A Group Decision Support System for Staging of Cancer

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Abstract. The TNM classification system was developed as a tool for physicians to stage different types of cancer based on standard criteria, according to a common language of cancer staging. Staging reports are usually performed by oncologists but sometimes are also done by physicians not specialized in this area. In this paper, it is presented a multi-agent system to support group decision that helps meeting participants to reach and to justify a solution. With the increasing use of web applications to perform the Electronic Medical Record on healthcare facilities, this system has the potential to be easily integrated in order to support the medical and clinical e-learning and to improve patient assistance. In fact, the usual need for documentation and specific information by the medical staff can be easily provided by these systems, making a new steep towards a paper free healthcare system.

Keywords: e-Health, Group Decision Support System, Staging of Caner.

1 Introduction

In a healthcare unit, a firm knowledge of specialized areas and their uniform lexicon are required from physicians and other staff, in order to normalize information communication. This necessity is to the need for unambiguous methods when relaying information to others, making perceivable to all the exact meaning of reports and other documents. When dealing specifically with group decision this becomes an even more important factor, as several physicians and other researches with specific thesaurus may be involved. These different backgrounds may result in misjudgments or distortion of information. Considering these facts, several index and norms were created to share among the medical community standard terms of addressing stages, illnesses, symptoms and other technical issues. A common language of cancer staging is mandatory to fully homogenize the flow of information when indicating prognosis, aiding in treatment planning, facilitating treatment stratification and aiding in the analysis and information exchange between different treatment centers for clinical studies [18]. This need for medical staff to share the appropriate nomenclature when reading or receiving a cancer staging report was the driving force that the led ultimately towards the development of an uniform staging system by international organizations. The AJCC (American Joint Committee on Cancer) Cancer Staging

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Manual [1] brings information on staging of cancer at various anatomic sites and incorporates knowledge on the etiology and pathology of cancer.

The staging information is uniform between the AJCC and the UICC (International Union Against Cancer). The Manual contains printable copies of each of the 45 Staging Forms for both individual and institutional use. The Manual remains the essential reference for oncologists, pathologists, surgeons, cancer registrars, and medical professionals worldwide to assure that all those taking care of cancer patients will be trained in the unambiguous nomenclature of cancer staging. Staging is the process of determining how much cancer there is in the body and where it is located. Staging describes the extent or severity of an individual's cancer based on the extent of the original (primary) tumor and the extent of spread in the body. Knowing the state of the disease helps the doctor plan a treatment and determine a prognosis (likely outcome or course of the disease). Staging provides a common language with which doctors can communicate about a patient's case. Knowing the stage is important in identifying clinical trials that may be suitable for a particular patient.

Staging is based on knowledge of the way cancer develops. Some staging systems cover many types of cancer; others focus on a particular type. For most cancers, the stage is based on main factors such as the location of the primary (original) tumor; the tumor size and number of tumors; the lymph node involvement and the presence or absence of metastasis. Different staging systems are used for many cancers of the blood or bone marrow such as lymphoma. Doctors gather different types of information about a cancer to determine its stage. The various tests used for staging depend on the type of cancer. Tests include physical exams, imaging tests (XR, CT or MRI), laboratory tests (blood, urine, fluids or tissues), pathology reports and surgical reports, available in the Agency for Integration, Diffusion and Archiving of Medical Information (AIDA) [2] [3]. There are three different types of staging: clinical staging (based on physical examination, imaging and biopsies), pathologic staging (on patients who gave had surgery) and re-staging (to determine the extent of the disease after a cancer comes back).

The TNM Staging System is one of the most commonly used in Medicine. This system was developed and is maintained by the AJCC and UICC. The TNM classification system was developed as a tool for doctors to stage different types of cancer based on certain standard criteria. The TNM Staging System is based on the extent of the tumor (T), the extent of spread to the lymph nodes (N), and the presence of metastasis (M). Each cancer type has its own classification system, so letters and numbers do not always mean the same thing for every kind of cancer. Once the T, N, and M are determined, they are combined, and an overall "Stage" of I, II, III, IV is assigned. Sometimes these stages are subdivided as well, using letters such as IIIA and IIIB. Stage I cancers are the least advanced and often have a better prognosis or outlook for survival. Higher stage cancers are often more advanced, but in many cases can still be treated successfully. The formal "stage" of a cancer does not change over time, even if the cancer progresses. A cancer that returns or spreads is still referred to by the stage it was given when it first diagnosed. Sometimes, after a period of remission (cancer being undetectable) for certain cancers, if more treatment is planned, a doctor might re-stage the cancer. The same process that was done when the cancer was first diagnosed will be repeated: exams, imaging tests, biopsies, and possibly surgery to re-stage the cancer. If the cancer is re-staged, the new stage will

be recorded with a lower case "r" before the re-staged designation. As previously stated, this is not done often. The use of the TNM staging system requires all the staff to bare its current specifications in mind or to search through an immense documentation. The TNM system however is not a static protocol, it is designed to be able to evolve as new discoveries and breakthroughs are carried out in the oncologic area, making it essential to all staff to be updated with new specifications in order to conduct an adequate staging [19]. This difficulty associated to the fact that physicians that are not oncologists may perform staging reports, complicates the use of TNM. Besides slowing down the procedure, it may cause term misjudgment or some incoherence of the staging with the TNM system. Therefore, some mean of helping and hasting the elaboration of the staging report, while at the same time improving their quality is an excellent opportunity for the use of information technologies.

More information in [4].

2 Group Decision Support

Group Decision Support Systems (GDSS) are computer-based systems that aim to support collaborative work, and particularly to increase the benefits and decrease the losses associate to collaborative work [5] [6]. GDSS intend to support collaborative work. We will call “meeting” to all the processes necessary to the completion of a specific collaborative task. A meeting is a consequence or an objective of the interaction between two or more persons [7].

Physically a meeting can be realized in one of the four scenarios: same time / same place, same time / different places, different times / same place and different times / different places. Each one of these scenarios will require from the GDSS different kind of support.

But present group members are not the only persons involved in the process, however it is very common to see a third element taking part in the course of action, the facilitator. The meeting facilitator is a person welcomed by all the members of the group, neutral and without authority to make decisions, which intervenes in the process in order to support the group in the identification of a problem and in the finding of a solution in order to increase group efficiency.

According to [8] a meeting one has three distinct phases: in the Pre-Meeting phase the facilitator prepares the meeting, in the In-Meeting phase the participants will be working in order to accomplish the meeting goals, and in the Post-Meeting phase, it is important to evaluate the results achieved by the group. To model the group formation process it is necessary to establish the steps for the creation of a virtual community of participant agents. The importance of maintaining a community of agents is directly related to the need of obtaining information about their credibility, reputation, as well as their past behaviours.

The selection of agents to participate in a specific group is made from a community of participant agents (AgPs). The agent must be registered for selection. Some information about potential participants should be available in order to allow the acceptance of a particular participant agent by the system:

$Agent (Id):: area_of_expertise,
organizational_factors,

interest_topics,
credibility,
reputation,
availability.

where Id, area_of_expertise, organizational_factors, interest_topics, credibility, reputation and availability denote, respectively, the identification of the agent, the set of areas where the agent is an expert, the information about the institution where the agent is enrolled (e.g., employee numbers, production capacity), the interest topics for the agent, the credibility and the reputation of the agent and its availability at a given moment.

The information at the (participant) agent profile is divided into public and private. Public information is supplied by the organization at the time of registration (e.g., area_of_expertise, organizational_factors, interest_topic). At this moment the system does not detain any information about the agent attributes like credibility, reputation (i.e., private information). This information will be determined with more or less detail during the life time of the system [9].

3 The Electronic Medical Record

The Electronic Medical Record (EMR) is a core application which covers horizontally the health care unit and makes possible a transverse analysis of medical records along the services, units or treated pathologies, bringing to the healthcare arena new methodologies for problem solving, computational models, technologies and tools. EMR is the start point for the implementation of Ambient Intelligence in Medicine [14][15]. One aims to develop a comprehensive, structured approach to EMR development and analysis.

The process to collect data comes from Problem Oriented Medical Record (POMR) method [16]. This is a format for clinical recording consisting of a problem list, a database including the patient history with physical examination and clinical findings, diagnostic, therapeutic and educational plans and a daily SOAP (Subjective, Objective, Assessment and Plan) progress note [17]. The problem list serves as an index for the reader, each problem being followed through until resolution.

This system widely influences note keeping by recognizing the five different phases of the decision making process, i.e. data collection, problem specification, devising a management plan, reviewing the situation and revising the plan if necessary. One's goal is to replace hard documents by electronic ones, increasing data processing and reducing time and costs. The patient assistance will be more effective, faster and the quality of service will be improved [3]. The system uses freeware tools or software database packages, which licenses belong to the Portuguese Health Ministry (e.g. Oracle software). According to the ontology, messages are processed, integrated and archived in large databases. The administrators define the ontology, which can be managed using web tools. The "intelligence" of the system as a whole arises from the interactions among all the system components. The interfaces are

based on Web-related front-ends, querying or managing the data warehouse. Such an approach can provide decision support. A context dependent formalism has been used to specify the AIDA system incorporating facilities such as abstraction, encapsulation and hierarchy, in order to define the system components or agents; the socialization process, at the agent level and the multi-agent level, following other possible way of aggregation and cooperation; the coordination procedure at the agent level; and the global system behaviour.

4 The System

The GDSS follows a client-server hierarchy and can be decomposed into four tiers.The first three tiers are responsible for the communication system, while the other one is responsible for the agents monitoring and control. According to the architecture, each agent has an individual and personal role and can interact with the users, answering questions and establishing a dialogue. The users, through web browsers, and mediated by software agents, converse and negotiate with other agents that are able to help the user in a particular area of his interest. This communication is achieved through conveyed messages between users and agents, stored and managed by relational databases.

Using JavaScript, the GDSS allows for a dynamic service that constantly checks in real-time if messages were sent to the user and if whether or not other actions of his concern were performed by any user or agent. This lightweight service runs on an application server that communicates with the database. The XMLHTTPRequest object in JavaScript is used to send and receive commands to and from the server. The messages, the user status, the chat rooms, the buddylist and the blocked users are set and managed by objects following the JSON (JavaScript Object Notation) format and other PHP scripts. The chat rooms allow for users to find the specific agent for their area of interest. The users open these rooms and the agents have permission to act. Chat rooms are spaces for open discussion among users, and places where the agents can be found to perform private tutoring. Personal tutoring allows a better adaptation of the agent to the user's needs and doubts.

With the increasing use of web applications to perform the EMR on healthcare facilities, the GDSS has the potential to be easily integrated in order to support the medical and clinical e-learning and to provide life assistance. In fact, the usual need for documentation and specific information by the medical staff can be easily provided by these systems, making a new steep towards a paper free healthcare system. Moreover, this system allows a better performance of cancer staging, saving time and effort while tutoring the users at the same time. More specifically, the intricacy and length AJCC Cancer Staging Manual can be easily dismembered in its 45 main areas in which the GDSS agents will specialise in and tutor when called for staging a subject with a cancer in that area.

A considerable part of the GDSS backend is developed in JAVA. JAVA is a multiplatform object-oriented language, which proved to offer good performance with most databases, besides allowing the use of several API and middlewares further improving this system.

Agents can exchange information in the same way users can and moreover store and exchange information about their particular expertise areas. These areas are coherent with the protocol underlying in the TNM system. In an analogous way TNM separates staging with a specific tissue and body part, the GDSS uses an agent system that emulate this model increasing performance. Following this line of thought, as an agent asserts the interaction with the user based in its area, it considers if the information that is provided is meaningful to the user. Based on this analysis, it may advise the user a more suitable agent to help him.

The use of these entities in an extensible architecture, allows for the easy adding of more capabilities to the agent and the use of the same methods by different agents. Thereby, an expert agent on a certain expertise area can have its specific behaviour and knowledge and still use the basic methods of communication with the database. This expert agent is designed to be responsible for that specific chat room and that area of expertise. These rooms are created based on the TNM system and oriented to fit the needs of physicians and other healthcare related staff.

The agents have been designed using JADE, the Java Agent Development Framework, which implements in JAVA a Framework that simplifies the development of agents according to the Foundation for Intelligent Physical Agents (FIPA) specifications [20]. The adoption of an ontology that follows the definitions and requirements of AIDA, allows the agents to be integrated with the healthcare environment and opening further opportunities to this agent based system.

5 Conclusions and Future Work

In this paper, a simulated medical practice scenario has been developed for intelligent decision support in the area of staging of cancer.

Decisions about the staging of cancer are taken in the context of a group meeting aiming collaborative work. The system uses agent oriented programming and agents can exchange information in the same way users can and moreover store and exchange information about their particular expertise areas.

The group decision support system emulates the TMN cancer staging system increasing performance and eliminating paper circulation. Information that is provided is meaningful to the user, following the principles of quality, credibility and security. The system advises the user about the most suitable agent to help him and to justify decisions.

Case Based Reasoning (CBR) is the process of solving new problems based on the solutions of similar past problems, but it is also a powerful method for computer reasoning, or a pervasive behaviour in everyday human problem solving tasks.

In future releases, after having a significant set of available classified cases; the system will be upgraded with CBR algorithms. The system will embody dynamic virtual world of complex and interacting populations, entities or agents built as evolutionary programs that compete against one another in a rigorous selection regime, providing a solution to produce the optimal solution to a particular problem, in which its fitness is judged by one criterion alone, the Quality-of-Information.

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