From the e-Health TC of the IEEE ComSoc ...

Dear All,

The IEEE Communication Society (ComSoc) eHealth Technical Committee has now completed five years - I had the privilege of seeing its formation as a technical subcommittee in 2008. Its subsequent elevation to a full technical committee and its successful re-endorsement last year indicate a few things thanks to your continued support.

The IEEE ComSoc recognizes the importance of eHealth and telemedicine that has seen some great developments in the recent past. Although many of the engineering developments in healthcare have been in the field of biomedical engineering (supported by the IEEE EMBS Society), the revolution in telecommunications (e.g., IP based convergence, sensor and body area networks, mobile phone-based health services) is instrumental in much of the present and future high impact developments in healthcare. For example, mHealth (healthcare based on mobile phones and M2M) is recognized as a major factor in helping countries improve the access, cost and quality of healthcare, as emphasized in the World Health Assembly of UN since 2005. Thanks to the rapid proliferation of mobile phones in the developing countries, mHealth is now being harnessed for various types of public health problems, from TB/HIV control to disease surveillance and polio vaccination management.

However, the success of such technologies may require rigorous evaluation methodologies for new technologies, similar to those used for new drugs (e.g., randomized controlled trials). Hence it will be necessary for technologists and engineers to work in a multi-disciplinary research environment with health professionals to reduce the time to market new ideas.

The ComSoc eHealth TC has been working on several initiatives with other IEEE technical committees within and outside ComSoc, and also with sister societies and global bodies, such as ITU-D and WHO. This TC sponsors several major international conferences, such as IEEE Healthcom and symposia at major IEEE events, such as ICC and Globecom. This TC has also sponsored special issues in top IEEE magazines (e.g., IEEE Communications) and journals (e.g., JSAC). Having developed the collaborations with ITU-D and WHO, this TC has the opportunity to make major contributions in the policies for eHealth in many developing countries through the joint work of the Ministries of telecommunications and health that are guided by ITU-D and WHO respectively. In addition, this TC could work further with the IEEE Life Sciences initiative to help fashion the growth of personalized medicine based on the upcoming developments in bioinformatics.

Therefore, more collaborations with biologists, health professionals and public health policy makers, would be required to help the society reap the benefits of new technological developments in harnessing the rapid increase of healthcare costs. We hope out TC will play a major role in coming years to realize these important global objectives.

Best Regards,

Pradeep Ray,
Chair, e-Health TC of the IEEE ComSoc

- Aravind Kailas (UNC Charlotte, USA) and Nazim Agoulmine (University of Evry, France)
Automated Diabetic Retinopathy Detection Based on Remote Computational Intelligence

José Tomás Arenas-Cavalli
DART (Telediagnosticos SpA)
Dept of Electrical Eng,
Dept of Industrial Eng,
University of Chile
jarenas@ing.uchile.cl

Abstract
Automated detection of the ophthalmologic pathology known as diabetic retinopathy (DR) has the potential of preventing vision loss and blindness cases, when promoting massive screening of diabetic patients. This work aims, in an early stage, to design and develop a functional classifier at a prototype level, allowing to discriminate between patients with and without presence of the disease by means of automated digital eye fundus images processing. Procedures are based in adaptation and integration of publicly available algorithms. Secondly, after validating the results, it is expected to apply the computational intelligence module to an e-health environment; an automatic detection and web-based telemedicine system implemented in the healthcare institutions.

1. Introduction
Diabetic retinopathy (DR) is one of the most important problems of the healthcare systems worldwide, affecting and blinding specially working population. Although early detection and laser treatment of DR are effective in preventing visual loss, many diabetic patients are not treated in time because of inadequacies of the currently available screening programs. This applies to almost the majority of the patients with diabetes who do not undergo any form of regular documented dilated eye exam.

Automated detection of DR has the potential of preventing vision loss and blindness cases, when promoting massive screening of diabetic patients. This work aims, in an early stage, to design and develop a functional classifier at a prototype level [1], allowing to discriminate between patients with and without presence of the disease by means of automated digital eye fundus images processing. Procedures are based in adaptation and integration of publicly available algorithms. Furthermore, the computational intelligence module can be deployed and installed into a web-based telemedicine system implemented throughout remote public and private healthcare centers.

2. Development
The objective here is to develop a system for automated DR detection. The input of the system is a digital image corresponding to a retinal exam. All images were clinically validated as appropriate for DR diagnosis. Basically, DR presence results from any of two type of abnormalities. Selected approaches for each step of detection need completeness of one another. For bright lesions detection, optic disc (OD) must be located. For OD localization, blood vessels must be segmented. Now, for red lesions detection, pixels of the image corresponding to bright lesions, blood vessels and OD are discarded to analyze the background of the retina for additional abnormalities.

Digital retina images processing developed stages were: blood vessels localization, OD localization, bright lesions detection and red lesions detection. For each one of the stages, used techniques were, respectively: Gabor wavelets and Bayesian classifiers; vessel features and kNN regressors position prediction; fuzzy c-means segmentation and multilayer neural network classification; and, optimally adjusted morphological operators.

3. Concluding Remarks
This work concentrates on bright lesions and red lesions detection from DR patients' non-dilated pupil digital retinal images as a preliminary phase of an automated DR screening system. The system intends to help the ophthalmologists in the DR screening process to detect symptoms faster and more easily. The tool is oriented to make the health system more efficient and effective, allowing massive retina screening for diabetic patients and demanding ophthalmologists intervention only in certain cases. These cases are reduced to the ones that involve algorithm detection of structures that may note disease manifestation.

Regarding future implementation, some key actions are necessary. First, training and test database growth. Besides, fine-tuning of each main intermediate stage is possible. Thus, a general prototype user-level round of implementation will allow designed and developed methods evaluation and improvement. As the automation system is reaching clinically acceptable precision levels, practical implementation is taking place. Taking advantage of cloud computing, automatic digital images processing and web telemedicine, the system is used to aid ophthalmology specialists to reach unattended populations; both in the geographical sense, and in-terms...
of the public and private health systems attention span, as in Fig. 1.

Further Reading

Remote Polysomnographic Monitoring with a Data Mining Pre-diagnostic Process Via a Cloud-based Centralized Healthcare Center
Claudio Estevez‡, IEEE Member, Sebastián A. Ríos†, and Pablo E. Brockmann‡
‡Department of Electrical Engineering, Universidad de Chile, Santiago, Chile (cestevez@ing.uchile.cl)
†Department of Industrial Engineering, Universidad de Chile, Santiago, Chile
‡ Department of Pediatrics, School of Medicine, Pontificia Universidad Católica de Chile, Santiago, Chile

Abstract
Sleep disorders affect a great percentage of the world population, particularly in large cities. The polysomnography is a commonly administered test that helps diagnose sleep disorders. Polysomnographs have many sensors that gather data that is collected for approximately 8 hours. This process can generate vast amounts of data and consume valuable local resources. An alternative that can save local resources while generating patient data backups, and can even pre-diagnose patients, is having a centralized health center with a cloud architecture. Additionally, indicators can be configured and calibrated to set alarms in the case of an adverse situation.

1. Introduction
Sleep disorders affect a large percentage of the world population. Very often sleep disorders arise when the patient’s circadian rhythm in unsynchronized with their daily activities, particularly in children. Many chronic cases in children are underreported or untreated [1]. Various countries lack the resources to provide massive polysomnography tests, which is a method of detecting sleep disorders. Only the more vulnerable undergo these tests and the vulnerability is determined by a simple open-loop model based on the age (children and elderly). This model is sub-optimal. There are alternatives to determine vulnerability based on a closed-loop model with massive low-cost polysomnographic tests that can feedback indicators that help determine which patients are more vulnerable. The key is a low-cost autonomous centralized healthcare system.

Technology and health are rapidly fusing together. The age of information has created a bridge where interaction between telecommunication engineers and medical doctors is relatively simple. This interaction has served as a catalyst to the fast growing field of eHealth. One of the most accepted next-generation telecommunication models is to have a centralized health data center [2], [3], with a cloud-computing architecture, that stores and analyzes patient data, see Fig. 1. To analyze vast amount of data a specialized architecture called data warehousing must be implemented. In this case, the raw data enters the data staging area where using extraction, transformation and loading techniques (ETL) the warehouse is generated. Afterwards, data mining techniques attempt to discover disease patterns and other relevant information to assist medics, generate automatic alarms, etc. This information can exit in the form of a pre-diagnostic (premature diagnostic). A pre-diagnostic is defined, in this context, as a predictive assessment that attempts to conjecture a diagnosis based on a set of measurable physical states or symptoms. The pre-diagnosis is obtained using data mining techniques, which essentially correlates the data patterns of cases where the patient is known to suffer a disorder or disease with the data patterns where the diagnosis is still unknown (which are performed with supervised learning techniques). One purpose of obtaining pre-diagnostics is to compute a degree of confidence (of presence of illness) and the cases with higher probability of illness are considered vulnerable and are treated with higher priority. This collaborative work, works under this model, specifically in respiratory diseases.

2. Polysomnography
The primary device in respiratory disease studies and diagnosis is the polysomnograph. This device is used to detect diseases and disorders that include: narcolepsy, idiopathic hypersomnia, periodic limb movement disorder (PLMD), rapid-eye movement (REM) behavior disorder, parasomnias, and sleep apnea. The polysomnograph is composed of various sensors that record the following (but are not limited to these): electroencephalogram (EEG), electrooculogram (EOG), electromyogram (EMG), electrocardiogram (ECG or EKG), audio/snorning, temperature, and oxygen saturation.
European Data Format Files: Polysomnographic data is recorded in the European data format (EDF), which is an open (non-proprietary) format, this allows files to be easily imported and analyzed. EDF files have a header (coded in ASCII) followed by binary data. Each data sample is coded as a 16-bit integer (int16) using two's complement and little-endian notation. The sampling rates vary depending on the sensor, but are typically between 100 and 200 samples per second. Since each sample contains 16 bits, this translates to up to 3.2 kbps per sensor. A 60-second extract of a polysomnogram is shown in Fig. 2.

A typical polysomnogram has 8 hours of data (while patient sleeps) and occupies approximately 200 MB per test. The information is stored in blocks (typically with one second of data) where each sensor has a recurrent fixed size, i.e., it occupies N samples in every block. Not all sensors have the same amount of samples per block; the header contains the samples per block per sensor information. It is recommended that the data per block (for all signals) does not exceed 61440 bytes; if it was exceeded the duration of the block should be reduced. This is critical to reconstruct the signals from the data stored in the file.

Problem Statement

An interesting study in sleep disorder research, from a telecommunication's point of view, is the amount of data generated and the necessary throughput required (assuming the data is going to be transmitted to a data warehouse). The amount of data generated is related to the quality of the signal. In this work, the metrics considered for signal quality are: quantization levels and sampling rate.

When designing the quantization process of any system it is important to understand the tradeoffs. Having low levels of quantization will result in poor signal integrity, perhaps even to the point where the quantized version provides no useful information about the original signal. In contrast having very high levels of quantization will yield large
amounts of data, which (in a cloud-based network) could cause network congestion. Even if the transfer rate is paced, i.e. spread over time, large quantities of data can consume vast resources. Optimal values for this criterion are determined by the frequency content of the messages that are being sampled, in this case the polysomnographic signals.

2. Research Team and Concluding Remarks

Feasibility of remote polysomnographic monitoring with a data mining pre-diagnostic process via a cloud-based network with a centralized healthcare center is currently been studied by our research team. This research work is a collaborative effort that combines professionals with diverse backgrounds, which include the fields of telecommunication, data mining and bronchopulmonary illnesses. Dr. Claudio Estevez works on telecommunications, particularly on networking protocols and wireless personal area networks with focus on e-Health applications. Dr. Sebastián A. Ríos main research field is the data mining techniques and its application to enhance management in organizations, which is also called Business Intelligence. Dr. Pablo Brockmann works on sleep medicine and respiratory diseases in children. Preliminary results demonstrate that the proposed e-health network will not encounter significant problems related to throughput since the polysomnograph requires relatively low bit rates, but due to the prolonged tests the amount of data generated per patient can be overwhelming. These estimates are using conservative quantities, actual values can be greater; hence, the demand for greater quality will further increase the storage requirements. Furthermore, it would hinder the communication between specialists as the data would not be easily shared. For this reason, cloud-based networks that support e-Health applications will benefit tremendously for implementing a data warehouse system, which a specialized architecture that stores massive, aggregated and time invariant data that can be queried and retrieved in faster times than a traditional transactional database. Afterwards, this data can be used by data mining techniques to aid medics in pre-diagnostic of illness or other tasks.

From a broader point of view, it can be concluded that polysomnographic tests can be performed remotely. Also the information can be stored in high capacity data warehouses that would compute pre-diagnostics based on a trained system. The system training would be a collaborative work between engineering and medical doctors and is essential for the success of the system. This will also reduce the storage requirements and will enable easier interaction between specialists, considering that everyone would have access to a centralized health data center. Additionally, since the system is designed to return a pre-diagnostic, opposed to a full diagnostic, the remote unit does not need all the sensors of the professional version. This will reduce the cost of the remote testing unit; and finally, by having numerous remote testing units the amount of patients that can be tested will increase, therefore reaching a greater number of vulnerable patients.

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Further Reading