ARTIFICIAL INTELLIGENCE IN MEDICAL APPLICATION: AN EXPLORATION

Wan Hussain Wan Ishak, Fadzilah Siraj
School of Information Technology,
Universiti Utara Malaysia, 06010 Sintok, Kedah, MALAYSIA
Email: {hussain; fad173}@uum.edu.my

Abstract

The advancement in computer technology has encouraged the researchers to develop software for assisting doctors in making decision without consulting the specialists directly. The software development exploits the potential of human intelligence such as reasoning, making decision, learning (by experiencing) and many others. Artificial intelligence is not a new concept, yet it has been accepted as a new technology in computer science. It has been applied in many areas such as education, business, medical and manufacturing. This paper explores the potential of artificial intelligence techniques particularly for web-based medical applications. In addition, a model for web-based medical diagnosis and prediction is proposed.

1.0 Introduction

In most developing countries insufficient of medical specialist has increase the mortality of patients suffered from various diseases. The insufficient of medical specialists will never be overcome within a short period of time. The institutions of higher learning could however, take an immediate action to produce as many doctors as possible. However, while waiting for students to become doctors and the doctors to become specialists, many patients may already die. Current practice for medical treatment required patients to consult specialist for further diagnosis and treatment. Other medical practitioner may not have enough expertise or experience to deal with certain high-risk diseases. However, the waiting time for treatments normally takes a few days, weeks or even months. By the time the patients see the specialist, the diseases may have already spread out. As most of the high-risk disease could only be cured at the early stage, the patients may have to suffer for the rest of their life.

Computer technology could be used to reduce the number of mortality and reduce the waiting time to see the specialist. Computer program or software developed by emulating human intelligence could be used to assist the doctors in making decision without consulting the specialists directly. The software was not meant to replace the specialist or doctor, yet it was developed to assist general practitioner and specialist in diagnosing and predicting patient's condition from certain rules or "experience". Patient with high-risk factors or symptoms or predicted to be highly effected with certain diseases or illness, could be short listed to see the specialist for further treatment. Employing the technology especially Artificial Intelligence (AI) techniques in medical applications could reduced the cost, time, human expertise and medical error.

Computer program known as Medical Decision-Support System was designed to help health professionals make clinical decision (*see* Shortliffe, 1987). The system deals with medical data and knowledge domain in diagnosing patients conditions as well as recommending suitable treatments for the particular patients. Patient-Centred Health Information Systems is a patient centered medical information system developed to assist monitoring, managing and interpret patient's medical history (Szolovits et al., 1994). In addition the system provides assistance to patient and medical practitioner. The system serves to improve the quality of medical decision-making, increases patient compliance and minimizes iatrogenic disease and medical errors.

Computer technology also helps reducing the cost and time during registration process. Hospital attendance could simply key in patient's ID and update patient's record. Signal are sent to notify the doctor. While diagnosing the patient, doctor can refer to patient's history record for a history treatment. A prescription of medicine can automatically sent to the dispensary. Using the technology, problems in preparing the medicine and drug complication can be avoided (Mohd Rais and Zahari, 1988).

The advancement in computer technology and communication encourages health-care provider to provide health-care over the Internet or telemedicine (Shortliffe, 1998). Telemedicine is the integration of telecommunications technologies, information technologies, human-machine interface technology and medical care technologies for the purpose of enhancing health care delivery across space and time (Warner, 1997). Rusovick and Warner (1997) define telemedicine as any instance of medical care occurring via the Internet and using real-time video-teleconferencing equipment as well as more specialized medical diagnostic equipment. In general, telemedicine means the use of computer and communications technologies to augment the delivery of health-care services (Chellappa, 1995). Telemedicine can improve access to care, increase health-care quality and reduce the cost (Warner, 1997). Patients from rural areas can access to the same quality of health-care as those in big city. As an example patients suffered from heart-attack do not have to consult cardiologist directly. Local doctors or medical practitioners could perform the diagnosis with the help from cardiologist using communication channel such as Internet, telephone line and others. The approach reduces the cost and time for both patients and doctors.

The benefits of the electronic records would be many, namely enhance traditional records, fast storage and retrieval, promote telemedicine and encourage research in medical applications. As many applications are geared toward web-based, this paper proposed a model for web-based medical diagnosis and prediction, specifically for medical practitioners. Several artificial intelligence techniques for diagnosis and prediction tasks were explored and identified.

2.0 Artificial Intelligence in Medicine

Artificial Intelligence (AI) is a study to emulate human intelligence into computer technology. The potential of AI in medicine has been expressed by a number of researchers. Hoong (1988) summarized the potential of AI techniques in medicine as follows:

- Provides a laboratory for the examination, organization, representation and cataloguing of medical knowledge.
- Produces new tools to support medical decision-making, training and research.
- Integrates activities in medical, computer, cognitive and other sciences.
- Offers a content-rich discipline for future scientific medical specialty.

Many intelligent system have been developed for the purpose of enhancing health-care and provide a better health care facilities, reduce cost and etc. As express by many studies (such as Mahabala *et al.*, 1992; Manickam and Abidi, 1999; Alexopoulos *et al.*, 1999; Zelic *et al.*, 1999; Ruseckaite, 1999; Bourlas *et al.*, 1999), intelligent system was developed to assist users (particularly doctors and patients) and provide early diagnosis and prediction to prevent serious illness. Even though the system is equipped with "human" knowledge, the system will never replace human expertise as human are required to frequently monitor and update the system's knowledge. Therefore, the role of medical specialist and doctors (or medical practictioner) are important to ensure system validity.

Early studies in intelligent medical system such as MYCIN, CASNET, PIP and Internist-I have shown to out performs manual practice of diagnosis in several disease domain (Shortliffe, 1987). MYCIN was developed in the early 1970s to diagnose certain antimicrobial infections and recommends drug treatment. It has several facilities such as explanation facilities, knowledge acquisition facilities, teaching facilities and system-building facilities. CASNET (Causal ASsociational NETworks) was developed in early 1960s is a general tool for building expert system for the diagnosis and treatment of diseases. CASNET major application was the diagnosis and recommendation of treatment for glaucoma. PIP an abbreviation for Present Illness Program was developed in 1970s to simulates the behaviour of an expert nephrologist in taking the history of the present illness of a patient with underlying renal disease. The work on Internist-I in early 1982s was concentrated on the investigation of heuristic methods for imposing differential diagnostic task structures on clinical decision making. It was applied in diagnoses of internal medicine.

In 1990s, the studies in intelligent system was enhanced to utilize the system based on current needs. In several studies two or more techniques were combined and utilized the function of the system to ensure system performance. ICHT (An Intelligent Referral System for Primary Child Health Care) developed to reduce children mortality especially in rural areas (Mahabala *et al.*, 1992). The system success in catering common paediatric complaints, taking into consideration the important risk factors such as weight monitoring, immunization, development milestones and nutrition. ICHT utilized expert system in the process of taking the history data from patients. Other expert system have been developed such as HERMES (HEpathology Rule-based Medical Expert System) an expert system for prognosis of chronic liver diseases (Bonfa *et al.,* 1993), Neo-Dat an expert system for clinical trails (Theodorou and Ketikidis, 1995), SETH an expert system for the management on acute drug poisoning (Droy *et al.,* 1993), PROVANES a hybrid expert system for critical patients in Anesthesiology (Passold *et al.,* 1996) and ISS (Interactive STD Station) for diagnosis of sexually transmitted diseases (Walker and Kwon, 1997).

Experienced Based Medical Diagnostics System an interactive medical diagnostic system is accessible through the Internet (Manickam and Abidi, 1999). Case Based Reasoning (CBR) was employed to utilize the specific knowledge of previously experienced and concrete problem or cases. The system can be used by patients to diagnose themselves without having to make frequent visit to doctors and as well as medical practitioner to extend their knowledge in domain cases (breast cancer).

Data mining is an AI technique for discovery of knowledge in large databases, could be used to collect hidden information for medical purposes (Siti Nurul Huda and Miswan, 1999; Siti Fatimah and Rogayah, 1999; Neves *et al.,* 1999). It could also be combined with neural network for classification of fuzzy pattern of HIV and AIDS using unsupervised learning (Siti Nurul Huda and Miswan, 1999). Patients status life or dead was classified as training and testing pattern. Data mining was also used to generate a scatter diagram and a model of rules statement to enhance current rule base system (Siti Fatimah and Rogayah, 1999). Neves *et al* (1999) developed information system that supports knowledge discovery and mining in medical imaging.

Fuzzy logic is another branch of artificial intelligence techniques. It deals with uncertainty in knowledge that simulates human reasoning in incomplete or fuzzy data. Meng (1996) applied fuzzy relational inference in medical diagnosis. It was used within the medical knowledge-based system, which is referred to as Clinaid. It deals with diagnostic activity, treatment recommendations and patient's administration.

Neural Network (NN) is one of the powerful AI techniques that has the capability to learn a set of data and constructs weight matrixes to represent the learning patterns. NN is a network of many simple processors or units (Sarle, 1999). It simulates the function of human brain to

performs tasks as human does. As an example, a study on approximation and classification in medicine with incremental neural network shows superior generalization performance compared with other classification models (Jankowski, 1999). NN has been employed in various medical applications such as coronary artery (Lippmann, 1995), Myocardial Infarction (Heden *et al.*,1996), cancer (Street *et al.,* 1996; Karkanis *et al.,* 1999), pneumonia (Caruana *et al.,* 1996) and brain disorders (Pranckeviciene, 1999). In Karkanis *et al* (1999) NN was implemented as a hybrid with textual description method to detect abnormalities within the same images with high accuracy.

Partridge *et al* (1996) listed several potential of NN over conventional computation and manual analysis:

- Implementation using data instead of possibly ill defined rules.
- Noise and novel situations are handled automatically via data generalization.
- Predictability of future indicator values based on past data and trend recognition.
- Automated real-time analysis and diagnosis.
- Enables rapid identification and classification of input data.
- Eliminates error associated with human fatigue and habituation.

3.0 Centralized Databases and WWW

To date, most of the systems developed were standalone applications with specific databases for certain diseases. This implies that patients information in one system can only be used by that particular system. On the other hand, other systems require another databases for other patients or for the same patients whose records were kept in other databases. Another problem with standalone database is that, the database for the same system in another places would differ as the number of patients using the systems increases. This problem affects the knowledge acquired from the databases and thus influence the decision made by the system. For system using AI techniques, when the number of patients is high the system will produce more accurate results compared to the system with less number of patients. The patients records are valuable information for the knowledge-based system. The current patients data would enhance and strengthen the validity of the system reasoning (Manickam and Abidi, 1999).

Current enhancements in information technology such as development of information superhighway inevitably encourage many organizations including government to develop electronic medical information and make it available on the Internet. The patients can use the information and monitor their risk level from their home or office without having to consult the physician (Manickam and Abidi, 1999). However, the proposed model do not meant for the patients to monitor their health, rather to assist clinician in making diagnosis and prediction of patients illness. This will enable the clinician to access the system and provide the consultation as expert does regardless of the location. Patients record or patients database could be installed at the main server. The electronic record could be accessed by health-care providers and the data could be stored and updated frequently. By using this method, the system knowledge will always be updated. The interface for the interactions between the database (and the system) and the clinician (health-care providers) would be through WWW.

The Internet supports two-ways communications between users around the world at minimum cost (*see* **Figure 1**). In medical, communication is very important as new information or new discovery is the key for the future survival (*see for example* Shortliffe *et al.,* 2000). In addition, communications helps doctors sharing their knowledge or expertise (Detmer and Shortliffe, 1997). As an example, a specialist from Sydney can provide on-line medical assistance to doctor at Kuala Lumpur who is treating a patient that suffers from serious cancer problem. Another doctor from other country such as United Kingdom can share his

experience dealing with the same cases. Communications between doctors or specialist from other region helps doctor at Kuala Lumpur diagnosing his patient and provides appropriate treatment. In telemedicine, Multimedia and Internet (or computer network) are two of the main tools that support the collaboration and distribution of information. Multimedia is a combination of media such as text, audio, visual and graphics can be used in medical application such as in image transmission (X-Ray images, pictures and etc.).

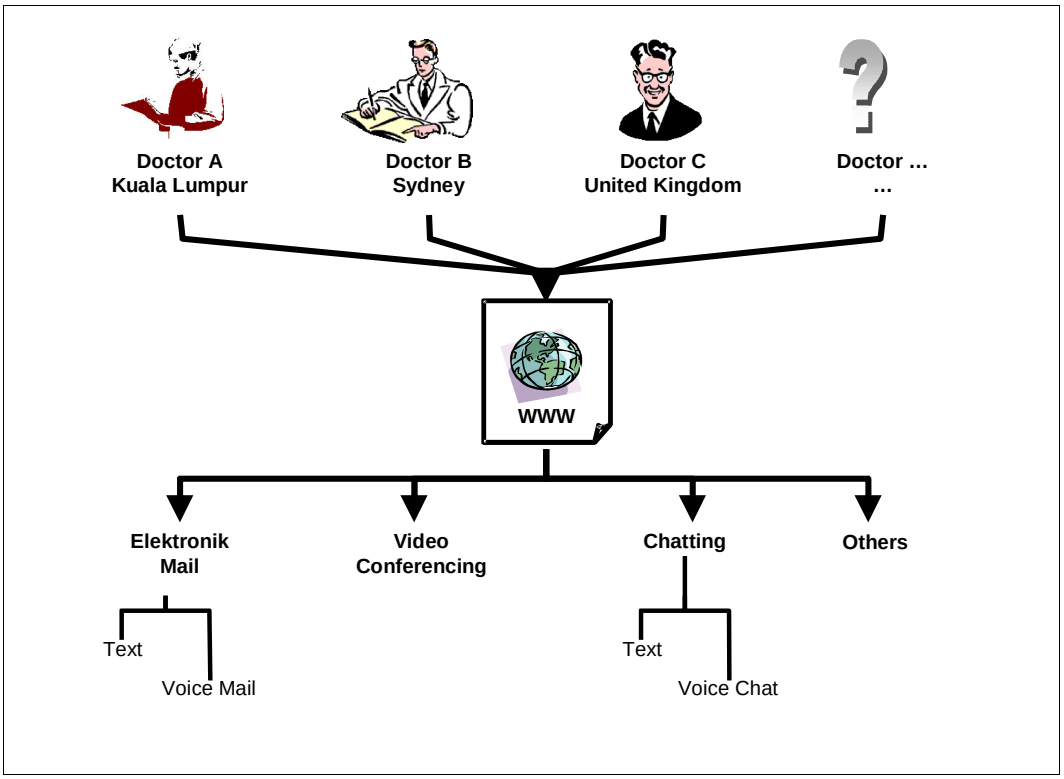

Figure 1: Information Sharing

4.0 Web-Based Medical Diagnosis and Prediction

The proposed model for Web-Based medical diagnosis and prediction (see **Figure 2**) consists of four components, they are databases, prediction module, diagnosis module and user interface. The databases consist of patients database and patients-disease database. Patients database will be used to store patient's information such as name, addresses, and others particulars details. Patients-disease database stored all the information about patients and their illness. The information stored in the database includes types of diseases, the treatments and other details about the test and administering therapy. Patients information are separated in a different database to enhance the patients records storage, so that other departments could use the records when the patients are referred to them. This method could prevent other departments or unauthorized users from accessing the information about patients diseases and provide a centralized information access for the patients records.

Prediction module and diagnosis module are two of the main features in Web-Based Medical Diagnosis and Prediction. Prediction module utilizes neural networks techniques to predict patients illness or conditions based on the previous similar cases. Data from the patients and patients-disease database will be used for training and testing. The weight from the training will be stored to predict a new data fed into the system. Diagnosis module consists of expert

system and fuzzy logic techniques to perform diagnosis tasks. A set of rules will be defined using the patients and patients-disease databases as well as the expert knowledge on the disease domain. Expert system uses the rules to diagnose patient's illness based on their current conditions or symptoms. In addition, fuzzy logic is integrated to enhance the reasoning when dealing with fuzzy data. The combination of expert system and fuzzy logic that forms a hybrid (expert-fuzzy) system could increase the system performance.

In the proposed model, WWW acts as the user interface for the interaction between the users and the systems. Several processes involve in the models are collection data (patients information and patients illness), diagnosis, prediction and managing databases or systems administering.

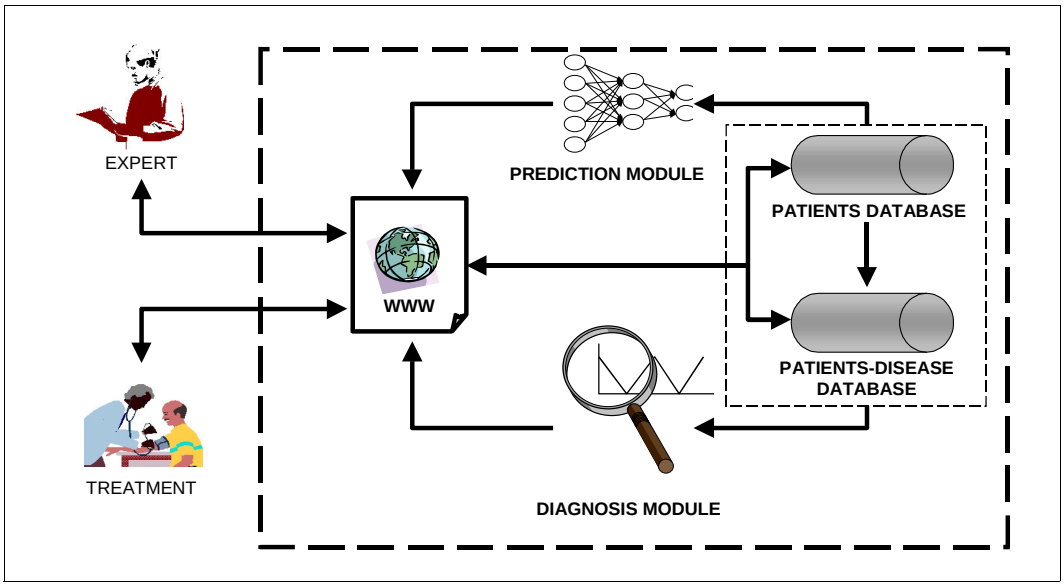

Figure 2: A model for Web-Based Medical Diagnosis and Prediction

5.0 Conclusion

The future for medicine will be better and better (Altman, 1999). The used of computer and communication tools can change the medical practice into a better implementation. Consolidation in health-care provider will happen by focusing on cost and later on quality of services (Chellappa, 1995). Advancement in technology will form a platform for development a better design of telemedicine application. Telephone line and Internet will be the most important tools in medical applications.

The main features in medical diagnosis and prediction using artificial intelligence techniques will make the consultation to be more interactive. As clinical decision making inherently requires reasoning under uncertainty, expert systems (Shortliffe, 1987) and fuzzy logic (Meng, 1996) will be suitable techniques for dealing with partial evidence and with uncertainty regarding the effects of proposed interventions. For the prediction tasks, Neural Networks have been proven to produce better results compared to other techniques (such as statistics) (Partridge et al., 1996; Machado, 1996). Such techniques are worth to explore and integrate in the system for medical diagnosis and prediction. The Internet or the WWW will be used as the medium to provide the tele-healthcare to the clinician or to the public.

Centralized databases over the WWW have many advantages. Information sharing, collaboration between medical practitioners, on-line discussion, on-line treatment and

diagnosis are among the main features which enable the doctors from around the world to share their knowledge and expertise. Centralized medical record helps doctors to improve the quality of treatment and provide a better diagnosis based on patients medical history. In addition, researchers in medical applications could use the data in their investigation of a new medical solution, patient's management and treatment (Shortliffe *et al.*, 1996a; Shortliffe *et al.*, 1996b).

References

Alexopoulos, E., Dounias, G. D., and Vemmos, K. (1999). Medical Diagnosis of Stroke Using Inductive Machine Learning. *Machine Learning and Applications: Machine Learning in Medical Applications*. Chania, Greece, pp. 20-23.

Altman, R. B. (1999). AI in Medicine: The Spectrum of Challenges from Managed Care to Molecular Medicine. *AI Magazine*, Vol. 20, No. 3, pp. 67 - 77.

Bonfa, I., Maioli, C., Sarti, F., Milandri, G. L., and Monte, P. R. D. (1993). HERMES: An Expert System for the Prognosis of Hepatic Diseases. *Technical Report UBLCS-93-19*, Universiti of Bologna.

Bourlas, P., Giakoumakis, E., and Papakonstantinou, G. (1999). A Knowledge Acquisition and management System for ECG Diagnosis. *Machine Learning and Applications: Machine Learning in Medical Applications*. Chania, Greece, pp. 27-29.

Caruana, R., Baluja, S., and Mitchell, T. (1996). Using the Future to "Sort Out" the Present: Rankrop and Multitask Learning for Medical Risk Evaluation. *Advances in Neural Information Processing Systems 8*, The MIT Press, Cambridge, pp. 959-965.

Chellappa, M. (1995). Telemedic-Care. *NCIT'95: 8'th National Conference Information Technology'95 (16-18 August 1995)*. Gabungan Komputer Nasional Malaysia.

Detmer, W. M. and Shortliffe, E. H. (1997). Using the Internet to Improve Knowledge Diffusion in Medicine. *Communications of the Associations of Computing Machinery*, Vol. 40, No. 8, pp. 101 - 108.

Droy, J. M., Darmoni, S. J., Massari, P., Blanc, T., Moritz, F., and Leroy, J. (1993). SETH: An Expert System for the Management on Acute Drug Poisoning. http://www.chu-rousen.fr/dsii/publi/seth.htm

Heden, B., Ohlsson, M., Rittner, R., Pahlm, O., Haisty, W. K., Peterson, C., and Edenbrandt, L. (1996). Agreement Between Artificial Neural Networks and Human Expert for the Electrocardiographic Diagnosis of Healed Myocardial Infarction. *Journal of the American College of Cardiology*, Vol. 28, pp. 1012-10s16.

Hoong, N. K. (1988). Medical Information Science - Framework and Potential. *International Seminar and Exhibition Computerization for Development-the Research Challenge*, Universiti Pertanian Malaysia: Kuala Lumpur, pp. 191 - 198.

Jankowski, N. (1999). Approximation and Classification in Medicine with IncNet Neural Networks. *Machine Learning and Applications: Machine Learning in Medical Applications*. Chania, Greece, pp. 53-58.

Jorand, M. I., and Bishop, C. M. (1996). Neural Networks. *Technical Report No. A. I. Memo No. 1562*, Artificial Intelligence Laboratory: Massachusetts.

Karkanis, S. A., Magoulas, G. D., Grigoriadou, M., and Schurr, M. (1999). Detecting Abnormalities in Colonoscopic Images by Textual Description and Neural Networks. *Machine Learning and Applications: Machine Learning in Medical Applications*. Chania, Greece, pp. 59-62.

Lippmann, R. P., Kulkolich, L., Shahian, D. (1995). Predicting the Risk of Complications in Coronary Artery Bypass Operations Using Neural Networks. *Advances in Neural Information Processing Systems 7*, The MIT Press, Cambridge, pp. 1053-1062.

Machado, L. O. (1996). Medical Applications of Artificial Neural Networks: Connectionist Model of Survival. *Ph.D Dissertation*. Stanford University.

Mahabala, H. N., Chandrasekhara, M. K., Baskar, S., Ramesh, S., and Somasundaram, M. S. (1992). ICHT: An Intelligent Referral System for Primary Child Health Care.

Proceedings SEARCC'92: XI Conference of the South East Asia Regional Computer Confederation. Kuala Lumpur.

Manickam, S., and Abidi, S. S. R. (1999). Experienced Based Medical Diagnostics System Over The World Wide Web (WWW), *Proceedings of The First National Conference on Artificial Intelligence Application In Industry*, Kuala Lumpur, pp. 47 - 56.

Meng, Y. K. (1996). Interval-Based Reasoning in Medical Diagnosis. *Proceedings of National Conference on Research and Development in Computer Science and Its Applications (REDECS'96)*, Universiti Pertanian Malaysia: Kuala Lumpur, pp. 220 - 224.

Mohd Rais Mustafa and Zahari Taha (1988). Sistem Pakar Maklumat Interaksi Ubat-Ubat. *Siri Seminar Sains Komputer II: Inovasi Komputer Di Malaysia*. Universiti Kebangsaan Malaysia.

Neves, J., Alves, V., Nelas, L., Romeu, A., and Basto, S. (1999). An Information System That Supports Knowledge Discovery and Data Mining in Medical Imaging. *Machine Learning and Applications: Machine Learning in Medical Applications*. Chania, Greece, pp. 37-42.

Partridge, D., Abidi, S. S. R., and Goh, A. (1996). Neural Network Applications in Medicine. *Proceedings of National Conference on Research and Development in Computer Science and Its Applications (REDECS'96)*, Universiti Pertanian Malaysia: Kuala Lumpur, pp. 20 - 23.

Passold, Fs., Ojeda, R. G., and Mur, J. (1996). Hybrid Expert System in Anesthesiology for Critical Patients. *In Proceedings of the 8th IEEE Mediterranean Electrotecnical Conference - MELECON'96 (ITALIA)*, Vol. III, pp. 1486-1489.

Pranckeviciene, E. (1999). Finding Similarities Between An Activity of the Different EEG's by means of a Single layer Perceptron. *Machine Learning and Applications: Machine Learning in Medical Applications*. Chania, Greece, pp. 49-52.

Ruseckaite, R. (1999). Computer Interactive System for Ascertainment of Visual Perception Disorders. *Machine Learning and Applications: Machine Learning in Medical Applications*. Chania, Greece, pp. 27-29.

Rusovick, R., and Warner, D. (1997). The Webification of Medicine: Interventional Informatics Through the WWW. http://www.pulsar.org/febweb/papers/mwww3.htm

Sarle, W. S. (1999). Neural Network FAQ, part 1 of 7: Introduction. *Periodic posting to the Usenet Newsgroup comp.ai.neural-nets*, ftp://ftp.sas.com/pub/neurl/FAQ.html

Shortliffe, E. H. (1987). Computer Programs to Support Clinical Decision Making. *Journal of the American Medical Association*, Vol. 258, No. 1.

Shortliffe, E. H. (1998). The Evalution of Health-Care Records in the Era of the Internet. http://smi-web.stanford.edu/pubs/abstracts_by_author/

Shortliffe, E. H. and Buchanan, B. G. (1975). A Model of Inexact Reasoning in Medicine. *Mathematical Biosciences*, Vol. 23, pp. 351 - 379.

Shortliffe, E. H., Barnet, G. O., Cimino, J. J., Greenes, R. A, Huff, S. M. and Patel, V. L. (1996a). Collaborative Medical Informatics Research Using the Internet and the World Wide Web. *In Cimino, J.J. (Ed.), AMIA Annual Fall Symposium*, Washington, D. C. pp. 125 - 129.

Shortliffe, E. H., Barnet, G. O., Cimino, J. J., Greenes, R. A. and Patel, V. L. (1996b). InterMed: An Internet-Based Medical Collaboratory, *Proceedings available on CD-ROM*, Montreal, Canada.

Shortliffe, E. H., Fagan, L. M. and Yu, V. L. (2000). The Infectious Diseases Physician and the Internet. *In Mandell, G.L., Bennett, J.E. and Dolin, R. (Eds.), Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases*, Churchill Livingstone, Inc., Pennsylvania, pp. 3258-3263.

Siti Fatimah Md Saad and Rogayah Ghazali (1999). Data Mining for Medical Database. *Proceedings of the First National Conference on Artificial Intelligence Application in Industry*. Kuala Lumpur, pp. 72-79.

Siti Nurul Huda Sheikh Abdulah and Miswan Surip (1999). Satu Metodologi Perlombongan Data Untuk Pesakit AIDS. *Proceedings of the First National Conference on Artificial Intelligence Application in Industry*. Kuala Lumpur, pp. 57-71.

Street, W. N., Mangasarian, O. L., and Wolberg, W. H. (1996). Individual and Collective Prognostic Prediction. *Thirteenth International Conference on Machine Learning*.

Szolovits, P., Doyle, J., Long, W. J., Kohane, I., and Pauker, S. G. (1994). Guardian Angel: Patient-Centred Health Information Systems. *Technical Report MIT/LCS/TR-604*. Massachusetts Institute of Technology.

Theodorou, T., and Ketikidis, P. (1995). Neo-Dat An Expert System to Support the Designers of Clinical Trails. *5th Hellenic Conference on Informatics*.

Walker, N. J., and Kwon, O. (1997). ISS: An Expert System for the Diagnosis of Sexually Transmitted Diseases. *11th Annual Midwest Computer Conference (MCC'97) March 21*, Springfield, Illinois.

Warner, D. (1997). Malaysian Medical Matrix: Telemedicine in the age of the Multimedia Super Coridor. http://www.pulsar.org/febweb/papers/m3web.htm

Zelic, I., Lavrac, N., Najdenov, P., Rener-Primec, Z. (1999). Impact of machine Learning of the Diagnosis and Prognosis of First Cerebral Paroxysm. *Machine Learning and Applications: Machine Learning in Medical Applications*. Chania, Greece, pp. 24-26.