From Personal Health Informatics to Health Self-management

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Abstract
Our research team is developing Salud!, an open and free infrastructure for developing and deploying personal health informatics applications. In addition, we are investigating and designing interaction techniques that support individuals engaged in health self-management. These interaction techniques make use of personal informatics applications' potential to guide users through experiences of personal mastery, which are an effective method for increasing self-efficacy—a key factor in the success of self-management efforts. The goals of this position paper are two-fold: (1) to present the Salud! infrastructure and invite interested researchers from the personal informatics community to make use of this resource; and (2) to initiate a discussion about how personal informatics applications could support goal management for those users for whom such functionality would be desirable.

Keywords
Personal health informatics, self-efficacy, IT

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction

Health self-management education seeks to empower individuals living with chronic illness to improve their quality of life and health outcomes by making informed decisions about actions and behaviors that effect their health. Individuals taking part in such educational programs are taught problem-solving skills which, combined with the disease-specific information and technical skills taught in traditional patient education, enable them to identify health problems and take the actions necessary to overcome them [2]. Because individuals participating in health self-management education programs learn to understand relationships between their health status and behavioral and/or environmental factors (e.g. diet, physical activity, and so forth), personal informatics software has been shown to be helpful in this context [4, 6].

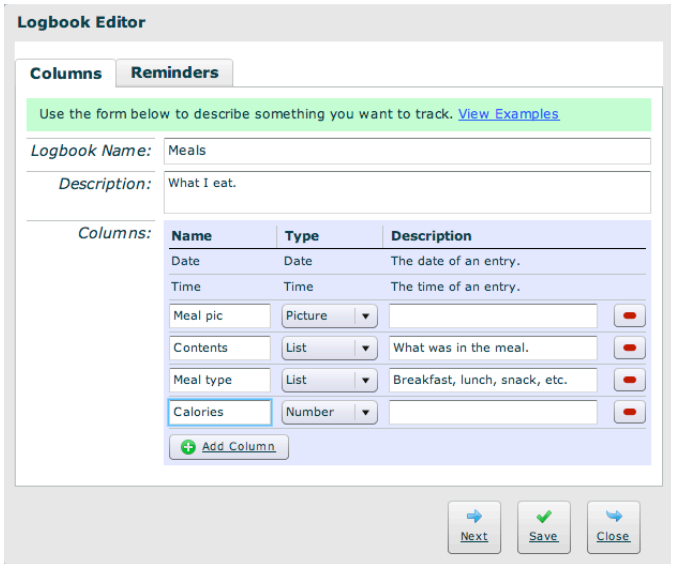

Figure 1. Example of a Logbook created by a user of the Salud! application.

While there are general health self-management strategies which are effective in improving health outcomes for individuals living with a range of chronic conditions [5], these strategies must nonetheless be made relevant to specific chronic conditions. Similarly, personal health informatics applications based on health self-management principles are generally targeted toward a specific chronic condition, such as diabetes or asthma.

This burgeoning interest in personal health informatics applications led us to design and develop an open web services infrastructure that would allow interested researchers to more easily develop and deploy such applications. We strive for two complementary goals:

1. To provide a set of easy-to-use web services that incorporate best practices and common paradigms for personal health informatics applications.
2. To provide a flexible, extensible set of personal informatics tools that can be customized by researchers to support a broad range of health self-management interventions.

Our project, titled Salud!, provides a ready-made backend to facilitate the development and deployment of a range of end-user applications. We are making Salud! available to the broader research community as a set of web service APIs. Documentation and sample source code to utilize the Salud! API are provided on our developer wiki at http://wiki.cc.gatech.edu/salud. Researchers and developers interested in integrating with the infrastructure are encouraged to contact the primary author.

We are also developing an personal health informatics application, targeted at end-users, using the Salud! infrastructure. This application allows users to track self-selected data variables using the full range of input mechanisms supported by Salud! (see below) and provides basic analytics tools to review and analyze the collected data (see Figures 1 and 2). The application is available at http://salud.cc.gatech.edu.

Our goal for creating the Salud! application is to develop and deploy interfaces for health self-management. Because personal informatics can play an important role in health self-management, we are interested in designing interfaces that integrate with such applications to more thoroughly support the practice—specifically, the setting and achievement of personal health goals. Our current endeavors in this space, described in more detail later in this position paper, involve interfaces which guide users through experiences that increase self-efficacy [1], which in turn increases the chances of success of a health self-management endeavor.

The Salud! Infrastructure

The Salud! infrastructure is designed in line with principles culled from literature on health self-management and personal informatics applications, e.g. [1, 2, 5, 7]. In this section, we briefly describe several key aspects of the infrastructure. More detailed discussions of the design specifics are available elsewhere [8, 9].

Architecture Overview

The Salud! infrastructure and associated API allow researchers[1] to manage end-user accounts and data for a custom personal informatics application. All data stored on the Salud! infrastructure is associated with a particular end-user's account. Accounts can be created by end-users themselves through a simple registration page, or can be created programmatically by making an API call to the user management interface. Data in an account is organized into structures called Logbooks. A Logbook is a named collection of timestamped data points and each data point in a Logbook is called an entry. The simplest kind of Logbook consists of entries which only contain timestamps—for example, approximate times for when the account's owner reported going to the gym. In addition to timestamps, entries in a Logbook can contain other values, including numbers, text, and pictures. The number and type of these additional values are defined by a Logbook's columns, which are defined at the time of its creation and can also be changed later. The core Salud! API provides a set of web services for managing Logbooks and their entries.

The Salud! infrastructure also provides several services that facilitate data entry by end-users. Currently, all end-users can enter data into their own accounts via text messages, email, a smartphone application, and a web-based interface. Developers and researchers using the infrastructure can choose which services they make available to their end-users, and can also extend the data entry interface to fit their needs. In the remainder of this section, we will describe how various aspects of the design and architecture of the Salud! infrastructure can support personal health informatics applications.

Key Aspects of Salud!'s Design

All data stored in a user's account on the Salud! infrastructure is associated with a timestamp. This design decision leads from the importance of temporal relationships between variables in health self-management education. Helping individuals understand how physiological metrics are affected by behavioral and environmental factors is a key goal of health self-management education.

[1] We use the terms "researchers" and "developers" to refer to individuals who create applications that use the Salud! API and the term "end-users" to refer to the users of those applications.

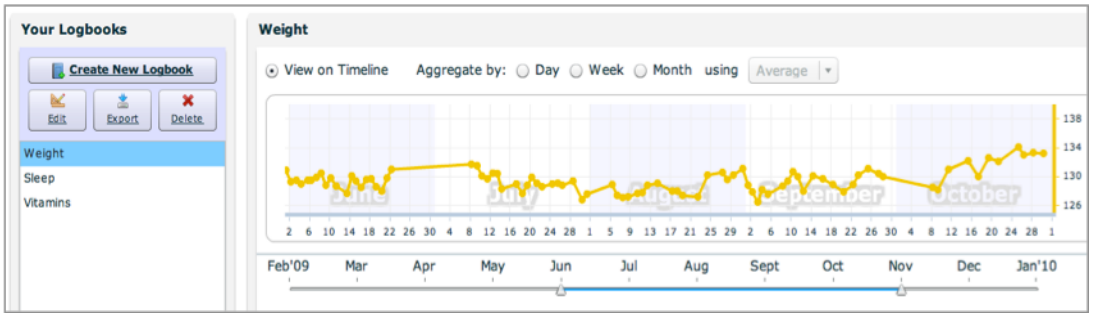

Figure 2. A portion of the Salud! application's interface, showing a user's self-reported weight measurements plotted on a timeline.

The infrastructure also provides a flexible data representation mechanism, which allows both developers and end-users to create Logbooks which track a wide range of data. Columns in Logbooks can hold text and numeric data, photos, and data which comes from sets (list data). Columns of the list data type allow for a middle ground between quantitative data and free-form text. List columns work akin to tag lists on social bookmarking services, in that a vocabulary is built up from data values entered into that column.

The Salud! infrastructure also explicitly allows incomplete data entries. Only a timestamp needs to be initially provided to create a new entry in a Logbook—all other columns (if any) can be populated at a later time. This functionality is meant to encourage prompt and accurate logging. At the time of an event or action that is being recorded (e.g. a meal, or an occurrence of chronic pain), an end-user may not have the time or desire to fill out a complete Logbook entry. In this case, she may choose to create only a minimal entry, noting only the time and possibly adding a picture (e.g. for a meal). Such entries can serve as placeholders and reminders until the end-user has more time to review them and input additional data.

Logbooks can contain image columns, which allow end-users to associate photos with individual Logbook entries. The infrastructure handles the storage, resizing and retrieval, so developers and researchers can incorporate photos or other images into their personal health informatics applications with less effort.

The final aspect of the Salud! infrastructure that we wish to highlight is the extensibility of the data entry system. We have developed several data entry interfaces to try to accommodate the preferences of a variety of end-users. Currently, individuals with Salud! accounts can create entries in their accounts via email, SMS/MMS messages, a mobile application, and a Flash-based online interface. There is additionally an API for managing and sending data entry reminders (currently text messages) to end-users. Importantly, however, Salud!'s data entry management web services make it straightforward to develop both automated and interactive data entry services for specific needs. Researchers can also request special system-level authentication tokens, which allow their applications to add or retrieve data from their end-users' accounts without requiring an interactive login. This functionality enables the creation of services which automatically populate data into end-users' Logbooks. For example, one research team used the Salud! infrastructure to develop a personal health informatics application for families with children with asthma, which regularly updated a Logbook with outdoor air quality data from sensors in end-users' neighborhoods. Similarly, services

could be developed that allow end-users to enter personal data via, Twitter posts, instant messages, etc.

Health Self-Management with Personal Informatics Applications

Personal informatics applications show promise for supporting individuals in meeting personal health and wellness goals. For example, a history of health and wellness data can provide opportunities to gain a deeper understanding of a health condition and reflect on the effectiveness of past actions [4, 6]. We are currently investigating how individuals can use personal informatics applications to effectively select and meet self-defined goals and are developing and evaluating generalized interaction techniques that support this activity. Specifically, we are focusing on experiences of personal mastery as a class of behavioral processes that support this process by increasing self-efficacy with respect to self-selected goals.

An individual's expectations of efficacy mediate the initiation of coping behaviors, as well as persistence in the face of failure. In fact, efficacy expectations are a better predictor of future performance than either past performance or outcome expectations [1]. Though there exist several methods by which individuals' self-efficacy may be raised, the most influential is performance accomplishments based on personal mastery [1]. In this scenario, the individual performs the same behaviors for which stronger self-efficacy is desired. Repeated successes raise mastery expectations (while repeated failures lower them).

In this section, we briefly outline two specific interfaces we are developing to support the achievement of personal goals through experiences of personal mastery. Both interfaces must be integrated into a personal informatics application, and will be built on top of the Salud! infrastructure. We are planning that necessary medical decision inputs will come from health professionals, via a Wizard-of-Oz setup [3].

Setting Actionable Goals

The first interface will encourage users to set actionable goals—those that can be directly performed. Action plans, which consist of actionable goals, have been found to increase the chance of success for health self-management programs [2].

When the user begins to set a goal, the system will evaluate whether the Logbook for which the goal will be set captures an activity over which the individual has direct control (in practice, a wizard will make these choices). For example, setting a goal for weight loss is not actionable—there are no activities which lead directly to weight loss. Instead, weight loss is usually achieved by changes in diet, increased physical activity, etc. Thus, related actionable goals may include reducing the daily or weekly consumption of calories, increasing one's step count (as measured by a pedometer), and so forth.

If a goal is inactionable, the system will suggest that the user additionally set a related, actionable goal. To do this, the user will be able to select an existing Logbook, create a new Logbook from a list of related actionable goals, (suggestions for related actionable Logbooks will be provided by the wizard), or create a completely custom Logbook that she judges to be actionable.

Interface to Support Effective Goal-setting

The second interface will support individuals in setting appropriate goal objectives. When an individual is beginning a new activity, she is likely to have a low perception of self-efficacy with respect to it [1]. To reduce the likelihood of failure, the individual should be encouraged to set goals that she feels she can achieve with confidence [2]. As such, the system will guide the user in selecting a short-term goal that she is confident about. As the user builds self-efficacy with respect to the goal, the system will gradually adjust the goal to provide for a more challenging experience. A key requirement of this interaction is the ability to gracefully handle missing data and failed goals. The interface should avoid passing any kind of judgment on the user's performance, as this may have an unintended effect on the user's perceived self-efficacy.

Workshop Goals

Due to the abbreviated format of a position paper, we have had to significantly limit the depth at which we discuss the Salud! infrastructre and our proposed interfaces. If accepted to the CHI 2010 "Know Thyself" workshop, we hope to contribute by:

- Presenting the Salud! infrastructure and seeking ways in which it can be made useful to other workshop participants; and
- Discussing our experiences in using the psychological concept of self-efficacy to design interfaces for personal informatics applications.

Acknowledgements

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