays. Secondly, the existing academic research and market application in the field of robotics are compared. The design concept and criteria of Companion Robot for children based on AI are proposed, including user targeting, function definition, material selection, modeling definition and ergonomics application, and finally the design practice under its guidance is presented.

4.2 User Targeting

Bill Gates once said, "Robots, ubiquitous screens, voice interaction, all of these will change the way we look at computers." In short, robots will change our world in the future. The degree of segmentation of the robot market depends on the diversity of user needs. UX has always been an important basis for the market in the robotic segment market. If the user experience is good, the market will be good.

Children Aged 0 to 6. This research is aimed at the design of Companion Robot for preschool students of 0–6 years old. It is found that children learn things most quickly during this period. As a partner at home, Companion Robot needs to create an imperceptible learning environment to help children develop the ability of adapting to the society and developing their independence, and also act as a little assistant to take care of their safety.

0–3 years old is the initial stage of human beings. Regarding their language, thought, behavior, balance of limbs and other aspects, they are in the shaping stage. At this time, game is the main activity. 2–3 years old is also the key period of children's oral development. They become very fond of speaking, and their vocabulary increases rapidly. They can express their ideas with simple compound sentences. They can also understand commonly used simple sentences. Their listening and speaking abilities are basically formed. During this period, children will pay attention to and be interested in bright colors, voices and moving things, which can make them familiar with the environment and participate in activities. Many interior changes of three-year-old child emerge gradually. Memory and ideological activities are produced in direct contact with things. At the same time, children will begin to try to imitate and repeat, it is in the repeated interaction of the object, combined with the development of language and action at the same time, that leads to the gradual understanding of the simple relationship of things and generation of imagination.

After the initial stage, children would gradually begin to be independent, they would learn to take care of themselves, but they are slow, clumsy, and still need help. Let's call this period developing period. During this period, children are emotionally unstable, they tend to be affected by the environment. 3–6 years old is exactly the golden period of children's growth and development. Children's mastery of vocabulary has made the fastest progress in this period, and their language ability has developed rapidly. With the rapid development of intelligence, children's personality can form. When children of this age see something interesting, they approach it actively, observe it carefully, touch it, and explore its mysteries. At the same time, we begin to understand the attributes of things around us, such as size, color, length, number, simple shape and so on. The understanding of things is more specific and can only be relied on.

Customer. Companion robots are aimed at the user group of children, but consumers are their parents. At present, the mothers and fathers of children aged 0 to 6 are basically after 80 and 90. They pay more attention to the quality of life and have higher demands in aesthetics and user experience. And in the peak period of career, the level of economic income is continuously rising, and the potential consumption capacity is huge. According to Roy Nielsen's latest consumer confidence index survey, the average monthly income of consumers in the 1980s and 1990s was 3,111 yuan, which was higher than the average of 3,022 yuan.

Compared with people in the 1970s and 1980s, the post-1980s are more casual and have more unplanned shopping. They tend to rely on all sectors of society and choose friends with common values as their social circles.

Function Definition. With the increasing pressure of life, parents tend to use smart devices such as mobile phones and iPads to let their children learn. However, with the development of the Internet and the flood of information, children who lack the ability of discrimination and self-management become more and more addicted to them. Companion robots can just overcome this problem and become a kind of novel education method which is suitable for contemporary children. Based on the application of AI technology, it can realize a diversified learning method with multiple mediums, including games, stories, music, etc. so that children can learn knowledge in a relaxing atmosphere.

The prime demand of parents on Companion Robot is education. Preschool children are not fully developed psychologically and physiologically. Parents are also at the peak of their careers. They can't take care of their children in person for a long time. Under such circumstance, it is necessary for robots to use the rich resources on the Internet instead of parents for heuristic education. Children begin to perceive the world around them and are more sensitive to color and shape. Therefore, they need to provide a great number of picture books for recognizing color and articles. At this time, children's language ability is also beginning to take shape, which is the best time for language exercises. Therefore, companion robots need to communicate with children bilingually to increase their vocabulary and improve their memory.

The second is companionship. Children's companions will influence their behavior and personality in the future. Having good interaction objects will bring them a positive environment. Because children of this age like to touch things, compared with previous robots, it would be way better if Companion Robot for children can let them ride on it. Children can climb up the body of the robot and "ride" at home, so the robot have to own a larger body shape, a stable seat, and intelligent body sensors which can also provide touch feedback. Robots should also be equipped with interactive projection to protect children's eyes and reduce direct use on the display screen. To increase the authenticity of interaction, robots with high-definition cameras and touchable screens can follow children around at home and become good partners.

Considering that children of this age are not separated from their parents, they need to be looked after by their guardians, but they also need to be given independent space. At the same time, parents are also at work, do not know the status of children at home, so companion robots should also be equipped with surveillance cameras, microphones, and speakers, so that parents who are not around their children can clearly understand their every single move and communicate with them in real time, improving the flexibility of their work and life.

It has a preinstalled patrol function. It can map the structure of the home simultaneously, route automatically and interact with children or adults. It stops [7] when people are close to the path of the robot.

In terms of endurance, as a free-moving robot at home, it should have the function of wireless charging. when it detects that the battery is low, it will return to the charging base and charge itself (Fig. 1).

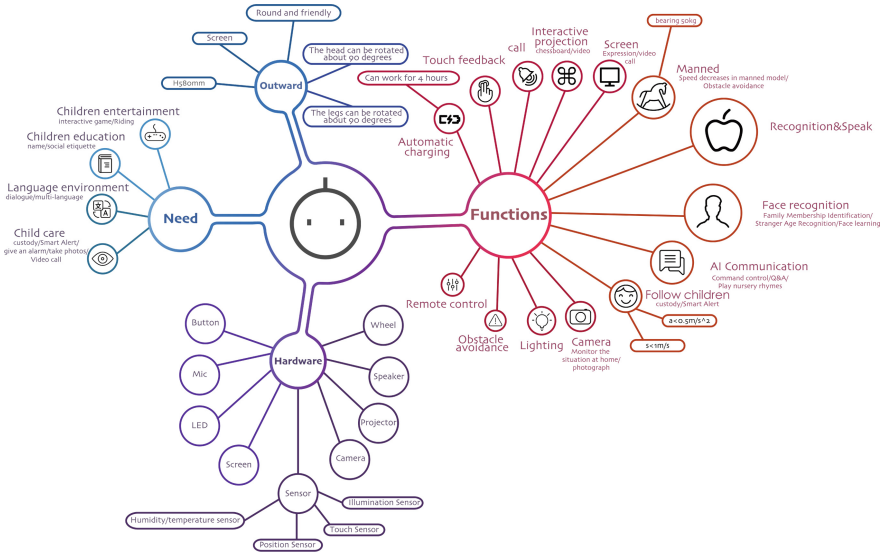

Fig. 1. Function diagram

4.3 Material Selection

In the selection of materials, we should meet the functional requirements of the robot, and consider the safety, load-bearing, environmental protection and other aspects of children. Generally, smooth and flat, environmentally friendly, 3C certified materials should be considered first, and we should also pay attention to fire prevention and so on. After comparison, ABS plastic is selected as the main materials. It is a copolymer of acrylonitrile, butadiene, and styrene. It has the characteristics of chemical resistance, high dyeability, high strength, good toughness, high impact strength, water resistance, inorganic salts, alkali and acid resistance, insoluble in most alcohols and hydrocarbon solvents, and excellent comprehensive performance. It is an ideal material for companion robots.

4.4 Ergonomics

The dimension design of Companion Robot for children needs to consider various users, including children learning to crawl, children who can walk, and adults at home.

When children use the robot, the height is lower than that of the robot's head, which will show a state of looking up to observe the robot's facial expression. Therefore, in order to prevent children from feeling fatigue, the head height is set at about 500–600 mm.

When a child is a little older than one or two years old, he can ride on a robot and play with it. Referring to the size of some mature Trojan products on the market, and considering the safety of children, the height range of his back should be set at about 300–400 mm.

At the same time, as the main interactive medium of the robot, the size of the display screen is also of great importance. Taking into consideration of both the display effect and proportion, the face diameter is set at about 150–250 mm.

Firstly, the overall design semantic of Companion Robot for children should conform to the special target group of children, and use more round shapes to ensure safety and enhance the affinity of the robot, while using fewer square shapes with sharp edges and corners. Secondly, to meet the market demand, the design style needs to be concise and fashionable, with a geometric shape as the main body, mellow and lovely and in line with modern aesthetics.

4.5 Design Practice

Based on the design concept of companion robot proposed in this study, a new type of companion robot, Shaun, is designed based on AI technology. Shaun's black, round head with two handles on both sides is like a sheep's blackface. Its body is white. It has a round curve like a head. It's like a sheep's fat body. Its limbs and legs are oval. It can reduce unnecessary harm to children. The wheels used to move are hidden at the end of the limbs.

Shaun is aimed at children's daily companionship and children's education. It has such basic functions as object recognition, face recognition, riding, interactive projection, automatic follow-up, AI communication, video, touch feedback, calling, automatic charging, remote control and so on.

The robot is about 60 cm high, the back is about 30 cm high, with round and intimate appearance. The head can rotate around 90°, the legs can rotate for up to 40°, reflecting its loveliness and flexibility and has a authentic sense of interaction with children. In order to achieve its rich functions, hardware is equipped with wheels, speakers, projectors, cameras, screens, LED lights, microphones, keys, as well as light, temperature, humidity, location, touch sensors to meet the children's entertainment, education, language environment, child care, growth records and other needs (Fig. 2).

Shaun also has his own wake-up password. When parents or children call "Hey Shaun", Shaun will be waked up and come to you to listen to your next command. It can identify different family members, store memories of relatives and friends, and follow designated members. Shaun can communicate with children in simple words. Children can ask questions like "How far is the Earth to the Moon?" Through the application of AI technology, Shaun can recognize the object in front of him through a camera mounted on his face, such as an apple in his hand. Shaun will tell the child that it is an apple. Children can climb up onto Shaun's body while playing. The antiskid rubber on the back increases friction and prevents falling. When weight sensor on Shaun's back detects gravity, it switches to cycling mode. The pedals on both sides stretch out, the driving speed drops back, and children will route Shaun to enjoy riding on horseback. For parents, the high-definition touch screen on Shaun's face can set up the robot. By default, the screen is Shaun's eyes. After touching, it enters the operation page. At the same time, parents can use the mobile app to control it. For example, you can view the activities of your children through the camera, or you can chat with your children via video. This can alleviate the anxiety that parents can't accompany their children. Shaun can also take photos or videos to record the moments of family life.

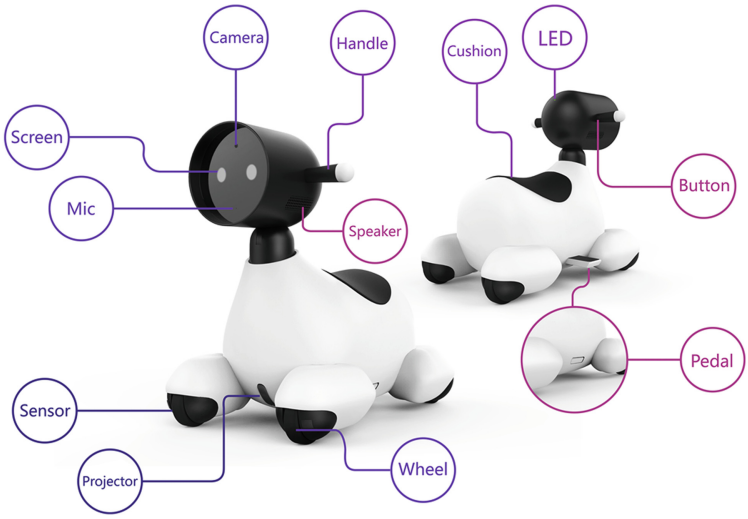

Fig. 2. Hardware distribution diagram

In addition, Shaun can automatically do wireless charging through SLAM technology. In the tail, a wireless charging receiving coil is installed to connect the internal charging battery, and inside the wall at home, a wireless charging transmitting coil is installed to provide the power supply. When the robot senses that the power is insufficient, it will reserve the return power to find the charging base. When Shaun's tail touches the charging base, it can be charged.

The following table shows the main functions for each age group (Table 2):

Table 2. The main functions of each age group:

Functions	1 year old	2 years old	3 years old	4–5 years old	5–6 years old	Parent
Object cognition	•	•				
Color cognition	•	•				
Digital cognition		•				
Interactive projection			•	•	•	
Relationships cognition		•				
Bilingual interaction				•	•	
Reading and writing training					•	
Read a story		•	•	•	•	
Sing a song	•	•	•	•		
Arithmetic training				•	•	
Learning English				•	•	
Develop a habit			•	•	•	
Play a game	•	•	•	•	•	
Riding			•	•	•	
Video chat			•	•	•	•
Security monitoring						•
Take a photo						•

See the ergonomics diagrams below (Figs. 3, 4, 5, 6, 7 and 8):

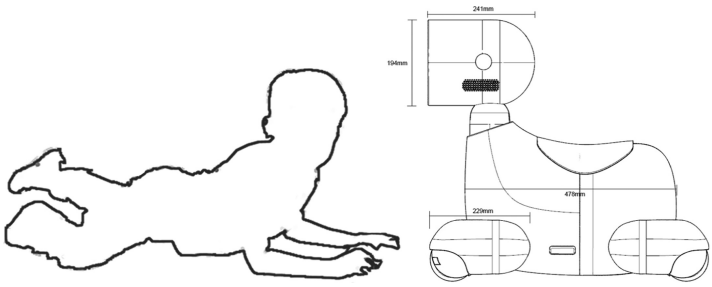

Fig. 3. Ergonomics diagram (Face-to-face) for children below 3 years old

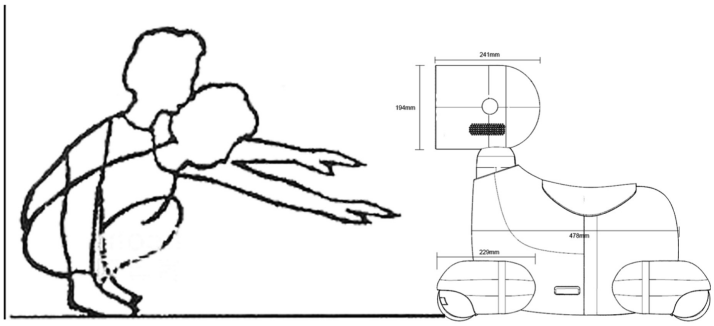

Fig. 4. Ergonomics diagram (Face-to-face) for children aged 3 to 6

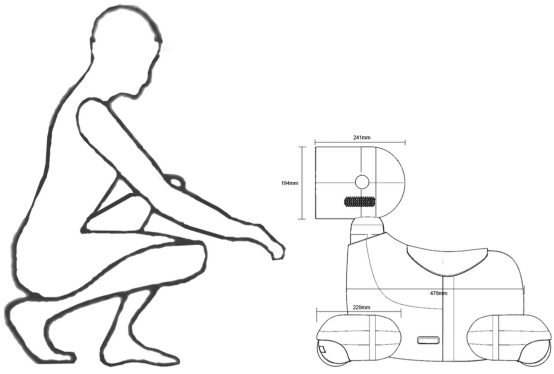

Fig. 5. Ergonomics diagram (Face-to-face) for adults

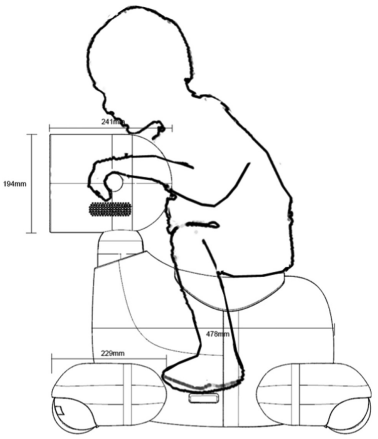

Fig. 6. Ergonomics diagram (Riding) for children

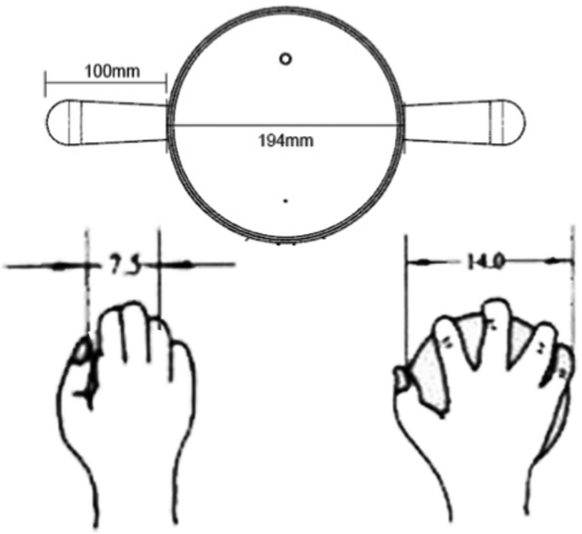

Fig. 7. Ergonomics diagram (Gripping) for children

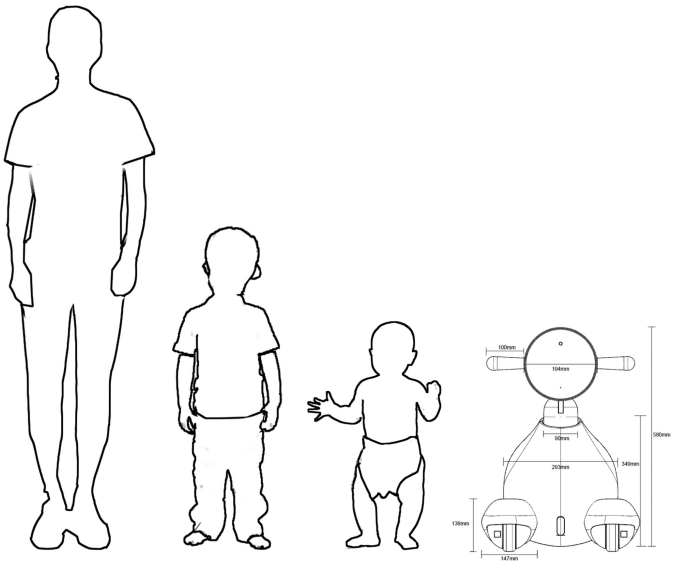

Fig. 8. Ergonomics diagram (Standing) for all ages

5 Conclusion

Owing to the rapid development of AI technology, Companion Robot for children is a hot research topic at present, which involves a lot of knowledge in science and technology. From shape to function to material, the characteristics of children are supposed to be considered in every step.

Based on AI technology and the current status of the mainstream consumer groups, this research systematically puts forward design concepts and guidelines for the design of companion robot from the aspects of user targeting, function definition, material definition, and ergonomics. In terms of dimension, the size of larger service robots and the one of smaller desktop robots on the market are averaged in order to meet more abundant human-computer interaction needs. Different from most of the stationary desktop children's education robots nowadays, a new size is defined. In terms of function, combined with AI technology, some interesting functions that companion robots should have been proposed heuristically, especially the novel interactive mode of riding, which has not appeared in the market at present. Designers can adopt some of the concepts and guidelines to instruct the design of companion robot in the future according to the specific needs and the design background at that time. This research can make the design and orientation of companion robot clearer.

There are still some shortcomings in this study. The threshold of companion robot is not technology, but the content it can provide and the way it interacts with children and parents. The emotional interaction between robots and children is an integral but difficult point. In the follow-up study, we will continue to do in-depth discussion in this area. Let companion robots implicitly help children develop good habits, good mentality, and make education more interesting and diverse. But the significance of this

study is to put forward design concepts and guidelines so that companion robots can truly enter our lives and become good partners of children and good assistants of parents and teachers. It still has guiding effect for the future design of companion robot and improves the quality of design results.

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