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Evaluation Framework for Interface Usability in Visualization of Electronic Health Records

Muhammad Sheraz Arshad Malik[1], Suziah Sulaiman[2]
Dept. of Computer & Information Science, Universiti Teknologi PETRONAS, Malaysia.
sheraz_awan@hotmail.com[1], suziah@petronas.com.my[2]

Abstract: Information Visualization Frameworks potentially help designers to drive a visual tool to infer data from single or multiple Electronic Health Records (EHR) for clinicians. Different types of Frameworks have been evolved to address the interpretation issues from complex datasets and associated problems in interfaces of Visual Analytic Systems for EHR. But less attention has been provoked towards the process of data representation in a standardized format as per convenience for physicians to visualize these records. Existing frameworks are based on different ideas mostly dataset like 2D or 3D applications but lacking use of complex datasets as multiple EHR. Visualization of multiple EHR in a user friendly format often leads to complexity by representing an unnecessary, out of line and unwanted information format making difficult for clinicians to grasp patients history information.The major objective of this paper, is to highlight the issues pertaining to interpretation difficulties using interfaces of the existing applications and leading to a framework generation for a future EHR application. This framework is based on combination of both designers and clinicians perspectives. It will help to better encompass the only required information in an understandable representation at interface level to eliminate complexity of generated visualization.

Keywords: Visual interfaces; EHR; Information visualization model, Visual analytic Model.

Introduction

A graphical interface plays an important and vital role in representing the information using different formats out of Electronic Health Records (EHR) in the form of understandable visualizations. Different applications use different kind of graphical format structures to represent single or multiple EHR like dots, triangles, histograms and lines with different colours to represent different textual or pictorial form of data sets [1].Different formats are adopted by different researchers and applications depending upon the approach adapted to represent based on structure of applications and demand of the clinicians within the existing approaches.

To reduce time consumption in inferring the results within complex medical data sets include multiple information like lab test results, doctors comments from previous patient visits and any particular ongoing medicine dosage recommendations etc.This is one of the basic purpose of using currently existing EHR visualization applications. Different EHR applications try to formulate data representation in different forms like events based approach [2] that is more sophisticated way for articulating time stamp data. But couple of problems result in user time wastage arises e.g. pop ups that hinders user to move to the next phase of any data visualization due to prior completion of unnecessary steps, prevention of application switching or unavailability of any quick data view at earlier stage for physician. This results in frustration and tends lesser adaptability to such kind of applications for doctors and physicians and reduces the overall quality of health care standard practices.

One of the potential benefit of a user friendly and easy to understand interface with reference to point of information in EHR application is to increase level of trust for clinicians about data visualization in lesser time thus giving more attention to patients in organized form[3] [4]. Couple of different approaches are being followed in different existing EHR applications from past couple of year's research to improve the overall quality of representations of information i.e. simple to complex based on patient to patient vs. region to region as well. Most simple kind of EHR applications can be just consisting of patient data in simplified static form like of LifeLine1[5] with couple of datasets representations in the form of single entry representations via lines and some of the applications used complex set of representations in the form of event based approach segregation for multiple patients records like LifeLine2 [2], CareViz[6] and TimeLine[7].

Above mentioned solutions tried in different ways to simplify the visualization by either working on time frame or on event based approaches. Normally EHR for single patient or multiple patients contains data both in textual and numerical format and may contain the information in the form of pictures or graphical representations e.g. cardiac reports, X rays or MRI scans etc. This information is coming from different resources or data banks within similar hospital or geographical distant places depends upon the EHR vendors in different regions around the globe. Mostly in developed healthcare units these facilities are coming from same hospital but from different departments. Major impact in visual representation of the required data only to the doctor based on the requirements of query set is carried out with filtering processes that are less addressed in these above application or less focused. These applications try to resolve the issues of viewing the data but observing the information in small fraction of time with reference to complex data creates issues like dialogue boxes appearances, extra details in case of only comparison of fewer results of urine and comparing of x ray results of same patient within last six months or inference of doctor notes[8].

Emergence of a well managed and organized EHR visualization is a significant requirement for clinicians in today's fast paced and health care time consumption health care units[3]. This is possible if a frame work presenting the process of representing visual interface in a simplified format by identifying the requirement of clinician query set. This can be formulated using a filter and hide unnecessary information based upon the request set of clinician and information retrieval from single or multiple resources to a single point only within parameters requested.

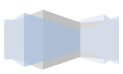
Most of the previously developed applications and research work tried to attempt these kind of issues but as data is mostly temporal means an event or activity with respect to time in databases, so to encompass all the issues relating interfaces particularly to understand the visualizations are difficult to cover. Even in future work recommendations of the most of the above work , evaluation of those framework as well as recommendations for further enhancements are highly suggested. Some are good in one perspectives of only representation of disease, patient status or other temporal data formats in one form and some are good in presenting the information in timeline format. As most of them are divided on the basis of events, activities, time stamps , disease or organ based division etc. This paper focuses on representing a framework to facilitate the development of an application that provides a visual representation from multiple resources and doctors comments and patient health care suggestions just like adapted as a chart sheet book in the regular hospital beds. Only major objective is to overcome the problem of overloaded information and alignment of required fields in a suggested and required format as per doctor query. This framework is a part of our ongoing research in development a complete solution CARE 1.0 for simplifying the visual interfaces and providing only maximum details on demand and ability to transform from one phase of information to other for visualizers without any hindrance of the popups, multiple dialogue boxes or interventing in details data sets. This will help in simplifying the facilitation process of health care practices using multiple resources and trend setting for future standardized medical practices. As in case of multiple EHR visualization , often past experience and knowledge helps a lot in directing the suggestion of medicine dosage and care practices or informing about any test continuation in particular case study. Second part of the paper is presenting a general overview of background for emergence of this solution while third and fourth parts will be explaining the solution and architectural details for evaluating the interfaces and development of framework for interfaces. Future work is also described in later part.

EHR- Interface Problems & Background

Interface design is one of the key role playing area in Information visualization while determining different information within single patient EHR or multiple EHRs from same or multiple resources. Different formats in various implacable applications provide understanding to physicians in different ways. This results in mostly rejection of EHR adaptation as patients feel from doctors for more time consumption as well frustration sequence arises in physicians for not extracting to the point information in easiest way. This also results in elongating the processes of health care practices if results have to be derived from multiple resources in not an aligned time as mostly required in temporal queries. Best approach to visualize information from EHR can be summarized on the basis of Ben Schneider man's mantra: " Overview first, zoom and filter , then details on demand"[5]. This is one the key rule as a backbone for this piece of work.

Normally EHR are not able to give doctors complete information if they are not properly well managed in presentable and required information. Thus existing EHR models are presenting the records in time wasting and more complex unwanted information that results in more time consuming for clinicians. As time is reducing in day to day basis operations for physicians to over view the information about the patients as due to increase in load so unnecessary information may result in overload of information thus causing more frustration and trouble for doctors. There are different approaches followed to seek the information within EHR based on the same mantra of Ben Schneiderman as discussed above. applications like Lifeline1 and 2 [5] [9] trying to navigate these issues in the best way based on temporal stamps using both event based approach and alignment of data in query set requirement format. Both applications work as time line set of data representation in the form of lines as well as in the form of triangles to with different colours to understand the disease and class of patients division in particular phase. Although later it was being nominated as event based division with approach to classify the division of time based activities in events form. This focused on visualization of events on filtering and zooming data of clinician choice. Although former application was the base version for representing data in the format of simple lines to represent the status of patient whether they are at which stage of disease and what are possible lab test results depiction about the trends. But this is also lacking the part of sequencing of information on a filtered basis as required for representing single or multiple records in easiest way like doctors notes on side frames if introduced separately regards to any particular lab tests.

Timeline [7] another ontological data derivation to represent data against a time that is famous most quoted application utilized mostly for temporal data patterns visualization. This application is based on data access, data mapping and data visualization using pattern approach same on entity based division. Data is retrieved from databases and shown by the help of different icons facility in interface. Icon based interface approach is adopted here to segregate different portions of application and its functionality on a time based line. Even still its pended with some of the exact fields representation missing in visual interface with same medical terminologies as being used for nomination within different domains e.g. treatment responses again tumor development and decay etc. 2D and 3D visualization interfaces are also one of the development started quite early within these kind of EHR applications and various frameworks have been proposed like classification of data segments from text, graphics, and picture vs. video [10], using metaphor graphics in VIE-VISU [11] including multiples to identify the progress of patient in various phases against a disease or status in a hospital depending upon medical condition from wards to ICU as also represented in figure 1 showing intake of fluids and urinary output in an ICU environment.



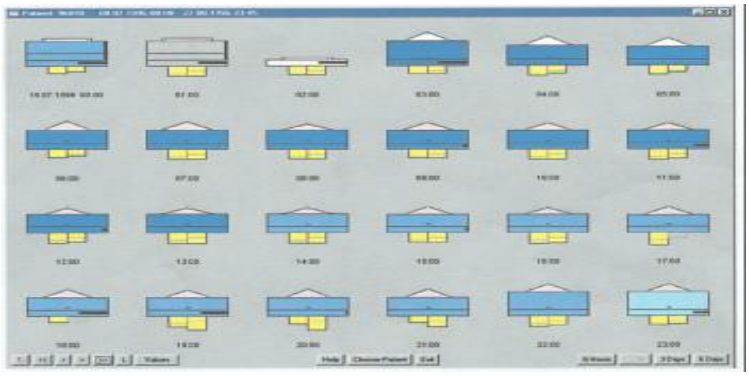


Fig. 1: Screenshot of VIE-VISU (From Horn et al.)

Based on this above approach most of the modern applications focused on increasing the efficiency of EHR tools interfaces like recent works of Adapt EHR is one of representing a framework of disease and chronological events of patient history on multiple window based environment [8]. Framework relating to this application depicts on ontological models used in various neurons based diseases and potential effects of evaluation of drugs within the passage of time for that effects. Data retrieval, integration and data annotation are used as primary part within this framework naming under biological ontologies while functionality is based on graphic model based on BBNs (Bayesian Belief Networks). Relational integration of variables, inter connections of various events and parameters are key role playing factors to represent the survival as well as variance among variables. Markov assumption and markov blanket are majorly represented to assess the sequence of various variables and then to aggregate a joint effect in the form of pattern representation showing a contextual approach[8]. This is mostly adapted as due to absence of a standardized disease model as based on various health care practices in different countries adapted.

Closely related to this similar variable representation for showing more understandability in a user interface in 2D applications LOD (Level of Demand) is also developed [4]. This is dividing a body model into 5 different layers so that division of representation of record details can be retrieved on organ based approach from viewer'perspective. This tries to encompass a graphical interface switching between five different layers based approach. Although an approach to simplify the process of details retrieval but time consuming in case of multiple data records retrieval for a general comparison or role of medicine influence in a set of different patients given similar kind of doses.

Sequencing of event patterns is another approach to organize the events and compare them for a clinician's query based on a pattern resulted in Life Flow application[12]. Life Flow is an application to visualize the summarized view of multiple EHR records at same pane with time line frames and inheriting most of the properties of Lifeline 1 and LifeLine2 and also can represent the similar view comparison of temporal events in a sequence format.

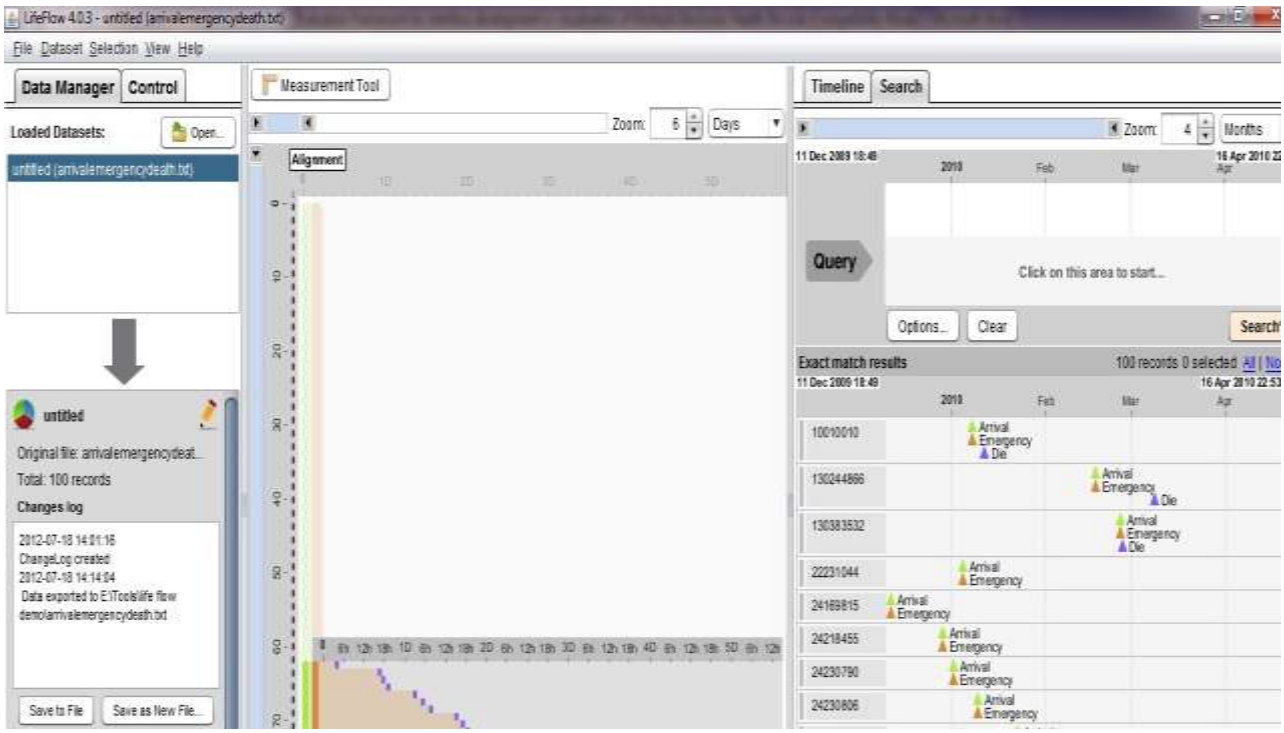


Fig 2: Screenshot of Life Flow (From Wang et al.)

The above mentioned picture is representing the data of arrival, emergency and death of patients associated with a patient ID on different number of days and represented with triangles marked for either three of them in a complex set of file. If look on the side panes it's also showing the graphical representation about number of arrivals, deaths and emergencies but it's confusing sometimes to match the information together. Also pane details regards to death arrival comments or other details are not randomly generated with this interface. Laters on Craig[1] tried to present a single interface by collaborating the resources of records in a central location for helping physician to interpret the maximum data via visualization. Multiple separate view panes comprises an interface to better understand patient history and exploring temporal data trends based on physician query within EHR. This interface framework addresses the information flow in EHR just like bed to bed daily report files as adapted in normal hospital wards. Elimination of unnecessary information details in front of the physicians is a key factor while gathering the information visualization without depicting its coherent details on a user interface thus focusing more on adaptability.

All above frameworks, applications and models used within those tried to focus on functionality related to information retrieval but missing a major factor of user adaptability due to absence of an evaluation metrics framework for such applications interfaces. Different evaluations are carried out for different applications by using the requirements of physicians based on their need based query set either by case studies within this projects or by use of single of multiple small level groups with minimized study focus areas. But there is a strong demand of evaluation framework for identifying the capability of adaptability within running clinics, hospital centres and other resources as due to of non trivial applications , incomplete architectural structure of whole EHR and EMR systems in prevailing conditions due to economic conditions as well as also less attention to this area for medical applications using information visualization satisfactory factors in balanced groups [13].

Near medical professionals most important thing is satisfaction with reference to an information visualization based on give set of query set based on requirements meeting as well ease of understanding of application thus encouraging faster adaptability and usability in day to day operations. Uncompleted information provision and difficult understanding of a complex systems leads to lower the usability of an even best functionality generating EHR system. As most of doctors may lose the role of interest due to more information key punching than observing more about patient disease and human interaction behaviour. Thus here the importance of an evaluation framework arised for giving better sequence of research in development of EHR application interfaces and applications.

The proposed framework proposes a structure encompassing all the key factors to be considered important while presenting the information flow within a information visualization so that each stake holder i.e. application developer, information visualization designer and clinician could be kept on a streamlined process.

This is also being implemented as a part of our ongoing research while in phase of methodology developmental stage to better focus these areas as well as better idea not to miss the salient key roles within usability of an EHR application with reference to requirements of doctors on case to case varying structure. Although each case study in medical science varies but this framework refers to a generalized situation thus encompassing its role to more easier and understandable way for evaluation of an EHR application requirements.

Discussion For Evaluation-Framework

Any EHR application processes must be complying to client or users usability demands using user centred design (UCD) approach based on set standards of Usability Maturity Model relating to demands of processes it used for any EHR application [14]. This is key concept and method for deriving this evaluation framework for completely making it closer to a single principle that an interface for EHR applications should comply with the requirements of clinician or physician or its end users. If a very best EHR application in retrieving information is failed to comply with basic rules of usability it results in the phase of unacceptance frequently by its end users as resulting frustration and complexity of information understanding.

The following evaluation framework CARE Flow1.0 for EHR comprises on the basis of three major portions as People, Process and EHR Product *Qualities.* As a framework basically provides the base necessities to develop a system or application to its stake holders i.e. including its users, developers and visual designers in this case. As requests are passed by physicians or normally the people of the rank of health care managers for certain query set and information processes from multiple resources presented in a form of a visualization. This resulting visualization will show only true the point information to the users rather than extra related info e.g. in case of urine test reports for last 6 months in a diabetic patient should show urine decomposition but not required to visualize the status of intestinal infection if any , till it is required as fulfilling the base purpose of EHR usability efficiency clause[15] [14].

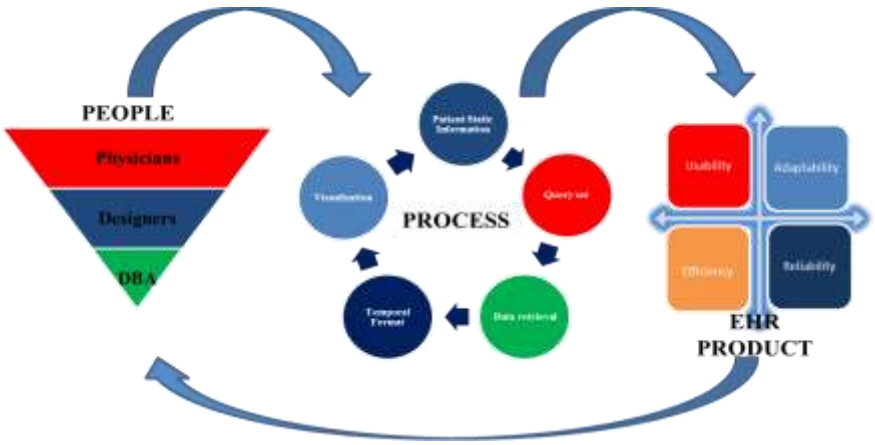


Fig. 3: Care Flow 1.0 for EHR Visualization

The above mentioned framework consists of majorly three portions that is divided as:

a) PEOPLE
b) PROCESS
c) EHR PRODUCT

Each of these components are associated with each other and inter related to context of information from cognitive to inter operable approach within this system. Later section contains the details about it.

a) PEOPLE

As in every EHR system the users are considered very important part of that system relating to its developers who develop it on the basis of requirements produced by the doctors, product/project managers as well as nursing people or any other one who is involved in its use. Designers help in designing the outlook and visual representation of information as per desired requirement and in some cases developers and designers role both are merged as well based whether organization is smaller or budget constraints. Information flows from doctors in the form of a query set to retrieve information and is sent for the next cycle of framework and results are retrieved and visualized by either single set of person i.e. doctors or could be by multiple set of people including physicians and developers/designers as well.

b) PROCESS

The process within this framework represents the transition state after the cognitive interconnection of its users for visual representation of temporal data with relation to events and activities related to patients. There are filters and data view zooming sections referred to data extraction from single or collaborative resources much quite similar to already existing approaches but in a conjunct way in this framework [5] [1]. This portion of framework mostly refer to quantitative part as due to results extraction and visual representation while the next portion is more towards the qualitative side. Resulting visualization should satisfy the stake holders requirements based on its associated qualitative characteristics within EHR application phase. This portion is connected with both phases to maintain the pyramid of quality.

c) EHR PRODUCT

An EHR product how much good it is mostly checked on the basis of number of qualitative factors and if categorized they are usability, adaptability, efficiency and reliability with reference to its stake holders request [14]. The basic purpose of keeping this in our evaluation framework is to determine the quality of the EHR application whether it should not come in utility as that differs more than usability means to ease of understanding to use with the help of interfaces. Clinicians are more concerned with the interface operability whether they are more easier to understand the words, icons, colour schemes, disease and organ parameters changes, any notes understanding, medication recommendations & dosage specifications variations as well as multiple patients data inferences for special event without intervening much. This will result in easy adaptability and more reliability based on the factor of temporal data representations associated with certain objects. This phase is interconnected with all previous phases so that only more focus should not to make an interface good just by figures but it should provide easy and to the point information in a visualization to clinicians and other stake holders.

Conclusion & Future Work

This research work is a part of ongoing work for designing a complete Visual Analytic System CARE1.0 for multiple EHR representation for its multiple stake holders including physicians, designers and database administrators. Visual interfaces play a vital role for primary beneficiaries of EHR i.e. clinicians and any medical program/project managers to identify facts without wasting time on extra windows, dialogue boxes or extra number of steps. This framework represents not only the base of an EHR applications but also the evaluation characteristics that it should posses within different phases for usability and adaptability in existing health care units with existing data sets. A details empirical study for validation of its different phases is going on using survey and focus group methods. This will help in determining the future prospects for fast adaptation of EHR systems in health care units within evaluated and controlled format to better encapsulate the information in visualization. More work is required in determining the factors that are involved in removing temporal formats mismatches within different applications adapted in different health care units. As still different hospitals and health units do not follow similar kind of standards and vary from one another so the visualizations may generate different kind of results in temporal form for different scenerios and cases. This kind of work can be used in other areas like agriculture, weather forecast and stock exchange where temporal data representations are based on their stake holder query set and required format. But more validation is required on case to case basis and more future work is still required in areas of interfaces dimensions and division of complexities of information representations while making it simpler but showing more information with reference to existing applications.

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