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PROSPECTS FOR WIRELESS TECHNOLOGY IN REMOTE CARE PROCESSES

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ABSTRACT

The average age of Finnish population is expected to rise. Simultaneously, the amount of nursing staff is not increasing at the same rate. This leads us to the situation where, i.e., we have too much patients for one nurse. On the other hand, sparse population in some regions, such as North or East Finland, cause a problem that doctors are far away from the patient. In this paper, we summary possibilities and applications that utilization of wireless technologies in healthcare sector can bring with to help nursing activities. The use of new innovations is one way to solve the problems that are based on the expected lack of professional staff in the future. Despite of the very natural hospital link, the technology developed has applications outside the hospital. Remote care of aging people and other special groups need to be done almost real-time and daily. Keeping people home instead of hospital is one way to decrease the entire care costs. In addition to the obvious human context, we derive some other applications where we can benefit wireless nursing and remote sensing techniques.

I INTRODUCTION

Recently it has been recognized that the processes at hospitals are inefficient. By reorganizing current practices, it is possible to significantly improve these manners. New methods to monitor humans by using non-invasive techniques and devouring or implantable devices could improve the quality of care and extend the possibilities of real-time observation. How can this be happened in practice?

In Oulu region in Finland, there has been ongoing work within a, so called, *WILHO Consortium* [1] to define bottlenecks and new innovative procedures for hospitals. The key players in WILHO Consortium are *Centre for Wireless Communications*, *Intelligent Systems Group* at the Computer Engineering Laboratory, and *Optoelectronics and Measurement Techniques Laboratory*, all at the University of Oulu. *Oulu University Hospital* combines the academic and clinical experience. In addition to the academic players, the WILHO consortium has two active SME's: *ODL Health Ltd.* that is a private hospital and *WHealth Ltd.*

One possible answer to improve care processes is *a wireless hospital concept* which utilizes all the possible solutions new Information and Communication Technology (ICT) can provide [2, 3]. By utilizing wireless technologies and new innovative approaches to handle daily nursing procedures, the effectiveness at hospital can be significantly increased. By doing so, medical staff can redirect more time to nursing, instead of supporting actions. In addition to hospital environment, new solutions and ideas could be utilized in elderly and children home care.

Again, utilization of wireless technology can open new directions, for example, in animal herding or corresponding areas, where modern technology has not been applied yet in large scale.

Also in Japan, more attention to improve hospital, child and elderly care has been paid during the last years. One example of the Japanese activities in this field is a research centre at the Yokohama National University that is focused only on medical ICT research, which gives also its name MICT [4].

Collaboration between MICT and CWC has already been established, and it will focus on creating new innovations for the healthcare sector.

II FACING A PROBLEM

One common factor in Finland's and Japan's inhabitant statistics is the age structure. In the future, the average age will be higher than nowadays. This increases the need of elderly people's care taking. The estimation of population age structure for year 2050 has been illustrated in Figure 1 for Finland and in Figure 2 for Japan [5]. According to the same reference, the total fertility rates in Finland and Japan are 1.7 and 1.2 children per woman, respectively. These numbers clearly indicate the problem what we are facing in the future. To manage this fact, new and more effective care processes are definitely needed.

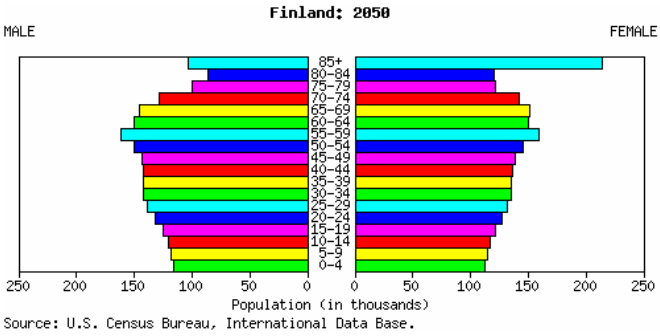

Figure 1. Finland's age pyramid estimation for year 2050.

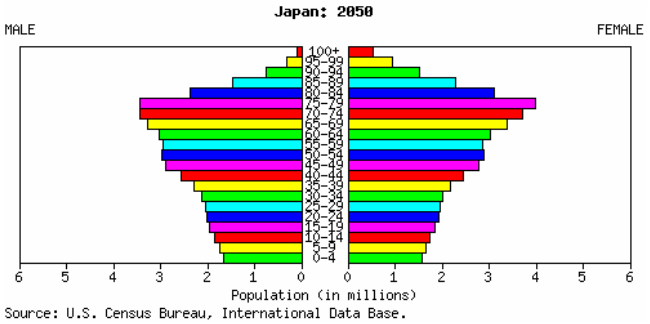

Figure 2. Japan's age pyramid estimation for year 2050.

III TECHNICAL POSSIBILITES

How the current situation could be improved? By adopting wireless technologies in healthcare, the way towards more efficient processes could be smoothed. The need of double work which is currently done, e.g., in medicine or other goods booking could be done faster, and in more reliable way, if modern technologies are utilized. For example, electrical systems allow that information is easy to carry forward to different electrical databases, ordering systems, and corresponding applications. And this is possible to do automatically. The important benefit is that all the records stay updated, and the latest information is available real-time for all the medical staff members who might need it. By getting rid of the double writing, one important slip source will also be removed. In addition, added value comes from the fact that the access to electrical information is location independent.

Ubiquitous monitoring using small, non-invasive sensor devices will offer new methods to collect medical information from patient. Intelligent clothes [6], sensor belts such as [7], coating materials with pressure sensors or other tiny devices that are easy to wear, that consume little energy and whose operation is robust are nowadays available. Even the technology is obtainable it has not been utilized in medical applications in a full strength in practice, yet.

Medical sensors including 3D accelerometers could provide information on vital parameters simultaneously with the human posture or gesture. This is important help especially in remote monitoring when patient is staying home. A novel monitoring system could automatically provide medical information to a doctor, but also activity and behaviour statistics of a remote patient. All this information is important extra to the whole nursing process. In addition, the consciousness of existing real time medical support increases the safety feelings of persons who don't need to be at hospital but who still requires external charge.

Since late 1950's, in-body pacemakers are used to help people who have heart problems. Also in human vital parameter measurements, the use of implanted sensors or devouring devices will be a natural direction. Capsule endoscopes are examples for the latter application [8]. These devices could provide video stream inside a body in real-time and they could get energy outside of body. That makes capsule endoscopes easy and safe to use. Merging drug delivery to the capsule allows accurate medicine dosing into the diseased organ.

Mechanical structures and materials used in the implanted devices need to be extremely safe for in-body use. Typically, these devices have long life times to reduce the need for battery changes. Fortunately, current technology provides medical devices which are safe to implant inside a body.

For the use of ultra low power active medical implants, the ECC has already defined frequency bands between 401-402 MHz and 405 - 406 MHz [9]. The dedicated frequency bands made it possible to develop standardized apparatuses which can be used globally, which is needed for successful product commercialization.

IV RADIO PROTOCOLS

In the modern remote sensing network, all the sensors worn by the human are connected to each others using wireless body area network (WBAN). For that reason, IEEE 802.15.6 study group is defining a standard for medical WBAN to guarantee the compatibility between different sensors and actuators linked in the system. According to the implementation technique, WBAN systems can be divided in wearable and implantable networks [10].

WBAN establish a connection with home network and home server, which could connect to the health service provider through Internet or mobile/fixed telephone or wireless local area network connection. Peer connection using standardized radio link could offer mobility aspect for WBANs and the connected devices.

Due to the several wireless standards available at the moment, health monitoring systems could easily be modified to fit regional regulatory requirements. Radio techniques such as ultra wideband (UWB) [11, 12], ZigBee [13], RFID [14] or IEEE802.11 -family [15] could be used in different kind of applications at homes. In Finland, IEEE802.11 wireless local area network (WLAN) is generally used also at hospitals.

Safety regulations play a key role when adopting new technologies, devices and services especially into the healthcare market. Because the applications are touching human health and life, the fault tolerances are much smaller than in the other commercial applications. The global standards create the platform for medical applications and devices, and make it possible to utilize those in a clinical work.

Different requirements and data transmission protocols that could be used in home monitoring will raise also new problem that have to be faced up. Patients are not willing to install several radio transceivers in their homes to serve all the complementary applications. This might require more complicated solutions and installations for home terminals. Fortunately, software defined radio (SDR) [16] could link different radio technologies and protocols into one device.

Depending on the data transmission needs and available networks, the radio could reconfigure itself to the required service. Modern digital signal processing solutions do not increase the price of the radio device in a same ratio than it could offer new services.

V CARE PATH: EXAMPLE FOR REMOTE CARE

A remote care path will start from a medical sensor stimulus. If the value of the measured vital sign exceeds the predefined threshold, an alarm to backbone system will be sent. Depending on the sign to be measured, the backbone system or service provider will return instructions for patient's self-care. The measured vital sign could be electrocardiogram (EKG), SaO2, blood pressure, temperature, respiration or perspiration.

In the case of emergency, such as heart attack etc., the home system could make instant alarm straight to the emergency centre. Simultaneously, the measured vital parameters will be directed to responsible doctor. This procedure might save the critical minutes from the healing, or mortality, point-of-view. On the other hand, the patient's medical history saved to the electrical patient record (EPR) is available for a doctor or other nursing staff. This additional information could be automatically linked to the alarm event. This render effective way to prepare more detailed and tailored treatment plan for the far patient.

If the vital signs and all the available medical information could be linked to the patient in early phase, the possibilities for customized care will improve. A natural continuation for extending the care path is to include all patient transportation services, such as ambulances, into it [17]. Cellular or satellite networks have globally a coverage that fulfils these needs.

To improve the personal data security, the use of designated data networks, such as Tetra [18], could be used by the authorities, hospitals and ambulances. However, the home application and home network should be based on some open radio standard still having a strong encryption to guarantee the personal data security.

However, increasing and unsupervised utilization of automatic measurements could also increase the number of false alarms. This might raise a new problem that needs to be solved before the technology is used ubiquitously. In medical applications, every fault could lead to loose of life. In that sense, remarkable benefits from the new technology could be filtered out if the security level is not high enough. The number of false alarms and wrong diagnoses has to be minimized.

Wearable sensors with artificial intelligence or advanced algorithms could also be used to recognize emotional feelings [19]. From the referred web-site, some examples about the possible applications can be found.

Taking into account the technological improvements the previous sections discusses, aftercare procedures could be made effective in a rehabilitation program. Technology makes it possible a doctor to monitor remotely that disbanded patient is following the instructions and exercises home.

Though the discussion above relates on civilian application, the remote control of vital signs could be obtained in military. The status of a wounded soldier could be transmitted to medical care centre, and the coming actions could be planned based on the seriousness of the injury.

VI TELEMEDICINE

Finland has only about 5.4 million inhabitants, which is the same amount that several metropolitans all around the world only have. This means that the population density in Finland is quite sparse. To make the situation more tangled, inside Finland the population is not evenly distributed either. Though being a high educated country, there are no doctors available all over the country, in particular at the regions which suffer leaving population problem. This situation has been observed and one solution to provide medical help to such regions is tele-health.

There are lots of experiences in, e.g., Asia-Pacific region in tele-medicine. It is almost the only way to offer medical services for all inhabitants in large developing countries, such as India.

However, the technology fits well also to other regions than poor countries. Typically, special nursing does not have resources in every hospital. Using the possibilities tele-health could offer, the expertise and knowledge is possible to spread for much larger areas than inside one hospital. Tele-health could also be seen as a way to extend care processes to home. As a service providers' viewpoint, the technology could save lots of money and improve the efficiency of whole regional nursing system. Again, if the patient does not need to travel to hospital for every medical treatment or check saves overall care costs.

Not only in clinical use, tele-health approach could be used in video conference type connections in medical education. Far located experts could help in regular teaching at regional medical schools. In addition, the experts could give lessons from another continent via electrical connection.

VII INCREASING THE TECHNOLOGICAL SCOPE

People are just one target new technologies could be utilized in remote medical monitoring. In sparse populated areas, such as Finnish Lapland, the technology could bring help in other activities such as reindeer herding. Typically, the animals are herding freely in the wilderness but once a year reindeers are collected together during round-ups.

Lot of work nowadays is required to find the reindeers from the wilderness and then guide them to the round-up enclosure. If the animals are equipped with low cost sensors that offer also positioning information, the collection work could abate significantly. Cheap global positioning system

(GPS) chips could nowadays be implemented very cost effective way in small remote sensors apparatuses.

Due to the simple sensor devices attached to the reindeers, the health condition of each animal could be monitored remotely which gives added value for utilization of new technology. The biomedical signs similarly than from people could be monitored from animals. Due to the individual sensor tags, the life cycles from new born animal to the finished food could be traced. Of course, when talking about equipping wild animals, light weight and low power consumption requirements for the wearable devices are emphasised even more than with people.

Of course, reindeers are just one possible animal group which could be equipped with tiny medical sensors. The application field covers all farms with cows, horses, etc.

VIII SUMMARY

As the previous discussion shows, wireless remote monitoring services could be used in several types of applications in healthcare. Modern technology could increase the level of nursing in far and sparsely populated regions as well as give the possibility for patients to stay at home. Hopefully, the positive impacts could be seen as decreasing nursing work load and costs that whole care system have. In many countries like in Finland, the medical services are provided by the government and the expenses are cover by the tax payers.

In addition to human medical care, the remote monitoring systems could be used in military field and animal herding. These applications are giving added value to the technology developed for hospital, or remote human care.

How these new approaches in wireless hospital environment are taken into account will be discussed in separate papers at the ISMICT'07 symposium.

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