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学位論文の要旨

This dissertation addresses new forms of ICT use in telemedicine and health management system of disaster victims for the purpose of contributing to public welfare promotion and solution for Japan's structural problems. In what follows, we summarize these researches one by one.

(a) SAS screening at home as a form of telemonitoring

In Japan, the number of sleep apnea syndrome (SAS) patients is estimated to reach 2 million. However, only 30,000 patients consult doctors and it is assumed numerous potential patients exist. Typical subjective symptom of SAS is strong sleepiness during day. But, it is deemed that many of those who are aware of sleepiness do not recognize they suffer SAS. It is reported that SAS is accompanied by complications such as myocardial infarction, angina, coronary artery reconstruction, cardiac failure, and cerebrovascular disorder. Therefore, it would be very useful for public health improvement to construct an inexpensive SAS telemonitoring system through the use of ICT. We evaluated a method of a home screening for SAS with the use of envelope data of sleeping sounds. Envelope data provide various kinds of information that can be used as screening test data, and may provide a means for telemonitoring SAS patients at home. Patients do not generally act to consult a physician unless influenced by the presence of subjective symptoms which severely impact daily life. Even when daytime drowsiness is felt, few potential patients may recognize this as due to SAS and seek treatment at hospital. One of the merits of our system is that it does not depend on particular devices, but rather requires only a personal computer or cellular phone that can record breathing sounds, execute signal processing, and transmit the envelop data to a medical institution. Because file sizes for original sound data are presently too large

to allow transmission via the web, patients must bring their data to their hospital with them. In contrast, data transformed into envelope data by our present method can be transmitted easily by any ICT device. Further, the use of this envelope data system reduces both the physical and psychological load of measurement.

(b) Health information management system for disaster victims

Natural disasters can have various influences on residents' lives, and cause mental disorders from the shock of experiencing a disaster including the feeling of loss of important ones such as family, friends, and unfamiliar life in the shelter, etc. Caretakers such as medical doctors and nurses who are dispatched to disaster sites also face difficulties due to the disruption of communications and transportation. Thus, a system which enables efficient health management is needed. Recently, smart phones or tablet PCs equipped with a touch screen have become strong tools to digitalize data whenever data which are to be digitized occur, and have been used as a data entry system at medical facilities so far. In a data entry system using a tablet PC, GUI input function is generally used, but creation of such data input form requires special computer programming skills. Therefore, it is not suitable as a tool to collect data from victims in a disaster area by sending only questionnaires. There are always risks that such systems become unusable due to unpredictable circumstances at the disaster site, and thus it becomes necessary to invent some flexible systems which can cope with various unexpected occurrences. This dissertation proposes a system which has high affinity with paper-based information gathering systems and reduces labor of caretakers including doctors and nurses in a disaster area who are involved in health information management system.

In a disaster-stricken area where communications and transportation systems are disrupted immediately after a disaster, it is often impossible to obtain information about victims. To help those with a physical or mental disorder who require appropriate medical or nursing care, the necessary information must be collected immediately after a disaster. The use of ICT devices is one solution, but it takes time to transport such devices to a disaster-stricken area and set them up. Even accounting for this delay, a problem remains that these devices cannot be used if power is not recovered. Before the information transmission system is set up, which should be done in the earliest possible stage of a disaster response, information must be passed along on paper. Mobile phones, being small, convenient, and battery-powered, can be easily carried into disaster-stricken areas and can be used for several days to a week without a charge, which is why these devices are often used to collect and transmit information in emergency circumstances. On the other hand, the small display that a mobile phone

offers makes it difficult to operate, causing mistakes in input and communication. In addition, since a mobile phone handset has fewer operating keys than a PC keyboard, one key has more than one assigned function and operation becomes difficult, in particular for aged persons. For these reasons, a system this dissertation proposes can combine the conveniences of both paper-based data entry and mobile phones would be a realistic and promising solution for transmitting crucial information. The system has the following characteristics.

- (1) The proposed OPR system was developed on the premise that nurses who go to a disaster-stricken area communicate using mobile phones. In order to collect information, mark-sensing cards are provided to victims.
- (2) The proposed tablet-PC system is designed to be used on a mobile handset with a touch panel such as tablet PCs and smart phones which send gathered information to a support center by email so that high-risk victims can be extracted and information can be shared among concerned parties engaged in support activity.

論文審査の結果の要旨

本博士論文は ICT の利活用の分野として、SAS（睡眠時無呼吸症候群）を判定するためのデータを在宅でも収集できるテレモニタリングと、災害時に被災地での医療や看護を行う主体間での情報共有としての災害健康情報管理システムとを取り上げ、現実に活用できる独自の情報技術を開発したことにある。前者では、無呼吸状態を音響解析により検出する方式を研究しているが、主観的な SAS スクリーニングテストがあるが、患者の主観に依存するため正確ではない。客観的な確定検査としては、終夜ポリグラフィーによる診断や、パルスオキシメータによる在宅検査あるいはセンサー付きマットレスでの検査といったスクリーニング検査があるが、これらは侵襲であり患者の負担が大きく、かつ検査機器も高価となる。そこで本博士論文では、いびきの音響解析により睡眠時呼吸状態を判断する方法を開発した。これは非侵襲であり、利用者への負担も少ない。本研究の手法は、呼吸音の大小でなく、呼吸間隔に着目するものである。つまり、骨伝道マイクで録音した信号の周波数スペクトルに対して、周波数成分の時間変化をとり、FIR フィルタによりノイズを除去して、包絡線を検出する。この包絡線を並び替え、このデータから呼吸時と無呼吸時を判定するものである。本手法による評価は、SPO2 による呼吸・無呼吸と一致していることで示される。さらに、送信するのは包絡線データであり容量が小さく、寝言等も除去され患者のプライバシーも守られる点に特徴がある。本手法は、200 万人の潜在患者いると言われる SAS に対して、簡便な検出手法を提示するものであり、その意義は大きい。

本博士論文での今ひとつのテーマは、被災地での情報共有としての災害健康情報管理システムの構築である。災害時には多くの医療チームが交代で派遣され、また被災者は避難所を移動することもあり、被災者の健康情報の調査や伝達、さらには情報共有が機能しない。このような状況で利用できる携帯電話やタブレット端末によるシステムを開発した。マークシートによる調査は簡便で大量の被災者を対象とできるが、マークシート用紙は汚損に弱く、大量の調査用紙が必要となるなど問題もある。本論文では、マークシートを読み取る方式として、携帯電話のカメラとタブレット端末による方式を開発している。前者では、携帯電話のカメラで撮影し、送信し、それを受信したサーバーでは、メールから写真を取り出し、認識して被災者 DB に登録するものである。これには、メールアドレスの一部に組み込まれた様式 ID からマークシート用紙を区別して認識するようになっている。PM の認識や射影変換といった点に特徴があり、これが実用上の利点となっている。一方、タブレット端末による方式では、キーボードでなく手書きメモのように文字を画像として入力できるので多くの人ができる。アンケート用紙は写真として取り込み、その上から手書きメモができる仕組みを開発した。

以上、本論文は、これまで十分には行われなかった分野で、独自のアイデアにより実用性が高い ICT の応用例を開発したものであり、博士（応用情報科学）に値するものと判定する。