Intensive Care Unit – Clinical Decision Support System

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***Abstract*- The Intensive Care Unit Automation System and Clinical Decision Support System (ICU-CDSS) were developed in the scope of our project as a multi-disciplined study within 1507-TUBITAK. ICU-CDSS software collects vital information from medical equipment and makes it available for the needs of the medical doctors and the nurses of the Intensive Care Unit (ICU) via Web based and mobile interfaces. Collected data could also be easily accessed immediately, using the query tools for research purposes by the authorized physicians. The forms which were formerly filled manually will be able to get reported digitally. Also, data mining assisted decision support system is developed and used. Decision Support System will be able to make suggestions to the physicians for detecting critical states before they happen. The appropriate size ICU automation devices will be sterilized and will allow easy data input by the side of the patient bed. Doctors and nurses will be able to use the system within the authorities granted to their roles. The performed operations will also be registered in log records. ICU-CDSS will be tested and used primarily in Dokuz Eylul University ICU Clinic.**

Keywords- Data Mining; Hospital Information Systems; Web Services; Decision Support System; Vital Risk Scoring.

I. INTRODUCTION

The aim of the project is to create an easy to use intensive care unit automation software and decision support system. The software also has capabilities for integrating ICU medical devices and Hospital Information System (HIS).

All of the brands that work intensively in this market in Turkey are foreign companies. Major brands; GE, Siemens, EvoluCare, Drager, IMD (MetaVision) are companies. All of them are serving only 10% of intensive care units in our country. The automation is not available by 90% of the intensive care unit because of the high price of the products and the stipulating of the firms to use their own brands.

The outline of this project could be summarized as follows:

-An electronic data collection device is used for collecting data from the Hospital's Intensive Care (IC) Division.

-A Web Based Software is implemented for Automation. Apachi, Sofa, Rifle Scoring Techniques are implemented for monitoring current status of IC Division Patients.

-Clustering and Classification Techniques are used for predicting patient's future state.

-A mobile Web application was developed for providing mobile access to our system.

The software will use vital patient information, such as the one obtained from mechanical ventilator, etc., for clinical research and also will collect information for future data mining analysis.

Using digitally collected data will decrease errors instead of using manually entered data. Intensive Care Unit staff physicians and nurses will be able to access the database which contains fresh information gathered from related devices.

Through Risk Identification and Data Mining Decision Support System, which use techniques to gather information prior to a possible critical situation, physicians are informed on and can be guided in their type of treatment based on these Vıtal Operations. Because of this, it is a positive development in the patient's health status.

II. RELATED WORK

The main reference projects related to our work are described below.

Artificial Neural Networks, which are one example of the Data Mining algorithms, showed successful results in the ICU [1]. The ICU data center stores in the database

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clean and reliable data for medical studies. The Multi-parameter Intelligent Monitoring in Intensive Care II (MIMIC-II) study consisted of almost 25,000 intensive care unit stays. It established a resource for research, supporting a diverse range of analytic studies, clinical decision-rule development, and electronic tool development [2].

Intensive Care Information System Impacts (ICSI) enable intensive care physicians and staff to use the system in a more meaningful way for better patient care. This study provides a better understanding and greater insight into the effectiveness of ICIS in improving patient care and decreasing health care expense [3].

The PDMS innovation has been selected in 2003 has been configured in 2004 and has been in use since 2005 [4]. Large-scale employees are held daily in intensive care units due to the workload required to carry out the regular work plan. It has been observed that a lot of time is wasted for other administrative work. Therefore, we emphasize the importance of a data management system that is easy to control [5].

Successful results for intensive care unit have been observed in real-time by using of the support vector regression algorithm in this study. The implemented interfaces are also included in the study and shed light on our project [6].

Business planning, management, monitoring, and decision support systems in Intensive Care have provided successful results [7].

The results have been obtained for renovation forecasting with data from the ICU data mining algorithms (Decision Tree Learning, First Order Random Forests, Naive Bayesian networks and Tree-Augmented Naive Bayesian networks) and also, they have been compared [8].

Consisting of clean data from the device and formed by the continuous flow of current data, intensive care unit's data-intensive data mining and artificial intelligence algorithms constitute an important input to yield successful results. This study has highlighted that the use of these algorithms in the intensive care unit of a smart system appears to play an important role in the quality of patient care observed [9].

The study SANDS_A demonstrates the feasibility of the architecture, which is a Service-oriented Architecture for the National Health Information Networks for clinical decision support. Service-oriented Architecture is used for the Decision Support System [10].

This article shows that the information platform assists in the presentation of user queries from the services in order to form individualized suggestions. A service-oriented architecture model is used that calculates asynchronous duties, modularity and flexibility. It is shown that this study is used to discover and process data in Web for transforming into knowledge [11].

In another study, a service-oriented architecture is used for communication with each other; XML, Service-Oriented Architecture Protocol and Web-Service Description Language communication protocols are used for supplying Web services functionalities. This paper gives a comprehensive account on improving the software system for Clinical Decision Support by using Health Level Seven. By means of this architecture, the implementation of rule based CDSS will be developed [12].

III. BACKGROUND

Requirements Analysis, Functional and non-functional requirements were determined. The requirements analysis report has been prepared in accordance with the IEEE 830 standard. The design modeling part of the "Unified Modeling Language" has been using. The design modeled User Scenarios (Use-Case diagram) and class / object diagrams have been drawn. To create the database, we designed the Entity Relationship Diagram. SOA (service-oriented / based architecture) was drawn on the diagram.

A. Device Integration

The serial interface of the Ethernet enables a conversion between the hardware units developed in this project. To use in intensive care units, a device that transfers data to the snapshot automation software is developed and designed. This data can be accessed instantly via any mobile or fixed devices. Our software is based on the V model process and collects this data for the decision support system. The patients are able to start the required device sterilization process with the appropriate touch interface.

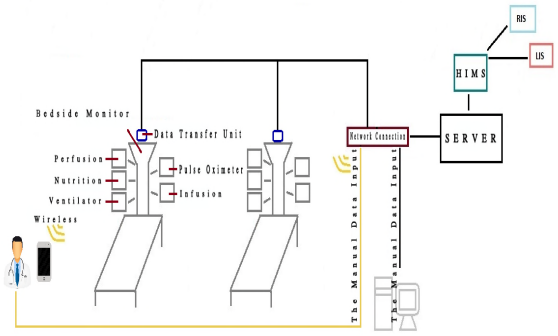

Figure 1. Hospital System View

This unit supports more than one medical device connection and has a buffer against communication failure (Figure 1).

B. ICA-DSS Operation Steps

- *Requirements Analysis*- At this stage, all standards and requirements (interfaces, security and performance requirements) were defined by physicians in team meetings.

The documentation with the standards defined and all the requirements has been prepared.

- *Data Transferred to The Intensive Care Device*- This module's task is to obtain real-time data transfer to the database through the front of the devices formed in the design stage.

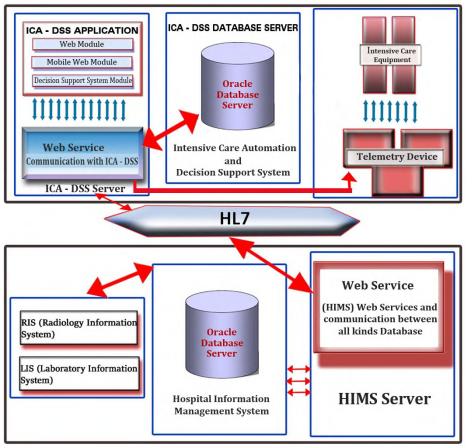

Figure 2. Interaction Modules

- *Development of Intensive Care Patient Tracking Application Process*- Patient registration and other patient medical information are connected by Web-Based Software. This service is used with both the Web-Based Software Module and Mobile Web Module. It increases the security of the system and provides the ability to support the new platform.

- *Risk Identification and Development of Decision Support System*- It includes patient demographics, laboratory results, diagnostic and treatment data, such as results formed an important part of parameters to be investigated. Subsequently, data mining literature review on the use of algorithms provided a vision for the work to be done.

- *Development of Mobile Web Applications*- The main task was to improve the visual interface on the stage of the Mobile Web application. Therefore, we considered the ease of use of mobile devices and requirements analysis to provide all of the components obtained at the design stage.

- *Integration and Testing of Software Modules*- The project team worked together in an integrated process, analyzing the potential problems and testing again

- *Pilot Application and User Tests*- The project team worked together in the testing process, analyzing the potential problems and testing again.

IV. PROPOSED SOLUTION

Our project provides the ability for medical devices used in a system to instantly record patient data from the intensive care unit. Patient data from intensive care units in Turkey is not stored in the electronic media. It is a big disadvantage in terms of operation and clinical research. Patient data can be often taken automatically by the system software modules. Data from patients participating in clinical trials can be accessed in batches, in seconds.

ICA-DSS hospital is the primary recording system "Hospital Information Management System" able to communicate with the HL7 protocol. Another factor is that it enables private cloud computing innovation of our project (Private Cloud Computing) to be used.

The goals of our project are listed as the following list;

- decreasing the error accrued by reducing the manual entry of the patient records
- storing the data obtained from the medical instruments automatically.
- creating a new database which is capable for clinical researches.
- reducing the diagnosis and treatment time
- reducing the duration of hospitalization in intensive care unit
- reducing the mortality and morbidity rates.

There are 8 parameters for diagnosis Sepsis. A clinical decision support system is introduced by analyzing data with these parameters. By using this system the mortility rate is predicted to be reduced by 50%.

The project, Knowledge Discovery in Databases (Knowledge Discovery in Databases - KDD) steps (Problem Definition, Data Processing, Data Mining and Information Report) was monitored.

Clustering, Data Mining Association Rules such as classification and analysis methods were used. Neural network classification algorithms, decision trees and Bayesian, Association Rules Apriori and Fp-Growth for the analysis, clustering algorithm was also planned to be used as SOM and K-means ++. APACHE, SOFA, ICU and RIFLE were used as scoring standards. In addition, Decision Support Systems for solving complex problems of ensuring the effective use of data and models were created. Thus, this system was able to identify situations that could occur in advance, use instant analysis capabilities and provide advanced communications capabilities.

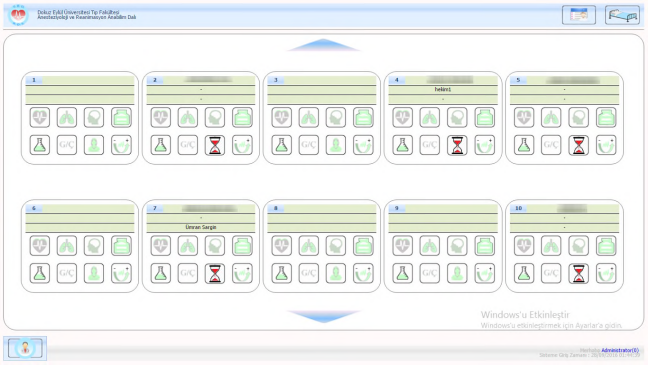

Figure 3. An example interface of ICU-CDSS

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Hygiene, Activity, Excretion, Security, Infusion, Neurovascular, Rubbing and Scratching, Vital, Ventilator, Neurology and other topics are elaborated in our project. Figure 3 shows an example interface for all patients with the status of these topics.

V. Conclusion and Future Work

In our country, healthcare cost takes up a good part of our country's budget because of the importance of human health. Another important fact is that there is too much dependence on foreign countries for medical expenses. In addition to the software, hospital devices also come from abroad. The software does not contain any Data Mining algorithms for Decision Support Systems which help physicians and the nurses.

ICU-CDSS is developed in the scope of our project as a multi-disciplined study. Using digitally collected data will help decrease errors compared to using manually entered data. Intensive Care Unit staff physicians and nurses will be able to access the database which contains recent information gathered from related devices. Thus, our country will have a large data warehouse for future medical research.

ICU-CDSS software collects vital information from the medical equipment and makes it available for the needs of medical doctors and the nurses of the ICU via Web based and mobile interfaces. The collected data could also be easily accessed immediately, using the query tools for research purposes by the authorized physicians. The forms which were formerly filled manually are archived and will be able to get reported digitally. Also, a data mining assisted decision support system is developed and used. The Decision Support System will enable the users to make suggestions to the physicians in order to detect critical states before they happen. The appropriate sizes ICU Automation devices will be sterilized and will allow easy data input by the side of the patient bed. Doctors and nurses will be able to use the system within the authorities granted to their roles.

VI. Acknowledgement

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