waTree, Collaborative Hydration for Social Spaces

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ABSTRACT

UPDATED—December 21, 2018. waTree is an interactive hydration monitoring system, which uses Internet of Things (IoT) devices designed to fit around drinking receptacles in order to monitor drinking habits. These devices send this data to a cloud based server which is used to create an interactive display giving visual feedback on the hydration of users, in this case represented by growing trees.

KEYWORDS

interactive device; hydration; health; collaborative; social spaces; student life, social accountability

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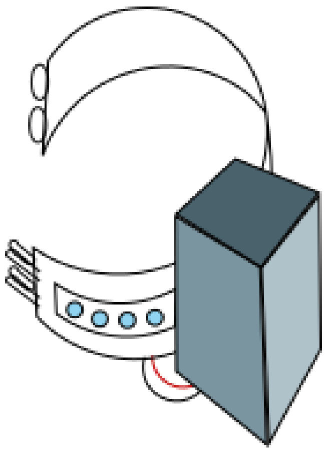

Figure 1: Visualisation of bottle device.

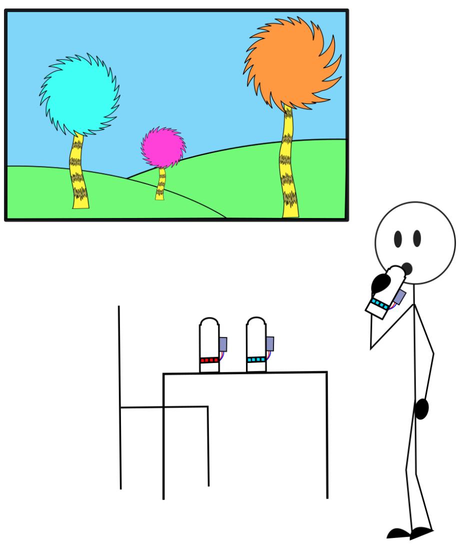

Figure 2: Visualisation of whole system in action, complete with display mounted in study space.

INTRODUCTION

Dehydration is a common problem that results in feelings of tiredness and fatigue. One in ten cases of tiredness and fatigue treated by GPs in the UK are thought to be a result of dehydration and a third of people in such cases felt better after improving their hydration habits [1]. We ran a survey to try and glean how much of an issue dehydration is among students. Of the 67 responses: 36% said they didn’t drink enough water and 52% said they often need reminders to drink water. There is research suggesting a high correlation between dehydration and deterioration in mental functions [4]. This can be a problem around examination periods for students, particularly as this is already a stressful time for them.

Our solution is a novel combination of IoT enabled devices designed for water bottles and cups, and a visual feedback system designed for student social areas such as libraries and study centres. The devices monitor drinking habits for the time period that the student is in the social space and send this data to a cloud based server. This data is then used to create a virtual forest; each tree is linked to a single device and the student using it. Healthy drinking habits result in tree growth, and poor drinking habits lead to the deterioration of a student’s tree.

The aim is that this will lead to an atmosphere of social support and accountability with respect to healthy habits. This is backed by findings from our study, where 59.1% of students said they thought they would feel a combination of supportiveness and competitiveness when given feedback on their friends’ drinking habits.

WALKTHROUGH

A key target user for this system is someone who carries a water bottle, but who feels like they do not drink enough water. In order to use the device, the user would fit it onto their water bottle and find a social area with a display in view. They would add themselves as a user on the local system, then proceed to drink as usual. Observing the display gives feedback on their drinking habits through a virtual tree growing on the screen which responds to drinking rate. A competitive and supportive environment is encouraged by displays featuring the trees of other users.

Fig. 1 shows a visualisation of the bottle device, complete with electronics housing and LED strip band wrapping around the bottle. Fig. 2 shows another visualisation of the system as a whole in action, with the display featured in a public social space.

Figure 3: Simple cardboard prototype.

Figure 4: The final frontend display

RELATED WORK

Social Computing

Numerous studies have been done on the impact of personal monitoring devices coupled with a socially situated display giving feedback on the multi-user data. The Fish'n'Steps [5] study showcased a system using pedometers and a virtual fish tank with fishes representing users. The virtual fishes' health was directly tied to the activity of the participants. A significant positive lifestyle change was found in most users.

In another similar study [2] children were encouraged to be more physically active by having their activity levels represented by a virtual garden. The so called "FitBit Garden" was a mobile application that would use information from the FitBit and from the child's parents to extend the ecosystem. This gamification did encourage regular use, though the application did not provide instant feedback which was noted as a concern. For this reason we provide the animation of rain in waTree, so the user can see feedback immediately.

Chiu et al's 2009 paper [3] on their "PlayFul Bottle" explored the use of an on-bottle display with varying levels of social interaction, to motivate users to drink more water. Their system used a mobile-phone camera to detect water-levels in the bottle, with some users having no display and others able to send digital reminders to one another with a forest-like display. Our study builds on this but we minimize the footprint of the on-bottle device and bring the display out into a physical study space, enabling users to interact with each other in the real world.

DESIGN

Prototyping

Initially the system was illustrated with a simple sketch to ensure the vision of the project was consistent between the team members.

Following this, a simple cardboard prototype that replicated a phone screen with a series of different sketches was used to represent different stages of the visualization, shown in Fig. 3. Each sketch represented a state of the tree associated to the functionality of our cardboard prototype. This system was built to help understand the user stories and the flow of the device as a whole and gave us a good guideline for the device design.

A second prototype of the system was created using a website with growing and shrinking trees controlled by the keyboard, and a cardboard unit representing how the IoT device would look. This was used to present a simple *Wizard of Oz* demo to users, where a single drink would result in their tree growing and a period of no drinking resulting in their tree shrinking. This provided useful initial feedback on the system.

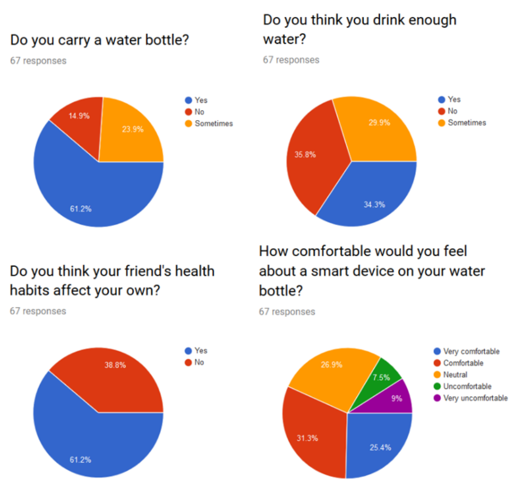

Figure 5: Results from our survey.

Device

For the IoT water bottle device, a Feather Huzzah ESP8266 wifi enabled arduino was used with an Adafruit LIS3DH triple-axis accelerometer. A drinking motion was identified by looking for large peaks and valleys in the accelerometer inputs. A button was used to activate this sensing ability, ensuring erroneous motion (for example carrying the bottle in bag) was not identified as a drink. When a drinking motion was identified, a GET request was made to the cloud based server.

Housing for the devices were made using 3D printers. We tried to mount the electronics on a stripboard, but this proved unreliable, so we switched back to breadboards for user testing.

Server

The data was held in a simple NeDB database, on a Express/Node.js server that was hosted on Heroku. Data could be added and read through a REST API, which the Arduino could access through its built-in WiFi in order to register that a user had drunk. The API also had various other endpoints to reset users, add drinking datapoints for each user, and access all the data in order to generate the display.

Display

The display was a simple client-side Javascript app hosted on Github Pages. The D3.js data visualisation library was used to call the server via the API to retrieve data, and then draw the different sized trees onto the page. Using this library allowed us to display consistently changing data quickly, which provided instant feedback to the user on their actions.

STUDIES AND EVALUATION

Survey

An online survey was created and sent out; 67 responses were received. Fig. 5 shows some results from our survey. These initial responses are promising, and indicate a potential for this kind of device in student social spaces. 66% of responses from this survey indicated that people felt they did not drink enough water, despite 85% saying that they sometimes or always carried a water bottle around. This suggests that the lack of hydration is due to forgetting to drink water and that a reminder system could prove helpful.

Respondees also indicated that social effects (e.g. peer pressure) could be positive reinforcement towards healthy habits in the right conditions, with 61% saying that they felt friend's health habits affected their own and 63% saying that they'd feel some combination of supportiveness and competitiveness towards friends having seen data on their health habits.

Figure 6: The final device used for user testing.

Figure 7: Drinking from the device

Initial Qualitative Feedback

The second prototype was used to walk some users through the system, to gain useful feedback before real implementation began.

Student 1 commented that he would *"use [the system] for himself, even if it wasn't with friends"*, but said he would *"like some form of 'in-game' bonuses for being on top of the act"*.

Student 2 said *"having stats for ... local spaces is great. But having stats for a team of co-workers in a lab would be really fun"*, and to maybe *"add props or things that help show that you're a good rank [in the game]"*.

Student 3 said that they *"immediately felt worried about the tree dying"*, and suggested *"unlocks for streaks"* which they think *"would motivate them to use it more"*.

The sample of users who tested the system was unfortunately fairly demographically limited; students studying a computer science related degree). This information can still help to provide some useful pointers for the direction that the system should be taken in. Generally the feedback seems to show that the potential for an entertaining, and therefore engaging system, is high and that gamifying the system would increase engagement.

User Testing

Two full user studies were run to understand how users would interact with the system, with 4 participants in each study. Before the study they were asked about the water consumption so far that day, their typical drinking habits, and how important they thought drinking water was, results can be seen in Figure 5. The studies consisted of participants studying as usual, while eating provided snacks and substituting their usual water bottles for our devices. The time was broken down into 3 periods -

- 20 minutes of monitored drinking without visuals
- 30 minutes of monitored drinking, with participants able to see the visualisation
- 10 minutes of monitored drinking without visuals

There was initially very little commentary about drinking water within the group, with more discussion starting once the screen was introduced. While there was some initial confusion with a few of the participants about which tree belonged to them, they were all quickly able to understand the interface.

With both groups, it was clear that the participants viewed the waTree system as a competition once they could see how much they had each drunk - with one of the first comments after the screen was first shown being *"User 1 - you're winning"*. Throughout the half an hour when the screen was visible, there was much more interaction between the participants, with comments such as *"I'm going to win"*, *"What's the biggest the tree can get"*, *"Yeet"*, *"I drank a lot "*.

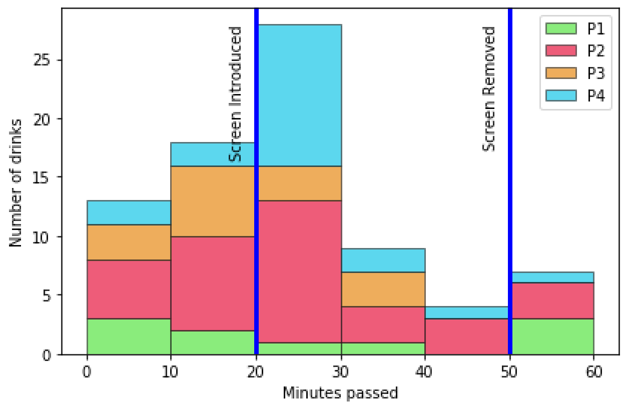

Figure 8: Results for first test group

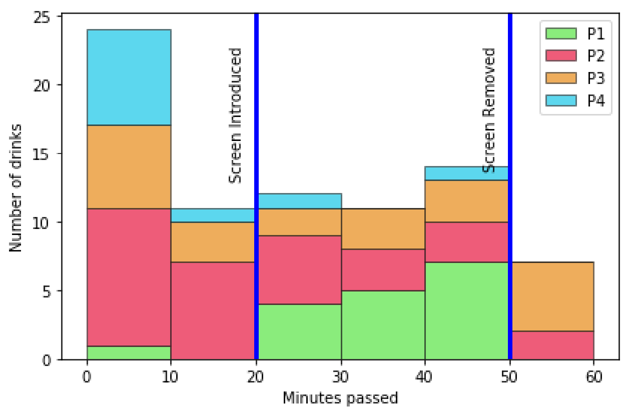

Figure 9: Results for the second test group

There were also many attempts to try to cheat, with participants shaking the bottle or holding it upside down.

Once the screen was removed again, the participants quickly stopped talking about their water consumption, and we saw a dip in the number of drinks per person.

After the experiment, we asked the participants about how their water consumption changed, whether they felt supported or competitive with their friends, and whether they would use a device like this in the future. The consensus was that the participants felt competitive with their group, with one person commenting *"When I saw someone had a bigger tree, I wanted the bigger tree"*. This sense of competition seemed to encourage most the participants to drink more water, but seemed to also provide a distraction from studying - *"I drank quite a lot more water than i would have"*, *"It kinda distracted me from work as well"*.

There was also a lot of user feedback on how the device and system could be improved - *“[Measure] based on how much you drink rather than how many times”*, *"Get battery packs for devices"*, *"I took a sip, and the whole tree grew. It wasn’t really the effect I was expecting"*, *"Has almost no more overhead to use than a real water bottle"*.

FUTURE WORK

To improve the robustness of drink detection, machine learning more accurately detect the motion of drinking water from the accelerometer, while still remaining resilient to false positives such as the bottle being chucked in a bag, or falling over. The device could also be updated to provide more extensive data to the server about each drink.

Building PCBs for the device could also improve reliability over stripboards or breadboards, as would a more extensively designed housing which could properly hold the components in place.

It would also be interesting to put feedback on the bottle, say in the form of how many LEDs are lit, to show users how long it was since they last had a drink.

Expanding the user testing demographic could provide more informative results. Generally feedback was gathered from friends in university, with the majority of feedback from Computer Science students at the University of Bristol. This has likely skewed our results.

CONCLUSION

In conclusion, we found that though the device encouraged slightly more water to be drunk while studying, its largest influence was in increasing social interaction, and also promoted a more competitive environment. In order to create a more supportive and positive social impact, we could create a different algorithm that rewarded group drinking, such an individual’s tree will grow only if their friends have also had enough water.

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