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Master’s Dissertation 2011

A Practical Extension of Technology Acceptance Model for Adopting Real-Time Telemedicine System

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Graduate School of System Design and Management,

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Major in System Design and Management

SUMMARY OF MASTER'S DISSERTATION

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Abstract

A real-time (synchronous) system is regarded as an important technology for telemedicine. Through this technology, a medical professional can communicate with their associates and patients in an environment which is close to an actual clinical setting. This technology, however, is not yet to be widely adopted in actual diagnosis due to medical professional has no intention to adopt this technology. In other words, medical professional`s low motivation is the main impediment to low adoption rate of this system.

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Keywords:

1. Real-time telemedicine system 2. Technology acceptance model 3.experiment investigation 4. Questionnaire investigation 5.requirement analysis

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Chapter 1 Introduction

1.1 Overview

(1)what is telemedicine

Telemedicine is the use of information technology in order to provide clinical health care at a distance [1]. Through telemedicine system, the medical information can be transferred via electronic communication such as telephone line or internet for the purpose of consultation or diagnosis. It provides a new choice of application to medical professional who wants to improve his/her work efficiency. The main advantage of telemedicine is to create a platform for medical communication without distance limit. It is not only as simple as phone connection, but also might be equipped with advanced communication technology. For instance, there is a typical case that most medical professionals are nowadays regularly contact each other or discuss medical cases through e-mail or telephone. And also, there are some telemedicine cases with satellite transmission can be regarded as practicality of telemedicine integrated with advanced technology.

Telemedicine is increasingly important in our society since it has been considered as a critical information service and solution for the issue of medical professional insufficient, especially in the remote resource constrained areas. Different from simple discussion of cases, development of information technology has brought out a revolution of telemedicine in a variety of fields such as Tele-education, Tele-surgery and Tele-consultation. Besides, more and more patients want to gain the medical service as well as in hospital by using telemedicine system recently. It triggers a progress of telemedicine in many countries.

In Japan, the first experiment of telemedicine was triggered back to 1971, researchers used telephone line to send and receive medical picture and text at a long distance [2]. Since the first experiment, substantial researches in terms of telemedicine are in progress, and kinds of new technologies are introduced into telemedicine. For example, satellite was introduced in telemedicine as a second choice to transmit medical data for the purpose of support the medical resource-constrained areas in the south of Japan [3].

(2) Types of telemedicine system

Telemedicine can be classified into two categories:

Real-time (synchronous): this type of telemedicine system mainly manifest in(1) presence of both sides at the same time during the medical procedure.(2) a real-time interaction does happen between two sides. It ranges from simple Tele-consultation by telephone call to complex robotic surgery. Since it allows patient to contact medical professional directly, the patient could be responded by professional as quickly as possible.

Store and forward (asynchronous, store and forward is abbreviated as S&F in this thesis): it does not need a direct link between both sides at the same time. Data or image are acquired and transported from one side to the other side at a convenient time [1]. Comparing with real-time type, this type of telemedicine encounters an omission of an actual communication between medical professional and patient. This type has to rely on a historical report or audio/video information in lieu of a physical examination.

On the other hand, Telemedicine is also broken into three types from another perspective:
1. Doctor to Doctor Model (D to D): connection only takes place between medical professionals. Patient is not involved in this model, instead of that, only communication between medical professionals has been considered in this model. This model plays a role when a professional want to consult to or discuss with other medical professional. Therefore, this model mainly represents education in telemedicine, Teleconference and Tele-consultation.

2. Doctor to Patient Model (D to P): interaction between medical professional and someone who needs medical advices or treatments is the key feature of this model. This model is rather complex that D to D due to intervention of patient.

3. Doctor to Nurse Model (D to N): Besides medical professional and patient, paramedic is also involved in this model. In general, Medical service is mostly required by people without enough IT experience or lives in nursing house. Paramedic, in this model, works as a bridge between patient and medical professional that help patient with professional`s support (Fig 1.1 shows the three types of model for telemedicine system).

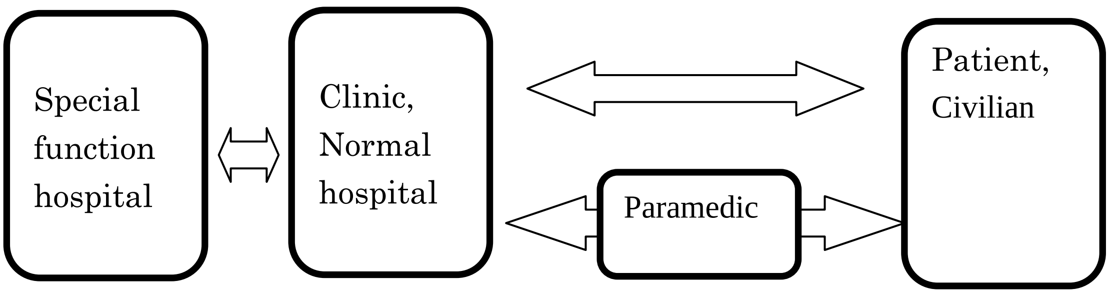


Fig.1.1: Three models of telemedicine

(3) Use of real-time telemedicine system
As an increasing of requirement for using telemedicine, an important advantage of real-time telemedicine system should be noted in this study:

Due to the influence of urban concentration and a rapid aging population, Telemedicine system is a useful means for uneven distribution of medical resource. However, it is still difficult to admit telemedicine system instead of actual consulting doctor. The main reason is that patient can only accept medical examination in an environment of face to face in principle [5]. This results that telemedicine system can be only used as assistant until it can really provide a face to face condition.

On the other hand, according to the report of information and communication statistic database for year 2001, `Services using your screen in which you can receive health consultations and diagnosis from a doctor and provide welfare and care services for the elderly` is selected as the first position by 43.2% in the list of Japanese householders expected IT service ranking (Fig 1.2). The probability is more than twice as much as the second one which is `Administrative services such as applications and notifications, and reservation services for public facilities`. It suggests that real-time telemedicine system for diagnosis is in high demand and it is no doubt that more detailed problems will arise in telemedicine by intervention of patient.

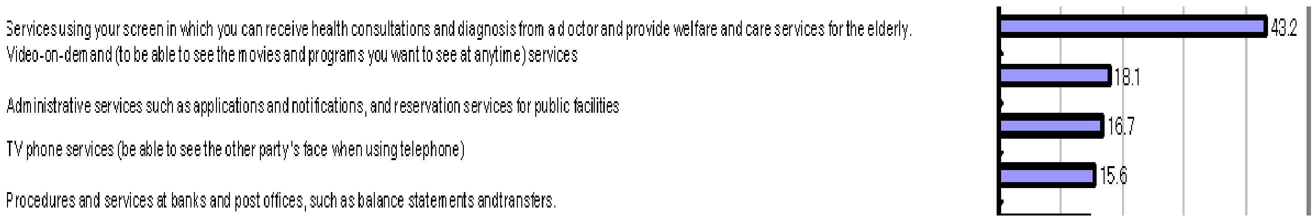


Fig.1.2: From year 2001 information and communication statistic database

In conclusion, patient demands for an environment provided by telemedicine which is close to clinical setting to take an actual diagnosis at a distance. These issues cannot be resolved only by store and forward system. Thus, it indeed needs an effective telemedicine system which can resolve medical issue for remote medical resource-constrained areas.

1.2 Current problem

From patient`s perspective, direct communication with medical professional is of important. This is the main benefit of real-time telemedicine system. Although, real-time telemedicine system is expected to provide a virtual clinical environment, low adoption rate is the fact partly because real-time telemedicine system is not enough to meet this requirement of medical professional for several reasons such as low quality of image and high cost. And it also has an issue refer to motivation [6]. Therefore, we need to investigate the effective real-time telemedicine system which has to comprise a multitude of new communicative elements to provide higher performance and reproduce an environment which is close to a real clinical setting (patient and professional are in the same room). Besides, motivation to adopt this type of telemedicine system is also critical concern in this study. In next section, we will discuss the current status of telemedicine and the barriers to adoption in detail.

1.2.1 Current status of telemedicine system

At first, it is needed to have certain knowledge in terms of current status of telemedicine. This study has collected certain actual cases or long-term program of Telemedicine system and listed part of them below.

Table 1.1: list telemedicine applications

Project	**Abstract**	**Type Model**
Katsurao telephone telemedicine system (Real case)	In Katsurao village, Japan, videophone system is adopted. The doctor can observe and communicate his patient through videophone. Support from government is a critical reason for decreasing cost for individual which makes this project successful and benefits chronic disease patient.	Real-time S&F D to P
PLANET (Real case)	A medical information community network has been constructed in Chiba, Japan. The patients could receive their medical record and send their own medical data to doctor through the internet any time. When it comes to transmit individual information via the internet, Security is an important problem that i have to consider. This system offers an advantage information protection service which makes it successful.	S&F D to P D to D
K-MIX (Real case)	This medical network is managed by Kagawa Medical Association which is composed of Kagawa University Hospital, Kagawa Central Hospital and likes. It provides medical service from medical professional to people who live in Kagawa prefecture. The system enable medical professional to gain medical from each other support by diagnostic imaging	S&F D to D
UTMB to the South Pole	This telemedicine system works for people who are in Antarctica which is the remotest place on the earth.	Real-time S&F

teledermatology (lon-term program)	When this system works, image of patient is sent to partner hospital via satellite. Although videoconference system is installed in the system, it only works sometimes due to the limit of satellite availability.	D to D
Telemedicine for Neonatal intensive care unit	An internet-based telemedicine system has been used for neonatal intensive care. The parents can view real-time video of their newborns. It reduces cost of health care and regarded as a new field of telemedicine.	Real-time D to N
Video conferencing system for Okayama pharmaceutical association	A video conferencing system is adopted in Okayama pharmaceutical association for seminar, discussion and conference. The introduction of this system is useful for cost reduction and communication increase.	Real-time D to D
Video conferencing system for older in Sandefjord , Norway	A real-time system installed in five older families. The patient can consult professional by this system. Because of high performance of this system, there is a plan for increasing the adoption if economic permit.	Real-time D to N D to P

From the case study of Telemedicine system, regardless of type of telemedicine system, it has found that the system has effectively improved professional`s work efficiency and decrease economic and time cost. Nevertheless, amount of telemedicine cases and programs suggests several points in current status of telemedicine system that should be notice: (1) Store and forward type of telemedicine is more widely adopted than real-time telemedicine system in case of Tele-care (2) although there are some practical cases or experiments related to real-time telemedicine system, mostly could only provide service for limit medical use. It has not yet to be adopted in actual diagnosis.

1.2.2 Barriers to adoption of real-time telemedicine system

In fact, adoption of real-time telemedicine involves an overcharging question that what the barriers to progress of real-time telemedicine system are. Kinds of factors would contribute to the barriers to adoption of real-time Telemedicine.

From the economic perspective, a practical real-time telemedicine system requires relatively more complex devices and stable network for both sides in order to guarantee the quality of service. It will result in an issue which includes availability of home device and high cost. Although the equipment cost of real-time telemedicine system has decreased in recent years, it has little significance [7]. For instance, a video conferencing system cost approximately 1200000(yen). This is a critical reason which impedes the patient or medical professional to adopt it if no change in the price of device. And also, other potential expense is ongoing which includes telecommunication cost, technical support, maintenance and likes. Neither patient nor medical professional, thus, can support this system easily.

In addition, immaturity of system also plays an important role. A real-time telemedicine system is composed of hardware (display, computer processing unit, camera, etc.), software (OS), network and likes. Lots of existed cases of real-time telemedicine are reported above. Nevertheless, available range is still limited due to uncontrollability of network, low definition of image. For instance, real-time time delay due to network traffic is a main reason for constraining availability of conventional real-time telemedicine system. A test for real-time system demonstrates that as network become unstable, longer time delay happened and block of color spot appeared on screen which causes difficulty in actual diagnosis. This problem results in low confidence to adopt this system. It is no doubt that this issue must be addressed if we want to import it into medicine.

Resistance to new technical system is a crucial issue when it comes to adoption of new technology. In other words, motivation of adopting real-time telemedicine system is needed to increase. From medical professional perspective, replacing a conventional system with a new system always is challenged by behavioral change in work, familiarity of conventional medical system and mistrust of new system [9]. Furthermore, there is no enough evidence and evaluation to prove the advantage of real-time telemedicine system to professional. And the need for real-time telemedicine system from patient`s perspective is still not recognized clearly which might influence the motivation of medical professional.

Other potential impediments are influencing the adoption. First, standards issues of real-time telemedicine are still underway. A lack of clinical standards in terms of telemedicine system that result in the use of real-time might be not in permit of patient and professional. Second, legal issues are always discussed in development of telemedicine system. Confidence for telemedicine cannot be built without concern of privacy and security-related aspect [10].

In conclusion, four main reasons to impede real-time telemedicine system have been discussed in this section. Based on this, we can identify the issue of this research and prepare, design the research.

1.3 objective and significance of this research

In this research, we propose to adopt a real-time telemedicine system for actual medical applications.

Virtual Face-to-Face diagnosis (P to D model) by which patient can communicate with medical professional through real-time telemedicine system. Patient can be examined by medical professional through system. professional can determine the disease by patient`s signs and symptoms.

Objective of this research: In order to enhance the usage of real-time telemedicine system for diagnosis. The core objective of this study is to investigate medical professional`s requirements for real-time telemedicine system and improve the motivation of professional by psychological perspective. The first purpose is to analyze the requirement to real-time telemedicine system in medical professional`s perspective. In this study, new real-time telemedicine system will be adopted to compare with existing real-time telemedicine system and demonstrate to medical professional, that might be helpful to identify what medical professional really want from the system. Second, as presented in [6], motivation is critical factor for adoption of telemedicine. This research is to identify the factor of resistance and relationship between each factor. It is expected to extend a practical technology acceptance model for real-time telemedicine system. By this model, it is supposed to predict the adoption of system and confirm the key point to improve low adoption intention to high adoption intention as in Fig 1.3.

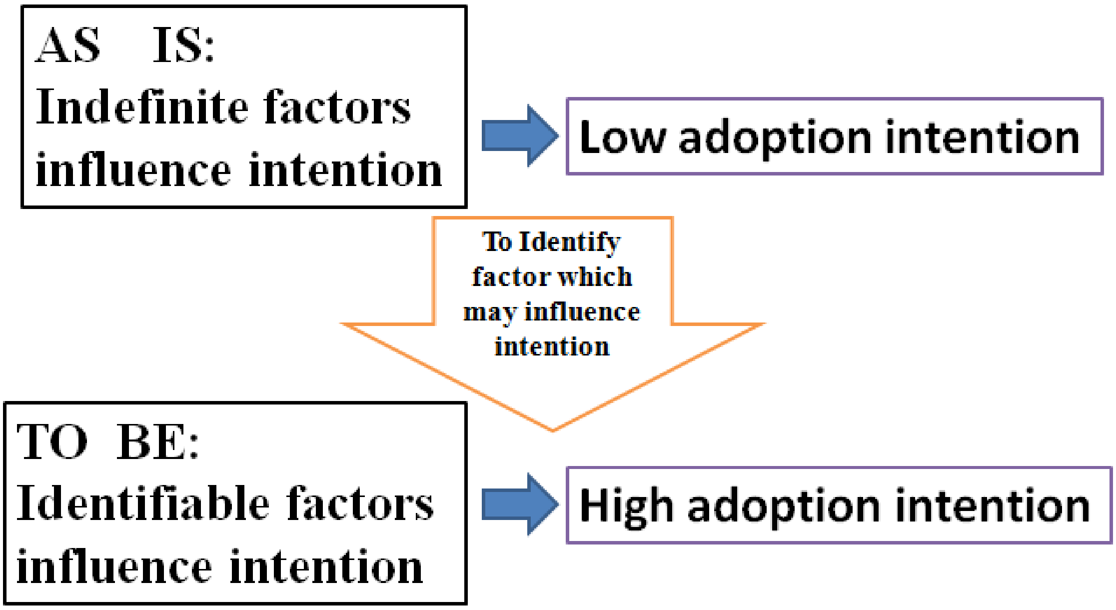


Fig 1.3: As is to be of research

In other words, the aim of this study is to develop specific research objectives as follow:

1. By comparing three types of real-time telemedicine system to understand the requirement from medical professional. And identify what type of system is accepted easier and why it accepted easier.
2. To investigate medical professional`s current attitude toward real-time telemedicine system.
3. To investigate the influence of each factor. And identify the relationship between factors
4. To investigate the requirement of real-time telemedicine system by questionnaire and semi-interview.
5. To review literature of technology acceptance model and theory in terms of telemedicine.

6. To investigate the usefulness of real-time telemedicine system, especially the system we proposed
7. To expand a practical model for promotion of real-time telemedicine system based on Technology acceptance model.

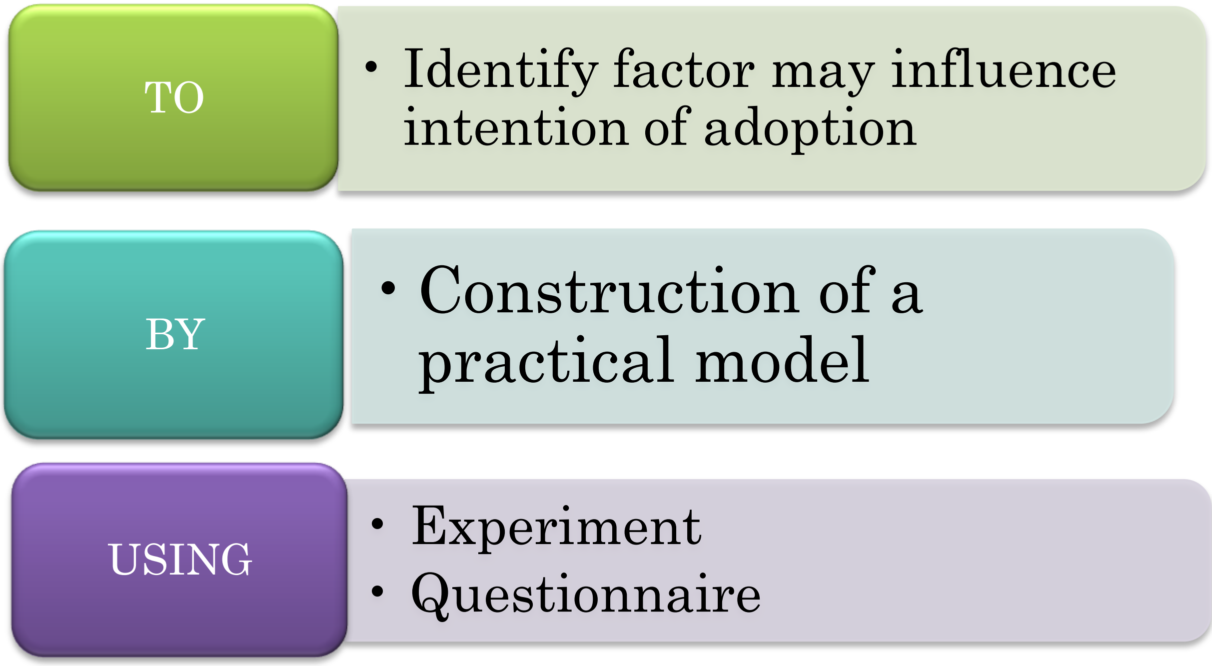


Fig.1.4 The object this study is demonstrated by TO-BY-USING.

Significance of this research: The findings of this research is not only to introduce the technology acceptance model into real-time telemedicine from medical professional`s perspective, but also integrate proposed factors into this model different with traditional models. The achievement from this research should help the researcher and engineer of real-time telemedicine system to plan their strategies to support and motivate medical professional to use the system more in their work. And, the model generated from this research should provide a useful tool for understanding the determinants of behavior intention which might help the researcher and engineer to achieve their goals.

In other words, this study is useful for points as follow:

1. It is helpful for understanding the requirement of medical professional for real-time telemedicine system.
2. To investigate the factors this might affect the adoption of real-time telemedicine system.
3. To expand a practical model for predicting the adoption of real-time telemedicine system

1.4 Structure of this Thesis

This thesis is organized as follow. Chapter 2 introduces the real-time telemedicine system we adopted for research, and it also reviews the theory of technology acceptance model and existing technology acceptance model related to telemedicine. Chapter 3 describes the initial investigation for medical professional requirement and the consequence of this investigation. Chapter 4 discusses the hypotheses and framework of model, research preparation and the method of research are described in Chapter 5. Result of data analysis is in chapter 6 and Chapter 7. Chapter 8 concludes this thesis and gives a summary of future work.

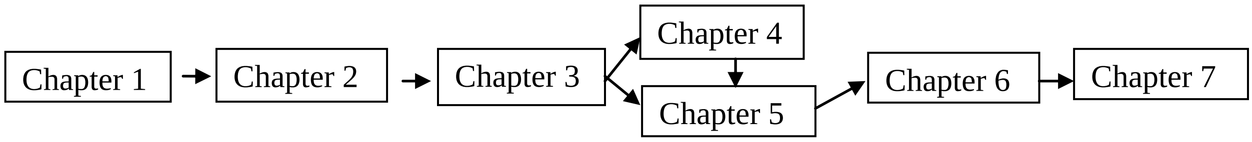


Fig.1.5 Logical dependence between chapters

Chapter 2 Real-time telemedicine system and TAM

2.1 The real-time telemedicine system and TAM

A real-time telemedicine system is to (1) reproduce a condition which is close to a physical clinical setting in order to meet the requirement of both sides of system (2) transmit data in real-time. For the purpose of that, real-time telemedicine system is gradually developing which provides many types of systems for professional to choose. It is not difficult to note that advanced technology does not mean the most appropriate choice for professional. A system which can really meet the requirement of professional must be designed based on a complete understanding of medical professional`s requirement. In order to analyze the requirement of professional, it is necessary to adopt the advanced real-time telemedicine system besides existing real-time telemedicine system to demonstrate and compare. The difference between the systems will be helpful for studying the factors which might influence the adoption behavior of real-time telemedicine system. The real-time telemedicine system, in this research, as a means to simulate an environment that (1) two sides of system can communicate as well as being face to face (2) the quality of service (image, video, and voice.) is enough for medical examination and treatment. The Real-time telemedicine system adopted in this research is integrated with (1) full high-definition communication system or (2) stereoscopic system. Besides, previous research had found that conferencing telemedicine system is still useful in certain situations despite its relatively lower quality of image and real-time capability.

In addition, technology acceptance model is used as a framework to expand a practical model. In this chapter, we will review this model and introduce the main factors and relationships included in this model. We also explain the reason why we adopt it in this research.

2.2 Real-time telemedicine system

1. Real-time telemedicine system with high-definition system (non-compressed): As discussed in previous researches, it is difficult to provide a service in medical level only by existing real-time telemedicine system in market. The purpose of integrating a high-definition communication system is to meet requirement of medical professional by providing a high quality service in medical quality. The first important feature of this system is large-size display (>=32``) which can provide wider view of filed than conventional system. This advantage will be helpful for medical education, discussion and conference.

Second, more precise (pixels size<=0.5mm) and higher resolution (1920*1080 pixel) display are two other significant features for this system. According to the report of [12], treatment or medical consultation can operated better with high-definition display.

Last but not least, in general, video of real-time telemedicine system is compressed before transmission. In order to improve the quality of image of real-time telemedicine system, transmission of non-compressed video is considered when capability of network is enough to support this service.
In conclusion, this system aims to provide an application of observing high-definition image at a distance to medical professional.

In previous research, real-time telemedicine system with full high-definition communication system has been evaluated by medical professional of different professional specialties. Comparing with conventional real-time telemedicine system, high-definition communication system demonstrates a high performance in presentation of color and detail. It was suggested that this system might appropriate for diagnosis of affected part such as dermatology [12].

2. Real-time telemedicine system with 3D system: The basic principle of conventional stereoscopic system (as 3D below) is presenting the left and right image to the appropriate eyes. By difference of images we perceived, we can visualize the stereoscopic structure of objects via the display. In other words, stereoscopic parallax (observing different images of object with each eye) is the key point for most stereoscopic display. We can also perceive depth information through movement parallax (observing different images of object by our movement) besides stereoscopic parallax [13] [14]. In this research, stereoscopic displays we adopted for research are all based on stereoscopic parallax.

In order to project the image to appropriate eyes accurately, Some stereoscopic systems requires optical devices close to user`s eyes (e.g. glasses, helmet, and likes), while other systems can project a field in where user could observe stereoscopic images without devices. Although wearing glasses is inconvenient that results in limited commercial value, most stereoscopic displays in the market still require observer to wear special glasses. The special glasses are categorized in three types which include shutter glasses, colored glasses and polarized glasses. We adopted stereoscopic display with shutter glasses for this study. And also, Acquirement of Stereoscopic video needs special stereoscopic camera with two lenses.

Conventional researches and experiments demonstrate the benefit of stereoscopic system in many aspects of medicine. By conveying more accurate depth information, the stereoscopic display is playing an important role in many aspects of medicine.
(1) The first benefit of stereoscopic technology is stereoscopic image for medical diagnosis or consultation. Through stereoscopic display, professional is able to recognize the shape and depth of tissue without rotation of 3D model such as 3D CG or extra images. There are many researches related in stereoscopic image have reported the medical use in x-ray angiography [14], in surgery of minimally invasive operation [15] and ophthalmology [16].

(2) It is no doubt that medical training is critical for medical students to gain experience before they become professional, yet medical training in operating room might delay the speed of operation and risk the patient. Thus, medical training needs to simulate a real medical environment for increasing opportunities of experience accumulation. Stereoscopic technology is a useful method for this purpose.

First, there was an important finding in [18] as it reported that lack of stereoscopic display results in difficulty in recognition of structure especially when students have low spatial abilities. Correspondingly, stereoscopic display is beneficial for students with low spatial abilities. And also, the advantage of improvement in depth perception is mostly cited for Tele-education in medicine [19].

(3) The third benefit of stereoscopic display is for surgery including both surgical planning and procedure. In [20], it has reported that viewing 3D structure through stereoscopic display had several advantages over 2D image by reducing workload, planning time and increasing accuracy in surgical planning. Other researchers have also found the advantages of stereoscopic technology for surgical planning in different medical fields.

On the other hand, as increasing adoption of minimally invasive surgery, stereoscopic display can provide depth information to professional in the process of surgery. It has also proved the usefulness of stereoscopic display in improvement of visualization of image and decrease in time required for surgical task achievement comparing with non-stereoscopic display [21].

3. Teleconferencing system: Besides the real-time telemedicine system we proposed before, it still need to note that teleconferencing real-time telemedicine system is playing an important role in medicine by its availability. In order to transmit the high-definition image via low bandwidth network, this system compresses the data by H.236 and display the high-definition image without decreasing quality of image in theory. On the other hand, this type of system keeps the quality of image by sacrificing real-time capability that causes the difficulty in observation of patients in dynamic situation. In this study, we will adopt it to compare with the telemedicine system we proposed and expect to obtain more information.

Table 2.1: The different effect among the three systems

system	**With High-definition**	**With stereoscopic technology**	**Teleconferencing system**
Main Benefit	High definition More detail can be observe	More depth information provided High-definition image	Work in relatively low bandwidth High-definition image

	Non-compressed		
Main Drawback	High cost	Wearing Glasses 3D discomfort	Low real-time capability

2.3 Adoption of technology acceptance model

In order to successfully complete the objectives of the research, we need a logical framework to carry out our work related to the research. In this research, we adopted technology acceptance model as a main framework.

Since the first technology acceptance model (abbreviated as TAM) has developed, it has been used for analyzing how users come to accept and use information technology system. For the simplicity and understandability, TAM had been tested and extended in a variety of fields and it has proved that it is an important method to investigate how to promote new technology by researching the determinants that influence the adoption of information system and predicting the adoption behavior.

There is a number of researches for TAM involved in adoption of information technology, and research related to telemedicine system have been published. In this model, however, relationship, determinant and construction might be varied with distinguishing cultures or situations [22]. It is therefore, in this study, I use it as a fundamental model to extend a practical model for analyzing adoption behavior of real-time telemedicine system in perspective of medical professional.

In this study, partly because of understandability and simplicity of TAM, it will be used for this study. We adopted several determinants as standards to evaluate the attitude toward systems. And then, TAM would be extended and tested for analysis of adoption behavior in position of medical professional. In this chapter, we firstly review the concept of TAM, introduce some existing models related in telemedicine and represent a practical model for real-time telemedicine.

Technology acceptance model was relying on a model of reasoned action (TRA) which applied to analyze and predict human behavior on adoption of new information technology. It has found that even a system met the technology performance might still were not widely used [23]. There are many factors might influence the adoption of new technology besides perceived effect factors. As an important model in information management, TAM aims to apply an explanation for behavior intention in adoption.

In TAM, usage and intention are two core measures to judge the adoption behavior which we have to note and distinguish. Usage means the actual behavior: in some research, usage is used to measure whether user really like to use the technology actually. Different with usage, intention is not an actual behavior but suggested link to actual behavior. In addition, perceived usefulness and ease of use are core determinant which has direct influence to behavior intention. More detail will be present in chapter 4.

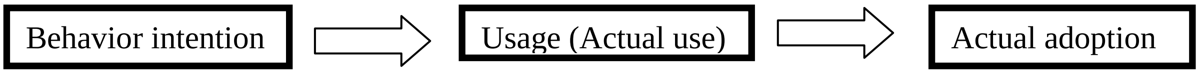


Fig.2.1: Main relationship in TAM

In many researches, TAM as a core of a boarder evolutionary structure has includes four major categories which include (1) Prior factors (2) the incorporation of factors derived from other theories (3) contextual factor, they are considered as direct or indirect determinant to behavior intention [23]. As described in fig 2.2, the most important and effective factors in TAM are perceived usefulness and ease of use which directly effect on user`s behavioral intention.

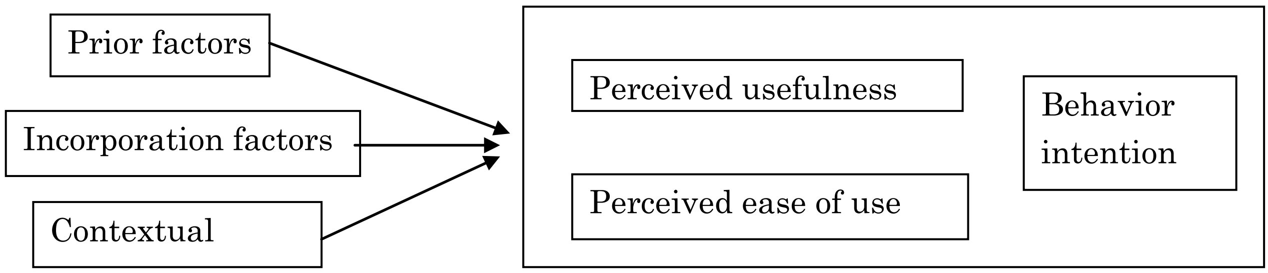


Fig.2.2 Core construct and relationship in TAM

TAM have been continuously studied and expanded, an important upgrade-TAM 3 has also been proposed. Because of widely adoption, TAM has also come to one of used model to analyze the adoption behavior in telemedicine in some researches. For instance, in [24], the model has been extended and tested by different groups of physicians, as the consequence showed that there are little correlation coefficients between social factors such as social image and adoption behavior of medical professional which is very different from previous researches. And also, perceived voluntariness of use has nothing to do with intention to adopt. Another test of TAM has demonstrated that previous experience regarding information technology is a reason for increasing demand for quality of telemedicine service. And also, it has investigated that training for system, technical and administrative support effects on intention to adopt directly [25]. The subject-norms has no direct influence but indirect influence on behavior intention has been found in [26]. It has also found that the influence of perceived ease of use toward perceived usefulness and behavior intention is not significant in telemedicine [27].

In conclusion, as presented before, the constructs and relationships in TAM might different as the situation and role of users. There is no TAM for real-time telemedicine system currently. It is needed to develop a model for real-time telemedicine. And we also integrated other perceived effect factors in TAM.

Comparing with existing model in previous researches, in this study, TAM is not only a model analyze and predict the behavior of medical professional but also a framework to evaluate and develop a standard for real-time telemedicine system. (1) It will include prior factors, contextual factors. (2) It also includes local hypothesis and existing hypothesis from previous researches. (3) The requirement-based factors will be adopted in this model for evaluation and test. More detail will be introduced in chapter 5 and 6.

2.4 Summary

In this chapter, we introduce the real-time telemedicine system we proposed for this research and the difference between systems. They will be demonstrated to medical professional for the purpose of evaluating telemedicine system and find the determinant and factor for extending acceptance model for real-time telemedicine.

On the other hand, we had reviewed the technology acceptance model in terms of telemedicine. This model will be adopted as a framework to evaluate the attitude toward real-time system and expanded for the real-time telemedicine system we proposed in this study. In other words, this chapter introduces two important respective to achieve our research goals. The next chapter will present the initial investigation by semi-interviewing with medical professional.

Chapter 3 Initial investigation

3.1 Introduction

For the purpose of requirement analysis, initial investigation of this research is to obtain the voice of medical professional in terms of attitude, expectation to the real-time telemedicine system. Semi-interview was used in this initial investigation which included an open conversation, simple questionnaire and open-ended questions. The consequence will be helpful in reorganization of requirement, design of research and extension of practical model. In order to improve the reliability of result, we had demonstrated the three types of real-time telemedicine system proposed in previous chapter to medical professional and compared systems by using the factors of TAM (such as ease of use, usefulness). More than ten medical professionals who are from five different specialties (including dermatology, internal medicine, surgery and The ENT) have been invited to attend this initial investigation. The interviewed and questionnaire survey were used to gain the information from professional after demonstration. In the next section, the procedure and result will be presented.

3.2 The demonstration of system

The demonstration has been carried out twice in Keio university hospital and Suginami medical association respectively. Due to lack of actual usage of this type of system, how to enable the professional to perceive and experience the advantage and disadvantage of real-time telemedicine system is the main purpose of this demonstration. After this demonstration, a semi-interview, open-ended questions and a simple questionnaire have been executed. The content of conversation and data were recorded and expected to further research.

Table 3.1: Demonstration in Keio University and Suginami

Location	Keio university hospital	Suginami medical association
Number of participator	Four medical professionals in university hospital	Five medical professionals from independent hospital or clinical
Professional specialty	Surgery, internal medicine,	Surgery, Dermatology, internal medicine, ENT
Demonstrated system	High-definition sys. 3D sys.	High-definition sys. 3D sys. Teleconference sys.

The system we demonstrated for the initial investigation will be introduced in detail in next chapter.

There were three types of system we have demonstrated to medical professional. By comparing these three types, we can (1) assess the effects of existing real-time telemedicine system, (2) evaluate the attitude toward advanced real-time telemedicine system of medical professional with high-definition system or 3D system, (3) gain a thorough understand of requirement from medical professional, (4) investigate the factors might influence the adoption behavior. Medical professional in Keio university hospital had been consulted their expectation for real-time telemedicine system while the professional from Suginami medical association had been investigated their attitude toward each real-time telemedicine system.

3.3 Attitude toward real-time telemedicine system

Professional attitude is a key point that contributed to requirement and acceptance [26]. In this study, attitude comprised several factors which derived from the previous research of TAM. The result of demonstration has turned out that three types of system we adopted can support some medical application such as consultation and simple diagnosis.

As a consequence, medical professionals have showed a positive attitude toward real-time telemedicine system regardless which type of it. Although, the cost might impede the adoption, Real-time telemedicine system is really considered as a useful means with two points: (1) it is a proper method in consideration of providing service to remote resource constrained areas but has little significance in modern metropolis such as Tokyo or Osaka, (2) it will be actual used by medical professional if practicability for diagnosis advance and reach a level which the system is safe and accurate enough. During the interview, the professional have showed their interest in system as we expected. This result might be from curiosity to a new technology rather than intention of adoption. A simple questionnaire was used to study their attitude.

The items in simple questionnaire comprised several factors such as do you think it is useful for you jab, do you think it is easy to use, do you want to adopt it for job and do you think it is useful in telemedicine. These questions were designed based on previous research of TAM. And we also requested medical professional to give their evaluation to technical standard such as perceived accurate color, perceived definition, perceived depth information and sense of presence. Medical professionals were requested to give a score for each system they observed. The range of score is from one (strongly disagree) to five (strongly agree), the higher one means higher evaluation to system. In this demonstration, conventional telemedicine system and High-definition system were classified into one group as 2D system. We demonstrated three types of systems in the same time for one hour that enable the professional observe the system clearly. As a result, an important finding represented that 2D system (High-definition system and teleconferencing system) has received more positive support rather than 3D system has received from medical professional. The result will be analyses associated with the information from interview.

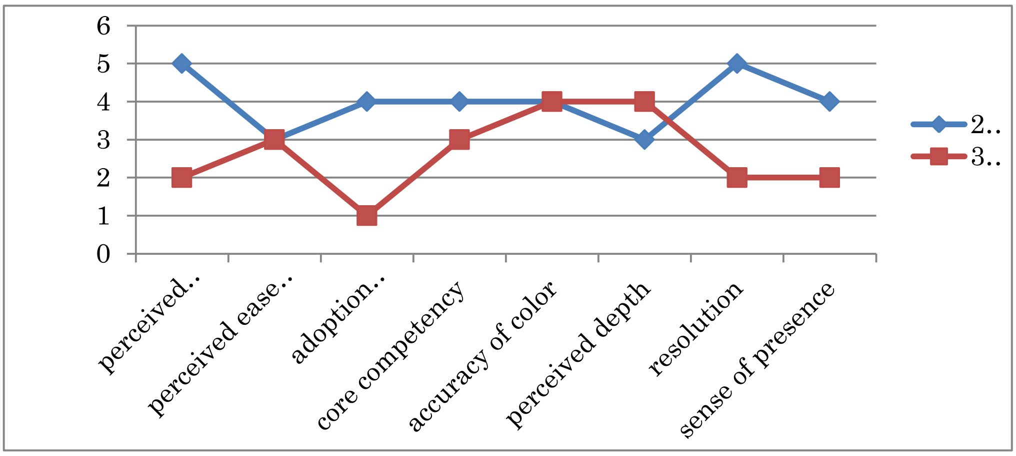


Fig 3.1: Score from otolaryngologist 2D telemedicine system (mean: 3.875)
3D telemedicine system (mean: 2.625)

From otolaryngologist`s perspective (Fig.3.1), the 2D telemedicine system is advantaged in all factors except perceived depth perceived ease of use and perceived accurate color. The otolaryngologist gave a high evaluation (4~5 point) to usefulness, perceived definition, adoption intention but low evaluation to perceived depth information as we predicted. In contrast, despite the 3d system has accepted a high evaluation in perceived depth information, it still did not show its usefulness to otolaryngologist which resulted in low score in adoption behavior. According to the interview, otolaryngologist prefers to use special tools for diagnose the inner of nose or throat. When it comes to telemedicine, both of image quality and depth information from the display are important. Therefore, stand on the position of otolaryngologist, high-definition system might be useful to otolaryngologist as a support. By contrast, although 3D system can provide more accurate depth information from the display, it showed no significance to an otolaryngologist with experience.

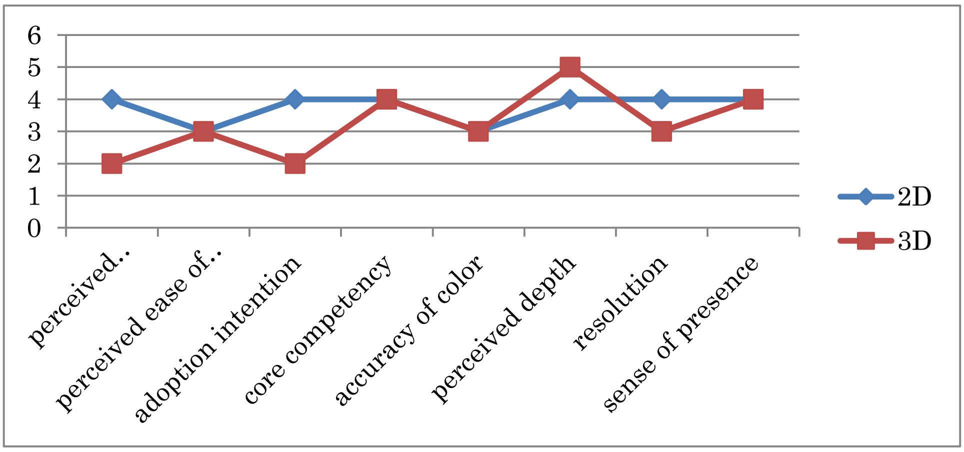
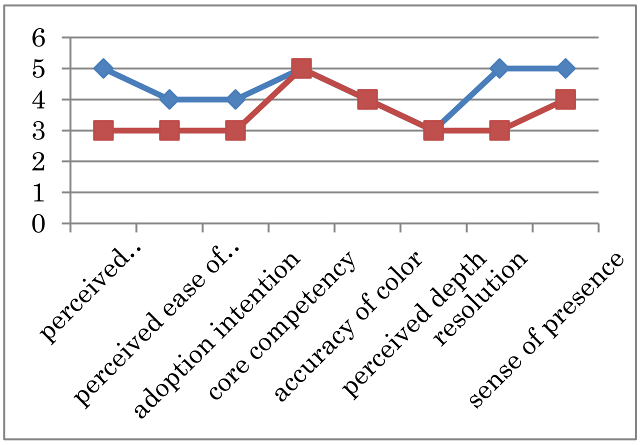


Fig 3.2: Score from dermatologist 2D telemedicine system (mean: 3.75)
3D telemedicine system (mean: 3.25)

From dermatologist perspective (Fig.3.2), as we predicted before the semi-interview, the 2D telemedicine system is advantaged in all factors except perceived depth information and accepted a higher evaluation than 3D system. Compare with otolaryngologist, the dermatologist gave a 4 point to quality of image which means the 2D system is still need to improve in quality of image for diagnosis in dermatology even it can provide a better quality of image than existing system. In contrast, despite the 3d system has accepted a high score in perceived depth information, it still did not show its usefulness and performance in transmission of image to dermatology which resulted in low score in adoption behavior. According to result of interview, dermatologist mainly focuses one point (affected part) that 3D has nothing to do with the diagnosis in dermatology.



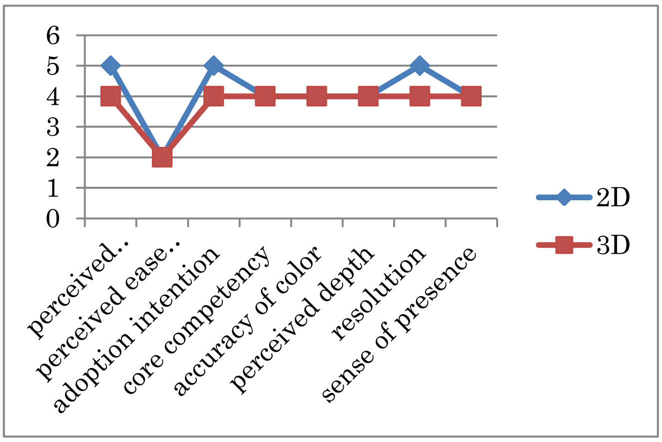


Fig 3.3: 2D telemedicine system (mean: 4.375) 2D telemedicine system (mean: 4.125)

3D telemedicine system (mean: 4.0) 3D telemedicine system (mean: 3.75)

Two surgeons have attended this semi-interview (Fig3.3). From the graphic, it presented that different from other professional, there is a no significant difference between two systems. As we predicted, depth information is an important advantage to surgeon that might increase the practical value of 3D system. According to the result of interview, 3D system has indeed showed its usefulness in surgeon especially in the minimally invasive operation or Tele-surgery. However, this advantage cannot significantly improve its practical value unless for educating young doctor who have no enough experience.

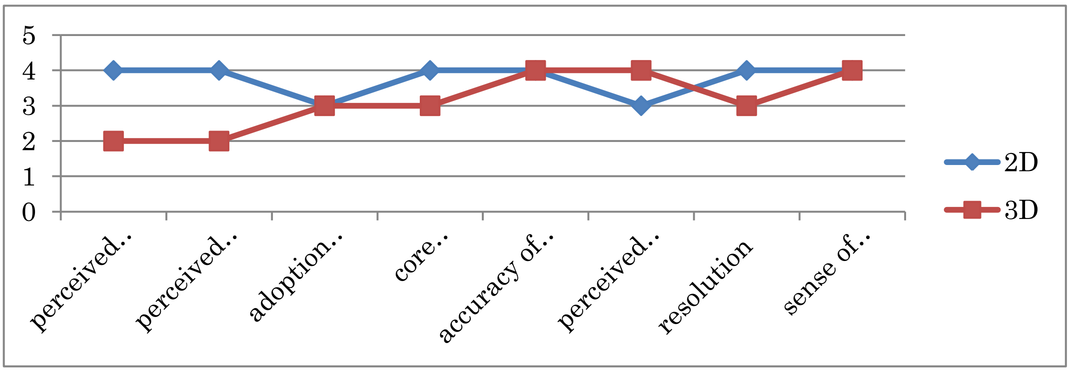


Fig 3.4: 2D telemedicine system (mean: 3.75)

3D telemedicine system (mean: 3.125)

From physician perspective, a little difference between two systems has found in this graphic. Physician mainly focuses on the communication between both sides. In other words, physician might pay more attention to voice transmission rather than dermatologist. Through this investigation, it has found that physician might believe the usefulness of high-definition telemedicine system but has no significant intention to actual adopt the system.

In the initial investigation, we also compare each medical professional `s attitude toward system. Four of findings are described as follow. First, in the Fig 3.5, it has found that the 3D system received less score in usefulness and adoption intention which means the stereoscopic video is not a critical issue in the process of diagnosis. Only one surgeon has given a relatively higher score to 3D system as we predicted before. Against to expectation, physician has showed a lower attitude to both of systems. The reason will be discussed in next section.

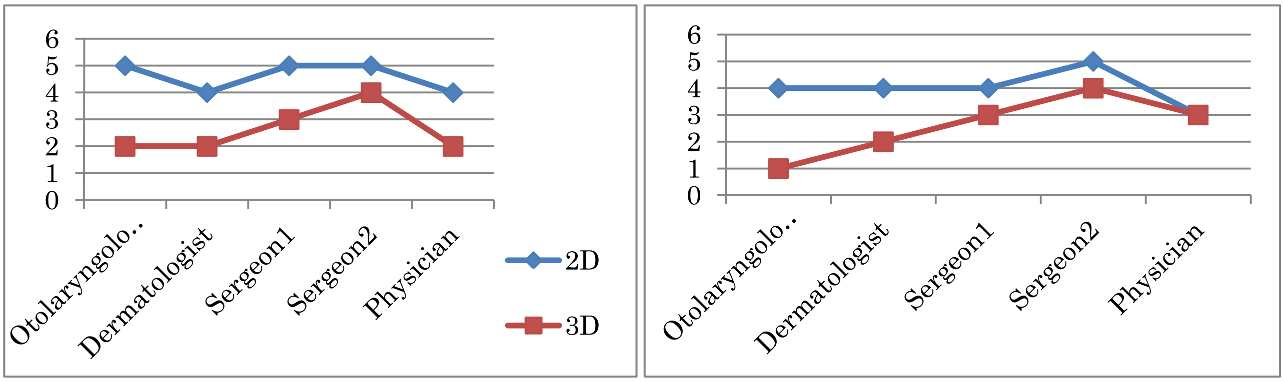


Fig 3.5: Usefulness and ease of use

Second, the Fig. has demonstrated that medical professional can perceive depth information through 2D system as well as 3D system, since medical professional has much professional experience in medicine. The practical value of 3D system is in education for young doctor or medical student.

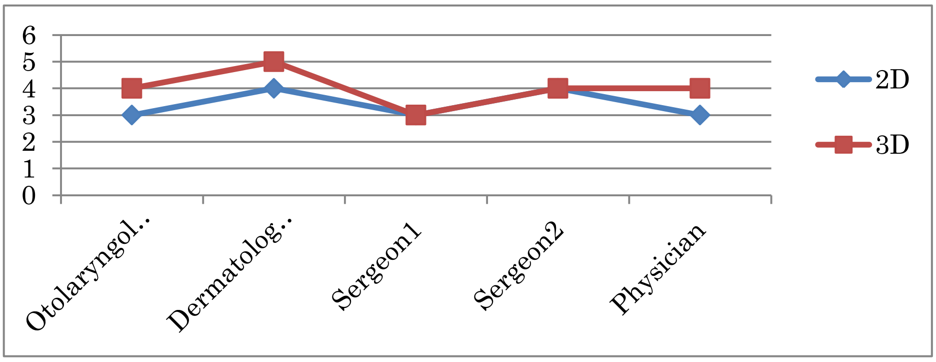


Fig 3.6: Perceived depth information

In conclusion, 2D high-definition system is regarded as an effective means to used in telemedicine for medical examination by interview, however, it still need to be improved in representation of image for dermatology diagnosis. The practical value of 3D system mainly involves in tele-education and tele-surgery due to medical professional is not familiar with 3D display. In addition, the result indicates that (1) as described in previous research, medical professional has no requirement for perceptive of depth from 3D system because of their experience. 3D system might be helpful to young medical professional for increasing accurate of operation and to medical student for a deeper understanding. (2) The attitude to system is influenced by professional specialty as we predicted before. The professional might focus on different function of system (3) although the teleconferencing system has compressed the data which result in time delay, it can work in medicine as non-compressed system in certain conditions (4) it has found that medical professional has no high intention to use the system in diagnosis regardless of high performance of the system.

3.4 Expectation for real-time telemedicine system

The second purpose of the semi-interview is to collect advices from medical professional to find the points which are needed to improved, (it can also be regarded as what are the important factors they concern) in real-time telemedicine system. Before we consult medical professional, several factors might influence the effectiveness of telemedicine system have been summarized by researcher.

They are (1) usability: how ease to operate the system, (2) real-time capability: the quality of real-time service. It mainly involved in time delay or smoothness of live video (3) perceived definition: the professional can observe the object clearly, (4) perceived accurate color: the professional can observe the color of object clearly, (5) perceived depth information: the professional can observe the color of object easily. Besides, we also acquired medical professional to give other factors which need to improve. The consequence as follow:

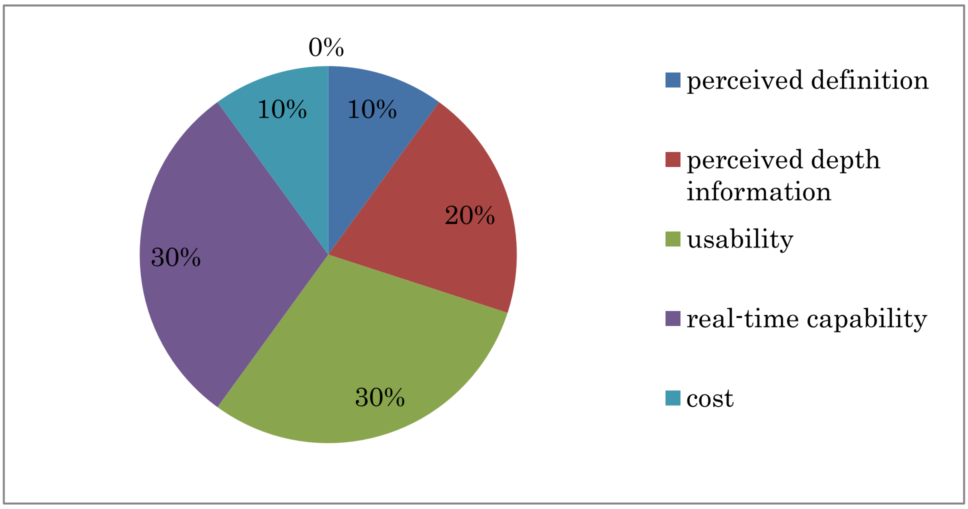


Fig 3.7: The important factors

The usability is an important factor to improve. Both of medical professional and patient can communicate without complex operation like store and forward telemedicine system. However, there are some new issues related to ease of use might rise when use the real-time telemedicine system. For example, the ease of use might include definition of image (the professional can observe easily through the display), voice transmission (the professional and patient can take a conversation easily) and likes. There is no significant difference between 2D system and 3D system in ease of use except the glasses. The need of glasses might be a detractor for medical professional who wearing glasses. Visual fatigue is also an issue mentioned by medical professional when they observe the display for a long time.

The Real-time capability is another significant concern of medical professional especially in the procedure of diagnosis. It presents that, offering a smooth communication without time delay is needed by medical professional in diagnosis. For example, negative effect from time delay is significant in the procedure of medical consultation such as dermatological diagnosis. It has found that, with support of GI-POF network, the time-delay has been decreased effectively [12]. It indicates that advantage system with support of stable network is a useful method to improve real-time capability.

Table 3.2 Results of Communication Delays (average) [12]

Communication Delay	A: GI-POF	B: Videoconference	C: Web Camera
Round Trip Delay – Measured (msec)	115	1,096	451
One Way Delay – Calculated (msec)	58	548	223

Perceived depth information is placed the third place that need to enhance. Although the advantage of 3D telemedicine system is to offer more accurate depth information, it is still need to improve in order to practical use in medicine. This issue might also be related mainly to resolve the 3D-discomfort.

The cost also has power to influence the adoption of real-time telemedicine system. Despite the cost of system is decreasing in recent years, medical professional still expected a significant decrease in system cost.

In conclusion, real-time telemedicine system has showed an acceptable performance in image display but it still needs to improve in usability (30%), need an improvement in real-time capability (30%) to support its performance. This research will focus on usability since the real-time capability is investigated in previous research.

3.5 Other aspects from initial investigation

Besides the perceived effect factor, we had also investigated other factors which might influence the attitude toward real-time telemedicine system such as professional characteristic.

Working preference: working preference is a work condition the professional like or dislike that influences the attitude toward system. For instance, an important benefit of our real-time telemedicine system is large screen which capability for more observers to watch at the same time. Nevertheless, in general, the size of display which medical professional adopted is around 24inch, it turns out that large display meets the requirement of medical professional properly for discussion or conference but individual work.

Professional specialty: as mentioned in last section, professional specialty is important factor that influence the attitude to system. For example, quality of image is the most important factor in dermatologist perspective while fluent communication is the most important factor in physician perspective. On the other hand, perceived depth information is important for surgery but dermatologist.

IT usage: in previous research, computer attitude of course plays a role to impact the attitude of system user [24]. Medical professional using computer might cause a positive effect to adoption of new system. In this initial investigation, we studied medical professional`s IT ability by asking questions such as how often do you use you use your computer to send email or how often do you use your computer to search information. It has found that medical professional who is familiar with information technology has a negative attitude to both of 2D and 3D systems. Although this result might be regarded as small probability event since the P-value is larger than 0.5, we assumed that a medical professional with higher ability in information technology might be severer on new technology than other medical professionals. This result can be considered as a reference for further research.

Table 3.2: correlation between IT usage and attitude

Correlations

		ITscore	Foe3D	For2D
ITscore	Pearson Correlation	1	-.854	-.800
	Sig. (2-tailed)		.065	.104
	N	5	5	5

Affiliation: Through a comparison of two groups, it has noted that medical professional from university has a positive attitude in 3D system rather than professional from Suginami since it can play an important role in medical education. In addition, medical professional in clinical or hospital might pay more attention to cost than professional from university hospital. Therefore, the Affiliation is a factor which might influence the adoption of new system.

Network: it is no doubt that network is an important factor to impact the real-time telemedicine system. Although, with advent of FTTH, the high bandwidth network can support more stable, safer real-time telemedicine system to work, no stable and high bandwidth network can be provided in rural sites. Thus, it is needed to understand the influence from bandwidth to real-time telemedicine. In other words, one purpose of this initial investigation is to identify the lowest bandwidth for practical diagnosis and consultation, how network influence the effect of system and whether the influence of bandwidth might be impacted by professional specialty. We demonstrated real-time requested medical professional to judge as well as actual diagnose. We digest the part from the result as follow:

Table 3.3: Bandwidth survey

physician	**Bandwidth**	**Evaluation**	**Detail of image**
1	4.4Mbps	can diagnosis	60fps
2	2Mbps	cannot diagnosis	60fps (image noise)
3	3Mbps	cannot diagnosis	60fps (Posterization)
5	1.5 Mbps	cannot diagnosis	30fps
6	1.4 Mbps	can diagnosis in certain condition	30fps deteriorate the quality of image
7	80Kbps	cannot diagnosis	30fps (Posterization)
8	450 Kbps	cannot diagnosis	30fps
9	1005 Kbps	can diagnosis in certain condition	30fps

demonologist	**Bandwidth**	**Evaluation**	**Detail of image**
1	50Mbps	can diagnosis	60fps
2	20Mbps	can diagnosis	60fps
3	14Mbps	can diagnosis	60fps
4	18.5Mbps	can diagnosis in certain condition	60fps
5	10Mbps	can diagnosis in certain condition	60fps

In this open experiment, all medical professional has been acquired to observe the image displayed from teleconferencing system and high-definition system without image compressed. 3D system is not included in this open experiment. Medical professionals have been categorized in to two types: image focus such as demonologist and non-image focus such as physician. The professional will observe the display while assess that whether the image can be used in actual diagnosis.

We adjusted bandwidth randomly and then acquire the professional to assess the quality of image. As a result, in 1005Kbps/30fps or above, the physician can examine the patient through display in certain condition, 4.4Mbps is the lowest standard for physician`s examination. In 10Mbps or above, the demonologist can observe the affected part through display in certain condition. 50Mbps is the lowest standard for demonologist` examination. This result has indicated that (1) the physician who focuses on the communication in diagnosis can diagnose the patient with a relatively low quality of image. (2) in contrast, the demonologist who focus on the quality of image has a higher requirement for diagnosis. And it also elicited that whether we can use bandwidth as a measurement to assess the quality of real-time telemedicine system.

3.6 Summary

By and large, this chapter describes the achievement of initial investigation for research which includes the attitude toward real-time telemedicine system, the mostly concern of medical professional and important respective might influence the adoption of real-time telemedicine system. It has found that high-definition telemedicine systems can be used in diagnosis regardless of compressed or non-compressed. Medical professional can gain the information they need through 2D system although it still needs to test by actual usage. However, associated with an open experiment and interview, it has found that network is a key point might determine the performance and impede the professional to adopt. In particular, as a low cost system, the influence of network to teleconferencing system is high than need to investigate. In addition, there are some other factors related to professional characteristic might influence the adoption behavior.

On the other hand, 3D system were not accepted by most professionals due to medical professional can perceive the depth information through 2D system by their experience. It has found that 3D system might be more powerful in education. In other words, 3D system is usefulness when the user are younger professional or with no much medical experience.

The achievement and other findings from this investigation will be adopted for further research of practical model. Much detail will be discussed in next chapter associated with the theoretical framework and hypotheses in this research.

Chapter 4 Theoretical framework and hypotheses

4.1 Introduction

The integrated real-time telemedicine system, review of technology acceptance model and initial investigation of professional attitude have been discussed in the previous chapters. This chapter is to represent the basic concept and explain the factors of practical technology acceptance model for real-time telemedicine system. The key determinants, moderator and certain factors based on requirement we proposed for the model will be discussed.

4.2 Research objectives and basic concept of model

As mentioned in chapter 3, using of TAM as a framework to extend a new practical model for real-time telemedicine is the main objective of this research. Through expanding the original model and thorough understanding of determinant and relationship in this model, we can predict the possibility of adoption, diagnose the reasons of adoption behavior and increase the possibility of acceptance. There is another important objective of this research is to associate non-psychological factor related to practical perceived effect factor in the model and measure their influence using experiment and questionnaire.

One benefit of TAM is to successfully measure the adoption behavior for new technology. In many previous researches of TAM, intention to use technology or actual usage is elected as key variable to measure the adoption. When a technology is yet to be widely adopted or in the development, possibility of actual adoption can be measured by intention behavior as well as actual use. This might raise an issue: can intention accurately predict the actual usage? In research of TAM, some previous longitudinal researches have proved the effectiveness of behavioral intention when the new technology had never been introduced before [28]. The important role of behavioral intention is a critical point in this research because the real-time telemedicine system has a low adoption rate in fact. This study will only adopt the behavioral intention as core concept to test and measure since we expected the behavior intention for real-time telemedicine will lead actual use. Besides, we will adopt the basic theory from [29] and use some of variable in the model for real-time telemedicine system.

In addition, existing TAM has only reflect the influence of psychological factors such as social influence and characteristic factor such as age and sex, but nothing to do with the direct influence from the system. In this research it is expected the influence from system toward behavior system. It will be to explore the direct influence from system and integrate them into model.

4.3 Theoretical framework

In this study, theoretical framework is defined as an assembly of factors and logical relationships which might be important to the adoption behavior. It is essential to develop this conceptual framework for thorough understanding of the variables and their influence in this model. There are four types of terms adopted in this study.

The core construct (direct determinant) comprised perceived usefulness (PU), perceived ease of use (PEOU), IT usage (ITU) and expectation of system (EOS). These core constructs are regarded as influences to adoption of real-time telemedicine system.

Four Moderating constructs consist of three items related to medicine. They are Affiliation, medical specialty and medical work experience. In contrast, individual character such as age, gender and sex are not included in the model. These moderating variables are expected to impact the relationship among core constructs and the influence toward the behavioral intention for adoption in this study.

Five perceived effect factors (requirement-based factors) are proposed for this model in this study. Different with previous researches of TAM, perceived effect factors are not expected to impact the intention directly in this research. There are consisting of five factors: including perceived accurate color (PAC), perceived definition (PD), perceived depth information (PDI), perceived sound (PS) and perceived smoothness video (PSV). They are considered to impact the usefulness and effectiveness of telemedicine system.

Based on the proposed constructs, variables and relationships in the model, several hypotheses will be tested and measured in this study.
(1)Whether core constructs can significantly impact the intention of adoption of real-time telemedicine system, (2) whether moderators have significant impact on the influence of core constructs toward the behavior intention of adoption of real-time telemedicine system, (3)whether moderators affect the relationship of the requirement-based factors,(4) How perceived effect factors will be influenced by moderators.

(1)Direct determinant
In previous researches, a number of determinants have been proposed in TAM. For this study, I mainly focus on the direct determinants that based on the prominent previous research of TAM and in combination with previous investigation in chapter 3. The major determinants in this study are perceived usefulness (PU), perceived ease of use (PEOU), IT usage (ITL) and Expectancy of system (EOS). I will explain the reason of adaptation of these determinants.

Perceived usefulness:

The direct power of perceived usefulness has been proved in lots of previous researches of TAM. From it has been theorized by first TAM, it has been tested and supported as a direct determinant to behavior intention in many cases.

In this study, perceived usefulness is defined based on first TAM as the degree to which a medical professional believes that using the real-time telemedicine system would enhance his/her medical job performance.

Perceived ease of use

Perceived ease of use was also supported in previous researches and cases. It has presented a direct influence on both of behavior intention and perceived usefulness with strong evidence. Thus, it is justified as an important direct determinant in this model as the degree to which a medical professional believes that using the real-time telemedicine system would be free of effort for medical task.

IT usage

IT Usage might be analogous to self-efficacy referred to computer ability in some previous researches of TAM. It has been proved in many previous researches that people with higher ability of computer might have more positive attitude toward new technology. In previous investigation, a negative correlation has been found between attitude toward real-time telemedicine system and ability of computer. It turns out that medical professional might have a higher expectation on new telemedicine system. In this model, IT usage might be classified into several factors and tested respectively in this research. It is justified as the degree to which a medical professional has experience in information technology in life and work environment.

Expectancy of system

Although in previous research, performance expectancy is an important variable that influence the behavior intention. It means a degree to which an individual believes that using a system will help user to attain gains in job performance [26].The five constructs that pertain to performance expectancy are perceived usefulness, extrinsic motivation, job-fit, relative advantage, and outcome expectations. In this model, we adopted the relative advantage as a new variable - expectation of new system (derived from attitude determinant) is potential determinant in this model which link up perceived effect factors with behavior intention for adoption. In previous investigation, relatively lower degree of satisfaction toward teleconferencing real-time telemedicine system has been indicated. In order to improve the system to meet the requirement from medical professional, I used KJ method to collect and categorize professional`s requirement (the detail will be described next) and hypothesized that the degree to which a medical professional believes that existing system is not meet their requirement and a more advanced real-time telemedicine system is needed.

Social influence

Social influence based determinants have been supported as a significant determinant in TAM by many researches. However, in previous research of TAM, inconsistency of social influence has been found in TAM of telemedicine [31]. Social influence (or subject norms) has no significant influence on behavior intention comparing with perceived usefulness and perceived ease of use. Furthermore, in this research, the social influence cannot be perceived by medical professional by its low adoption rate. Thus, the social influence will not be adopted in this research.

Behavior intention

Actual usage behavior cannot be measured because the real-time telemedicine I proposed system has never been used in real work environment. It means that only behavior intension can be measured in this study. Results of much research have indicated the correlation between intention and usage was significant in the TAM. Therefore, behavior intention is a proper measurement for predict the adoption behavior of medical professional. However, it has also found that intention is more predictive when users have experienced technology before. Therefore, I had demonstrated the system we proposed to medical professional before I tested this model. Consequently, behavior intention for adoption of real-time telemedicine system is the main measurement for prediction in future.

(2) Moderator

The moderator as the third type of variable in the model might modify the value of other variables. Through testing the different groups of medical professional, we can test the effectiveness of moderator. If the test result shows a significant difference between groups, it indicates the effectiveness of moderator.

People personally differ with their age, gender, position for preference of technology. Thus, the same system might provide different effectiveness to different people, especially when it used in the medicine. This model will take account of professionalize of telemedicine system that only includes professional-related moderators. There are four moderators in this model: (1) professional specialty presents major field of medical professional such as dermatology, internal medicine. This moderator is to influence the focus point in the medical task. For instance, dermatologist might focus on image while physician might focus on communication. The difference between medical professional is expected to impact the perceived usefulness or perceived ease of use. (2)Medical work Experience means the degree of specialization. (3) Medical background indicates the type of medical professional. More detail will be described as follow:

Professional Specialty

Despite professional specialty has never been associated with TAM as moderators in previous researches, it is playing an important role in acceptance of new telemedicine. In many previous research, professional specialty always been used as a background rather than a variable [32]. It is found that the requirement for telemedicine system will be significant different. For example, the dermatologist mainly diagnoses a patient by observing the color of skin which indicates the importance of display of color. In contrast, the physician might put more focus on the communication and sound. There are several categorizes will be tested in this model as (table 4.1)

Table 4.1 Assumption of category based on initial semi-interview

Image focus: **perceived accurate color, perceived definition, video fluency**	**Communication focus:** **sound, depth information, video fluency**
Dermatologist (from initial investigation)	Physician (from initial investigation)
Otolaryngologist (from initial investigation)	surgeon (from initial investigation)
Etc.(depends on the result of questionnaire)	Etc. (depends on the result of questionnaire)

Medical work Experience

Experience has been clearly theorized in TAM2 that it has a significant impact on the influence of subject norm toward intention. The previous research has showed that effectiveness of subject norm was decreasing with increasing of experience in system operation. In this study, medical work experience is a measurement for professional skill and knowledge. In previous investigation, the work experience has explicitly demonstrated its influence on attitude toward system. For instance, medical professional experience has more negative attitude toward 3D telemedicine system than medical students do. It is expected to impact the influence of perceived usefulness and perceived ease of use to intention.

Individual background is important respect that influences the intention of adoption. In this study, medical background is a concept of the institution which the professional belong to. For instance, it has been found that a medical professional from a university hospital might accept new telemedicine system easily because he/she has a background as educationalist or researcher [33]. In contrast, some medical professionals might tend to reject use new technology when they are in a position of manager.

(3) Perceived effect factors

Perceived effect factors are new factors which link the effect of telemedicine system and requirement. They were expected to directly influence usability of system. In this research, they represent that how medical professional perceive the system on their own perspective. Relationship among these factors was regarded as a critical respective which needed to conduct a further study. The perceived effect factors were derived from medical professional`s requirement, we will investigate the influence, relationship and importance of this group.

This part will mainly introduce the process of perceived effect factor design. In the first stage, we used

KJ method to collect the requirement from professional based on the semi-interview, and then classified these items into several groups.

Before the initial semi-interview, we have classified the requirement into four groups based on previous research: (1) perceived accurate color (PAC): the factor to which a medical professional believes that color is displayed accurately, (2) perceived definition (PD): the factor to which a medical professional believes that he/she can observe the object in more detail through system, (3) perceived depth information (PDI) the factor to which a medical professional believes that he/she can gain the depth information through display, (4)sense of presence (SOP): the factor to which a medical professional believes that he/she can perceive a work environment which is close to clinical setting.

Through the initial semi-interview, the AHP method has been taken to investigate the weight of each factor as a pilot test. The table represents the weight of factors on medical professional`s standpoint. According to this result, it have found that the weight of each factor is different and it also showed that the weight has been influenced by medical professional`s specialty. Stand by otolaryngologist`s position, display perceived accurate color and High-definition for medical use are more important than perceived depth information and sense of presence. Stand by dermatologist and physician`s position, the result is a little different with otolaryngologist`s. With pilot test, we could confirm that medical professional has different perspective in effect of system. Yet, it is still difficult to confirm the weight of each factor only based on the semi-interview because of small sample size. And we found that the factor we proposed in semi-interview could not satisfy the requirement for actual diagnosis. It needs to re-abstract the factors based on the semi-interview.

Table 4.2: Weight of perceived effect factors

otolaryngologist	PAC	PDI	PD	SOP	weight
PAC	1	7	1	7	0.438
PDI	0.143	1	0.143	1	0.063
PD	1	7	1	7	0.438
SOP	0.143	1	0.143	1	0.063
				C.I.	0

(PAC, PD) > (PDI, SOP)

dermatologist	PAC	PDI	PD	SOP	weight
PAC	1	9	1	9	0.45
PDI	0.111	1	0.111	1	0.05
PD	1	9	1	9	0.45
SOP	0.111	1	0.111	1	0.05
				C.I.	0

(PAC, PD) > (PDI, SOP)

physician	PAC	PDI	PD	SOP	weight
PAC	1	4	0.5	4	0.35
PDI	0.25	1	0.5	1	0.126
PD	2	2	1	4	0.424
SOP	0.25	1	0.25	1	0.1
				C.I.	0.062

PD>PAC>PDI>SOP

According to the table, it has found that the weight of each factor has no significant difference in their ranking regardless of professional specialty. The three medical professional has all focused on the quality of image that against our expectation. This result is still needed to investigate again in further research.

In the semi-interview, in order to enable medical professional to experience the system, we stimulated a condition in which the professional can communicate with patient through the system. The conversation in the process of stimulate diagnosis has been record (Fig 4.1) on which we used KJ method to analyze.

It has found that sense of presence comprise two detail factors perceived sound (PS) and perceived video smoothness (PVS). The weight of five factors will be tested in further research. (1) Perceived sound: medical professional can communicate with patient normally and learn information from sound. (2) Perceived video smoothness: the image can be transmitted fluently without breakdown (Fig 4.2).

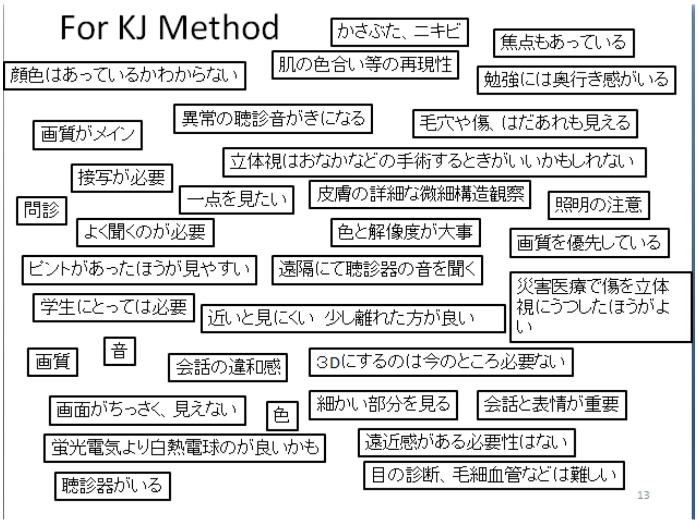


Fig 4.1: Voice from medical professional

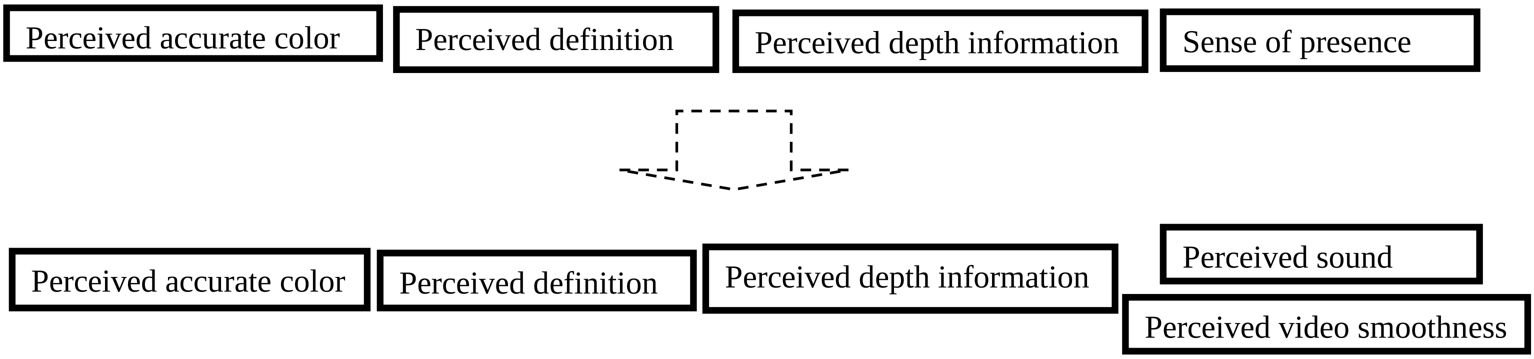


Fig.4.2: New factors abstracted

Influence of network

In previous semi-interview, real-time capability is important and needed to improve in medical professional`s perspective. Besides real-time capability, other effects of system might also be influenced by network. In order to investigate the relationship, we propose bandwidth as a measure which is expected to influence the effect of telemedicine system. In this research, an experiment will be conducted to identify the relationship between network and system.

4.4 Research hypotheses

The categories of hypotheses will be tested and technical (requirement-based) factors will be investigated. The first category is hypotheses for the direct influence between behavior intention and direct determinant. The second one is hypotheses for the testing the moderator impact the influence of direct determinants. And last but not least, perceived effect factors will be investigated.

Direct hypotheses

The direct hypotheses will be tested the relationship between behavior intention and direct determinant.

H1. Perceived usefulness has a significant influence on behavior intention of adoption

H2. Perceived ease of use has a significant influence on behavior intention of adoption

H3. Perceived ease of use has a significant influence on Perceived usefulness

H4. IT usage has a significant influence on behavior intention of adoption

H5. Expectancy of system has a significant influence on perceived usefulness

Moderating hypotheses

The hypotheses for moderator will be tested.

MH.1 The influence of perceived usefulness toward behavior intention is moderated by professional Specialty

MH.2 The influence of perceived usefulness toward behavior intention is moderated by medical work Experience

MH.3 The influence of perceived usefulness toward behavior intention is moderated by Affiliation

MH.4 The influence of perceived ease of use toward behavior intention is moderated by professional Specialty

MH.5 The influence of perceived ease of use toward behavior intention is moderated by medical work Experience

MH.6 The influence of perceived ease of use toward behavior intention is moderated by Affiliation

MH.7 The influence of Expectancy of system toward behavior intention is moderated by professional Specialty

MH.8 The influence of Expectancy of system toward behavior intention is moderated by medical work Experience

MH.9 The influence of Expectancy of system toward behavior intention is moderated by Affiliation

Perceived effect factor hypotheses

This research is to test the influence of network toward real-time telemedicine system. Several hypotheses will be tested by experiment and online questionnaire.

PEFH.1 The weight of each factor is moderated by Professional Specialty.

PEFH.2 The weight of each factor is different.

PEFH.2.1 Bandwidth is an effective measure (stimulus) to evaluate the relationship between perceived effect factors and network.

PEFH.4 The influence of bandwidth toward perceived effect factor is different.

4.5 Summary

In this chapter, we proposed a concept framework associated with the result of initial investigation based on which a practical model could be developed. In Fig 4.3, there are four parts in this model: behavior intention, moderator, direct determinant and perceived effect factors. The relationships between each construct which will be tested. In the next chapter, we will introduce the method of this research.

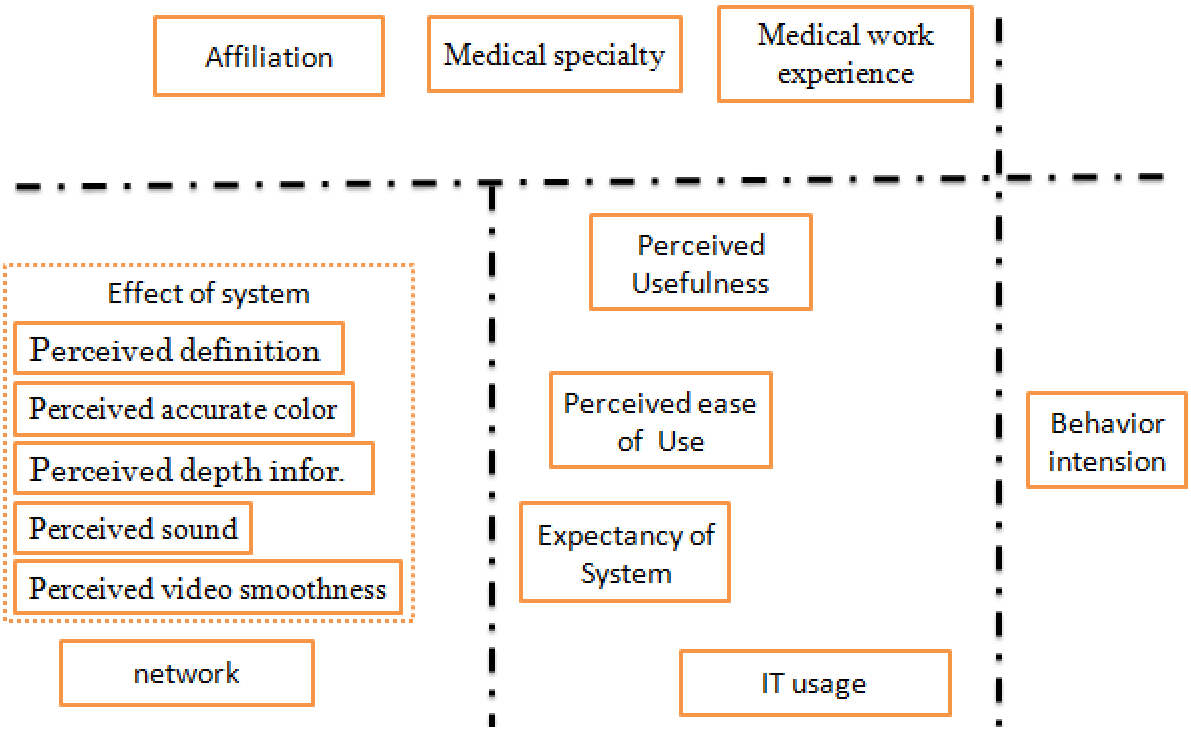


Fig 4.3 Image of practical model: relationship among constructs would be tested

Chapter 5 Research preparation

5.1 Introduction

In last chapter, we derived the information for our model from the initial investigation. After we obtained the information from the initial investigation, a further research is to extend a practical model for real-time telemedicine system based on technology acceptance model. Extension of a model is a haphazard and tough task due to a number of hypotheses needs to propose and test. It needs to choose a logic methodology in order to successfully achieve the research objectives. And process of preparation will be presented in this chapter. First, the rational of methodology in this study will be discussed and explained in terms of research design, scope of research, development of questionnaire, testing plan, data collection, data analysis and deduction. Second, the actual experiment for system will also be discussed. In sections 4.2 and 4.3, we review the detail of real-time telemedicine system we adopted and the research process with V-model.

5.2 The adoption of real-time telemedicine system

As mentioned in chapter 2, the real-time telemedicine system we adopted in this study integrated with two important technologies (chapter 2): (1) high-definition communication system (no compressed) (2) stereoscopic system. Moreover, the teleconferencing system was also adopted for research. In semi-interview, we have demonstrated these systems to medical professional. And we also used this system for experiment of bandwidth survey. The detail of specification is described in this section.

(1) Real-time telemedicine system with high-definition communication system (no compressed)

The high-definition real-time telemedicine system is used for demonstration. It will be involved in semi-interview and questionnaire. The Fig 5.1 shows the detail of this system.

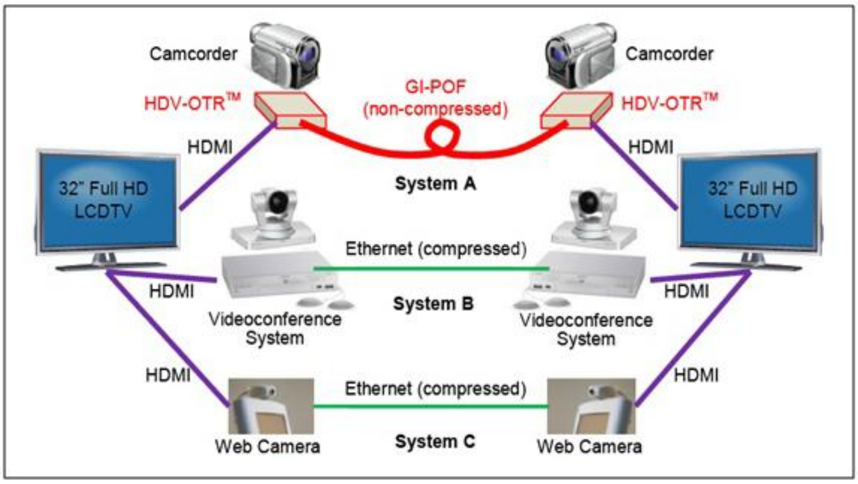


Fig 5.1 Real-time telemedicine system (non-compressed)

(2) Real-time telemedicine system with stereoscopic system

The 3D real-time telemedicine system is used for demonstration. It will be involved in semi-interview and questionnaire. The Fig 5.2 and table 5.1 showed the detail of this system.

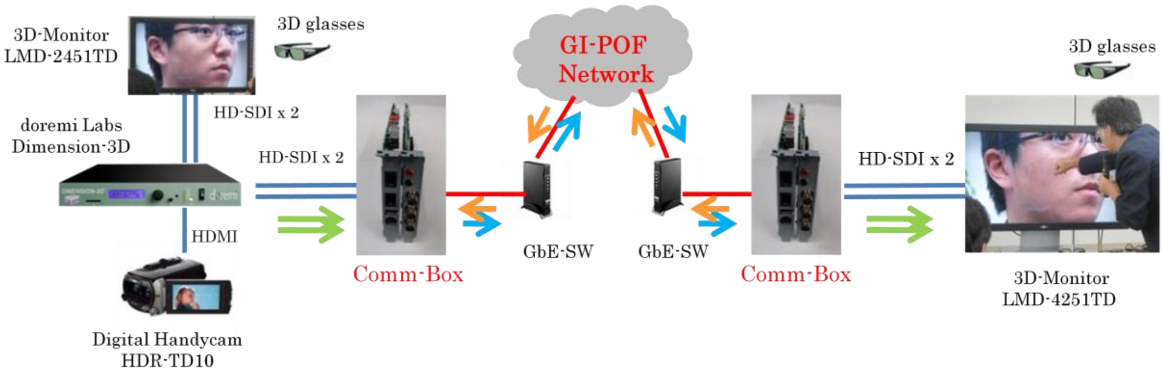


Fig 5.2: real-time telemedicine with 3D system

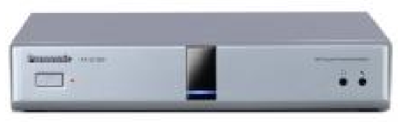
Table 5.1: System specification

Item		**Specification**
Video	Input	HD-SDI x 2
	Output	HD-SDI x 2
	Codec	H.264 AVC (HP Level 4.0)
	Video Format	1920x1080 59.94i
	Bit Rate	6-24Mbps
Audio	Input	HD-SDI x 2 (Embedded Audio)
	Output	HD-SDI x 2 (Embedded Audio)
	Audio Format	AAC-LC 256kbps
	# of channel	2
System	Transport	RTP
	Stream Format	MPEG2-TS
	3D Transmission	Dual Stream
	QoS	FEC
	Signaling	SIP

(3) Teleconferencing real-time telemedicine system

The 3D real-time telemedicine system is used for demonstration. It will be involved in semi-interview and bandwidth survey. There are two types of teleconferencing system we adopted. (1) Cisco Telepresence System QuickSet C20 and Panasonic VC500.

Table 5.2: System specification of teleconferencing system

Specification	**Description**	
Type	QuickSet C20	VC500
Image		
Bandwidth	• H.323/SIP up to 6 Mbps point-to-point	1.5 Mbps minimum* for 720p 512 kbps minimum* for 4SIF
Video Standards	• H.261, H.263, H.263+, H.264	ITU-T H.264 high profile level 4.0 (B picture is not supported)
Video Features	• Native 16:9 Widescreen • Advanced Screen Layouts • Intelligent Video Management • Local Auto Layout	Resolution: 1080i Resolution: 1080i

5.3 Research process

This whole procedure in this study is in accordance with a research logic based on V model. Section 4.3 is to review the whole research process:

(1) Defining the issue (Chapter 1): Through observing the current status of real-time telemedicine including type and adopted rate. And through investigating previous researches and cases, the issue of why real-time telemedicine system cannot be adopted widely has been defined.

(2) Proposition for issue (chapter 2): in order to resolve the issue of low adoption rate of real-time telemedicine system, I propose a practical model using technology acceptance model as a basic framework. By this practical model, we can identify the factors which might influence the adoption behavior and predict the possibility of adoption behavior.

(3) Initial investigation (chapter 3): preliminary information (requirement from medical professional) gathering through VOX for purpose of information collection on what and why. By demonstrating different types of systems to medical professional and semi-interviewing with them, it will make sense for further understand and feel the current problem. The achievement of this step will be

helpful for developing hypotheses of practical model.

(4) Modeling and hypotheses (chapter 4): based on previous research and initial investigation, developing a theoretical framework incorporating correlative factors which contribute to behavior intention is the main objective in this step. We not only propose the factor and relationship for the practical model, but also integrated the factors into this model in a logical manna.

(5) Test and modify the practical model (chapter 6, 7): after the work in chapter 5 and 6, an experiment and online questionnaire were used to identify the determinant to the behavior intention. By data collection and analysis, the reliable and validation of practical model can be tested, modified and proved. In the chapter, more details of data analysis and specific topic will be involved.

(6) Summary for Extension of practical model (chapter 7,8): a process of conclusions by interpreting the meaning of the results of the data analysis and prospect for the future work.

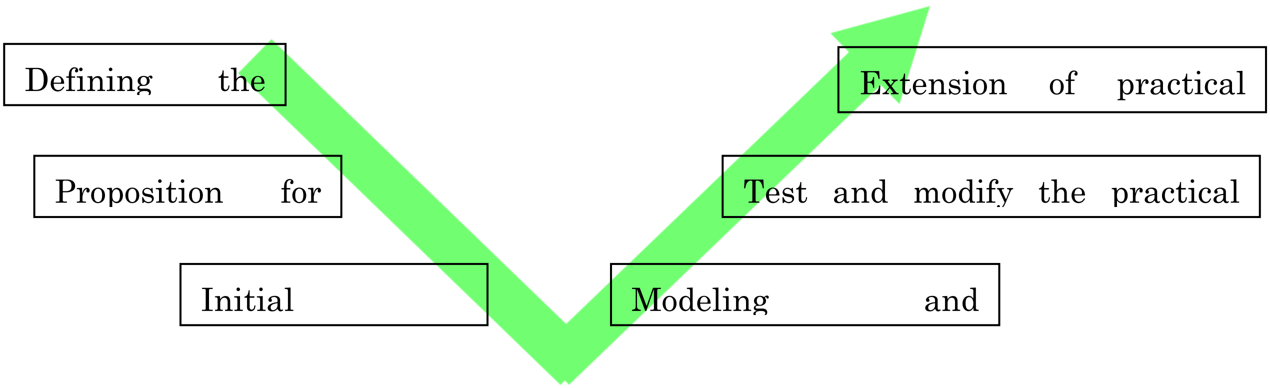


Fig. 5.3: V-model for this research

5.4 Scope of research

Survey is the core of this study which involved in a series of rational respective. Based -on the purpose of research, it devised following a number of decision associated with what the type of this study, what method will be used in this study such as semi-interview or questionnaire, the definition of study setting in relation to where the study would be conducted, unit of analysis and the level of investigation, time horizon of study which is temporal aspect and how the data would be collected, measured and analyzed. The following are the research considerations for this research in accordance with the research process derived from V-model.

(1)The type and setting of study

Before we expand a practical model from TAM for real-time telemedicine, the type of research needed to be identified. There are two types used in this research. First, it is a correlational type since it is interested in delineating the variables that associate with research problem, and deducing the relationship among variables. For instance, in this research, the relationship between behavior and psychology has been researched in this research. On the other hand, this research also attempts to investigate the difference between the groups of medical professional and identify the influence of network toward real-time telemedicine system by experiment. Therefore, it can also be regarded as an experimental type [35].

As both of correlational type and experimental type are involved in this research, it needs to involve non-contrived setting and contrived setting in this study. An investigation of the behavior intention of medical professional and the relationship among variables is surveyed through an open questionnaire which can be carried in a nature environment without artificial setting. In addition, a contrived setting is deserved when it comes to evaluate the influence of network to system. In order to insure the quality and accuracy of result gathering from experiment, the subject was assembled in one room and respond to researcher (us) according to the experiment plan.

(2) Unit of analysis and Time horizon of research

For this study, the units of analysis comprise two independent units: (1) the Keio university hospital which is a university hospital includes academy and a hospital. It refers to the level of semi-interview, data collection and subsequent analysis, (2) the Suginami medical association which is a professional academic organization in Suginami area. It refers to the level of semi-interview, data collection and subsequent analysis as well as the Keio university hospital. The difference between the two groups is academic position which many influence their attitude to adopt new technology. The Suginami physician association comprises lots of manager of hospital. Their focus is different from medical professional from university hospital or research institution. For example, the professional from Suginami physician association attend to cost of system rather than educational effect.

In addition, the time horizon of this research classified as a one-short study, since it is to aims at gather data for analysis through online questionnaire and experiment.

(3) Data collection and analysis

The procedure of data collection includes semi-semi-interview, experiment and online questionnaire. The more detail will be described as follow. Analysis is a step in where the data is analyzed for identifying the hypotheses we proposed and investigating the requirement from medical professional.

(4) Research methodology

Research methodology is the approach of the research process and certain concerns with the following issues: the reason of data collection, the type of data needs to collect, from where and when I can collect the data for this research and the method for last data analysis.

5.4.1 Reason of data collection and type

Before we enter into the main research of this study, it is necessary to identify what type of data needs to collect, that is important to this research in order to choose the research method and design the experiment. A number of previous researches for analysis of requirement are proposed, in this study, collection the voice of customer (medical professional) is a basis for further analysis of requirement. When it comes to the step of modeling, the statistic data is needed to collecting and editing. Besides, from the initial investigation, it has found that network might influence the effectiveness of real-time telemedicine system. We need to identify the influence of network and find a way to control the influence. The data for judge the influence is collected through experiment.

5.4.2 Adoption of method

Methods adopted in this research were categorized into three groups according to the objective of the study and type of data for collection: (1) Semi-interview method is to collect the voice (requirement) and basic information for evaluation of system and extension of practical model, (2) Questionnaire method is to gather primary statistic data for modeling, (3) experiment is to evaluate the influence of network to effectiveness of telemedicine system, (4) statistical method is used for data analysis.

(1) Semi-interview method:
The semi-interview is conducted by direct communication as face to face to collect information from medical professional. The first advantage of this method is that Because of the specialty of medicine, compare with statistic method, it is easy to collect the data by semi-semi-interview even from a small group (3~5 persons) and conducted in the initial step of the research. In addition, there is another advantage of this method is to establish a relationship for further research and gain motivate respondents. This is important in this study since the difficulty of inviting medical professional to attend our research. When we semi-semi-interview with medical professional, the real-time telemedicine systems were demonstrated for improving the responds quality.

(2) Questionnaire method:
In this research, we need amount of data for test the hypotheses we proposed. Questionnaire is an efficient method for primary data collection in the situation of we can predict the consequence and know exactly what we want to gain from our questions. The [36] suggested that questionnaires to large numbers of individuals simultaneously is less expensive and less time consuming than semi-interviewing with each subject. It also does not require as much skill to administer a questionnaire as to conduct semi-interviews which are important to the researcher of this study. In this research, online questionnaire is used to collect the data from professional for each variable and hypotheses. Because

medical professional can complete the questionnaire at their own convenience and no distance limit for questionnaire delivery. In short, questionnaire is a convenient way for both sides.

(3)Experiment

In order to learn the influence of network to system and test the hypotheses we proposed, an experiment will be conducted in hospital and our laboratory. Experiment, in this study, is to evaluate the influence of network toward real-time telemedicine system. First and observation is conducted. We will request the subject (medical professional and student) to observe the display, and then some questions related to quality of effectiveness will arise. The result of this experiment will be used for forming a practical model and understanding the influence of network. Although medical professional is the main research subject of this study, however, non-professional (student) is also included in the experiment. Method of limit will be used in the process of experiment, after the experiment, T-test, ANOVA, will be used for data analysis. The detail will be represented in section 4.6.

5.5 Experiment design

In initial stage of this research, the network is an issue that influences the quality of telemedicine service. In this research, it has questioned that how to measure the quality of real-time telemedicine with perspective of medical professional. Bandwidth is proposed by us to address this issue. We will develop a simple telemedicine system with teleconferencing system and change bandwidth artificially to whether bandwidth can be considered as a measure. The image will be assessed by subjects and analyzed. Non-compressed system will not be included in this experiment this time. Although, it might questioned that teleconferencing system which is from different manufacturers might cause difference in effect of system. The existing teleconferencing is compressing the image with same protocol which could support our hypotheses in this research. In this study, bandwidth was adopted as a measure to adjust and evaluate the quality of telemedicine service. There were three 3 steps in this research. (1) Through semi-interviewing with medical professional, it is to identify a standard image for consultation or diagnosis in medicine(completed in chapter 3), (2) using one system for testing the reliability of the threshold derived from the initial semi-semi-interview, (3) compare two different real-time telemedicine systems to confirm the generisability of bandwidth.

5.5.1 Experiment setup

The experiment was separated into two parts and conducted in Shinkawasaki campus of Keio University by Subjects of students and staff who are from KPRI. In the experiment, two different teleconferencing systems were adopted for transmitting the real-time video of researcher to subjects. A simple communication was taken between researcher and subject to enable it easier to judge the effect of system. As we hypotheses we proposed, bandwidth is regarded as measure for evaluate the system effect, a Packet-shaper was inserted into the network path for adjusting bandwidth during the experiment. The process of experiments was controlled by the researcher.

Table 5.3: Experiment

Experiment part NO.	**Experiment part1(Step 2)**	**Experiment part2 (Step 3)**
Adopted system	Panasonic teleconferencing system	Panasonic teleconferencing system Cisco teleconferencing system
Number of Subject	5 subjects	6 subjects

5.5.2 Method for experiment

In the experiment part1, we used the method of limits to determine a video threshold and judge whether the result from the semi-semi-interview is reliable. Bandwidth begins with an undetectable stimulus and then gradually increases or decreases the intensity until the max limit of bandwidth. In this research, the range of bandwidth is from 1.0Mbps to 6.0Mpbs. And the two threads (down-thread and up-thread) were conducted. The subject had to response to each stimulus through comparing two displays. And evaluate the effect of system by choosing 'equal', 'low' or 'higher'. Theoretically, only when the stimulus was 4.4Mpbs, did the subject respond 'equal'. In fact, the threshold for observe the stimulus was expected lies somewhere around 4.4Mpbs. In the experiment part 2, the same method was used as well as part 1. However, two systems were adopted and demonstrated in the same thread which will be helpful to compare two systems and investigate the influence from bandwidth.

5.5.3 Process of experiment

The subjects were 5 persons in part 1 and 6 persons in part 2 with normal vision. During the experiment, subject were acquired to response each stimulus in four respects which are (1) Collective impression, (2) perceived accurate color, (3)perceived definition, (4) perceived depth information, (5) perceived . The factor of perceived sound would not be included in this experiment since some technical problems.

The first step was to introduce the objective of the experiment and the way to response the question to our subjects. In experiment part 1, the subject were assembled in front of one display and showed a real-time video which was equal to the standard image derived from initial investigation. When the experiment begins, bandwidth was adjusted to 1.0Mbps and gradually increased by step of 0.5Mbps. The subjects were acquired to response to the real-time image and response to each stimulus. If they perceive one stimulus is the same as the standard one, they would choose `equal`, otherwise they would choose 'lower' or 'higher' instead of 'equal'. After one trial, the process was repeated from 6.0Mpbs to 1.0Mbps. The data from this experiment part 1 would be used to test the relationship between each perceived effect factor and network.

In experiment part 2, two systems were used to display real-time image to subjects. Subjects were acquired to compare two real-time images from each system. The image from Cisco system will be used as a standard (it used in the initial investigation before). The subject could choose the `equal` if they believe the images from Panasonic system are in the same level to standard. Otherwise, they would choose 'lower' or 'higher' instead of 'equal'. It was to confirm the hypotheses in the model.

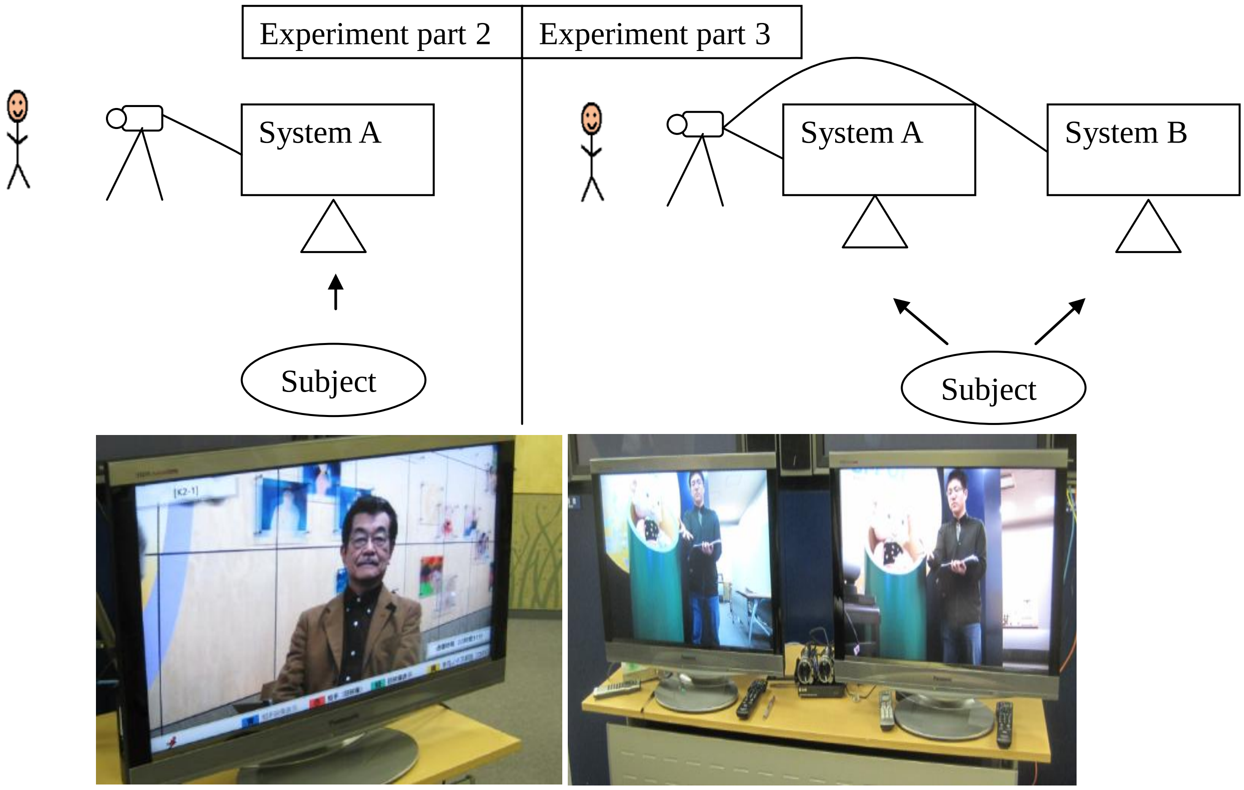


Fig 5.4: Experiment part 1 and part 2

5.5.4 Data collection and analysis

In this experiment, we had used a simple questionnaire which established as 5 point scale, we measured and recorded evaluation score from the subjects while they were viewing each stimulus of the two different systems

After we gain the primary data from experiment, we would (1) use one-sample t-test or Mann-Whitney U to explore the differences between sample value and standard value. It is used because this study needs to compare the mean score on some continuous variables for identify the impact of network, and the hypotheses we proposed in the research, (2) One-way ANOVA or Kruskal-Wallis H to compare the effect for each bandwidth.

5.6 Development of questionnaire

For the purpose of developing a questionnaire to collect primary data, this research conducted preliminary information collection by semi-interview integrated with information derived from literature survey in previous research. There were three steps in design of questionnaire.

5.6.1 Preliminary information collection

Because the objective of initial semi-interview conducted in this research is not only to gather information for requirement analysis, but also expected to provide important information that would be necessary in design of questionnaire and extension of practical model. As mentioned in chapter 3, a mass of information was collected. Key variables have been abstract from the semi-interview, and elaborately combined with the classic variables from the previous research with the aim of developing an effective questionnaire to be used in next survey.

Several professional aspects (such as medical work experience) associated with organizational position (such as Affiliation) are abstracted from the semi-interview. For instance, the relationship between IT self-efficacy and attitude has showed the influence of IT self-efficacy variable. Besides of this, some other key variables from previous research had been supported by the information from the semi-interview such as perceived might affect behavior intention, perceived ease of use might has positive on behavior intention. These variables were all integrated into the questionnaire design.

In conclusion, questionnaire was formulated in order to elicit important information for this research associated with the real-time telemedicine system adoption intention, professional aspect, organizational position and other aspects.

5.6.2 Questionnaire design

In the stage of questionnaire design, how to minimize the bias and ensure the reliability and validation of result is a main concern. We had focus on three areas during the design of the questionnaire, (1) the wording of question: accuracy of wording for question is important for avoiding the bias, (2) planning of issue in terms of how the variables will be categorized, scaled, and coded and (3) enable the general questionnaire easy to understand and respond.

The items used for measure in questionnaire are based mostly on the previous research. Since there are no exclusive question items for real-time telemedicine system, we adopted and modified the items from previous research associated with new items. We integrated questions from previous research into the questionnaire only when they really related to the research objectives and some items might possibly for further data analysis were selected to become part of the input into the questionnaire design process. In this research, new items were also made for questionnaire. In the chapter.3, we have found the influence of IT usage that included in the questionnaire consequentially. However, there is no proper group of items to measure the variable because existing items have difficult to describe the objective of my research. Thus, we made the items and test them before the last version questionnaire sent.

It was essential to explain the questionnaire objectives and the image of real-time telemedicine system that we adopted for this research. We firstly explained that the study was a research which is to gain voice from medical professional. In the questionnaire, it was clearly stated the system with vivid picture to make the questionnaire easy to answer. A test has been conducted before that only about 15 minutes need to answer the all questions. In addition, an important point we had to note, as showed in initial investigation, 2d and 3d system are different in evaluation. Therefore, we design this questionnaire and analyze the data for 2D system and 3D system respectively.

In order to improve the response rate, we formed this questionnaire separated into three sections. Some of them used a five-point Likert scale which is a popular for measuring attitudes. By Likert scale, respondents indicate their attitudes by checking how strongly they agree or disagree with the question that range from very positive to very negative. In this study, the scale ranges from strongly disagree =1, quite disagree = 2, neutral = 3, quite agree = 4, strongly agree = 5. And paired comparison is used in questionnaire for measuring the degree of importance in effectiveness of real-time telemedicine system.

The three sections in this questionnaire as follow:
Section A focused on characteristic information, it comprised questions established as character symbols such as how long you have been working as a doctor or which association you are belong in right now. The design at this section was based on literature survey.

Section B focus on the information of IT usage, it comprised questions referred to the frequency of technology usage and degree of how interested in new technology. This section is important to measure the IT usage of medical professional and the amount of items for measure is constricted. The process of this section design as follow:

(1) KJ method and brainstorming were used in the first step of question design. At first, the topic of brainstorming is identified as “how to judge a person`s IT usage”. The participators of this research consult the previous research while review the behavior related to IT in their mind while referenced

and then recorded their ideas on the sticky-note. The ideas were categorized into several groups which based on the Fig.

Fig.5.5 IT usage

(2) After the first step, several categories have been identified. Next step is to test the items for confirming the reliability. A simple online questionnaire is conducted in SDM to collect the information of the students and professor`s IT usage. The data has been analyzed by factor analysis, the result showed in the table. By relatively fewer items, the questionnaire has been considered to cover the usage of information technology.

Rotated Component Matrix(a)

	Component			
	1熟練度	2高級技術	3高技術接觸	4技術興趣
Eメールの利用	0.078	0.011	0.038	-0.038
facebook sns	0.090	0.079	0.137	0.306
net shopping	0.072	0.328	0.250	0.057
スマートフォン	-0.046	-0.102	-0.009	0.813
ipad	0.033	0.160	0.387	0.691
３D映画	0.046	0.125	0.836	0.228
情報雑誌	0.047	0.391	0.663	0.138
ゲーム	0.167	0.086	0.116	0.123
プログラミング	0.203	0.664	0.054	-0.053
インタネットニュース	-0.064	0.174	-0.082	0.208
google	0.294	0.028	-0.618	0.237
ｐｐｔ	0.797	0.181	0.063	0.264
論文検索	0.834	0.077	-0.205	-0.180
専門ソフト	0.693	0.360	0.184	0.067
download	0.546	-0.071	0.016	-0.088
upload	0.669	0.071	0.252	0.135
ハッドウェア雑誌	0.088	0.817	0.376	0.143
情報サービス	0.291	0.250	0.070	0.660
遠隔会議	0.263	0.052	0.630	0.053
自分のサイト運用	0.132	0.907	0.030	0.068

Fig 5.6 Result of factor analysis for IT usage items

Table5.4: Category of IT usage

Category	Specific behavior
Normal information technology ability	Give a presentation by PowerPoint or likes
	Use database to search paper
	Use the professional software such as spss
	Download the file from website
	Upload the file to website
Advanced information technology ability	Read the magazine related to hardware
	Make programming
	Own and operate a website
Keep in touch with information technology	Watch the 3D film
	Use search engine
	Read the information magazine
	Experience the Tele-conference
Interested in information technology	Own a smart phone
	Own a tablet PC
	Use the internet service such as Amazon.com

(3) Through the result of the step 2, we modified the first result and deleted some items of them. Consider of the actual IT usage of medical professional, some of items abstracted from the table will be associated with questionnaire. By relatively fewer items, the questionnaire can cover the ability of information technology. The question was established as 3-scale and 2-scale.

Section C was an important section used for testing and generating the models for 2D real-time telemedicine system and 3D real-time telemedicine system especially the model of technology acceptance for this research. It focused on the determinants that were expected to influence behavior intention based on theories and models in Chapter 5. The question items were established as a 5-point Likert- scale. In this section, besides the items derived from previous research, some new items have been designed for construct of expectancy of system.

Section D is investigating the degree of effectiveness of real-time telemedicine system. Paired comparison (established as a 7-point scale) was used for measure the weight of effect. Based on the result in chapter 3, it has noted that medical professional focus on the different effect of system. For instance, the dermatologist might focus on the perceived accurate color display rather than depth information. This section was developed to investigate how medical professional judge the importance of effect. It comprised 5 items and 10 questions.

5.7 questionnaire items

The items in this model we adopted are derived from previous research and designed by us. In order to suit the question items to this research. It is needed to redesign the question items based on original items. This section is to list the question items for each structure (Table 5.). They will be grouped into two questionnaire section for 2D and 3Dsystems.

Table 5.5: Questionnaire items for IT usage (Japanese in actual questionnaire)

Behavior intention	I attempt to use this system in diagnosis
	I want to recommend this system
	I plan to use the system in diagnosis
perceived usefulness:	I find the system to be useful in diagnosis
	Using the system is to know better about the patient
	Using the system enhances my effectiveness in diagnosis.
Perceived ease of use	The operation of this system is easy to understand
	I find it easy to get the system to diagnose
Expectancy of system	I am satisfied with low definition system
	I am satisfied with 2D system
	I expect a safe and high-accurate system

5.8 population, sample, data collection and data analysis

The population of further research is two groups of medical professional. One is medical professional who from Keio university hospital and have already had experience the demonstration which mentioned in chapter 4. And another group is medical professional who from Suginami medical association. Part of them has experienced the demonstration in chapter 4. The total population is more than 600 and 10% of it is expected to answer the questionnaire. And the medical has different background which is supposed for extension of practical model.

Sample size of this study is expected to more than 30 and less than 500 is appropriate for most research. In this study, respondent for this study is expected to 40~50.

This research was seriously concerned about the response rate for this survey since the response rate from in medical professional is usually very low. Instead of that, we used a professional online questionnaire system [37] for questionnaire which is easy to enhance the respondent rate and the result can be collected by us quickly. In terms of the response rate, we tried to keep the questionnaires as brief as possible and prolong the period of respondent.

After collecting data, data will be edited and analyzed using professional software. In this research, SPSS, Excel and AMOS were used in the step of data edition and data analysis. This process mainly focuses on data editing and analyzing. In order to quantify the data, we had coded by assigning numerical symbols, each question, and item has assigned a unique name, and some information of them were identified clearly such as specialty and medical work experience. This will be help for further data editing and analyzing.

Before we enter to the actual analysis of Data, it is necessary to check and adjust for errors, legibility, omission and consistency for further research. Error of data might be due to the stage of inputting data. It is necessary to confirm there is no inputting error in this study. In order to avoid this problem, this inputting data have been executed by two times. Omission of data was due to the low intention for responding questionnaire and amount of questions. It is very difficult to avoid due to the relatively complex questionnaire. In this study, expectation and maximization (EM) in professional software was used to define the missing data. The missing data will be filled in through professional software.
Legibility and consistency of data are important issue which directly influences the result of data analysis. This would be tested after collecting data.

After data editing, statistic method was used to analyze data for extension of practical model.

(1) T-test and Mann-Whitney U: Independent sample t-tests and U test were used to explore the differences between two groups such as males and females, young medical professional and specialist in many researches. It is used because this study needs to compare the mean score on some continuous variables for identify the impact of moderator we proposed in the model.

(2) One-way ANOVA and Kruskal-Wallis test: Although it is similar to t-test as a comparing means method, it can be used when the groups is more than two. For instance, the moderator medical specialty in this model refers to five groups that out of capability of t-test.

(3) Structural equation modeling: The main objective of this research was to generate a model of Technology Acceptance that described behavior intention. Structural Equation Modeling was considered to be suitable. The generated model is expected to be a model that is both substantively meaningful and statistically well-fitting.

5.9 Summary

In summary, this chapter introduces the main construct of this research, system detail in the research, method of research and questionnaire development. In the next chapter, we will analyze the data and conclude the result.

Chapter 6 Primary data analysis

6.1 Introduction

The goals of data analysis in this chapter are to test and investigate the results of (1) the reliability of the instrument based on internal consistency of the measures by testing the Cronbach's alpha together with inter-item correlation (2) the descriptive analysis associated with primary data, (3) the attitude to real-time telemedicine system, (4) whether there are significant differences between different groups including Affiliation, professional experience, and professional specialty. This preliminary data analysis will be achieved by using descriptive statistical techniques (5) whether there are significant differences in weight between perceived effect factors, (6) how the network (bandwidth) influence the effect of system, (7) whether we can measure the effect of telemedicine system by bandwidth, (8) whether the require-based factor might be influenced by professional specialty.

6.2 result analysis of network experiment

In chapter 3 and chapter 4, the hypotheses and result have been proposed. In this section, the result of experiment of bandwidth survey will be discussed. As mentioned, the purposes of this experiment were to investigate the influence of network to perceived effect factors and investigate whether we can use bandwidth as measure to assess different real-time telemedicine system.

In the part 1 of experiment, (1) interval of uncertainly (IU) is to determinate the range of uncertain about the stimulus. In this experiment, the measure represents the influence of bandwidth to each factor. As the value of IU is increased, the subject judges the standard stimulus more difficulty which means bandwidth has little influence on this factor (2) Point of subjective equality (PSE) is a subjective judgment for standard stimulus. In previous research, PSE is also different with standard stimulus. It is a measure to judge whether the people is sensitive to the standard stimulus (3) Different threshold (DL) is smallest detectable difference between a starting and secondary level of a particular sensory stimulus [39], it is a detectable difference for measuring how difficult subject notice the standard stimulus.

1. Collective impression: in the initial investigation, we acquire medical professional to assess the quality of image and give a score for collective impression. Thus we acquired the subject to assess the collective impression. From the table, it shows that responses of subject in each trial were not the same. As the experiment is repeated (trial 3 and trial 4) the responses differ from trial to trial. Average value is adopted as measure to judge the stimulus. In this experiment, the subject detected the stimulus at a level of 4.15 Mbps. 1.3Mbps of UI is a range of uncertain range that the subject could not judge the standard stimulus accurately.

Table 6.1: Collective impression

Collective impression	1	2	3	4	5	6	7	8	9	10
Bandwidth (Mbps)	UPWA	Upward	Upward	Upward	Upward	DOWN	DOWN	DOWN	DOWN	DOWN
6.00	+	+	+	+	+	+	+	+	+	+
5.50	+	+	+	+	+	+	+	=	+	+
5.00	=	+	+	+	+	=	+	-	=	=
4.50	+	+	=	+	+	-	=	-	-	-
4.00	=	-	+	=	=	-	-	-	-	-
3.50	=	=	=	-	=	-	-	-	-	-
3.00	=	=	-	=	=	-	-	-	-	-
2.50	-	=	-	-	=	-	-	-	-	-
2.00	-	-	-	-	-	-	-	-	-	-
1.50	-	-	-	-	=	-	-	-	-	-
1.00	-	-	-	-	-	-	-	-	-	-
0.50	-	-	-	-	-	-	-	-	-	-
Ll(Mbps)	4.25	4.25	4.75	4.25	4.25	5.25	4.75	5.75	5.25	5.25
Ln(Mbps)	2.25	1.75	2.25	2.75	2.25	4.75	4.25	5.25	4.75	4.75
aver Ll(Mbps)	4.8									
aver Ln(Mbps)	3.5									
Unconfirmed IU	1.3									
DL just noticeable different	0.65									
PSE	4.15									
4.4MPbs-PSE	0.25									

2. Perceived accurate color: after the initial investigation, perceived accurate color as an important factor in diagnosis has been confirmed by the semi-interview. In order to assess the influence of network to this factor, it has been measured in this experiment. From the fig. Average value is adopted as measure to assess the stimulus. In this experiment, the subject detected the stimulus at a level of 3.75 Mbps which is significant different with standard stimulus 4.4 Mbps. 2.2Mbps of UI is a range of uncertain range that the subject could not judge the standard stimulus accurately. In other words, perceived accurate color is not influenced by network significantly.

Table 6.2: Perceived accurate color

perceived accurate colour	1	2	3	4	5	6	7	8	9	10
Bandwidth (Mbps)	UP	UP	UP	UP	UP	DOWN	DOWN	DOWN	DOWN	DOWN
6.00	+	+	+	+	+	+	+	+	+	+
5.50	+	+	+	+	+	+	+	+	+	+
5.00	+	+	+	+	+	=	=	=	=	=
4.50	+	=	+	+	+	=	–	=	–	=
4.00	–	=	=	=	=	=	=	–	–	–
3.50	=	=	=	=	–	=	=	–	–	–
3.00	=	=	–	+	=	–	–	–	–	–
2.50	=	–	=	=	=	–	–	–	–	–
2.00	–	–	=	=	=	=	–	–	–	–
1.50	–	=	=	=	=	=	–	–	–	–
1.00	–	–	–	=	–	–	–	–	–	–
0.50	–	–	–	–	–	–	–	–	–	–
Ll(Mbps)	4.25	4.75	4.25	4.75	4.25	5.25	5.25	5.25	5.25	5.25
Ln(Mbps)	2.75	2.75	1.25	0.75	1.25	1.25	3.25	4.25	4.75	4.25
aver Ll(Mbps)	4.85									
aver Ln(Mbps)	2.65									
Unconfirmed IU	2.2									
DL just noticeable different	1.1									
PSE	3.75									
4.4MPbs-PSE	0.65									

3. Perceived definition: after the initial investigation, perceived definition as an important factor in diagnosis has been confirmed by the semi-interview. In order to judge the influence of network to this factor, it has been measured in this experiment. From the table 6.3, Average value is adopted as measure to judge the stimulus. In this experiment, the subject detected the stimulus at a level of 4.05 Mbps which is different with standard stimulus 4.4 Mbps. 1.4Mbps of UI is a range of uncertain range that the subject could not judge the standard stimulus accurately. In other words, perceived definition is influenced by change of bandwidth comparing with perceived accurate color.

Table 6.3: Perceived definition

perceived definition	1	2	3	4	5	6	7	8	9	10
Bandwidth (Mbps)	UP	UP	UP	UP	UP	DOWN	DOWN	DOWN	DOWN	DOWN
6.00	+	+	+	+	+	+	+	+	+	+
5.50	–	+	+	+	+	+	+	+	+	+
5.00	+	+	+	+	+	=	=	=	+	=
4.50	+	+	+	=	+	=	–	=	=	=
4.00	=	=	=	=	=	–	–	–	=	–
3.50	–	=	–	=	=	=	–	–	=	–
3.00	–	=	=	=	–	–	–	–	–	–
2.50	–	–	=	–	=	–	–	–	–	–
2.00	–	–	–	–	–	–	–	–	–	–
1.50	–	=	–	=	–	–	–	–	–	–
1.00	–	–	–	–	–	–	–	–	–	–
0.50	–	–	–	–	–	–	–	–	–	–
Ll(Mbps)	4.25	4.25	4.25	4.75	4.25	5.25	5.25	5.25	4.75	5.25
Ln(Mbps)	3.75	2.75	2.25	2.75	2.25	3.25	4.75	4.25	3.25	4.25
aver Ll(Mbps)	4.75									
aver Ln(Mbps)	3.35									
Unconfirmed IU	1.4									
DL just noticeable different	0.7									
PSE	4.05									
4.4MPbs-PSE	0.35									

4. Perceived depth information: after the initial investigation, it has found that a experienced medical professional can perceive depth information from 2D system as well as 3D system which has been confirmed by the semi-interview. In order to judge the influence of network to this factor, it has been measured in this experiment. From the fig. Average value is adopted as measure to judge the stimulus. In this experiment, the subject detected the stimulus at a level of 3.31 Mbps which is different with standard stimulus 4.4 Mbps. 3.1Mbps of UI is a range of uncertain range that the subject could not judge the standard stimulus accurately. In other words, Perceived depth information is influenced by change of bandwidth.

Table 6.4: Perceived depth information

perceoved depth information	1	2	3	4	5	6	7	8	9	10
Bandwidth (Mbps)	UP	UP	UP	UP	UP	DOWN	DOWN	DOWN	DOWN	DOWN
6.00	+	+	+	+	+	+	+	+	+	+
5.50	+	+	+	+	+	+	+	+	+	+
5.00	+	=	+	=	+	=	=	–	=	=
4.50	+	+	=	=	+	=	=	–	=	=
4.00	=	=	=	=	=	–	=	–	=	=
3.50	–	=	=	=	=	–	=	–	=	=
3.00	=	=	=	–	=	–	–	–	=	=
2.50	=	–	=	=	=	–	=	–	–	=
2.00	–	=	=	=	–	–	=	–	=	=
1.50	–	=	=	=	–	–	–	–	=	=
1.00	–	=	–	=	–	–	–	–	=	=
0.50	–	–	–	–	–	–	–	–	–	–
Ll(Mbps)	4.25	4.25	4.75	5.25	4.25	5.25	5.25	0	5.25	5.25
Ln(Mbps)	2.25	1.25	1.25	1.25	2.25	4.25	1.75	0	0.75	0.75
aver Ll(Mbps)	4.375									
aver Ln(Mbps)	1.575									
Unconfirmed IU	3.111111									
DL just noticeable different	1.555556									
PSE	3.305556									
4.4MPbs-PSE	1.194444									

5. Perceived video smoothness: after the initial investigation, it has found that perceived video smoothness is a critical factor contributing to perceived presence which has been confirmed by the semi-interview. In order to judge the influence of network to this factor, it has been measured in this experiment. From the fig. Average value is adopted as measure to judge the stimulus. In this experiment, the subject detected the stimulus at a level of 4.2 Mbps which is different with standard stimulus 4.4 Mbps. 1.1Mbps of UI is a range of uncertain range that the subject could not judge the standard stimulus accurately. In other words, perceived video smoothness is influenced by network significantly comparing with other factors as we expected.

Table 6.5: Perceived video smoothness

smooth perception	1	2	3	4	5	6	7	8	9	10
Bandwidth (Mbps)	UP	UP	UP	UP	UP	DOWN	DOWN	DOWN	DOWN	DOWN
6.00	+	+	+	+	+	+	+	+	+	+
5.50	+	+	+	+	+	+	+	+	+	+
5.00	+	+	+	+	=	=	=	=	–	+
4.50	+	=	+	+	+	=	–	–	–	=
4.00	–	=	=	=	=	–	–	–	–	–
3.50	=	=	=	=	–	–	–	–	–	–
3.00	=	=	=	–	–	–	=	–	–	–
2.50	–	–	=	–	–	–	–	–	–	–
2.00	–	–	–	–	–	–	–	–	–	–
1.50	–	=	=	=	–	–	–	–	–	–
1.00	–	–	–	–	–	–	–	–	–	–
0.50	–	–	–	–	–	–	–	–	–	–
Ll(Mbps)	4.25	4.75	4.25	4.25	4.25	5.25	5.25	5.25	0	4.75
Ln(Mbps)	2.75	2.75	2.25	3.25	3.75	4.25	4.75	4.75	0	4.25
aver Ll(Mbps)	4.225									
aver Ln(Mbps)	3.275									
Unconfirmed IU	1.055556									
DL just noticeable different	0.527778									
PSE	4.166667									
4.4MPbs-PSE	0.333333									

As a conclusion of experiment part 1, it has found several important points as showed in table 6.6. (1) Larger value of IU has showed that bandwidth has relatively less influence on perceived accurate color and perceived depth information. This result as we expected before this experiment that influence of network to each factor is distinguishing. (2) Although the subject tends to choose a stimulus which is lower than standard stimulus, it generally approximate to 4.40 Mbps by which we could believe subject were sensitive enough to the influence of network to image. (3) Bandwidth could be regarded as a measure in certain situation although it is not accurate enough.

Table 6.6: Comparison of each factor

Factor	**Collective impression**	**Perceived accurate color**	**perceived definition**	**Perceived depth information**	**Perceived video smoothness**
IU (Mbps)	1.30	2.20	1.40	3.11	1.06
PSE (Mbps)	4.15	3.75	4.05	3.31	4.17
DL (Mbps)	0.65	1.10	0.70	1.56	0.53

In experiment part 2, two systems were adopted to assess. The Cisco one was set as a standard to compare. The t-test and were used to Kruskal-Wallis test to analyze. In this part, we acquired the subject to assess the four factors without collective impression.

In the first stage of this analysis, one-sample t-test was used. The test value was set as 3 (equal).

According to the Central limit theorem, the t-test valid for large samples from non-normal distributions. We used one-sample t-test to analyze the data when the sample size is large enough (equal=83 in this research).

Table 6.7: Result of experiment part 1

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
PNresolution	84	2.18	1.077	.118
PNaccuracycolor	84	3.08	1.089	.119
PNperceiveddepth	84	3.33	.923	.101
PNvideotrans	84	2.62	.775	.085

One-Sample Test

	Test Value = 3					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
PNresolution	-6.989	83	.000	-.821	-1.06	-.59
PNaccuracycolor	.701	83	.485	.083	-.15	.32
PNperceiveddepth	3.311	83	.001	.333	.13	.53
PNvideotrans	-4.507	83	.000	-.381	-.55	-.21

The table 6.7 shows the result of how the subjects assess the Panasonic system comparing to Cisco system. There are important finding in this result. (1) The result shows that it has a significant different between two system in perceived definition, perceived depth information and perceived video smoothness despite they are observed at the same bandwidth. (2) The Tandberg system performance better in perceived depth information but perceived video smoothness and perceived definition. (3) There is no critical essential difference between two systems in perceived accurate color. We could conclude that the performance of teleconferencing system are different even they use the same protocol to compress the image data.

In order to analyze the influence of network (by bandwidth), we compare each groups of bandwidth from 3Mbps to 7Mbps. The result from table has showed that difference in the four perceived factors between systems was not modified by network significantly.

Table 6.7: Result of experiment part 2

	bandwidth	N	Mean Rank
PNresolution	3	12	29.54
	4	12	25.00
	5	12	33.92
	6	12	32.58
	7	12	31.46
	Total	60	
PNaccuracycolor	3	12	30.29
	4	12	30.75
	5	12	28.17
	6	12	31.25
	7	12	32.04
	Total	60	
PNperceiveddepth	3	12	27.96
	4	12	33.17
	5	12	37.13
	6	12	27.17
	7	12	27.08
	Total	60	
PNvideotrans	3	12	32.33
	4	12	25.25
	5	12	35.42
	6	12	34.25
	7	12	25.25
	Total	60	

Test Statistics[a,b]

	PNresolution	PNaccuracycolor	PNperceiveddepth	PNvideotrans
Chi-Square	2.154	.364	3.628	4.518
df	4	4	4	4
Asymp. Sig.	.707	.985	.459	.340

a. Kruskal Wallis Test

b. Grouping Variable: bandwidth

In conclusion, according to the result from two experiments, it has found that the network has a significant influence to system. It impacts the perceived video smoothness, perceived definition but perceived accurate color and perceived depth information. In other words, unstable network impact the professional who focuses on perceived video smoothness and perceived definition in their work. It supposed to assess teleconferencing system with bandwidth in this research. However, the result suggested that bandwidth can only be regarded as a measure for one system. Each system has its own advantage and drawback which causes a difficulty in assessment of the system only with bandwidth.

6.3 weight of perceived effect factor

In order to investigate the importance of each perceived effect factor from medical professional perspective, we used the paired comparison to acquire the professional compare each factor. Paired comparison of AHP and paired comparison of Haga were used for analysis. Because the subject might mistake in consistency when they respond the Paired comparison of AHP, it needs to adjust the primary data by researcher. We used the method which developed by Pro.tanaka [39] to adjust the primary data for a fit consistency index. In this section, there were 26 medical professional have taken this questionnaire. In this questionnaire, α1: perceived accurate color, α2: perceived definition, α3: perceived depth information, α4: perceived sound, α5: perceived video smoothness.

The result from 26 medical professional has shows that perceived definition and perceived accurate color are the most important factors and followed by perceived sound, perceived depth information, perceived video smoothness. (Perceived definition, perceived accurate color> perceived sound, perceived depth information, perceived video smoothness) this result represent that medical professional mainly focus on the quality of image rather than depth information or fluency of video. After discuss the collective result, we will discuss more detail as follow.

Table 6.8: Data from all subject (N=26)

α1	α2	α3	α4	α5
0.376923077	0.623077	-0.30769	-0.36154	-0.33077

α1-α2	0.246154	0.764267	-0.27196		
α1-α3	-0.68462	-0.1665	-1.20273	significant	difference
α1-α4	-0.73846	-0.22035	-1.25657	significant	difference
α1-α5	-0.70769	-0.18958	-1.22581	significant	difference
α2-α3	-0.93077	-0.41266	-1.44888	significant	difference
α2-α4	-0.98462	-0.4665	-1.50273	significant	difference
α2-α5	-0.95385	-0.43573	-1.47196	significant	difference
α3-α4	-0.05385	0.464267	-0.57196		
α3-α5	-0.02308	0.495036	-0.54119		
α4-α5	0.030769	0.548883	-0.48734		

(1) The table has shows the weight of factors only from perspective of physician. According to the table, the most important factor is perceived definition and perceived accurate color and followed by perceived sound, perceived depth information, perceived video smoothness. This result was against our assumption. (perceived definition, perceived accurate color> perceived sound, perceived depth information, perceived video smoothness)

Table 6.9: Data from physicians (N=15)

α1	α2	α3	α4	α5
0.546666667	0.573333	-0.10667	-0.50667	-0.50667

α1−α2	−0.02667	0.677381	−0.73071	
α1−α3	0.653333	1.357381	−0.05071	
α1−α4	1.053333	1.757381	0.349285	significant difference
α1−α5	1.053333	1.757381	0.349285	significant difference
α2−α3	0.68	1.384048	−0.02405	
α2−α4	1.08	1.784048	0.375952	significant difference
α2−α5	1.08	1.784048	0.375952	significant difference
α3−α4	0.4	1.104048	−0.30405	
α3−α5	0.4	1.104048	−0.30405	
α4−α5	0	0.704048	−0.70405	

(2) The table has shows the weight of factors only by perspective of surgeon. According to the result, there are no significant different between factors except perceived accurate color and perceived depth information. Referencing this result and semi-interview, we could conclude that (perceived definition, perceived video smoothness, perceived sound>perceived depth information> perceived accurate color). It is questioned that perceived depth information was not the most important factor in the system which contraries our expectation. This could be explained that experienced surgeon can perceive depth with their experience.

Table 6.10: Data from surgeons (N=4)

α1	α2	α3	α4	α5
−0.8	0.55	−0.15	0.15	0.25

α1−α2	−1.35	−0.55563	−2.14437	significant difference
α1−α3	−0.65	0.144368	−1.44437	
α1−α4	−0.95	−0.15563	−1.74437	significant difference
α1−α5	−1.05	−0.25563	−1.84437	significant difference
α2−α3	0.7	1.494368	−0.09437	
α2−α4	0.4	1.194368	−0.39437	
α2−α5	0.3	1.094368	−0.49437	
α3−α4	−0.3	0.494368	−1.09437	
α3−α5	−0.4	0.394368	−1.19437	
α4−α5	−0.1	0.694368	−0.89437	

(3) The table has shows the weight of factors only by perspective of dermatologist. According to the result, there are no significant different between factors except perceived accurate color and perceived depth information. Referencing this result and semi-interview, we could conclude that (perceived accurate color, perceived definition, perceived video smoothness > perceived depth information, perceived sound). This result was in accordance with our assumption. Dermatologist is mostly focus on the quality of image.

Table 6.11: Data from dermatologists (N=3)

α1	α2	α3	α4	α5
0.8	0.533333	-0.46667	-0.93333	0.066667

α1-α2	0.266667	1.911734	-1.3784		
α1-α3	1.266667	2.911734	-0.3784		
α1-α4	1.733333	3.3784	0.088266	significant difference	
α1-α5	0.733333	2.3784	-0.91173		
α2-α3	1	2.645067	-0.64507		
α2-α4	1.466667	3.111734	-0.1784		
α2-α5	0.466667	2.111734	-1.1784		
α3-α4	0.466667	2.111734	-1.1784		
α3-α5	-0.53333	1.111734	-2.1784		
α4-α5	-1	0.645067	-2.64507		

(4) Because the sample size was small that some data cannot be analyzed by paired comparison of Haga, we used paired comparison of AHP to analyze this type of data. The table has shows the weight of factors only by perspective of Orthopedist. Three orthopedists responded this question. We will calculate each weight of factor and analyze the result based on the average. According to the result, although orthopedist has different opinions in their responses, no significant difference between them. The last result has showed that in perspective of orthopedist, perceived definition is the most important factor which followed by perceived depth information and perceived video smoothness, perceived accurate color and perceived sound are in the last two places. This result was in accordance with our assumption.

Table 6.12: Data from orthopedists (N=3)

Orthopedist 1	PAC	RES	PDI	PS	PVS	Weight
PAC	1	1	3	5	5	0.34
RES	1	1	5	5	5	0.392
PDI	0.333	0.2	1	3	3	0.137
PS	0.2	0.2	0.333	1	0.333	0.051
PVS	0.2	0.2	0.333	3	1	0.08
					C.I.	0.072

Orthopedist 2	PAC	PD	PDI	PS	PVS	Weight
PAC	1	0.333	0.143	0.143	0.143	0.034
PD	3	1	0.143	0.143	0.143	0.054
PDI	7	7	1	1	0.333	0.241
PS	7	7	1	1	1	0.289
PVS	7	7	3	1	1	0.38
					C.I.	0.075

Orthopedist 3	PAC	PD	PDI	PS	PVS	Weight
PAC	1	0.2	0.333	3	1	0.134
PD	5	1	1	3	1	0.315
PDI	3	1	1	3	1	0.265
PS	0.333	0.333	0.333	1	0.333	0.071
PVS	1	1	1	3	1	0.214
					C.I.	0.082

Perceived effect factor	PAC	PD	PDI	PS	PVS
Average score	0.169	0.254	0.214	0.137	0.181

(5) The table has shows the weight of factors only by perspective of otolaryngologist. Two otolaryngologists responded this question. We will calculate each weight of factor and analyze the result based on the average. According to the result, otolaryngologist has different opinions in their responses. However, it is the same to focus on the display of medical image. The last result has showed that in perspective of otolaryngologist, perceived accurate color and perceived definition which present the quality of image are the most important factors. And then it is followed by perceived sound, perceived depth information and perceived video smoothness.

Table 6.13: Data from otolaryngologists (N=2)

otolaryngologist 1	PAC	PD	PDI	ST	PVS	Weight
PAC	1	5	5	5	7	0.547
PD	0.2	1	1	3	5	0.163
PDI	0.2	1	1	5	5	0.185
ST	0.2	0.333	0.2	1	1	0.058
PVS	0.143	0.2	0.2	1	1	0.048
					C.I.	0.079

otolaryngologist 2	PAC	PD	PDI	ST	PVS	Weight
PAC	1	0.333	1	1	1	0.15
PD	3	1	3	1	3	0.341
PDI	1	0.333	1	0.333	1	0.114
PS	1	1	3	1	3	0.282
PVS	1	0.333	1	0.333	1	0.114
					C.I.	0.038

Perceived effect factor	PAC	PD	PDI	PS	PVS
Average score	0.346	0.252	0.150	0.17	0.081

(6) The table has shows the weight of factors only by perspective of pediatrician. Although only one pediatrician responded this question, we calculated each weight of factor and analyze the result based on the result. According to the result, it suggested that in perspective of pediatrician, perceived definition is the most important factor which followed by perceived depth information and perceived video smoothness, perceived accurate color and perceived sound are in the last two places.

Table 6.14: Data from pediatrician (N=1)

pediatrician	PAC	PD	PDI	PS	PVS	Weight
PAC	1	0.2	1	3	5	0.191
PD	5	1	3	3	5	0.473
PDI	1	0.333	1	3	3	0.184
PS	0.333	0.333	0.333	1	3	0.1
PVS	0.2	0.2	0.333	0.333	1	0.052
					C.I.	0.095

In conclusion, as we supposed before this analysis, medical professional focus on different point when if they use the real-time telemedicine system to diagnose. In generally, most medical professional focuses on the quality of image. The result of this analysis will be used in the model to describe the relationship among perceived effect factors. It will also be adopted in the test of moderator.

6.4 Reliability analysis of primary data

After the data edition and initial analysis (chapter 5), this step is to enter the analysis process.

To test the reliability of questionnaire, we adopted Cronbach's alpha analysis for the measurement. According to the DeVellis(1991), the questionnaire can be regarded as strongly reliable survey when the value of Cronbach`s alpha is more than 0.8, reliable when the value of Cronbach`s alpha is range from 0.6 to 0.8, and unreliable when he value of Cronbach`s alpha is under 0.6. In addition, inter-item correlation value is used to test the correlation between items. As suggested by Cohen (1988), correlation (r) = 0.10 to 0.29 (small correlation, both positive and negative correlation), r = 0.30 to 0.49 (medium correlation), and r = 0.50 to 1.0 (large correlation). It might support the results of Cronbach's alpha coefficient in the questionnaire.

For the items of 2D system, internal consistency reliabilities based on Cronbach's alpha for measurement items are considered to be strongly reliable as showed in the table 6.15 (0.803). as the item-Total table showed, Cronbach`s alpha if item deleted value indicates the change of Cronbach`s alpha value when the item was deleted. It suggested that the it is needed to review the item if Cronbach`s alpha if item deleted value exceed 0.803. Based on the result associated with inter-item correlation value, **IT 1** was deleted for next analysis. However, considering the importance of EOS 12D, we reserved this item for next analysis.

Table 6.15: Reliability test for 2D system in total

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.803	.815	22

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
IT1	55.06	48.844	.213	.	.805
IT2	55.03	46.824	.465	.	.789
IT3	54.46	50.827	.278	.	.800
IT4	56.15	50.867	.239	.	.800
IT5	54.63	49.105	.380	.	.795
IT6	56.05	49.722	.421	.	.795
IT7	56.05	49.988	.292	.	.798
IT8	55.20	47.077	.400	.	.793
IT9	54.41	50.509	.321	.	.798
IT10	55.70	50.105	.301	.	.798
IT11	55.43	50.437	.378	.	.797
IT12	55.84	50.302	.267	.	.799
BI12D	53.99	43.059	.613	.	.777
BI22D	54.18	42.744	.669	.	.773
PU12D	53.31	46.168	.574	.	.783
PU22D	53.56	46.925	.405	.	.792
PU32D	54.01	45.931	.513	.	.786
EOU12D	54.17	46.847	.430	.	.791
EOU22D	54.24	47.772	.325	.	.797
EOU32D	54.07	43.873	.662	.	.775
EOS12D	54.02	59.540	-.537	.	.850
EOS22D	53.59	44.130	.584	.	.780

For the items of 3D system, internal consistency reliabilities based on Cronbach's alpha for measurement items are considered to be strongly reliable as showed in the table 6 (0.889). as the item-Total table showed, Cronbach`s alpha if item deleted value indicates the change of Cronbach`s alpha value when the item was deleted. It suggested that the it is needed to review the item if Cronbach`s alpha if item deleted value exceed 0.889. Based on the result of Cronbach`s alpha if item deleted value associated with inter-item correlation value, **IT 1, IT 3 and IT 9** were deleted for next analysis. In this research, **EOS13d** as an important item for construct EOS has showed a relatively lower correlation with other items caused by its ambiguity. However, we still reserved this item for further analysis.

Table 6.16: Reliability test for 3D system in total

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.889	.872	22

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
IT1	52.19	75.663	.216	.	.894
IT2	52.15	75.190	.306	.	.889
IT3	51.58	79.006	.127	.	.891
IT4	53.27	76.934	.395	.	.887
IT5	51.75	77.144	.253	.	.889
IT6	53.18	76.732	.408	.	.887
IT7	53.18	77.684	.217	.	.890
IT8	52.32	73.057	.428	.	.886
IT9	51.54	78.794	.150	.	.891
IT10	52.82	77.918	.209	.	.890
IT11	52.56	77.038	.456	.	.887
IT12	52.96	77.551	.248	.	.889
BI13D	51.24	64.433	.830	.	.872
BI23D	51.69	66.486	.804	.	.873
BI33D	51.53	68.607	.800	.	.875
PU13D	51.05	70.274	.663	.	.879
PU23D	50.99	71.429	.615	.	.880
PU33D	51.50	65.994	.801	.	.873
EOU13D	51.32	70.607	.639	.	.880
EOU23D	51.50	64.535	.862	.	.870
EOS13D	51.46	78.777	.058	.	.895
EOS23D	50.97	68.290	.745	.	.876

6.5 Demographic Data and Cross-Tabulation

After the reliability analysis of primary data, a general analysis was conducted to know the basic characteristic of this data. The questionnaire was sent to medical professional who from Keio university hospital Suginami physician association and other institutions (N=42). The basic information was including sex, age, medical work experience, professional specialty and Affiliation as presented in the table 6. The information derived from the data will be helpful to understand the construct of respondent.

Table 6.17: Demographic data

Characteristic	Group	Percentage (%)	Case (person)
gender	Male	86	36
	female	14	6
age	Under or equal 30	2	1
	30 ~ 40	10	4
	41 ~ 50	24	10
	51 ~ 60	38	16
	Over or equal 61	26	11
medical work experience	Under or equal 3 yeas	5	2
	4 ~ 10	7	3
	11 ~ 20	19	8
	21 ~ 30	43	18
	Over or equal 31	26	11
Professional specialty	Physician	39	16
	dermatologist	10	4
	Surgeon	15	6
	otolaryngologist	7	3
	pediatrician	5	2
	ophthalmologist	2	1
	radiotherapist	2	1
	medical student	2	1
	orthopedist	17	7
Affiliation	clinical	68	28
	hospital	12	5
	University hospital	17	7
	Research institution	2	1

(1) As is showed, the majority of medical professional who responded to the survey were male (86%).

(2)A substantial number of professional were in the age range from 51 to 60 years (38%), Over or equal 61 (26%), from 41 to 50years (24%), from 31 to 40 years (10%), and Under or equal 30 (2%).

(3)Regarding medical work experience, the majority experience year is of 21 ~ 30 (43%) compared to Over or equal 31 (26%), 11 ~ 20 (19%), 4 ~ 10 (3%) and under or equal 3 years (2%) which indicates a lack of young doctor in this survey. In this study, they were grouped into younger with no enough experience (0~3 years) , moderate medical professional (4~10) and ,experienced medical professional(over 10 years) in order to find the big picture of whether there were any differences

(4)The highest percentage of Affiliation is from clinical (28%), compared to university hospital (17%), hospital (12%), and research institution (2%).

(5)Several types of professional specialty have been reported in the questionnaire which comprised Physician (39%), orthopedist (17%), surgeon (15%), dermatologist (10%), otolaryngologist (7%), pediatrician (5%), ophthalmologist, radiotherapist, medical student (2%). They were categorized into several types by what they focus on during the medical task.

After initial demographic analysis of primary data, cross-tabulation has been used for a better understanding of respondents. In this analysis, cross-tabulation has been produced within medical professional related measurement such as medical work experience and professional specialty, gender and age have not been included.

Not only were there more physician (39%) than other specialty in hospital and clinical, but there was also more physician in research institution and university hospital. This might help to provide supplementary information in terms of who played important roles in this questionnaire or who interested in real-time telemedicine system. The second share is comprised by surgeon and other (orthopedist (7 cases), (radiotherapist (1 case), ophthalmologist (1 case), pediatrician (2 cases)). They are all from hospital and clinical.

professional position * professional speciality Crosstabulation

Count

		professional speciality						Total
		physician	surgeon	dermatologist	medical student	other	otolaryngo logist	
professional position	university hospital	3	3	0	1	0	0	7
	hospital and clinical	12	3	4	0	12	3	34
	research initiution	1	0	0	0	0	0	1
Total		16	6	4	1	12	3	42

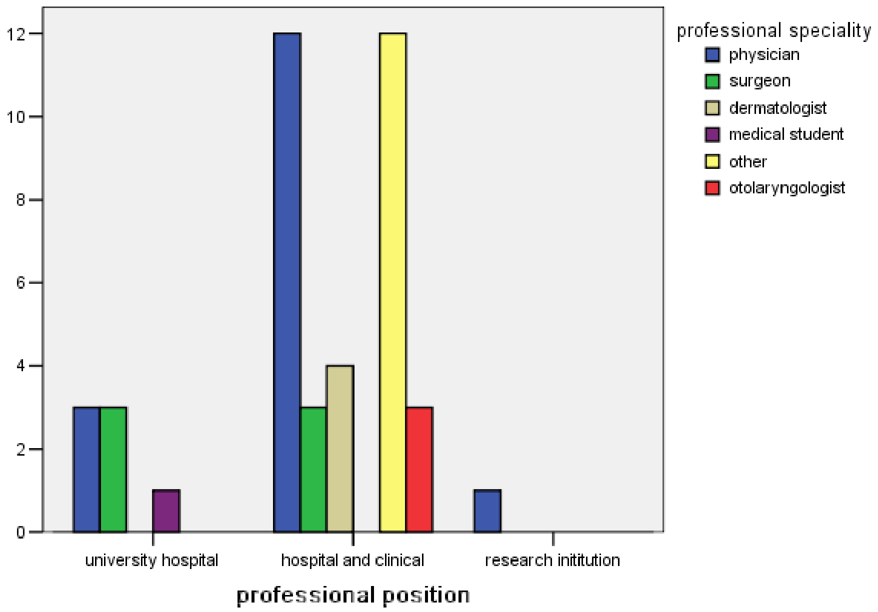


Fig.6.1: Professional position and professional specialty

Medical professional with Medical work experience of 21~30 (17.2%) works in hospital or clinical rather than professional with experience of over 31 years. In university hospital, respondent comprised 21~30. It should be noted that medical professional in this survey mostly with a high work experience which might influenced the result such as the attitude to new technology, and improve the quality of survey in professional level.

professional position * work experience Crosstabulation

Count

		work experience					Total
		under or equal 3	4-10	11-20	21-30	over 31	
professional position	university hospital	1	1	1	4	0	7
	hospital and clinical	1	2	9	12	10	34
	research inititution	0	0	0	1	0	1
Total		2	3	10	17	10	42

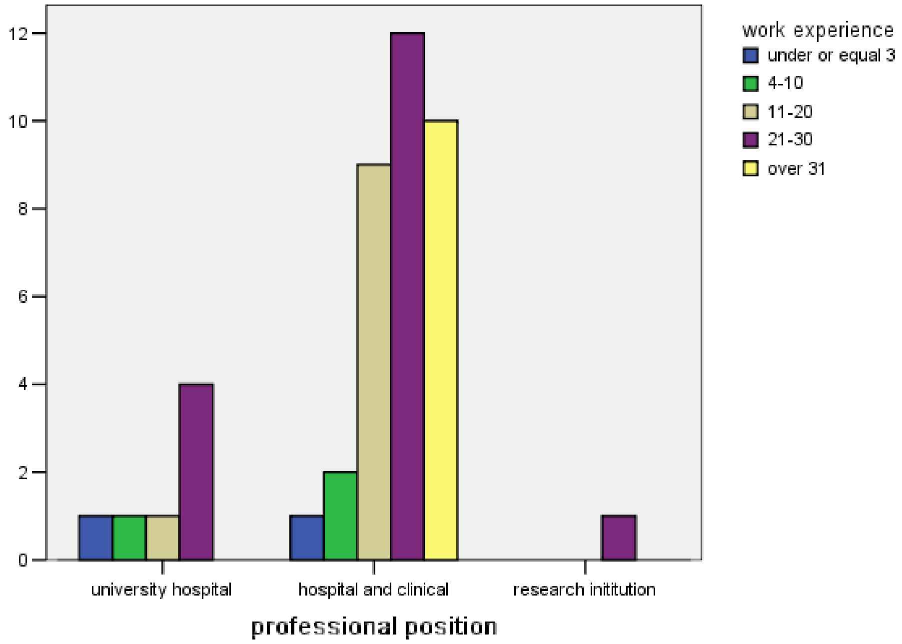


Fig. 6.2: Professional position and professional experience

In conclusion, medical professional mostly from clinical and are of experienced were important points that might influence the result potentially. Thus, it needs to investigate the primary data with descriptive analysis.

6.6 Descriptive analysis of primary data

The investigation of this questionnaire was divided into two groups: 2D system (it also can be identified as high-definition system) and 3D system.

6.6.1 Background of IT usage

As the table shows, medical professional demonstrates an IT usage as well as other IT users. In other words, medical professional has showed their interest to information technology, however, there is no significant evidence can suggest they are skill in information technology. The IT usage is classifies into several types by factor analysis in chapter 5. This will be useful to understand the IT usage of medical professional. Medical professional shows their skill in basic IT skill (giving presentation, using professional software), and unfamiliar with advanced IT skill such as programming or operation of personal website. They has shows their interest in internet and use the internet service frequently. Although they are not professional in information technology, however, most of them responded they were interested in information technology. As a summary, although medical professional we questioned comprised old professional, they keep in touch with IT as well as us.

Table 6.18: IT usage score

1 = no, 2= occasionally, 3= frequently	Mean	Mode
Making slide to give a presentation	2.29	3
Using the professional software	2.10	3
I can do programming	1.17	1
Watching 3D cinema	1	1
Using the internet service	2.48	3
Experiencing the teleconferencing	1.1	1
Using the SNS	1.95	2
Using search engine to search online information	2.71	3
Sending e-mail	2.79	3

1 = no, 2= yes	Mean	Mode
I have my own site	1.29	1
I am interested in information technology	1.71	2
I have smart phone or tablet PC	1.45	1

6.6.2 Attitude toward real time telemedicine system

At the time of this survey, the subjects who responded the questionnaires have been inquired their attitude toward system by investigating adoption intention.

(1) For 2d system:

Medical professional tends to have neutral attitude toward the system. They might tend to use the system in their job because the advantages of system (3.24), yet they might stop to use the system by the high cost and lack of standard.

Table 6.19: behavior intention for 2D system

BI for 2D system	Mean
1 = strongly disagree, 2= disagree, 3= neither agree nor disagree, 4= agree, 5= strongly agree	
I attempt to use this system in diagnosis	3.24
I want to recommend this system	3.10

It indicates that medical professional has a relatively more positive attitude to usefulness. This system is usefulness in their job (3.95), it tends to be know better the patient`s condition (3.74). Yet, they have a neutral attitude in enhancement of their effectiveness in diagnosis (3.31).

Table 6.20: Perceived usefulness for 2D system

PU for 2D system	Mean
1 = strongly disagree, 2= disagree, 3= neither agree nor disagree, 4= agree, 5= strongly agree	
I find the system to be useful in diagnosis	3.95
Using the system is to know better about the patient	3.74
Using the system enhances my effectiveness in diagnosis.	3.31

The table perceived ease of use indicates that medical professional tends to believe this system is easy to use (3.14), but no significant since the mean only around 3.0. It has found that medical professional has no enough confidence in ease of use of this system.

Table 6.21: Perceived ease of use for 2D system

EOU for 2D system	Mean
1 = strongly disagree, 2= disagree, 3= neither agree nor disagree, 4= agree, 5= strongly agree	
It will be easier to diagnose if I use the system	3.14
The operation of this system is easy to understand	3.12

Expectancy of system shows medical professional was not satisfied with the low definition system (2.78) and tends to expect a safe and high-definition system (3.60)

Table 6.22: expectancy of system for 2D system

EOS for 2D system	Mean
1 = strongly disagree, 2= disagree, 3= neither agree nor disagree, 4= agree, 5= strongly agree	
I am satisfied with low definition system	2.78
I expect a safe and high accurate system	3.60

(2) For 3D system:

Compare with 2D system, the result of 3D system shows a lower intention from medical professional. They have no plan to use the 3D system recently (2.67).

Table 6.23: behavior intention for 3D system

BI for 3D system	Mean
1 = strongly disagree, 2= disagree, 3= neither agree nor disagree, 4= agree, 5= strongly agree	
I attempt to use this system in diagnosis	3.14
I plan to use the system in diagnosis	2.67
I want to recommend this system	2.88

It indicates that medical professional has a relatively positive attitude to usefulness. This system is usefulness in their job (3.36), it tends to be know better the patient`s condition (3.40). Yet, they have a neutral attitude in enhancement of their effectiveness in diagnosis (2.93).

Table 6.24: perceived usefulness for 3D system

PU for 3D system	Mean
1 = strongly disagree, 2= disagree, 3= neither agree nor disagree, 4= agree, 5= strongly agree	
I find the system to be useful in diagnosis	3.36
Using the system is to know better about the patient	3.40
Using the system enhances my effectiveness in diagnosis.	2.93

The table perceived ease of use indicates that medical professional tend to believe this system is easy to use (2.93), and they tend to keep a neutral attitude to operation of 3D system (3.07). in generally, medical professional does not believe the system is easy to use.

Table 6.25: perceived ease of use for 3D system

EOU for 3D system	Mean
1 = strongly disagree, 2= disagree, 3= neither agree nor disagree, 4= agree, 5= strongly agree	
It will be easier to diagnose if I use the system	2.93
The operation of this system is easy to understand	3.07

Expectancy of system shows medical professional was not satisfied with the 2D system (2.95) and tends to expect a safe and high accurate 3D system (3.40)

Table 6.26: perceived ease of use for 3D system

EOS for 3D system	Mean
1 = strongly disagree, 2= disagree, 3= neither agree nor disagree, 4= agree, 5= strongly agree	
I am satisfied with 2D system	2.95
I expect a safe and high accurate 3D system	3.40

In conclusion, despite the type of system, medical professional did not show much positive intention to adopt the system although they believe that the system can be used in medicine. Relatively lower ease of use might be a barrier to system adoption as we expected. In addition, the professional were unsatisfied with existing system.

6.7 Difference between groups

In this research, it was investigated whether there were any significant differences in the mean scores of four constructors between groups (moderator): (1) whether there were significant difference in behavior intention, (2) whether there were significant difference in perceived usefulness, (3) whether there were significant difference in perceived ease of use, (4) whether there were significant difference in expectancy of new system. We used statistic method to analyze the primary data.

(1) Professional specialty

For professional specialty, we firstly analyzed the primary data for all professional specialties. It has found no significant difference in items between groups.

In the second step, based on the result of paired comparison, we categorized this moderator into two types (1) focus on quality of image: perceived accurate color and perceived definition (2) focus on perceived presence: perceived sound, perceived depth information and perceived video smoothness (3) No significant focus. The result shows no significant difference between groups.

(2) Affiliation

This moderator has categorized into several categories at first: (1) with research attribute and without research attribute. The result shows no significant difference in items regardless of types of systems. (2) With educational attribute and without educational attribute. The result shows no significant difference in items regardless of types of systems. (3) Independent clinical and integrated hospital. The result shows no significant difference in items regardless of types of systems.

(3) Medical work experience

In chapter 5, we hypothesized that medical work experience is an important moderator. It comprised five groups: low experience (under or equal 3 years), moderate experience (4~10 years), high experience (11~20 years) and Higher experience (over 21 years). We firstly investigated and compared all groups to identify whether there is significant difference between different groups. The results (Table) clearly showed that the a number of items that were significantly different between groups, it suggests that 10 years medical work experience might influence the attitude of medical professional to new system. And then, we categorized medical professional by work experience into two groups: under 10yeasr and over 10 years, it has found that younger professional believe that it is easy to use the system.

Table 6.27: between under 10yeasr and over 10 years

	PU32d	EOU12d	EOU22d
Mann-Whitney U	44.000	35.500	38.500
Wilcoxon W	747.000	738.500	741.500
Z	-2.058	-2.381	-2.267
Asymp. Sig. (2-tailed)	.040	.017	.023
Exact Sig. [2*(1-tailed Sig.)]	.061(a)	.023(a)	.033(a)

(4) Experienced demonstration

In the respondents of this questionnaire, some medical professional has experienced the demonstration and interviewed by us before. According to the previous research, the system users might have a positive attitude to system if they have experience in development of new system. Thus, we expected that medical professional with experience of demonstration might have different attitude toward new system from medical professional without experience. The result shows that there were significant differences in three items which including perceived usefulness and expectancy of system. Experience of demonstration elicited statistically significant higher perceived usefulness. Medical professional who has attended demonstration before represents more positive attitude to adopt 2D system. This finding was correspondent with our expectation.

Table 6.28: between experienced demonstration and non-experienced

	PU12d	PU22d	EOS13d
Mann-Whitney U	54.000	52.000	35.000
Wilcoxon W	720.000	718.000	701.000
Z	-2.167	-2.163	-2.895
Asymp. Sig. (2-tailed)	.030	.031	.004

6.8 Summary

The descriptive analysis of primary data was carried out in this chapter. It focuses on three sections in terms of (1) influence of network (2) influence of perceived effect factors (3) analysis of primary data from questionnaire.

(1) Through analysis of data derived from experiment, it has proved the influence of network and effectiveness of bandwidth as a measure for real-time telemedicine system but generality for

different systems.

(2) Weight of each factor has been investigated and it has found that the weight might be influenced by medical specialty.

(3) This chapter analyzed the data collected from questionnaire and states the reliability analysis of questionnaire items. The results were satisfactory and confirmed that the items and result were reliable and valid. After using statistic method to investigate the difference between groups. The results indicated that experience played an important role. Medical professional with lower medical work experience or had experienced the demonstration showed a positive attitude to 2D system and relatively lower attitude to 3D system.

Further analysis using SEM will be presented in next Chapter, in relation to assessing the relationship between construct and behavior intention.

Chapter 7 SEM for real-time telemedicine system

7.1 Introduction

In this chapter, through descriptive analysis and experiment, it has found that medical professional generally has a neutral attitude toward systems regardless of what type the system is. There are important questions associated with determining the reasons behind their intention. This chapter will investigate what significant determinants influence medical professional`s behavior as these determinants are expected to play important roles in explaining medical professional`s behavior intention. In order to answer these questions, a model derived from the primary data will be tested, and modified in this chapter with careful consideration associated with the goodness of fit of the model to the data.

The practical model being generated and its interpretation might help promote real-time telemedicine system adoption and consequently help improve possibility of developing a system which actually meet requirement of professional. And we also would investigate the impact of moderators on the generated model. It is to examine whether the moderators impact on the influence of the variables toward behavior intention.

In order to improve the reliability of our practical model, a two-step approach is adopted in test process. It needs to ensure that the item used to measure each of the constructs is adequate at first. And then, the second step involves the assessment of the structural model which shows the relationships between the constructs.

In this research, we acquired subjects to respond two systems: high-definition real-time telemedicine system and 3D real-time telemedicine system. Thus, this chapter will introduce two types of models and compare them.

7.2 Modeling for system

7.2.1 Model estimation and remodeling

After we test the reliability of items and deleted some items in the model. We will estimate the relationship between constructs of this model with reliability test, validity test and model fit measures. This research is not only a test of a model but also includes new constructs we proposed. Therefore, in the procedure of modeling, [41] Standard estimate will be used in path analysis. The default method of computing parameter estimates is maximum likelihood. The standardized regression weights, correlation, squared multiple correlations will be displayed in the model. In the first step of the process, we had proposed the original model to which only included three constructs as a pilot test. And then we would add the new constructs in this model and use the trial and error to test the constructs. In the process of modeling, RMSEA is based on the non-centrality parameter which regarded as currently the most popular measure of model fit. The value of 0.05, and 0.08 to indicate good, and mediocre fit respectively. In this model, this value is the most important value to find the most fit model and relationship. In spite of GFI and AGFI are used for measure the model fit in some previous research, we chose not to adopt in this research due to the value of GFI and AGFI are affected by sample size. Another important measure is the p-value by which we can judge whether the relationship between two construct is significant or not. In some situation, however, it neither confirm the relationship nor negate a relationship when p-value is larger than 0.05. In this research, we will consider three types of P-value of 0.05, 0.01 and 0.001(two-tailed). Two steps of modeling would be conducted. First step: test only three existing constructs from previous research which including behavior intention, perceived usefulness and perceived ease of use. Second step: add two proposed constructs in the model for testing. Relationship between expectancy of system and behavior intention, between IT usage and behavior intention would be tested.

1. In the original model for 2D real-time telemedicine system, we firstly test the by sample correlation among each latent constructs, it was expected that the correlation among latent constructs was not larger than 0.8 or 0.9. The table 7.1 shows that three constructs in the model are empirically distinguishable. This was important to conduct further research. The second is to observe the fit of model. The model has showed a good fit and it has found that increase of perceived ease of use will improve perceived usefulness. The relationship between behavior intention and perceived ease of use was of higher correlation (0.274, statistically significant at 0.5 level) than relationship between behavior intention and perceived usefulness (0.229, not statistically significant).

Table 7.1: Independency of constructs

			推定値
behavior intention	<-->	perceived usefulness	.418
perceived usefulness	<-->	perceived ease of use	.094
behavior intention	<-->	perceived ease of use	.268

Table 7.2: Fit of model

ﾓﾃﾞﾙ	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.962	.911	1.003	1.008	1.000
飽和ﾓﾃﾞﾙ	1.000		1.000		1.000
独立ﾓﾃﾞﾙ	.000	.000	.000	.000	.000

ﾓﾃﾞﾙ	RMSEA	LO 90	HI 90	PCLOSE
Default model	.000	.000	.149	.611
独立ﾓﾃﾞﾙ	.480	.431	.531	.000

Table 7.3: Correlation among constructs

			推定値
perceived usefulness	<---	perceived ease of use	.020
behavior intention	<---	perceived usefulness	.229
behavior intention	<---	perceived ease of use	.274

In the second step of 2D system modeling, we added expectancy of system (EOS) and IT usage as the fourth construct and fifth construct into this model and test the relationship among them. It has found that EOS is strongly correlative with behavior intention. It needs to reconsider the validation of question items. We found that one item of EOS was ambiguous to behavior intention. It has to delete it in order to guarantee validation of this model. IT usage shows its independence from other constructs. This model has showed a good fit and demonstrated two important relationships. Perceived usefulness is an important construct which influence the behavior intention (0.319, statistically significant at 0.01 level) and expectancy of system has demonstrated its influence on behavior intention (0.636, statistically significant at 0.001 level) than other construct. Comparing with expectancy of system, IT usage has no significant impact to behavior intention although correlation between IT usage and behavior intention is negative.

Table 7.4: Independency of constructs

			推定値
behavior intention	<-->	perceived usefulness	.519
perceived usefulness	<-->	perceived ease of use	.098
perceived usefulness	<-->	expectancy of system	.499
perceived usefulness	<-->	IT usage	.323
behavior intention	<-->	perceived ease of use	.350
behavior intention	<-->	expectancy of system	.977
behavior intention	<-->	IT usage	.358
perceived ease of use	<-->	expectancy of system	.436
perceived ease of use	<-->	IT usage	.253
expectancy of system	<-->	IT usage	.399

Table 7.5: Fit of model

RMSEA

ﾓﾃﾞﾙ	RMSEA	LO 90	HI 90	PCLOSE
Default model	.067	.000	.117	.310
独立ﾓﾃﾞﾙ	.288	.262	.315	.000

基準比較

ﾓﾃﾞﾙ	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.811	.731	.965	.946	.962
飽和ﾓﾃﾞﾙ	1.000		1.000		1.000
独立ﾓﾃﾞﾙ	.000	.000	.000	.000	.000

Table 7.6: Correlation among constructs (skype2D: Expectancy of system)

			推定値
perceived usefulness	<---	perceived ease of use	.024
behavior intention	<---	perceived ease of use	.089
behavior intention	<---	perceived usefulness	.319
behavior intention	<---	IT usage	-.105
behavior intention	<---	skype2D	.636

In conclusion, the model for 2D system (high-definition system) has indicates that expectancy of system has a positive influence on behavior intention. It also proved that perceived usefulness and perceived ease of use can impact behavior intention respectively. We also found that IT usage has no significant impact to behavior intention. The next section would introduce modeling for 3D system.

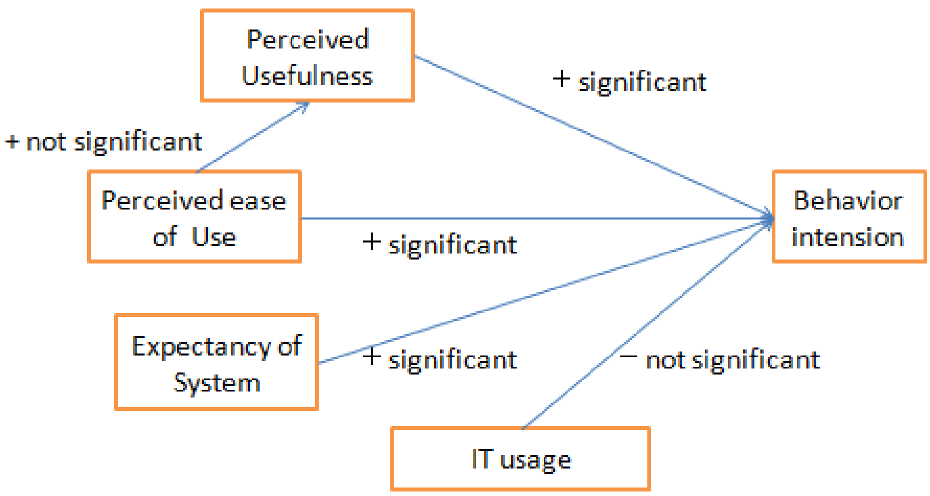


Fig 7.1: Image of model for 2D system

2. In the original model for 3D real-time telemedicine system, only three constructs have been included which are behavior intention, perceived usefulness and perceived ease of use. By validation test, it has found strong correlation among constructs. Thus, we need to delete some items for improving validation of model. After deleting several items, the validation of model has been improved as table the data shows in the table represent a good fit of this model and relationship between each constructs. It has found that perceived ease of use indeed influence the perceived usefulness (0.632, statistically significant at 0.01 level) and behavior intention (0.455, statistically significant at 0.001 level). And perceived usefulness impacts behavior intention (0.249, statistically significant at 0.05 level). This result has proved our assumption that in 3D system, ease of use is an important factor which determine whether medical professional decide to use adopt the system.

Table 7.7: Independency of constructs

			推定値
perceived usefulness	<-->	behavior intention	.756
perceived usefulness	<-->	easytounderstand3D	.644
behavior intention	<-->	easytounderstand3D	.614

Table 7.8: Fit of model

ﾓﾃﾞﾙ	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.974	.934	1.005	1.012	1.000
飽和ﾓﾃﾞﾙ	1.000		1.000		1.000
独立ﾓﾃﾞﾙ	.000	.000	.000	.000	.000

ﾓﾃﾞﾙ	RMSEA	LO 90	HI 90	PCLOSE
Default model	.000	.000	.186	.588
独立ﾓﾃﾞﾙ	.540	.474	.609	.000

Table 7.9: Correlation among constructs (easy to understand 3D: perceived ease of use)

			推定値
perceived usefulness	<---	easytounderstand3D	.632
behavior intention	<---	easytounderstand3D	.455
behavior intention	<---	perceived usefulness	.249

In the second step of 3D system modeling, we added expectancy of system (EOS) and IT usage as the fourth construct and fifth construct into this model and test the relationship among them. This model has showed a good fit and represented that Perceived ease of use influence the perceived usefulness (0.632, statistically significant at 0.01 level) and behavior intention (0.337, statistically significant at 0.01 level). It is the most critical construct which influence intention than other constructs. We also found that perceived usefulness (0.283, statistically significant at 0.05 level) and expectancy of new system (0.206, statistically significant 0.05 level) have impacted to behavior intention. IT usage (0.045, not statistically significant), however, has no significant impact toward behavior intention in this model.

Table 7.10: Independency of constructs

			推定値
perceived usefulness	<-->	behavior intention	.749
perceived usefulness	<-->	easytounderstand3D	.655
perceived usefulness	<-->	notwoD3D	.041
perceived usefulness	<-->	IT usage	.237
behavior intention	<-->	easytounderstand3D	.614
behavior intention	<-->	notwoD3D	.140
behavior intention	<-->	IT usage	.223
easytounderstand3D	<-->	notwoD3D	.132
IT usage	<-->	easytounderstand3D	.253
IT usage	<-->	notwoD3D	-.359

Table 7.11: Fit of model

基準比較

ﾓﾃﾞﾙ	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.838	.757	.971	.954	.969
飽和ﾓﾃﾞﾙ	1.000		1.000		1.000
独立ﾓﾃﾞﾙ	.000	.000	.000	.000	.000

RMSEA

ﾓﾃﾞﾙ	RMSEA	LO 90	HI 90	PCLOSE
Default model	.066	.000	.129	.349
独立ﾓﾃﾞﾙ	.306	.273	.340	.000

Table 7.12: Correlation among constructs (easy to understand 3D: perceived ease of use, notwo3D: Expectancy of system)

			推定値
perceived usefulness	<---	easytounderstand3D	.632
behavior intention	<---	easytounderstand3D	.337
behavior intention	<---	perceived usefulness	.283
behavior intention	<---	IT usage	.045
behavior intention	<---	notwoD3D	.206

In conclusion, the model for 3D system has indicates that perceived ease of use is the main factor which influences behavior intention.

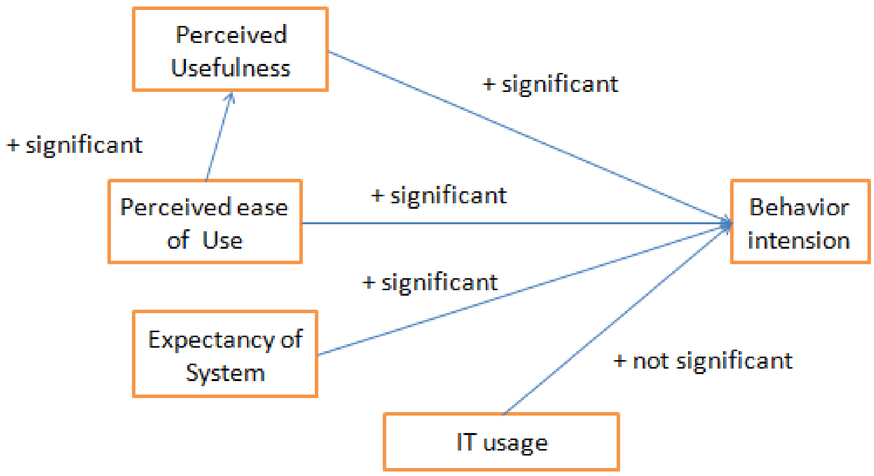


Fig 7.2: Image of model for 3D system

7.2.2 multiple- group analysis

In this research, the second step in SEM analysis is related to multiple-group analysis has been carried out for moderator of professional specialty. In order to investigate the impact of moderators on the influence of determinants toward behavior intention, groups of hypotheses would be tested by multiple-group analysis. The objectives of comparing between groups are to investigate whether there are any significant differences between them. We will test whether there are any differences among groups. Three main categories of moderators are: (1) medical professional specialty (2) medical work experience (3) Affiliation.

As mentioned, the analysis is sensitive to sample size. In this research, only 42 cases have received. In this step of multiple group analysis, therefore, we used the model we proposed without IT usage construct for analysis of null hypotheses due to (1) small size of sample and (2) insignificance of model we proposed.

In 2D system:

(1) Medical Affiliation: independent clinical and integrated hospital. There was no significant difference in the model

(2) Professional specialty: two groups of image focus and perceived presence focus. It has found that this moderator impact the influence of perceived ease of use toward perceived usefulness and influence of expectancy of system toward behavior intention

(3) Medical work experience: two groups of less than 20 years experience and over 20 years experience. It has found that this moderator could impact influence of the perceived ease of use toward perceived usefulness and influence of expectancy of system toward behavior intention.

			推定値	標準誤差	検定統計量	確率	ラベル
F2	<---	operationturntoeasy2d	.614	.141	4.366	***	b2_1
F1	<---	F2	.424	.276	1.537	.124	b1_1
F1	<---	operationturntoeasy2d	.226	.245	.924	.356	b3_1
F1	<---	F3	.291	.175	1.662	.097	b4_1

			推定値	標準誤差	検定統計量	確率	ラベル
F2	<---	operationturntoeasy2d	.397	.135	2.942	.003	b2_2
F1	<---	F2	-.531	.435	-1.218	.223	b1_2
F1	<---	operationturntoeasy2d	-.038	.403	-.093	.926	b3_2
F1	<---	F3	2.302	1.142	2.016	.044	b4_2

Fig 7.3: image focus and perceived presence focus (F1 behavior intention, F2 perceived usefulness, F3 Expectancy of system)

			推定値	標準誤差	検定統計量	確率	ラベル
F2	<---	operationturntoeasy2d	.424	.133	3.189	.001	b2_1
F1	<---	F2	.030	.289	.103	.918	b1_1
F1	<---	operationturntoeasy2d	-.044	.269	-.163	.870	b3_1
F1	<---	F3	1.052	.224	4.698	***	b4_1

			推定値	標準誤差	検定統計量	確率	ラベル
F2	<---	operationturntoeasy2d	.654	.129	5.074	***	b2_2
F1	<---	F2	.281	.376	.747	.455	b1_2
F1	<---	operationturntoeasy2d	.171	.342	.501	.616	b3_2
F1	<---	F3	.623	.314	1.984	.047	b4_2

Fig 7.4: Less than 20 years experience and over 20 years experience (F1 behavior intention, F2 perceived usefulness, F3 Expectancy of system)

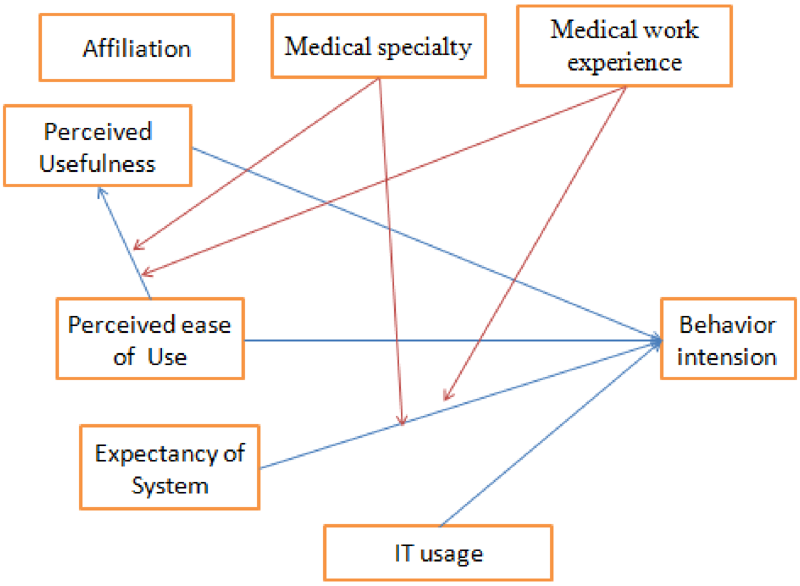


Fig 7.5: Image of moderator in 2D model

In 3D system, the proposed model only with expectancy of system was adopted since it concludes most information.
(1) Medical Affiliation: independent clinical and integrated hospital. No significant impact from moderator in model has been found in this research.
(2) Professional specialty: image focus and perceived presence focus. It has found that this moderator impact the influence of perceived ease of use toward perceived usefulness and influence of perceived ease of use toward behavior intention.
(3) Medical work experience: Less than 20 years experience and over 20 years experience. It has found that this moderator could impact influence the perceived ease of use toward perceived usefulness and influence of perceived usefulness toward behavior intention.

			推定値	標準誤差	検定統計量	確率	ﾗﾍﾞﾙ
F1	<---	F2	.702	.178	3.953	***	b1_1
F3	<---	F1	7.691	31.303	.246	.806	b2_1
F3	<---	F2	-4.587	22.299	-.206	.837	b3_1

			推定値	標準誤差	検定統計量	確率	ﾗﾍﾞﾙ
F1	<---	F2	.479	.164	2.917	.004	b1_2
F3	<---	F1	.131	.757	.172	.863	b2_2
F3	<---	F2	1.075	.441	2.439	.015	b3_2

Fig 7.6: image focus and perceived presence focus (F1perceived usefulness, F2 perceived ease of use, F3 behavior intention)

			推定値	標準誤差	検定統計量	確率	ﾗﾍﾞﾙ
F2	<---	F3	.528	.156	3.388	***	b2_1
F1	<---	F2	1.059	.321	3.298	***	b1_1
F1	<---	F3	.106	.150	.706	.480	b3_1

			推定値	標準誤差	検定統計量	確率	ﾗﾍﾞﾙ
F2	<---	F3	.575	.149	3.850	***	b2_2
F1	<---	F2	.976	.814	1.199	.231	b1_2
F1	<---	F3	.326	.449	.727	.467	b3_2

Fig 7.7: Less than 20 years experience and over 20 years experience (F1behavior intention, F2 perceived usefulness, F3 perceived ease of use)

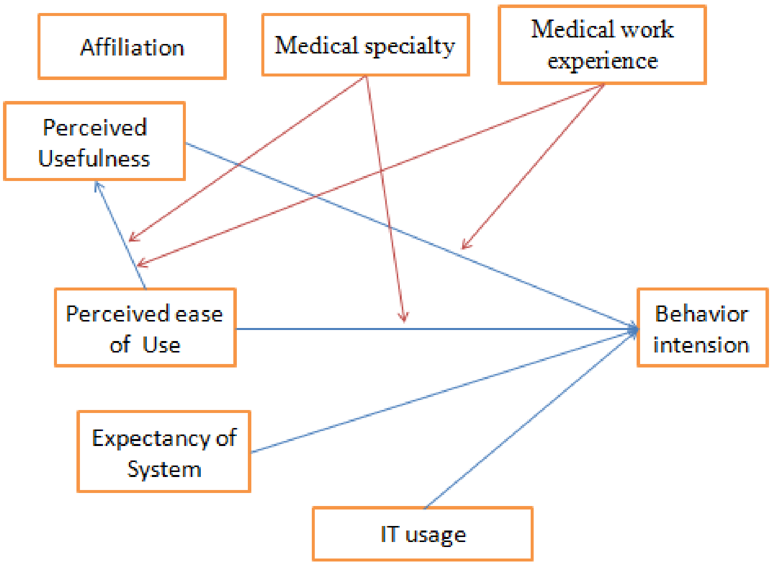


Fig 7.8 Image of moderator in 3D model

7.3 Summary

In this chapter, we mainly discussed the process of modeling for 2D real-time telemedicine system and 3D real-time telemedicine system respectively. Through test of the model, data analysis and experiment (chapter 6), it has found the relationships among determinants and test the hypotheses proposed in chapter 4. The result of this chapter will associated with chapter 6 as follow:

(1) Direct hypotheses
H1. Perceived usefulness has a significant influence on behavior intention of adoption
In 2D system, perceived usefulness has a significant influence on behavior intention
In 3D system, perceived usefulness has a significant influence on behavior intention

H2. Perceived ease of use has a significant influence on behavior intention of adoption
In 2D system, perceived ease of use has a significant influence on behavior intention

In 3D system, perceived ease of use has a significant influence on behavior intention

H3. Perceived ease of use has a significant influence on Perceived usefulness
In 2D system, perceived ease of use has no significant influence on perceived usefulness
In 3D system, perceived ease of use has a significant influence on perceived usefulness

H4. IT usage has a significant influence on behavior intention of adoption
In 2D system, IT usage has negative influence to perceived usefulness (not significant)
In 3D system, IT usage has negative influence to perceived usefulness (not significant)

H5. Expectancy of new system has a significant influence on perceived usefulness
In 2D system, Expectancy of system has a significant influence on behavior intention
In 3D system, Expectancy of system has a significant influence on behavior intention

(2)Moderating hypotheses
MH.1 The influence of perceived usefulness toward behavior intention is moderated by professional Specialty
In 2D system, impact of moderated professional Specialty is not identified
In 3D system, impact of moderated professional Specialty is not identified.

MH.2 The influence of perceived usefulness toward behavior intention is moderated by medical work Experience
In 2D system, impact of moderated medical work experience is not identified.
In 3D system, influence of perceived usefulness toward behavior intention is moderated by professional work experience.

MH.3 The influence of perceived usefulness toward behavior intention is moderated by Affiliation
In 2D system, impact of moderator affiliation is no identified.
In 3D system, impact of moderator affiliation is no identified.

MH.4 The influence of perceived ease of use toward behavior intention is moderated by professional Specialty
In 2D system, impact of moderated professional Specialty is not identified.
In 3D system, influence of perceived ease of use toward behavior intention is moderated by professional Specialty

MH.5 The influence of perceived ease of use toward behavior intention is moderated by medical work Experience

In 2D system, impact of moderator medical work experience is no identified.
In 3D system, impact of moderator medical work experience is no identified.

MH.6 The influence of perceived ease of use toward behavior intention is moderated by Affiliation
In 2D system, impact of moderator affiliation is no identified.
In 3D system, impact of moderator affiliation is no identified.

MH.7 The influence of Expectancy of system toward behavior intention is moderated by professional Specialty
In 2D system, influence of expectancy of system toward behavior intention is moderated by professional Specialty
In 3D system, impact of moderated professional Specialty is not identified.

MH.8 The influence of Expectancy of system toward behavior intention is moderated by medical work Experience
In 2D system, influence of expectancy of system toward behavior intention is moderated by medical work experience
In 3D system, impact of moderated medical work experience is not identified

MH.9 The influence of Expectancy of system toward behavior intention is moderated by Affiliation
In 2D system, impact of moderator affiliation is no identified.
In 3D system, impact of moderator affiliation is no identified.

(3)Perceived effect factor hypotheses
PEFH.1 The weight of each factor will be moderated by Professional Specialty
The weight of each factor is moderated by Professional Specialty

PEFH.2 The weight of each factor is different
The weight of each factor is different.

PEFH.2.1 Bandwidth is an effective measure to evaluate the relationship between perceived effect factors and network.
Bandwidth is an effective measure for assess of one system. Yet, it has no generalinzability for different systems.

PEFH.4 The influence of bandwidth toward perceived effect factor is different
The influence of bandwidth is indeed moderated by perceived effect factor

Through modeling, we had found some important factors which will influence medical professional to adopt the real-time telemedicine system. It will be useful to improve the motivation and enhance the adoption of real-time telemedicine system. This research includes a number of points that concluded as follow:

(1) Requirement analysis from medical professional has suggested that both of 2D system and 3D system can meet the requirement of medical professional in certain situations. However, medical professional still has no enough intention to adopt the system due to psychological reasons. Through this research, we can address the critical points for the issues. We can find out the psychological reasons which will influence the adoption behavior.

(2) The second important finding in the research is analysis of real-time telemedicine system. It includes the influence of network to system and how to improve the system for meeting the requirement of medical professional.

(3) Medical professional has different requirement based on their personal characteristic. Investigation in this issue will be helpful to improve the system and thorough understand their requirements to real-time telemedicine system.

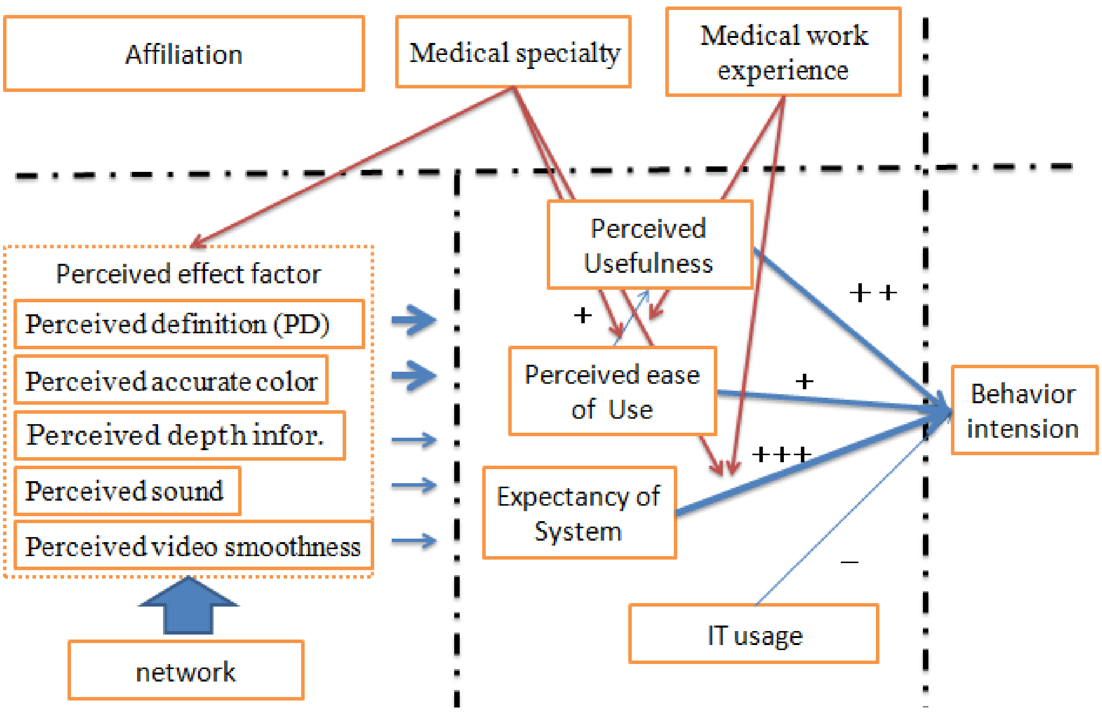


Fig 7.9: Image of 2D system model (moderator: red line, direct determinant: blue line, indirect determinant: blue wide arrow)

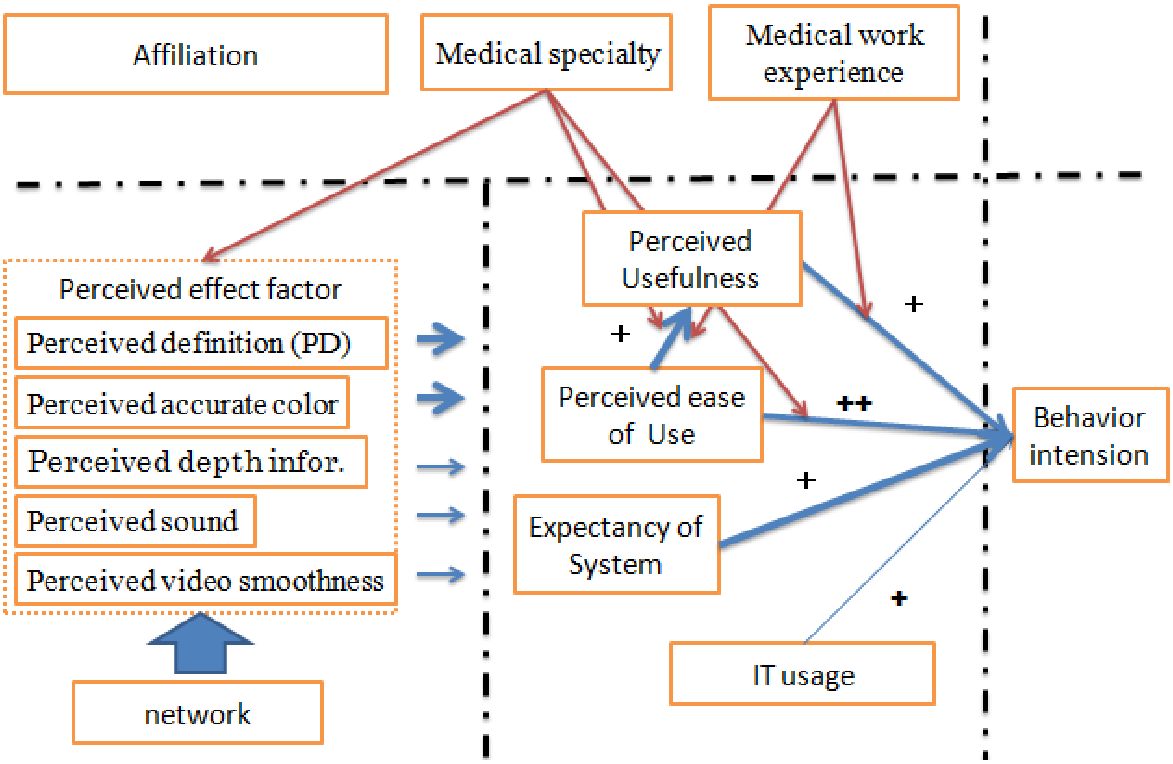


Fig 7.10: Image of 3D system model moderator: (red line, direct determinant: blue line, indirect determinant: blue wide arrow)

Next chapter is to conclude important findings of this research and future prospect of further study.

Chapter 8 Conclusion and prospect

8.1 conclusion

In this final chapter, we will conclusion all achievements of this research. We also will review the limitations of the research and suggestions for further research are also discussed. This research is to analyze requirement of medical professional and extend a practical model based on technology acceptance model.

The findings associated with attitude to real-time telemedicine system, adoption intention, direct determinant and indirect determinant, difference between groups, improvement of motivation to adopt real-time telemedicine system. Detail key findings according to the chapter 4 will be briefly summarized and discussed in detail in this chapter.

8.1.1 Attitude toward real-time telemedicine system

From initial investigation, we have found that 2D high-definition system can meet the requirement of medical professional in a degree of diagnosis. When it comes to adopt this real-time system in actual diagnosis, however, low intention from medical professional has been studied. This result shows us that improvement in performance of system is not the most critical determinant to behavior intention. Psychological factor such as perceived usefulness or perceived usability are also critical in order to improve their motivation. Improve the usability such as perceived accurate color, perceived definition are helpful to spread the system. Comparing with 2D telemedicine system, 3D system has shows a relatively lower degree in acceptability regardless its high performance. Through semi-interview with medical professional, it has found that medical work experience as the main determinant which could influence adoption intention of 3D system. In semi-interview, experienced medical professional can perceive depth information with 2D system easily which results medical professional do not prefer to choose a glasses-based 3D system for obtaining depth information. On the other hand, younger medical professional or medical students have showed more positive attitude to 3D telemedicine system. They might accept this type of system easier since they are not experienced as well as old professional.

In conclusion, medical professional has a neutral attitude toward real-time telemedicine system. They can really perceive the improvement in performance of system and be impacted by effect of real-time system. However, this system is not `must ` to be accepted currently in actual diagnosis. Besides high cost or social need for this system, it needs to improve system in usability according to their medical backgrounds. It needs to convince medical professional that this system is important in their job and it is easy to use this system in diagnosis with low risk.

8.1.2 Adoption intention and determinant in model

By Building this model, we could make a thorough understand about adoption intention of real-time telemedicine system and discuss influence of determinants and relationships among determinants.
To the model, it mainly involved in four types of parts: (1) behavior intention: indicates the adoption behavior. It is a measure by which we can predict whether medical professional want to adopt the real-time telemedicine system (2) direct determinant: represents the determinants which might influence the behavior intention (3) moderator: represents medical professional`s personal characteristic which might influence the relationship among direct determinants and perceived effect factors (4) perceived effect factor: proposed based on requirement of medical professional which might influence usefulness and influenced by network. Through experiment and modeling, we tested the hypotheses in chapter 4. The relationship in this model has been described in chapter 7.
(1) From the average score of behavior intention for 2D system and 3D system, medical professional

tends to keep a neuter intention to adopt or recommend this system.

(2) From the average score of perceived of usefulness, 2D system has gained a relatively higher score contrast with 3D system. Although medical professional tends to believe they could use this system in diagnosis, they have no confidence in improvement of their performance with system.

(3) From the average score of perceived of ease of use, 2D system is advantaged in ease of use. Glasses-based 3D system is the main reason to decrease ease of use.

(4) From the average score of expectancy of system, medical professional demonstrated that they are not satisfied with existing real-time telemedicine system and relatively high expectancy for safer and accurate system.

In conclusion, through observing average score of each construct, we could understand that medical professional showed their interested in new system but relatively lower usefulness and ease of use. The relationships among them are discussed as follow.

8.1.3 How to improve motivation to adopt real-time telemedicine system

Through analysis of model, certain relationships among constructs have been identified which is helpful to clarify what the determinant influence behavior intention. In 2D model, perceived usefulness in diagnosis and expectancy to system are two important factors which influence behavior intention. It needs to increase opportunities of demonstration of ream-time telemedicine system and enable medical professional to realize importance of this system in diagnosis. For instance, demonstration of lower quality system will be helpful to make medical professional know importance of new real-time telemedicine system. In 3D model, perceived ease of use is the main resource to improve behavior intention. As we expected before this analysis, 3D system can not only provide high-definition image to medical professional but also offer depth cues, however, wearing glasses is decreasing ease of use especially for some professional with glasses. Different with 2D system, we need to focus on ease of use in order to improve motivation to adopt 3D system. Although IT usage has showed negative effect upon behavior intention which suggests IT usage might cause a severe attitude toward new system, low coefficient and no significant result were not enough to support this hypotheses in this study.

In addition, as mentioned in chapter 4, medical background is really critical in adoption intention of real-time telemedicine system. In the last chapter, multiple-groups analysis estimates influence of medical work experience and professional specialty in the model. As discussed in chapter 7, in condition of 2D system, medical professional with less medical work experience might be influenced by expectancy of system easily. It suggests that they accept new system easier rather than experienced professional. It also tested role of professional specialty in the model. Image focus group tends to believe that increasing of ease of use will lead improvement in usefulness while perceived presence

focus group tends to experience new system. In condition of 3D system, less medical work experience cause professional to be influenced by perceived usefulness easily. To image focus group, ease of use in 3D system is important and impacting their adoption intention.
Although affiliation has showed nothing important cues in this model, it is still important that influence professional`s attitude to system. For instance, in semi-interview, we have found that some medical professionals with educational background have more positive attitude to 3D system.

Last but not least, perceived effect factors which were derived from usability influence behavior intention indirectly. As result of analysis in chapter 6, in step of designing real-time telemedicine system, it needs to consider two issues (1) what medical professional wants from proposed real-time telemedicine system. (2) Is the system we proposed can work in a relatively unstable or low bandwidth network while meet requirement of medical professional. In issue (1), medical professional focuses on different functions of system such as perceived depth information or perceived definition by their medical specialty. Designing system based on their different requirements will be useful to improve usability of system. And a defective system can also meet requirement of medical professional. For instance, orthopedist might focus on perceived depth information and perceived video smoothness while dermatologist focuses on image. In issue (2), real-time telemedicine system can also perform on a relatively lower bandwidth or unstable network because medical professional might focus on different effect of system. This finding suggests that low quality real-time telemedicine system can be adopted in certain situations since they can work with relatively lower bandwidth network.

8.1.4 Limitation of this research

The results of this research were valuable because this research has drawn upon a wide range of viewpoints. However, there are still some limitations for this research. The limitation concerns the sample size for questionnaire survey. The sample size was less than 50 cases which might questioned valid of this research, however, MLE been found to provide valid results with sample sizes as small as 50 cases.

8.2 Prospects

A real-time telemedicine system acceptance model is still ongoing which needs to extend and test. Further research is to (1) investigate latent technical and psychological factors which influence the behavior intention of medical professional. For instance, we would not include cost in the model in this research. However, it plays an important role in making decision. It will be discussed in further research. (2) Further expand perceived effect factors besides the factors we proposed in this thesis. (3) Further investigation in relationship between network and perceived effect factors needs to be conducted.

Appendix

Question items

私ども慶應義塾大学大学院システムデザイン・マネジメント研究科では、遠隔医療の普及を目指して、「遠隔対面診療システムの構築」の研究に取り組んでおります。今回のアンケート調査は、対面診療システムの利用可能性に向けてのデータ収集を目的にしております。

ご多忙の中大変恐縮ですが、アンケート調査にご協力くださいますようお願い申し上げます。

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質問1. まず、あなたのことをお聞かせください

●性別

男性	女性
○	○

●年齢

30歳以下	31－40歳	41－50歳	51－60歳	61歳以上
○	○	○	○	○

●主な診療科（ご自身の診療科）

（複数標榜されている場合は患者数の多い診療科に1つをお選びください）

◯ 内科 ◯ 皮膚科 ◯ 外科 ◯ 耳鼻科 ◯ 小児科 ◯ 眼科 ◯ 婦人科 ◯ 泌尿器科 ◯ リハビリテーション科
◯ 精神･神経科 ◯ 放射線治療科 ◯ 救急科 ◯ 放射線診断科 ◯ 歯科･口腔外科 ◯ 看護師 ◯ 薬剤師
◯ 看護師、薬剤師以外のコメディカル ◯ 医療系の教員 ◯ 医療系学生･生徒 ◯ 研究員 ◯ 救急救命士
◯ その他 [ ]

●就業の経験年数

3年以下	4年-10年	11年-20年	21年-30年	31年以上
◯	◯	◯	◯	◯

●従事医療機関

◯ 診療所 ◯ 病院 ◯ 医育機関（大学病院） ◯ 研究機関 ◯ その他 [ ]

●経営による分類

◯ 国公立 ◯ 私立 ◯ その他 [ ]

●従事医療機関の病床数

無	1-19床	20－99床	100-199床	200-399床	400床以上
◯	◯	◯	◯	◯	◯

●慶應義塾大学フォトニクス・リサーチ・インスティテュートの遠隔医療研究の取り組みをご存知ですか

実証実験に参加したことがある	知っているが、実験には参加したことがない	知らない
○	○	○

●インターネット使用年数を教えてください

1年未満	1-5年	6-10年	11-15年	16年以上
○	○	○	○	○

●日常のITの使い方を教えてください

	よくある	たまにある	全くない
医療用の専門ソフトを使っている	○	○	○
パソコンで、スライドを作って、発表している	○	○	○
インターネットで、情報検索(例:グーグル)をしている	○	○	○
3Dの映画を見ている	○	○	○
ニュース以外で、インターネットのサービスを利用している(例:楽天、グーグルマップ)	○	○	○
遠隔会議を利用している	○	○	○
プログラミング経験がある	○	○	○
mixi、facebook、skype、msnなどを使っている	○	○	○
Eメールを利用している	○	○	○

	はい	いいえ
タブレットPC(例:iPad)あるいはスマートフォンを持っている	○	○
情報技術に関する情報に関心がある	○	○
自分のサイト、ホームページを運用している	○	○

●前項の説明を受けて、以下の質問にお答え下さい。

(当てる項目にチェックをしてください)

	積極的に同意する	同意する	どちらともいえない	あまり同意しない	同意しない
高精細遠隔対面診療システムは診断などに対して役に立つ	○	○	○	○	○
同システムの導入はより患者の状況を把握できる	○	○	○	○	○
同システムを使うと、仕事の効率が上がる	○	○	○	○	○
同システムの操作法は理解しやすい	○	○	○	○	○
同システムの使い方は簡単そうである	○	○	○	○	○
どう利用すればいいか直感的に習熟できそうである	○	○	○	○	○
もし患者だったら、医師に同システムを使ってもらいたい	○	○	○	○	○
もし自分が同システムを使用したら、他人に薦めたい	○	○	○	○	○
同僚が同システムを使用していたら、私も使ってみたい	○	○	○	○	○
同システムの導入にあたって、保守サービスに入りたい	○	○	○	○	○
同システムと自分のパソコンとの互換性は重要である	○	○	○	○	○
同システムの導入により、自分の診断エリアが広がる	○	○	○	○	○
これから高精細対面診療システムを使ってみたい	○	○	○	○	○
高精細対面診療システムを薦めたい	○	○	○	○	○
skype型対面診療システムより、高精細遠隔対面診療システムを使いたい	○	○	○	○	○
skype型の対面診療システムに満足できる	○	○	○	○	○
高精度、高安全性の高精細遠隔医療システムを期待している	○	○	○	○	○
高精細遠隔医療システムで、診療が容易になりそうである	○	○	○	○	○

●3D(立体視)を遠隔医療システムに導入することについて

支持	反対	関心がない	分からない

●以下の質問にお答え下さい。

(当てる項目にチェックをしてください)

	積極的に同意する	同意する	どちらともいえない	あまり同意しない	同意しない
3D遠隔対面診療システムを使ってみたい					
3D遠隔対面診療システムを導入したい					
3D遠隔対面医療システムで、診療が容易になりそうである					
同システムを使うと、診療の効率が上がる					
2D対面診療システムに満足できる					
同システムは診断に対して役に立つ					
同システムの導入は、より患者の状況を把握できる					
高精度、高安全の3D遠隔対面医療システムを期待している					
3D遠隔対面医療システム操作法は理解しやすい					
3D遠隔対面診療システムを薦めたい					

質問4. 自分の専門の立場で、遠隔対面診療のシステムを使う際に重要視することについて、お聞かせください

●遠隔対面診療システムの設計において、5つの基準があります

色の精度:　　映像の色が実際の色を反映している

解像度:　　細かいところでも、詳細まではっきり観察できる

奥行き感知:　　立体視の映像で、対象の距離や三次元的な広がりがつかめる

音、声の伝送:　　音ズレがなく、患者の声、音がはっきりに聞こえる

画像の連続感:　　映像はコマ落ちしておらず、非常にスムーズである

例:勉強が遊びより重要だと思ったら、勉強の方に●をします

左の方重要	圧倒的に重要	かなり重要	少し重要	左右同じくらい重要	少し重要	かなり重要	圧倒的に重要	右の方重要
勉強	●							遊び

●以下の質問において、当てはまる項目をチェックしてください

左の方重要	圧倒的に重要	かなり重要	少し重要	左右同じくらい重要	少し重要	かなり重要	圧倒的に重要	右の方重要
色の精度	○	○	○	●	○	○	○	解像度
色の精度	○	○	○	●	○	○	○	奥行き感知
色の精度	○	○	○	●	○	○	○	音、声の伝送
色の精度	○	○	○	●	○	○	○	映像の連続感
解像度	○	○	○	●	○	○	○	奥行き感知
解像度	○	○	○	●	○	○	○	音、声の伝送
解像度	○	○	○	●	○	○	○	映像の連続感
奥行き感知	○	○	○	●	○	○	○	音、声の伝送
奥行き感知	○	○	○	●	○	○	○	映像の連続感
音、声の伝送	○	○	○	●	○	○	○	映像の連続感

質問は以上です。ご回答お疲れ様でした。
ご協力大変ありがとうございます。誠に有難うございました。

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