

An Eye on the Fingertip

Research and Development of a Wearable Optical Character Recognition (OCR) Device

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Abstracts

Visual impaired take a high proportion of disable population of China. And the inconveniences they encounter in life are more prominent with greater impacts on their qualities of life. In order to make their work and life move toward "Sound Humanization", improving their quality of life, this research attempts to develop an OCR device that can be worn on a finger by utilizing target-oriented research method. Through its interconnection with the mobile APP, this device can convert text into speech quickly and accurately. Supplemented with other helpful features, it is helpful for the disabled and more people.

Keywords: Visually Impaired; Disability equipment; Inventions; OCR;

Chapter I Introduction

1.1 Backgrounds

According to the second national sample survey, the population of disabled in China is 82.96 million.

The proportion of disabled people in the population composition of China

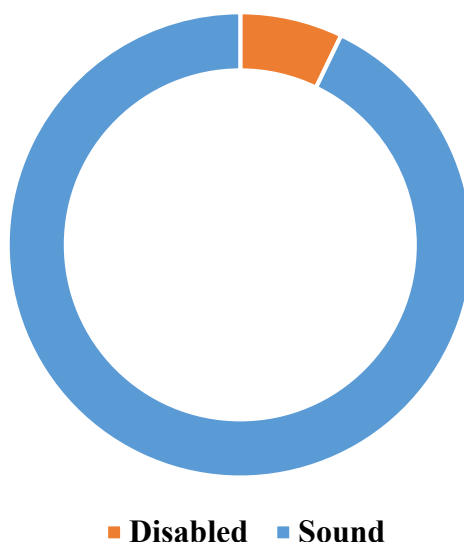


FIG.101

According to current data, the population of visually impaired is about 12.33 million, accounting for 14.86% of total disabled people.

The proportion of visually impaired in the disabled population of China

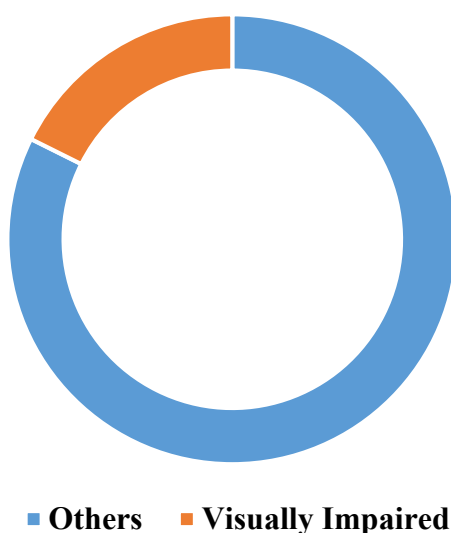


FIG.102

People with visual disability often experience greater inconvenience in their lives. The following are excerpts of real cases that the author interviewed¹:

On the morning of July 12, Wang Haiping went out with me. Only to get out of the building, she was almost knocked down by the threshold of the big iron gate at the exit. She kept holding my arm and worried that she would fall again. On our way, she explored the road with a blind cane, clicked a little, explored step by step, and fumbled forward. Some shops placed signs, parking notes and other items on the blind alleys, which are hard for Wang Haiping to detect and prevent; because there is no braille tags on the goods, Wang Haiping often takes the wrong things when shopping in

¹ The names appearing in the excerpt are all pseudonyms

the supermarket; when she went to the toilet, she often makes mistakes because she can't identify the gender. Wang Haiping said that her biggest wish was to be able to go out freely one day. Now if her husband is not at home, she can only stay at home and kill her time with bore and moonshine. "We are blind, but ought to enjoy a free and happy life." That's Wang Haiping said the most frequently during my interview.

Moreover, according to the survey conducted by the author, among 1,500 ²visually impaired who were surveyed, 974 listed "unable to recognize words" as "the main inconvenience encountered in life".

The proportion of visually impaired in the disabled population of China

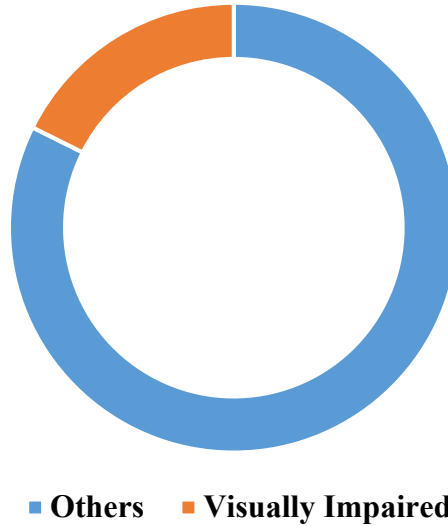


FIG.103

To sum up, in order to make the life and work of disabled people with visual impairments move toward "sound humanization" and improve their qualities of life, helping them move freely with dignity and convenience, the author decides to develop a wearable OCR device with the function of converting text into voice quickly and accurately and output through the interconnection with the mobile APP, thereby facilitating the visually disabled and even more people.

1.2 Research Process

After comprehensively considering various feasible research methods, the author decided to adopt target-oriented research method, an elastic and dynamic cycle research method that is based on the needs of the target group, combined with dynamic feedbacks and suggestions of experts and targets in the research process to adjust the research outcomes in time to balance target needs and actual production capacity.

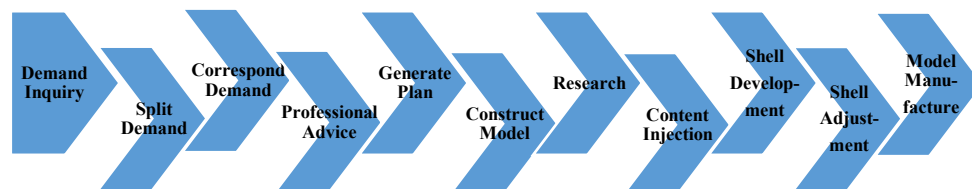
The specific process illustrated as following:



The workflow of obtaining demands and feedbacks is shown below:



The workflow for conducting the research is shown below:



² 1462 valid questionnaires recycled in total.

FIG.104

Chapter II Development and Improvement

2.1 Demand Processing

According to the research method utilized by the author, the author decided to conduct a questionnaire survey on the target group first to determine their needs. Based on the author's reference ³, the author designed the questionnaire in right:

In consideration that the surveyed group is visually impaired, the author also referred to 《Braille Usage》⁴ and designed braille version questionnaire in right, printed in the printing technique of coated paper stamping to make it readable for targets.

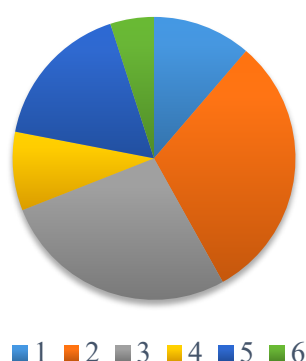


FIG.203

The author together with volunteers are distributing questionnaires.

A total of 1500 questionnaires were distributed and 1462 valid questionnaires were collected. The author briefly analyzed the questionnaires to obtain the following survey results providing guiding references.

Percentage of Choices



针对视力障碍者在生活中遇到的不便所进行的调查

本调查旨在真实了解残疾人生活中遇到的困难与不便,以便我能更好地帮助你们,所有参与均为匿名,敬请放心填写!

您认为生活中遇到的最大的不便是什么? (选项不唯一)

- A. 难以获取他人的帮助
- B. 无法快速辨识文字信息
- C. 不能自如地行动
- D. 不能畅快地与他人交流
- E. 无法参与许多必须或感兴趣的活动
- F. 其它: _____

FIG.201

盲文版:

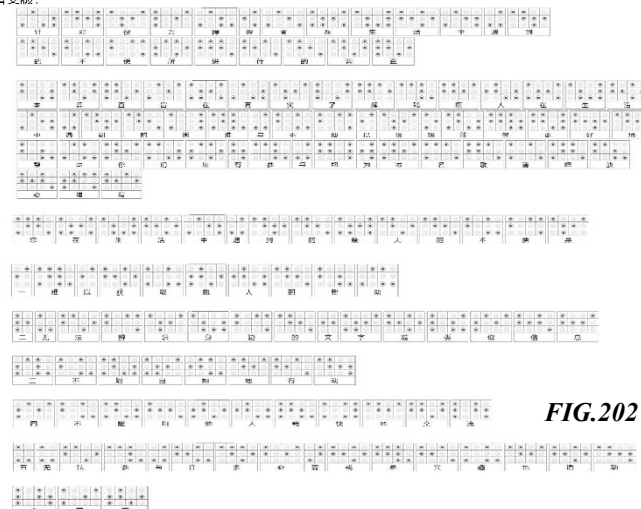


FIG.202

Quantity of Choices

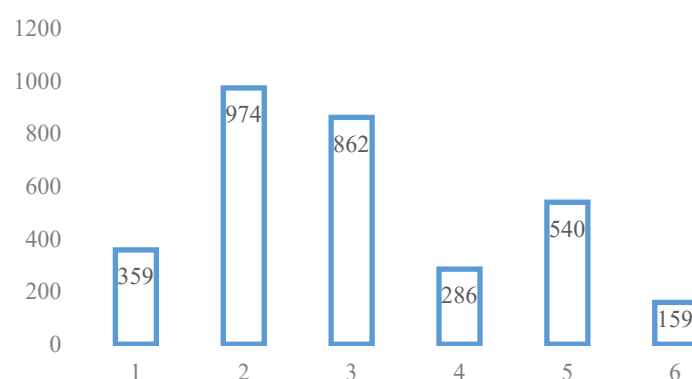


FIG.204

In this survey, 66.62% of respondents chose “Difficulty in recognizing text” as the biggest challenge they encountered in their lives. Based on the result of this survey, the author concludes that the inability to identify textual information is the main inconvenience to the lives of visually disabled, and integrated it into the target-oriented research system as the target demand. In summary, the research goal is to develop a device helping visually disabled people comprehend textual information quickly and easily.

³ Janice Rattray PhD MN DIPN CERT ED RGN SCM. Essential Elements of Questionnaire Design and Development [J]. Journal of Clinical Nursing, 2007, 16(2):234–243; Jing Enying. The Procedure and Attention of Questionnaire Design [J]. Journal of Hubei University for Nationalities (Philosophy and Social Sciences Edition), 2009, 27(6): 99-102;

⁴Huang Jiani, Zhang Kemin. Braille Usage [M]. China Braille Press, 1985;

2.2 Research Goals

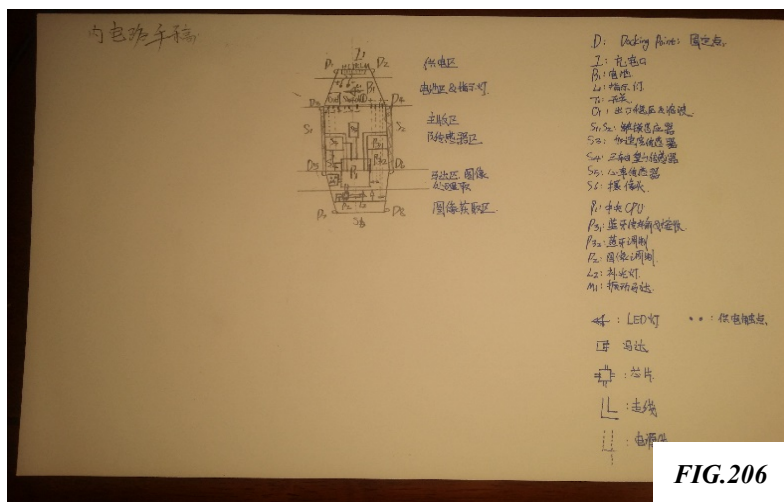
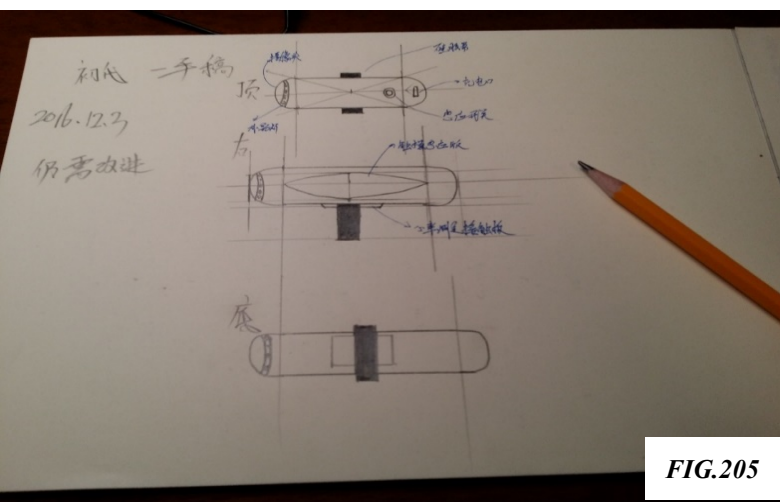
After the demand processing process, the goal of research shall be basically determined as: developing a portable OCR device recognizing texts and outputting into verbal information by interconnecting with the mobile APP, thereby facilitating the disabled suffering from visual impairment. On this basis, the scope of application of the result can be extended, making it a powerful assistant that empowers everyone's life.

This device belongs to a high-tech category integrating image acquisition, image recognition, text conversion, speech synthesis, and mobile software. It is a portable, integrated and multifunctional system cooperating with mobile platform software to realize text conversion, color recognition, QR code recognition, biological data detection and other functions.

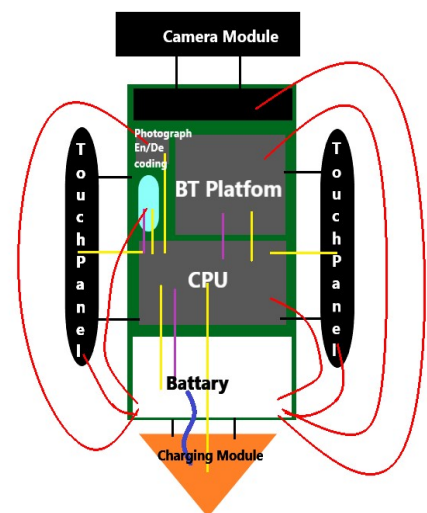
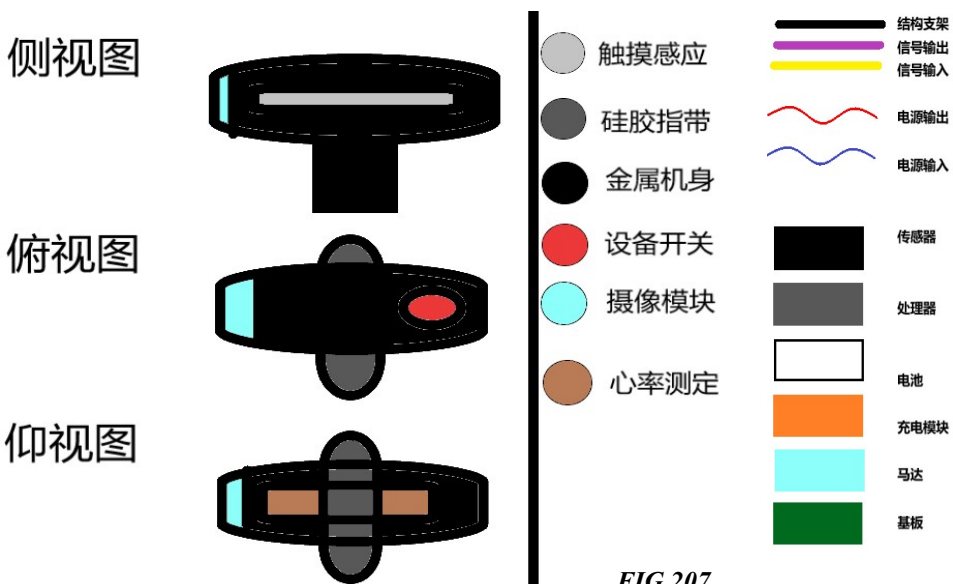
2.3 Research Process

2.3.1 First Generation of Result

After passing the feasibility consultation, the author further made some concrete improvements to preliminary ideas about the external design and internal content of the device and plotted the diagram as shown below.:



After revising the manuscript and studying relevant professional knowledge, the author drew the digital version of the three-view diagram of outer-shell design and the internal circuit assumption on the computer:



DEVELOPMENT AND IMPROVEMENT

The author obtained guidance and improvement suggestions from professionals after submitting the above atlas for reviewing. And used Paint 3D⁵ to render the first generation 3D model as following:



FIG.209

2.3.2 Improvements on the First Generation of Result

After obtaining the initial result as first generation, the author decided to continue to improve the research project. In order to gather suggestions from the target group for further development, the author designed the following questionnaires based on the specifications of braille questionnaires⁶. A total of 500 questionnaires were distributed and 412 valid questionnaires were collected, with a recycling rate of 82.40%. After collecting the questionnaires, the author briefly analyzed the data and obtained the following survey results with reference value:

⁵ Paint 3D is a trademark of Microsoft Cooperation.

⁶ Due to space limitations, the braille version of the questionnaire will not be displayed.

DEVELOPMENT AND IMPROVEMENT

1.满意度评分			2.改进选项		
评分	数量	百分比	选项	数量	百分比
1	14	3.40%	A1	37	8.98%
2	19	4.61%	A2	375	63.88%
3	38	9.22%	A3	212	51.46%
4	51	12.38%	A4	200	94.34%
5	82	19.90%	A5	12	2.91%
6	72	17.48%	A6	400	97.09%
7	48	11.65%			
8	36	8.74%	B1	317	76.94%
9	41	9.95%	B2	95	23.06%
10	11	2.67%			
			C1	35	8.50%
3分及以下评分	71	17.23%	C2	377	76.78%
6分及以上评分	208	50.49%	C3	114	27.67%
			C4	298	72.33%

调查问卷

本调查旨在真实了解您对于本设计的评价与建议以改进本产品，所有参与均为匿名，敬请您放心填写！感谢您的热心参与！

1. 您对您这款产品外观的满意度如何？（请勾选您的分数）

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

2. 您认为这款产品的外观最主要还有什么改进之处？

尺寸（请在 A1/A2,A3/A4,A5/A6 中做出选择，最多选 3 项）

☐ A1. 增长 ☐ A2. 变短 ☐ A3. 增宽 ☐ A4. 变窄 ☐ A5. 增高 ☐ A6. 降低

材质（单选）

☐ B1. 阳极氧化铝（例：iPhone 外壳材质） ☐ B2. ABS 工程塑料（例：Galaxy S8 外壳材质）

结构（请在 C1 / C2, C3 / C4 中做出选择）

☐ C1. 更加修长 ☐ C2. 更加紧致 ☐ C3. 更加圆润 ☐ C4. 更加立体

FIG.210

调查问卷到这里就完成啦！感谢您的参与和配合！祝您生活愉快！

Satisfaction Score Result

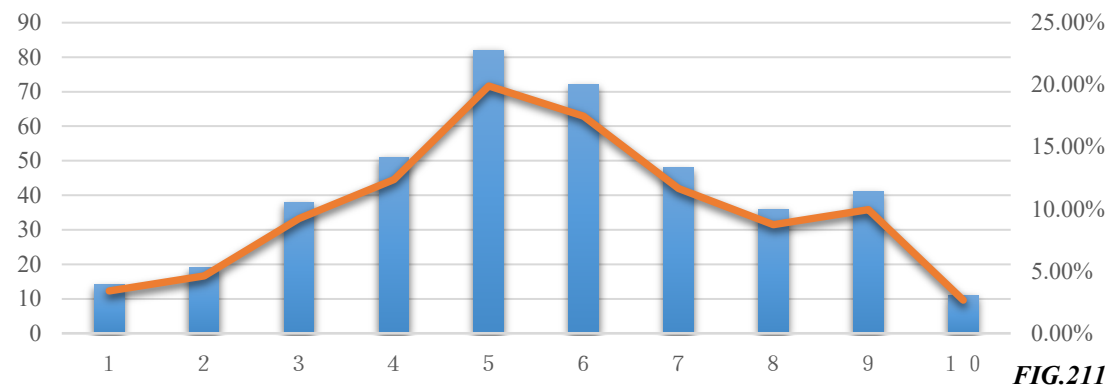


FIG.211

Scoring Trend Analysis

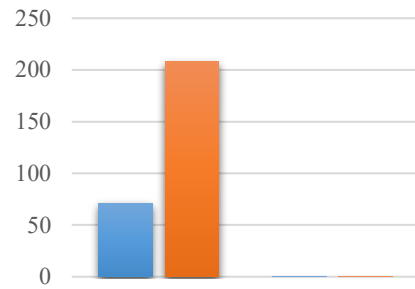


FIG.212

Improving Option Choices

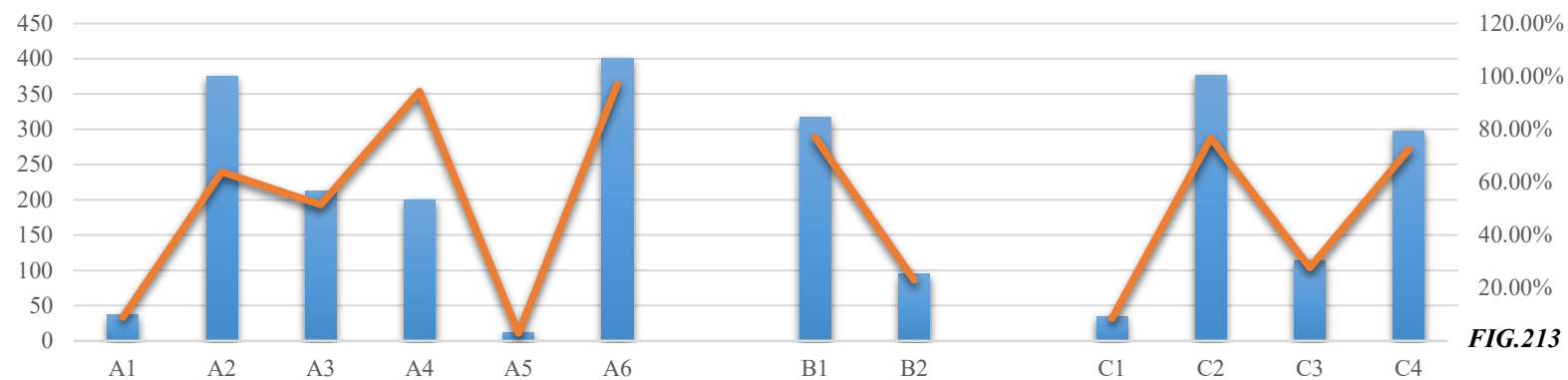


FIG.213

According to the survey results above, the first generation of result is generally a success. But the flaws in it were also exposed: About 20% of respondents scored first-generation design with points of 3 or less. This high proportion of low-scoring intervals indicates that there are many unsatisfactory errors in the first-generation design.

Based on this survey, the author believes that the first-generation design shall retain the following:

1. The original width.
2. The outer-shell material, matte anodized alumina.

While improvements to the original design should focus on the following:

1. Shorten the length.
2. Reduce the height.
3. Compress the volume.

At the same time, the author read a few relevant professional literatures⁷ and managed to disassemble, research similar products, and then improve the first generation model.

2.3.3 Second Generation of Result

After a long period of study, improvement, consultation, and practice, the author succeeded in obtaining the improved version, the second generation, based on the first generation of the outer design and the inner circuit:

Shell Design Manuscript

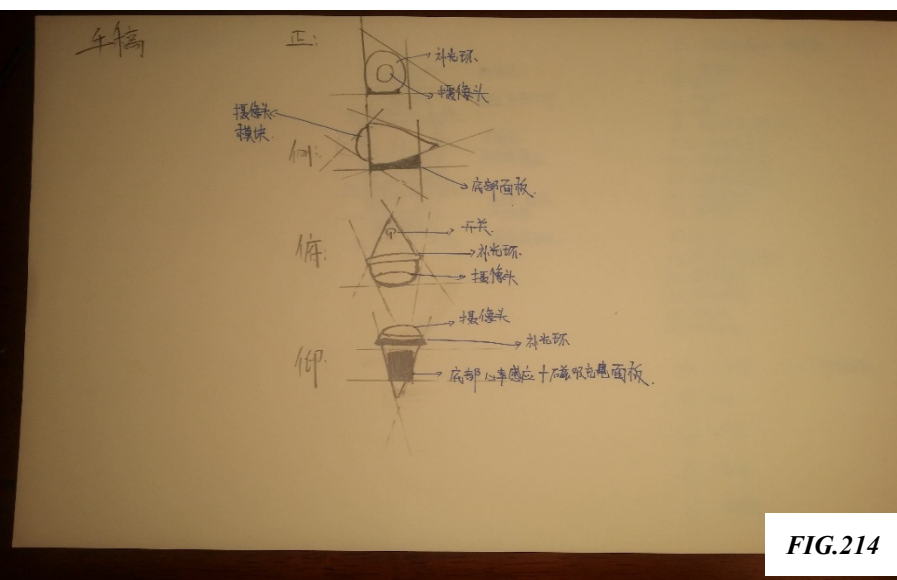


FIG.214

Inner Circuit

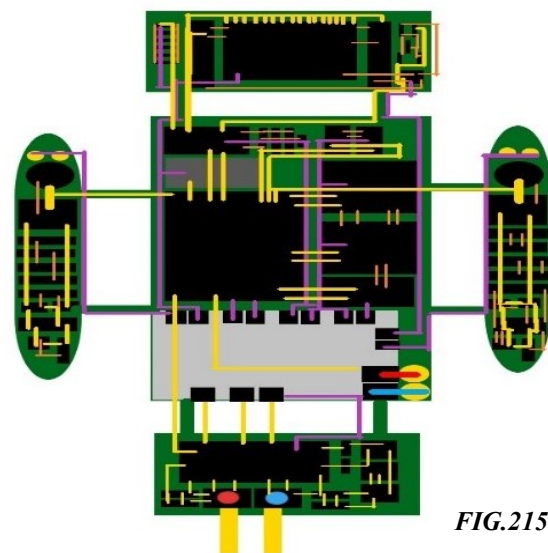


FIG.215

The 3D render of Second Generation Shell Design

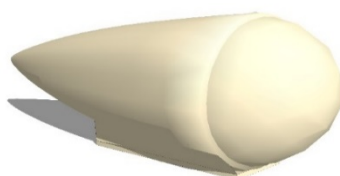


FIG.216

2.3.4 Improvements on the Second Generation of Result

After obtaining further results of the second generation, the author decided to continue to improve the project to make it more in line with the needs of the target group. Therefore, the author designed another questionnaire as shown in the right chart with reference to the questionnaire design specifications.

A total of 1000 questionnaires were distributed and 872 valid questionnaires were collected with a recycling rate of 87.20%. Based on the questionnaires, the author briefly analyzed the data and obtained the following valuable survey results:

调查问卷

本调查旨在真实了解您对于本设计的评价与建议以改进本产品，预计用时1分40秒左右。所有参与均为匿名，敬请您放心填写！感谢您的热心参与！

1. 您对这款产品外观的满意度如何？（请勾选您的分数）

1 2 3 4 5 6 7 8 9 10

2. 您认为这款产品的外观最主要还有什么改进之处？

尺寸（请在A1/A2/A3/A4/A5/A6中做出选择，最多选3项）

A1.增长 A2.变短 A3.增宽 A4.变窄 A5.增高 A6.降低

材质（单选）

B1.阳极氧化铝（例：iPhone外壳材质） B2.ABS工程塑料（例：Galaxy S8外壳材质）

颜色（从最多到最少）

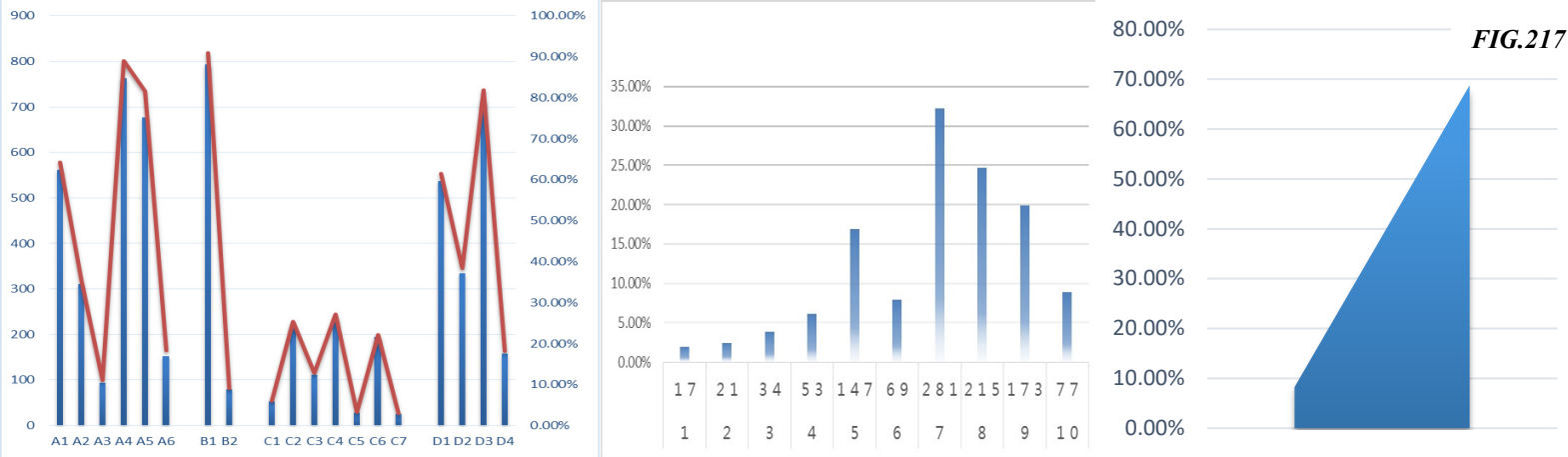
C1.黑灰红 C2.黑灰蓝 C3.黑橙灰 C4.白蓝黑 C5.白绿黑 C6.白橙黑 C7.白蓝橙

结构（请在D1/D2/D3/D4中做出选择）

D1.更加修长 D2.更加紧致 D3.更加圆滑 D4.更加立体

调查问卷卷到这里就完成啦！谢谢您的参与和配合！祝您生活愉快！

⁷ Jian Zhaoquan. Industrial Design Methodology (3rd Edition) [M]. Beijing Institute of Technology Press, 2011; Su Jianning, Li Hezhen. Research on Sensory Characteristics of Materials in Industrial Design [J]. Mechanical Design and Research, 2005, 21(3):12-14; Li Shiguo, Hua Meili, Jia Rui. A new model of product design-interactive design [J]. Packaging Engineering, 2007, 28(4): 90-92; Bloch P H. Seeking the Ideal Form: Product Design and Consumer Response [J]. Journal of Marketing, 1995, 59(3):16-29.



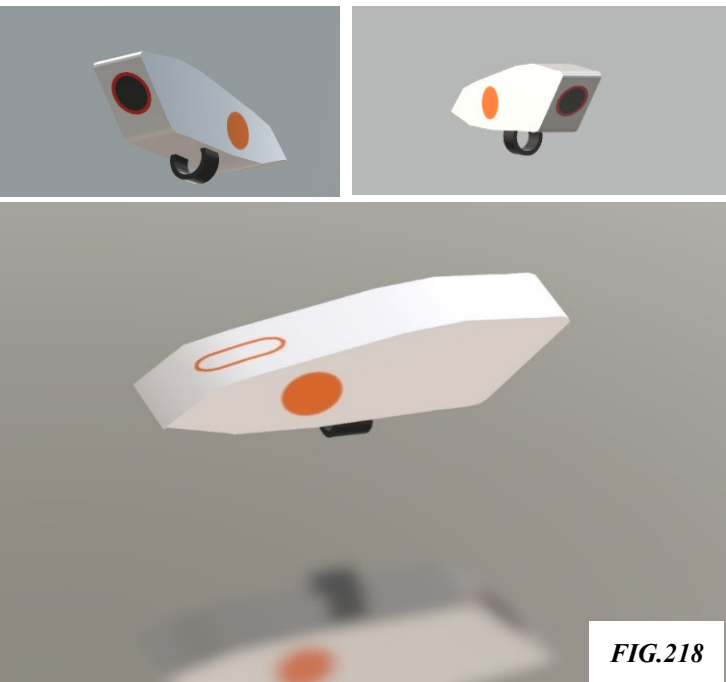
As the questionnaires issued this time shown above, the respondents' satisfaction with the second-generation design was significantly improved compared with the previous generation----those with a score of 6 or above accounted for about 70%,while only 7% accounted for 3 points or below, and the mode was 7 points-----the second generation design was generally successful and much more in line with the needs of targets and more user-friendly. However, the defects in the second-generation design were also exposed: 27% of respondents scored the second-generation design with 5 points or less. Though improved in comparison with the first generation, it's still a high and unacceptable rate. Such high dissatisfaction rate shows that there are still many areas for improvement in the second generation of design. As the survey suggested, the author took the followings as focus for further improvement:

1. Shorten the length. 2. Tighten the width. 3. Reduce the height. 4. Further compress the volume and weight.
 5. Enhance the smoothness of the design.6. Immediately give up the close tail, enlarged head, conical design.
- Reduce the head enlargement ratio and flatten the whole body.

2.3.5 Third Generation of Result

After consulting the experts and practicing advancements, the author successfully obtained the improved version-third generation. After integrating expert opinions and solicited feedback from targets into the development process, the third generation (model A) was improved accordingly, generating the third generation (model B) :

Model A



Model B



Later, based on the author's knowledge of integrated circuit design, the author rendered the 3D model of the internal circuits and parts under the guidance and advice of relevant professionals:

Touch Sensor Panel

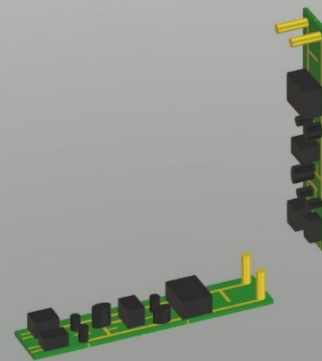
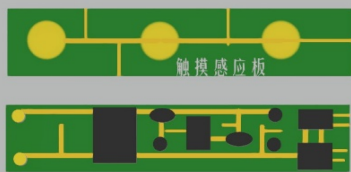


FIG.219

Camera Module

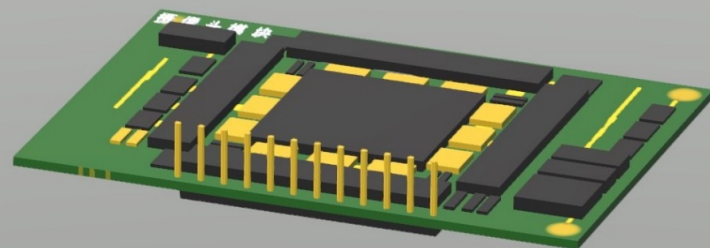
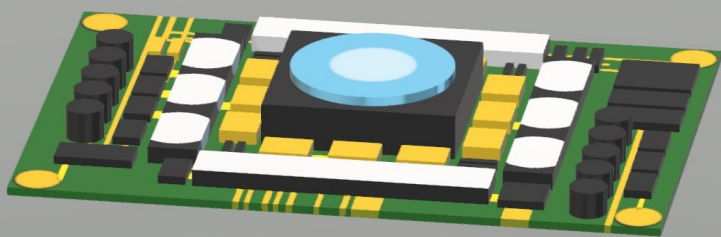


FIG.220

Motherboard

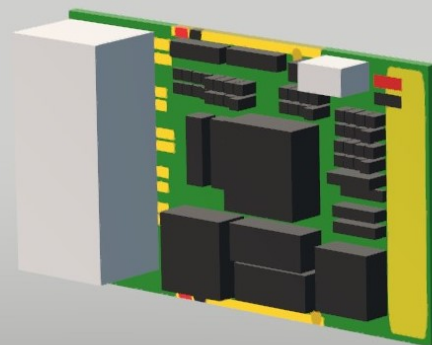
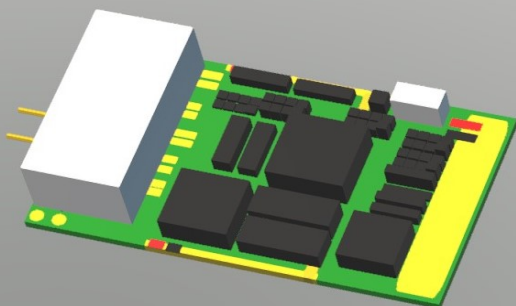


FIG.221

2.4 Research Result

2.4.1 Introduction to the Finale

Existing devices for visually impaired persons can process texts or images, such as Chinese Patents CN1761343A, CN105989317A. Some can also pick bio-data of users like Chinese Patent CN106137154A. However, the above-mentioned devices (patents) are unable to achieve text reading and restricted because of functional singleness, making them not suitable for visually impaired people. This device, on contrast, realizes multiple functions by interconnection with the mobile terminal and the software. It has a spindle-like streamline out-shell with a size of 4.8cm*2cm*1.1cm and the material of CNC machined, 600# frosted anodized aluminum----- with built-in Bluetooth communication module, gravity sensor, acceleration sensor, vibration motor, lithium battery pack and magnetic charging contacts.-----The bottom is softened with an elastic non-slip silicone fixing strap of a width of 1 cm. The front of the device is an image sensor with assistant light module, the left and right sides are touch panels, the top is an integrated touch switch, and the bottom is a heart rate measurement contact.

The main functions implemented by this device are:

1. Through the interconnection of the camera module and the mobile APP via the Bluetooth module, texts, QR code and barcode, environmental information can be quickly and accurately converted into visual disabled friendly forms and stored for further use.
2. With multiple sensors and heart rate measurement module, biometric data of users such as heart rate, exercise and abnormal activities can be monitored, processed, and reported.
3. With the cooperation of multiple sensors and touch panels on sides, the activities of the user's hand can be monitored, transferred to the mobile APP via the Bluetooth module, and translated into instructions of other devices enabling the user to operate other devices.
4. Generate vibration feedback with built-in motor and Bluetooth interconnect module.

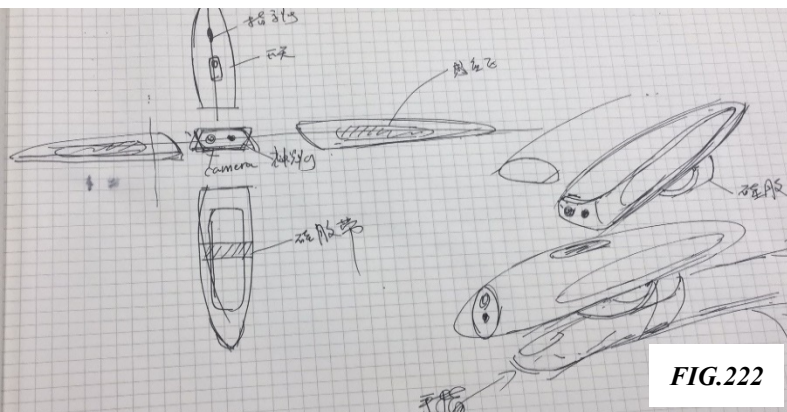
Innovative Highlights:

1. The camera collects information, and then the CPU recognizes and converts the information into an effective output, which is controlled by the mobile APP. The feature is that: the information is first collected by the camera module is output to the image feature analysis module, and then the image feature analysis module feeds back parameters to the mobile APP. Thereby achieving fast intelligent text recognition, conversion, speech synthesis, voice reading and other functions.
2. The Bluetooth interconnection technology is used to wirelessly connect the information acquired by the device with the APP, and the hardware and software are constructed as an organic whole to realize integrated data interaction of the system.
3. The multi sensor-----central processor cooperative working architecture (S-PCA) greatly enriches the functionality and scalability of the device.
4. The design is ergonomic and artistic, combining design and function organically.

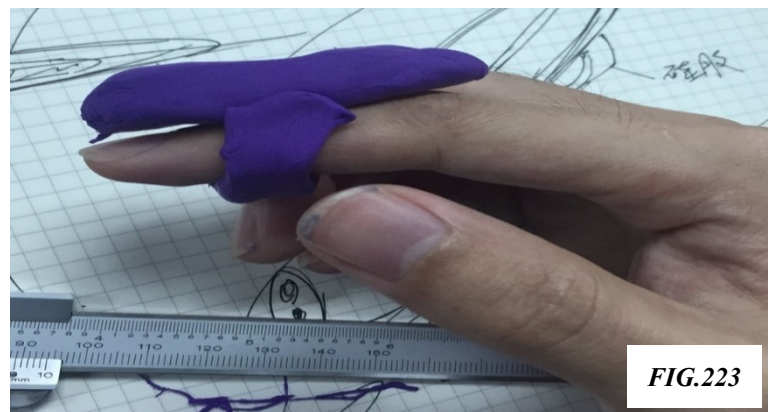
2.4.2 Showcase of the Finale

The following is the finale, which will be the only effective outcome of this research and the basis for all subsequent research and development activities.

Manuscript of Finale



Prototype of Finale



3D Render of Finale



In-real Imaginary of Finale



Chapter III Evaluation and Reflection

3.1 Evaluation of Efficacy and Process of Research

This is the first systematic and large-scale, long-period scientific research activity carried out by the author. From the perspective of effectiveness, **the advantages worth learning are mainly as follows:**

1. The research results is convincible and the experience of considering the details of research in a comprehensive manner and dealing them in time teaches the author with valuable lessons.
2. The research method is suitable therefore problems existing in the research process can be corrected in a timely manner through dynamic feedback.
3. The survey activities are carried out richly. Sufficient raw data provides valuable guidance for the development process; the survey content is detailed and accurate reflecting problems quickly and accurately; the surveys are conducted scientifically, increasing the reliability of results and reducing the difficulty of processing.
4. The research report was written elegantly; overall organization is clear; arrangement is reasonable; content is rich and the format is standardized.
5. When presenting research results, 3D printing was innovatively adopted, offering low cost solution to the problem of lack of physical references.
6. The method of storing the research results was improved in time. The three-in-one preservation method of paper originals, local scan versions and cloud encryption backup was adopted, effectively prevented the information damage from happening again.

The main problems are as follows:

1. The lack of in-depth study on professional issues such as integrated circuit design leads to the missing of key technical details.
2. The selection of samples and their size were unreasonable, and there were omissions in the selection of representative samples, which greatly weakened the practical value of the survey results.
3. Some problems are still unsolved. Such as: development of mobile application, heat dissipation of device, power consumption of Bluetooth module and anti-interference issues.
4. The enforceability of the results is not strong. Although the result is generated, it is still only a “paper talk”. There is still a long way to go before it can be put into prototype manufacturing or even small-scale trial production.
5. Fatal mistakes were made in data preservation, causing research data be destroyed to an almost completely unrecoverable state, which directly led to interruption and delay of the research, adding many unnecessary costs.
6. The work log is too abstract, which has affected subsequent verification, reference and improvement work to a certain extent and hindered research progress.

3.2 Epilogue

This is my first in-depth experience of scientific research. From the procedures of issue proposing, process design, research arrangement, data processing and results analysis and report writing, I deeply tasted the high degree of rigor, logic and challenge of scientific research. In order to obtain scientific and reliable results, rigorous process design, strict quality control and standardized operating procedures are all essential.

But in fact, my greatest achievement is not the method or the result, but the joy and contentment of turning a sly creativity into reality; but the perseverance and tenacious, optimistic attitude those visually impaired have towards life. Their lives may be dark and cold, but their hearts are always filled with unimaginable, rushing light and love!