

Visualization of Patient Data at Different Temporal Granularities on Mobile Devices

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ABSTRACT

The capability of accessing, analyzing and possibly updating patients' medical records from anywhere through a mobile device in the hands of clinicians and nurses is considered to be a particularly promising application. Information Visualization has explored interactive visual formats to help users in analyzing patient records, but they are meant for the desktop context. This paper begins to explore the problem of visualizing patient record data with the limited display and interaction capabilities of mobile devices, focusing on common PDAs and temporal data.

Categories and Subject Descriptors

H.5.2 [Information interfaces and presentation]: *User Interfaces – Screen Design (graphics)* J.3 [Life and medical sciences]: *Medical information systems*

Keywords

Information visualization, patient records, mobile devices.

1. INTRODUCTION

Recent years have seen a growing interest towards the adoption of mobile devices by the medical community [2, 3, 7, 8, 12, 15]. In particular, the capability of accessing, analyzing and possibly updating patients' medical records from anywhere through a mobile device in the hands of clinicians and nurses is considered to be a particularly promising application. Besides clinical contexts, mobile solutions can be useful also for homecare contexts, e.g. as electronic diaries that can be kept by the patient's carers (or the patient herself, if her condition allows to) to collect patient's history, improving efficiency and effectiveness of communication between doctors, carers and patients [7].

Information Visualization techniques have been used to visually present patient data in more intuitive and easy to navigate ways, in order to help users in analyzing and managing patient records [4,6,9,10,11]. Unfortunately, the proposed systems are meant for

the standard desktop computer scenario and cannot be trivially downscaled to the limited screens and interaction techniques of mobile devices (a thorough discussion of information visualization issues on mobile devices is provided in [5]).

Recently, Ardito, Buono and Costabile [1] have proposed the PHiP system, which aims at bringing visualizations of patient histories inspired by Lifelines [9,10] to PDAs. Our work is different and complementary in two main ways. First, while PHiP uses a single time granularity, we specifically focus on addressing the problem of handling multiple temporal granularities. Second, while PHiP has concentrated mainly on events and intervals, we extend our analysis to quantitative temporal series to deal with other kinds of patient data (such as temperature and blood pressure) that typically belong to patient records. The visualizations are employed in a prototype we implemented on the PocketPC platform, considering the currently most common screen resolution, i.e. 240*320 pixels.

2. PROPOSED SOLUTION

In this section, we propose six different visualizations: four of them are detailed visualizations of specific types of data, the other two are overviews of all the considered data. We first present some general features of the interface that allows one to interact with the visualizations, then we discuss each of the visualizations.

2.1 Common features

The data we consider belong to the temporal category in the taxonomy proposed by [13]. We employ a temporal representation at multiple granularity levels (minutes, hours, days, weeks, months). We exploit multiple granularities also to face the data presentation problem on small screens by allowing the user to switch among granularities to get coarser visualizations of large quantities of data and then focus on finer visualizations of selected subsets of data. All 6 visualizations share thus some common interface features to manage the temporal aspect: a timeline, a temporal scroll-bar, and zoom buttons (see Fig. 1). The timeline is graphically divided into two parts: when the user chooses coarser levels of temporal granularity, the upper part of the timeline indicates the weeks (or the days), while the lower part shows month and year; when the user chooses finer temporal granularities, the upper part shows the hours (or the minutes) and the lower one the date. The level of temporal granularity is chosen by tapping on the zoom buttons at the left of the timeline (the chosen level of granularity in Figure 1 is days). The scroll-bar allows the user to scroll the visualization when it is not possible to display all data in one screen at the selected temporal granularity.

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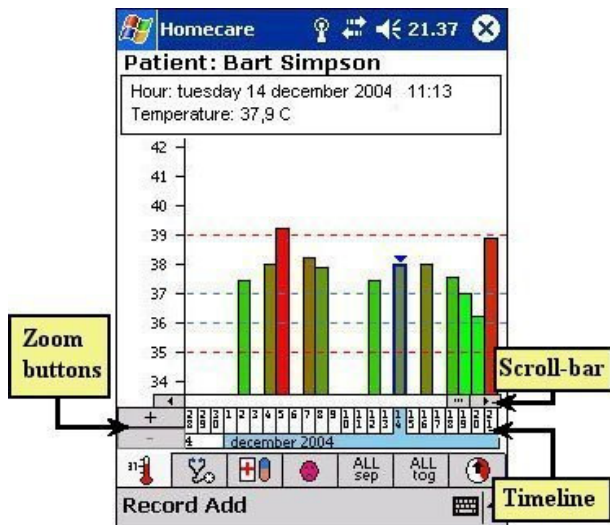


Figure 1. Temperature visualization

The different visualizations are presented in a tabbed panel; the tabs are located below the visualization to allow for a more practical selection with the stylus. In each visualization, the screen is divided into 24 parts, each one corresponding to a temporal unit of the chosen granularity. When the chosen granularity is hours, it is thus possible to analyze a full day on a single screen without scrolling.

All the visualizations support a details-on-demand functionality: the user can tap any graphic element and get detailed information about the corresponding data in a box located in the upper area of the screen (see, e.g., Fig. 1). When an element of a visualization is selected, it is graphically highlighted by a blue edge and a little blue arrow over it (for temperatures and blood pressures) or by a blue background (for medicines and events).

2.2 Visualizations of single types of data

Each of the first four visualizations we present concerns a single type of data: temperature, blood pressure, medicines or events.

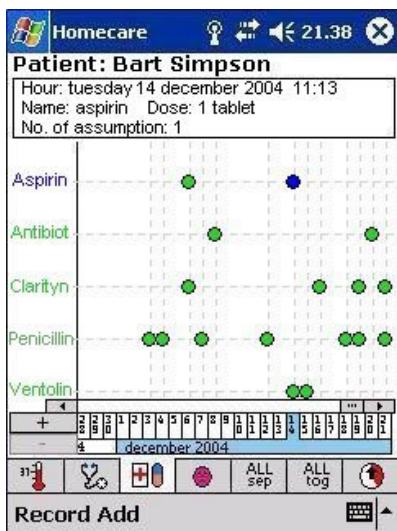


Figure 3. Medicines visualization

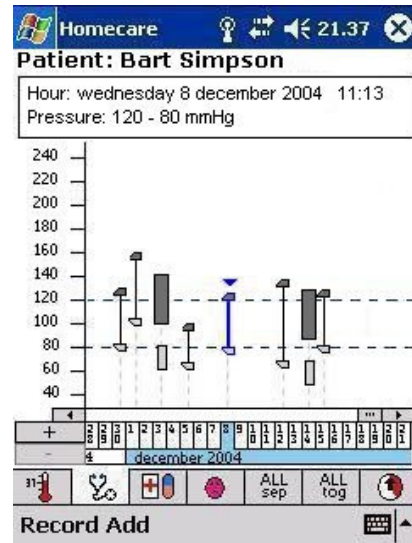


Figure 2. Blood pressure visualization

Temperature data (Fig. 1) are represented using bar charts. We adopted this solution because bar charts have the advantage of being very familiar to clinicians and thus do not need to be learned. Moreover, they are known to allow for an easy comparison among data values (see [14] for a discussion). When working with multiple granularities, the level of temporal granularity of a visualization can be coarser than the granularity of the measurements. As a result, more than one measurement can fall in the same temporal unit. When this happens, a single bar in our temperature visualization represents aggregated multiple measurements. In particular, the bar displays the highest among the aggregated measurements (this ensures that the highest temperature values are always pointed out, regardless of the granularity chosen by the user). Temperature values are visually mapped both on the height and the color of the bar. The color scale is based on a red-green-red sequence (where red corresponds to abnormal and green to normal temperatures) and the color of a bar is computed by interpolation. Since the blue-red scale is a common choice for temperature values (e.g., weather reports, water tap scale, thermostats,...), we had initially tried that scale but with unsatisfactory results: for values in the range of normality, interpolation produced colors that were not easy to visually discriminate.

Single measurements of blood pressure (Fig. 2) are represented using two grey marks connected by a vertical line: the upper one (darker) shows the systolic pressure and the lower one (lighter) the diastolic one. For aggregate multiple measurements, we use two grey bars representing ranges: the darker one is the systolic pressure range, the lighter one is the diastolic pressure range.

Administrations of medicines (Fig. 3) and events of medical interest (Fig. 4) are mapped into a visualization inspired by Lifelines [9,10]. Administrations of medicines are represented by circles (Fig. 3): their horizontal position identifies when they have been administered to the patient; their vertical position identifies medicine name. Color is used to indicate if the circle refers to a single administration of the medicine or temporally aggregated multiple administrations. For events of medical interest (Fig. 4), a cross is used to represent an event that happened at a given instant (e.g., the patient fell from the stairs), while events with duration (e.g., headache) are represented by an horizontal bar that spans

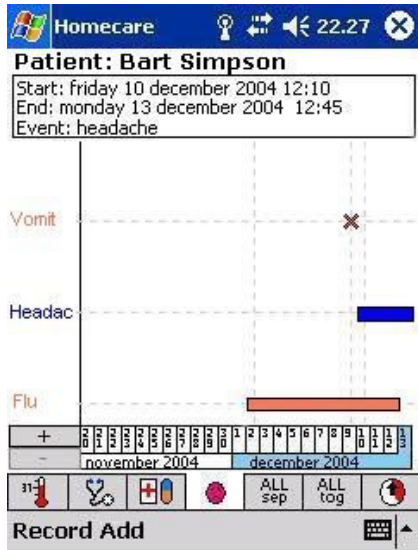


Figure 4. Event visualization

the entire duration of the event.

2.3 Overview visualizations

The visualizations we discuss in this section provide overviews of the four types of considered data in a single screen to give the user the possibility of visually relating them.

Due to the limited screen resolution, showing the four types of data simultaneously is not trivial. The first overview visualization (Fig. 5) tries to face the problem by drawing the 4 data visualizations in different areas of the same screen. Although this solution is simple and does not require to learn any new visual conventions with respect to the single data visualizations, it suffers from limited height of the display area that can be assigned to each data type. This can make the visualization difficult to read in some cases, especially for the pressure data.

The second overview visualization (Fig. 6) aims at overcoming the limitations of the first by allowing the user to rearrange and

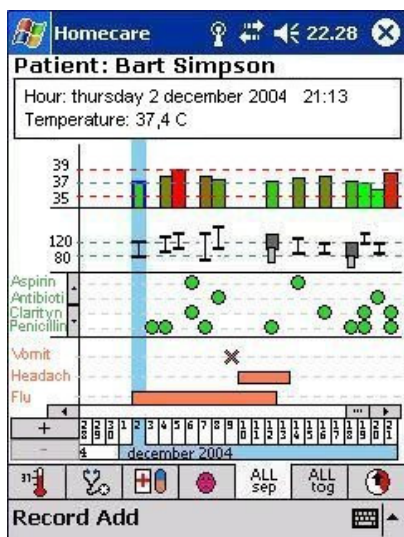


Figure 5. First overview visualization

possibly overlap the four data types, and introducing an alternative way of visualizing pressure and temperature through a broken line chart. Circles in the chart identify measurements, and the vertical position of a measurement indicates how close or far its value is from normality (a normality range can be defined by the user for each patient, and a part of the axis on the left in the visualization is green to highlight normality, while the two remaining parts are red). This is based on an idea discussed by Powsner and Tufte who point out how the use of scaled values simplifies interpretation when gross vertical displacement corresponds to clinical significance [11]. In this way, although this visualization loses details (it does not show the precise values), it can simplify interpretation of data: users are informed at-a-glance if temperature and pressures are normal, high or low. If the user needs a more detailed account of values, she can switch to previously described visualizations. The medicines and events visualizations do not change with respect to the first overview visualization, but they can be moved up and down by tapping and dragging with the stylus on the screen. In this way, the user can arrange the visualization of the four types of data on the screen in the way that she finds most readable. To further extend the possibility of rearranging the visualization, the four buttons above the visualization allow the user to turn on or off each of the four data types. In Fig. 6, all four data types are shown and the button labels indicate that. If a data type is turned off, a “NO” appears on the corresponding label (e.g., “NO Pressure”).

2.4 Entering data

Users enter data into the system through interactive forms based on the standard widgets of PocketPC applications. For example, Fig. 7 shows the form for entering pressure data: hour and date information are automatically proposed by the system based on current time (but the user can change them, if needed), pressure data can be entered either by moving the two sliders or directly.

3. CONCLUSIONS

This paper motivated and proposed visualizations for analyzing typical patient data on mobile devices at multiple temporal

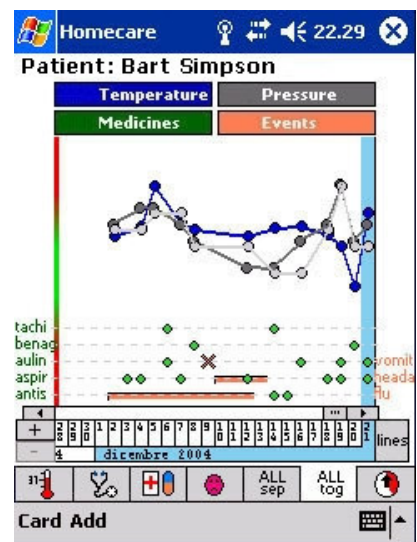


Figure 6. Second overview visualization

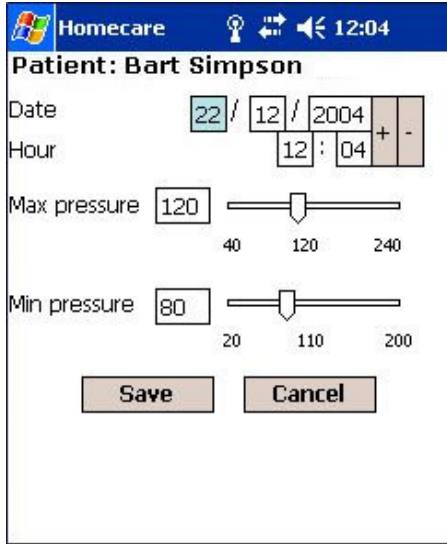


Figure 7. Pressure Data Input

granularities. Our project is currently proceeding in two main directions.

First, as previously mentioned, the data that we have chosen to visualize in the prototype are those typically found in most medical records, to make the application potentially useful in several medical domains. We are now working at identifying additional information that could be useful, and how to properly visualize them.

Second, since the prototype has been informally tested on only one clinician, a more thorough evaluation of the system strengths and weaknesses in clinical and homecare contexts is needed.

4. ACKNOWLEDGMENTS

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