Physics Education with Google Glass *gPhysics* Experiment App

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UbiComp'14 Adjunct, September 13-17, 2014, Seattle, WA, USA
ACM 978-1-4503-3047-3/14/09.
http://dx.doi.org/10.1145/2638728.2638742

Abstract
We present a fully functional application prototype *gPhysics App* based on the Google Glass platform which is designed to perform an educational physical experiment in the area of acoustics. The initial applications aims towards students whose task is to find the relationship between the frequency of the sound generated by hitting a water glass and the amount of water.

Author Keywords
Google Glass App, Education, Physics, Acoustics, Students

ACM Classification Keywords
H.5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces.

Introduction
Our work is based on the observation that correlating real world events (experiments) with abstract information (previous observations, theories and abstract laws) is what much of science education is about. Students perform experiments, record their observations and measurements, put them in relation to previous results and background information and, based on this relation, develop an understanding of the underlying laws and causal relationships. Ideally this would be an iterative,

explorative process in which hypothesis emerge, lead to new measurements and observations and are eventually rejected, modified or accepted with different students following their own paths and ideas. Unfortunately, today the effort and time involved in this process makes it impossible to include significant amounts of exploration in day to day classroom practice. The Google Glass platform with its concept of micro-interaction, the integrated HMD and a variety of sensors can be described as an attempt at reducing "the distance between the physical and the virtual world". It facilitates fast and seamless posting of information from the real world, any time any place retrieval of information from the virtual world, and most of all, unprecedented possibilities of easily and quickly correlating real and virtual information.

Approach

We present a method for a physics experiment where the students task is to find the relationship between the frequency of the sound generated by hitting a water glass and the amount of water. Each measurement is automatically plotted in the display. Thus the student can view the results on the display as the experiment evolves (while he fills/removes water into/from the glass). He/she can test different glass shapes, different fluids and other parameters in the time it would normally have taken him to do a single experiment.

Related Work

While wearable computing in general is an active research area [8], [5] Google Glass was introduced recently by Starner [6] to the academic community. Lately, research in the field of activity recognition showed that Google Glass yields to new ways and improvement of activity recognition, by detecting and analyzing the users blink frequency [2] with the built-in proximity sensor. While using Google Glass as an experimental tool for physics experiments is completely new, this project relates to an extremely dynamic trend in physics education: Using internal sensors of everyday modern communication technology as experimental tools [4], [7], [3]. The method described here takes previous research into new directions with the specifics of Google Glass.

Google Glass *gPhysics* Application

Experimental Background

The Google Glass application aims at helping students understand coherences between water glass fill level and the resulting tone when the water glass is hit with an object as visualized in Figure 2. Technically when water is added to the water glass, the pitch or frequency gets lower. This happens because as water is added, more mass is added to the water glass. More mass results in a slower/lower vibrating frequency, and less mass produces a faster/higher vibrating frequency. Noticeably, the phenomenon to be detected by students is that the pitch does not correlate linearly with the fill level. When the water glass is nearly empty the pitch will change less when a fixed amount of water is added compared to when water glass is nearly full. During the experiment the user is equipped with a single empty water glass and a secondary water deposit. The user has to manually fill the water glass to different levels and record the pitch.

Application Design

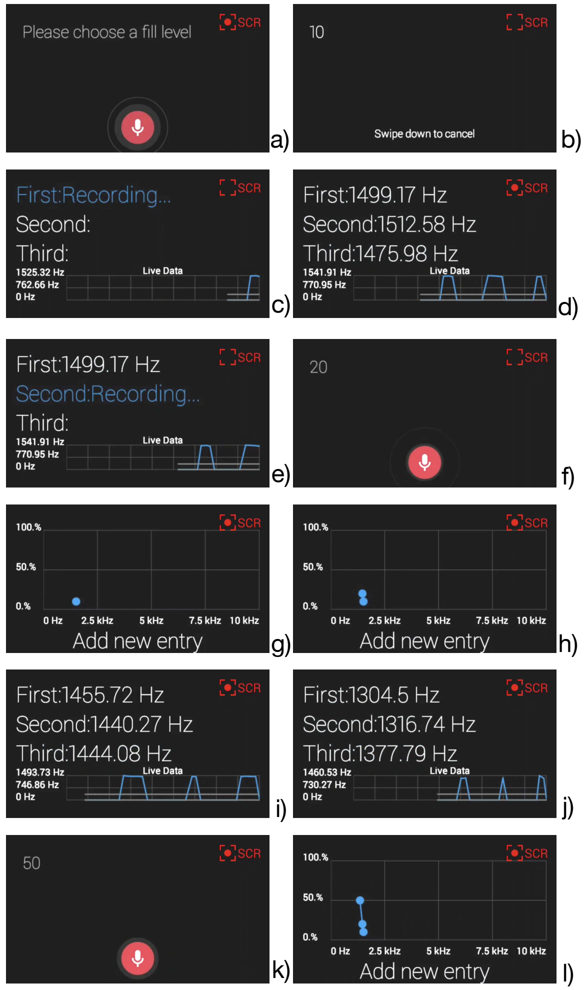

Figure 1: Google Glass *Physics App* screenshots in the order of appearance during an experimental task

After launching the application the user is directed to indicate any current water glass fill level (0-100%) by voice as shown in figure 1a-b. We use Google based speech recognition (1) for the input of the current fill level. We reject invalid voice inputs not representing a correct values. Once the voice input is successfully recognized the next screen is automatically presented to the user 1c. The application is now listening to any relevant audio input via the microphone. To ensure that the sound is representing the current fill level of the water glass it has to be produced three times by the user. If the deviation is within the defined boundary the recording is accepted or otherwise rejected. If accepted, the current frequency is added to a diagram displaying water fill level (x-axis) and frequency (y-axis). After this step the user has the ability to add a new entry, delete the last entry or delete all entries by swiping with a finger on the sidewards Google Glass touch pad. Adding a new entries by recording more frequencies at different fill levels the measurements will be added to the diagram.

Methods

We implemented the Google Glass application with the Glass Development Kit (GDK) which is an add-on to the Android SDK which let us build Glassware running directly on the Google Glass (as opposed to the Google Glass *Mirror API* does not allow full hardware access and interaction). We used the FastYin pitch tracking algorithm for detecting the fundamental frequency in the audio spectrum. FastYin[1] is an implementation of the YIN pitch tracking algorithm which uses an FFT to calculate the difference function. The algorithm uses autocorrelation to detect the pitch with the highest probability. To avoid false detection during recognizing water glass sounds, the minimum detectable frequency was set to 500 Hz which is above the pitch of adults and

Figure 2: Applied method of generating a pitch using a water glass

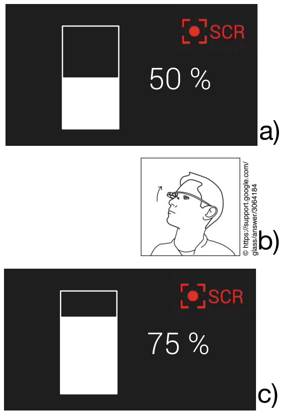

Figure 3: Google Glass *Physics App* alternative water level input method.

children. Any sound level may be used above this frequency threshold for detecting the pitch. For each fill level three sound inputs are needed for verify a reproducible result. It might happen that other audio input might be received by the microphone during. If the deviation between any of the three pitches is more than 10% (+/-) the entry will be discarded. If the deviation is within the boundary the mean value between the three pitches is calculated and visualized in the diagram.

Discussion and Conclusion

As the speech recognition for the input of the current fill level inclined to be really useful to enter a value in a lab setting. We noticed that an experimental class room like setting results in different students speaking at the same time results in errors in the speech recognition. As a selectable alternative to the speech input and recognition we present a head gesture based input of the fill level. As visualized in figure 3 the current fill level can be set by moving the head up or down. While the head is in default position the fill level is displayed as 50%, moving 30° down the fill level is 0% and moving the head 30° up the fill level is 100%.

Future Work

Future work will contain empirical studies. We will conduct studies with school children and university students where Google Glass based experiments will be compared with conventional methods and with new computer and smart phone based approaches. We will evaluate the effectiveness and the acceptance of the interface, analyze how the system is used.

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