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What’s in Store for Mobile Health & Telemedicine Technologies?

Interviewee

Constantinos **S. Patticхes,***PhD*
Co-contributers
Christos N. Schizas, *PhD.* **Andreas Panayides,** *PhD*
Department of Computer Science, University of Cyprus
Nicosia, Cyprus

Efthyvoulos Kyriakou,*PhD*
Department of Computer Science, Frederick University
Nicosia, Cyprus
Reported by
Dervla Gleeson
Managing Editor

Constantinos Pattichis is Director of the Department for Computer Sciences at Nicosia's University of Cyprus. He has a keen interest in the development of mobile health and e-emergency services both nationally and across the globe. Here, he shares his thoughts on the capabilities of mobile technologies, and discusses the need for improved infrastructure.

You Were Involved in Several European-Funded mHealth and E-Emergency Projects – What has Happened Since These Concluded?

Yes, I was involved with several e-health projects awarded via the EU European Regional Development Fund (INTERREg) to the University of Cyprus, in collaboration with the Ministry of Health of Cyprus, Nicosia general Hospital, Makarios Hospital, Pafos general Hospital, and Polis Chrysohous Hospital (including the rural medical centres at Kyperounta, and Pyrgos). These projects covered the development of an integrated platform for improving healthcare provision in the Mediterranean region and on mobile and robotised telemedicine for emergency vehicles, and monitoring of children with cardiac diseases funded by the Research Promotion Foundation of Cyprus. Unfortunately, although these services were successfully deployed and their need has been clearly demonstrated, they have not been placed in routine clinical practise, so that patients could truly benefit.

Is There Any Data Assessing How Cost-Effective the Use of M-Health and E-Emergency Services are in Comparison to Traditional Methods?

It is generally argued that m-health & e-emergency services are still largely undeveloped not only in Cyprus but in other EU countries as well. The success, experience, and benefits of clinical services in emergency telemedicine have only recently been published on a large scale of emergency cases by the telemedicine programme at the State University of New York at Buffalo School of Medicine, and the Erie County Medical Center (UB/ECMC). It was shown that the use of emergency telemedicine services could result in an approximate 15 percent decrease in the number of ambulance transports when it is added to the pre-hospital care provider's services, with an emphasis on younger subjects. However, more convincing studies are encouraged in order to promote the wider deployment of e-emergency systems and services.

How Does Remote Diagnosis and Care in Emergency Medicine Systems Benefit Geographically Isolated Locations?

The use of remote diagnosis and care, and emergency telemedicine systems is of vital importance in Cyprus given that people living in remote locations on the island do not have access to specialised health services at a satisfactory level. As a result, inadequate health service provision and quality of life deterioration associated with the long distances that have to be travelled to reach specialised medical care, especially for the elderly, are greatly improved using robust telemedicine systems, enabling adequate medical access to remote habitants.

To this end, a unifying framework for an efficient endto- end mobile-healthcare system for transmission of diagnostically robust medical ultrasound video has been developed within the framework of "Real-Time Wireless Transmission of Medical Video", funded by the Research Promotion Organisation of Cyprus. It is based on a spatially varying encoding scheme, where video slice quantisation parameters are varied as a function of diagnostic significance. Clinical criteria are first used for determining the regions of diagnostic interest. The regions are then used to specify video slices with independent coding control. Video slices can be automatically set based on segmentation algorithms or manually defined by the relevant medical expert. They are then encoded using a modified version of H.264/AVC Flexible Macroblock Ordering (FMO) technique that allows variable quality slice encoding and Redundant Slices (RS) for resilience over error prone transmission mediums.

Evaluation of the proposed scheme was performed on a representative collection of 10 ultrasound videos, nine of the carotid and one of the femoral arteries, for packet loss rates up to 30 percent. Extensive simulations incorporating three FMO encoding methods, different quantisation levels, display resolutions, frame rates, and different packet loss scenarios were investigated. Overall, a coarse to fine parameter optimisation was used for determining the minimum diagnostically acceptable source encoding parameters and corresponding bitrates for transmission over 3g (beyond) wireless networks.

Quality assessment was based on a new clinical rating system that provides for independent evaluations of the different parts of the video. Objective video quality assessment metrics were also employed and their correlation to the clinical quality assessment was derived. To this end, some objective quality assessment measures computed over the diagnostic ROI video slices gave very good correlations to Mean Opinion Scores (MOS). Here, MOS were computed by two medical experts.

Experimental results show that the proposed method achieves enhanced performance in noisy environments, while at the same time achieving significant bandwidth demands reductions, providing for transmission over 3g (and beyond) wireless networks. The proposed unified framework can be applied with minor modifications to other medical modalities.

What are the Main Challenges for the Application of M-Health in Clinical Practice?

The main challenges for the application of m-health in emergency healthcare systems and services can be grouped under communication systems, computer technology, biosignals and emerging technologies on the transmission of wireless digital images and video.

In many countries 3g (i.e. UMTS) and 3.5g (HSPA) mobile cellular networks are currently installed and operational, which provide typical upload bandwidth of up to 4Mbps (3g: 200-300kbps, 3.5g: 500kbps – 4Mbps) something that will enable the transmission of more information or example, continuous 12 leads of ECg when monitoring cardiac patients from a moving ambulance, as well as bandwidth-demanding real time medical video transmission for emergency telemedicine and remote diagnosis and care. Depending on bandwidth availability, different quality, resolution and frame rate encoding may be considered to facilitate efficient system deployment. Towards this end, diagnostically relevant scalable video coding (SVC) may be employed to provide for different encodings that correspond to different bitrates, and therefore clinical capacity. Efficient encoding methods, incorporating error resilient implementation and error concealment mechanisms for recovering from transmission errors over aforementioned error-prone wireless channels, are also key to the success of emerging m-health systems for medical video transmission.

The diagnostic capacity of the transmitted medical video should be thoroughly evaluated by medical experts to investigate the effect of compression on medical video transmission. Traditional mean-square error measurements do not necessarily correspond to perceptual quality, and may correspond even less to diagnostic quality. As an example, image quality assessment over the near-regions of ultrasound video is not useful, while in general, users expect the highest quality in regions that are in the focus of the ultrasound beam. In addition, there will continue to be strong interest in region of interest (ROI) and object-based coding methods. The challenges associated with applying these methods require the development of effective segmentation methods.

Another important factor is the emergence of wireless metropolitan area networks (WMAN) in cities (e.g. WiMAX with tens of Mbps), something that will significantly improve communication in wireless healthcare systems operating within city boundaries. Fixed and mobile WiMAX are already deployed for that purpose, with some commercial applications already installed. The use of such networks will be very important because healthcare providers will have immediate and high-speed telemedicine access from anywhere in the area of a city.

The emergence of 4g technologies (Wireless MAN Advances and LTE-Advances) conforming to IMT-Advanced requirements, promise ubiquitous access to differing radio network technologies, thus offering, beyond extended coverage, the most effective connection mode at the point of contact, even simultaneously using several wireless access technologies and seamlessly moving between them. 4g networks will facilitate even greater availability of bandwidths, lower latencies, enhanced mobility and quality of service support, enhanced service provision near the cell edge, security, and other cutting edge technologies, all of which are highly beneficial for future m-health systems and services development.

What Other Technological Advances Will Aid More Efficient Remote Healthcare?

The use of GPS (global Positioning System), gIS (geographical Information Systems) and intelligent traffic control systems has potential to improve healthcare services. For example, when a moving ambulance vehicle is trying to reach a patient using the fastest route, or when an ambulance carrying a patient is trying to get to the base hospital.

Modern portable computer systems have smaller size and weight but provide almost the same computational capabilities as non-portable computer systems making their use in wireless telemedicine systems highly applicable. Nowadays the introduction of portable devices like PDAs, smartphones, netbooks and iPads is something that enables wireless telemedicine systems designers to create faster, better and smaller systems. However, there is still a need to develop compact devices with fast processing and power that are tuned in to the varied and demanding telemedicine applications.

Biosignal acquisition is another technological field that affects wireless telemedicine systems. The collection of biosignals such as ECg was till now performed using expensive devices which could only be handled and supported by medical personnel. Nowadays, very small devices can collect biosignals. They might be wearable, have the shape and weight of a necklace, etc. These devices will enable the use of wireless telemedicine systems almost anywhere and at less cost. Such devices can be used for home care purposes more easily than standard medical devices.

What are the Most Important Infrastructures Needed for M-Health Technologies to Really Make an Impact in Fields Such as Emergency Services?

For medical wireless video transmission systems, the two most significant components include medical video compression technology and the wireless infrastructure that will be used for the transmission. Medical video compression needs to address some of the unique requirements associated with the intended diagnostic use. Efficient video compression systems can be built using current state-of-theart video coding standards such as H.264/AVC, to provide for efficient (size-wise) real-time encoding. On the other hand, increasingly available bitrate through revolutionary wireless transmission channels realise communications previously only available to wired infrastructures, while coverage is extended practically across the globe with the latest mobile cellular and satellite systems.

H.264/AVC offers bitrate reductions up to 50 percent for equivalent perceptual quality compared to its predecessors, while currently developed H.265 aims to achieve similar reductions with respect to H.264, for an even improved coding efficiency.

The evolution of mobile telecommunication systems from 2g to 2.5g (iDEN, GPRS, EDGE) and subsequently to 3g (W-CDMA, CDMA2000, TD-CDMA), 3.5g (HSDPA and HSUPA, HSPA+), mobile WiMAX, and LTE systems, facilitates both an always-on model, as well as the provision of faster data transfer rates and lower delays, thus enabling the development of more responsive telemedicine systems. More specifically, typical upload data rates range from:

(i) GPRS: 40 - 50 kbps;

(i) EDGE: 70 - 135 kbps;

(iii) Evolved EDGE: 150 - 300 kbps (expected);

(iv) UMTS: 200 - 300 kbps;

(v) HSPA: 500 kbps - 2 Mbps, and (vi) HSPA+: 1 - 4 Mbps.

The 4g family of technologies targets improved uplink and downlink rates of hundreds of Mbps and 1gbps respectively, increased coverage and throughput, enhanced mobility support (up to 350 km/h), reduced latencies less than five milliseconds, enhanced QoS provision, efficient spectrum usability and bandwidth scalability and security, with simple architectures in favour of the end user. The latter will enable the development of m-health systems and services that were previously unimagined.

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