

Exploratory Study to Investigate the Applicability of existing Digital Stethoscopes in a Telehealth Setting

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Abstract— This paper provides an overview of a current research project being undertaken at the University of Southern Queensland, Australia. The project addresses the issue associated with an existing remote area health care system, through the development of a digital stethoscope suitable for the telehealth environment in the state of Queensland, Australia and the telemedicine environment in India. The economic and social benefits of this technology are highlighted throughout this paper, as is the background that leads to the undertaking of this research, the methodology being undertaken, and the future of the research project over the coming months.

Index Terms— digital stethoscope, healthcare, remote patient care, telehealth.

I. INTRODUCTION

DIGITAL stethoscopes are being increasingly used in remote patient assessments. While these stethoscopes are technically advanced, they may not meet user needs for remote assessment. Focus groups have been conducted with Queensland Health physicians and it was found that the sound quality in digital stethoscopes, that already exist, is not acceptable. The current research study surrounding the development of a digital stethoscope suitable for a telehealth or telemedicine platform seeks to design a stethoscope suitable for video conferencing in remote area consultation. As such, sound quality plays a major role in this clinical assessment. This project investigates existing digital stethoscopes and their usage in a telehealth setting and seeks solution to improve these devices, thus filling a crucial gap in telehealth service delivery.

A variety of problems have been identified with the digital stethoscopes currently available in the market through a close analysis of these devices, as applicable to telehealth. These problems encompassed sound quality, real-time connectivity, transmission speeds associated with limited bandwidth, and the positioning of the stethoscope on the patient's body. All of these factors contributed to the existing technology being unsuitable for a telehealth environment. Subsequent examination of these difficulties concluded that with the Internet Protocol (IP)-based video-conferencing predominantly

used by telehealth, 'echo' is a major problem. Based on these investigations the research project's aim is to transmit sound on a telehealth network, and to improve clinician-patient interactions using existing video-conferencing systems. Research questions for the study can be formulated as follows:

- What are the issues associated with the existing digital stethoscope for the telehealth setting?
- How can the quality of sound transmitted through digital stethoscopes be improved for telehealth infrastructure?

II. LITERATURE REVIEW

In the absence of telehealth technology, pre-surgical services require rural patients to visit 'in person' the regional or metropolitan hospital at which they will be presenting for future surgery. In a Queensland case study, travel costs were estimated to be around \$15 600 per individual patient based on current rate of expenditure [1]. Auscultation of the patient's heart and lungs via a stethoscope is an essential and routine procedure carried out during the pre-admission consultation and is normally conducted by the attending anaesthetic consultant. Currently, the only component of the patient's assessment that cannot be completed by the remote anaesthetist is auscultation of the patient's chest using a stethoscope. Clinicians have identified that the inclusion of a digital stethoscope in a telehealth environment would provide real-time audio of the patient's heart and lung sounds and would allow for comprehensive patient assessment to be performed remotely [2], [3].

In combating previously discussed problems with the usage of digital stethoscopes on a telehealth platform, commercial software and hardware algorithms can be employed to control echo to some extent. It is important to note however, that deploying these solutions and configuring them in the digital stethoscope context is a challenge [4], [3]. Other studies (for example, [5], [6], [7]) have also found similar problems. Despite these weaknesses, IP communication is commonly employed due to its relatively low cost. In the case of a digital stethoscope for telehealth, the clinician must interact with the patient and the nurse when assessing sounds [8].

The economic and social benefits associated with this

research project are numerous, and will now be briefly discussed. The outcomes from this research will open up new commercial avenues via cutting-edge techniques and new knowledge in the area of remote/rural health. Better and faster responses in remote medical care will also be established through this new technology. A substantial reduction in travel costs for patients and medical specialists will be obtained through the use of an effective digital stethoscope. The operational environment of medical care personnel will be enhanced through solutions being provided that support effective and efficient interactions with remote patients. Better service performance will be offered through the enhancement of access between patients and clinicians. Anxiety in patients will be reduced, as this anxiety is usually caused by travel cost and the length of absence from home and family. There is also commercial potential associated with this project, through the offering of a superior device in international markets. These economic and social benefits are further endorsed in the body of literature with particular reference to travel costs. This technology would contribute towards saving each individual patient \$15 600 in travel [1]. The author also refers to the fact that Queensland Health spends approximately \$32 million per year in travel subsidies, with this current project being capable of reducing this figure by \$2 million a year.

III. METHODOLOGY

This research used a mix mode methodology to address the research questions. A qualitative approach was employed to get first hand information from the healthcare professional involved in the telehealth setting about the digital stethoscopes. This was followed up with an ‘observation’. While using the stethoscope, a video as well as an audio recording was conducted in order to capture users’ opinions on using a medical device.

The rationale for using a mixed methodology within qualitative techniques was to enhance understanding in this particular research domain. The relationship between the device usage and the healthcare professional was crucial in establishing the suitability of the device. In order to accomplish this, data has been collected through (a) observation, (b) think (talk) aloud protocol, and (c) retrospective protocols, interviews and focus groups. The main significance of this approach was to identify new knowledge that will create positive user experiences, and further clarify the issues and users’ needs and priorities. This provided additional benefits in reducing complexity of the device’s design, and provided positive experiences to all user categories.

Both techniques, interviews and observations, have distinct advantages associated with them. Observation technique allows for the measurement of the actual behaviour, as compared to the intended or recalled behaviour [9]. Researchers are then provided with the opportunity to confirm actions in a discreet manner, such as negative or positive issues associated with a new digital stethoscope design and its

use in a telehealth setting. Interview techniques on the other hand allow researchers to contact respondents in specific ways and control the level of interviewer involvement [9]. In terms of the data obtained during an interview this is considered to be rich [10]. Interviews also enable a researcher to establish a rapport with interviewees, to read non-verbal cues, and to clarify questions, add new questions, and subdue any doubts the interviewees may be having [10]. In relation to this current research project interviews were utilised to explore user experiences and interactions with the new technology in a telehealth setting.

IV. INITIAL FINDINGS

Initial findings of this research indicated a wide variety of aspects requiring improvement in existing digital stethoscope models. In a simulated point-to-point video conferencing system, identical to that in the telehealth environment, a current model of a digital stethoscope was tested. Through this testing it was determined that using a digital stethoscope in this environment created a substantial amount of ‘echo’, this was particularly prominent when the sound card level in the computer was increased.

The second aspect of digital stethoscopes hindering remote patient assessment was the existence of a ‘delay’ in the transmission of the ‘echo’. This is of particular concern due to the requirement of doctors needing to hear where the noise in the body is coming from in that particular instant. The existence of this ‘delay’ does not enable this to occur.

The third aspect of current digital stethoscopes that was determined to be a hindrance in remote patient assessments was sound level. Both body noises and friction in applying the stethoscope to the human body influenced the quality of sound physicians received. Additionally, when these stethoscopes are used in traditional hospital settings there are numerous background noises to contend with. All of these factors contribute to a sound quality that is considered to be reasonably poor, but from which doctors are expected to diagnose from.

V. ANTICIPATED RESEARCH OUTCOMES

There are numerous outcomes anticipated through this research project, which are important to highlight within the context of this paper. In addressing important issues facing remote (rural) medical care across the world, this research is targeting a selected market niche, this being digital stethoscope users (patients and clinicians). It is anticipated that through this research being conducted the following major significant innovations will be established:

- **A novel approach to investigating and developing real-time network connectivity.** Existing knowledge is insufficient to respond to remote (rural) health care needs. Currently, commercially available digital stethoscopes do not provide real-time connectivity on telehealth networks. These stethoscopes are suitable for physical face-to-face

use, but perform inadequately when used for remote assessment, especially for assessing non-heart sounds [11].

- A **novel approach to manipulating data and telecommunication transmissions** to accommodate the transmission of (a) sound files, to facilitate real-time dialogue between clinician, rural telehealth worker and patients, (b) scanned patient records, and (c) the sounds from the enhanced digital stethoscope.
- **Innovative data compression techniques** for remote patient assessment to facilitate simultaneous audio and video interfaces currently in use.
- **Innovative approach to integrating a new device** within the bandwidth constraints of telehealth networks. For example: Telehealth infrastructure is used to carry various electronic signals, including video-conferencing, scheduling, e-mail and other communications—the new digital stethoscope must function in conjunction with these services.
- **Novel approach to understanding the context of rural and remote communities** by investigating in detail their needs and experiences (patients and clinicians). Integration of qualitative, quantitative and experimental research methodology applied for user studies will facilitate this.
- **Innovative methodology to be applied in an integrated fashion** because of the research multidisciplinary team. Previous work was done on an individual basis. The composition of the team is innovative as well.
- **Research advisory panel of industry and community representatives** will promote the validity of the research approach and integrity of its outcome. This is another innovation within this research.

With regards to advancements made by this research to the current knowledge base, these will be provided through:

- **New knowledge about digital stethoscope users** and how they interact within the remote health context.
- **New contributions to knowledge** by investigating and developing specific **echo-controlled algorithms** based on software modules that are platform- and device-independent.
- **New knowledge about data compression** in relevance to the remote locations.

VI. CONCLUSIONS

Overall, this paper has outlined the initial stage of an important piece of research, relevant to both the academic domain and the health care industry. The project aims to fill a gap in telehealth service delivery through the development of a digital stethoscope that will function effectively and efficiently on the telehealth network.

This research is work in progress due to this fact that there are other phases to this research project that are beyond the scope of this paper. The next phase in this research project is to undertake field testing of the digital stethoscope that will be developed, taking into account the nature of the telehealth environment.

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