Tangible Tube

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Abstract
Tangible Tube is a device that invites users to play in a completely unprecedented form of interactions. Instead of utilizing traditional devices such as keyboards, mouse, joysticks and wii remote controls that challenges users on how swift and composed their fingers' movements are, Tangible Tube challenges users to play games using a tube that they will control through breathing.

Keywords
Tangible User Interfaces, Interaction Design, Children, Entertainment, User Experience, User Interface Design, Usability Research

ACM Classification Keywords
H.5.m [**Information interfaces and presentation (e.g., HCI)**]: User Interfaces, user centered design.

General Terms
Design, Experimentation

Introduction
Video games have become one of the most popular entertainments for children, teenagers, even young adults. Consoles such as Nintendo and Sony PlayStation are considered as the pioneers that popularize video games in our society. However, most video games only require the

users to press the buttons on the controller in which the results will be displayed on the built-in screen or TV. There is no other interface between the users and the system besides pressing the button in the handheld controller. In 2006, Nintendo released Wii, a console that uses a remote controller which detects users movements in 3-D. This console introduced a new and interactive way of playing video games because it requires the user to be physically moving the controller instead of only pressing the buttons.

In this paper, we present Tangible Tube, an interactive and tangible user interface system that explores a unique kind of interaction with the user, *i.e.,*through breathing control. We will discuss the features and possibilities of Tangible Tube becoming a new system to be used on interactive applications and games. There has been a number of existing works which examine the same interaction, but none has been aimed for a general entertainment system.

Tooka [1]: This is a tube which acts like a musical instrument. Two players can blow from the opposite ends of the tube and produce sound collaboratively by controlling their breathings using their tongues and lungs and by pressing the buttons. The main difference of this tube and our Tangible Tube is in the output produced. While the Tooka focusesmore on producing sound like a musical instrument, our tube is simply a device used for interaction between the users and our software which focuses primarily on gaming. Our tube is also capable for more different user interaction as it detects rotation and translation while the Tooka seems to support only pressure modulation and button inputs.

BLUI [2]: BLUI (Low-cost Localized Blowable User Interface) is a hands-free interaction between user and computer by blowing the computer screen to control the interactive application. Both Tangible Tube and BLUI seem to be able to support similar applications; however BLUI supports blowing directly to the computer screen while Tangible Tube uses a tube as a device for interaction.

The Pipe [3]: This is an input device using breath pressure as control input. The Pipe uses similar sensors that are used in Tangible Tube such as accelerometer and force sensing sensor. The main difference is the output; The Pipe focuses on building a musical instrument while Tangible Tube acts as a device for users to control applications.

Implementation

Our Tangible Tube system has two components; the tube itself and the screen. As shown in Figure 1, the tube is attached to an acrylic enclosure that houses a small Force-Sensing Resistor (FSR) and an Inertial Measurement Unit (IMU) that possesses 5 degrees of freedom from 3-axis accelerometer and 2-axis gyroscope. The IMU captures the three-dimensional motion of the tube and translates it into 2-dimensional position on the screen using rigid body kinematics and Eulers discretization method for the integration. Additionally, it also records the angle in which the tube is rotated and how fast it is rotating. With the FSR integrated in the tube, the magnitude of the users breathing into the tube is also captured. All of these informations will then be passed into Arduino which then will be read by a processing module.
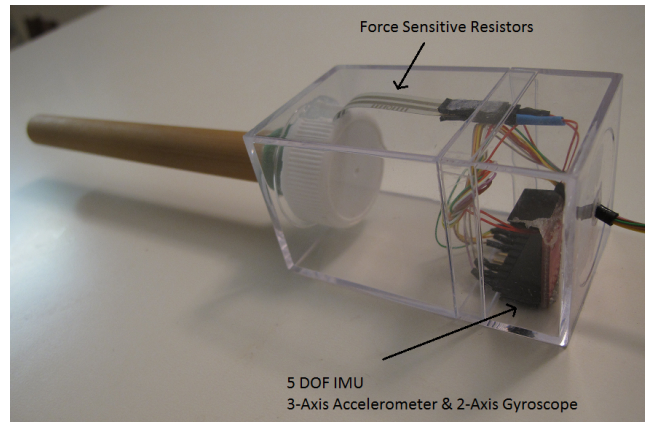
Figure 1: Our Tangible Tube with all the sensors.

Figure 2 shows an overview of how our Tangible Tube system works as a whole. As we move or rotate Tangible Tube, our movements are recorded by an Arduino microcontroller. Arduino will then send all of the data it received to be used by the applications in the computer.
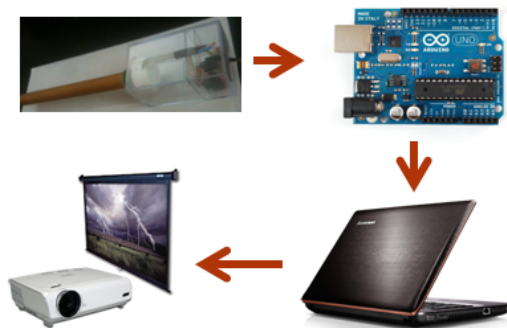

Figure 2: Overview of how our system works.

We have developed two applications to demonstrate the uniqueness and interactiveness of Tangible Tube. The applications that we developed are written in processing since it provides a smooth interface with Arduino while boasting numerous easy-to-use graphical functions. Making new processing applications to work with our Tangible Tube requires very minimal changes to the existing base code since we have made the interface to the hardware simple and generic.

Painting Application

Our first application is a painting application program. In this application, the user will be able to paint by blowing into the tube and the harder the user blows, the thicker the paint will be. Changing the color of the paint is achieved by rotating the tube. The painted color will disappear after some time. We implement the strokes to be brush-like, as if the user is painting with a real brush.
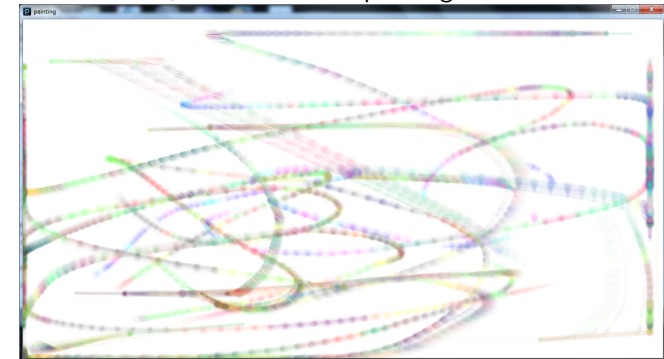

Figure 3: A screenshot of our painting application, drawn by our tester.

Balloon Popping Game

The next application is a game in which the user is required to pass through a set of levels by popping down balloons that randomly appear on the screen, as shown in

Figure 4. This is done by moving the pointer to where the balloons are and blowing into the tube. The game consists of two levels: in the first level, the pointer and the balloons' color are all black so that user only needs to point and shoot. This level is intended to familiarize the user with the basic concept of controlling the movement of our Tangible Tube to pop the balloons. In the second level, red, blue and green balloons are randomly generated therefore the user will have to rotate the tube to change the color of the pointer and match it with the color of the balloon in order to pop it.
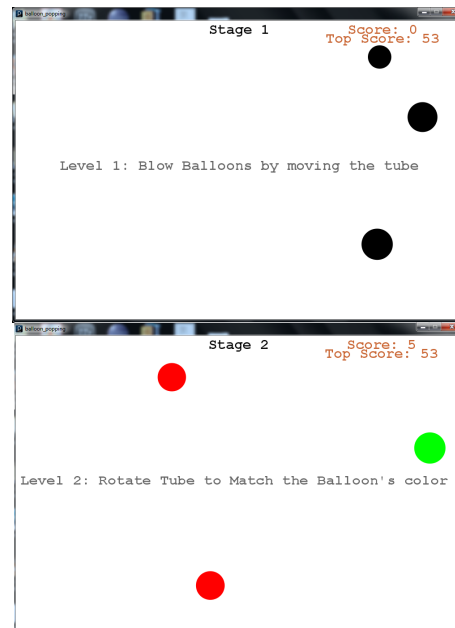

Figure 4: A screenshot of the beginning of each level of our balloon popping game.

Design

In this section, we describe the points that we took into account when designing our tube. Firstly, we would like to make sure that the users will immediately understand how to use Tangible Tube at the first sight of it without any instruction given to them. In order to accomplish this, we design the mouth piece of the device similar to a blowgun so that the users will understand immediately that the tube is meant for blowing. We also add a color circle in front of the mouth piece to let the user know that rotating the device will change the output color accordingly.

We also plan to create multiple applications and games that can be controlled with the tube so that the users will not be bored easily and we will keep on testing the possibilities for new tube features.

Evaluation

In order to measure how interesting and interactive our Tangible Tube is, we developed our applications to be able to accept inputs from both traditional input devices (*i.e.,*mouse and keyboard) and our Tangible Tube. For instance, in the balloon popping game the user will be able shoot down the balloons by clicking them with the mouse. To match the balloons colors, the users will have to press corresponding keys on the keyboard. After describing to our participants how Tangible Tube works, the participants tried out the applications that we have developed first with mouse and keyboard,and later with Tangible Tube as the input device.

The first thing that our testers did when trying out the Tangible Tube was figuring how to control the small pointer on the screen. Since pointer is correspondingly moving on the screen, our testers adapted to the system naturally and in no time successfully played with Tangible

Tube. Additionally, the bursting animation and sound that is generated whenever a balloon is popped gave the users a sense of accomplishment.

Figure 5: The participants trying out Tangible Tube during a project showcase at UC Berkeley campus.

The challenging part is when the users have to match the color of the pointer with the color of the balloon by rotating the tube. It is not that obvious for our testers that they needed to rotate Tangible Tube in order to change the color of the pointer for this type of interaction is one of a kind. After observing that they could not pop the balloon without matching the colors, they started experimenting with orienting Tangible Tube in different positions and started blowing while rotating the tube. However, we may need to improve on our hardware design since some users lamented on the motion sensitivity of our Tangible Tube.

Discussions and Future Work
In the future, we would like to explore how well Tangible Tube works in a collaborative setting. For instance, for the balloon popping game that we developed, we could extend the game so that two players may compete to get the highest score or collaborate to shoot down a number of balloons under a limited time. This will definitely ameliorate the interactivity and persistence of our tube.

Following up to our previous point, a wireless Tangible Tube is essential to maximize the user experience. Our current Tangible Tube prototype is still wired to the laptop. The users were still constrained the length of the wire extending from the tube to the computer and therefore, could not move freely when using the applications. In a collaborative setting, this problem is exacerbated since multiple users might impede each other's progresses in the game due to space constraints which will definitely detriment the user experience.

Finally, instead of utilizing computer screen as the output device of Tangible Tube, we believe that Tangible Tube output is best displayed on an unconventional output system such as a tabletop since that will enhance the interactiveness of our Tangible Tube. This way our Tangible Tube system will not be regarded by the users as merely "another computer application".

Conclusion
In this paper, we have reported the design and the first prototype of a tangible user interface that revolves around breathing actions of the users instead of having the users press buttons. We believe that Tangible Tube invites the users into a realm of interactions that they have not explored before. The amusement experienced by our testers, even just by playing simple games we developed,

has confirmed our success and encouraged us to explore Tangible Tube possibilities further.

This project is still ongoing and will continue to develop. From the feedbacks given by the testers, we believe that we can improve the systems greatly by adding few more important features as mentioned in the future work section.

Acknowledgment

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