Consortium for Computing Sciences in Colleges
In co-operation with

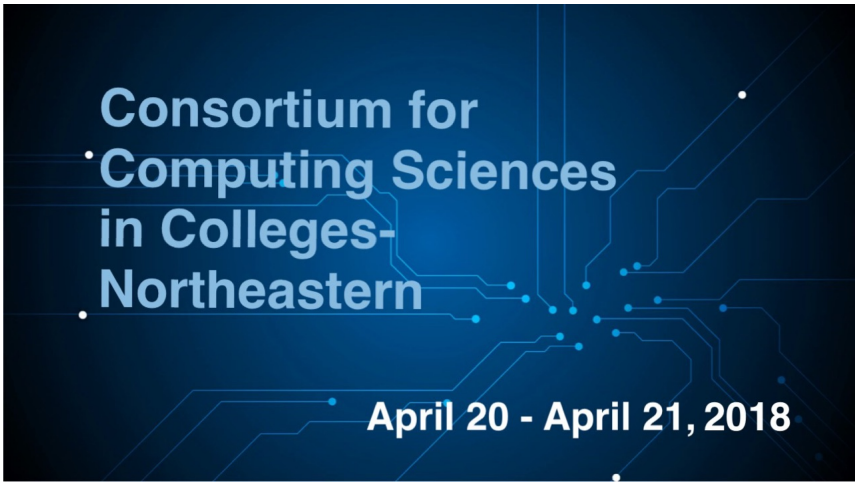
University of New Hampshire at Manchester

The ACM SIGCSE
presents

CCSCNE-2018

The Twenty-Third Annual Consortium for Computing Sciences in Colleges, Northeastern Conference

Student Poster Abstracts



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Poster 5001

AR Enabled Emotion Capture for Health IoT platforms

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We present our experience of creating an augmented reality application for capturing emotional stimuli as a supplementary tool for a Health IoT SaaS platform being developed at St. John's University. The problem posed before us was to design an immersive user experience that stimulates certain emotions as a subject's physiological indicators (pulse, galvanic skin response, head tilt, oximeter reading, airflow) are being recorded. Augmented reality apps have been shown to provide such experiences, however only a few standardized affective stimulus databases have been created for auditory, language, and visual materials. We chose to use the Nencki Affective Picture System (NAPS), which consists of 1,356 realistic, high-quality photographs that are divided into five categories (people, faces, animals, objects, and landscapes). Each of these images have normative ratings for categories such as fear, anger, happiness, sadness, and arousal. Using these images and subjects connected to a health IoT sensor collection platform, we are able to create the back-end requirements for data curation and future psycho-physiological analysis. Our AR application is created using Unity on the MIRA headset, making it portable across various mobile platforms. The back-end is hosted on an Amazon cloud server, and our test protocol is designed following the best medical practices available. Our poster will highlight this application, it's backend infrastructure and testing protocol, and propose algorithms for correlational analysis with the health IoT sensor data collected.

Poster 5002

adVantage – Seeing the Universe: An Immersive, Laboratory-like Virtual Reality Environment Modeling a Star-Planet-Satellite System for Undergraduate Astronomy Students

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This poster introduces the "adVantage – Seeing the Universe" system, a learning environment designed to augment introductory undergraduate astronomy education. The goal of the adVantage project is to show how an immersive virtual reality (VR) environment can be used effectively to model the relative sizes and distances between objects in space. To this end, adVantage leverages the benefits of three-dimensional models by letting users observe and interact with astronomical phenomena from multiple perspectives. The system uses pre-set vantage points to structure students' progress through a variety of "missions" designed to improve their understanding of scale. The adVantage system departs from two-dimensional, textbook illustrations by adding navigable depths to a star-planet-satellite system and distinguishes itself from existing pedagogical 3D space-simulation environments (that we know of) by establishing a laboratory for student investigation. Students exploring in adVantage will be able to adjust parameters, like radius and orbital distance, of the subjects of the system: e.g., the exoplanet WASP-12b, its Sun-like star, WASP-12, and imagined satellites constructed to resemble the Earth and its Moon. This combination of astronomical bodies will engage students by introducing the new star-exoplanet system and provide context by incorporating familiar elements. We have already implemented a JavaScript prototype of the adVantage system and are currently developing the VR system using the game engine Unity. Students will interact with adVantage using a Head Mounted Display (HMD) and hand controllers. We will carry out preliminary investigations of student response to the system once the VR version of adVantage is complete.

Poster 5003

DocuWare Voice Accessibility

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Software that has limited accessibility can create difficulties for users with physical limitations; it should provide universal access to all users. The goal of the DocuWare Accessibility senior design project is to implement accessibility options for users who may have trouble reading or navigating the standard DocuWare user interface due to limited eyesight, manual dexterity, or mobility. DocuWare is a developer of web-based Electronic Content Management software, helping businesses organize their paper and digital files in a database management system.

Our application provides a new interface that has voice control and text-to-speech technology to provide easier access to the content of the documents stored in the system. For example, users will be able to speak a command such as "DocuWare, read my next document." and have the application execute the command appropriately, reading their next document using text-to-speech technology. Additionally, basic DocuWare functionality will be available such as structured and unstructured searches as well as organization, filtering, and searching through file cabinets via voice commands.

This application is a standalone web page that interacts with DocuWare through their REST API, allowing users to log in with their DocuWare account and utilize these new accessibility features. The web page is designed using MVC as the main design pattern, which separates the application into three groups: models, views, and controllers. The user interface is separated in to views. Models manage the data and logic of the application. Controllers accept input and perform interactions on the data models. The framework used is Microsoft's ASP.NET MVC. Some external packages are used in the handling of data tables, speech recognition, text-to-speech, and PDF reading technology, but most of the functionality is provided in Microsoft's system libraries.

This project will have the potential to support DocuWare and bring better accessibility to their users with physical limitations.

Poster 5004

What are we looking at? An interactive 360º Video Viewing Experience

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While Virtual Reality and 360-degree video are getting more attention from individual users and entertainment industry, how these immersive viewing environments can enhance the narration has not been fully explored yet. This research aims to develop a 360° video streaming environment that tracks and analyzes viewers' navigation pattern and also gives the future viewers access to these data as a viewing guide. The streaming environment in Unity was developed to record user behavior data and we conducted a user study with 34 participants using two different 360º testing videos. Then the data is visualized on scatter plot using Python and JavaScript C3 library. We performed content analysis in order to find some potential audience behavior patterns in relation to the 360º content. We found users react differently based on the genre of the video and further findings will be presented in detail on the poster. We expect the analysis will help the content creators to improve or expand on their visual project. This research is an ongoing project and our current goal is to further develop the streaming environment in Unity to use effective visual representations to display past viewing data, making the data accessible to future audience and fostering a more engaging social watching experience.

Poster 5006

Waste Management Web Application for a More Sustainable Haiti

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Our research project stems from our desire to examine ways to alleviate the substandard conditions of the urban waste management infrastructure in Haiti and focuses on the country's capital: Port-au-Prince. The first phase of the project was the design of a prototype web application that allows any existing or potential small-to-medium waste handling companies to have a management system that could help increase its productivity. The second phase was a study of the business implications of introducing the software product to the Haitian market. This poster will address the first phase, as it pertains to the technical portion of the study. Initially, we worked on building a preliminary documentation that we made available online via the college's web server. The second part of the work, and one of the most challenging, was to decide which JavaScript library to use for design, as well as model the structure of the application. Lastly, we have been building the waste management application and testing/optimizing its features. The final version of the web application is written on the React JS library and includes three distinct modules: a route optimization module using the Google Maps API, a scheduler/planner module with BigCalendar and Google Calendar API integration, and a billing module. On the poster, we will elaborate on the reasoning behind React JS as the chosen library for implementation, delve into the description of each module, and discuss the efficiency of the web application in the Haitian environment. Our goal here is to provide an example for a software product that can help more small waste management companies grow and increase their productivity to serve a larger low-income population that has the need for proper disposal of their solid waste.

Project sponsored by the Saint Anselm College Undergraduate Research Fellowship (2017-2018)

Poster 5007

Analysis of a Build vs Buy approach to Software Acquisition for Student Government

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"Do we build it or do we buy it?" This is a question that is asked time and time again when acquiring tools for businesses. When this question is asked by student government, a unique set of factors come into play. This project is a case study of the various issues that come into play when a student government organization embarks on the acquisition of a petitioning software system, using which students can put up petitions on various topics. The student body at large should be able to sign these petitions online. Student government should then be able to monitor these petitions and act on them accordingly - i.e, they should be able to delete offensive petitions, recognize petitions that have reached a certain threshold of signatures and convey them to the campus administration, etc. At the start of this project, the variety of open source software tools for this very purpose appeared to indicate that this acquisition should be trivial. As we progressed, we realized that the numerous stakeholders that influence our requirements - from college administration, to campus IT services who will support the software frameworks and provide the server space for deployment - create a unique set of functional and non-functional requirements specific to our campus that make the "buy" option rather challenging to adopt. Furthermore, we discovered that even open source tools can have licensing issues that impose financial constraints, especially if advanced features are to be used. We, therefore, explored the "build" option for a customized tool, and considered a process we should adopt (including deciding on software, server and database infrastructure) to stay within our budget. This research investigates the pros and cons of both approaches and keeps in mind both technical as well as organizational constraints.

Poster 5008

Refining the Mathematical and Linguistic Standards of *Lexos*

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We present improvements made during our summer research on *Lexos*, a computer application meant to lower the barrier of entry to lexomics, a type of computational linguistics, and challenge assumptions often present therein. The two assumptions in question are the definition of a word, the fundamental unit on which much of lexomics relies, and the mathematical foundations of the field as a whole. Our poster critiques *Lexos*'s previous definition of 'word', a sequence of letters, through comparative linguistics, linguistic typology, and orthographic convention. We discuss our alternative, a character sequence surrounded by whitespace, which increases *Lexos*'s language-agnosticism while simplifying document preparation for both users and developers. This definition is used when tokenizing a text to create a Document Term Matrix, which lists unique words and their frequencies. The DTM allows uploaded documents to be treated as mathematical vectors for cluster and other analyses. As the analytical rigor of *Lexos's* clustering techniques was unknown, we created a model to estimate the reliability of the process as a corpus's word count changes. Our model establishes a relationship between the root mean squared error and the portion of words that are different from an ideal Zipf distribution, allowing for all distance and linkage formulae to be stated in terms of word count and RMSE. By comparing the generalized centroid movement during clustering to distances between an idealized Zipf vector and vectors of varying RSME, our model became an optimization problem, allowing us to calculate a minimal word count required for compact clusters. Our poster presents these findings, including documentation with user guidelines for best practices when using computational text analysis software. Together, these two developments greatly increase the consistency of *Lexos*'s behavior and experimental results, furthering the program's goal of providing intuitive and transparent lexomic tools for researchers of all experience levels.

Poster 5009

Emergent Mapping Systems via WIFI

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In this modern age, radio signals are present everywhere except in the most remote regions of Earth. They create an invisible network composed of different frequencies that overlap with each other. This makes it possible to approximate a location using those overlapping frequencies. The focus of this research is to see if WIFI signals can be used to develop an Emergent Mapping System (EMS). An EMS allows for a person with a mobile device to walk around a building and generate a map that shows where they walked. To accomplish this data from wireless access points would be collected at different points in a building which we will call nodes. Each node consists of a key value pair which is the wireless access point ID and the received signal strength. By correlating the data of each node, it may be possible to approximate the distance and relative position of all the nodes. As a result, a map is generated which will show the approximate location of where a person has walked. Future development of this research opens up possibilities into other domains: reconnaissance tools for mapping buildings; collecting data on the flow of human traffic patterns in buildings; robot navigation systems; improving navigation in GPS dead zones.

Poster 5010

Smart Locking and Tracking System

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According to FBI statistics, the number of bicycle thefts in the US during 2016 was more than 1.6 million. The majority of those incidents took place on college campuses while the bicycles were locked. The challenge: traditional bicycle locks do not have the ability to communicate with the owners.

As our senior design project, we developed a smart locking device that is able to connect wirelessly via cellular networks through a GSM module. It provides users with a real-time monitoring system through a mobile application that can be used from any distance. The GSM module communicates with a corresponding mobile application through a web server and allows the users to monitor and control their locking systems using their phones. For data transmission (between device and user application) we utilize libraries to encrypt the data.

The current functionality of the app allows the users to lock or unlock their locking devices, eliminating the need for carrying a separate key that could be lost. It also provides the current battery status of the locking device and a notification in case the battery is critically low. The integrated GPS module allows the locking device to send GPS data to the app which provides a real-time location tracking capability. The app alarms the user if the locking device has been taken outside a safe zone that is specified by the user. This serves as a security measure to notify the users in case their valuable items are being stolen.
Through this project, we hope to satisfy the users' need to have an IoT security device that can potentially reduce the number of thefts and allows the users to take quick actions.
Acknowledgement:

We thank our sponsor, Mr.Terrry Gilbert, for his support and for giving us the opportunity to work on this project.

Reference:
https://ucr.fbi.gov/crime-in-the-u.s/2016/crime-in-the-u.s.-2016/topic-pages/tables/table-15

Poster 5011

Digit Memory Tests

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We have created a functional web-based testing tool to measure working memory and malingering: Digit Span Backward, Digit Span Forward, and Number Sequencing. After providing the username, the participant reads the instructions for completing Digit Span Backward. The program displays a sequence of digits. Each digit is displayed at an interval of 2 seconds. The user enters the sequence in reverse to continue the test. For Digit Span Forward the user enters the exact sequence seen on the screen instead. For Number Sequencing, a 5-digit number is presented to the user for 5 seconds. A blank screen is presented for 5 seconds followed by screen presenting a new 5-digit number with the previous number for the user to select which one they previously saw. The blank slide time increases after 24 trials at 5 second to 10 seconds, then 15 seconds. Our web-based tool provides immediate results stored in password-protected databases; thus, it is valuable for examining the participant's score relative to norms and tracking changes under experimental conditions.

The web-based tool is built on the school server and is accessible by everyone on campus. Our tool is more than putting together three tests, it provides a template for adding any tests of similar type and the code was written in a modularized way. The software used includes HTML, CSS, JavaScript, PHP and MySQL.

This tool provides three tests for psychology students to use in their research with faculty and course projects.

Project sponsored by INBRE G230 grant for 2017-2018

Poster 5012

Weather Sensitive Smart Stylist

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This research is a user-focused application for clothing choices. The goal is to create a custom system that will recommend clothing items from your wardrobe. Originally, a rule-based relationship between weather and clothing was made for recommending a complete outfit. The rules created as a baseline for the general user was deduced by surveying a group of 100 people. Once the general rules were established, we wanted to explore the possibility of adapting to a specific user. To create a "smart stylist" and enhance user experienced, we asked the user to give feedback about the recommended outfit. This way the system could learn and adjust with machine learning. We used case-based reasoning to compare a given recommendation to the user's previous response to recommendations similar, in order to better recommend an outfit. This adaptive rule-based system was inspired by Haosha Wang's paper titled "Machine Fashion: An Artificial Intelligence Based Clothing Fashion Stylist". In this study, the user input their style preferences and the program recommended an outfit for them. Yet, we wanted to take a different approach by asking for the user's thoughts post-recommendation.

Poster 5013

Unpopularity of LinkedIn in Japan

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The purpose of this research was to study why LinkedIn is not popular in Japan. I conducted a pilot study and found that some cultural factors affect how Japanese people use social media. Based on these results, I conducted interviews to further investigate the reasons for the unpopularity of LinkedIn in Japan. The need for this study was highlighted by the assignment given in the computer science class I took in the fall of 2017, which was to create a LinkedIn account. Although LinkedIn is one of the most popular social networking sites worldwide, it is not popular in Japan, which is one of the most developed countries. LinkedIn has 146 million users in the US, which is about 45% of the population, however, it only has 1 million users in Japan, which is about 0.8% of the population [1]. More surprisingly, 60% of the interview participants said they had never heard of LinkedIn before. It was important for me to get a better understanding of cultural differences and how they affect the use of social media in Japan because I will be working in Tokyo after graduation. In this mixed methods study, I conducted 15 interviews and used Excel to do quantitative analysis and NVivo to do qualitative content analysis of interview transcripts. Some interesting findings include the presence of existing recruiting websites that are widely used for job hunting in Japan, unique Japanese recruitment system called "potential hiring" (meaning companies look for candidates who have communication skills and ambitions rather than job-specific skills or experience) which does not match up with LinkedIn recruiting features, and a high level of privacy especially about sharing personal information related to work. My poster will discuss more findings and how they affect the unpopularity of LinkedIn in Japan.

[1] LinkedIn. (n.d.). 546,000,000+ Registered Members [Infographic]. Retrieved from https://news.linkedin.com/about-us#statistics

Poster 5014

Design and Implementation of a Web-based Database System to Support Music Research

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Our project is to design and implement a web-based, interactive, *Troubador Songs* database system to assist music researchers, in particular, a professor in the Music Studies Department at Brockport. Troubadour songs, composed between 1100 and 1300 CE are the first major repertory of secular songs in Western Europe, still performed today. The sources that transmit the songs to us provide the words and the pitches for the melodies, but no information on rhythms, vocal timbres, or instrumental accompaniment. A few musicologists have analyzed performers' choices, but not in a systematic way. The proposed database system provides a framework to input data about recordings, ranging from the documentation that comes with the recording to listening analyses of actual performance practices and help further research in this area.

To design our database, we gathered our client's requirements and determined the nature of data to be stored and manipulated, and types of questions the users of this system would want answered. After reviewing sample data and conducting interviews, we were able to identify eleven distinctive *entities*. We were then able to identify *relationships* between the entities by creating a normalized entity-relationship model. Some examples of entities are TRACK (Id, Title, TrackNumber, Notes, Albums, Composers, Instruments), INSTRUMENT(Id, Name, Notes, SHClassifications, InstrumentsAlias, Musicians, Tracks, Periods, Regions), etc. After some exploration, we found that C# language, with its support for SQL through Entity Framework and LINQ, and the Visual Studio IDE was best suited for our implementation.

We have implemented the database using the Microsoft Azure technology and created web-based GUI for data entry and validation. We are currently collecting queries that our client wants, writing the necessary SQL code and include them in the GUI. When the system is completed, it will be a useful tool for Troubadour researchers.

Poster 5015

Redesign of the Bridgewater State University Website

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I redesigned a website that demonstrably improves users' success at information seeking and navigation while reducing frustration and hassle compared to the current Bridgewater State University (BSU) website (www.bridgew.edu). A goal of the project is to apply suggestions from Human Computer Interaction (HCI) research to the usability analysis of an existing website.

I explored various reasons behind what makes websites crowd-pleasing and appealing. I read books and articles on HCI, User Experience (UX), and User Interface (UI) Design as a start and analyzed trends in some university websites. I redesigned the BSU website first with wireframes, then built it. I conducted 17 user testing sessions to test the proposed redesign against the current BSU website. This valuable feedback revealed important issues BSU students have with the current website, and what they wish to see in a new website.

This study showed that current BSU students are unhappy or indifferent about the current university website. They expressed that they are not fans of how difficult it is to find information, especially through the search bar. However, there was a much more positive reaction to the proposed redesign. Every participant had something positive to say about the changed navigation. They had an easier time finding the information they were seeking. The general layout as well as the more "modern" look and feel to the website were well-received.

While conducting the user study, various staff members of BSU from departments such as marketing and communications took interest and invited me to become a part of the school's website redesign team. My poster will discuss my preliminary research on HCI, usability experiments, and challenges I encountered during the project. The full description and implementation features of the project and working URL will be presented in detail.

Poster 5016

Generations of the Web

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We present our research on the web and how it is evolving. The goal of this research is to evaluate the web so that we can predict what will come next and the arising technologies that will reshape how use the internet.

In the early 1950s, the structure for our current internet infrastructure began and the first vision of what it could be what conceptualized. J. C. R. Licklider imagined an electronic common where people could communicate, work together, shop, bank, transfer documents, and participate in entertainment; do anything and everything. These ideas started to become reality and pick up traction in the 1990s when the internet became public. Although, the early web was mostly informational, new visionaries found new ways to use the technologies and gain interaction from consumers. Without this interactivity, the internet had several critics, whereas it has become an essential tool used by over 4 billion people every day.

Our research also presents how automated machines have adapted to using the internet in the age of the semantic web, where web pages are structured in ways that make them easily parsable by computers. The adoption of structure is a technology that is viable is certain circumstances while unnecessary in others.

Our poster will present an informational description on the generations of the web as well as talk about the important structures developed from each generation.

Poster 5017

Hexagon: Remote System Command and Control

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Hexagon is a command and control (C2) system for device automation and management that will support penetration testing. Hexagon provides a centralized server which is designed to manage the multiple devices that Crowe Horwath LLP (our industry partner) specifies during a client assessment. Hexagon uses a master/minion relationship between its master instance (hosted by Crowe), and each minion (a client device). The goal of hexagon is to help Crowe's Technology Risk Consulting group overcome the challenge of having to manually configure devices on the client's network to contact their home services during an assessment. Our system manages deployable devices using inbound connections as a command channel to create reverse network connections on a client's network. Penetration testers performing an assessment are now able to contact devices on multiple networks, regardless of last usage time, and automate the first-time connection process.

Masters can be hosted in multiple locations worldwide. Using a web interface for the master, minions can be validated as approved devices. Once a device is approved during an assessment, Crowe staff can open connections, close them, and alter data on the minion system. Each action sent by Crowe staff is signed using RSA public-key cryptography to ensure high security, validation, and availability. The hexagon project successfully allows Crowe to establish a full communication channel between their environment, and a client's. This, on top of the other features for altering minion data, and automation of key-transfer, adds much functionality to the current methodology Crowe uses for management during an assessment.

Our poster will discuss the reasons behind choosing certain features or security measures to implement, as well as the challenges we faced during design and implementation.

Poster 5018

Snap'N'Go: Towards Coordinating the Crowd in Mobile Crowd Sensing Platforms

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We present our ongoing work on improving task-allocation algorithms in Mobile Crowd Sensing Platforms, in which our goal is to open opportunities for the use of crowd sensing in data collection through the development of algorithms that make collection more predictable and trustworthy.

Crowd sensing is a model of sensing in which people, already equipped with smart devices, are recruited to collect data from the environment. The process of crowd sensing is best explained through example. Consider an environmental scientist that wishes to learn about changes in appearance of urban vegetation over time in a particular location. This researcher could set up cameras to take photos of the vegetation at regular time intervals, but cameras are susceptible to damage, theft, and other maintenance requirements. Using of crowd sensing, the researcher can request that data be collected, and passersby will collect that data with their own smartphones, abolishing the need for devoted infrastructure. For collecting the data and contributing to the system, the passersby receives a monetary incentive for their work. While this process is straightforward, there are challenges with this system. How can we ensure that high-quality data is consistently collected? How can we fairly compensate workers?

Our work focuses on the development of a prototype for a mobile crowd sensing platform to be launched on the Wellesley College campus, namely Snap'N'Go, which will be used evaluate various task allocation and incentive models and their effect on crowd behavior. The details of the design and implementation of this prototype will be presented in this poster. Moreover, a demo of the prototype will be presented, with which the conference attendees can engage.

Poster 5019

"Who's There?": Designing Sensor-Aided Wearable Assistive Technology for The Visually Impaired

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Approximately 4% of the world's population is visually impaired, with 82% of them over age 50; and an estimate of 90% of them living in low and middle-income countries. While these numbers are shocking, the bigger challenge is the reduced confidence and life satisfaction that the visually impaired experience as a result of loss in independence and diminished sociability. This project tries to mitigate the problem of dependence using low cost computing. Interacting with visually-impaired users, we identified 3 specific problems: difficulty recognizing those in their surroundings; inability to proactively greet persons entering their social space; and not knowing if the person they are interacting with is within hearing range as they move around. While previous research in assistive technology for the blind has largely focused on enabling smoother navigation, there has been less focus on improving their social interactions.

We employ the Think Aloud Protocol to gain insight into the user's cognitive processes, comfort level and feelings while they are interacting with the device and performing various tasks. Furthermore, we use standard scales to measure changes in sociability and independence as the users use the device.

We developed two distinct prototypes with several iterations of the design-thinking process. The first relied on a smartphone to notify the user. While it performed the tasks, it was too cognitively overwhelming, frustrating and exhausting for a blind user because of the phone's many notifications Therefore, it was an ineffective way of augmenting their perception.

Our second prototype, and current solution, is threefold: building a smart environment; designing a single-purpose, wearable bracelet with sonifications and vibro-tactile communication; and creating a novel audio-haptic user interface. Our poster will discuss our reasons for choosing this solution, the description and implementations features of the design in detail along with the challenges we encountered during the project.

Poster 5020

chU – Campus Eats

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Many students wait on long lines not knowing what is on the daily menu or any specials. This can be frustrating, especially when being asked to pay upfront. Some students will not even find food, due to their eating habits. For this reason, we created a crowd-sourced platform for our Senior Design Project that allows students to upload images of meals around campus. This will help reduce potential waste of a student's meal plan as well as time in lines.

Not only will this help students, it will promote the dining halls and activities going on around campus. Whether there is a one-time event that involves food, or it is the available items at one of the dining halls for that day, students can upload creative images to help others get an idea about what to eat today. Uploading an image of food will allow other students to receive notifications based on any preferences that they have chosen.

For our project, we named it chU (pronounced chew with 'U' for University) and we use Google Vision API to automatically detect if the image is of food and what type of food it is. To use the service, a web application and a phone application can be downloaded on iOS cellular devices. Functionality such as creating accounts, receiving notifications, uploading images, and "favoriting" other students pictures will be used. A phone application is best because receiving notifications through emails could easily be unpopular or get lost in student's accounts, whereas push notifications on your phone are more likely to be seen and easier to deal with by turning them off or swiping them away. This application can help students save time and money and can be used elsewhere.

Poster 5021

Runtime Optimization of the Classification by Discriminative Interpolation Algorithm

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Classification by Discriminative Interpolation (CDI) [1] is a recently developed state-of-the-art supervised learning algorithm that performs classification for functional data. CDI processes the training set by finding approximate representations for each function so that functions of different classes are pushed farther away while functions of the same class are pulled closer. This push–pull behavior is accomplished by iteratively adjusting the coefficients on a wavelet representation. Each function from the testing set is likewise approximated with similar push–pull algorithm that is separately computed for each class. The class whose approximation yields the least error is the predicted label. This research is an investigation of optimizing MATALB machine learning code using C++ and parallelization. The CDI algorithm, as originally implemented, suffers from slow runtime performance.

We optimize CDI's performance by first translating the algorithm into C++ using the Armadillo open source linear algebra library for matrix operations. We then introduced a variety of low-level optimizations without fundamentally changing the CDI algorithm. Next, we addressed the expensive gradient descent and k-nearest neighbor procedures by introducing parallelism and exploiting the fact that each class is examined independently. After each change, we evaluated the revised implementation using standard time series classification datasets and compared the runtimes to the original runtimes. All our experiments exhibited dramatically improved execution times. We expect that these optimizations will support experiments with CDI on significantly larger datasets.

ACKNOWLEDGEMENTS: The authors acknowledge support from National Science Foundation (NSF) grant No. 1560345. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the NSF.

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Poster 5022

Computing Tool for the Psychological Study of Choice Behavior

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The computing tool described here was developed with the help of our advisor for Dr. Lori-Ann Forzano's psychology lab at The College at Brockport and designed to aid in the study of self-control and impulsivity across age ranges. Impulsivity can be defined as the choice of a smaller, less delayed reward over a larger, more delayed reward. Self-control can be defined as the opposite. These two concepts are often studied in various psychological contexts, notably with consumable reinforcers such as food. Computer programs such as the one described here allow for the study of choice behavior in regards to different consumable reinforcers, specifically video reinforcers. The current program recreates and expands upon a previous program used in Dr. Forzano's lab in order to make it compatible with new technologies and to assist in current studies as well as studies to be developed in the future. During development of this program, we worked closely with psychology faculty and examined the psychological principles being studied, as well as how the program would be used to collect data and worked to understand the program previously in place. In addition, we designed and developed the code in a way that would ensure the program meets standards necessary to be considered a legitimate, precise and useful tool in scientific research. This program controls delay and reinforcer length, while also keeping track of the participant's responses and outputting and analyzing them for the researcher in a user-friendly manner. This program improves upon the previous program by making it easier to use for the researcher running the study as well as improving its compatibility with newer technologies. This program also improves upon previous versions of the program by allowing retrieval of videos from additional sources, allowing new studies to be developed depending on specific video qualities.

Poster 5023

3D Modeling to Virtual Viewing: Providing Access to Wheaton's African Collection

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We present our work using photogrammetry to digitize part of Wheaton's Permanent Collection. The project will allow users to view three-dimensional models of objects through an online interface in a web browser and in virtual reality (VR). VR is now available on a variety of platforms: computers; gaming consoles; tablets; and smartphones. Digitization of collections strengthens both documentation on, and access to, objects in museums and academic institutions. Our project focuses on Wheaton's collection of more than 230 African objects, ranging from Ancient Egyptian jewelry to contemporary South African prints. Photogrammetry thus far appears to be the most versatile and reliable method of 3D scanning, capable of processing objects of almost any size. Using software called PhotoScan, we stitched together photos to create a point cloud describing the object to generate a 3D mesh. We used this technique to successfully scan a 3,000-year-old Egyptian necklace. As the project progresses, we will scan larger items like a masquerade costume. With the initial success of our first full scan, we plan to automate and document our process, so the project may continue after we graduate. This includes design of an apparatus to accurately and consistently photograph objects of varying size and condition, development of standards, and creation of a system to store and display the digital files for public viewing. The project's long-term goal is to create a virtual reality collection in which users may walk, observe, and interact with Wheaton-owned objects just as if they are in a physical museum.

Poster 5024

University of New Hampshire Undergraduate Speech Recognition Research Project

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The senior capstone experience for computing students at the University of New Hampshire at Manchester is a research project in speech recognition and machine learning [1][2]. The project goal is to create an optimal set of models using the Switchboard data set and the Sphinx CMU Speech Recognition Toolkit. Speech recognition enables voice input to be understood by machines. With each new capstone project, groups are created based on current needs including managing the computing infrastructure, verifying the validity the data set, analyzing, debugging and optimizing the code base, running experiments using a set of in-house developed scripts for automation to tune speech models, and researching advanced concepts and speech recognition studies to develop deeper understanding of the speech process. Additionally, incorporating newer technologies such as linear discriminant analysis and recurrent neural networks to augment the existing hidden markov model based Sphinx speech recognition system are also explored. This poster highlights the collective objectives of combining and streamlining the complex processes of speech modeling that have been established by previous student-work. Halfway through the project, two teams are created with members from each of the previous subgroups. Each team's goal is to develop an optimized speech system in a friendly competition to develop the most accurate speech models.

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Poster 5025

Mid-Level Feature Detection in Abstract Images

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Can abstract images be described and categorized? Humans use concepts like shape, proximity, and symmetry – can computers learn to recognize similar properties? Most image recognition research focusses on finding either high-level features, such as whether an image has a certain object in it (i.e. a cat), or low-level features, like the location of edges in an image. However, neither approaches are particularly helpful for describing abstract images. Instead, this research focusses on the extraction of mid-level parameters such as roundness, messiness, or blurriness.

Neural networks are used as a model to predict the value of these features after they learn their definitions from thousands of example images. Each network can generate values for a single parameter, or a single network can generate the values for multiple parameters, leveraging the similarity between various parameters. Training images are generated specifically to define parameters with the *Processing* toolkit, which, compared to using existing images, gives the author much more control over the definitions of the parameters the networks learn. Multiple training sets are created for each parameter to broaden its definition and to increase performance on completely new examples. Having more information about these mid-level aesthetic features could open up new opportunities in the generation of abstract images or art.

Poster 5026

Rendering Hypercomplex Fractals

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Fractal mathematics and geometry are useful for applications in science, engineering, and art, but acquiring the tools to explore and graph fractals can be frustrating. Tools available online have limited fractals, rendering methods, and shaders. They often fail to abstract these concepts in a reusable way. This means that multiple programs and interfaces must be learned and used to fully explore the topic. Chaos is an abstract fractal geometry rendering program created to solve this problem. This application builds off previous work done by myself and others [1] to create an extensible, abstract solution to rendering fractals.

Chaos is capable of rendering fractals with different rendering methods and shaders applied dynamically. The program is extensible so new fractals, shaders, and rendering methods can be added. These fractals can be saved to and loaded from files. Each file has keyframes and video settings. Chaos uses these keyframes and settings to produce .mp4 video using linear interpolation between keyframes. Chaos also supports exporting .png images. Fractals currently implemented include the Cantor set, Julia, Juliabulb, Mandelbox, Mandelbrot, Mandelbulb, Newton Basin, and trees. Chaos can render fractals using either Java2D or OpenGL. The poster will detail what fractals are, how they are rendered and colored, implementation, issues that were encountered, and finally planned future improvements.

[1] Tom Beddard's Fractal Lab http://sub.blue/fractal-lab

Poster 5027

Detecting Empathy through Facial Coding

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Finding ways to detect empathetic emotional reactions is a growing area of research interest in the Human-computer Interaction (HCI) community [1],[2]. In this study, we explore the use of facial recognition and eye tracking technologies using the commercial program dumbstruck (dumbstruck.com) to detect levels of empathy and explore the factors that influence the empathetic response experienced by our study participants as they watch a video clip from the movie Forrest Gump. The video clip depicts bullying behaviors based on mental and physical disabilities. The aim of this study is to work towards validating the use of the facial coding/emotion data to detect empathy by exploring the correlation between the participant survey responses indicating empathy and the facial coding/emotion data. Learning how to read micro emotions can be as hard as learning a new language. This is why it is vital to have this technology in order to fully understand how an individual is feeling, way beyond what they might be telling you or even thinking themselves. The implications of these findings offer possible innovative methods of detecting empathetic responses and possible bullying prevention opportunities.

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[2] Slovak, P. (2014). Supporting teaching and learning of situational empathy by technology. CHI '14 Extended Abstracts on Human Factors in Computing Systems. ACM, 315 – 318.

Poster 5029

Exploring Online Game Development

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I present my independent study in multiplayer online game development in the Computer Science Department at Siena College. The goal of this independent study was to practice and learn about the capabilities of multiplayer online games using Javascript, HTML5 and some other Javascript tools. The tools used included Phaser.io a game framework, socket.io a framework for real-time bidirectional event-based communication, and Node.js/Express.js as the web framework and server system. I chose this project for an independent study because it incorporates several topics I am interested in encompassing gaming, server and client communication and synchronization, database and account management among others. I wanted to learn the ins and outs of designing a multiplayer game with accounts that would work in a browser on any computer similar to agar.io and slither.io. For this project, I created a space shooter in a 2D environment, the game allows players to log into accounts, and play online against each other. This requires enemy player movement prediction on the client side and efficient use of updating to insure the game is fast and responsive when hosted on a web server with connections from different locations. To accomplish this goal, latency estimation and other topics such as delta packets had to be researched in order to make sure my servers and clients are only updating the information they need when they need it. The full description and implementation features of the game will be presented in detail.

Poster 5030

Transmission: Anonymous self-advocacy for marginalized people

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I present the development of Transmission, an optimized solution platform whose goal is diversity training on the university faculty and staff level at Wellesley College. As a women's college, Wellesley College recently opened its admissions policy to transgender women. During the years before the policy change, there were a series of campus-wide conversations around gender and what it means to be transgender. A student organization I participated in ran these talks, but few faculty and staff attended them. I conducted follow-up research via anonymous surveys and in-person interviews, concluding that the lack of faculty and staff attendance stemmed from fears of "saying the wrong thing," seeming "stupid" in front of their students, and admitting they didn't already have all the answers, as well as simply not having time to attend sessions during typical hours. In direct response, I developed Transmission. Transmission is a first-of-its-kind platform providing resources, references, and an anonymous, moderated question and answer section centered on the experiences of transgender people. Transmission's patent-pending dual-anonymity model (transgender students anonymously answer faculty and staff's anonymous questions) removes the power dynamics that previously kept faculty and staff from accessing information in typical training sessions. An anonymous user survey (n = 58) conducted after one semester of use at Wellesley College showed that 97% of respondents are very satisfied or satisfied with the application, 97% find Transmission informative, and 93% would "definitely recommend" Transmission to a colleague. I foresee this model applied to sharing knowledge from a variety of groups on topics where sensitivity and anonymity are paramount, and the general societal knowledge base is low, such as disability and mental illness. This further work will be completed and distributed by my company, The Source University.

Poster 5031

Creating Cybersecurity Managers for an Insecure World

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The emergence of large-scale cyber attacks has companies scrambling to defend themselves. On a national level, there are an estimated 285,000 cybersecurity job openings that are unfilled [1]. In 2016, President Obama declared a national emergency on cybersecurity. No organization is too big or small for Cybercriminals. Yahoo, eBay, Equifax, Uber; Even companies of this size are not safe.

Many colleges have begun to teach Cybersecurity. However, of the nearly 300 teaching Cybersecurity, around 60 have degrees in Cybersecurity Management. It seems to be a common issue with CISOs and similar positions where the individual may have the technical knowledge, but no business or management principles to communicate findings or implement policies. In fact, many of the big name companies don't even have a CISO (or similar role) which leads to massive breaches and other large-scale issues occurring.
Cybersecurity is proving to be one of the fastest growing and most highly demanded fields of our current generation. According to the Bureau of Labor Statistics, Information Security is expected to grow at a faster rate than the average, with security analysts growing at 20% [2] and information systems managers growing at 12% [3]. This is why colleges need to start offering more Cybersecurity Management programs; Not only does it secure the graduate a highly-demanded job, it benefits the professional world by offering more cybersecurity managers to protect these establishments.

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Computer and Information Systems Managers Job Outlook, Bureau of Labor Statistics, https://www.bls.gov/ooh/management/computer-and-information-systems-managers.htm

Poster 5032

Emojis and Weather

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We present a machine learning model that predicts the weather of a given location based upon the emojis posted to Twitter by residents of that area. To obtain a represention of a population's collective emotional state, we extract sentiments from tweets posted by individuals at that location. Unlike other models, we rely entirely on emojis for our sentiment analysis.[1],[3] We collect tweets and weather data across 21 major cities in the US. We then train a variety of machine learning algorithms, using a combination of SciKit-Learn[5] and Keras[4], to predict a weather classification (rain, snow, clear, etc.) given a vectorized representation of emojis. We find that the only algorithm to outperform our baseline (ZeroR) is an artificial neural network, with an accuracy of 88%. This supports prior studies regarding the relationship between weather and mood, and also provides evidence for the representational power of emojis. We then conclude by analyzing our trained model to discover which emojis correlate to each weather condition. For instance, we find that the sleeping emoji occurs frequently when there is fog.

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Poster 5033

Ethics and Morality in Game Design

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When concerns are raised about the potential negative effects of video games the focus tends to be on the inclusion of violence and the number of games in which shooting a gun is a core mechanic. In focusing on this, one can easily ignore other, potentially more important, aspects of how games can have an effect on their players.

Like any other type of media, video games do not exist in a cultural vacuum and often, intentionally or not, present players with a certain view of the world. Furthermore, video games, just as other form of media, can be used as a tool of propaganda. With the goal of identifying the design decisions that can be made to influence player opinions, I investigated cases of games made with the intent of propagating certain ideologies as well as cases of games which expressed certain ideas unintentionally as a result of their design. I also began work on a game that aims to illustrate how even small design decisions can have an impact of the message of a game.

My poster will discuss the ways in which game design can be manipulated to advance a moral or political viewpoint, as well as the design decisions I made for my own game. The poster will also address the larger implications of this topic for both game design specifically and software engineering as a whole.

Poster 5034

ClarkEats

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The idea for our project emerged in a Software Engineering course taken last year, and developed with the funding provided through the Geller Endowed Research Award. We wanted to address the two issues of food wastage and students' accessibility to food, especially for those living off-campus. Our website and application, ClarkEats, is a platform where users can post left-over food they have from an event or from cooking, and make that available to other students. The application also supports students who want to market and sell their food/beverages, such as through the popular entrepreneurial courses taking place throughout the semester. This will minimize food wastage at Clark University, alleviate student costs on food and beverages, and create a closer-knit community within the college campus. The application encompasses a user-friendly, location-based interface and allows for Clark University's students, faculty, and staff to share food and take the steps towards becoming a more sustainable campus. After surveying phone usage on campus, the team decided to develop an android application using CSS and a website using HTML. We are collecting data on the amount of food being thrown out at departmental and social events on campus, as well as conducting surveys among students living off-campus to better understand their needs. By conducting multiple surveys, we will establish helpful data around the types of food most being wasted, the common causes, and how to prevent wastage through our technological solution. We will also be visiting campuses that have already implemented a similar application on campus, including Northeastern University and Carnegie Mellon, to receive real-time feedback and to work on modelling our app to fit the specific needs of Clark University.

Poster 5035

Pun Detection and Interpretation: a Recurrent Neural Network with Long Short-Term Memory Cells approach

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Word Sense Disambiguation (WSD) has been considered a solution to the ambiguity which arises due to different meanings of words in different context. Traditional approaches to WSD rest on the assumption that there is a singular meaning for each word in a context. However, there exists an instance of language known as *pun,* which relies on the lexical-semantic ambiguity of words in a context to evoke humor or laughter. This research studies homographic pun, a form of wordplay that exploits the multiple meanings of words. This research aims to answer the question of whether or not an artificial intelligent system can detect and interpret the different layers of meaning of the pun words.

In order to achieve this, I divide the task into three subtasks as described below.

i. Subtask 1 – Pun Detection: Given a document with multiple sentences, the system classifies sentences with pun from those without.
ii. Subtask 2 – Pun Location: Given a sentence with pun, the system locates the exact word intended for pun.
iii. Subtask 3 – Pun Interpretation: Given the exact pun word in the sentence, the system determines the two intended meanings.

While there are differences in the approach for each subtask, the underlying idea behind my method is to utilize word embedding to represent words as vectors of real numbers, also known as *sense vectors*. These vectors are then passed into a recurrent neural network with long short-term memory cells for the detection of pun word. In addition, I also present a knowledge-based method for pun location and interpretation using the cosine similarity and the lexical database WordNet. My system indicates a comparable result to the current state-of-the-art system in subtask 1, while the results in subtask 2 and 3 can be improved.

Poster 5036

Large Scale GPU-accelerated Particle Simulation

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This study examines the increased performance of large-scale particle simulation on the Graphics Processing Unit (GPU) against conventional implementation on the CPU. Usage of General Purpose GPU (GPGPU) programming, which utilizes massively parallel computational algorithms, has grown substantially over the last decade and particle simulation is one of such examples. We developed a particle simulation program using a Compute Shader on the GPU to calculate particle motion with a 3 dimensional Perlin noise algorithm. The current implementation shows around 60 frames per second (FPS) in 4K resolution for about 8 million particles of a point primitive type as well as a quad sprite model. The performance gain over the equivalent version on the CPU is about a 200x speedup in frame rate. Both the CPU and GPU versions of the program were created using C# and HLSL with Unity and DirectX. The GPU used for testing was a Nvidia Geforce GTX 1080 and the CPU an Intel Core i7-6700k @ 4GHz. We deployed this program for the art installation of The Posture Portrait Project at Connecticut College to achieve an image-dissolving visual effect where each particle is generated from image pixels. Moving forward, we will be implementing boids flocking algorithms using a Compute Shader. This particle motion will require significantly more computation than Perlin noise as each particle will need to be aware of each other particle's location.

Poster 5037

Analysis on the History of Programming Languages

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I present my experience with a directed study last semester. The goal of the directed study was to analyze older programming languages, as well as the culture that surrounded them, in order to better understand today's languages and the culture surrounding them. Included in this was learning older languages such as Lisp and BASIC, interacting with older hardware such as an IBM PC and a PDP11/70 running UNIX v7, and reading books such as Steven Levy's *Hackers* to better understand the culture starting from the mid 60s to late 90s. In doing so, I discovered that many early languages were influenced by how rudimentary early computers were. These languages gave programmers more control over their programs at the cost of more complexity. Early programming was mostly done in assembly, with MIT students spending hours on end trying to "bum" lines of code to achieve the most elegant, and clever, programs possible. Later languages would offer abstractions to make easy what would otherwise be complicated problems to solve. Languages were also influenced by the realm of mathematics, with John McCarthy's Lisp stemming from the realm of mathematics called "lambda calculus." While all of these languages, including languages today, can be made to solve the same problems, some are better at different problems than others. Lisp excels at higher level, more mathematically-inclined problems because of its origins, while languages like BASIC and FORTRAN are more business-inclined. My poster will demonstrate how different languages have grown off of each other, in the form of a family tree, as well as five programs, each written in five different languages (Lisp, BASIC, C, Java, and Go) in order to demonstrate the differences between each language, which also includes defining the features of each language. I will also present functioning versions of these programs in detail.

Poster 5038

Stop Falling for Fake News: Three Easy Steps

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Researchers have developed various strategies and checklists for verifying online source credibility, but the average fact check takes several minutes. A paradigm-shifting improvement was proposed by researcher Mike Caulfield who suggests "four moves": check for previous work, go upstream, read laterally, and circle back. To further simplify this process, we have summarized the four "moves" into three questions to ask when verifying an article: 1) "has this been fact checked?" 2) "what's the story with the links?" and 3) "who else is talking about this?" However, even answering these three questions requires too much time for most people to evaluate the credibility of online sources. People's unwillingness and inability to fact-check suggests the need to build semi-automated tools to assist with evaluating source credibility. Our vision is to create a "nutrition label" to help users evaluate web sources' credibility. Just as a nutrition label does not label foods as "healthy" or "unhealthy," our label would not label sources as "reliable" or "unreliable." Instead, by examining many known fake, pseudoscience, conspiracy, and reliable sites we have started to determine the appropriate analogies for the calories, fats, and carbohydrates on the credibility nutrition label. We have discovered several features that can be used to assess source credibility, such as domain registration information, the quantity of external links, the subjectivity of the content of the page, and whether the site is imitating a news organization. Some of these features by traversing large swaths of the Web and generalizing the findings. Other features need the implementation of machine learning algorithm that mimics how humans solve the same task.

Poster 5039

Chess Piece Recognition

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In this paper, we describe a system we have built to detect, identify, and find the position of chess pieces on a physical chessboard in order to provide sufficient information to a chess engine that can generate a suggested best move. Several methods have been proposed for solving this problem, and most make assumptions about the chess set being used. We have refrained from using a top view and thereby tracking the game since it would trivialize the problem. Topics and difficulties that are addressed in this project include: segmentation, shape recognition, lighting differences, occlusion, board/piece color identification, and camera angle. The system takes an RGB image of the chessboard from a player's viewpoint, locates each piece, crops the image region, binarizes it to find the silhouette, then calculates Fourier descriptors (FDs) for every one using an angle-normalized centroid distance function. FDs for the extracted pieces are compared to FDs from a database of ground truth images. This database contains sets of images of single chess pieces, each image taken from a different angle to make it invariant to camera position. The recognition results are good providing 73% accuracy for scenarios that contain minimal occlusion – a piece, partially hiding behind another. We are currently experimenting with 3D images to ensure that we can properly identify each piece, even those that are partially occluded. We are using an Xbox Kinect to retrieve a depth image of the board in addition to a standard RGB image. This depth image will increase our ability to differentiate an occluded piece from the foreground piece. Once labeled and assigned to a square on the board based on their location in the original image, the physical board state can then be sent to a chess engine to be evaluated and a move to be recommended.

Poster 5040

Smart Bogs

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The Smart Bog project, funded by Bridgewater State University, is helping further ecological research for the Tidmarsh Living Observatory in Plymouth, MA. Tidmarsh is six-hundred acres of land that was a functioning cranberry bog for over a hundred years. During the past few years, this property has been restored into an ecologically productive natural wetland through the support of researchers from the University of Massachusetts with Massachusetts Institute of Technology with funding from the Massachusetts Audubon Society. Tidmarsh's restoration to a natural wetland was guided by live data fed from MIT Responsive Environments' sensor nodes. We are developing our own sensor nodes with the help of Bridgewater State University Professors Dr. Thilina Surasinghe and Dr. Michael Black that are intended to be compatible with the existing network setup by MIT.

MIT's Responsive Environments group is still developing sensor nodes that collect data using specific environmental sensors. The Responsive Environments group typically has a network of 20 low power sensor nodes operational and are distributed through the 600-acre section of Tidmarsh.

Dr. Surasinghe believes that we can make these sensor devices at a lower cost than what MIT is creating and help expand the current sensor network. As of late February 2018, Smart Bogs has successfully integrated light sensitivity, temperature and humidity, and water temperature sensors with an Arduino Uno. The data is stored persistently on an SD card. We have field tested our node with Dr. Surasinghe at Tidmarsh and have data for light, temperature and humidity. We are in the process of getting our Arduino to wirelessly connect with the network using the ZigBee 802.15.4 protocol, and integrating our pH sensor onto our sensor node. In the future, we will be implementing a solar panel, water conductivity sensor, dissolved oxygen sensor, and soil moisture sensors.

Poster 5041

Freemail: Web Application Development with Node.js

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We present our experience developing web applications as a course project. We used Node.js, a modern JavaScript server-side framework featuring an event-driven, asynchronous API consistent conceptually with standardized JavaScript APIs found in web browsers.

We also used a package manager (npm) that simplifies building web applications with third-party components, such as Express, Angular, React and more. Express's API organizes web applications into the model-view-controller (MVC) architecture, thereby decoupling routes (the controller) from logic (the model) and decoupling presentation (views) from logic either through templates or by serving model state as JSON asynchronously to the web browser.

We deployed our project to Heroku, which is a cloud web-hosting platform that offers free hosting and supports multiple web frameworks, including Node.js. PostgreSQL is used as a database, which is hosted on Heroku's servers, and is offered free of charge. Heroku uses Git, the distributed version control system, to handle deployment of web application updates to their servers. Our project is written in Node.js, featuring access to a database behind an authentication layer (provided by the passport.js, express-session and bcryptjs packages).

Our project, Freemail, is an advertisement-free experience, free of categories such as “Promotions”, “Travel”, “Coupons” which are provided by even spam-filtered email services such as Gmail and Yahoo - these categorized spam receptacles are simply spam that the offending party pays the email provider to get into the user’s realm of view.

Our poster will discuss our challenges we encountered during the project. The full description and implementation features of the project and working Heroku URL will be presented in detail.

Poster 5042

An Interactive System for Conducting Music

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Score following is a research topic at the intersection of music and computing where a computer program accompanies a live musician by playing music along with him or her in real time. Most score followers use audio or MIDI input from a soloist, compare what is being played with where it should be in the score, and play the accompaniment accordingly. This research focuses on creating a score follower that follows the movements of a conductor rather than the notes of a musician during playback of a computer score. We have implemented the oscillator detailed in Edward W. Large's paper titled "Periodicity, Pattern Formation, and Metric Structure"[1] in C++ using a number of libraries that support input/output devices. We integrated the model into our conducting system and were able to produce a predictive entrainment of the computer's instantaneous tempo and beats times with that of the live conductor. We use a high-resolution tracker, namely, the Polhemus G4 electromagnetic sensor to accurately track the position of the conductor's right hand. The conductor shows a beat by moving his or her hand swiftly downward and back up again. The beat is characterized by reversal of direction and peak acceleration. The oscillator uses the intervals between the successive detected beats to adjust its score position, and in turn, control the playback of a MIDI file. This technology has many practical uses and we are focusing on the capability to conduct the computer as an instrument in a performance setting as well as using the program as a learning tool for new conductor

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Large, Edward W. "Periodicity, Pattern Formation, and Metric Structure." *Journal of New Music Research*, July 2001.

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