An Interface Model for Information Visualization of Multiple Electronic Health Records

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ABSTRACT

Different visualization tools and systems facilitate physicians and medical professionals in interpreting both temporal and non-temporal patient's information using Electronic Health Record (EHR). But due to lack of information organization, physicians and experts still find it difficult to infer concise patient's data. Current EHR applications focus on different data type representation using multiple colour schemes and format. This trend indicates lesser emphasis on enhanced and detail level of patient information as per requirement of physicians for understanding complete patient history. This limitation raises the need, to propose a conceptual interface model to design a visual analytical solution for EHR. Patient record comprise of different data format including personal & disease details, lab results , x ray and doctors recommendation. This paper highlights the importance of this model with the support of preliminary results of a study on a group of physicians understanding about EHR tools in public hospitals. This model adjuncts the collaboration of data representation with enhancing the multiple sections of EHR interface by collaborating different data sources from query section, past data, lab results and data representation style. This model proposes to generate multiple portions of an interface in visualization for temporal information in patient data set. Possessing multiple interfaces features within the same interface, is envisaged to be detailed enough in terms of the data presented yet easy to be understood by the physicians.

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1. INTRODUCTION

Electronic Health Record (EHR) is a key source for physicians in storing, retrieving, extracting and visualizing maximum useful information about single or multiple patients with the help of various automated analytic applications. Existing EHR systems focus more on providing patient's details and health status from different data resources using unified format in order to improve medical and health care facilities[1] [2]. This approach, not only focuses on providing enough technical and professional support to physicians but has also improved the overall efficiency of health care systems in a better, organized and more sophisticated way[3][4]. Single EHR shows details about one patient while multiple EHR represents details about multiple patients.

In general, physicians obtain information by using a simple application interface and determining the current status of the patient's health. Decision Support Systems (DCS) and computing analysis with in EHR help to provide maximum doctor's time to patient in addition to better quality utilization of public health care facilities to end users[5][6]. Unfortunately, it is hard to retrieve all the useful information upon demand on a single application interface due to the complexity of different EHR systems, unavailability of data flow linkages such as interactive laboratory results retrieval, x-ray reports transmission, blood samples analysis and, previous patient prescriptions with reference to time stamp. Differentiation in data types,

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existing records format mismatch and complicated data extraction within a given data set result in providing incomplete information, are the main factors leading to a more time consumption and frustration for physicians[7][9].

There are many visual analytical solutions in EHR proposed in the form of tools based on time stamps, events criteria , organ approach, disease classification strategies like CareViz[9], LifeLine [10] [11], Leval on Detail Navigation (LOD)[12] and TimeLine[5][13]. These tools based on their resulting information visualization (IV) for a given EHR dataset provides different patterns of data. Some are representing information against time lines and patient health status in graph, some with color code in the form of dots, some with bars and triangular shapes. These approaches tried to solve different complicated issues in the domain of EHR visualization with different level of solution granularity but still gaps are left as the one is addressed in this work. Practical implementation of even other corporate tools like TURF and Microsoft Amalga are still, considered as a burden on budget due to high cost based on IT resources limitations and potentially available trained man power within different health care units [14][15][16].

To comprehend complete information for multiple EHR on single screen is one of the challenging area for past couple of years in health data representation. Above mentioned applications succeed to solve this issue but lead to a complicated and complex information representing interface for application including mismatch of information like multiple patient history relation with different doctors comments etc. However, some EHR visual tools proposed information representation using multiple dialogue boxes as that is one key subject area of this research work. Previous applications did not focus much on the importance and significance of its implementation in an articulated way as due to lesser attention [12][15][17][18][26].

This paper is an ongoing part of research work of authors, as CARE 1.0 [26] and also results from initial study with doctors regarding factors affecting EHR numerical temporal data are represented. Paper defines proposed user interface design in 5 sections representing introduction, literature review, design and conclusion discussion about the model subsequently.

2. EHR INTERFACE ISSUES AND RELATED WORK

Different complex formats and non-uniformity with information representation features in EHR tools result in over flow of information on single user interface on daily routine computer screens. This lead to lesser adaptation and attraction of such applications and more time in training for doctors such tools that vary in each hospital with lesser trained medical professionals[5][19]. Presence of unrelated information in single format on a computer screen often confuses the doctors and physicians that lead to frustration. This becomes a cause of reduced efficiency and applicability of EHR applications in daily routine operations [9][20].

A complete information interface always bring a well-managed , designed and properly organized data contents to its end users query requirements within EHR applications. This is best depicted via Schneider man's mantra about data visualization –"Overview first, information zoom and filter and details on demand" [10].Various other researchers presented the same concept in different way but the base theme is same. Overwhelming information, too much pop ups , concatenation of dialogue boxes and alignment of required information result in more search time and distraction of physicians as per dedicated to patients [7] [21].Life Line and its different versions are one of the similar kind of tools in practical form of this mantra that represent the health records based on disease, alignment, filter and rank by criteria among multiple patient. These tools have limitations of representing a minimized level of patient information mostly patient entry and exit in addition to life, death or discharge status presentation in the form of colored triangles Still it is unable to provide in detail insight of patient data [10][14][22] . Still these applications provide a better visualization but still unable to address the temporal numerical data i.e. blood pressure readings, comparison of drug effects and their implication on body organs within multiple EHRs.

Timeline another application represents the single patient record against time interval using health status of different body organs as well as test results comparison. This application is bit complicated with reference to understand the interface as clinicians and medical experts normally having lesser IT technology experience are more in overall population of medical community. Furthermore, these tools also work on chronological approach based on two phase interface. It has navigation panel one side and time interval representation on other phase. Craig [5] proposed the collaboration of information visualization from multiple resources at single interface to maximize the efficiency of EHR application. The proposed work in this paper is also using the same approach but with some modifications of the use of resources.

All the above applications, framework and models tried to focus on user friendly functionality of application based on doctor's feedback but lesser efforts were given on improvement of interface development. This was also addressed in CARE1.0 [26] previously completed work but still needs the strengthening of this work with the help of doctor's feedback. This need has been given highlight in later part

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of this paper with the help of results conducted by study specifically with relation to factors of EHR applications interfaces for temporal data.

3. THE PROPOSED INTERFACE MODEL

EHR application represents temporal data in visualization that can be both numerical or categorical based on patient history details like name, weight, blood pressure, last visits to doctor, disease identification and medicine recommendations or any surgery details [14][23]. This section contains a brief introduction about the details of proposed model that is an integral part of an ongoing research for development of a Visual Analytical Model termed as CARE 1.0 [12][26].This model is an effort to encompass the physicians need to represent on demand temporal data in multiple patients by using collaboration techniques of resources and data integration as also discussed in Section 2. As collaboration covers the information matching, retrieving, segregating and representing in a single interface for multiple patients query from different data bases or single data base source based on IT infra-structure of the hospitals.

Figure 1 as represented in pre proposed model CARE1.0 [26] represents the 4 different phases to represent and facilitate the visualization process. These phases are termed as query set, events of interest, temporal data and lab results respectively. Basic principle within this model is to adapt a centralized approach as such followed partially or less frequently in previously developed tools that focused more on individual or more detailed insight areas of information. Following are the details of each phase and its function individually.

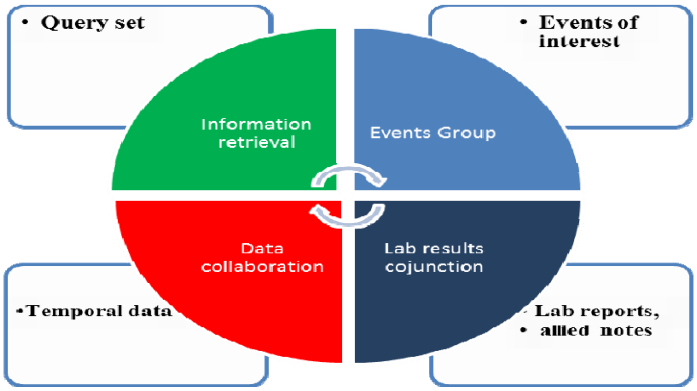

Figure 1. EHR Interface Model CARE1.0 (M.S.A et.al. 2013)

3.1 Query Set:

This phase of model involves the questions , facts and information finding commands and desired query requests from doctors and medical professionals in an interactive way as mentioned in figure 1.Previous HER visualization applications termed this as ranking or alignment feature with criteria selection boxes in the tool interfaces[8][24]. Simpler the query, easier to understand and relieves the user by time saving. Doctors can select a query set and can access it to retrieve information from patients data set based on level of data on demand.

3.2 Events of Interest:

Doctors are interested in different scenarios based search like simpler to deep insight of a patient liver and heart status, x ray report in diabetic or cancer patients or to see the previous doctors comments about medicines. This phase deals in grouping those events based on choice and demand in department wise distribution of hospital like ICU, Emergency, Ward and Operation theatre data. This also been referred by previous people in same fashion but with different form [7][11][25].This section directly deals with the database professionals who help to segregate based on groups like disease based, time based or ward based criteria. This will help to minimize the unwanted data retrieval . Data set and medical database management is only accessed by database professional in case of processes other than retrieval and query processes.

3.3 Lab results:

Lab results for x rays and other tests normally transferred via internal and external links between labs and hospitals to aggregate the EHR at a central location [5]. Most of doctors are interested highly in viewing the representation of multiple patients test reports without going in further details. This portion of the model helps to excavate that information for single and multiple patient at single interface so that it help for a comparative analysis and medicine or treatment recommendations. Lab results are constituent part of

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distributed data base but mostly located at different location and in separate database. This will help in retrieving results from multiple locations based on doctors demand using query set and event of interest coinciding only for particular lab results like blood sugar tests of a heart patient and a cancer patient.

3.4 Temporal data:

Patient data contains both static and non-static data as some researchers termed it as temporal numerical and categorical data. As to visualize the information against time is complex in case of categorical data like pulse rate variations and brain cells regeneration or breakage percentage in easier format so much work is done towards numerical side [13]. This part of the model is trying to bring maximum numerical and partial categorical data associated and can be retrieved without much change in overall visualization of single and multiple patients. This is the main part of the a resulting visualization that needs a careful implication of application developers and designers to facilitate the doctors in understanding the means of information in easy way as like proposed via this model. Collaboration of results is also carried out at this phase. Temporal data is directly retrieved from data set based on its category and can be visualized directly from query set even by passing the lab results. This will help to find the doctor not to visualize lab results if he is only interested in viewing patient's numerical temporal data for last two months. This will avoid time consumption and make interface more simple and concise.

4. EHR MODEL AND DOCTORS STATISICS

Above mentioned model represents the four different phases in a collaborated format of information on EHR applications interfaces in simpler and easier way. Traditional applications bring the data either from single source at one point or just represent the limited information but details overview that raises complexity to understand data means. This technique is used in partial functionalities and architecture of existing applications and tools [5][13][23]. Figure 4 is representing graphical analysis of different factors to support the need of above model based on conducting a survey based questionnaire study within the 18 doctors from emergency department of two different hospitals. These factors have been selected based on different future work and areas of gaps of existing and previous applications and tools[10][11][13][19]. As doctors from emergency are facing direct patients and their records on urgent and frequent basis so their feedback carries more importance both with their level of understanding and adaptation of these tools. Likert scale from 1 to 5 are representing in different color bands from poor to expert level understanding about the technology and knowledge based interface use in EHR tools. Factors like knowledge about EHR tools, interface visualization easiness, IV data, doctors skills to enter and interact with applications and understanding the limitation of application are plotted here.

Results in figure 2 shows that 70% of doctors have lesser knowledge about factors like IV data , features understanding of IV tools, comparison of multiple patients data and limitation of application within the existing patient chart based EHR daily use IV tools. This also lead to fact that only 30% of doctors have expert level or near ability to compare the multiple patients record based on the data visualization and icon understandability at different portions of interfaces.

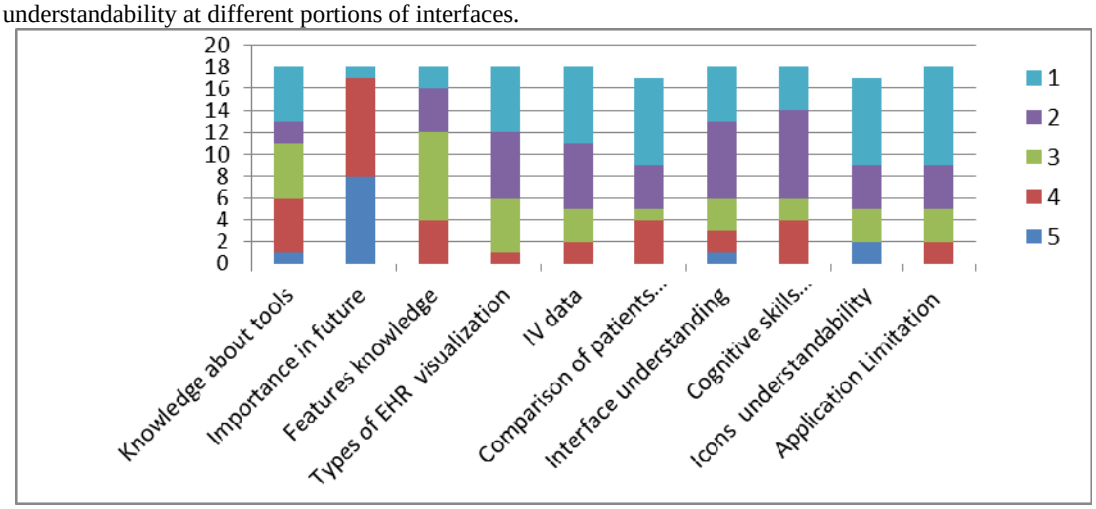

Figure 2. Comparison of EHR Interface factors for Physicians

The above mentioned interface model CARE1.0 tries to represent the single and multiple patient data at single screen only with desired information as per doctor demand. Un necessary information is filtered out during the retrieving process to avoid overcrowding of data in visualization development. But

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detailed insight about record like doctor's notes and allied history on multiple dialogue based on click sequence to avoid complexity of information understanding. This feature will help the health care management and medical professionals to compare and analyze the data in a given visualization with lesser IT training and minimized time consumption.

5. CONCLUSION & FUTURE RESEARCH AREAS

This work so far proposed the importance of development of an interface model in IV tools for EHR using collaborative and retrieved data segmentation approach using on demand query approach. Although the work is an integral part of ongoing research for CARE1.0 has been discussed in previous sections but the results in case study tried to focus on importance of interface use within medical professionals. Simpler and easier the interface in EHR visualization tools will results in frequent and more adaptable use of such tools in public hospitals based on doctors interest and expertise level. This model is a constituent part of overall work for the EHR solution encompassing the needs of doctors but in conjunction with other stake holders like designers and data base professionals. Current work is an enhancement in the overall developmental process of EHR tool for IV in multiple EHR by integrating and highlighting the need of interface improvement and restructuring.

As it is mentioned that still the work is ongoing and still there are lot of areas of research interest and future work pending. Detail survey base studies with primary stake holders about their complete demands and deficiencies understanding for operating and handling such applications are also one of the future step works in this domain. Influence of temporal data representation based on designers and database professionals' feedback inputs and comparative analysis of multiple patients data are also point of interest to measure and improve efficiency of such tools. More work can still be addressed towards the level of detail insight presentation of records and criteria of selecting the information from EHR datasets. Still the icons, colors and pane standardization are missing in unifying the information at single user screen during implementation of such tools that can be interesting future research work areas in this domain.

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