

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



Jason Bustani
Computer Science
Third Year
UC Berkeley
Wireless Health Institute

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

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.



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

Jason Bustani, Susie Tan, William Kaiser
1. Department of Electrical and Computer Engineering



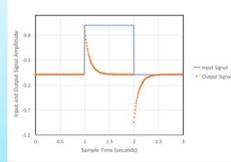
Motivation

- IoT devices can provide real-time data to enhance performance or learn new features that weren't discovered before.
- Human motion is one of the most difficult motions to capture using modern sensors. Research towards a performance enhancing Judo IoT device can further the field of capturing and analyzing human motion digitally.
- Beginning with 2-Dimensional projection of the footwork is a great steppingstone towards more complex 3-Dimensional Motions.

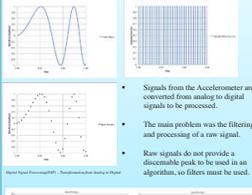


- A 10 x 10 cm square was drawn on a piece of paper with the SensorTile following the path.
- The State-Machine method was used when designing the algorithm with 4 states total.
 - 1) SensorTile moving up (positive Y).
 - 2) SensorTile moving left (negative X).
 - 3) SensorTile moving down (negative Y).
 - 4) SensorTile moving right (positive X).

- The resonance frequency for the High-Pass filter is changed from 0.3 to 0.8 to fine tune the signal for more desirable results. The higher frequencies are attenuated for lower ones creating more consistent, but large, errors that are more manageable and predictable.

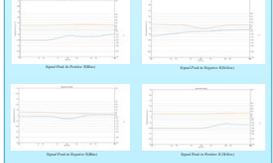


Introduction



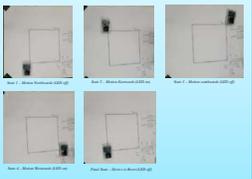
- Signals from the Accelerometer are converted from analog to digital signals to be processed.
- The main problem was the filtering and processing of a raw signal.
- Raw signals do not provide a discernable peak to be used in an algorithm, so filters must be used.

SensorTile Accelerometer Square Algorithm

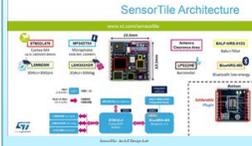
Results

- The proper motion of a square was recognized, when the resonance frequency of the High-Pass Filter was adjusted to give more consistent but smaller values from the accelerometer.
- The LED on-board of the SensorTile was used to indicate the successful recognition of each state.



Materials and Methods

SensorTile Architecture



- STMicroelectronics SensorTile was used for the experiments soldered onto a small board inside a plastic crate.
- It has on board an Ultra Low Power 80MHz 32-bit ARM Microcontroller (CPU) with an Accelerometer that measures magnitude/gravity or 9.8 x 10⁷ in 3-Dimensions.

Conclusion

- The development of the square motion state-machine demonstrates that proper signal processing is required to yield desired results. The complexity of the algorithm and innovative solutions reach a limit, when confronted with the reality of attenuated signals. Therefore, a well-designed approach to processing the signals could lead to optimal results. These conclusions apply only to 2-dimensional motion. 3-dimensional motion will most likely lead to more complexities, including the mapping of motions that are inclusive to Judo.

Future Works

- A new technology coming out of Dr. Kaiser's lab is embedded machine learning. Embedded machine learning is compact and can fit inside IoT devices' firmware to allow more flexibility.
- Embedded ML would make this project easier, and would allow new technologies such as Machine Learning built into security cameras to detect potential threats.

Materials and Methods

Path	Trial 1	Trial 2	Trial 3	Trial 4
Up	75%	80%	80%	80%
Left	40%	25%	60%	60%
Down	10%	10%	5%	5%
Right	50%	30%	50%	50%

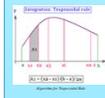
Path	Trial 1	Trial 2	Trial 3	Trial 4
Up	77%	87%	80%	80%
Left	86%	92%	91%	91%
Down	89%	94%	86%	86%
Right	63%	60%	60%	60%

Acknowledgments

- ONSP National Science Foundation
- UCLA Samueli School of Engineering and Applied Sciences
- (SURF) Summer Undergraduate Research Program
- (WHI) Wireless Health Institute
- (MESA) El Camino College Mathematics, Engineering, and Science Achievement
- (CSSPP) Transfer Student Summer Research Program



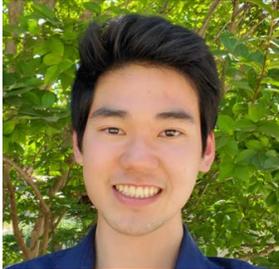
Integration: Trigonometric



Low pass filter (anti-aliasing) filter is initial applied to the raw acceleration signal, then a high pass filter is applied to each successive integration.

Conclusion

(Actual - Measured) / Actual X 100 = Percent Error



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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.

TSSRP
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Summer Research Program

Environmental Detection Using Mobile Sensors

Tyler Kaplan, Sean Dao, Mani Srivastava, Luis Garcia, Joseph Noor
UCLA Wireless Health Institute
Networked and Embedded Systems Laboratory (NESL)

Motivation

- ❑ IoT and Ubiquitous computing has led to the advancement of medical technology and innovation
- ❑ Detecting room to room movement can correlate environment to brain activity and recollection
- ❑ Can be implemented on nearly any phone and is much more private than a camera

Results

Bruin Walk

Fig 2) graph of waveform and FFT at Bruin Walk

- the overall loudness is greater in this outside area
- there is also a plethora of frequencies and noises occurring
- 22 kHz can barely be heard, hardly any reverberations

Library

Fig 3) graph of waveform and FFT in Library

- the overall loudness is much quieter compared to outside
- however, there is still numerous sounds occurring
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Hallway

Fig 4) graph of waveform and FFT in Hallway

- the hallway is very quiet
- there isn't that much ambient noise either
- however, the 22 kHz is the loudest here; the most reverberations of any location

Without HFT Model – Results

	Bruin Walk	Student Store	Hallway	Library	NESL
Precision	100	90	100	96	100
Recall	100	100	90	96	100
Overall Accuracy		97 %			

Fig 5) specific results of Random Forest classifier model based on data without HFT

Background

- ❑ Localization has been done in outside environments through the use of GPS signals
- ❑ Indoor positioning systems rely on pedometers, speedometers, and predetermined maps
- ❑ Using sound and its properties may be the key to pinpointing someone's position regardless of location

Methods

- ❑ Recorded 800, three-second audio clips at 4 different locations
- ❑ Sample Set A – 400 samples with a High-Frequency Tone (HFT) of 22 kHz played from an external source
- ❑ Sample Set B – 400 samples without HFT
- ❑ Extracted audio features from the data to train supervised machine learning classification model based on a Random Forest algorithm

Phone Lanyard

Fig 1) mobile device attached to plastic lanyard for capturing data

Conclusion and Future Works

- ❑ Utilize a variety of mobile sensors with time synchronization to dramatically increase accuracy of room detection
- ❑ Implement a neural network to learn distinguishing factors as much more data is collected
- ❑ Train better models based on better locations, more samples, and more representative audio features

References

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Gustavo Diaz
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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.

UCLA Samuelli School of Engineering

TSSRP TRANSFER STUDENT Summer Research Program

Programmable Transdermal Drug Delivery with a Iontophoretically Enhanced Microneedle System

Gustavo Diaz,¹ Feroq Akhtar,² Christopher Yeung, and Sam Emaminejad

¹Department of Electrical Engineering and Computer Engineering, University of California Los Angeles, CA, USA
²Department of Material Sciences and Engineering, University of California Los Angeles, CA, USA

Abstract

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.

Wireless Device

The device uses an array of 3D-printed biocompatible hollow microneedles to penetrate the outer layer of skin (stratum corneum). Drugs are loaded into hydrogels and embedded into the microneedles, then the device is packaged with double-sided tape and other flexible 3D-printed components to realize a wearable platform. After device assembly, the application of ITP can deliver drugs through the microneedles. The rate of iontophoresis is controlled remotely by Bluetooth communication between a mobile application and flexible printed circuit board (FPCB) to programmably deliver drugs to the wearer.

Figure 1: Schematic depiction of the wearable platform with all of its components, assembled as a prototype wristband containing ITP-enhanced microneedles.

Figure 2: Simple depiction of the mobile application and its wireless Bluetooth communication with the drug-controlling FPCB.

Figure 3: Simple depiction of drug storage and release using hydrogels. Polymer chains form porous structures that contain drug molecule. The drug is passively released overtime as the polymer chains expand.

Iontophoresis (ITP)

Iontophoresis works by placing positively-charged therapeutic agents between the skin and the anode (positive terminal). Then, the current running through the anode generates electrostatic forces which drive the ionized molecules into the skin.

Figure 4: Cross-sectional diagram of the ITP transdermal drug delivery method.

Figure 5: 3D model depiction of the ITP-enhanced microneedle platform used in the wireless device. The electrodes are located above the drug-loaded hydrogels and microneedles.

3D Printed Hollow Microneedle

The purpose of the hollow microneedle array is to create micrometer sized channels in the skin which serve as delivery paths for pharmaceutical agents. The microneedles only need to puncture the stratum corneum, which does not contain sensitive nerves in the skin and blood vessels. As a result, the microneedles are virtually painless and has a greatly reduced risk of infection. Hollow needle tips were chosen for their greater control in drug dosage and their larger drug capacity in comparison to alternatives (e.g., solid coated, dissolvable, and two step application). The microneedle array consists of 100 individual syringe-shaped needles that are 3D-printed using stereolithography.

Figure 6: Dual chamber microneedle arrays loaded with drugs. Microscopic imaging of the microneedle tips, pictured on right. Tips are 0.9 mm in height and use a syringe-shaped design.

Figure 7: Simple demonstration of applying microneedles to porcine skin. Microscope imaging of the skin after application, pictured on right.

Insulin Delivery

In order to demonstrate the effectiveness of the iontophoresis-enhanced microneedles, the delivery system was tested on porcine skin. The device was loaded with fluorescent-dyed insulin that was infused in a hydrogel. The skin samples were analysed under a confocal microscope in order to capture and detect the fluorescent emissions. The intensity levels of the fluorescence was captured at various depths to determine the synergy between ITP and MNA in drug penetration. All images used to generate intensity data were taken at the same depth level. ImageJ software used to gather intensity level data.

Figure 8: Confocal Laser Scanning Microscopy (CLSM) of porcine skin subjected to 0.5 mA, taken at varying times: a) 0.5h, b) 1h, c) 2h.

Figure 9: Imaging depth versus the fluorescence intensity at the different ITP times. The focal plane is centered at 0 on the graph.

Figure 10: Normalized intensity versus time and current. The left graph represents the drug delivered with MNA and ITP. Right graph depicts drug delivery with ITP only.

Conclusion

This study demonstrated that the effective penetration rate of insulin was proportional to ITP time and current, and that drug delivery was enhanced with the addition of MNA. Further investigation into other potential drug candidates could expand range of suitable drugs for application with ITP enhanced MNA. Further analysis using Franz cell diffusion testing will reinforce the current method of fluorescence analysis. Device applications may include use in future wearable medical devices and Lab-On-A-Chip systems.

Acknowledgements

We gratefully thank the Wireless health institute for the financial support used to conduct this research and the Summer Undergraduate Research Program for their assistance. Additionally, we would like to thank the department of computer and electrical engineering and the Interconnected and Integrated Bioelectronics Lab for the opportunity to explore this research.



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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.

Custom Printable Robotic Boats for Early STEM Education

Chelsea Lai, Shantinath Smyth, Dr. Ankur Mehta
 Dept. of Electrical and Computer Engineering, University of California, Los Angeles

Introduction

Problems with Existing Robotics Kits

Expensive

Middle- and high-school age group

Limited hands-on design

Our Solution

- Creating a design tool for low-cost foldable robotic boats

Educational Applications

- Students design, build, and redesign robotic boats
- Hands-on experience with cycle of scientific experimentation

Developing the Design Tool

Built prototypes of mechanically powered paddleboat design

Motorized boat and integrated electronics into design

Finalized template

Model 2D template and 3D structure on RoCo

Student Design Process

1 Design in web-based app by inputting parameters

2 Print and cut out template

3 Fold and assemble boat, Test effects of chosen parameters

Easily modify components

Results

- Iterative design process and customization allows for personalized products
- Encourages experimentation and hands-on learning approach
- Teaches gateway STEM skills and engineering/design process

Total cost: ~\$30 (Retail), ~\$15 (Bulk)

Ultra-thin Power Bank: \$13

Plastic film: <\$1

2 Continuous Rotation Servos: <\$10

NodeMCU board and Motorshield: \$6

Robot	Retail Cost (USD)
Thymio	189
LEGO Mindstorm 3	340
Scribble Makerbot	199
miBot	69
Our bot	30

Acknowledgements

Summer Undergraduate Research Program
 Fast Track to Success Program
 LEMUR Lab, Dr. Ankur Mehta
 Wireless Health Institute

References

[1] McLarkin, James, et al. "Using multi-robot systems for engineering education: Teaching and outreach with large numbers of an advanced, low-cost robot." IEEE transactions on education 56.1 (2012): 24-33.
 [2] Blumenfeld, Phyllis C., et al. "Motivating project-based learning: Sustaining the doing, supporting the learning." Educational psychologist 26.3-4 (1991): 369-398.
 [3] Rubenstein, Michael, et al. "iRobot: An affordable one-robot-per-student system for early robotics education." 2013 IEEE International Conference on Robotics and Automation (ICRA). IEEE, 2013.
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 [6] Mehta, Ankur M., and Daniela Bus. "An end-to-end system for designing mechanical structures for print-and-fold robots." 2014 IEEE International Conference on Robotics and Automation (ICRA). IEEE, 2014.



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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.

Summer Undergraduate Research Program

Fast Track to SUCCESS

Studying changes of mind in decision-making

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²Department of Physical Sciences and Mathematics, Mount Saint Mary's University – Los Angeles

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

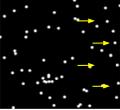


Figure 1. Random Dot Motion. Image of the random dot motion.

Data Collection

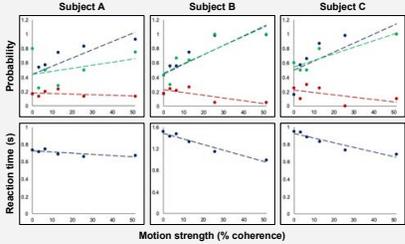


Figure 6. Accuracy improves through changes of mind. Data is from three subjects (A, B, and C). The top row shows the probability of a correct decision (blue), probability of change (red), and probability of a correct decision after change of mind (green) according to motion coherence strengths. Probability 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.

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

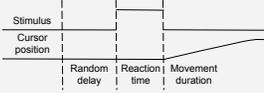


Figure 4. Timeline of Trial. The time course of events that make up a trial. Following a random delay, subjects viewed stimulus and indicated the direction of the dot motion by moving the cursor to leftward or rightward target. Motion stimulus vanished upon initiation of hand movement.

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.



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

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.

Future Directions

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

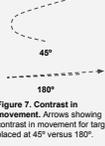


Figure 7. Contrast in movement. Arrows showing contrast in movement for targets placed at 45° versus 180°.



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

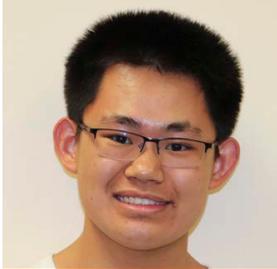
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Acknowledgements

This work was supported by the National Science Foundation through the UCLA Summer Undergraduate Research Program, specifically under the UCLA Electrical and Computer Engineering Department. We thank William Herrera and Muhammad Shahzain Raiz for their guidance throughout the program.



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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 Liu¹, Jiawei Tan^{1,2}, Christopher Yeung^{1,2}, Sam Emaminejad¹

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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) (PNIPAA)-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.

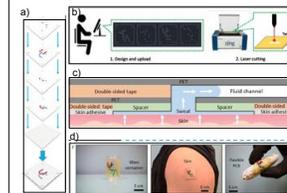
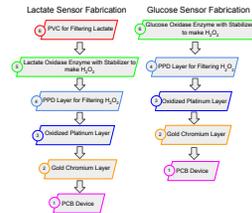


Figure 1: a) Double-sided tape and PET are stacked vertically to form the device. b) Devices designed on AutoCAD are fabricated using a laser cutter. c) Sample schematic of the microfluidic sweat collection device. Sweat passes through the skin adhesive and fluid channel layers. d) Sample microfluidic 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.
- PCB device controls the on/off of heaters and transmit signals of current to microcontroller.
- Gold-Chromium layer patterned using photolithography and evaporation of gold and chromium.
- Platinum and H₂O₂ 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).
- M-Phenylenediamine (PPD), and organic polymer, is used to filter H₂O₂ from higher layer. Platinum and PPD are deposited onto the electrode surface via electrodeposition.
- Lactate oxidase and glucose oxidase have enzymatic reaction with lactate and glucose, respectively, to make hydrogen peroxide (H₂O₂).
- Polyvinyl Chloride (PVC), an industrial plastic polymer, is used to filter sodium lactate from sweat solution.

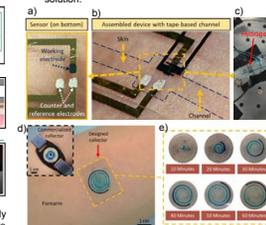


Figure 2: a) Sample 3-electrode sensor system. b) Fluid flows through a tape-based channel and comes in contact with sensors. c) Sample microfluidic device with a PNIPAA hydrogel as a fluidic valve. d,e) Sample sweat collection demonstrating the volume of sweat captured over time [1].

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.

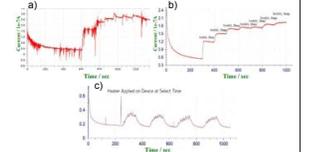


Figure 3: a) Noise/disruption in the current signal during initial sensor tests. b) Noise-reduced current variation of the lactate sensor responding to the addition of lactate. Tests here were performed in phosphate buffer saline solution to imitate lactate changes in the human body. c) Current levels 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 PVC 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.

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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.

TSSRP
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Summer Research Program

Precision in Computing and Communication with Feedback

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Background

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Figure 1. A comparison of digital and analog signals. Digital is the conversion of analog signals into digits.

Other Problems

The different problems we looked at are all signal processing problems. There were two antenna problems that can be also tackled similarly to the filtering problem: antenna and multipath. The difference between the multipath and antenna problems is that in multipath the signals are coming from the same source. Though the antenna problems are different from the filter problem, the results should be the same.

Figure 7. A visual representation of how the multipath problem adapts.

Figure 8. A visual representation of how the antenna problem adapts.

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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.

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Results

Figure 5. The graph of the linear method against SNi impairment, that has run 85000 times.

Figure 6. The graph of the linear method against SNi impairment, that has run 85000 times. This iteration has individual impairments throughout.

Methods

Our goal in the simulations is to compare the digital paradigm with the analog computation paradigm for the problem of filtering. We used Matlab and Octave to carry out the simulations. Digital setup: computations are exact. Analog setup: computations are impaired. We used linear models (LMS adaptation) and neural network models (backpropagation) to compute the solution to the filtering problem in both digital and analog setups. We particularly focused on problems for which there is an analytical solution (or a computable brute force numerical solution) so that we could evaluate how well the calculations were working.

Future Applications

We can further our work and its application in various ways. One way would be to create an analog GPU that could solve all the problems neural networks could solve. This will be substantially valuable for wireless health and self-driving cars, where there are incredibly complicated inference problems. Applications of an analog GPU will be to perform fast computations that are low in power in a compact unit. Also, analog computing would be more effective than digital computing in pattern recognition, like speech, image recognition because of its inherent non-deterministic nature. One future work could be to improve the algorithm used for the neural network to enable them to converge in the presence of impairments as well as the linear method. A hypothesis for improving the algorithm for the neural network may be adding more layers or nodes. In a recognition, the future applications mentioned above are just a few of many circumstances analog computing is feasible, and further works could open a whole realm of possibilities. Hence, bringing analog computation out of the shadows of our digital world.

Figure 9. A visual representation of a neural network with two hidden layers

Acknowledgements

We would like to thank everyone who has supported us throughout this project. We want to use this medium to appreciate Professor Greg Pottie, Kartik Ahuja, Muhammed Shahzain Rizaz, Arturo Hernandez, and William Herrera for their contributions to our academic and career growth this summer. We would also like to acknowledge organizations like NSF, TSSRP, WHI and the MESA Program.



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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.



UCLA Samueli School of Engineering
Summer Undergraduate Research Program



Automated Speech Database Organization

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Fast Track to SUCCESS
summer scholar program
Summer Undergraduate Research Program
Department of Electrical and Computer Engineering
University of California, Los Angeles

Introduction

- 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.



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

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


~/^[Regular]Expression\$/



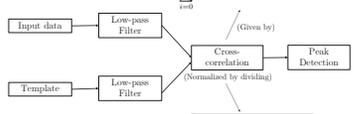
Design: Text Processing

- 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 (minusc)
- 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

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


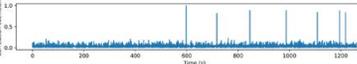
$$\sum_{i=0}^N (f[i])^2 \sum_{i=0}^N (g[i+k])^2$$


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

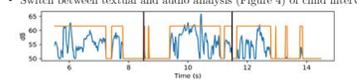


Figure 4. A small section of a sound file. The user selected section is between the two black vertical lines. The orange sound blocks can be moved to white scrubbing or can be ignored if fine scrubbing is desired.

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.

References

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[2] Yeung, G., & Alwan, A. (2018). On the Difficulties of Automatic Speech Recognition for Kindergarten-Aged Children. *InterSpeech*, 1661-1665.

We would like to thank Professor Abeer Alwan, Gary Yeung, Abeer Abshan, and Morgan Tanker for the opportunity, guidance, and warm welcome given to us. Additional thanks to the UCLA Wireless Health Institute, UCLA ECE Fast Track Program, and the NSF for their continuing support, financially and otherwise, for undergraduate research.

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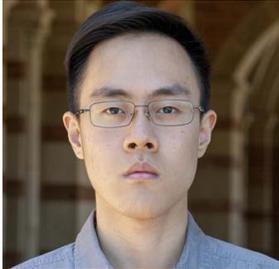
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Gait Recognition Using SensorTile – A State Machine Approach

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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Gait Recognition Using SensorTile – A State Machine Approach

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TRANSFER STUDENT
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UCLA TRANSFER STUDENT SUMMER RESEARCH PROGRAM

Introduction

Motivation: Lack of specialized equipment for stroke home rehabilitation

Background: Personal devices with wearable motion sensors and Internet of Things (IoT) can provide real time monitoring and feedback about training performance

Objective: Design and improve the performance of a state machine algorithm on a STMicroelectronics SensorTile utilizing only the onboard accelerometer module (LSM6DSM)

Materials and Methods

- Motion path of a foot in a gait cycle is divided into four states and mapped to a horizontal surface
- Recognition of a complete gait cycle is accomplished while SensorTile is moved along the path (Fig. 9)
- Integrate filtered acceleration signals to obtain velocity signals
- Integrate filtered velocity signals to obtain displacement signals
- Integrations in both steps are done by performing trapezoidal integral with the formulae below on the discrete acceleration data samples
- Analyze displacement signals to identify foot motions

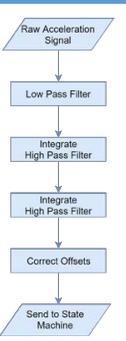
$$v_1 = v_0 + \left(a_0 + \frac{a_1 - a_0}{2} \right) \times \Delta t = v_0 + \frac{a_1 + a_0}{2} \times \Delta t$$

a_0, v_0, a_1 are the previous displacement, velocity, and acceleration samples respectively.
 a_0, v_0, a_1 are the current displacement, velocity, and acceleration samples respectively.
 Δt is the sampling period and is equal to 0.01 milliseconds in this engineering project.

$$d_1 = d_0 + \left(v_0 + \frac{v_1 - v_0}{2} \right) \times \Delta t = d_0 + \frac{v_1 + v_0}{2} \times \Delta t$$

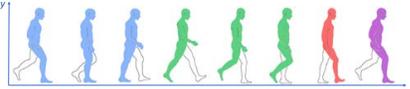
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Signal Processing

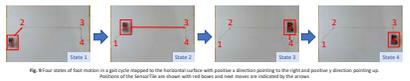


- Attenuate high frequency noises in acceleration signals with low pass filter
- Low pass filters with a smaller cutoff frequency can better attenuate noises but may reduce system sensitivity
- High frequency noises are introduced by friction between sensor package and desktop surface
- movements of human body
- Eliminate drift in velocity signals with high-pass filter
- Drift is usually caused by degradation of sensor components
- change of voltage in power supply
- Original (a) and high-pass filtered (b) velocity signals in x (top) and y (bottom) directions over time
- High-pass filters with a larger cutoff frequency can reduce signal offset and allow signal to restore
- Original (a) and high-pass filtered (b) displacement signals in x (top) and y (bottom) directions over time

State Machine Design

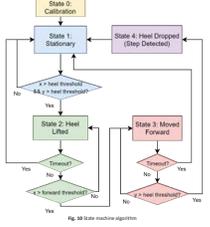


Four states of feet motion in a gait cycle: stationary (blue), heel lifted (green), moved forward (red), and heel dropped (purple).



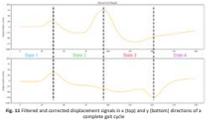
Four states of feet motion in a gait cycle mapped to the horizontal surface with position in direction pointing to the right and velocity in direction pointing to the right. Positions of the SensorTile are shown with red boxes and their motion is indicated by blue arrows.

- State 0: Calibration**
Transition 0 → 1: Signal offset of the sensor is calibrated using samples collected in 10 seconds
- State 1: Stationary**
Transition 1 → 2: Heel lifts, positive displacements in both x and y directions
- State 2: Heel lifted**
Transition 2 → 3: Foot moves forward, positive displacement in x direction, little to no displacement in y direction
- State 3: Moved forward**
Transition 3 → 4: Heel drops, little to no displacement in x direction, negative displacement in y direction
- State 4: Heel dropped**
Transition 4 → 1: Increase step count and go back to initial state



Results

The system demonstrates high reliability, with an identification accuracy of 90% when the cutoff frequency is set to 5 Hz for the low-pass filter, and 0.7 Hz for the high-pass filter.



Conclusions

- Accelerometer data could possibly be used to identify two-dimensional gait cycles and/or other human motions
- Estimation of small displacements using the method above using accelerometer gives relatively large errors but does not affect identification of motion patterns
- Future works may include utilization of gyroscope to detect 3-dimensional motions and reduce errors introduced by the tilting of SensorTile

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- UCLA Transfer Student Summer Research Program



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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.

Custom Printable Robotic Boats for Early STEM Education

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Introduction

Problems with Existing Robotics Kits

Expensive

Middle- and high-school age group

Limited hands-on design

Our Solution

- Creating a design tool for low-cost foldable robotic boats

Educational Applications

- Students design, build, and redesign robotic boats
- Hands-on experience with cycle of scientific experimentation

Developing the Design Tool

Built prototypes of mechanically powered paddleboat design

Motorized boat and integrated electronics into design

Finalized boat template

Model 2D template and 3D structure on RoCo

Student Design Process

1 Design in web-based app by inputting parameters

2 Print and cut out template

3 Fold and assemble boat, Test effects of chosen parameters

Easily modify components

Results

- Iterative design process and customization allows for personalized products
- Encourages experimentation and hands-on learning approach
- Teaches gateway STEM skills and engineering/design process

Total cost: ~\$30 (Retail), ~\$15 (Bulk)

Ultra-thin Power Bank: \$13

Plastic film: <\$1

2 Continuous Rotation Servos: <\$10

NodeMCU board and Motorshield: \$6

Acknowledgements

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 Fast Track to Success Program
 LEMUR Lab, Dr. Ankur Mehta
 Wireless Health Institute

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Prices of Existing Educational Robotics Kits

Robot	Retail Cost (USD)
Thymio	189
LEGO Mindstorm 3	340
Scribble	199
mBot	69
Our Boat	30



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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.



UCLA Samueli School of Engineering
Summer Undergraduate Research Program

Automated Speech Database Organization

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Fast Track to SUCCESS
summer scholar program
Summer Undergraduate Research Program

Introduction

- 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.



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

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





/^ [Regular] [Ex] pression \$ /

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+;v|d|d))")` searches for timestamps of the form (minusc)
- 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.

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

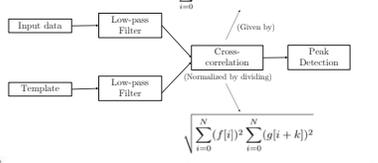
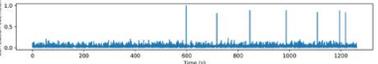



Figure 3. Results of one normalized cross-correlation. The large peaks are matches to some JIBO voice line. A vertical axis value of 1 indicates an exact match. Due to noise and microphone placement inconsistencies, an exact match was very rare and thresholding was used to determine whether a match took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

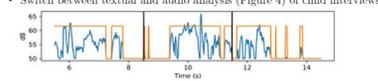


Figure 4. A small section of a sound file. The user selected section is between the two black vertical lines. The orange sound blocks can be moved to white scrubbing or can be ignored if fine scrubbing is desired.

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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