Guest Editorial
Special Issue on Emerging Health Telematics Applications in Europe

I. INTRODUCTION

Throughout the world, information and communication technologies—telematics technologies—form the basis of a new area in the practice of medicine and the delivery of healthcare. It is characterized as a revolution based on information and the expression of human intelligence targeting to improve the efficiency and efficacy of healthcare delivery. Europe is actively participating in this revolution, both through national strategic plans as well as European initiatives, such as the research and development programs of the European Union (EU). The main objective of this Special Issue of the IEEE TRANSACTIONS ON INFORMATION TECHNOLOGY IN BIOMEDICINE is to provide a snapshot of current European activities in health telematics. A total of 14 papers are published in this Special Issue and the December 1998 Special Issue under the following topics: Electronic Healthcare Records, Collaborative Technologies in Healthcare Delivery, Virtual Reality Applications in Medicine, and Healthcare Education. In this editorial, the papers are briefly introduced, together with a short reference on European past and current activities, outlining major difficulties toward the wider implementation of health telematics applications and services in Europe, and the future trends.

Rapid advances in information technology and telecommunications and their combination (telematics) are leading to the emergence of a new type of information infrastructure that has the potential of supporting an array of advanced services for healthcare. In Europe, during the last decade, information technologies have played a decisive role in the dramatic developments not only in diagnosis, treatment, surveillance, and rehabilitation of patients, but also on the side of the more collective aspects of healthcare and health prevention, such as clinical trials, epidemiology, and health education.

In the constant competition for resources in the health sector, these new so-called telematics technologies and applications would not stand much chance if they were not intended to improve the quality of care, directly or indirectly, to help in the cost-containment and better management of the health sector, and to increase competitiveness of the health telematics industry.

The case of quality improvement has long been proven by the older part of health telematics, medical informatics, which is the bread and butter of the clinical decision making process [1]. Among the many contributions of telematics applications to the quality of health delivery, we cannot overlook the new possibilities of fast access to vital patient data through sharable and secure electronic healthcare records (EHCR’s), the increasing use of telemedicine services, such as teleconsultation and emergency telemedicine, and the advancement in medical imaging.

In the case of cost containment, it is difficult to argue on a large scale since the telematics expenditure in healthcare and its cost effectiveness have not been properly monitored. There are many examples of hospital information systems that, with the combination of administrative and clinical data, provide managers with vital information leading to significant savings. For example, it has been shown that the use of electronic patient records in countries like the United Kingdom [2] and The Netherlands saves time and money for doctors as well as for healthcare authorities by receiving and processing data electronically. If the cost-reduction argument is substantiated on a large scale, it will be one of the strongest factors, together with the end-user acceptance, for the large deployment of telematics applications.

The healthcare telematics industry is on the rise mostly in the developed world. While the overall percentage of the healthcare budget spent on information and telecommunications technologies in Europe is relatively low in healthcare (approximately $400/employee compared to other sectors, such as manufacturing—$1500/employee—or finance—$5000/employee [3]), it is expected to grow due to the new policies and strategies of Member States or to the structural funds provided to some Member States for computerization of healthcare. In the United States, it is estimated that the growth of information technologies expenditure in the health sector will reach 15–20% per year [4].

The health telematics applications and services are the enabling mechanism for the continuity of care through all stages of care delivery, namely, prevention, diagnoses, treatment, and rehabilitation, as well as continuity across all points of care, such as hospitals, primary care centers, rehabilitation centers, laboratories, pharmacies, homes, etc., center around the patient. This patient-centered care is a result of a growing trend for more effective management, a need for collaborative work of health professionals (shared care), and a greater involvement of patients or citizens in receiving information, decision making, and responsibility for their own health. The continuity of care scenario is supported by the European Union (EU) through its research and development (R&D) program in health telematics.

In Section II, we briefly present the EU’s past and present activities and R&D programs in the area of health telematics. In Section III, we outline the major difficulties toward the wider implementation and acceptance of health telematics applications and services. In Section IV, an overview of the
papers published in this Special Issue is given. Section V introduces the future trends and plans of the next R&D program of EU, and Section VI covers the conclusions.

II. PAST AND PRESENT R&D PROGRAMS OF THE EU

The potential of the health telematics industry was realized by the European community as early as 1985 when it launched a combined effort to formulate a mid- to long-term strategy for Europe in the application of information and communication technologies to healthcare and biotechnology. This was done in the form of a planning exercise called Bio-Informatics Collaborative European Programme and Strategy (BICEPS-EUROAIM)(JL). An Exploratory Action was adopted by the Council of Ministers on November 4, 1988, with a community contribution of 20 million ECU (MECU).

The Exploratory Action was followed in July 1991 by the Program, Advance Informatics in Medicine (AIM), with community contribution of 111 MECU. This program has seen a move from prototype development to commercial product creation. One fundamental objective of AIM was to facilitate the convergence by concentrating not only on medico-technical problems, but also on the development of a common conceptual framework and “nontechnological” factors. The emphasis from 1991 to 1994 was on building prototypes and pilot applications. It required testing for acceptance by the users and demonstration of compliance with regulations and standards.

The political environment was very important during that period. From 1991 to 1994, several new political documents reinforced the implementation of the objectives of the program. The Maastricht Treaty, enlarging the program’s mandate from contribution to competitiveness of industry to contributing in addition to “other Commission policies,” for the first time allowed emphasis to be placed on the health content. The White Paper on Growth, Competitiveness, and Employment created the climate for the transition between the third and the fourth framework.

Presently, we are approaching the end of the Fourth Framework Programme of Research Technological Development and Demonstrations (1994–1998). Telematics Applications Programme (TAP) is one of the larger programs (902 MECU), with the objective to further promote the competitiveness of the European industry and the efficiency of services of public interest. One of the sectors of TAP is the Telematics Applications for Health (146 MECU). The main aim of the Telematics Applications for Health is to enable the entire health sector to benefit from access to telematics applications and services.

Approximately 130 R&D projects in healthcare telematics are currently financed by the European Commission. The research areas covered include EHCR, health cards, telematics applications for collaborative work for medical professionals, telemedicine, information services for citizens, and support issues, such as standardization, education, legal issues, and technology assessment [5]. A brief description of the projects is available at the website [6]. More than 1300 research establishments, hospitals, professional associations, industrialists, or European health authorities are supported, and more than 7000 EU citizens are directly connected with healthcare telematics.

Numerous representatives in the central and eastern European countries, or countries with which the EU has signed scientific and technical assistance agreements (Canada, Australia, Israel, Cyprus, etc.), also take part.

Some of the examples of products and services that are being developed in these projects include multimedia patient records, in which patient data can be retrieved seemingly and securely from different places, interoperable health cards in a multilingual environment, multimedia quality assurance systems for cancer diagnosis and treatment, reference medical image databases, regional healthcare networks using standardized electronic data interchange (EDI) communication, 24-h multilingual emergency telemedicine services for ships and remote areas, multimedia interactive information systems for community pharmacies to support responsible self-medication, multimedia citizen advisory services for healthcare, multimedia training material and courses for health professionals, and many more.

III. MAJOR CHALLENGES TOWARDS WIDER IMPLEMENTATION OF HEALTH TELMATIC APPLICATIONS AND SERVICES

Despite the many years of R&D, we cannot say that health telematics applications and services are widely used. A good example is the use of EHCR’s in countries like the United Kingdom, where 95% of the general practitioners use a computer in their practice and a large proportion of those are “paperless offices.” In Denmark, Germany, Sweden, and The Netherlands, the corresponding percentages are over 70% [7]. In hospitals, the most common information systems in use are the administrative hospital information systems. Not many hospitals in the world have information systems that integrate both clinical and administrative patient information and are accessible by all specialists and other health professionals. Also, most of the telemedicine services are still in the pilot phase and usually supported by some research grants. There are many challenges on the road to large implementation of telematics applications and services. These challenges can be either related to technological issues or to nontechnological issues relating to legal framework, market, vision of decision makers, and user acceptance issues.

Among the technological challenges, we could mention the problems of integration of heterogeneous systems to allow secure and fast communication of patient information that is located in different places (distributed patient record), the problems of standardized communications protocols for emergency telemedicine, pattern recognition for automatic analysis of medical images, standardization of the smart card technology to enable the use of health cards across borders, and the user friendliness of technologies to ensure accessibility and high-quality interaction for all potential groups of users.

Among the nontechnological challenges to implementation, it is important to mention the need for a clear legal framework and requirements on the confidentiality of personal data. The European Council and Parliament adopted on October 24, 1995, a directive on the processing of personal data and free movement of such data (95/46/EC), which needs to be implemented by appropriate national regulations in all Member States by October 24, 1998. Another challenge is the
problem of market fragmentation in Europe. The different legal requirements, language, and specificity of work processes of each country or region lead to a high cost for development and customization.

Among the market issues, we can mention the willingness of the industry to invest in good quality products that are based on user requirements. In general, the healthcare market is seen by the industry as large in size but not highly profitable, mainly due to lack of standards and high cost of customization. The situation is very fragmented in Europe. For example, most of the countries have a few dozen providers of mostly electronic medical records, which have few installations that cannot communicate and difficulties in exporting products, mainly due to the lack of standards and very different legal requirements mentioned above. Special industrial activities to tackle these problems are supported by the European Commission in the current R&D program.

Another important issue is the lack of vision and leadership of the healthcare managers and health authorities as well as the lack of willingness to reengineer the healthcare processes for the benefits of the quality and efficiency of care delivery. More than half of the Member States have recently adopted strategic plans for using the telematics networks in restructuring the care delivery to support the so-called shared care (managed care) plans for using the telematics networks in restructuring the care delivery. More

A. Electronic Healthcare Records

The EHCR is defined as digitally stored healthcare information about an individual’s lifetime with the purpose of supporting continuity of care, education, and research, as well as ensuring confidentiality at all times. The EHCR is not a goal in itself, but a tool for supporting the continuity of care and consequently the quality, access, and efficiency of healthcare delivery. In other words, the enabling factor of the patient-centered shared care is the availability of both clinical and administrative patient data through EHCR’s that are accessible, secure, and highly usable in the European multilingual environment.

As we mentioned in Section III, there are many technological and nontechnological issues related to the development and implementation of EHCR’s. Concerning the technology, the concept of “virtual” or distributed EHCR with data available at the point of origin has only been possible in recent years, thanks to the new technologies of distributed databases and the new communication possibilities (e.g., Intranet and Internet technologies). Some standards and prestandards concerning the architecture and exchange format (e.g., CORBA) are appearing and being discussed within standardization bodies, such as CEN TC 251 in Europe and ANSI-HISB in the United States. The work relating to the possibility of interfacing many different administrative and clinical systems to share records consistently, comprehensively, and securely, including the work on standardization of vocabulary, to ensure the same meaning of the content to all users is addressed in the papers in this Special Issue.

The paper by Hasman et al. introduces a new method in the development of the electronic medical record system, based on a combination of a scientific approach and prototyping. Their methodology is motivated by the fact that the underlying process of how physicians or nurses search for information is not completely understood. In more detail, prototyping offers a satisfactory way to obtain insight into the user’s wishes. However, when the underlying processes are not clear, usually more than one solution may be proposed. Therefore, the prototype should incorporate these possible solutions as well as monitor the use of the system. The adequateness of the various solutions should be tested in a scientific way, emphasizing the need for a good design study. In this study, a significant number of physicians or nurses should be actively participating, making the conclusions derived from the experiment generally applicable. Their methodology is documented with two examples. One concerns the determination of the optimum granularity of the narrative parts of the EHCR and the other concerns the use and impact of stand-alone protocol systems.
The paper by Grimson et al. reports the findings of the Synapses project, which addresses the problem of sharing EHR’s. The Synapses project provides the specifications of the Synapses Common Object Models (SynOM), together with its associated dictionary, the SynOD, and of the Synapses server and its interfaces. These specifications are currently evaluated in a variety of geographical settings and clinical domains using different technology solutions. CORBA is used as the underlying communications technology at two of the five main sites, Amsterdam Medical Centre, The Netherlands, and St. James’ Hospital, Dublin, Ireland. These two sites are investigated for two distinct, different records in the case of intensive care and diabetic chronic disease. The prototypes built using CORBA appear to be satisfactory, with most responses being delivered to the client within 3 s. The next phase envisioned is to apply the system in a real clinical environment.

The paper by Malamateniou et al. describes a workflow authorization system with the objective to enhance the security features of a virtual patient record implemented in an Intranet environment. It is shown that workflow information can be used to increase the confidentiality and availability of information. The proposed system is intended to be used in conjunction with the local and Intranet security systems and uses workflow specifications to dynamically control authorization as a workflow process proceeds. An implementation of the system in Java is currently under investigation.

B. Clinical Information Systems

Three papers in this Special Issue relate to clinical information systems by reporting on a unified framework offering semantic integration of clinical information in patient records, formal representations based on description logics for representing medical terminologies, and on a logic engineering approach for clinical decision support and disease management.

A unified framework to guide harmonization of semantic integration of clinical information in patient records is presented in the paper by Mori and Consorti. Their work is based on recent work on healthcare semantics within the European Committee for Standardization (CEN/TC251/WGII) and the EU project GALEN-IN-USE. They propose a harmonized system of handling clinical information from a semantic point of view based on the following four components:

1) documentation context (header of either messages or documents, including a structured description of kind of document, topic, who prepared it, who should receive it, their organizations, dates of preparation, revision, communication, and encoding format);
2) safety context;
3) containers (handling of sections and subsections, record items, and data elements);
4) content (coding systems, vocabularies, and collections of phrases).

Formal representations based on description logics or closely related formalisms are increasingly used for representing medical terminologies. The paper presented by Rector et al. describes the following four contentions derived within the GALEN project in developing large-scale ontologies:

1) natural language generation is essential for making a description logic-based ontology accessible to users;
2) description logic ontology should be treated as an “assembly” language and accessed via intermediate representation oriented to users and “perspectives” adapting them to specific applications;
3) independence and reuse are best supported by partitioning the hierarchy of elementary concepts into orthogonal taxonomies;
4) description logic must include support for transitive relations irrespective of the computational cost.

A unified logic engineering approach for clinical decision support and disease management incorporating the work of numerous EU projects (LEMMMA, DILEMMA, CREW, PROMPT, and MACRO) are presented in the paper by Fox and Thomson. A sound theoretical basis for the logic engineering approach for these tasks was shown, which led to the development of the PROforma representation language. This language allows the defining of clinical guidelines and is accompanied by an associate suite of software tools for delivering decision support and disease management functions at the point of care.

C. Collaborative Technologies in Healthcare Delivery

Telematics applications for collaborative work of health professionals are designed to promote national and international collaboration in the health sector to improve prevention, diagnosis, and treatment of disease, thus enabling the best medical practice irrespective of location [5], [9]. The technologies enabling collaborative work include PSTN, ISDN, ATM, VSAT, and GSM. In this section, four papers are presented that represent EU projects covering the topics of teleradiology, image-guided surgery, emergency telematics in the maritime sector, and emergency healthcare for mobile healthcare providers.

The paper by Gómez et al. introduces a new broadened multimedia telemedicine system based on ATM and DICOM 3.0 supporting the following four telemedicine scenarios that were identified in the BONAPARTE project after an indepth requirements analysis:

1) advanced teleradiology;
2) real-time medical imaging cooperative diagnosis;
3) telepresence in a clinical session;
4) remote access to long-term archive medical images.

The system has been installed in three Spanish hospitals since November 1997 and is used on average in one to two sessions per week. A detailed cost-benefit analysis of the system is currently in progress.

The paper by Breeuwer et al. summarizes the achievements of the European Applications for Surgical Interventions (EASI) project since the beginning of 1996. More specifically, in the area of neurosurgery, tools have been developed for accurate planning and intraoperative guidance of craniotomies, frameless biopsy, shunt catheter placement, and endoscopic procedures. Also, in the field of image-guided surgery, tools have been developed for accurate planning of the dimensions
and location for endoprothesis placement. Intraoperative localization (based on matching intraoperative x-ray to preoperative CT) was realized with an accuracy of circa 1 mm in the directions parallel to the plane of the x-ray projection and circa 5–10 mm in the perpendicular direction. Although this result was encouraging, it is less accurate than the 1 mm required by surgeons.

The next two papers focus on emergency telematics. The paper by Anogianakis et al. describes the findings and the system developed under the MERMAID health telematics project. In a survey carried out in the context of this project, it was documented that the number of marine telemedical calls is estimated to be between 15,000 and 20,000 per year worldwide. In general, the incidents reported are restricted to either sudden illness (37%) or accidents (63%). Nine out of the ten cases reported as “sudden illness” are in fact “neglected” cases that suddenly deteriorated. MERMAID attempts to combine mobile satellite technologies, VSAT technologies, and ISDN protocols to realize a 24-h global system for the provision of healthcare services to the maritime sector. Emphasis was given so that the technologies chosen guarantee reliability, continuity, seamless connectivity, ease of upgrading, and implementation at the lowest possible cost.

An emergency telemedicine system based on wireless communication technology developed under the project AMBULANCE is described by Pavlopoulos et al. A portable medical device was developed that allows telediagnosis, long distance support, and teleconsultation of mobile healthcare providers by expert physicians. The device allows the transmission of vital biosignals and still images of the patient from the emergency site to the consultation site using the GSM mobile telephony network. The system allows the expert physician to monitor patient data and issue directions to the emergency personnel on treatment procedures. The system has been successfully demonstrated in four European pilot sites.

D. Virtual Reality Applications in Medicine

New and innovative technologies are investigated for the development of new applications and services that should be as follows:

1) more mobile, accessible, usable, and portable;
2) more integrated and interoperable;
3) more user friendly [5].

In this Special Issue, three papers are reporting on augmented reality for diagnostic tasks and on virtual reality for neuroscience and three-dimensional (3-D) visualization of vascular images.

Berlage presents the CardiAssist project, in which a teleconsultation module has been implemented that uses ultrasound images linked to virtual heart models, thus providing an enabling system to support the communication. Such an enabling system provides orientation in complex tasks, but it also serves as a rich reference scenario in teleconsultation, accelerating the communication between healthcare professionals of different backgrounds.

The paper by Riva highlights recent and ongoing research related to applications of virtual environment and related technologies in the neuroscience area. The paper focuses on the European initiatives in this field, and it provides a general introduction to virtual reality, especially as it relates to its impact on cognitive and functional abilities.

The Virtual Vascular (ViVa) project is presented by Abdoulaev et al. The paper presents the efforts aimed at developing tools for the modern hemodynamicist and cardiovascular surgeon to assist him/her in the interpretation of noninvasive 3-D imaging. In particular, the system developed is able to process and visualize 3-D medical data, reconstruct the geometry of arteries of specific patients, and simulate blood flow in them.

E. Healthcare Education

The use of information technologies and the results of EU projects provide a framework, allowing the development of new tools for the education of healthcare professionals [5]. The target here is to train the 800,000 physicians and 1,600,000 nurses practising in Europe.

A computer-based simulation system enabling the demonstration and study of complex systems developed under the Courseware Authoring for Scientific Training (COAST) project is reported by Diomidous et al. A prototype was developed for the investigation of the major epidemiological factors for the transmission of the AIDS virus. The benefits of simulation-based experimenting related to the understanding of complex systems and the cost effectiveness of this technology are presented.

V. Future Trends and Plans

The fast penetration of information technology to all sectors of the society will continue, as indicated by the “Eurobarometer Survey ’97—Measuring Information Society,” which has shown that 28.3% of EU citizens use PC’s in their homes and 42.3% in their offices, 43.4% are interested in telemedicine, 14.9% are willing to pay for it, and Internet penetration has reached 25% of the population of some Member States. The expenditure on telematics, presently at a level of 1% on average in Europe of the total health expenditure, is growing at a rate of 15%, which is double the rate of investment on telematics in other sectors. Therefore, the health telematics industry is on the rise, bringing new opportunities for European industry.

The Internet, new generation of mobile services, and cards will all find strong application in the healthcare arena. The emphasis will be given in future R&D on accessibility and user friendliness of telematics applications by applying the theories and technologies of HCI [8].

The new paradigm of citizen-centered shared care is gaining ground in many of the Member States (see Fig. 1). It builds on health telematics networks and services, linking hospitals, laboratories, pharmacies, and primary care and social centers offering individuals a “virtual healthcare center” with a single point of entry. The information shared by all care providers is patient health-related information (EHCR’s) that is comprehensible, reliable, and confidential. These networks will vary in capacity and security features all the way from optical fiber networks to simple telephony networks and Internet
communication. Special emphasis will be given to systems for personal health monitoring and prevention, including advanced sensors and Microsystems. Internet health support services to citizens offering health monitoring and prevention services, or between the health professionals for teleconsultation and collaborative work, are being set up all over the world.

This new paradigm is supported by European Commission in the new Fifth Framework Programme [10]. The new proposed program “creating user-friendly Information Society” is split into four key actions. In the first key action, “systems and services for the citizens,” the proposed activities include creation of the next generation, user-friendly, interoperable, and cost-effective services in the areas of health, stressing the importance of continuity of care and citizen-centered care.

In particular, in the field of health, the European Commission plans to focus on the continuity of care and citizen-centered care through R&D and demonstration work on health information networks and EHR’s, personal health monitoring, and health support systems, including development of new Microsystems and transducers based on nano-technology and other monitoring devices that integrate the traditional biosignals and images with the health support and information systems. Also, the traditional work on specialized medical systems, such as the advance imaging systems and virtual reality tools, will be supported. Finally, new generation telemedicine services for emergency and teleconsultation are also under consideration.

VI. CONCLUSIONS

The 14 papers included in this Special Issue represent a snapshot of EU activities in the areas of EHR’s, collaborative technologies in healthcare delivery, virtual reality applications in medicine, and healthcare education. These advanced systems contribute to forming a new basis for the practice of medicine, targeting the better delivery of healthcare. However, more work and effort are needed at both national and international levels to enable the wider application of health telematics in all areas of medicine. It is anticipated that the new Fifth Framework Programme for R&D by the EU and the program “Technologies for the 21st century” by the United States will leverage the spreading of health telematics technology for the whole healthcare sector, offering a better service to the citizen [10]–[12].

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