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A STUDY OF THE IMAGE OUTPUT BY A SLIT LAMP MICROSCOPE EQUIPPED WITH SMART PHONE WITH SELF-MADE KIT

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Abstract – ***This study conducts semi-structured interviews with experts to analyze demand for and key points of image output from slit lamp microscope, introduces TRIZ theory of inventive problem solving and the contradiction matrix, combined with the physical and geometrical features to solve the self-made package kit appearance and convenient operation. The study can solve the problem of K digital output missing in general slit lamp microscope. The result of this study can present the eye image from slit lamp microscope in smart phones in real-time, with high-quality and easy to save on the smart phone since the screen of the smart phones possess high quality display capacity. It is also convenient for the industrial exchange, optometry teaching and clinical application, providing optometry students slit lamp microscope check skills in order to ensure solid skills for refraction and vision care in the future workplace.***

Keywords: Smart phones, slit lamp microscopes and TRIZ

I. RESEARCH BACKGROUND AND MOTIVES

The use of the slit lamp microscope is not widely spread among eyewear companies. Digital slit lamp microscope usage is also rare. Those companies that have employed the use of slit lamp microscope have to install, if they desire to obtain high-quality image output, besides its original slit lamp microscope basic structure, additional CCD adapter lens. It is not only costly, but also requires switching specifications of the spectroscope. Not every general type of slit lamp microscope can be installed with CCD. Also, it requires the installation of a display screen and image output register required by image output. These additional configuration needs about 0.5 tsubo with the cost ranging from NTD 200,000-500,000. Even after installing, it can only be used in single slit lamp microscope. All sorts of restrictions lead to the unwillingness for eyewear companies to purchase slit lamp microscope. Companies that are equipped with slit lamp microscope are not configured with image output device mostly or haven not purchased digital slit lamp microscope. The main reasons are as follows:

1. Eyewear companies use this instrument only to check the fitness of contact lenses, not much for other inspection items.
2. Digital slit lamp microscope is more expensive than ordinary slit lamp microscope, close to 3-4 times
3. Digital slit lamp microscopes need to at least 0.5 tsubo more in the examination room compared with the conventional slit lamp microscope
4. Digital slit lamp microscope image output device can only be used on one slit lamp microscope, and cannot be used on other instruments. Neither can it transfer the captured image immediately

This study is mainly aimed at the general type of slit lamp microscope equipped with image output in smart mobile phones, with the focus to be the image transferred to the smart phones screen. By the means of expert interviews, TRIZ theory, the innovative design of slit lamp microscope image output system is strengthened. This study connects the kit to the eyepiece of slit lamp microscope, this way, one can observe and capture images at any time through the mobile phone screen and then upload it through the display screen and the cloud through Wi-Fi, thus to facilitate storage and academic discussion. By applying TRIZ theory, this study will find out the solutions according to the following the purposes:

1. solve the problem that digital slit lamp needs to occupy more space
2. original equipment in eyewear companies can be used for image output
3. reduce the purchase cost of equipment
4. increase the use of slit lamps
5. improve the performance of video output
6. use slit lamp microscope to observe directly, also to use the smart phone kit to get connected to the display screen to observe. The two kind of methods can be employed interchangeably at any time.

II. LITERATURE REVIEW

Based on in-depth interviews with expert users and TRIZ theory, this study aims improve the convenience of self-made kit on general type of slit lamp microscope. It also adopts the innovative principle of TRIZ to improve the operation and appearance of general type slit lamp microscope for image output.

IN-DEPTH INTERVIEW

This study adopts the method of semi-structured interviews, which features the fact that before interviews,

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according to the research problems and purpose, to explore and design a series of interview outline related to the research as the interview guide. Such outline can be adjusted according to the actual interview situation. Before the interview, background and habits of interviewees must be learned in order to grasp the emotion and observe the hidden information in respondents' speech during the interview. Finally, the contents of the interview will be collected, organized and classified, so as to find out the users' real thoughts about image output of the general slit lamp microscope, their unmet expectations, and their proposals for the image output kit design. (Bi, 1996; Lee, Kong, Lin, Wang (trans), 1998; Yuan (ed.), 2002). The purpose of this study includes the exploration of interviewee's cognition, ideas, habits and key points about slit lamp microscope and discussion about the thoughts and opinions about image output package kit, including its convenience, operation, willingness to continue to use.

TRIZ THEORY OF INVENTIVE PROBLEM SOLVING

TRIZ is the short term for Russian expression Teoriya Resheniya Izobretatelskikh Zadatch, translated as Theory of Inventive Problem Solving (TIPS), meaning to solve problems in an innovative way. It is a set of methods developed by the late Soviet inventor and engineer Genrich Altshuller (1926-1998) and his team, from the analysis of patent documents (Genrich Altshuller, 1999). In 1992, TRIZ related consulting and software development tools began to appear in the United States. The recent TRIZ (Orloff, M.A., 2003) has been introduced to large enterprises in the United States; in Japan, TRIZ has also been introduced, promoted and widely applied to management and service industry in the summer of 1997. TRIZ (Marconi J. and, Works, M., 1998) provides a revolutionary way of thinking about the database knowledge. It describes and quantifies innovation and invention experience, establishes the principle of analysis to solve the innovation and invention problems, and can overcome the contradiction of various basic engineering. TRIZ (Chang &Lu, 2009) is a very valuable tool, providing an effective tool for universal design of problem-solving. Creative problem solving procedure guided by deductive method makes it easier to be put into actual use. According to the research of Zlotin, B.& Al, 2000, regarding the application of TRIZ to the non-technical field, since the TRIZ method covers a very wide range, the definition of 39 engineering characteristics have a very wide range. Therefore it is easily confused when converting the research demand to engineering characteristics. This study explores the TRIZ methodology and the principles of universal design to 39 engineering parameters, employs contradiction matrix tools (Chen, 2004) and set up 40 general design principles for innovation. Innovative methods have been used to introduce TRIZ tool. Models have been constructed to solve kit design problems. It aims to achieve ideal goal to improve the innovative design, concise appearance and easier operation of general type of slit lamp microscope.

SLIT LAMP MICROSCOPE

The application of slit lamp microscope and digital slit lamp microscope technology is becoming more and more popular nowadays, and the slit lamp microscope image output system design is currently the focus of world famous brand including ophthalmology, dermatology, and ENT. Digital slit lamp microscope is also equipped with laptop computer, so that the image can also be shot and transferred, making the multiparty consultation medical treatment services more complete and perfect. But in Taiwan eyewear company, digital slit lamp microscope penetration rate is not high, mainly because the purchase cost is relatively 3-4 times higher than the general type of slit lamp microscope , and also because before 2015, optometry personnel have not been included in the medical personnel. The rise of disposable contact lenses leads to digital slit lamp microscope image output parts not necessary at this stage. Currently, eyewear companies often use general type of slit lamp microscope eye refractive examination and preliminary fitting for corneal curvature of the slide. In order to improve the general type of slit lamp microscope function usage, saves cost and space, this study, based on the general basic structure of slit lamp microscope, connects the eyepiece of the microscope through the kit to the camera of the smart phone so that high resolution images can be obtained at any time through the mobile phone screen.

III. RESEARCH METHOD

According to the literature review, the purpose of this study is to design space-saving, easy-to-operate, practical general kit, which will enable digital image output function for general slit lamp microscope. It first proposes the outline of interviews with experts for their ideas and suggestions of general slit lamp microscope. Then, through the principle of TRIZ innovation and contradiction matrix tool as direction indicator, this study set the design direction for subsequent product improvement.

IN-DEPTH INTERVIEW

In this study, three aspects of the kit are discussed: stability, assembly, and image presentation, which will contribute to the understanding of expert's perception and expectation about the image output of general slit lamp microscope:

QUESTIONS ABOUT THE HABITS OF USING SLIT LAMP MICROSCOPES

1. When will you use the slit lamp microscope during the optometry process?
2. What method will you use to explain to the customer when abnormality is found using the slit lamp microscope?
3. What do you think about the use of general type of slit lamp microscopes in general?
4. What is inconvenient for the use of general slit lamp microscopes?
5. What is your opinion on the image output from general slit lamp microscope?

QUESTIONS ABOUT EXPERIENCE OF USING SELF-MADE KIT ON THE GENERAL SLIT LAMP MICROSCOPE FOR IMAGE OUTPUT IN SMART PHONES:

A. Questions about characteristics of the self-made kit design

1) How do you feel about the kit shape? Does it have the expected styling?
2) What about the size of the kit, the material? Do you have any material preferences?
3) Is it convenient to install the kit and is the kit installed securely?

B. Questions about operation of the self-made kit

1) How do you think about the convenience in the operation? What's your suggestion?
2) How is the safety performance and is it easy to cause cell phone to fall? What's your suggestion?
3) Is the slit lamp microscope main body injured? What impressed you the most after using it?

C. Questions about functions of the self-made kit

1) What is the most satisfactory and unsatisfactory part when using the home-made kit?

D. Questions about further suggestions and price of the self-made kit

1) How is the overall performance of the homemade kit? Would you recommend it to your friends?
2) Do you think it is worth developing after using the homemade set? What is the reasonable price?

E. The respondents selected in this study shall meet the following conditions:

1) Those who are still engaged in optometry and are professionals in contact lenses fitting,
2) Those who have been engaged in contact lenses fitting business for at least 5 years,
3) Those who work in eyewear companies or laboratories that are equipped with slit lamp microscopes

RESEARCH PROCESS

The research process includes the following 6 steps:

Step 1: define the research scope and subject, with glass optometry industry stores and optometry experts as the subjects.

Step 2: draw up interview outlines, collect expert opinions and ideas, conduct data analysis, and discuss the results

Step 3: match the attributes of literature with the technical attributes of the TRIZ

Step 4: build contradiction matrix for generic slit lamp microscope image output kits

Step 5: use interviews to organize, analyze and explore the application of innovation principles in the matrix

Step 6: propose the design and improvement of a new type of general slit lamp microscope kit

IV.RESEARCH ANALYSIS AND RESULTS

This chapter is to organize the content of interviews and the actual collection of information, to sum up problems and suggestions, propose improvement items according to the results.

INTERVIEW RESULT

The number of respondents was 10, the interview was from 16th March to 30th April 2017. Date and venue for each interview were set according to interviewees' demand. Each interview lasted for 60 minutes. The interviewees included 8 men and 2 women. all aged above 40, 4 interviewees of which have more than 10 years of practice, 5 over 20 years practice and 1 over 30 years practice. The interview results are as follows:

THE HABIT OF USING A CONVENTIONAL SLIT LAMP MICROSCOPE

(1)When will you use the slit lamp microscope during the optometry process?

Respondents said that the general use of slit lamp microscope in most time is to check whether the sliding range of fitting contact lenses on corneal contact lens are normal, or when the vision cannot be corrected to normal, ocular refractive media opacity such as lens opacity, corneal edema, iritis. Only in those cases will the instrument be used

(2)What method will you use to explain to the customer when abnormality is found using the slit lamp microscope?

Most of the stores operated by the respondents were equipped with general slit lamp microscopes. If abnormality is found during examination by the instrument, the situation will be narrated by the examiner.

(3)What do you think about the use of general type of slit lamp microscopes in general?

Respondents said general slit lamp microscope can be used for professional eye inspection, optometry process. For people whose vision cannot be corrected to normal, and for fast eye refractive media opacity check, the slit lamp microscope is an indispensable instrument that detects abnormalities of vision and help them decide whether the patient should be referred.

(4)What is inconvenient for the use of general slit lamp microscopes?

Interviewed experts said the general use is convenient, yet the equipment is unable to output image immediately, thus to records of the image can only be written with pen and paper.

(5)What is your opinion on the image output from general slit lamp microscope?

Interviewed experts said the invention can output images, which not only saves the cost of purchasing new equipment, but also saves space for new instrument.

EXPERIENCE OF USING SELF-MADE KIT ON THE GENERAL SLIT LAMP MICROSCOPE FOR IMAGE OUTPUT IN SMART PHONES:

A. Questions about characteristics of the self-made kit design:

1) How do you feel about the kit shape (satisfaction degree from 1-5 point)? Does it have the expected styling?

   Forthe first generation, the appearance looks unprofessional. So the current shape and appearance color of the kit can be adjusted according to the appearance of the general slit lamp microscope, so that it can be integrated with the whole set.

2) What about the size of the kit?

   Respondents said the overall size is acceptable, but the expectation is that the output screen would be larger and the resolution can be higher

3) Is it convenient to install the kit?

   Respondents said, the installation speed is fine, but because the mobile phone has its own weight, the whole kit will tilt, resulting in the fact that image cannot be complete presented on the mobile phone screen

4) Is the kit installed securely and steadily?

   The respondents said that the diameter of the sleeve mounted on the eyepiece was too large. Therefore the image shook. Slit lamp microscope images could be output normally if they were fixed with hand, otherwise the image could not be placed in the center or was too small.

B. Questions about operation of the self-made kit

1) How do you think about the convenience in the operation?

   The respondents indicated that the kit was mounted on the eyepiece. When binocular inspection is required and the kit is thus removed, the eyepiece was removed first and installed again. It caused some inconvenience.

2) How is the safety performance and is it easy to cause cell phone to fall?

   Respondents said the safety of the kit installed on the eyepiece has no problem and the mobile device in the carrier has not fallen off

3) What impressed you the most after using it?

   Respondents expressed the expectation that a general slit lamp microscope could have digital image output has been achieved

C. Questions about functions of the self-made kit

1) What is the most satisfactory and unsatisfactory part to use a homemade kit?

   Very Satisfied -image output can be achieved in the slit lamp microscope and then saved immediately

   Dissatisfied -The shape needs to be refined, and the assembly method and the degree of fixation need to be improved

   According to the above interview information and actual results, the following questions and suggestions will be considered as the priorities of future improvement.

2) After the kit is assembled, it will tilt due to the weight of the phone. The screen cannot display in full, resulting in defects in the image

3) During kit assembly, the binocular examination cannot be done by the slit lamp microscope. If further confirmation about the problem area is needed, experts wish to directly observe with eyes. It is quite inconvenient that they have to remove the eyepiece along with the kit and install it again.

D. Experts suggest that two items to be improved:

1) The kit should be firmly fixed to the eyepiece
2) Quick detachable kit

To make improvement, the first is to define and analyze the specific problems (find out contradiction), which will be classified into specific standard problems (corresponding to suitable parameters). TRIZ tool (contradiction matrix) is employed to find a suitable method for improvement. Finally, according to the problems, solutions to specific problems will be found with improved thinking. In the TRIZ contradiction matrix, 40 innovation principles and 39 engineering parameters are included, featuring a 39 * 39 matrix, with the longitudinal axis representing engineering characteristics to be improved and the horizontal axis the engineering characteristics to avoid deterioration. The middle column, the digit part, is corresponding to the 40 innovation principles. Contradictions that may result from these items will be further discussed and solved through TRIZ tools. Expert interviews are summarized as:

(3) Contradictions and problems

Problem 1:

To make the image fully presented on a smart cell phone screen, and the kit firmly fixed to the eyepiece without damaging the body of slit lamp microscope eyepiece (strength the stability Number 14, easy to operation. Number 33)

Problem 2:

Since the slit lamp microscope eyepiece for binocular examination will generate a stereoscopic image, so sometimes one need to check with eyes, therefore the kit should have 2 kinds of inspection methods that can be fast switched, and the loading can be quickly changed to eyes examination mode (reverse. No. 13).

(4)Selected engineering parameters: as shown in Table 1

(5)This study presents solutions via the TRIZ approach, as shown in Table 2

3 of the 40 invention principles such as those shown in table 4.2 can be used as improvement direction for new generation of product design. Improvement is needed for the eyepiece stability, to avoid the problem that mobile phone lens center and the eyepiece optical center cannot be aligned and incompleteness of image output. No. 13 reverse design in the 40 invention principles can be matched with the kit. The sleeved fixed to the eyepiece can be separated from the carrier of the phone using a slide, in order to allow the precise binocular inspection and fast loading of mobile phone image capturing kit. Based on the results, the first generation of image output kit is improved to avoid incomplete

presentation of images due to tilting sleeve and to secure the kit on the eyepiece.

V. CONCLUSION AND SUGGESTIONS

This study carries out in-depth interview method and TRIZ to summarize research points, employing the contradiction matrix to identify 3 recommendations and principles to solve the contradiction and improve the efficiency, and find out solutions that are not produced easily. Taking the problem blind spot into consideration, it reaches the following conclusions and suggestions for design idea:

VI. CONCLUSION

This study applies TRIZ contradiction matrix and 40 invention principles, to find out the suitable design direction for second generation image output kit. The TRIZ system is introduced into the contradiction matrix and engineering principles and parameters. The improved kit device is installed in the slit lamp microscope for image output for anterior surface and refractive examination. After the study results can be summed up as the following conclusions:

1) The sleeve device should be added to the eyepiece of the general slit lamp microscope to increase the stability of the mobile phone connecting with the general slit lamp microscope
2) The general slit lamp microscope eyepiece and mobile phone can be quickly installed and disassembled
3) For the company that has a general slit lamp microscope, it can have the image output from digital slit lamp images through the transformation of the customized image output kit
4) Reduce the huge cost to buy digital slit lamp microscope
5) Improve the overall space problem and wiring requirements of digital slit lamp microscope
6) It should be able to be employed with the general slit lamp microscope, and can also be used for teaching sharing for the interesting and excellent learning effect

VII. SUGGESTIONS

The following suggestions and future research directions are put forward in this study:

1) This study uses 2 invention principles indicated in the contradictory matrix of the TRIZ methodology, as a way of improvement, and other ways can be used to consider whether there are other methods to solve the problem
2) In the aspect of research methods, the future research can be about the image output kit for general type of slit lamp microscope in terms of convenient operation, operation stability and other issues. Quantitative survey questionnaire of the use of the general type of slit lamp microscope can be conducted, or to use qualitative and quantitative research methods, so as to expand the research, and show the result in a more complete way.

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Table1 Engineering parameter list (Compiled by this study)

Parameters to be improved	Deterioration parameter	TRIZ
Combination stability (13)	Easy operation (33)	32, 35, 30
Material strength (14)	Object stability (13)	13, 17, 35
Assembly operation (33)	Object stability (12)	32, 35, 30

Table 2 Solution list (Compiled by this study)

Invention number	**TRIZ**	**Improved project**	**Solution for improvement**
#13	Reverse	The image can only be presented by smart phone when the kit is on the slit lamp microscope	For the first generation kit, the structure of the mobile phone carrier and sleeve can be adapted, using separation disassembly design, which can provide the mobile phone image output, and can also allow binocular precise inspection to further enhance the function of the general slit lamp microscope
#17	Move to new space	Cell phone screen size is too small	By connecting to the same WiFi link through mobile phones with Android system version 4.2, images can be transmitted wirelessly to a 15 inch screen, so as to benefit the interpretation of the eyewear company's store
#35	Parameter change	Make the image complete, and the sleeve and the eyepiece size to be precise	To avoid the inclination during kit assembly resulting in the incompleteness of image output, the precision for the sleeve will be improved to 0.1mm. In this way, it will be perfectly aligned with the eyepiece diameter, producing the best image for smart mobile phone screen