Intelligent Systems for GIT Cancers Management

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Abstract: - The study discusses different types of intelligent systems that are being used in the diagnosis, treatment, and prognosis of various GIT cancer types. These intelligent systems include rule-based and case-based expert systems, artificial neural networks, genetic algorithms and machine learning, in addition to data mining techniques and statistical methods. The study aims at identifying different techniques and tools that may be used for each medical task. The results show that data mining techniques were mainly used for the diagnosis task because they rely on huge amounts of data, which may be used to discover new predisposing factor thus improving the diagnosis task. As for expert systems, they may be used in the prognosis task, since they rely on the specialist's experience. Finally, based on the study results, it is recommended to develop an Intelligent Tutoring System (ITS) that transfers the knowledge of early detection and diagnosis of GIT cancers. As a future work, it is suggested to develop an Expert System (ES) that deals with GIT cancers' treatment, to be used by medical doctors and specialists in both hospitals and healthcare institutions.

Keywords :- Intelligent Systems, GIT Cancers, Expert Systems, Decision Support Systems, Machine Learning, Artificial Neural Networks, Artificial Intelligence, Genetic Algorithms, Knowledge-based systems, Data Mining

1 Introduction

1.1 Background

Nowadays, Healthcare systems are focusing on the management of Cancer, which includes a large group of diseases that may affect different body parts and leads to the creation of abnormal cells that eventually affect other organs, causing death, because of its enormous widespread. However, based on the World Health Organization (WHO), nearly one third of the cases may be prevented and another third may be treated successfully [1]. This requires the contribution of Information Technology (IT) specialists so as to provide the decision makers with data, information, and knowledge, in order to have insights that help them in various medical tasks such as, risk factors discovery and assessment, early detection of the disease, proper diagnosis, suitable treatment, prognosis, and survival rate prediction.

Managing cancer requires huge amounts of accurate and updated clinical data. This is only made possible by using IT tools and techniques [2].

The study focuses on Gastro-Intestinal (GI) cancers, since they are the most common cancers. GIT cancer includes different types of cancer that affect the digestive system; they include "cancers of the esophagus, gallbladder, liver, pancreas, stomach, small intestine, bowel (large intestine or colon and rectum), and anus" [3].

1.2 Problem Definition

The Health care forum of 2016 declared "War on Cancer" [1]. It requires more efforts to design strategies that work on decreasing cancer burden. These strategies require assembling government and industry key persons, in addition to academic professionals to work on finding measures to fight this wide spreading disease.

To deal with different types of GIT cancer management, healthcare professionals need to have

sufficient data related to patient and disease details, and knowledge management techniques related to new algorithms. Moreover, there is a need for intelligent systems to support different medical tasks.

Although there are several types and techniques related to management of GIT cancers, there is no clear-cut definition of the most suitable type and technique based on the required task, whether it is early detection, diagnosis, treatment or prognosis.

1.3 Importance

Cancer management consumes huge amounts of funds in any country. The main cost, as per the American Cancer Society, is for treating the disease [4]. Therefore, governments are working on strategies that deal with this disease in order to reduce the costs and improve the quality of life of cancer patients.

1.4 Objectives

Based on the problem definition, the study aims at achieving the following objectives:

a-Discussing the current intelligent systems' types in the domain of GIT cancers.

b- Comparing between various techniques used to decide on the suitable technique for each medical task.

c- Finding out possible solutions to help in the knowledge discovery and transfer process related to GIT cancers' treatment.

1.5 Structure of the Paper

The paper is composed of four sections. The first section introduces the concept of Intelligent Systems and its types, such as Expert Systems, Case-based learning, Intelligent Decision Support Systems, and others, as well as GIT cancers. The second section discusses recent studies related to the domain in order to compare between various types of Intelligent Systems from an IT perspective. It then makes a comparison among them based on the medical task they are achieving from different aspects such as both the technique and tool used. Finally, results are presented and conclusions and recommendations are drawn.

2 State of the Art

2.1 Intelligent Systems

Intelligent System (IS) may be defined as "the system that incorporates intelligence into applications being handled by machines" [5]. They can achieve many tasks such as search and optimization. They can also be used for other tasks, such as diagnostic and robotic systems, because they require intelligent features.
Intelligent Systems may also be perceived as "a system that can imitate, automate some intelligent behaviors of human being" [5]. They include Expert systems, intelligent agents and knowledge-based systems. Currently, intelligent systems are considered "a discipline that studies intelligent behaviors and their implementations as well as their impacts on human society" [5].

2.2 Gastrointestinal (GIT) Cancer

The study deals with GIT cancer, since it is considered one of the most commonly diagnosed malignancies and a major cause of mortality [6]. Some of the problems related to this major health problem worldwide are poor prognosis and limited treatment options. Hence, the main focus is on preventing this serious disease in order to reduce its incidence and mortality.
Some of the predisposing factors are diet such as eating dried fish and meat and refined carbohydrates, genetic factors, infectious diseases such as H. pylori infection, in addition to alcohol consumption and smoking [7].

3 Comparison of IS Dealing with GIT Cancers

The following table shows the different types of IS used in the field of GI cancers, classified according to three tasks (Algorithm, Diagnosis, Prognosis)

Table 1. Comparison of IS According to Tasks.

Task	Type of IS	Technique Used	Tools	Results
Algorithms	Data Mining	Association rules	MATLAB	Data mining algorithm, based on ontology, led to more intuitive, appealing and understandable rules [8].
	Decision Support System	Machine Learning	N/A	"The outcome of the specific implementation is a set of clinico-genomic profiles, which are employed for decision support, automated diagnosis, prognosis, treatment and follow-up in colon cancer" [9].
	Expert systems	Genetic Algorithms	C-MANTEC algorithm	"Better cancer outcome prediction results were obtained using the Genetic Algorithm framework" [10].
Diagnosis	Decision Support System	Knowledge Base	C ++ &MySQL	The system focuses on the improvement of diagnostics quality of stomach cancer, based on the knowledge base containing the data of histological, cytologic, and clinical researches [11].
	Expert systems	Case-Based Reasoning (CBR) and Rule-Based Reasoning (RBR).	Java object-oriented	The study concluded that "this approach would be useful for general practitioners" [12].
	Artificial Intelligence	Artificial Neural Network (ANNs),	N/A	It was found out that the mode, developed using ANNs and based on the six serum tumor markers, was able to distinguish lung cancer, not only from lung benign disease and normal control, but also from other common gastrointestinal cancers [13].
	Artificial Intelligence	Image processing	Vector Machine Algorithm	The results of the study indicate that the suggested system, that makes use of a combination of methods, was able to achieve 91.8% accurate diagnosis [14].
	Data Mining	Artificial Neural Network (ANNs), Decision Trees, and Logistic Regression	N/A	The new validated discriminative GERD questionnaire, that made use of data mining techniques, was found to be "useful, friendly, and short, and therefore can be easily applied in clinical practice for choosing the appropriate diagnostic workup for patients with upper gastrointestinal complaints" [15].
	Machine Learning	Decision Tree, Majority, Nearest Neighbors, and Best Z-Score	Python	The study results show that Decision Tree technique would perform best since it is considered a very widespread machine learning algorithm [16].
	Decision Support System	Image analysis & decision fusion	N/A	The research discusses ways to improve the overall abnormality detection ability and provide the decision support by using artificial intelligent techniques [17]

	Expert systems	Genetic Algorithms	N/A	It was found out that the algorithms used were able to provide a list of biomarkers that play the most important role in this lethal disease as a by-product [18].
	Artificial Intelligence	Artificial Neural Network (ANNs)	Maruyama Computer Program (MCP)	The results of the study indicate that using ANNs, Lymph Node Metastases (LNM) in each Lymph Node Group (LNG) can be accurately predicted. Additional knowledge about one lymph node improves the results [19].
	Data Mining	Cluster analysis	SAS Enterprise Miner 6.1	The study concluded that "Enterprise Miner predictive modeling nodes were great at easily and quickly implementing classification models for colorectal cancer" [20].
Prognosis	Artificial Intelligence	Artificial Neural Network (ANNs), Cox regression models	R 2.12.0	The study showed that ANN model is a more powerful tool in survival prediction and influential factors of the Colorectal cancer (CRC) patients compared to the Cox regression model [21].
	Knowledge-based system	Bayesian model, Artificial Neural Network (ANNs)	MATLAB	The study dealt with the classification problem of high-dimensional patterns and especially of socio-demographic cancer questionnaires [22].
	Artificial intelligence	Machine Learning	N/A	The study showed that using machine learning classifier will become much more commonplace in many clinical and hospital settings [23].
	Decision Support System	Decision-theoretic model	N/A	The model has been incorporated into a computer-based system that can be used as a decision-support system. As per the study preliminary evaluation results, it was found that "the performance of the model in its present form matches the performance of experienced clinicians" [24].
	Artificial Intelligence	Artificial Neural Network (ANN) and Cox regression hazard (CPH) models	N/A	The study demonstrated that the ANN model is a more powerful tool in determining the significant prognostic variables for Gastric Cancer patients, compared to the CPH model, Therefore, this model is recommended for determining the risk factors of gastric cancer patients [25].
	Artificial intelligence	Machine Learning	MATLAB	The results of the study indicate that "Machine learning applied to information from a disease-specific (cancer) database can be used to predict clinical outcomes". [26]
	Artificial Intelligence	Artificial Neural Network (ANNs)	N/A	The study showed that "the performance of ANN model in predicting the probabilities of death is consistently high for all time points according to the accuracy and the area under the receiver operating characteristic curve" [27].
	Artificial Intelligence	Artificial Neural Network (ANNs)	N/A	The study concluded that "using trained ANNs, prognosis of cancer can be

				performed with least clinical and laboratory features and without requirement of much time" [28].
	Intelligent Decision Support System	N/A	Python	The study aims at surveying colorectal cancer (CRC) patients' survival rate using an intelligent clinical decision support system. The results show that the mean range of survival of HNPCC, which is a subgroup of high risk group, patients and FAP (Familial Adenomatous Polyposis) patients were respectively 77.7% and 75.1% [29].

4 Discussion of the Results

Based on the results extracted from the table, it was found out that Expert Systems, Machine Learning and statistical methods are used for both diagnosis and prognosis.
This may be due to their characteristics, since Expert Systems have both explanation and justification capabilities, Machine Learning focuses on making use of accumulated experience, and, statistical methods rely on historical data and statistical algorithms that are beneficial for both diagnosis and prognosis.
Concerning data mining techniques, they are mainly used for diagnosis since they are good in the classification and clustering tasks. Moreover, Artificial Neural Networks may be considered very useful and suitable for the prognosis task, due to its prediction capability based on past cases.

When it comes to working on algorithms, in order to enhance the performance of medical tasks, data mining, machine learning and expert systems are used.

5 Conclusion and Future Work

Based on the results of the study, it was found that, although there is no single technique or tool that is used to perform a specific medical task, Artificial Neural Networks are widely used for prognosis because GIT Cancers' treatment follows various protocols and the prognosis relies mainly on the expertise of oncologists, that is based on past cases. Hence, it benefits from the different capabilities of ANNs in classifying, clustering and predicting the consequences of following these different protocols.
As for data mining techniques, they may contribute to the diagnosis since they mainly rely on big amounts of data in order to discover new patterns and this is crucial in this medical domain, where more associated factors are still being discovered.

Regarding the recommendations for future work, the following projects are suggested:

a) Developing an Intelligent Tutoring System (ITS) that teaches and trains junior medical doctors on the early diagnosis of GIT cancers since all of the other medical tasks, such as treatment and prognosis, depend mainly on determining the right diagnosis.

b) Designing an Expert System that incorporates different protocols used to treat GIT cancers in order to transfer such important knowledge from senior Oncologists to others less experienced in various governmental and private hospitals.

c) Making use of relevant new IT trends, such as, Cloud Computing and Big Data analytics, since the medical data required in order to test existing models is huge and needs special handling when it comes to analysis and storage.

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