

Trends on Integrating Framework of Applications or Data

Findings from the Section on Health and Clinical Management

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Summary

Objective: To summarize current excellent research and trends in the field of Health and Clinical management.

Methods: Synopsis of the articles selected for the IMIA Yearbook 21014

Results: A comprehensive review of papers published in 2013 was performed by querying PubMed. 1079 were reviewed as papers without authors, without abstract or smaller than 4 pages were excluded from the selection. The editors reviewed all papers and 15 papers selected and provided to international reviewers. Four papers from international peer-reviewed journals were finally selected for the Health and Clinical Management section.

Conclusion: Many telemedicine applications are tested nowadays in medical situation, but the challenges emphasized by the best papers selection focus on the ability of proposing integrative frameworks for applications or data in order to handle efficiency of health and clinical management.

Keywords

Health and Clinical Management; patient care management; medical record systems; technologies in healthcare; telemedicine

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Introduction

Health and Clinical Management aims at improving quality, safety, and efficiency of health care. The HCM section stressed last year the importance of the introduction of mobile and personalized care related to this topic [1]. E-health remains a very important topic and the literature review for the 2014 yearbook reveals a plethora of applications dedicated to telemedicine. In order to assure efficiency of health clinical management while taking into account the existence of numerous clinical data as well as numerous clinical applications, challenges, as discussed in this yearbook contribution, include dealing with big data and smart health strategies. The goal of the Health and Clinical Management section editors is to provide an overview of the research trends in this area and to propose a “best” paper selection that illustrates these new challenges.

About the Paper Selection

A comprehensive review of papers published in 2013 was performed by querying PubMed. 1,600 papers were returned by a query built with representative keywords for this section in order to focus on Health and Clinical Management topic. A total of 1,079 references were retained as papers without authors, without abstract or smaller than 4 pages were excluded from the selection. Each section editor reviewed half of these references and selected the papers, which focused on the section topic and dealt with medical informatics issues. Papers including a Decision Support topic or involved in cost-saving topics were excluded. Only 179 references matched these selection criteria. All these references were blindly reviewed by both of the two section editors,

each of them retaining about 30 references. A discussion on the remaining papers resulted in 15 papers passed to a group of international reviewers. Based on the reviews of external reviewers and of section editors, four papers were retained as best papers for the HCM section. They are representative of the major issues for clinical management.

The Kauppi & al. paper [2] focuses on the construction of benchmark databases and on elaboration of protocols for medical image analysis. Benchmark databases, which provide verified and annotated medical images through expert grounded truth could play a major role in developing and evaluating medical image analysis systems. The authors emphasize key questions for the construction of benchmark databases proposed methods and tools to build them in the context of diabetic retinopathy. The Skalkowski & Zielinski paper [3] addresses the problem of processing data from medical personal devices with formalized rules for treatment procedures. Interesting requirements for such systems include the use of large datasets, the processing of the data online, or the personalization of the treatment procedures according to the patient's needs or preferences. A two-stage process with event processing stage and knowledge application stage is proposed in order to formalize the personal data measurement process. This work is implemented and evaluated in the TeleCare project. The Marceglia & al. paper [4] proposes a methodology for comparing heterogeneous dedicated healthcare systems. After a review of the literature for available e-prescribing systems, they propose a comprehensive model for the e-prescription process, which allows to represent, compare, and analyze the current systems. The model then provides interesting information to design new systems. The

Capozzi & Lanzola paper [5] copes with an interesting area of research for telemedicine system as it proposes a generic infrastructure to support telemonitoring services at home. This infrastructure would be able to manage a remote monitoring system integrating different devices such as continuous insulin delivery system and continuous glucose monitoring system in order to simulate an artificial pancreas while simplifying the implementation of telemedicine services. This study was performed in the AP@home project.

Conclusion and Outlook

The best papers selected for this section reflect some main challenges in today's Health and Clinical Management. The comprehensive review on papers published in 2013 reveals a lot of telemedicine trials. Most of these trials described specific applications often involving a small number of patients. However small, these trials provide evidence of an demanding need for distant and cooperative healthcare applications. This is particularly prevalent with chronic diseases, which are addressed by many different telemedicine studies. Two main conclusions can be reached from this aspect of the review: 1. telemedicine concepts are nowadays easily accepted and 2. these tele-applications still deal with heterogeneity and specificity as major issue. Going beyond the stage of proposals of telemedicine is mandatory, as shown by the work proposing a methodology to compare e-prescription systems [4] or the work to build integrative telemonitoring system [5].

Future work should take into account novelty in technology and in engineering models [6] or [7] as they will influence the future research through new infrastructures. Moreover, anticipating technological advances helps with proposing new devices as u-furniture [8] or the artificial pancreas [5].

Another important trend emerging from 2013 publications addresses the problem of smart and efficient exploitation of medical data. Two different issues are illustrated by the selected papers: the first one reflects on the need of providing useful medical data warehouses as illustrated by the paper on an efficient benchmark database, the second one deals with smart data processing as

Table 1 Best paper selection of articles for the IMIA Yearbook of Medical Informatics 2014 in the section 'Health and Clinical Management'. The articles are listed in alphabetical order of the first author's surname.

Section

Health and Clinical Management

- Capozzi D, Lanzola G. A generic telemedicine infrastructure for monitoring an artificial pancreas trial. *Comput Methods Programs Biomed* 2013;10:343-53.
- Kauppi T, Kämäräinen J-K, Lensu L, Kalesnykiene V, Sorri I, Uusitalo H, Kälviäinen H. Constructing Benchmark Databases and protocols for Medical Image Analysis: Diabetic Retinopathy. *Comput Math Methods Med* 2013;1-15.
- Marcegaglia S, Mazzola L, Bonacina S, Tarquini P, Donzelli P, Pincirolì F. A comprehensive E-prescribing Model to allow Representing, Comparing, and Analazing Available Systems. *Methods Inf Med* 2013;52:199-219.
- Skalkowski K, Zielinski K. Applying formalized rules for treatment procedures to data delivered by personal medical devices. *J Biomed Inform* 2013;46:530-40.

tackled in the paper on the formalization of rules for treatment procedures.

Nevertheless, the telemedicine aspect for clinical management actually becomes important enough to propose a section dedicated to these aspects in 2015.

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3. Skalkowski K, Zielinski K. Applying formalized rules for treatment procedures to data delivered by personal medical devices. *J Biomed Inform* 2013;46:530-40.
4. Marcegaglia S, Mazzola L, Bonacina S, Tarquini P, Donzelli P, Pincirolì F. A comprehensive E-prescribing Model to allow Representing, Comparing, and Analazing Available Systems. *Methods Inf Med* 2013;52:199-219.
5. Capozzi D, Lanzola G. A generic telemedicine infrastructure for monitoring an artificial pancreas trial. *Comput Methods Programs Biomed* 2013; 110:343-53.
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8. Chang Y-C, Lin C-C, Lin P-H, Chen C-C, Lee R-G, Huang J-S, Tsai T-H. eFurniture for home-based frailty detection using artificial neural networks and wireless sensors. *Med Eng Phys* 2013;35:263-8.

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Appendix: Content Summaries of the Selected Best Papers for the IMIA Yearbook 2014, Section "Health and Clinical Management"

Capozzi D, Lanzola G

A generic telemedicine infrastructure for monitoring an artificial pancreas trial
Comput Methods Programs Biomed 2013;10:343-53

Continuous subcutaneous insulin injection is used as a safe way to deliver insulin in patients with Diabetes Mellitus. When adding continuous glucose monitoring, a control loop is created: the artificial pancreas. AP@home European project exploits telemedicine infrastructure in order to conduct investigation on the artificial pancreas. Telemedicine can offer continuous monitoring of the patient condition, especially when using today's small devices. A functional architecture of the telemedicine infrastructure, inspired by agent notion is proposed. Remote agents acquire and provide patient information, clinic agents interface with the patient health record. Services help to exchange data and are able to address specific

tasks varying across context. A generic remote agent helps to partition into 3 categories: services, device independent components, and device dependent components in order to be flexible enough to support different platforms. The telemedicine hub middleware helps to exchange information. SyncML is used to encode and represent the data to be exchanged. This infrastructure was used to implement a remote monitoring service. A trial was conducted in order to test the artificial pancreas, which is designed as a remote agent. A web application is defined in order to provide data monitoring and perusal. The first trial of the project was performed on a PC and further investigation will use Android smart phones.

Kauppi T, Kämäräinen J-K, Lensu L, Kalesnykiene V, Sorri I, Uusitalo H, Kälviäinen H

Constructing Benchmark Databases and protocols for Medical Image Analysis: Diabetic Retinopathy

Comput Math Methods Med 2013;1-15

The authors address the problem of providing shared databases of medical images, with verified ground truth and evaluation protocol with the medical goal being the automatic detection of diabetic retinopathy. Patient image, ground truth, and evaluation protocol are the main components required by benchmarking image databases. A benchmarking framework provides guidelines to construct benchmarking databases. Using key questions related to the usefulness of such benchmark databases, an analysis of the most important public databases in retinal images is performed. Then the following issues are addressed: collecting patient images while respecting patient privacy, annotating images with an annotation tool in order to avoid great disparity of annotation and supporting annotation comparison, providing a data format for medical annotation, allowing the fusion of manual segmentation of multiple experts to avoid inconsistency by combining different medical expert advices. An algorithm of evaluation is proposed, with image-based evaluation or pixel-based evaluation, as well as a strawman algorithm. Two image databases with their ground truth are then proposed.

Marceglia S, Mazzola L, Bonacina S,

Tarquini P, Donzelli P, Pincioli F

A comprehensive E-prescribing Model to allow Representing, Comparing, and Analizing Available Systems

Methods Inf Med 2013;52:199-219

EPrescribing systems have been widely investigated over the past few years and are now available in most developed countries as an integral part of the healthcare system. The goal of this paper is to provide a deep analysis of existing ePrescribing systems and to define a general model to represent, analyze, and compare such systems and design new ones. The literature review was based on the Pubmed/Medline bibliographic as well as the Google Scholar search engine in order to collect papers on ePrescribing written between 2001 and 2011. Based on their review, the authors defined an ePrescribing model that is composed by two subgroups of actions: the administrative actions and the clinical actions. The administrative actions are the compliance of the system to current laws as well as the correct management for receiving a prescription or the prescribing of a treatment or even the cost analysis. The clinical actions are focused on medical outcomes such as the personal reactions to a treatment. The process is composed of 6 phases: 1) Assign, 2) Transmit, 3) Dispense, 4) Administer, 5) Monitor, 6) Analysis & decision. Based on these 6 phases the authors provide an analysis of the information to be included in the output documents of each phase and their properties. Based on this process and its formal checks, several benefits related to quality, access, and efficiency are listed. Finally in the last part of the paper an evaluation of the ePrescribing model is proposed with three cases studies. Each case study is a comparison between the proposed model and an existing model (i.e. the existing ePrescribing system in the Lombardy region in Italy, the ePrescribing system in the Andalusia region in Spain and the ePrescribing system deployed in the Italian national regulatory framework). Besides the proposition of a generic model for ePrescribing, an important outcome of this comparison is that the studied ePrescribing systems mainly focus on drug management control. Only one of the three systems provides a clinical support with benefits in terms of quality of care and none of the studied systems provide support for drug administration.

Skalkowski K, Zielinski K

Applying formalized rules for treatment procedures to data delivered by personal medical devices

J Biomed Inform 2013;46:530-40

To date more and more personal medical devices (PMD) are available leading to an increase of produced data. These data are very interesting from a medical standpoint but their analysis can be very time consuming for physicians. To deal with this issue, this paper presents the TeleCARE framework that proposes the application of formalized rules for medical treatment procedures to PMD's data to enhance patient safety and reduce physician workload. The TeleCARE framework is divided into two stages. First is the event processing stage, where PMD's data are treated by a complex event processing engine. Second is the knowledge application stage, where the processed events are evaluated against a set of rules with the help of a rule engine such as JBoss Drools Expert. These rules have been prepared by several medical experts such as cardiologists and nurses and have to be parameterized individually for every patient. The authors then present an implementation of their framework with an Android application for the gathering of medical data. The overall architecture has been developed with respect to the SOA architecture and relies on REST web services (designed as OSGi bundles) for the delivery of information between the Android application and the two stages of the framework. The TeleCARE system is then evaluated on a group of 20 patients with different illness such as hypertension or obesity for instance but unfortunately the results are not provided in the paper. Instead, the authors focus on the performance evaluation of their solution. Every stage is evaluated independently to see the potential bottleneck of the system. For this evaluation, the number of patients is increased up to 10,000 and the result shows that the framework is able to provide results with less than 1s. The number of rules has more impact but nonetheless, the processing time does not exceed 1s for less than 6,000 rules. Based on this evaluation, it seems then possible to manage one thousand PMDs with a single instance of TeleCARE.