UCLA Samueli
School of Engineering

Summer Undergraduate Research Program at the Engineering Student Resource Center
Office of Academic and Student Affairs
UCLA Samueli School of Engineering
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SUMMER
UNDERGRADUATE
RESEARCH PROGRAM

2019

RESEARCH JOURNAL

DEAN'S MESSAGE

The Summer Undergraduate Research Program (SURP) provides participants with an intensive 8-week summer research experience in a wide range of engineering fields. Undergraduate students participate in research with UCLA Samueli School of Engineering faculty and research teams to gain real-world lab experience. As part of this program, SURP students:

- Meet and network with peers who have similar goals and interests
- Learn to communicate research outcomes by participating in weekly Technical Presentation Labs
- Create a professional scientific poster of their research
- Write and publish a research abstract
- Present a detailed Summary of Project
- Become more competitive when applying to engineering graduate schools

This year, 39 undergraduate students were selected to join the 2019 SURP cohort. I would like to congratulate this SURP class on completion of their amazing research projects. Creating new knowledge is a very important, and a very difficult, task. These high-performing students have done an outstanding job working through the rigors and challenges of full time research. They should be very proud of the abstracts and posters they have published today. I encourage you to meet the students, ask questions about their projects, and learn about the cutting-edge knowledge that is being created here at the UCLA Samueli School of Engineering.

Sincerely,

Jayathi Murthy
Ronald and Valerie Sugar Dean

LAB NAME

Actuated Sensing & Coordinated Embedded Networked Technologies Laboratory

FACULTY ADVISOR

Professor William Kaiser

GRADUATE STUDENT DAILY LAB SUPERVISOR

Susie Tan

DEPARTMENT

Electrical and Computer Engineering

Jason Bustani

Computer Science

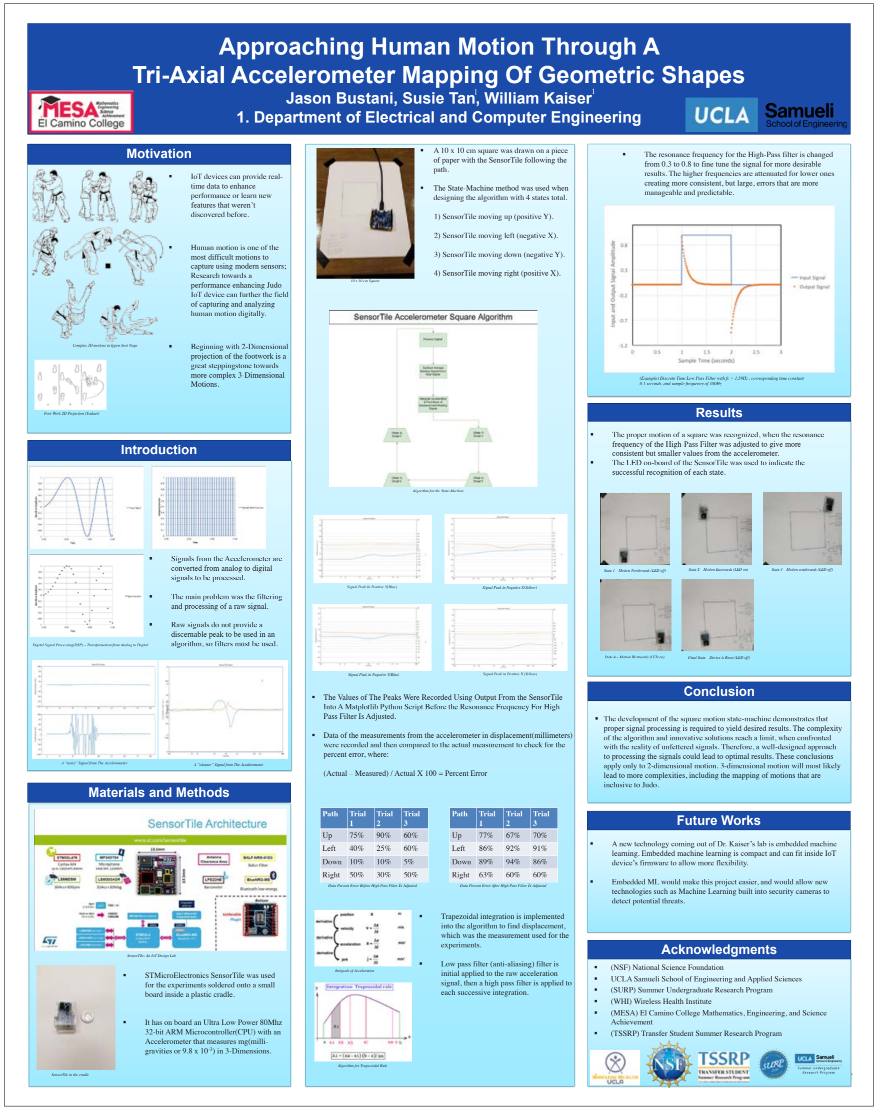
Third Year

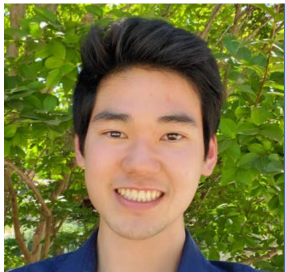
UC Berkeley

Wireless Health Institute

Approaching Human Motion Through A Tri-Axial Accelerometer Mapping of Geometric Shapes

Accurately detecting human motion via electronic signals is a feat that has yet to be mastered. It remains to be one of the most difficult and complex motions to be detected by an accelerometer, and its mastery could lead to many new technologies in the medical and sports field. Digital signals are by their nature probabilistic and stochastic, and mapping simple to complex shapes merely on a 2-dimensional plane is challenging. The initial hypothesis was to collect data using a 10 x 10 cm square and writing the outputs in a notebook and calculate the errors to find a consistent pattern. A consequent hypothesis was to play with the filters to attune the signal for a desired result. By changing the resonance frequency for the High-Pass Filter, a chaotic signal came within a decent amount of precision for mapping rectilinear and curved figures that come close to human motions projected onto a 2-dimensional plane. The errors were dependent completely on the filter and on the setup of the device. Proper sensor placement to avoid the effect of gravity and finding the right constant for the filter lead to successful results.





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Sean Dao
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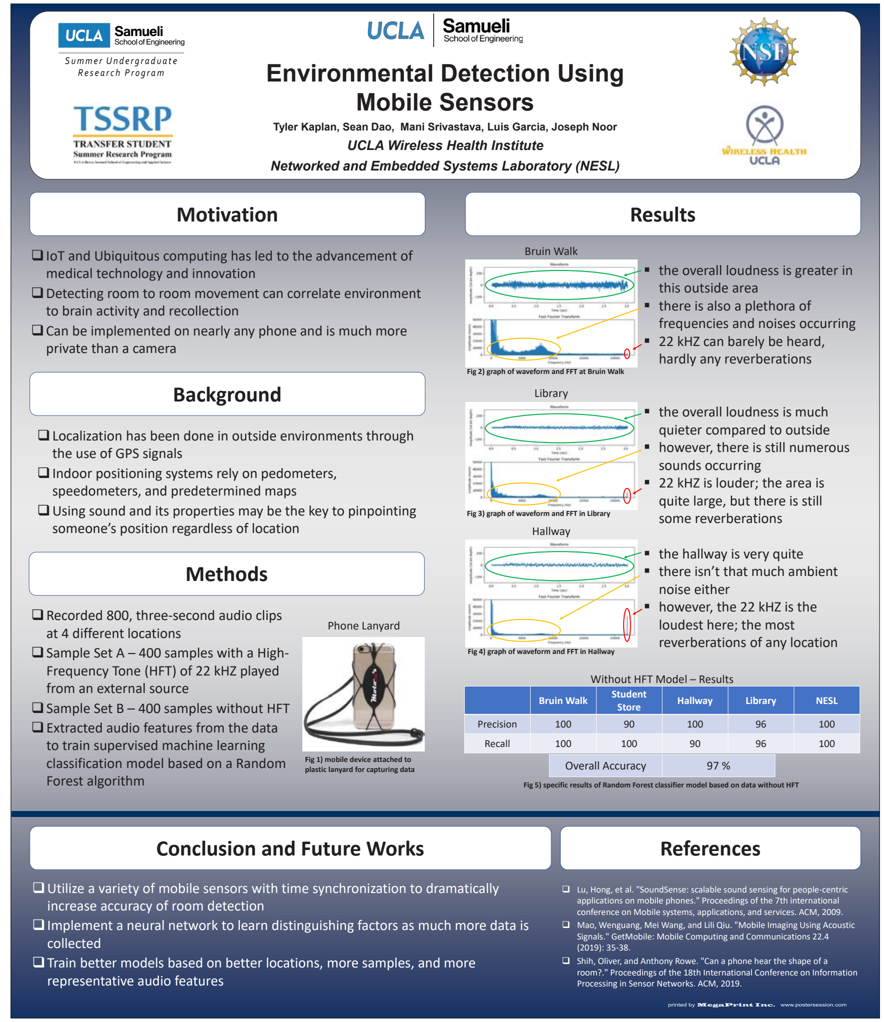
Environmental Detection Using Mobile Sensors

Machine learning has made significant strides in enhancing human situational awareness with respect to recollection. In order to improve this cognitive ability, it is necessary to have a baseline understanding of the environment, which can also provide context to particular applications. Although localization of a human combined with background knowledge of an area (e.g., having a map of a place) can provide some intrinsic understanding of an environment, there are limitations for both components. Typically, localization in outdoor settings relies on GPS, while indoor localization is dependent on existing infrastructure. In addition, it is neither scalable nor generalizable to rely on background information of an area for exploring new environments. In this work, we aim to provide a semantic understanding of human movement through different spaces using a mobile phone attached to the subject. In particular, we simplify the problem by detecting room-to-room movement instead of fine-grained localization. We further show that detecting room-to-room movement can be implemented using ubiquitous phone sensors that provide a less invasive means of interaction compared to that of a camera. Knowing when a user traverses from one room to another can provide a significant amount of information to make inferences about a specific location. These inferences can then be applied to a variety of applications, such as correlating environment with episodic brain activity.



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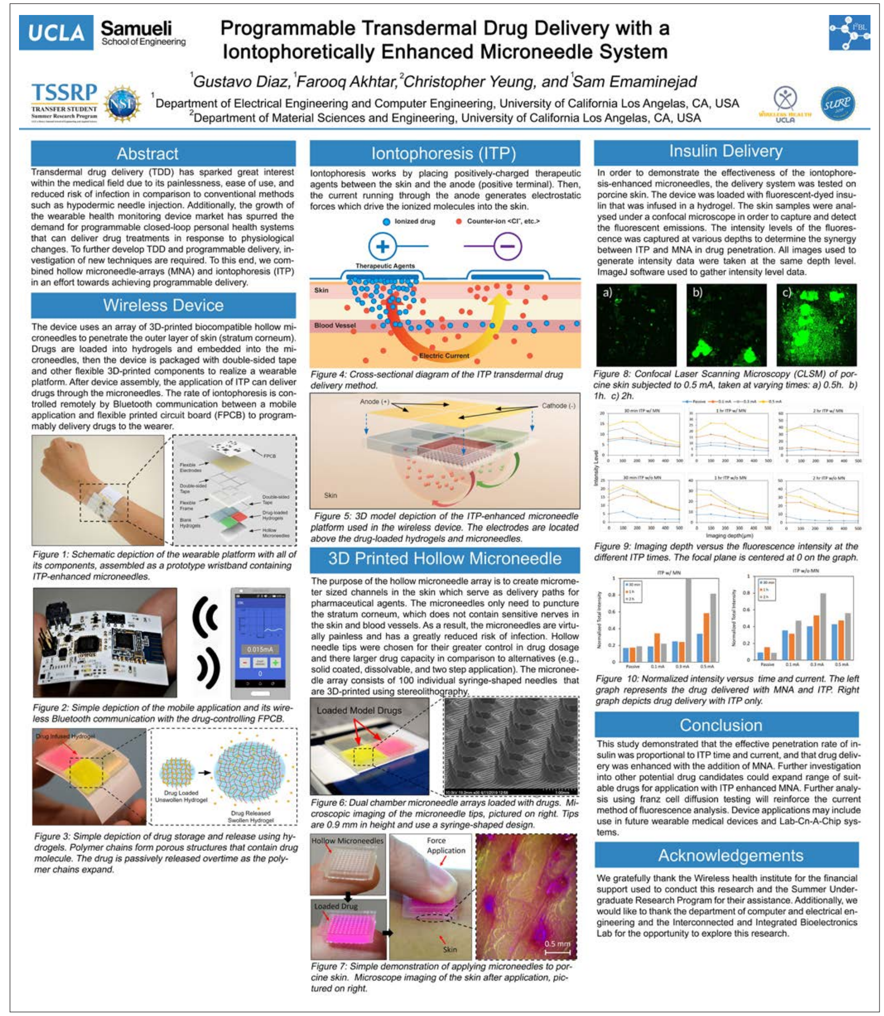
Programable Transdermal Drug Delivery with a Iontophoretically Enhanced Microneedle System

Transdermal drug delivery (TDD) has sparked great interest within the medical field due to its painlessness, ease of use, and reduced risk of infection in comparison to conventional methods such as hypodermic needle injection. Additionally, the growth of the wearable health monitoring device market has spurred the demand for programmable closed-loop personal health systems that can deliver drug treatments in response to physiological changes. To further develop TDD and programmable delivery, investigation of new techniques are required. To this end, we combined hollow microneedle-arrays (MNA) and iontophoresis (ITP) in an effort towards achieving programmable delivery. The MNA serves the purpose of creating tiny pores in the stratum corneum that act as drug delivery channels. In conjunction, ITP utilizes a small electric field in order to drive ionized drug molecules into the skin using electrostatic forces. Additionally, ITP allows for fine control over the delivery rate by adjusting the current strength. We tested the ITP-enhanced MNA by delivering fluorescent-dyed insulin into porcine skin samples at various time intervals and currents. The skin was then analysed using confocal laser scanning microscopy (CLSM) to determine the penetration depth of the insulin. CLSM imaging and fluorescent intensity analysis revealed that the ITP-enhanced MNA have a significantly greater penetration depth than individually applying either one. The ITP-enhanced MNA system proved to be an effective delivery strategy for larger molecule drugs in a small form factor and with easily-programmable control. Further testing of ITP-enhanced MNA with larger molecules could expand the range of suitable drugs for TDD applications.



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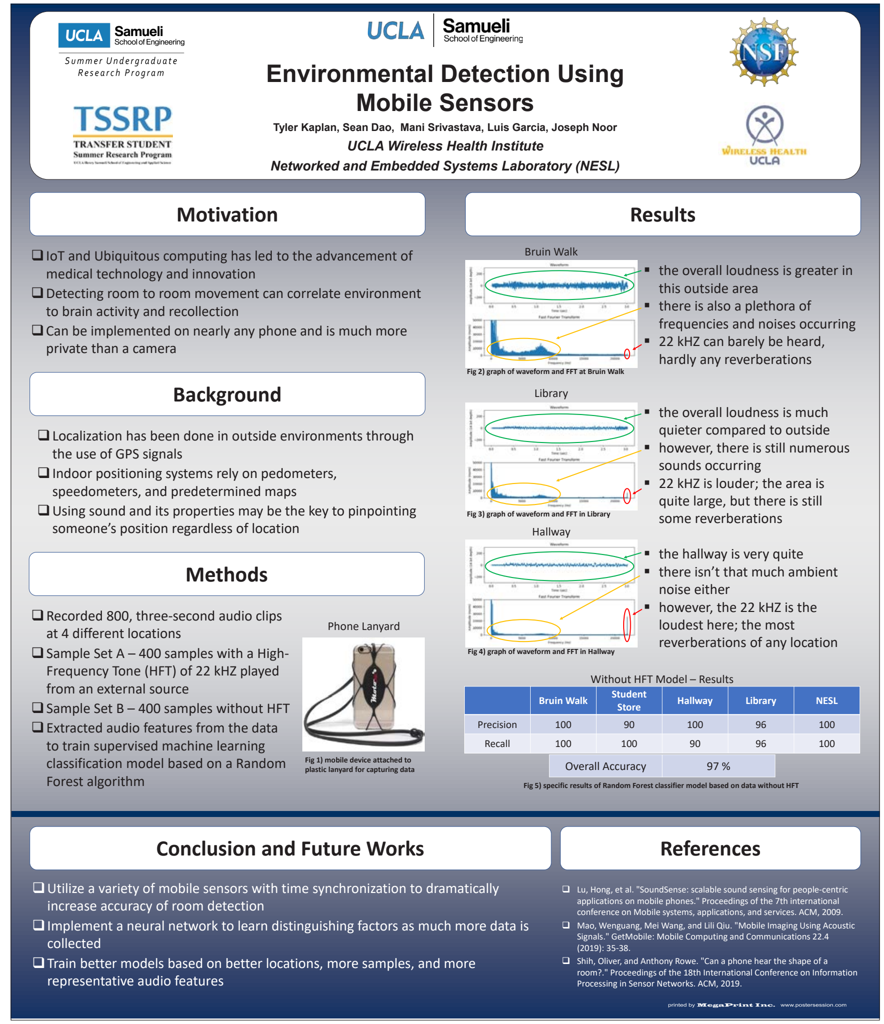
Environmental Detection Using Mobile Sensors

Machine learning has made significant strides in enhancing human situational awareness with respect to recollection. In order to improve this cognitive ability, it is necessary to have a baseline understanding of the environment, which can also provide context to particular applications. Although localization of a human combined with background knowledge of an area (e.g., having a map of a place) can provide some intrinsic understanding of an environment, there are limitations for both components. Typically, localization in outdoor settings relies on GPS, while indoor localization is dependent on existing infrastructure. In addition, it is neither scalable nor generalizable to rely on background information of an area for exploring new environments. In this work, we aim to provide a semantic understanding of human movement through different spaces using a mobile phone attached to the subject. In particular, we simplify the problem by detecting room-to-room movement instead of fine-grained localization. We further show that detecting room-to-room movement can be implemented using ubiquitous phone sensors that provide a less invasive means of interaction compared to that of a camera. Knowing when a user traverses from one room to another can provide a significant amount of information about a specific location. These inferences can then be applied to a variety of applications, such as correlating environment with episodic brain activity.



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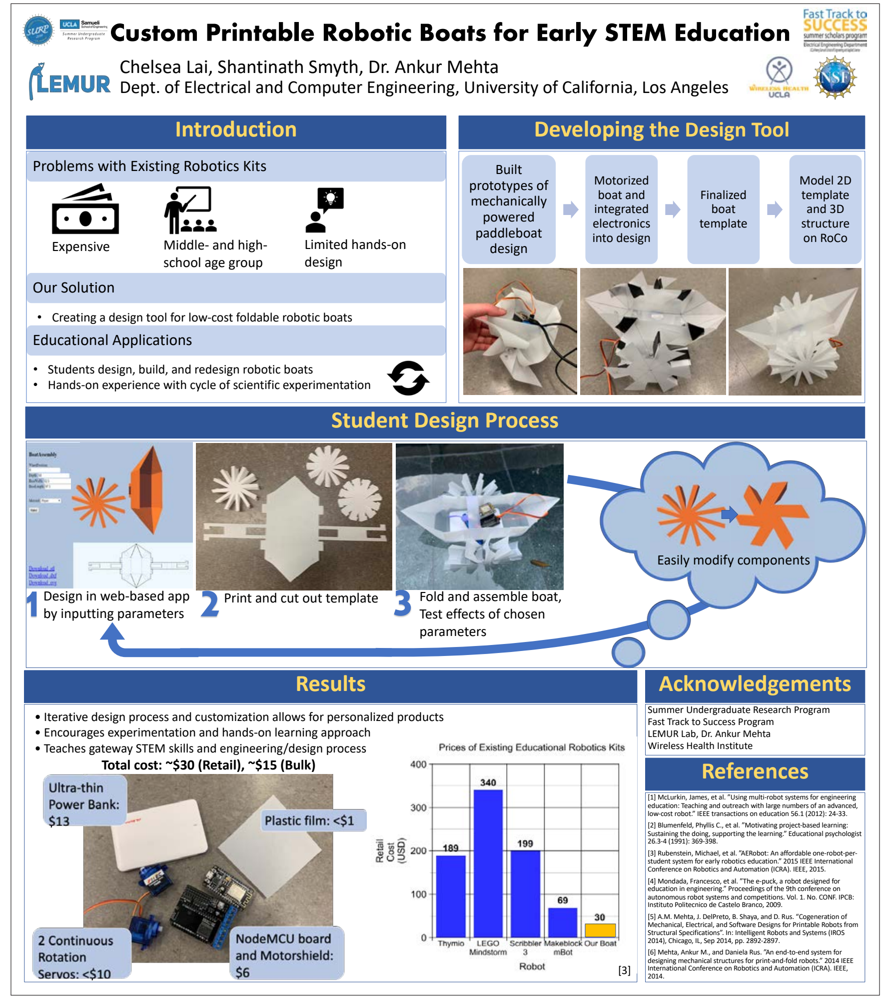
Custom Printable Robotic Boats for Early STEM Education

Robotics engages students in multiple disciplines of engineering, which is increasingly important in our technology-based society. However, existing robotics kits are mostly geared toward middle- and high- school students and either cost hundreds or thousands of dollars or have limited hands-on design capabilities. This leaves customizable robotics unaffordable to many schools, as well as neglects to introduce robots to impressionable elementary-age children. Our project focused on concurrently addressing three concerns: cost, age group, and creative potential. We developed a modifiable template for an affordable robot that students design themselves, supporting a project-based learning approach, with the goal of inspiring interest in STEM in kindergartners.

Since most robotics kits are cars, we designed a robotic boat and a web-based app, which students use to create and steer the boat. One boat is made of a flat sheet of plastic folded into a 3D structure, with basic electronics propelling the vehicle, and costs under $40 total. In the app, powered by Robot Compiler technology, students change parameters on the boat to see the effect on the 2D printable template and 3D model of the finished boat. This focus on customization encourages iterative design and engages students firsthand in the engineering innovation process. Students have flexibility in designing their robots down to the component level, fostering a sense of ownership over their project and resulting in a more self-motivated learning experience.



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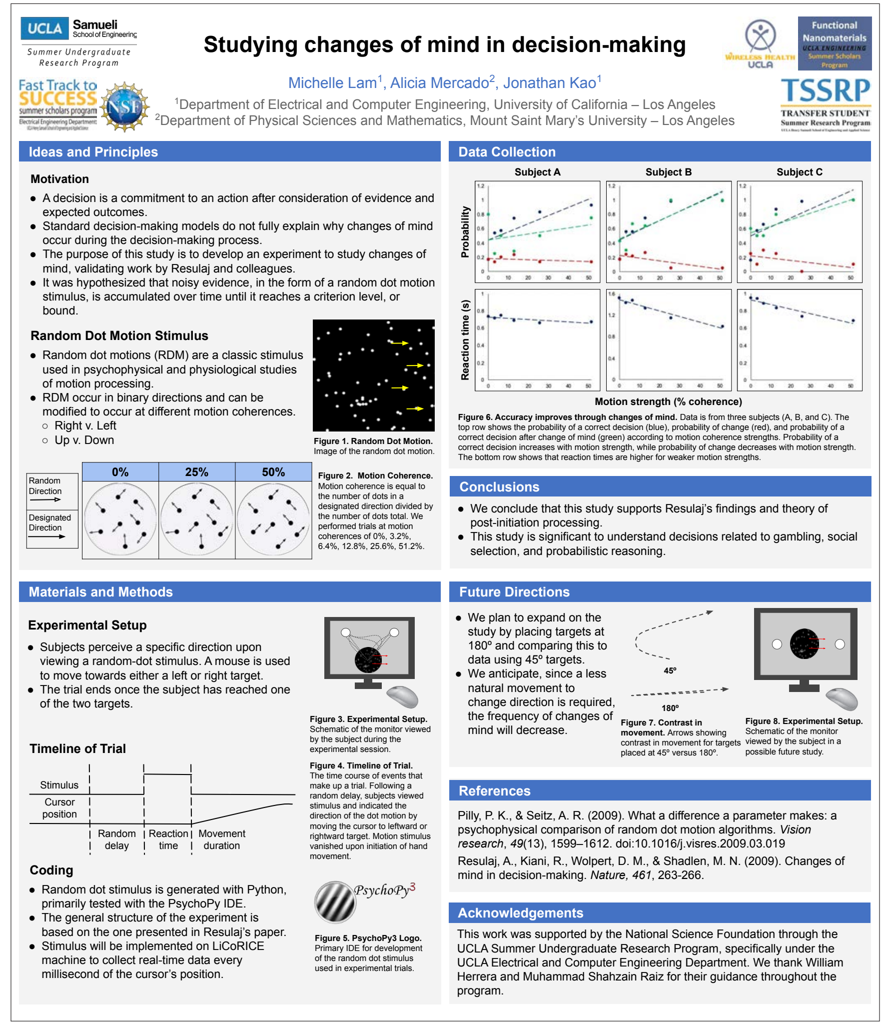
Studying changes of mind in decision-making

A decision is a commitment to an action after consideration of evidence and expected outcomes. The brain deliberates on available evidence to yield an action or decision. However, during cognition, we often change our minds; standard decision-making models do not fully explain why these changes of mind occur. The purpose of this study is to develop an experiment to study changes of mind, validating work by Resulaj and colleagues. It was hypothesized that noisy evidence, in the form of a random dot motion stimulus, is accumulated over time until it reaches a criterion level, or bound. An initial decision is made once this criterion is achieved. While the trials were conducted, subjects made decisions about a noisy visual stimulus, and then they indicated their choice of direction by moving a joystick according to the direction inferred. The brain then exploited further information that either reversed or reaffirmed the initial decision made. We conclude that this study supports Resulaj's findings and theory of post-initiation processing. This study is significant to understand decisions related to gambling, social selection, and probabilistic reasoning.



UCLA Samueli School of Engineering — Summer Undergraduate Research Program

Fast Track to SUCCESS summer scholars program

Studying changes of mind in decision-making

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Wireless Health UCLA — Functional Nanomaterials UCLA Engineering Summer Scholars Program — TSSRP Transfer Student Summer Research Program

Ideas and Principles

Motivation

- A decision is a commitment to an action after consideration of evidence and expected outcomes.
- Standard decision-making models do not fully explain why changes of mind occur during the decision-making process.
- The purpose of this study is to develop an experiment to study changes of mind, validating work by Resulaj and colleagues.
- It was hypothesized that noisy evidence, in the form of a random dot motion stimulus, is accumulated over time until it reaches a criterion level, or bound.

Random Dot Motion Stimulus

- Random dot motions (RDM) are a classic stimulus used in psychophysical and physiological studies of motion processing.
- RDM occur in binary directions and can be modified to occur at different motion coherences.
  - Right v. Left
  - Up v. Down

Figure 1. Random Dot Motion. Image of the random dot motion.

Random Direction / Designated Direction — 0% — 25% — 50%

Figure 2. Motion Coherence. Motion coherence is equal to the number of dots in a designated direction divided by the number of dots total. We performed trials at motion coherences of 0%, 3.2%, 6.4%, 12.8%, 25.6%, 51.2%.

Data Collection

Subject A — Subject B — Subject C

Probability — Reaction time (s) — Motion strength (% coherence)

Figure 6. Accuracy improves through changes of mind. Data is from three subjects (A, B, and C). The top row shows the probability of a correct decision (blue), probability of change (red), and probability of a correct decision after change of mind (green) according to motion coherence strengths. Probability of a correct decision increases with motion strength, while probability of change decreases with motion strength. The bottom row shows that reaction times are higher for weaker motion strengths.

Conclusions

- We conclude that this study supports Resulaj's findings and theory of post-initiation processing.
- This study is significant to understand decisions related to gambling, social selection, and probabilistic reasoning.

Materials and Methods

Experimental Setup

- Subjects perceive a specific direction upon viewing a random-dot stimulus. A mouse is used to move towards either a left or right target.
- The trial ends once the subject has reached one of the two targets.

Figure 3. Experimental Setup. Schematic of the monitor viewed by the subject during the experimental session.

Timeline of Trial

Stimulus — Cursor position — Random delay — Reaction time — Movement duration

Figure 4. Timeline of Trial. The time course of events that make up a trial. Following a random delay, subjects viewed stimulus and indicated the direction of the dot motion by moving the cursor to leftward or rightward target. Motion stimulus vanished upon initiation of hand movement.

Coding

- Random dot stimulus is generated with Python, primarily tested with the PsychoPy IDE.
- The general structure of the experiment is based on the one presented in Resulaj's paper.
- Stimulus will be implemented on LiCoRICE machine to collect real-time data every millisecond of the cursor's position.

PsychoPy3

Figure 5. PsychoPy3 Logo. Primary IDE for development of the random dot stimulus used in experimental trials.

Future Directions

- We plan to expand on the study by placing targets at 180º and comparing this to data using 45º targets.
- We anticipate, since a less natural movement to change direction is required, the frequency of changes of mind will decrease.

45º — 180º

Figure 7. Contrast in movement. Arrows showing contrast in movement for targets placed at 45º versus 180º.

Figure 8. Experimental Setup. Schematic of the monitor viewed by the subject in a possible future study.

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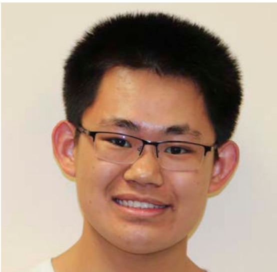

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Fabrication and Design of a Wearable Microfluidic Device Integrated with Electrochemical Sensors for the Detection of Glucose and Lactate Variation in Sweat

Traditionally, glucose and lactate levels are sampled via subcutaneously extracted blood tests. However, these previous methods often involve long and tedious processes such as laboratory testing, and they are susceptible to medical risks such as skin infections. In this study, we fabricated and designed a wearable microfluidic device that detects the glucose and lactate variation in sweat, which overcomes the shortcomings of previously reported methods. The microfluidic device is comprised of plastic, double-sided tape, microheaters, and thermoresponsive hydrogel valves to facilitate the active manipulation of sweat. Additionally, the device was integrated with a 3-electrode electrochemical sensor system capable of detecting changes in electrical current created by the chemical reactions between the sensors and biomarkers. Joined with a flexible printed circuit board, the final device can transmit the measured glucose and lactate levels to a mobile device. Interconnected with Internet of Things (IoT) devices, on-body microfluidics devices have the potential to switch the point of care from hospitals and labs to personalized health monitoring via wearable platforms.

Fabrication and Design of a Wearable Microfluidic Device Integrated with Electrochemical Sensors for the Detection of Glucose and Lactate Variation in Sweat

Jifei Liu[1], Jiawei Tan[1,2], Christopher Yeung[1,2], Sam Emaminejad[1]
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UCLA Samueli School of Engineering | Wireless Health UCLA | NSF | TSSRP Transfer Student Summer Research Program | SURP 2019 | UCLA Samueli School of Engineering Summer Undergraduate Research Program | I²BL

Abstract

Traditionally, glucose and lactate levels are sampled via intravenously extracted blood tests. However, these previous methods often involve long and tedious processes such as laboratory testing, and they are susceptible to medical risks such as skin infections. In this study, we fabricated and designed a wearable microfluidic device that detects the glucose and lactate variation in sweat, which overcomes the shortcomings of previously reported methods. The microfluidic device is comprised of plastic, double-sided tape, microheaters, and thermoresponsive hydrogel valves to facilitate the active manipulation of sweat. Additionally, the device was integrated with a 3-electrode electrochemical sensor system capable of detecting changes in electrical current created by the chemical reactions between the sensors and biomarkers. Joined with a flexible printed circuit board, the final device can transmit the measured glucose and lactate levels to a mobile device. Interconnected with Internet of Things (IoT) devices, on-body microfluidics devices have the potential to switch the point of care from hospitals and labs to personalized health monitoring via wearable platforms.

Microfluidic Device

- "CAD to 3D Device" fabrication combined with laser cutting technology allows rapid and low-cost prototyping of microfluidic devices [1] .
- Double-sided tape and transparent polyethylene terephthalate (PET) are used to fabricate the device through vertical multi-layer integration.
- Laser-cut fabrication forms microchannels for fluid to pass.
- The adhesiveness and flexibility of the device allows the development of wearable devices for sweat sensing.
- Poly(N-isopropylacrylamide) (PNIAP)-based thermoresponsive polymer hydrogels combined with electrical microheaters create valves which enable sweat manipulation [2].
- Electrochemical sensor arrays sense the lactate and glucose variations in sweat.

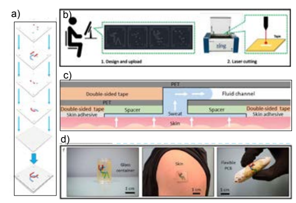
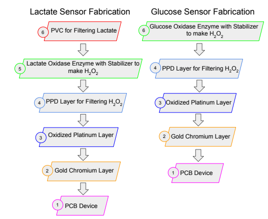


Figure 1: a) Double-sided tape and PET are stacked vertically to form the device. b) Devices designed on AutoCAD are fabricated using a laser cutter. c) Sample schematic of the microfluidic sweat collection device. Sweat passes through the skin adhesive and fluid channel layers. d) Sample microfluidic device attached to various interfaces: glass, human arm, and flexible printed circuit board (PCB) [1].

Electrochemical Sensors



- The sensors are based on the three electrode system to monitor potential and current.
  1. PCB device controls the on/off of heaters and transmit signals of current to microcontroller.
  2. Gold-Chromium layer patterned using photolithography and evaporation of gold and chromium.
  3. Platinum and H_2O_2 under oxidation generates electrical potential, allowing the electrodes to detect change in electrical current [3]. Silver chloride paste is used to cover the reference/counter electrode to set reference point 0 (as silver is not reactive).
  4. M-Phenylenediamine (PPD), and organic polymer, is used to filter H_2O_2 from higher layer. Platinum and PPD are deposited onto the electrode surface via electrodeposition.
  5. Lactate oxidase and glucose oxidase have enzymatic reaction with lactate and glucose, respectively, to make hydrogen peroxide (H_2O_2).
  6. Polyvinyl Chloride (PVC), an industrial plastic polymer, is used to filter sodium lactate from sweat solution.

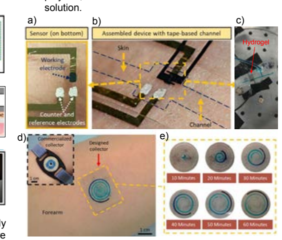


Figure 2: a) Sample 3-electrode sensor system. b) Fluid flows through a tape-based channel and comes in contact with sensors. c) Sample microfluidic device using a PNIAP hydrogel as a fluidic valve. d,e) Sample sweat collection demonstrating the volume of sweat captured over time [1].

Sensor Optimization

The initially-designed sensors are susceptible to significant noise/disruption. This noise can be caused by contaminated platinum or PPD solutions. Gold exposed during calibration can also contaminate the solutions. We addressed these issues by optimizing our fabrication process, which showed drastic improvements in noise reduction. Additionally, we discovered that the application of heat causes changes in sensor readings, which will be addressed in future studies.

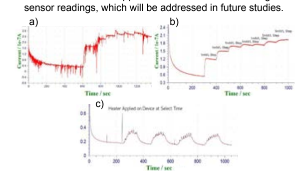


Figure 3: a) Noise/disruption in the current signal during initial sensor tests. b) Noise-reduced current variation of the lactate sensor responding to the addition of lactate. Tests here were performed in phosphate buffer saline solution to imitate lactate changes in the human body. c) Current levels with the heater applied on top of the device, showing that the applied heat causes changes in sensor readings.

Future Work

- To achieve reliable and stable lactate detection within the human body range (10-20 mM/L), additional testing is needed to determine the optimal PVC thickness (if the PCV is too thin, it will saturate sensor readings, and if it is too thick, the PVC will block lactate from the sensors).
- Current tests are done on synthetic sodium lactate and D(+) glucose in vitro. The device requires in vivo testing on a person exercising to capture and determine the variation of their lactate and glucose.
- PCB integration with microfluidic sensors and heaters require further testing and optimization.

References

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Acknowledgement

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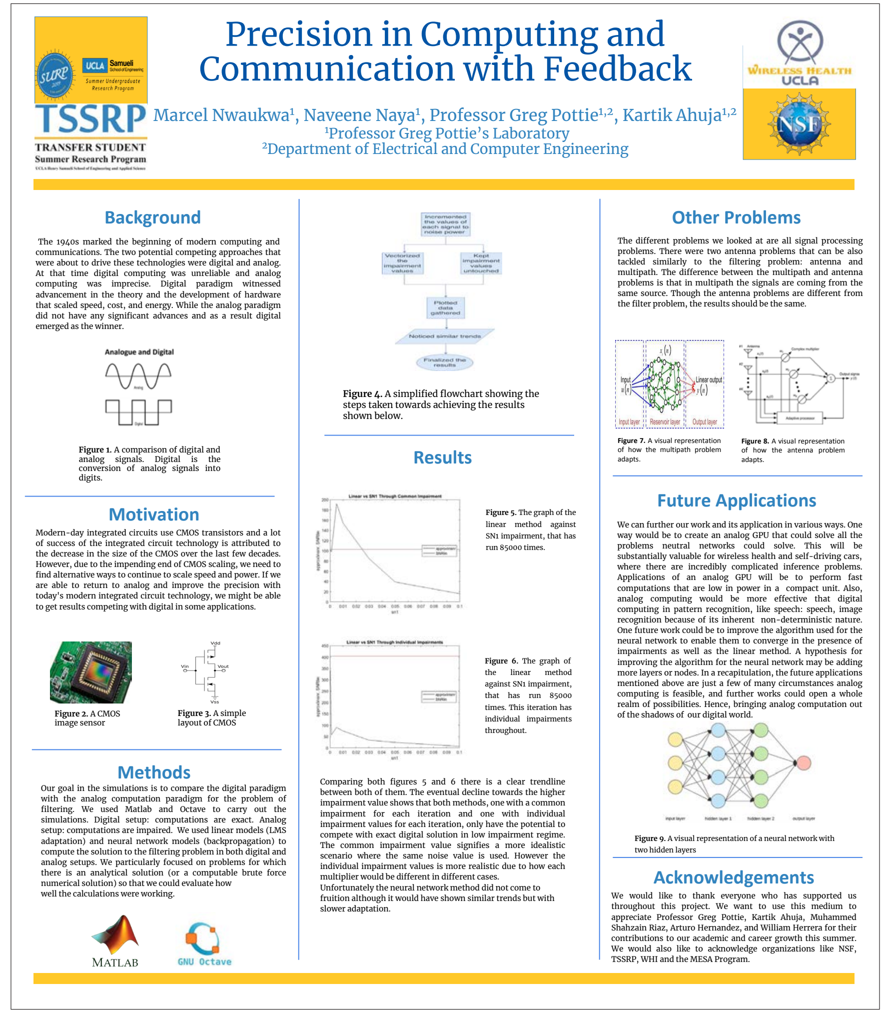
Precision in Computing and Communication with Feedback

The 1940s marked the beginning of modern computing and communications. The two potential competing approaches that were about to drive these technologies were digital and analog. At that time digital computing was unreliable and analog computing was imprecise. Digital paradigm witnessed advancement in the theory and the development of hardware that scaled speed, cost, and energy. While the analog paradigm did not have any significant advances and as a result digital emerged as the winner. Modern-day integrated circuits use CMOS transistors and a lot of success of the integrated circuit technology is attributed to the decrease in the size of the CMOS over the last few decades. However, due to the impending end of CMOS scaling, we need to find alternative ways to continue to scale speed and power. If we are able to return to analog and improve the precision with today's modern integrated circuit technology, we might be able to get results competing with digital in some applications. In this work, we focus on characterizing the types of impairments in computation that can be tolerated for two important classes of problems: those that can be solved with linear methods using LMS adaptation, and those that can be solved using neural nets with backpropagation. Studying the impact of these impairments helps us understand the range of imprecision that analog circuits can operate while still being able to result in a desirable behavior.



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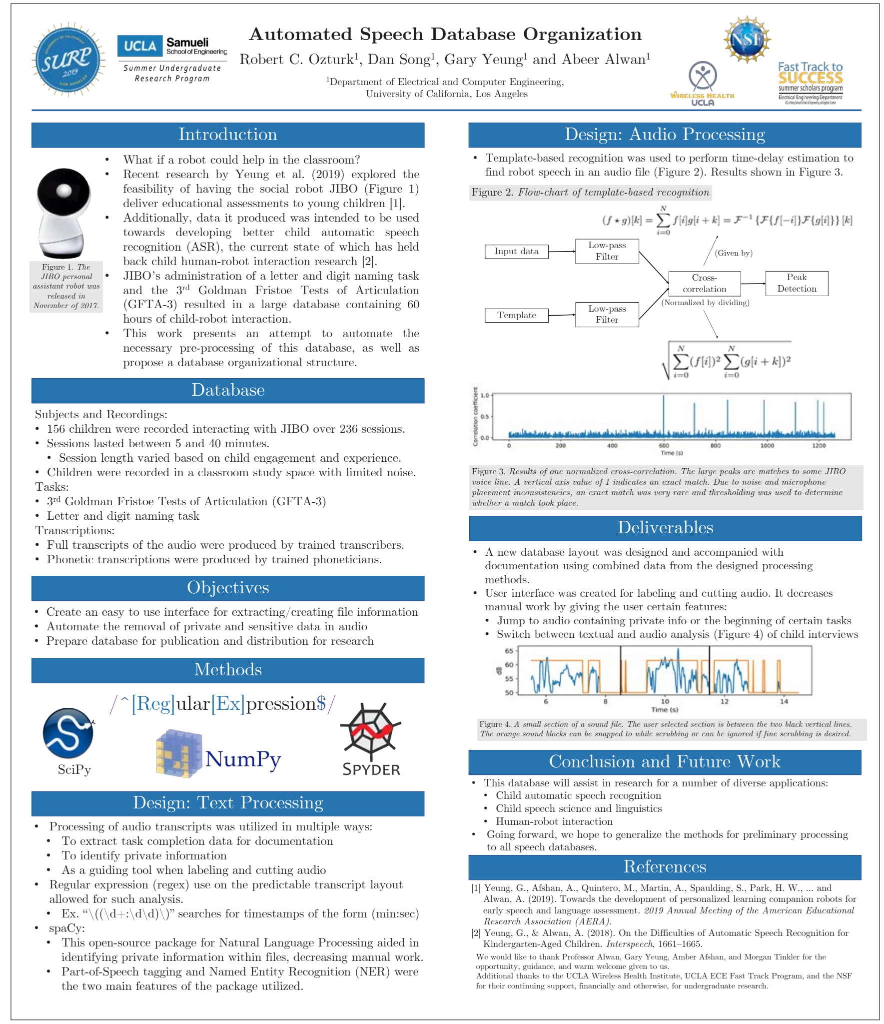
Automated Speech Database Organization

The development of an autonomous social robot, able to deliver clinical and educational assessments to young children, has great potential to aid in the efforts of educators and help students reach age-appropriate levels of proficiency in reading and oral language skills. A study researching the feasibility of the JIBO robot for such purposes, as well as gathering data needed to improve child automated speech recognition (ASR), resulted in a large dataset of verbal interactions between the robot and children via the administration of the Goldman-Fristoe Test of Articulation (GFTA) and other language tasks. Prior to database publication, time consuming and error-prone tasks such as matching audio data with corresponding prompt-answer pairs and the notation of private information for removal must be performed. We present a design and Python implementation for software automating and simplifying such processes. As robot prompts are known and consistent, timestamps are detected in audio files using a cross- correlation approach. We propose several methods of avoiding computationally expensive operations during such a search. For files with transcripts, processing is done using both a brute force search and the SpaCy natural language processing package, the latter to identify possible private information. Results are compared and combined with those from audio processing. Finally, we propose a database organizational structure and documentation in preparation for future publication.



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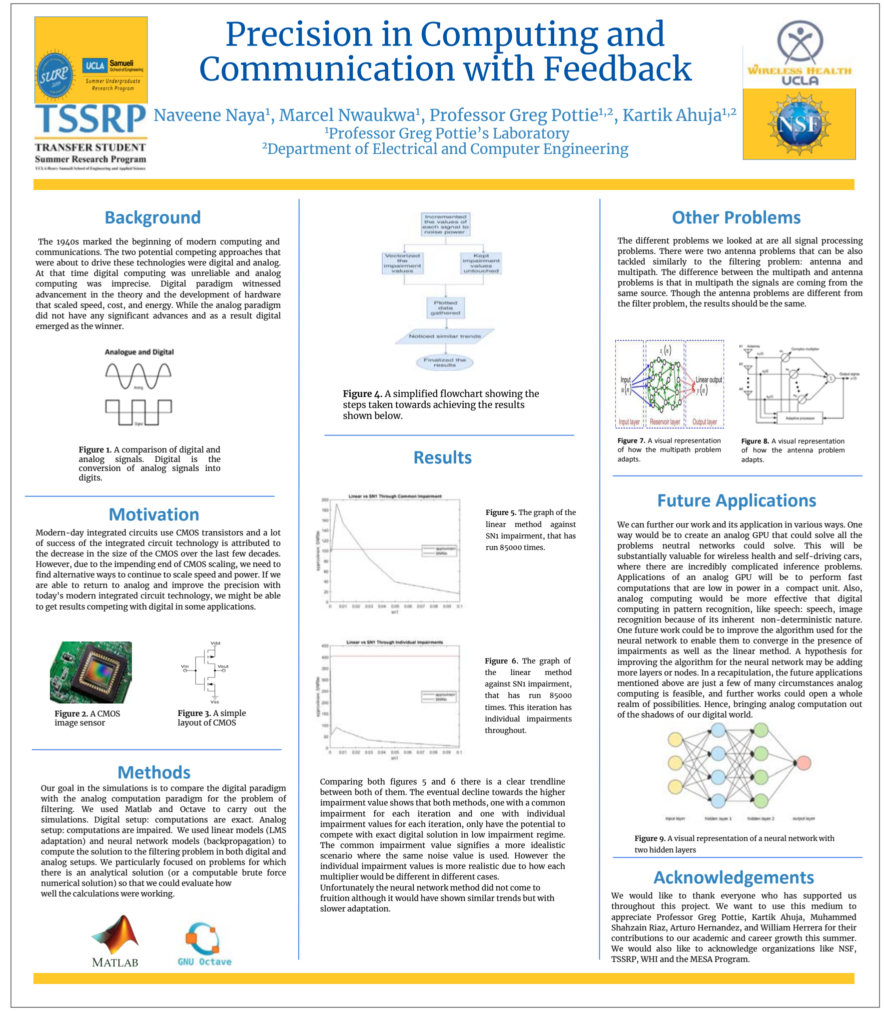
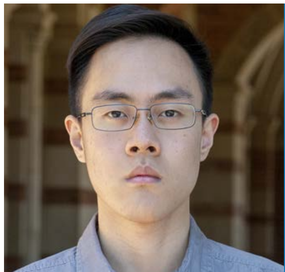
Precision in Computing and Communication with Feedback

The 1940s marked the beginning of modern computing and communications. The two potential competing approaches that were about to drive these technologies were digital and analog. At that time digital computing was unreliable and analog computing was imprecise. Digital paradigm witnessed advancement in the theory and the development of hardware that scaled speed, cost, and energy. While the analog paradigm did not have any significant advances and as a result digital emerged as the winner. Modern-day integrated circuits use CMOS transistors and a lot of success of the integrated circuit technology is attributed to the decrease in the size of the CMOS over the last few decades. However, due to the impending end of CMOS scaling, we need to find alternative ways to continue to scale speed and power. If we are able to return to analog and improve the precision with today's modern integrated circuit technology, we might be able to get results competing with digital in some applications. In this work, we focus on characterizing the types of impairments in computation that can be tolerated for two important classes of problems: those that can be solved with linear methods using LMS adaptation, and those that can be solved using neural nets with backpropagation. Studying the impact of these impairments helps us understand the range of imprecision that analog circuits can operate while still being able to result in a desirable behavior.





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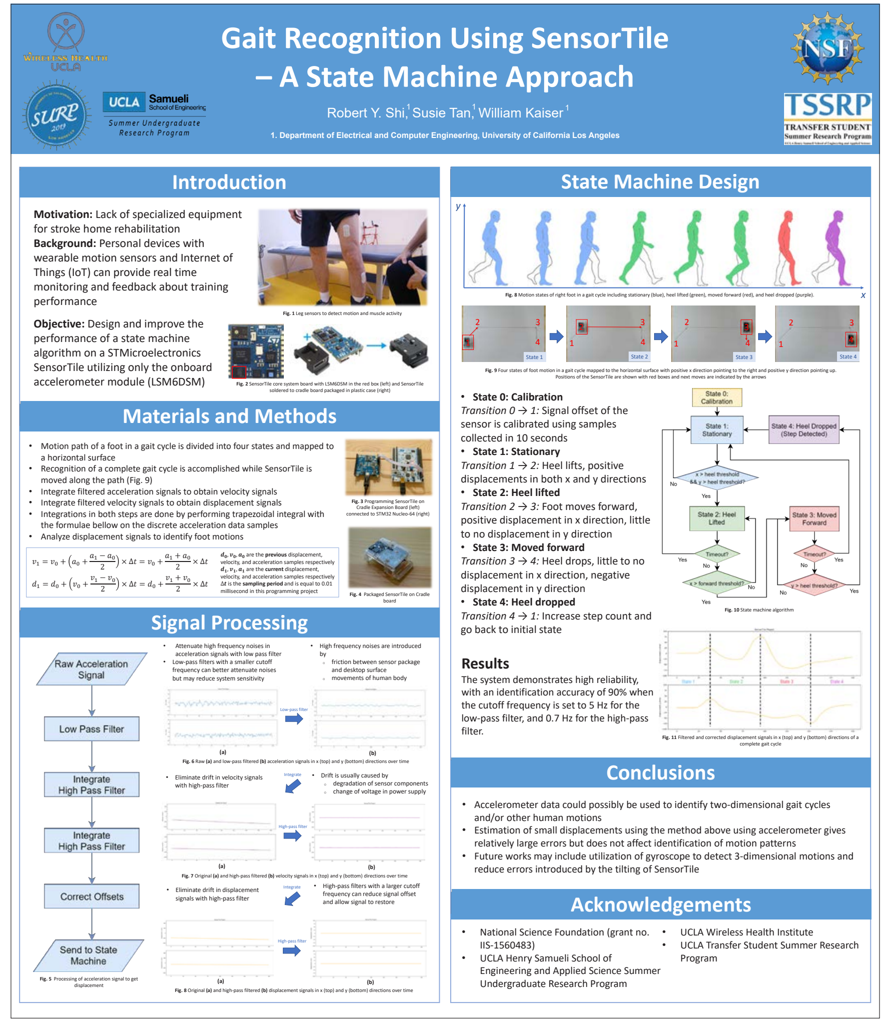
Gait Recognition Using SensorTile – A State Machine Approach

Personal devices, such as smart phones and wristbands, can be turned into mobile health devices with the help of embedded systems with wearable motion sensors and Internet of Things (IoT). Such devices are capable of providing real time monitoring and feedback about training performance for outpatients with hemiparesis during their rehabilitation process. A reliable algorithm for gait recognition is required for the system to give accurate feedback. The goal of this research is to design and improve the performance of a custom-built state machine algorithm on a STMicroelectronics SensorTile utilizing only the onboard accelerometer module (LSM6DSM). The motion path of a foot in a gait cycle is divided into four states and mapped to a horizontal surface. The recognition of a complete gait cycle is then accomplished by moving SensorTile along the path. Results have shown high reliability, with an identification accuracy of 90% when the cutoff frequency is set to 5 Hz for the low-pass filter applied to the acceleration signal, and 0.7 Hz for the high-pass filter applied to the velocity and displacement signals. The high accuracy demonstrates that accelerometer data can be used to identify two-dimensional gait cycles.



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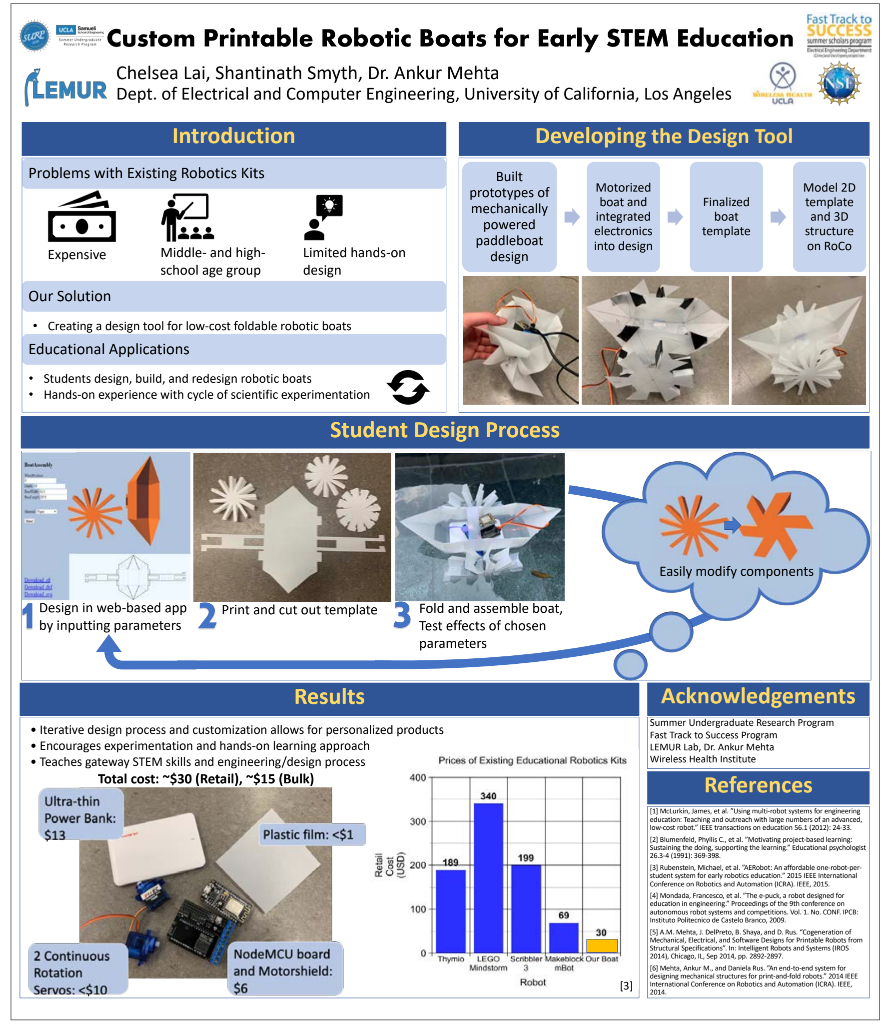
Custom Printable Robotic Boats for Early STEM Education

Robotics engages students in multiple disciplines of engineering, which is increasingly important in our technology-based society. However, existing robotics kits are mostly geared toward middle- and high- school students and either cost hundreds or thousands of dollars or have limited hands-on design capabilities. This leaves customizable robotics unaffordable to many schools, as well as neglects to introduce robots to impressionable elementary-age children. Our project focused on concurrently addressing three concerns: cost, age group, and creative potential. We developed a modifiable template for an affordable robot that students design themselves, supporting a project-based learning approach, with the goal of inspiring interest in STEM in kindergartners.

Since most robotics kits are cars, we designed a robotic boat and a web-based app, which students use to create and steer the boat. One boat is made of a flat sheet of plastic folded into a 3D structure, with basic electronics propelling the vehicle, and costs under $40 total. In the app, powered by Robot Compiler technology, students change parameters on the boat to see the effect on the 2D printable template and 3D model of the finished boat. This focus on customization encourages iterative design and engages students firsthand in the engineering innovation process. Students have flexibility in designing their robots down to the component level, fostering a sense of ownership over their project and resulting in a more self-motivated learning experience.



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Automated Speech Database Organization

The development of an autonomous social robot, able to deliver clinical and educational assessments to young children, has great potential to aid in the efforts of educators and help students reach age-appropriate levels of proficiency in reading and oral language skills. A study researching the feasibility of the JIBO robot for such purposes, as well as gathering data needed to improve child automated speech recognition (ASR), resulted in a large dataset of verbal interactions between the robot and children via the administration of the Goldman-Fristoe Test of Articulation (GFTA) and other language tasks. Prior to database publication, time consuming and error-prone tasks such as matching audio data with corresponding prompt-answer pairs and the notation of private information for removal must be performed. We present a design and Python implementation for software automating and simplifying such processes. As robot prompts are known and consistent, timestamps are detected in audio files using a cross- correlation approach. We propose several methods of avoiding computationally expensive operations during such a search. For files with transcripts, processing is done using both a brute force search and the SpaCy natural language processing package, the latter to identify possible private information. Results are compared and combined with those from audio processing. Finally, we propose a database organizational structure and documentation in preparation for future publication.

Automated Speech Database Organization

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Introduction

Figure 1. *The JIBO personal assistant robot was released in November of 2017.*

- What if a robot could help in the classroom?
- Recent research by Yeung et al. (2019) explored the feasibility of having the social robot JIBO (Figure 1) deliver educational assessments to young children [1].
- Additionally, data it produced was intended to be used towards developing better child automatic speech recognition (ASR), the current state of which has held back child human-robot interaction research [2].
- JIBO's administration of a letter and digit naming task and the 3rd Goldman Fristoe Tests of Articulation (GFTA-3) resulted in a large database containing 60 hours of child-robot interaction.
- This work presents an attempt to automate the necessary pre-processing of this database, as well as propose a database organizational structure.

Database

Subjects and Recordings:
- 156 children were recorded interacting with JIBO over 236 sessions.
- Sessions lasted between 5 and 40 minutes.
  - Session length varied based on child engagement and experience.
- Children were recorded in a classroom study space with limited noise.

Tasks:
- 3rd Goldman Fristoe Tests of Articulation (GFTA-3)
- Letter and digit naming task

Transcriptions:
- Full transcripts of the audio were produced by trained transcribers.
- Phonetic transcriptions were produced by trained phoneticians.

Objectives

- Create an easy to use interface for extracting/creating file information
- Automate the removal of private and sensitive data in audio
- Prepare database for publication and distribution for research

Methods

/^[Reg]ular[Ex]pression$/

SciPy NumPy SPYDER

Design: Text Processing

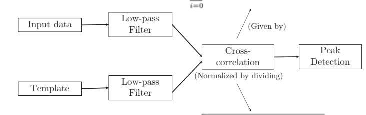
- Processing of audio transcripts was utilized in multiple ways:
  - To extract task completion data for documentation
  - To identify private information
  - As a guiding tool when labeling and cutting audio
- Regular expression (regex) use on the predictable transcript layout allowed for such analysis.
  - Ex. "\((\d+:\d\d)\)" searches for timestamps of the form (min:sec)
- spaCy:
  - This open-source package for Natural Language Processing aided in identifying private information within files, decreasing manual work.
  - Part-of-Speech tagging and Named Entity Recognition (NER) were the two main features of the package utilized.

Design: Audio Processing

- Template-based recognition was used to perform time-delay estimation to find robot speech in an audio file (Figure 2). Results shown in Figure 3.

Figure 2. *Flow-chart of template-based recognition*

$$(f \star g)[k] = \sum_{i=0}^{N} f[i]g[i+k] = \mathcal{F}^{-1}\{\mathcal{F}\{f[-i]\}\mathcal{F}\{g[i]\}\}[k]$$



$$\sqrt{\sum_{i=0}^{N}(f[i])^2 \sum_{i=0}^{N}(g[i+k])^2}$$

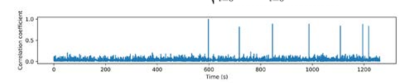


Figure 3. *Results of one normalized cross-correlation. The large peaks are matches to some JIBO voice line. A vertical axis value of 1 indicates an exact match. Due to noise and microphone placement inconsistencies, an exact match was very rare and thresholding was used to determine whether a match took place.*

Deliverables

- A new database layout was designed and accompanied with documentation using combined data from the designed processing methods.
- User interface was created for labeling and cutting audio. It decreases manual work by giving the user certain features:
  - Jump to audio containing private info or the beginning of certain tasks
  - Switch between textual and audio analysis (Figure 4) of child interviews

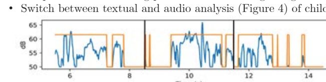


Figure 4. *A small section of a sound file. The user selected section is between the two black vertical lines. The orange sound blocks can be snapped to while scrubbing or can be ignored if fine scrubbing is desired.*

Conclusion and Future Work

- This database will assist in research for a number of diverse applications:
  - Child automatic speech recognition
  - Child speech science and linguistics
  - Human-robot interaction
- Going forward, we hope to generalize the methods for preliminary processing to all speech databases.

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