TOP: Tactile Opinion Poll System for Silent Feedback

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ABSTRACT

Abstract – **Voting is an integral part of modern day societies that yearn for democracy and transparency. For voting to be acceptable and wanted, it needs to be secretive, anonymus, fast, and reliable. The main aim of this paper is to propose the Tactile Opinion Poll (TOP) system for silent feedback that enables users to cast their vote and opinion in a secure and private way that is both intuitive and easy. The TOP system captures user feedback using haptic modality in real-time by squeezing a smart tangible ball (called the squeezometer) that securely communicates the user feedback to a central software via Wi-Fi. The squeezometer display vibrotactile clues to confirm user selection via a vibrotactile motor embedded in the squeezometer device. A preliminary evaluation is conducted to verify the effectiveness of the system and investigate an optimal voting protocol that the system may use.**

Keywords – Voting; Interactive Multimedia; Stress-ball

I. Introduction

A polling system permits the audience to provide feedback freely and let them to cast their opinions according to their wishes with simplicity and intuitivism [5]. An electronic polling system eliminates going to polling booths, paper ballots, time and cost and mobility [6]. With the availability of smart phones, mobile phone polling systems have become a commonplace where users provide real-time opinion about an event, typically via a graphical user interface. However, these systems do not provide continuous feedback, audience give feedback usually at the end of the event and thus do not measure sentiment throughout the event.

Continuous audience polling systems have been widely used to gauge views of an audience as a speech progresses and to measure student understanding of lectures. The most common form of audience voting system is known as "clickers", in which each audience member has a small transceiver (similar to a joystick device) with several buttons, which they use to respond to multiple-choice questions given throughout the event [1]. However, these systems are still fairly easy to shoulder-surf on, at least by immediate neighbors. Also, they can only measure responses to explicit stimuli, and do not measure sentiment throughout the event.

With recent advances in interactive multimedia systems, Haptic media is becoming a popular technology in a variety of applications ranging from entertainment and gaming, inter-personal communication, up to more serious applications such as Tele-operation, training and health care [2]. A key advantage of haptic information is that it is silent, discreet, and personal as it is experienced only by the intended user – unlike other types of media that may cause an unwelcome broadcast into the surroundings [7]. Furthermore, haptic modality can be used to facilitate intuitive and private means for hidden communication of emotions as well as real-time human reactions [3-4].

The proposed TOP system provides users with a real-time feedback voting/polling system that enables them to voice their opinions and vote in a private manner. The TOP system could be used as a voting/polling system in big and small lecture halls. Furthermore, capturing the interaction forces via Force Sensing Resistor (FSR) sensor, this system may also able to measure fatigue and/or stress of people at certain points during the event. The TOP system could also be used to provide silent feedback in many situations such as a classroom, in health care, or in rehabilitation systems.

The TOP system utilizes an interface – named the squeezometer – to capture forces applied by the user and pushes the signals to a server that compiles the collected data from a group of audience and displays them in an interesting graphical representation using a graphical user interface. Furthermore, the TOP system provides the user with a tactile feedback through a vibrotactile motor embedded in the squeezometer to give silent confirmation about the applied command. This feature would enrich the reliability of the polling system.

The remainder of the paper is organized as follows: section 2 outlines the software/hardware architecture and introduces the main functionalities of the proposed TOP system. In section 3, we present a usability study to examine the usability and efficiency of the interaction protocol as well as to capture user feedback about the system overall. Finally, section 4 summarizes the contents of the paper and provides perspectives for future work.

II. Tactile Opinion Polling (TOP) System

The TOP system works by distributing squeezometer devices to the audience. Users give real-time and continuous feedback about the event by squeezing the ball. The interaction forces are sent to the Poll server for further

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analysis. The architecture for the TOP system is shown in Figure 1.

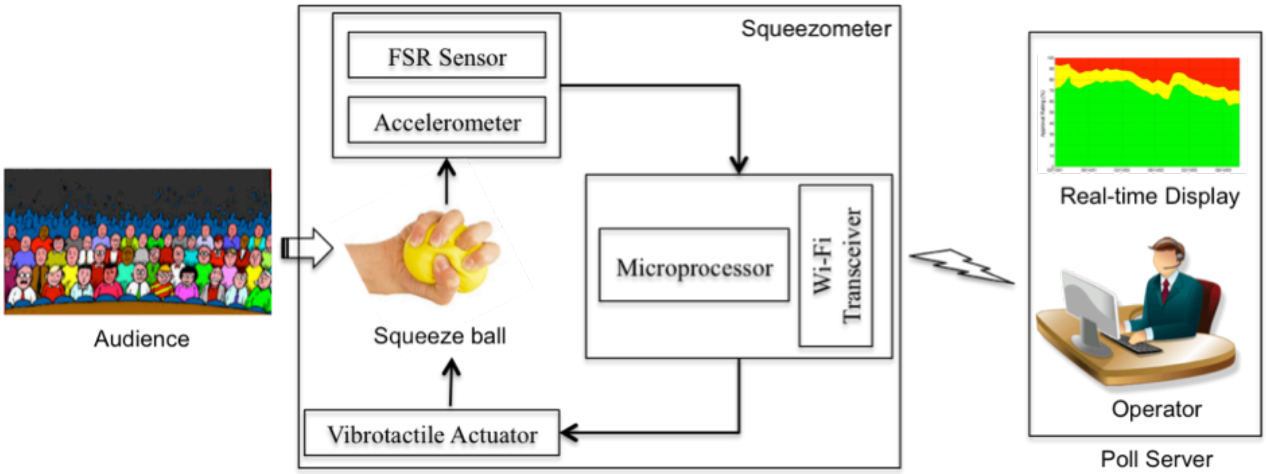

Figure 1: TOP system architecture

A. Squeezometer Device

The components of the TOP system are simple, widely available, and cheap. The squeezometer device uses FSR flex sensors and an accelerometer as input sensors to measure interaction forces and hand motion, an Electric imp module for Wi-Fi communication, and a vibration motor that provides vibrotactile feedback to the user. Every squeezometer device has a unique ID that is to the Poll Server to uniquely identify a device across the audience. The device ID is mapped to a username in the current implementation of the system. A snapshot of the squeezometer device is shown in Figure 2.

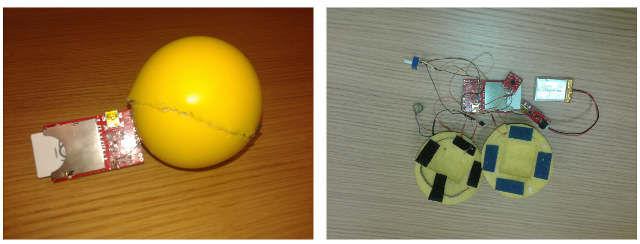

Figure 2: Squeezometer device prototype

The following is a brief outline of how the components are used:

- Force Sensing-Resistor (FSR)

Two FSR flex sensors are connected in series along the squeezometer ball surface to measure the overall 360° force applied by the user. The sensors are connected to a variable resistor in a voltage divider configuration to help calibrate the measurement. Using this calibration, one fixed resistor is placed in series with the flex sensors.

- Vibration Actuator

The vibrotactile actuator is a small motor that vibrates at various frequencies and intensities to convey tactile sensation feedback. The actuator used was a precision microdrives coin type motor that works on a maximum of 3 volts and offers 1.7g vibrations and was controlled by a microprocessor that defines the actuation pattern (such as frequency and intensity of vibration) and generates electrical signal to stimulate the motor to vibrate. An array of vibrotactile actuators might also be used however, for simplicity of feedback, we decided to use one vibrotactile actuator.

- Accelerometer

An ADXL 335 accelerometer is used to measure the movement and its intensity in order to gauge the emotions of the audience (if they are restless, etc.). It could also be programmed to turn on/off the Wi-Fi or function of the stress ball when moved in a certain manner.

- Wi-Fi Transceiver

The Wi-Fi Transceiver hardware is the Electric Imp Wi-Fi Module [8]; an integrated platform that allows users ease of connection to a Wi-Fi access point. As provided by the manufacturer, the Electric Imp has the following specifications:

  - It is 32mm x 24mm x 2.1mm
  - 802.11b/g/n Wi-Fi, complete with WEP, WPA and WPA2 encryption, along with a great antenna.
  - Cortex-M3 core processor with low power consumption
  - I/O: UARTs, I2C, SPI, analog in and out, PWMs, GPIOs

B. Poll Server

The Poll Server implements the communication with squeezometer devices that are distributed to the audience to retrieve audience feedback in real-time. The server receives communication frames that include the followings: squeezometer device ID, interaction force, acceleration data, and a feedback command (such as agree/disagree, strong agree/disagree, etc.), and a timestamp.

- Electric Imp Agent

The Electric Imp module, when connected to Wi-Fi, communicates with a custom agent stored on Sparkfun's servers. Each agent has a unique URL that can be used as an HTTP endpoint by external entities. Our agent waits for a ping on the URL, then reads flex and accelerometer data from the Imp or actuates the vibration motor as requested (therefore implements a bidirectional communication between the squeezometer device and the poll server). The custom agent sends data in CSV format in the body of the HTTP response.

- Data Analysis and Storage

Each imp agent registers itself with a central server once the imp is connected to Wi-Fi. The server pings each agent at regular intervals and reads sensor data. It then conditions data into a standardized format. Flex sensor data is mapped onto a 10-point scale, from "not squeezing at all" to "squeezing very hard", which is calibrated by the individual audience member before use. The same occurs for accelerometer data, measuring the strength of shaking; the accelerometer can also be used to determine whether the device is upside down or not, as determined by a mark on the device. The server can also actuate the vibration motor as necessary, for example to confirm that Wi-Fi connection or calibration was successful.

- Display

Each end user will have an account on the central server, which keeps track of the imps the user owns, uniquely identified using the squeezometer device ID. When an imp connects to the server, the data from that imp and all other connected imps is displayed in a dashboard-like format on a website which the end user can log into. Examples of data display possibilities are:

- Percentage of audience agreeing/disagreeing with statements (measured by number of yes/no answers)
- General sentiment (weighting yes/no with strength of feeling, measured by flex intensity)
- Controversial-ness of statement (measured by total flex intensity)
- Audience interest in lecture over time (measured by strength of feeling)

C. Interaction Paradigm Protocol

The Interaction Paradigm Protocol defines how the user interacts with the squeezometer device. The interaction comprises four phases: device initialization, interaction calibration, event (actual interaction), and shutdown. In the following, a brief introduction to these phases is presented.

- Initial Wi-Fi connection

The connection setup is completed using the BlinkUp technology that also uses an application installed on a smart phone for the setup [9]. Initially the device is turned on then the device application is started on a smart phone to configure the Wi-Fi network details. Holding the smartphone screen directly to the blinking status light on the device, the connection process would complete within 10-20 seconds. The status light will flash from red to green color, indicating a successful connection. Each Imp takes about fifteen seconds to activate; this can be done before the beginning of the event.

- User calibration

After distribution of the devices, each device must be calibrated to the individual user. This can be done by using the consumer website to initiate a calibration sequence for a chosen group of imps. The website will display a few prompts for the audience to follow, such as "Indicate strong disagreement" or "Indicate weak agreement", and the leader or speaker will mark when the audience is performing the task. The server will poll the device sensors at the times marked by the event leader, and actuate the vibration motor when polling is done to indicate to users that calibration is complete. The calibration data will also be used to calibrate "strong" and "weak" commands for each individual device.

- Event

The audience will be free to indicate agreement or disagreement at any point during the event, as the server will be constantly polling the imps. If the speaker asks the audience for a specific feedback at a specific point in the event, the speaker will be able to mark a time frame for the audience to respond, maybe using the vibrotactile feedback, and data for the corresponding responses will be collected from the devices and associated with the particular query. Since polling and data analysis happens in real time, the dashboard can be displayed for the audience if desired.

- Shutdown

Imps require little power, so the device can merely be put to sleep for storage. This can be done from the consumer website; the Imp will then wake up once every minute to check if a "turn on" signal has been sent. However, if the Imp is required to connect to many different Wi-Fi networks, this may make connecting to new networks difficult; if this will be a common use case, a hardware switch may be preferable.

III. INTERACTION PROTOCOL ANALYSIS

To assess the extent to which users would prefer using the TOP system against currently available polling systems on the market, and to examine which usage would be most natural and least intrusive, a survey on kwiksurveys.com was devised. The following selected questions are reported from a survey that 48 participants took part of:

Q1: Please rank the following options based on which you think is the most secretive way of agreeing and disagreeing to a certain prompt.

- Squeeze once to disagree, twice to agree
- Squeeze for 2 seconds to disagree, longer to agree

- Tilt the ball in one direction to disagree, another to agree
- Shake ball for 2 seconds to disagree, longer to agree

Q2: Please rank the following options depending on which you think expresses the strength of feeling of a user:

- Squeezing the ball harder
- Squeezing the ball longer

Q3: Please rank the following options based on which you think is the most intuitive way of agreeing and disagreeing to a certain prompt.

- Squeeze once to disagree, twice to agree
- Squeeze for 2 seconds to disagree, longer to agree
- Tilt the ball in one direction to disagree, another to agree
- Shake ball for 2 seconds to disagree, longer to agree

Q4: To what extent do you think current voting devices (such as clickers, etc.) provide secrecy and anonymity of vote? (Whether people around the user of the voting device can easily see the vote.)

- Votes are practically public
- Depends how close people around you are
- Very secretive
- I don't care if people can see my vote

The results for the conducted study are shown in Figures 3-5. First of all, the participants were asked to give their opinions about how private are the currently available polling systems. Results show that more than 75% of the participants agreed that current polling systems lack the adequate level of privacy needed for transparent polling (as shown in Figure 3). Only 12.5% thought that the current polling systems are adequately secretive.

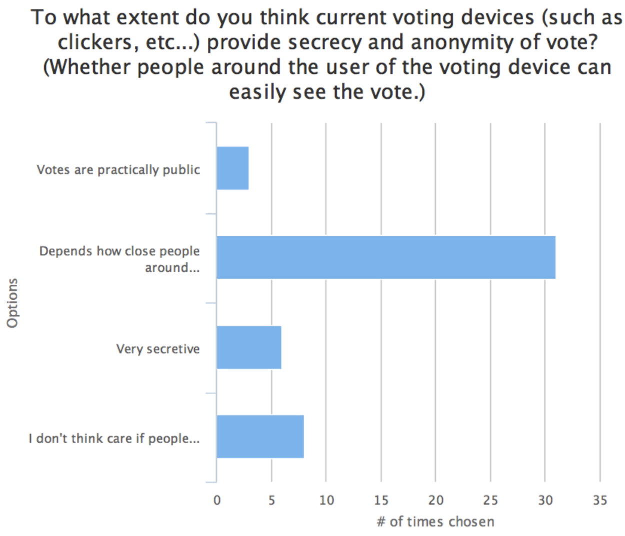

Figure 3: evaluating of privacy level of clickers systems

Figure 4 demonstrates the participant's feedback as per the association between emotional reactions (or state) and the physical interaction. The participants were divided equally in terms of their opinion about; 50% decided that squeezing the ball harder is a better indicator of emotions whereas the other 50% thought of squeezing longer. We believe that the squeezometer device should combine the two features to get an optimal interaction.

Participants were also asked about the most intuitive means of giving feedback about the event. Participants were given four interaction techniques (as shown in Q3). As shown in Figure 5, more than 90% of the participants selected option 1 ("Squeeze once to disagree, squeeze twice to agree") as the most intuitive to use. Also, we noticed that more than 85% of the participants thought that shaking the squeezometer device is not a great idea (some have pointed out that such a gesture can easily be shoulder-surfed as the feedback is visual). The results are shown in Figure 4.

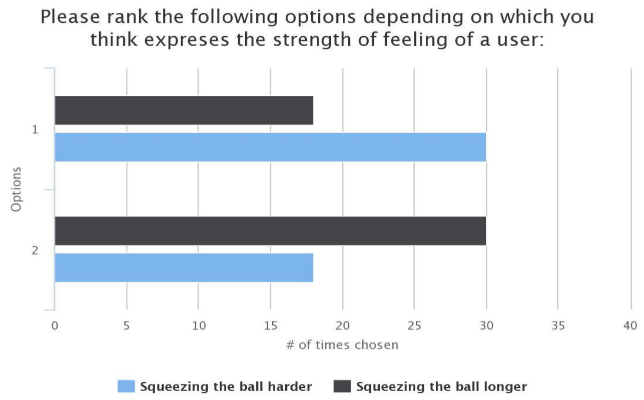

Figure 4: emotional reactions versus physical interaction

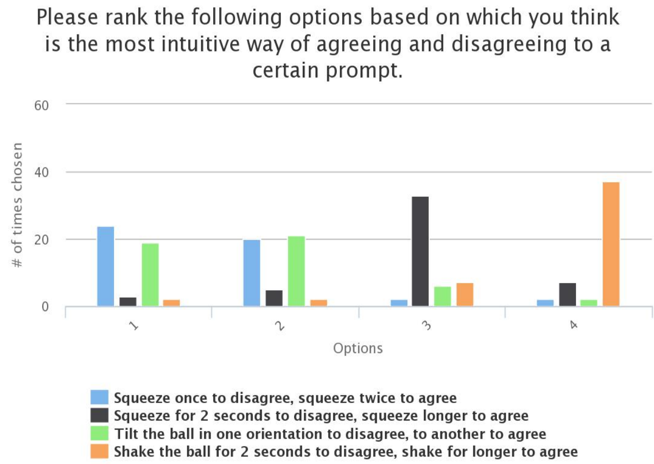

Figure 5: Interaction protocol with the squeezometer device

Finally, the fitness of the proposed system as a secretive method for giving feedback is examined. Results are documented in Figure 6. More than 90% of the participants agreed that a combination of squeeze intensity and duration would be the most secretive option for feedback. Less than 5% of the participants thought that shaking the squeezometer, or tilting it would still be a secretive option of interaction. Therefore, the current implementation of the system will use a combination of squeeze intensity and duration (which can be calibrated separately by the users) to provide the most private method for giving feedback.

In a summary, the participants thought that the most intuitive way of voting is through squeezing the ball once for disagreeing and twice to agree. To back that choice up, we obtained a majority vote for squeezing the ball harder as a better way of expressing one's emotion with 72% compared to 26% for squeezing the ball longer.

IV. CONCLUSION & FUTURE WORK

Based on the results of the survey, we chose to use number of squeezes as our agreement/disagreement indicator, and strength of squeezing as our measure of strength of feeling.

Next steps include experiments to test ease of use. We plan to conduct a trial with participants in which we will calibrate the device as we have described before and ask them to make a series of randomly chosen responses (for example, "agreement of strength 8"). We will then use this to set our calibration scale and to demonstrate whether the system can indeed distinguish between responses and thus support not only private, but also a reliable feedback system.

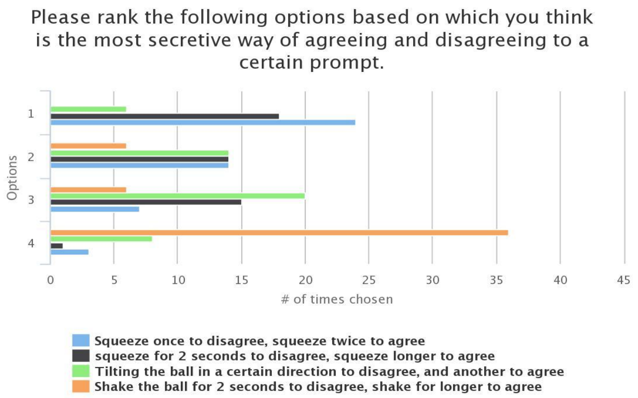

Figure 6: Privacy of feedback analysis

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