Gluballoon - an unobtrusive and educational way to better understand one's Diabetes

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ABSTRACT
Diabetes patients adjust their insulin injections according to their food consumption, physical activity and glucose levels. These adjustments are often trial-and-error, and newly diagnosed patients often use logbooks to catalog their daily activities and aid their physicians in developing an appropriate regimen.
Gluballoon is an electronic diabetes logbook that makes food/insulin/glucose/activity logging fun, easy and precise. Designed for newly diagnosed diabetes patients, working in conjunction with physicians, Gluballoon helps patients understand how their daily activities affect their blood glucose levels. The mobile service we built uses newly developed technologies to automatically log physical activity, insulin dosing and glucose levels. The collected data is compiled into a central service available from tablets, phones, and the web that displays their vital statistics (and the relationship between the statistics) in an easy and fun visual format.

Author Keywords Diabetes Management, Smart Insulin Pen, Motoactv, App, Visualization

ACM Classification Keywords H.5.2 User Interfaces (D.2.2, H.1.2, I.3.6): Graphical user interfaces (GUI), Input devices and strategies (e.g., mouse, touchscreen), Interaction styles (e.g., commands, menus, forms, direct manipulation); B.7.1 Types and Design Styles

General Terms Design, Documentation, Human Factors, Management, Measurement

INTRODUCTION
In the United States 25.8 million children and adults suffer from diabetes. 79 million people in the US have prediabetes, which becomes diabetes later in life, unless a healthy lifestyle including activity and healthy nutrition is promoted earlier in life. The complications of diabetes are various: Heart disease and stroke, high blood pressure, blindness, kidney disease, nervous system disease and amputations. This causes lots of costs for the health care system: $174 billon were spent on diagnosed diabetes patients in 2007 [3].

The most common form of diabetes is type 2: either the body does not produce enough insulin or the cells ignore the insulin. Insulin is necessary for the body to be able to use glucose for energy. The onset of type 2 diabetes can be prevented and the quality of life with it can be enhanced with a healthy lifestyle. Changing the diet, increasing the level of physical activity and maintaining a healthy weight contribute to a healthy lifestyle. Gluballoon is designed to foster a healthy lifestyle by giving feedback on those parameters. It displays them in relation to each other and provides a quick visual overview of the patient's current health status.

We wanted to create a simple interface that demonstrates the complex relationship between the factors that contribute to elevated or lowered blood glucose levels. After some iterative designs, we came to the *metaphor of a hot air balloon*. The height of the balloon represents the user's current blood glucose level. If it's too high, the balloon floats into the clouds, however if it is too low, it comes perilously close to a mountain top. This reflects the real life consequences of going too high (possible long-term effects) and going too low (diabetic coma and death). We wanted to visually indicate that both activity and manually injected insulin can bring the glucose level (and the balloon) down and represented these as sandbags hanging off of the balloon. We also wanted to show that food could raise the level of the balloon, so we placed an image of the most recent food that was logged inside of the balloon. Importantly, we do not need to know the exact calorie or carb count of the food as we know the exact values for all of the other parameters in the system.

The base framework used in the project was Indivo X, which is designed to support a rich ecosystem of third-party applications around a personally controlled health record (PCHR) as a web-based platform with feature-level substitutability [1]. CollaboRhythm, the platform Gluballoon was developed for, uses Indivo X as its backend. "CollaboRhythm is a platform that enables patients to be at the center of every interaction in their healthcare with the goal of encouraging them to be involved, reflective, and proactive so that they may become more self-efficacious." [2].

METHODS
We utilized a *MotoACTV fitness device* both to capture activity level (through step count) as well as to act as a wearable display for users to interact with their data through the Gluballoon visualization. We used step count

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as it is a good approximation of daily activity level for many people [3]. The step count was sampled on the device once every 15 minutes and if a network connection was present on the device, this data would be uploaded to the user's personal health record. Otherwise, data would be cached and uploaded in bulk at the next 15 minute interval when a data connection was available. The MotoACTV also presented a visualization of the Gluballoon as a custom watch face on the device. This visualization defaulted to the current day's balloon with the live step count from the device and data on insulin taken, blood glucose level, and food photos retrieved from the personal health record. Users could swipe back and forth on the watch face to see the balloons representing previous days and could double tap the screen to return to the current day. This interface can be seen in Figure 1.

In an effort to create a better insulin dosing logbook, we developed a *low-power insulin dosing sensor* that can be used in combination with any standard multi-use insulin pen. The sensor is designed to be small, convenient and easily attach to the body of the insulin pen. The insulin pen uses infrared light to determine changes in the inner mechanics or fluid contents of the insulin pen and reconstruct dosing information. The recorded data from the sensor is actively transferred to the Collaborhythm-enabled Gluballoon logbook through a Bluetooth interface, where it can be shared viewed and analyzed by the patient, family or a doctor.

The developed *plugin* focused on a visual metaphor used to represent the relationship between food, insulin, physical activity and glucose. The central metaphor was a *hot-air balloon* floating in the sky. The application was developed using the Adobe Air environment in the programming language FLEX. This has the advantage that it can work on either Android or Apple tablets. The only condition for it to work is that Adobe Air is installed on the device – therefore it is OS independent.

Food logging was accomplished through a simple Android application. Whenever the user ate, they could simply launch our food logging application which immediately opened the camera viewfinder on the device. Clicking once to take a photo, and once again to confirm that it's good and ready to be uploaded to their personal health record is the only effort required. This is much easier than current food logs that many physicians currently ask their patients to keep.

It also provides many benefits over manual log keeping. It has been shown that overweight individuals generally underestimate portion size and calorie count by close to 50% [4].

RESULTS

The resulting prototype combines all different sensors and forwards the data into the PCHR Indivo, which is the data basis for the visual demonstration of the health status. Figure 1 gives an overview on the structure of the prototype and illustrates the visualizations both on the Motoactv and the Tablet PC.

We validated the Gluballoon model both with clinical professionals as well as several individuals living with diabetes. They all agreed that the system vastly simplified the manual logkeeping that patients are supposed to be doing and that all of the major factors in understanding the diabetic condition were represented accurately. The yellow start in Figure 1 indicates the developments throughtout the Heealth and Wellness Innovation 2012, hosted by the MIT MediaLab PhD candidate, John Moore. By the way, please accept our best thanks.

Figure 1. The GluBalloon system with its sensor components above and its display possibilities on the bottom of the figure.

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