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Abstract
The Care and Condition Monitor (CCM) is a tablet-based, networked visual analytics tool for collecting, structuring and analyzing informal and qualitative healthcare data. Building off research into application usability and best practices for communicating complex information, CCM illustrates how visual analytics tools coupled with social communication within teams of caregivers enables capturing of longitudinal informal data that would otherwise go unrecorded.
This expanded scope of information can support medical decision making by making it possible to analyze informal and qualitative health care data, creating a multi-dimensional holistic picture of a person's health care and condition over time.

Author Keywords
Health informatics, informal data, long term care, mobile platforms, qualitative data, visual analytics.

ACM Classification Keywords
B.4.1 Data Communication Devices [Mobile Device]; H.5.2 User Interfaces [Prototyping]; J.3 Medical information Systems [Health];

Introduction

The Care and Condition Monitor (CCM) is a tablet based visual analytics tool that uses a simple voting strategy to collect and structure informal and qualitative healthcare data, presenting it in a circular visualization format to represent the data. Belden et al. established the following usability design principles relevant to healthcare delivery: (a) minimize caregiver cognitive load, (b) design for UI simplicity, naturalness and consistency, (c) make color meaningful, and (d) preserve context [1]. These principles guided the development of the application, ensuring it presents information in a simple and intuitive manner to caregivers: in the CCM, visualizations of data are prominently displayed in order to prompt user analysis, and visual and input complexity is reduced by only displaying relevant menus and functions to the task at hand, providing cues as to when a particular action is available.

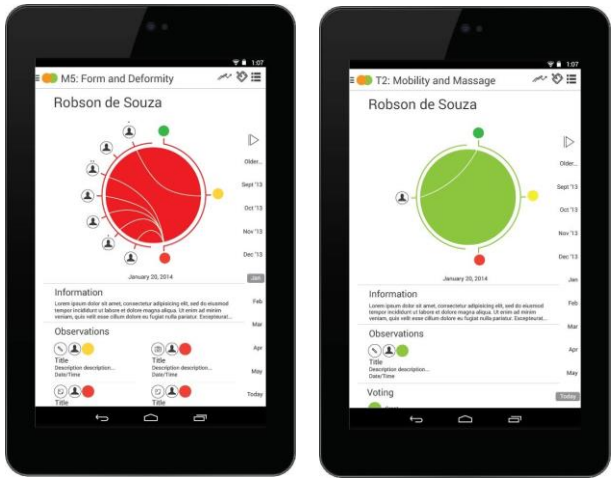
CCM was tailored to support the existing practices of caregivers at the partner facility, Clemente Ferreira CAIS hospital in Lins, Brazil, a long term care residential institution for people with a range of congenital mental and physical conditions. In CAIS, like many care facilities, in addition to traditional medical forms and notebooks, caregivers rely on informal communication practices, such as conversations at shift change, to analyze the full picture of a resident's status. The design of the application and research focused on capturing and translating informal practices into a system of qualitative data analysis that supports the caregivers' culture and practices, reinforces CAIS's sense of community, improves collaboration across professional categories, and improves overall understanding of care and condition data. The last two points, care and condition, were identified through the research of the CCM team as components of resident well-being which were necessary to record, visualize, and foster collaboration around. Condition is measured by five metrics (general health, morale, cognition, mobility and form) that were derived from CAIS's records and are standardized for all residents. Care, on the other hand, is individualized and organized around care goals tailored to the needs of each resident and translated into action that are described as treatments.

The Prototype

Clearly communicating recorded condition and care data became the core of the application design effort. The main component of this, the visualization/analysis system for the application, was guided by the work of Yi, et al. On insight formation Yi, et al. speculate that, "an insight does not appear suddenly "out of the blue," but instead there are paths or procedures leading to the insight" [3]. Two procedures Yi, et al. identifie bear specific relevance: Provide Overview and Adjust. Through Provide Overview users understand the larger body of relevant data. The Adjust process facilitates that exploration. This is achieved by changing perspective on the data through adjustments to the level of abstraction and data range selected. [3].

Taking these processes of insight generation into account, combined with Belden et al.'s principles, the core structure of the application was designed to provide a clear overview of data wherever possible. For example, by coupling the core navigation system for the app with the data visualization the user is rewarded for navigating through the application's various screens. She or he is always presented with a new unique visualization on each screen. Navigating down into the app from a user's profile into a particular treatment acts to filter the data range being viewed in the accompanying visualization, switching from an overview visualization of the patients care/condition to only visualizing that one treatment. This system provides the user with a clear conceptual model of how the data relates and assists in making more informed judgments. As Don Norman notes in his seminal book,

The Design of Everyday Things, "conceptual models allow us to predict the effect of our actions" [5].



(a) (b)

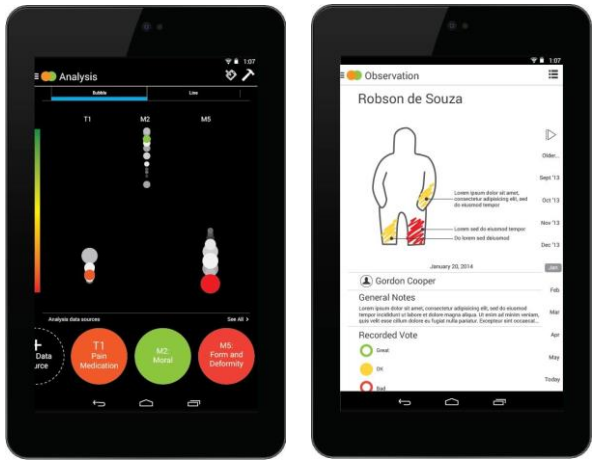
Figure 1(a) & (b): Care and condition visualizations.

The visualizations of caregivers' votes for treatments and condition metrics use a simple input system consisting of three possible states: green for positive, yellow for neutral, and red for negative. These are then aggregated and mapped along the green/yellow/red spectrum in the large coloured dot in the centre of the display. While this dot provides overview, building from Donath and Zhang et al.'s work [2][4], additional detail is also provided. The individual care or condition metrics that the central circle is derived from are arranged around one side of the circle along with the caregiver involved. The state of each metric (green, yellow, red) is indicated around the opposite side. Curved lines join the metrics, on one side, to the states, on the other.

The very process of creating these data visualizations has the additional benefit of fostering collaboration between caregivers, as it is integral to the cyclical relationship between a resident's condition and care. Condition, which is recorded by all caregivers, prompts the creation of new care goals, which are delivered by multiple caregivers and ultimately influence back upon the condition. As per Donath, the circular layout also spatializes the social relationship between the resident and his or her circle of care. It assists the user to build a mental map of the information structure, displaying who is participating on a given care goal, each caregiver's unique treatments, and those caregiver's recorded votes for those treatments.

Lastly, longitudinal data analysis and review is afforded in this setup by a mechanism by which a caregiver can scrub back and forwards in time in any visualization to understand change over time for a care or condition metric.

Deeper analysis of the data than is possible through the visualizations or time scrubbing mechanics is facilitated by an analysis function to graphically compare two or more datasets (condition metric, care goal/treatment). In the analysis function, a user can change visualization mechanisms, switching between a straightforward line graph or a novel bubble history view that allows for simultaneous visualization of the historical change in votes and the volume of voting activity. These analyses are created by navigating to each data set's visualization and selecting the analysis button. This provides the caregiver with the option to add that visualization's data to the analysis currently underway or to create a new analysis starting with that visualization's data. These analysis results and parameters can be saved for future reference.



(a) **(b)**

Figure 2(a): Bubble Analysis **(b)** Sketch observation.

Additional information is displayed on each app screen alongside the main visualization, such as observations recorded in any media that relate to it and the caregiver who recorded it. This information currently cannot be analyzed or visualized, yet it serves as a compliment to the structured observations produced by voting results. It also serves to facilitate communication between caregivers by readily displaying the activities and contributions by other caregivers. Such communication is enabled by an inter-application messaging system that combines both explicit and implicit messages into one unified messaging hub. In it direct messages between caregivers are collected in the messages page alongside invitations to collaborate on care goals for residents, which are automatically (implicitly) generated when a new care goal is created and caregivers are invited to it.

Conclusion

Although a work-in-progress, CCM illustrates and presents methods to collect and analyze informal and qualitative health care data while simultaneously fostering an environment of collaboration around care and condition in long-term healthcare environments. Future steps include the development of a high-fidelity prototype for testing and evaluation with healthcare workers regarding issues such as 'voter fatigue', vote weighting, which condition metrics to use in what context, usability and navigation.[i]

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