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Quantifying the Novice Programmer

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Abstract: Research in the field of computer science so far has determined that novice programmers do not have the skills expected of them after their first programming class. Our research is to determine new ways of approaching traditional curriculums for introductory programming classes so that novice programmers have a better grasp on the basic concepts of programming. This reports some quantitative results we found during our analysis of think aloud session data. Our results include times taken for each problem, the affective qualities with which students relayed their thoughts and ideas, as well as cognitive activities which will be discussed in depth later, and the students' answers as far as correct versus incorrect.

Introduction

In the last 15 years of research on the subject, it has been agreed that students had not reached the skill level expected of them after their first introductory programming course. Despite some efforts in adapting different curriculum, retention rates have not improved much and students are not better prepared for later programming endeavors. This spurred new venues of research with the goal of identifying the probable causes of these issues and some possible solutions.

Our research has been aimed towards finding the disconnect between how students think about and approach programming problems and how their teachers explain them. While our study has by no means been exhaustive, we have collected plenty of data through think aloud sessions with a small number of volunteer students in an introductory programming class.

Methodology

Our think aloud sessions were conducted with the intent of recording the complete thought process of each student while they solved a number of programming problems that required different skills. We conducted four sessions per class over the course of two semesters with a total of twelve subjects. Each student volunteered at the beginning of the semester and went through a mandatory practice session in order to acclimate to the think aloud environment. Our data was recorded through video which was later transcribed and a Livescribe^{TM} Smartpen. This is a device that does audio-recording as well as allows handwritten notes to be converted and saved as a pdf.

As far as translating our qualitative think aloud results into quantitative data, we kept track of the time each person spent on each problem, the length and duration of pauses, and what cognitive level each student was thinking at. These cognitive activities included abstracting, inferring, tracing, explaining, conjecture, reading, and writing. We also recorded what affective responses each student had during the course of each problem: these categories included confidence, uncertainty, and frustration. Along with all of this we denoted if the student got the problem correct or incorrect.

Findings

While the results from the affective categories of our data proves to be less informative than we hoped, it was very interesting to compare the total percentage of time spent for each cognitive activity. As seen in Figure 1, the overwhelming percentage of behavior fell under the category of explaining and guessing with little to no abstraction for most problems.

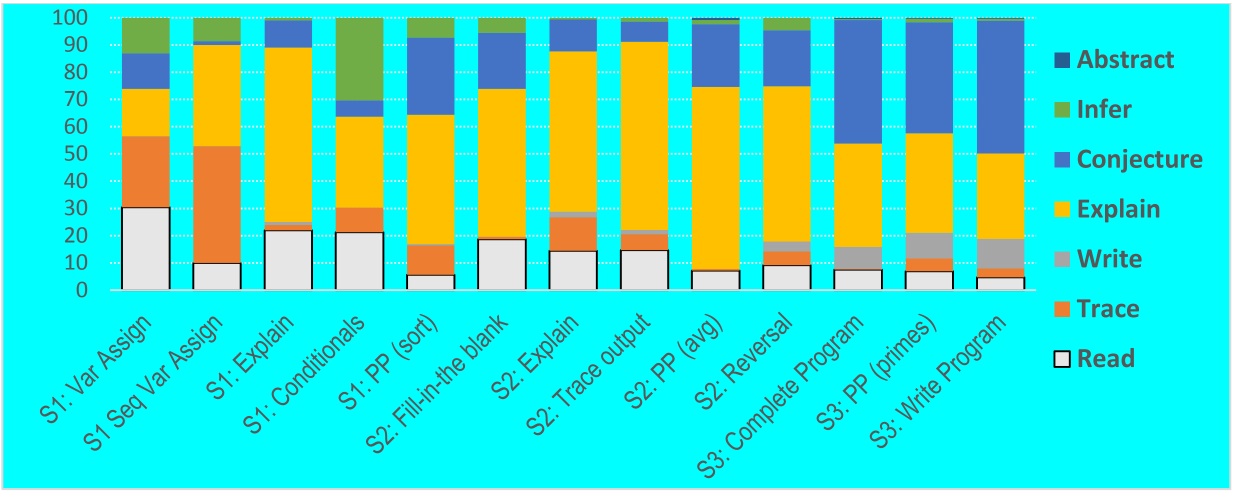

Figure 1. Percent of Cognitive Activities by Problem Attempted across Participants

This is to be expected of novice programmers at first but after almost a semester's worth of study, one would hope higher level cognitive processes were more common. One correlation of note was that while those who abstracted certain problems were more likely to get a higher percentage of the total problems correct although they did not always generalize the problem correctly. One result we expected but was not corroborated by the data was a correlation between time and performance. In general, our expectation was that the longer a subject needed per session, the worse their performance would be. However, from the data we collected from our pool of students we can safely conclude that this is not the case.

Conclusion

We chose to do think aloud sessions rather than traditional testing techniques because we believed that it would allow a more in depth analysis of how novice programmers approach programming problems. With the results we have gathered, we now have a better sense of what direction we need to go in to get better retention rates in computer science programs and a better foundation for new programming students.

Overall, the tendency of novice programmers to syntactically explain their way through a problem rather than tracing or abstracting shows that novices are still thinking at a lower level than their professors want even most of the way through their first introductory class. We believe that a stronger emphasis on concepts that are typically difficult for students to grasp as well as a more personalized testing and tutoring system will provide a better understanding for all our students and help those who may not understand certain concepts as quickly as others.

Interaction of LED Cubes and Mobile Applications Through Gaming

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ABSTRACT

This project explores the design and implementation of software to support games that combine an Android mobile device and an LED cube, specifically the L3D Cube developed by LookingGlassFactory [4]. Additionally, we are exploring methods of using the LED cube alongside the Android display to enhance the gaming experience and develop the potential of bringing traditionally two-dimensional gaming to a simple three-dimensional display. We are currently developing a sample mobile game that showcases the gaming experience when combining a L3D cube with a mobile device.

BACKGROUND

A traditional videogame can be broken down into two distinct parts that come together to create a single whole: the software portion and the hardware portion. The software can be boiled down to a set of instructions that communicate with the hardware, and the hardware is made up of the physical pieces of the game – such as the controller and the display. Advances in hardware lead to a more seamless human-computer-interaction (HCI), where humans are fully immersed in the games and getting the fullest experience the developers would like to engender. Programs must then be developed and changed based on this hardware, allowing all of the technologies to communicate together.

Researchers Pol Pla and Pattie Maes state that "as screen technologies become increasingly widespread, it is [their] belief that designers should evaluate the validity of current form factors and explore new shapes and configurations. Expanding upon visualization metaphors, such explorations have the potential to contribute to a broader ecosystem of output devices. [Their] works seeks to lay the foundation for designing such alternative output technologies. [They] do so by identifying limitations of current display technologies and conceptualizing, designing and building a new display technology that addresses them" [2]. To this end, Pla and Maes developed "Display Blocks", which are six-sided cubes that have screens on each side. They explain that traditional screens function in a way that alienates the user, because the screen is like a "window" that looks out into another entirely separate universe. In order to collapse this window model, they created the cubes as multi-dimensional spatial representations.

Pla and Maes innovative cubes are an example of a type of volumetric display – that is, a graphical display that emulates visuals in three dimensions. Three-dimensional imagery is created by the scattering of light on an (x, y, z) axis in either a "swept" or "static" volume [3]. The L3D cube is a volumetric display that works in a static volume by illuminating individual lights on a three-dimensional plane. Studies have shown that using a volumetric display as opposed to a two-dimensional display adds many degrees of freedom for user input and interaction [3].

RESULT

We have developed a software system that allows the mobile device to control the LED cube as an additional display. This is accomplished by sending the LED cube an array of pixel values through an UDP socket over WiFi. The LED cube is continually running a program that listens for new pixel values and instructs the LED cube to display those values. Changes to the display are initiated by the mobile device which maintains a data structure that fully defines the current LED cube display.

In order to create an immersive gaming experience, we created a game in which the L3D cube functions as a display for a mobile-based game. The planes of the cube encapsulate the world of the game character, which the player must then guide through several puzzles on both the phone and the cube. The main puzzle is a maze that is displayed on the cube where the player can move the character in three dimensions. The cube serves to extend the mobile display, as the phone is not used solely as a controller. The game incorporates various cutscenes and puzzles on the mobile device that expand the game's environment. The animations that serve to progress the plot of the game are displayed primarily on the mobile device and supplemented by other graphics on the cube. These mechanics allow for a gaming experience that eliminates the aforementioned "window" effect and creates a unique visual experience.

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Finding the Center of an Expanding Universe

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1 Introduction

The Big Bang Theory is the most accepted creation theory among the science community. This Theory is taught in many schools around the world. One common example when teaching about the Big Bang and the motion of galaxies is the balloon example. In this example imagine dots drawn on a deflated balloon. These dots represent galaxies. As the balloon inflates the dots get farther and farther from each other. This example implied to us that there is a center of the universe, and that it could be found using the motion of the galaxies. While the idea of a center is not supported with the Big Bang Theory, could a solution to a similar geometry problem exist?[1] In this problem we set up similar conditions to those that could be found out in space. The official formulation of the problem goes as follows.

2 Problem Formulation

Suppose there was a 2D explosion of particles such that the particles are moving radially out from the center denoted C. Let one particle, called E, be the particle we stand on and can observe some number of other particles, denoted P. Observations are restricted however: we can only observe the component of motion of other particles in the straight line between E and P. We can also observe the distance between E and P, for any particle P. The question we will answer is: how many particles P are needed to find the center of the explosion denoted C?

3 Results

This paper shows that to solve for the center C, no fewer than four P points are sufficient. This paper also outlines an algorithm to solve the problem with four points. We first show that with two *suitable* points, P_1, P_2, we can place the point C at two possible locations. We then show that we need at least two additional points, P_3, P_4, to disambiguate between the two possible locations for C. These two additional points, P_3, P_4, have to be *suitably chosen* from the observations of the first and second points, P_1, P_2. From the observations of the points, P_1, P_2, P_3, and P_4, we show that we can uniquely derive C.

We believe that the answer to this problem will help in many areas of computational geometry, and possibly in problems arising in the area of sensor networks. In the future we would like to see a solution to this problem for a 3D explosion.

ANALYZING BODY POSTURES AND SELF-INJURIOUS BEHAVIORS USING A KINECT

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ABSTRACT

Visual input devices like web cameras, the Kinect gaming device, and the Leap Motion gaming device are currently relatively cheap and easy to access. We are studying how best to leverage these devices for at-home monitoring of children with disabilities. We have three major goals for this research: to detect Self-Injurious Behaviors (SIBs), to detect body postures, and to test a mapping of body posture to emotion defined in previous research [1]. We have developed a program that detects both SIBs and body postures using the skeleton tracking features with the Kinect, and have begun initial testing of the accuracy of the interpretation of these postures.

INTRODUCTION AND MOTIVATION

The eventual goal for this project is to create software that uses visual input of all kinds to detect, predict, and react to emotional states. For example, when a child is in a hyper excited state, the lights can lower automatically. When they show emotional distress, a caregiver can be alerted. This visual input could also be applied to interactive spaces, which are rooms created for interactive learning techniques. Currently the systems require permanent installation or calibrated cameras. Our system is much cheaper and easier to use, making it more widely applicable.

BACKGROUND

Although there is no consensus on how to determine human emotion through software detection, there exists literature in attributing body postures to certain emotions through human recognition. The most prominent emotions studied in the literature are happiness, anger, sadness, fear and surprise. In these experiments people are shown pictures of static body postures and are told to identify which emotion is being portrayed. As a result, a mapping is created from body postures to emotions. For example, the body placements for happiness are characterized by the arms being raised above shoulder level and straight, with the head tilted forward [1] and surprise was characterized by the head and chest being bent backwards, abdominal twisting, and straight raised arms [3].

There are also common behaviors of children with emotional or mental disabilities that could be monitored for mood detection called self-injurious behaviors (SIBs). SIBs are "tics" that can be physically harming to a person [4]. Most SIBs build from non-harmful movements common in children with cognitive disabilities, like body-rocking or head-nodding [2]. They can be triggered by things like excitement, boredom, being focused, fatigue, or anxiety. These behaviors can become dangerous if a child begins to hurt themselves while doing them. SIBs are categorized by hitting head on objects, hitting objects to head, hitting body or head, self-biting, self-scratching, self-pinching, eye-poking, hair-pulling, and inserting objects into ears or nose. The danger of these behaviors presents a need to detect them [4].

METHODOLOGY

Based on a previous research paper [1] which defines body postures for specific emotions, we targeted four emotions to detect: happiness/excitement, disgust, sadness and anger. Using Simple OpenNI API, the Kinect records the positions of 15 joints in the body in 3D space. Our system takes these positions and converts them into postures using geometry. For example, we are able to detect hand biting, a behavior common in children with emotional or mental disabilities. However, the Kinect does not track the mouth specifically. By taking the midpoint of the head and neck points, this gives us a relative position of the user's mouth. This method is used for detecting body postures, as well as SIBs. We are currently able to detect slouching, sitting, hand-biting, head and body rocking, pacing, and lying down. The next step is to interpret the body postures we have detected. To collect this data, we will bring in 10 participants and read to each of them 15 statements meant to evoke strong emotion. There are at least three statements for each of the emotions we are targeting. The participants are told to pretend that the statements are real and to react however they would in that situation. Their reactions are recorded both through the Kinect and a video camera. To analyze the results, we will run the data collected through the algorithms we built to see if our system detected body postures indicative of the emotion for each statement. We will also be able to use the camera recordings to determine the accuracy of the Kinect system.

RESULTS AND CONCLUSIONS

We are currently still in the preliminary testing stage to determine the accuracy of the body posture detection system. To test this, we had two participants: one performing the movements and the other to record when the movements occurred. We found that the Kinect has certain limitations when recording postures. In the first trial, slouching was 64% accurate. The main limitation was that it was less accurate when participants turned sideways. It was, however, almost 100 % accurate when the participant was directly facing the Kinect. Similarly, the Kinect often detected slouching when the participant was upright, leading us to alter our definition of slouching to be less sensitive. Another limitation to consider is if the participant's body is out of frame. Lying down and sitting were accurate only at a proper distance from the Kinect. Overall, we are continuing to alter the system to be as accurate as possible.

We hope to eventually be able to predict SIBs before they occur. This process and its implications will be different for each participant, as each person's body postures are different. This long-term goal will involve the use of more complex machine learning techniques. Any future program in this project will be able to use our initial system to detect both SIBs and posture.

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Indoor Localization System for Visually Impaired Students

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The goal of our research project is to explore indoor localization systems for visually impaired students on campus. To accomplish this goal, we researched on-campus navigation, and localization systems for visually impaired students. We created an Android-based application that localizes user position inside a building by fingerprinting the signal strengths of multiple Wi-Fi routers.

Background

Traditionally, visually impaired students rely on guide canes, brail signs, and their memory to navigate. Navigation is particularly challenging for visually impaired students inside new buildings. Since the enactment of Americans with Disabilities Act of 1990 [1], better assistive technology services have become available for visually impaired students on college campuses. However, currently available navigation technologies are expensive, and require significant changes to infrastructure. Therefore, it was vital for our project to create an indoor localization system that can be easily deployed to a wide variety of buildings while using minimum new infrastructure.

Rationale

Currently, Global Positioning System (GPS) is one of the most widely used technologies for outdoor localization and navigation, although GPS technology is not accurate for indoor localization. GPS satellite signals are inaccurate indoors because they cannot effectively penetrate buildings. Common indoor localization relies on technologies such as Pedestrian Dead Reckoning, RFID, Bluetooth Beacons, Wi-Fi, etc. [2, 3]. College campuses usually have ubiquitous Wi-Fi routers and this makes a Wi-Fi based system a feasible starting point for an indoor localization study. The accuracy of Wi-Fi localization depends primarily on the number of Wi-Fi access points available and their signal strengths [4]. Moreover, our main criteria for choosing a technology was low cost and minimal additional infrastructure. Wi-Fi seemed the best choice for our system, hence we focused our research on Wi-Fi fingerprinting.

Approach

The architecture of our solution is based on a smartphone (Android) application and a backend database server using PHP and MySQL. The Android application collects location data that includes Wi-Fi signal strengths, compass orientation, and GPS latitude and longitude. The collected data is sent to the server, which processes it to localize the current indoor position of the device. After determining the location, the server responds to the smartphone that outputs appropriate audible results.

The localization algorithm recognizes an indoor location by comparing the received signal strengths of multiple Wi-Fi access points with the signal strengths in the database of Wi-Fi fingerprints. Using the query results, and based on signal strength differential, the algorithm calculates a confidence value for each location. After iterating this process, the algorithm ranks each location by confidence and outputs the mostly likely location. The system uses simple gesture input to initiate the localization algorithm, and speech output to replace text input/output for the application interface.

Results

An initial system was developed and tested inside Riley Hall, an academic building at Furman. The application was able to localize a user and provide feedback regarding their room and building location. As an additional feature, the user was able to request additional information such as directions of the nearest building exit, elevator, stairs, and/or restrooms.

Future Work

The next step is to improve the accuracy, as we scale the system to the entire campus. Additionally, we plan to add path-finding navigational services to provide indoor and outdoor navigation directions. Research will continue to enhance the system in efforts to make the campus more accessible to visually impaired students.

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Contextual Geotracking Service of Incident Markers in Disaster Search-and-Rescue Operations

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Faculty Sponsor: David Sykes, Department of Computer Science, Wofford College, SC

Problem statement

Destruction of infrastructure during natural disasters causes a lack of usable technology that national first response teams can bring into the field. In turn, this prevents first responders from performing their job as quickly and efficiently as possible. Current state-of-the-art technology is limited to hand-held GPS devices using a custom symbol set to mark incidents such as a critical patient, a deceased body, or a damaged structure. Immediately upon return from a search, responders must both upload and download data through a USB connection. A new search team is immediately dispatched, which does not allow enough time to provide situational awareness through data analysis. Therefore, no new information can be distributed until the second dispatch team returns and the third is dispatched. This lack of real-time information contributes to an incoherent overview of the scene for incident commanders, which consequently leads to difficulties in filtering accurate and updated information, allocating resources, and prioritizing patient triage.

Solution approach

Panacea's Cloud is a real-time communication and coordination tool designed to provide situational awareness to incident commanders and responders in disaster scenarios. Its use of an ad hoc network allows it to be independent of existing infrastructure. Consequently, first responders are able to work together to survey a scenario effectively and provide treatment. Decreased triage time ultimately allows for efficient allocation of resources and in turn can save lives. We designed and implemented a dashboard that is used by the incident commanders to view and track the location of responders, triage patients, and resources in real time. This allows them to dispatch resources, commands, and get a complete overview of the scene as more information is gathered.

Design

In the case of crisis response, big data visualization and dashboard usability are crucial. Given the dynamic nature and high-stakes involved in mass casualty incidents, the incident commander must be able to quickly interpret the available data of a scenario at any given moment and then use the information to best allocate appropriate resources.

- Custom markers are added to the dashboard, which correspond to the current GPS custom symbol set, to display a specific location. A pop-up of plain text and/or pictures is available through user interaction to allow for visual geotagging of static points (e.g., a road block) and dynamic points (e.g., a resource in motion).
- Paths are used to visualize the history of a survey through an area and differentiate incoming data, including but not limited to responder-to-search-area ratios, responder search efficiency, specific device failure, total areas searched and needing to be searched.
- Dynamic timeline playback combined with a gradient on the slider creates a static image that displays specific spatial and temporal information. This allows a user to process a single static image and extract spatial and temporal information about a scenario without continuous playback. Thus, a user can use the color of a gradient to determine the spatial record of resources and responders at a specific time or within a time frame.

- To focus on a particular event in an incident, a spatiotemporal filter is available on the Panacea's Cloud dashboard. A user is able to select the timespan for the desired view. Dragging the display slider through the filtered times changes the view dynamically. A play/pause button is available for event playback at a consistent rate, starting at either a specific time within the filter or at the start of the filter; the button allows for user interruption on the detection of change events within the slider. The filter determines the gradient paths displayed, while the marker above the filter indicates how far along the filtered path that the resource has traveled. The display therefore shows past, present, and future progression, and allows for greater precision in the playback of scenes. A reset button is placed on the dashboard to separate incidents.

Trial

To compare Task Force 1's current Garmin system to Panacea's Cloud, we ran two consecutive trials. Standard training procedure for Task Force 1 involves the placement of laminated placards, symbolizing "incidents", with characteristics corresponding to the custom Task Force 1 markers (e.g., number of victims, detection of human remains, destroyed structure, etc.) onto wooden stakes along a road to simulate a neighborhood for search-and-rescue. The placards are traversed by responders, and the characteristics are entered as quickly and accurately as possible into the given system. Times were recorded and a usability survey was completed.

Results

On average, the data entry time per incident for Panacea's Cloud was 3.6 times faster than the data entry time per incident for the Garmin system. This decrease of time in sending and retrieving data is indicative of a possible decrease in time of search-and-rescue missions as well decreased triage time. In terms of overall usability, Panacea's Cloud's Mobile View and dashboard scored better in 9 out of 10 categories, as rated by both participants and the incident commander.

Future Work

Outside of search-and-rescue operations, the Panacea's Cloud dashboard is extensible to other use cases where geovisual information must be displayed and filtered over a timespan, such as medical triage, device tracking, or environment monitoring. Because of these many use cases, future work on Panacea's Cloud dashboard is focused on increasing usability and adding to the available features. Further trials with a larger sample size and greater control of variables are needed for more conclusive results.

Functionalized Carbon Nanoparticles

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Faculty Sponsor: David Sykes, Computer Science

Background:

Carbon "quantum" dots (or carbon dots) are also can be small carbon nanoparticles with various surface passivation schemes. They are semiconductor-like nanomaterials and exhibit multi-color fluorescence emissions. There has been much recent interest in the use of carbon dots as ultracompact probes to replace organic dyes for bioimaging. In this project, a “carbon dot” is a collection of carbon atoms that are approximately 5 nm in diameters. For example, we synthesized carbon dots of less than 5 nm in diameter with the use of 2,2’-(ethylenedioxy)bis(ethylamine) (EDA) molecules for surface passivation. Surface passivation of the carbon dot resulted in strong fluorescent signal. The EDA-carbon dots were found to be brightly with fluorescent over the spectral range of green fluorescent protein. Our project was to evaluate passivation other EDA-like small amino molecules, such as 2-(2-aminoethoxy) ethanol (EOA). New carbon dot compounds are evaluated by their total fluorescent signal.

Problem:

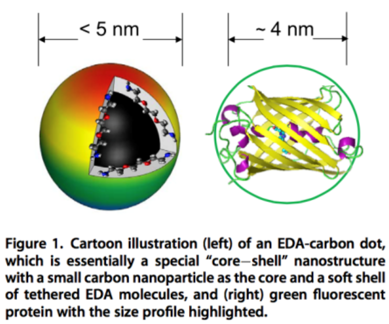
In order to publish an article on this subject, we needed pictures of fluorescent carbon dots. However, truly good pictures of carbon dots for the project were not available, so we needed to create them on our own. We wished to compare the similarities and the differences between previous carbon dots and the carbon dots synthesized in this project. In previous publications, PowerPoint was the tool used to create the 2D images of functionalized carbon dots. It was hoped that a full 3-D image with provided a richer framework from which carbon dots research can be explained. Since all previous images were presented as cartoon spheres, the real purpose of this project was to build an image of carbon nanoparticle to highlight individual atom.

Solution:

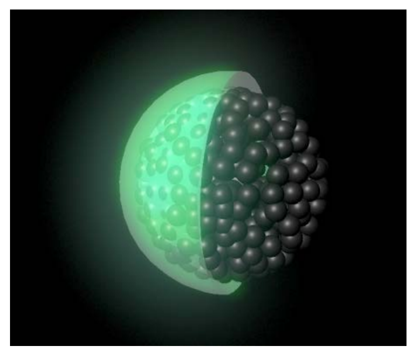
Our initial goal was to develop several 3D pictures for the type of fluorescent carbon dots synthesized in our lab. 3D images are more vivid and could easily show the fluorescent passivation layer. Autodesk Maya, a 3D computer graphics application, was used in this project to create the 3-D carbon dots. With the 3-D carbon dot image, the fluorescence emission was more clearly presented.

Result:

This project relates to the images of the quantum dots. The purpose of this project is to show where on the carbon dot fluorescence is initiated. The images show functionalized carbon dots with certain passivation agents. The left image from Figure 1 is the 2D image of carbon dots from a previous published article about a similar kind of carbon dot. The right image from Figure 1 is the new 3D image of the carbon dots from current project. The new image shows the individual carbon atoms build the carbon dots with fluorescent light from interaction between surface passivation groups and the carbon dot surface while the previous image only presents the carbon dot as a cartoon sphere. The most two time-consuming parts about this project were related to the intensity of fluorescent light and the representation of interaction between passivation agents and the carbon dot surface. The intensity of fluorescent light was hard to adjust because different textures of materials would affect the properties of fluorescent light, such as the glow intensity of the fluorescent light. The representation of the interaction between passivation agents and the carbon dot surface was also hard to create because the covalent bonding between surface passivation groups and carbon dot surface is not a real material. Finally, the representation of the interaction between passivation agents and the carbon dot surface was represented by a shell made up of phoneE1 material with a high transparency value. Although 3D image successfully shows the fluorescent properties and the texture of carbon dots, we still choose 2D image made by PowerPoint to publish because of the difficulties to compare 3D image of current carbon dots with the 2D image of the previous carbon dots. However, through this project, I've practiced and enhanced my skills on Autodesk Maya. This project also helped me understand the connection between chemistry and computer science.



2D Image of Carbon Dots From "Toward Structurally Defined Carbon Dots as Ultracompact Fluorescent Probes"[2]



3D Image of Carbon Dots Made by Autodesk Maya

Figure 1: Comparison of the 2D image (left) and the 3D image (right) of Carbon Dots

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Customizable and Immersive Educational Experiences in Mixed Reality for Individuals with Social and Learning Disabilities

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INTRODUCTION AND PURPOSE

Individuals with social and learning impairments often find it difficult to assimilate themselves into society. Current methods of socialization and education can be difficult to implement and are often contradictory (1). Traditionally, speech and other sorts of auditory cues have been the primary vector for this area of education (2). However, there exists the potential to integrate sight, sound, and spatial manipulation into existing practices using emergent technologies and a highly customizable experience.

This study explores utilization of an individual's home environment, a teaching aide that replicates the likeness of someone close to them, and modular learning experiences using wearable mixed reality to more effectively transfer knowledge and experience. Evidence has already shown that use of virtual reality can improve social impairments present in children with high functioning autism (3). Advanced actor modeling and phonetic vocal blending techniques can replicate the user or others familiar to them, which present highly focused learning modules. Combining these methods could effectively eliminate any social or environmental anxiety that may be inhibiting the developmental process. Implementing exercises that mimic 1:1 scale scenarios and require physical interaction may also improve the user's ability to learn. A limited form of handheld augmented reality, which highlights important characters or objects on a storyboard, has already shown that similar techniques can be effective at improving focus and thereby learning capacity in those with autism spectrum disorders (4).

PROOF OF CONCEPT

A prototype that offers an educational module in which customized actors are rendered, animated, and responsive to user input from a wearable mixed reality device. The prototype will utilize FaceShift markerless motion capture, Microsoft HoloLens, and Unity Game Engine to illustrate discrete examples of immersive educational experiences.

HARDWARE AND SOFTWARE IMPLEMENTATION

Mixed reality is a relatively new term that describes the blending of existing virtual reality and augmented reality technology. Through wearable equipment, this technique seeks to blur the line between what is real and what is virtual. The user can navigate a physical environment with virtual objects that possess physical attributes like depth and collision with real objects. Rony Abovitz, creator of the Magic Leap mixed reality device, has described a situation in which mixed reality will enable surgeons to see patient overlays while performing surgery, increasing both capability and accuracy (5). For use in this study, real world scenarios like safe street crossing or socializing exercises projected within a user's home could allow individuals with learning disabilities to remain within a familiar environment while simultaneously expanding the scope of situational possibilities within their physical space.

Markerless motion capture utilizes various techniques used to detect and process movements or shapes. Capture systems algorithmically analyze static images or reflected infrared light from traditional cameras to determine spatial positioning (6). The markerless motion capture industry's rapid growth can be seen in fields such as commercial animation (7) and clinical biomechanics (8). Expansive industrial use has driven down the cost of consumer capture systems, making them accessible and has led to repeated innovation through research. Current research also indicates that markerless motion capture, in cooperation with artificial intelligence and computer learning software, is capable of detecting personal attributes like facial cues and emotional inflection (9). The use of this data has been effective when addressing children with autism spectrum disorders and their difficulty detecting facial transitions to or from different emotions (10). This study seeks to utilize these advanced concepts and connect learning experiences directly to the user by implementing a facsimile of some well-known likeness as an aide in mixed reality scenarios. Then, exploit its familiarity to reduce distractions and increase focus. The user or an individual emotionally close to them would use markerless modeling to capture and record a list of predetermined expressions. When blended, key capture frames recreate their likeness as a virtual actor whose features could be dynamically manipulated according to text output and performance routines outlined within an educational module.

The captured expressions, which drive virtual actors within those modular performances, are called visemes. Visemes are facial poses that represent the shape of the mouth when speaking. A single viseme can represent multiple phonetic building blocks, phonemes, which are grouped together to form spoken language. Many phonemes are pronounced similarly so most of today's speech synthesizers are based on simplified libraries of phonetic transcription code. One such library, Arpabet, created by the Advanced Research Projects Agency (ARPA), represents every phoneme with a distinct sequence of ASCII characters. Once text is transcribed to Arpabet, queueing viseme models to represent speech can create facial animations. Syllable overlap, or co-articulation, is simulated using a blending technique called concatenative synthesis (11). This whole process animates a simplified facial viseme library, recorded through markerless motion capture, to create the illusion of dynamic speech. Lazalde and Maddock state, "[f]or a concatenative synthesizer, co-articulation within pieces is accounted for, since the dynamic movement of the mouth is part of the representation, although there is still an issue at joins between pieces" (12). To satisfy the level of user immersion required for this study, an aide would be prompted by the capture system to record a short library of fixed length visemes and phonemes that are used to create actor speech. Together, concatenative synthesis and a tiered ranking of visemes, based on how influential the viseme is in co-articulation, can be used to create a fluid text-to-audiovisual synthesizer.

CONCLUSION

Wearable mixed reality devices, when used in tandem with advanced vocal modeling and motion capture, as seen in the proof of concept implementation, create immersive environments that are connected to the user emotionally. The use of these environments to facilitate modular exercises may enhance current techniques used to educate and enrich individuals with social or educational impairments.

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Ensuring Secure and Fairly Timed Computer Network Communication

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Introduction

Given the rise in network based collaboration, online stock trading, and competitive online gaming, it has become increasingly important that all parties involved receive information almost at the same time. Also, as the cyber threat increases, it is important to avoid compromised vertices in a network. We propose an algorithm to fix the issue of unfair delay times between different parties participating in a collaborative application and avoid any known compromised vertices when establishing paths. The algorithm proposed works on a single source network with multiple destinations and known compromised vertices. It starts on a modified form of Dijkstra's algorithm that avoids compromised vertices and ensures that all destinations are leaf vertices. For any destinations that are outside a given delay bound, the algorithm finds a new path within the bound from the source vertex to the specific destination vertex and avoids known compromised vertices. The proposed algorithm also avoids cycles with the destination vertices. The algorithm works by concatenating simple paths, meaning that no vertex will be used more than twice if cycles arise, ensuring that bandwidth does not become an issue. The process used by this algorithm is similar to a depth first search, recursively branching out to adjacent vertices that meet certain criteria until a suitable path is found or terminating if no such path exists. This algorithm has a variety of direct applications where fair and timely communication is essential, including sending updates to distributed financial databases, maintaining quality of service in video conferencing, or ensuring fairness in online gaming.

Definitions and Notation

Let $G = (V, E)$ be an undirected graph where $V = \{v_0, ..., v_k\}$ is the set of vertices of G and $E = \{e_o, ..., e_j\}$ is the set of edges of G such that each $e \in E$ has a positive real number which we call the delay. We denote the delay of a single edge e as $d(e)$ and P as $d(P)$, which is the summation of the delay of all edges in P. We denote a path in a specific tree T between two vertices u and v as $P_T(u \sim v)$. Let $V^* \subseteq$

V be the set of known adversary vertices in G and $M \subseteq V$ be the set of destination vertices in G. Let $s \in V$ be the single source vertex from which a shortest paths tree T is calculated. From T we define our delay maximum $\Delta = max\{d(P_T(s \sim m)) \; \forall \; m \in M\}$ as the delay between s and the destination vertex of greatest distance from s. From Δ we calculate the delay minimum as $\delta = \Delta - \gamma$.

Problem statement

For every vertex $m \in M$ where $d(P_T(s \sim m)) < \delta$, find a walk W from s to m such that the net delay of W is greater than δ, less than Δ, contains no loops with a destination vertex, does not contain any $v \in V^*$, and no vertex or edge is used more than twice. Let the set of all W be W^*.

Algorithm Description

Input

Graph $G = (V, E)$, Vertex set $V^* \subseteq V$, Vertex set $M \subseteq V$, Shortest Paths Tree T rooted at single source vertex $s \in V$, Delay maximum Δ, Delay minimum δ

Output

For each $v \in M$ where the net delay of the path from s to $v < \delta$, return a walk W from s to v (if it exists), such that the net delay of W is greater than δ, less than Δ, contains no loops with a destination vertex, does not contain any $v \in V^*$, and no vertex or edge is used more than twice. Let the set of all W be W^* .

```
Fix-Timing( G, V*, M, T, s, δ, Δ )
        W* = {}
        for each m ∈ M
              if P_T (s ~ m) < δ
                     P = {m}
                     W* = W* ∪ Fix-Path-To( m, P )
              else
                     W* = W* ∪ P_T(s ~ m)
        return W*

Fix-Path_To( v, P )
        for each edge e = (v, w)
        if w ∈ V* continue
        if w ∈ M continue
        if marked[w] continue
        if d(P_T(s ~ m)) + d(e) + d(P) > Δ continue
        if d(P_T(s ~ m)) + d(e) + d(P) ≥ δ
              return P_T(s ~ w) + e + P
        else
              P = P + e
              marked[w] = true
              Fix-Path_To(w, P )

       marked[v] = false
       remove v from P
```

BIG Science: DOI Analysis using NCBI Knowledgebase

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Computer-supported cooperative work has aided in large-scale research projects aiming to improve cohesiveness amongst collaborators, yet still “show high volatility”[1]. Cohesiveness in research groups is determined by how unified the group is towards its goal [2]. Cohesiveness volatility causes communication breakdowns that lead to a lack of funding and issues with the dissemination of information across the project. Diam and colleagues indicate that communication breakdowns in global virtual teams are due to a lack of technology capable of resolving obstacles to cohesiveness [3]. The global virtual teams are similar to large-scale research projects in that they deal with varied eclectic individuals that must collaborate in order to achieve a task. One challenge in solving the problem of cohesiveness is *quantifying* cohesiveness in a group and evaluating whether it has improved or worsened over time.

In this research, we hypothesize that we can measure a large-scale project’s cohesiveness over time by implementing a bibliographic analysis that observes the increase or decrease of the same cited works in its corpus of publications. Our conjecture is that researchers in a project whose articles, published in and outside of the project, show an increasing number of common citations would be a more cohesiveness group because their unity in pursuing the project goal as well as their collaboration would be evident. Our goal of measuring the trend of commonly cited articles could show that more researchers are utilizing information disseminated through the project, thus affirming the usage of project cited articles as a source from which researchers can pull. This would potentially allow researchers to encounter innovative collaboration opportunities by including other works and perspectives in their own publications.

In this research, we analyze a corpus of papers from the South Carolina Project for Organ Biofabrication, a statewide research project that involves 10 colleges and universities across the state [4], to evaluate our hypothesis that the bibliographies of papers would reflect cohesiveness that developed in the project over time. We believe that due to the success of the project, there was an increase of cohesiveness over the course of the project.

We began by downloading the corpus of pdfs from [4], extracting all of the text from the documents, and isolating the DOI of each article. We then queried the online PubMed database, a part of the NCBI knowledgebase, with the DOIs using its API [5] to get some of the article’s metadata including: author, year of publication, and a full list of the articles’ citations. All of the corpus’ DOIs, found in PubMed, and all of their citations’ DOIs were then arranged in a table and checked against each other for matches, categorizing each match according to the publication year of the original corpus article. The results are below in Table 1 (see below).

Table 1: Articles and their Citations

	2010	2011	2012	2013	2014	2015	2016	Total
Papers in Corpus	15	51	21	30	4	0	0	**121**
Papers from PubMed	8	22	9	16	1	0	0	**57**
Common Citations	0	2	0	0	2	0	0	**4**
Normalized Citation Rate*	0	.0909	0	0	2	0	0	**2.0909**

* number of citations/ number papers found

In addition to using the metadata for the corpus articles' citations, we queried PubMed with each article's authors for all their publications from 2010 to present and extracted their citations. This added 555 more articles to our bibliographic analysis. The same analysis was done on these articles as was done on the corpus articles resulting in Table 2.

Table 2: Author Articles and their Citations

	2010	2011	2012	2013	2014	2015	2016	Total
Papers found	34	19	48	74	109	118	152	**555**
Common Citations	2	10	42	46	222	36	62	**416**
Normalized Citation Rate*	.058	.526	.875	.621	2.03	.305	.408	**.75**

* number of citations/ number papers found

Out of 121 articles from the project's original corpus, only 57 were found in the PubMed database, yielding only 4 common citations. The 555 articles by the project researchers had 416 commonly cited articles. As illustrated in Table 2, very few common citations were found in 2010 but this number improved over the next two years. There was a dip in 2013 but then the project crested in common citations in 2014. This preliminary result shows promise. In order to further isolate the cohesiveness within the project, the next progression of our research will include a filter of articles by the grant number referenced in the article. This will allow us to compare cohesiveness in articles directly related to the research project rather than including articles generally written by project authors.

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