Hydrate with Friends: Promoting Positive Behavior via Ubiquitous Computing Technology and Social Interactions

Andrew H. Chang[1], Van E. Custodio[1], David Hirschberg[2], Thomas M. Kwak[1], Anirudh Sethi[2], and Alfred Kobsa[1]
[1]Department of Informatics, University of California, Irvine
[2]Department of Computer Science, University of California, Irvine

***Abstract*—The quantified self-movement has spurred technological innovations to help individuals track and monitor data about his or her health, habits, and behaviors. Currently, various apps and hardware applications exist on the marketplace, tracking anything from exercise to productivity. Research in this area is likewise burgeoning. One area of interest is that of personal hydration. It has been well documented that individuals do not drink enough water. Some devices have been developed to address this issue such as smart bottles and smart coasters. While often stylish in design, smart bottles tend to be cost-prohibitive and restrict the user to drinking out of one bottle. Existing smart coasters on the market also lean towards trendiness and often suffer with usability. We propose a new kind of smart coaster system named "Hydrate with Friends" that will implement previously researched design requirements, such as incentives and social media, for promoting positive behavior change. This paper outlines the process taken to prototype this system.**

I. Introduction

THE many products addressing hydration on the market are a testament to the need for technological tools to help track water consumption and motivate individuals to persist. As noted by the World Health Organization, the average male should consume 2.9 liters of water and the average female should consume 2.2 liters of water per day [3]. With the average US citizen drinking less than these above numbers, there is a need to at least motivate people to drink more water each day up to the standard [1]. Although forgoing water may not seem like a detrimental problem, the lack of water consumption can lead to unhealthy behaviors, such as lower levels of physical activity and lower levels of fruit and vegetable intake [2]. However, keeping track of an individual's water intake may not necessarily a priority due to the busy nature of each person's schedule.

To remove these unhealthy behaviors without consciously having to keep track of an individual's water consumption, we propose the idea of incentivizing the individual to drink water up to a certain goal each day. Although adding an incentive to something that each person should already do each day may seem a little absurd, the aim of this project is to increase awareness of healthier drinking habits while motivating people to achieve those healthier goals without adding too much overhead upon the people's daily schedules. In order to accomplish this, we intend to apply design features from prior research that will allow for ease of use as well as clear feedback of an individual's progress [4]. This design proposes to reward the user, support social interaction, display system progress, and consider the lifestyle of the user. The name "Hydrate with Friends" reflects the use of social interaction to promote positive behavior change.

Our work builds upon previous research, but uses a different perspective through which to think about designing for human behavior in ubiquitous computing. The framework that we have chosen to implement focuses more on supporting motivation for positive behavior over the accuracy of sensed actions. The emphasis here is on reaching a goal of proper hydration rather than hitting an exact target of water intake. While these goals may sound synonymous, the fundamental difference lies in how we build the system. Hitting a target is dependent on system accuracy. The system needs to cooperate with the user to reach a behavior goal. Therefore, the implementations of a rewards system and social media are used to positively facilitate that bridge between the user and the computer.

II. Related Research

Research in behavior change roots the work we set out to do. We will not explain the scientific motivation, but rather we will explore the role ubiquitous computing has in what is known as "Behavior Design" [5]. With the ability to use sensors to measure hydration, several researchers have taken on the task of studying various technologies in their effectiveness to help individuals reach and maintain their hydration goals. We will also survey research that broadly explores behavior change or persuasive computing.

One such project called "Show-Me" uses ambient lights from LEDs built into a showerhead to visualize water consumption [6]. The aim is to make users aware of the amount of water they were utilizing while taking a shower. The system provided a visual cue of LEDs lighting up as if to simulate water levels rising. The user study accompanying this product resulted in positive behavior during the intervention,

but no maintenance of the behavior afterwards. This perhaps could be addressed with a detailed tracker showing statistics and progress, a feature we implement in our prototype.

More directly related research in hydration also looks at the notifications aspect. The Playful Bottle integrates motion based sensing of water intake with mobile games [7]. Computer-mediated reminders are triggered by the data collected from the sensors. Participants of their study responded more quickly to social reminders compared to computer-generated reminders. Another approach taken with motion-based sensing uses wearable tech to detect drinking motions [8]. Notifications, however, are still being investigated for their persuasive efficacy [10]. Our prototype opts to defer on notification functionality in favor of the design framework we have chosen to implement. Social reminders in our system would arrive indirectly through social media integration.

III. Project Description

The implementation of "Hydrate with Friends" consists of three parts: the hardware implementation of the weight sensor, the software implementation of the sensor's information posting and retrieval mechanisms as well as the mobile user interface for checking an individual's daily progress, and a reward system for incentivizing the individual to keep up with his or her daily goals.

A. Hardware System

The purpose of the hardware system is to calculate the weight change between drinks. In our current design, we used a load cell combined with a custom wooden coaster for mass measurement capabilities. This is then connected to a load cell amplifier that communicates the mass of the container and its contents placed on the coaster. These components are connected to an Arduino Uno microcontroller board. We used an Arduino board due to its prototyping ability and onboard functionality. These mass readings are processed via logical stages encapsulated by the software running on a computer. The software calculates the change in mass of water, and sends the data to the database server over an Internet connection if a small threshold is surpassed as seen in Figure 1. A threshold is implemented to account for non-consumption factors, such as evaporation.

B. Software System

The purpose of the software linked with the Arduino board is to send the information to a cloud server for later retrieval. The Arduino board is configured using Java for Processing environment and a C/C++ variant for the hardware control. Once the program computes the difference in weight, the information is sent to a server, which consists of an Ubuntu operating system running on an Amazon Web Services server. To store the difference in volume from the sensor, a Java servlet appends a timestamp in milliseconds to each entry received from the sensor. The two pieces of data are then stored into a MySQL table dedicated solely for water data and timestamps. Another MySQL table contains usernames, passwords, and daily goal amounts for each user, which can currently be changed to be any value between 1000 and 5000 under the settings page of the website.

The purpose of the client side software is to show the user's progress and recent posts. The client side setup utilizes PHP to retrieve the data from the MySQL tables as seen in Figure 2. The user must first authorize a username and password so that the client side knows which data belongs to that user. The data that is pulled using PHP queries are then stored in JavaScript arrays for graphical displays and uploaded directly as HTML5 entries under the feed tab. For graphical displays, the water cup is a CSS3 graphic that calculates a percentage based on the quantity of the sum of all entries that have a timestamp between the beginning of the day to the current time divided by the daily water consumption goal. The graphs under the dashboard are created from the Charts.js framework and contain the MySQL data stored in JavaScript arrays. The graphs either contain 8 or 31 indexes depending on if the day view or if the month view is displayed, respectively. All other front-end rendering is created using HTML5, CSS3, and jQuery.

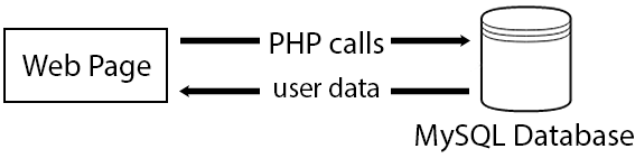

Fig. 2. Diagram between front-end webpage and Amazon Web Services MySQL database. PHP calls query for username, password, daily goal amounts, and all entries for the user. The MySQL database sends these items back, which are then used to populate the page.

C. Reward System

The reward system in our current design is purely conceptual. Users earn points every time they reach their daily goal. We have opted not to reward points proportional to the amount of water consumed, as we anticipated that this could potentially encourage excess water consumption, an undesirable and unhealthy behavior [9].

D. Lifestyle Consideration

Since people likely drink water in different locations, we plan for future iterations of our system to support multiple coasters. A user could have one in the home, at work, and in the car, for example. This would support the busy and active lifestyle that many users may experience in their everyday lives.

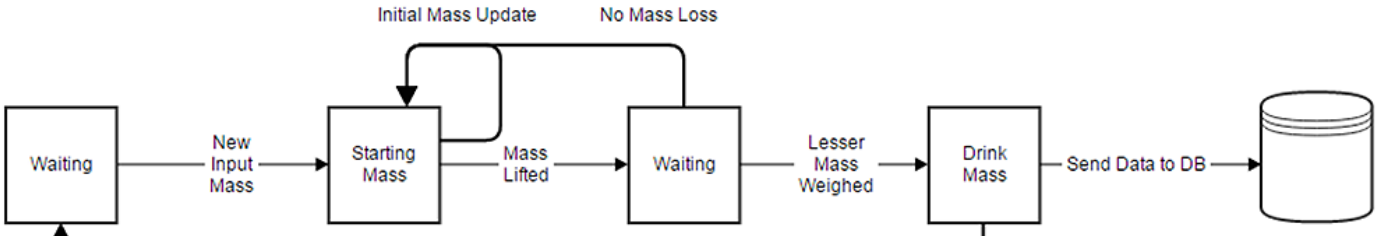

Fig. 1. Diagram of software logic showing the process of gathering and sending data from the user to the database for further use. The difference in mass (grams) is sent to the database and stored within the MySQL table.

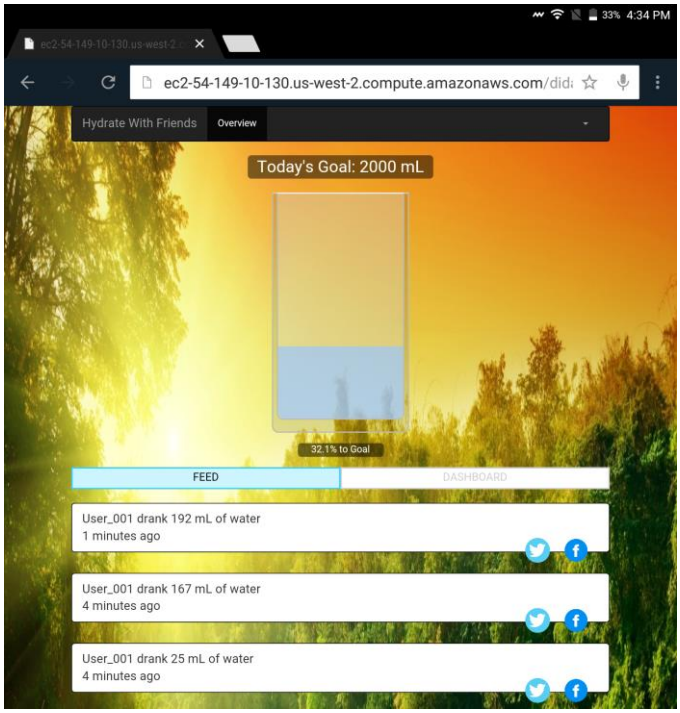

Fig. 4. Screenshot of "Hydrate with Friends" landing page taken on Android device. Water cup animates with amount consumed during the day. Feed below shows each entry with social media buttons.

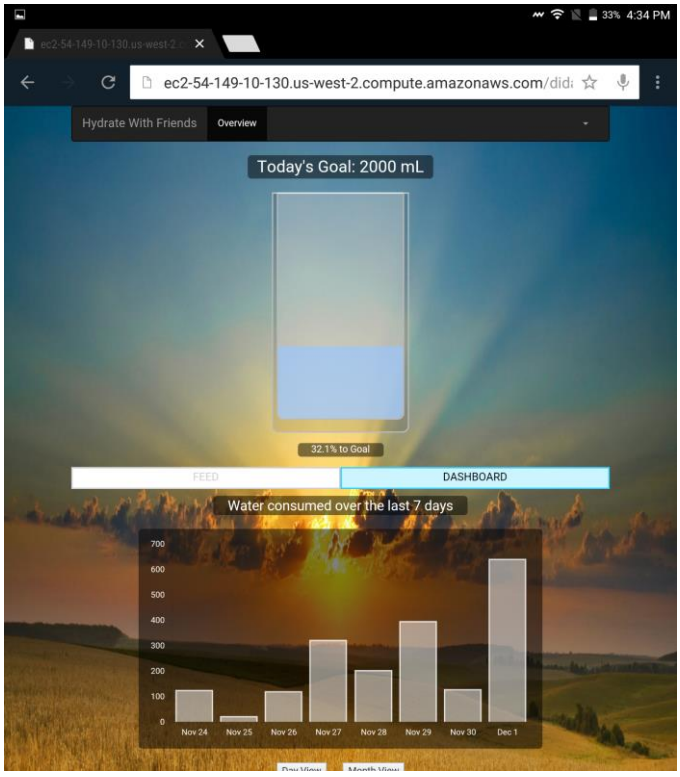

Fig. 4. Screenshot of "Hydrate with Friends" landing page taken on Android device. Graphical display of water consumed over the last week, including the current day. Can be changed to a month view to display water consumed over the last month.

IV. Conclusion

Hydrate with Friends proposes a different framework when thinking about designing ubiquitous systems for behavior change. The scope of this work is not restricted to the issue of personal hydration but extends to other areas of ubiquitous computing by which practitioners are building technologies to help users reach personal and social goals. These other areas include the invisibility from the human eye as well as the adaptability of our product into the daily lives of the users. Embedded sensing technology paired with a framework for behavior design may prove to be an innovative approach to addressing various challenges in the world.

V. Future Works

There are many areas in which this project can be expanded upon. Within the area of human interactions, implementing direct messaging and the ability to create groups can enhance social interactions. Adding additional contextual information, such as temperature and time of day, may help the user understand to drink more water when the day is hot, or to not forget to drink water at night. Although empirical studies on human behavior will be limited and the results may not be applicable to the general population, researching more in this area will nevertheless provide more insight as to which features may be more important in modifying or encouraging positive human behaviors.

Another area that could be improved is the software implementation of the project. The current implementation has a very basic point reward system in place. Future implementations will utilize these reward points to increase user motivation following the token economy principles. However, it is important not to place too much emphasis on physical rewards because users may feel a need to exploit the system or take shortcuts. This area falls under human behavior again. To combat such a problem, we would want to encourage to the user that the end goal of this idea is to improve the user's health and lifestyle. There is room for interactive and physical rewards, but the bottom line is that the user will only get out of the product as much as he or she is willing to put into it.

Paired with the software implementation, hardware improvements could also be made within future iterations. To reduce costs, the coasters could be printed via a 3D printer. The Arduino boards could be customized to include Bluetooth connectivity, which would help in making the coaster more portable. The Bluetooth solution could also allow for the transfer of information directly to the user's mobile device if there is no other wireless connection available.

We plan to run a deployment study through which we will have participants use our system. Quantitative data will be collected to see how the system often the system was used, how often the user logged into the website, and how much consumption was calculated. Interviews and surveys will be conducted to obtain qualitative data about how the design affected their motivation to stay hydrated as well as the ease of use of the product.

REFERENCES

[1] Drewnowski A, Rehm CD, Constant F. 2013. "Water and beverage consumption among adults in the United States: cross-sectional study using data from NHANES 2005-2010". *BMC Public Health* 13: 1068.

[2] Goodman AB, Blanck HM, Sherry B, Park S, Nebeling L, Yaroch AL. 2007. "Behaviors and Attitudes Associated With Low Drinking Water Intake Among US Adults, Food Attitudes and Behaviors Survey, 2007". *Preventing Chronic Disease 2013* 10: 120248.

[3] Howard G and Bartram J. 2003. "Domestic Water Quantity, Service Level and Health". World Health Organization.

[4] Consolvo S, Everitt K, Smith I, Landay J. 2006. "Design requirements for technologies that encourage physical activity". *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems – CHI '06.*

[5] Fogg BJ. 2009. "A behavior model for persuasive design". In *Proceedings of the 4th International Conference on Persuasive Technology* – Persuasive '09.

[6] Kappel K, Grechenig T. 2009. "show-me". *Proceedings of the 4th International Conference on Persuasive Technology - Persuasive '09*.

[7] Chiu M, Chang S, Chang Y, Chu H, Chen C, Hsiao F, Ko J. 2009. "Playful bottle". *Proceedings of the 11th International Conference on Ubiquitous Computing - Ubicomp '09.*

[8] Amft O, Bannach D, Pirkl G, Kreil M, Lukowicz P. 2010. "Towards wearable sensing-based assessment of fluid intake". *Pervasive Computing and Communications Workshops (PERCOM Workshops), 2010 8th IEEE International Conference.*

[9] Shaw G. 2009. "How Much Water Do You Need? Can You Drink Too Much?" Retrieved December 4, 2015, from http://www.webmd.com/diet/water-for-weight-loss-diet.

[10] Voida S, Jia Y, Karanam Y, Chambers A, Dara J, Alderhami A, Despard, J. 2015. "Challenges, feedback & notifications: empirical explorations to inform the design of interfaces to motivate and encourage long-term personal informatics use". *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2015 ACM International Symposium on Wearable Computers* (pp. 1081-1086). ACM.