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Poster Symposium and Awards Ceremony | August 16, 2019
First Floor Engineering VI: Mong Auditorium, Lobby and Patio

11:00 AM - 11:05 AM    Announcement (William Herrera)
11:05 AM - 12:30 PM    Poster Galley Walk
11:45 AM - 12:30 PM    Hors d'oeuvres service begins
12:30 PM - 2:00 PM     Awards Ceremony
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
Filter Behavior Characterization and Verification Utilizing Analog to Digital Converter and Digital Signal Processing

High-performance integrated electrical filters are desired in almost every aspect and found in almost all electronic devices. In realizing very sharp and linear analog filters with enhanced wave filtering applications, our lab began utilizing an intentional use of time varying circuits. However, for such filters to be truly useful, it needs precise characterization with fast, and preferably automated processes. Developing this automation involved signal generators and an analog-to-digital converter to create a quick and precise characterization of the behavior of various filters which would otherwise be done manually which is time consuming and inefficient. The ADC board combined with two synchronized signal generators allows the signal to be sent to a MATLAB algorithm and hence obtain the desired magnitude and phase responses of the filter. The signal generation and process is more complex than sweeping the input frequency because the automation produces many challenges including equipment noise. My research aims to overcome these obstacles with digital signal processing. Our process of characterizing the parameters of a filter quickly and precisely will contribute to our labs development of a frequency-channelized ADC that will use tens of such filters to separate the spectrum into multiple pieces.

Acknowledgements

I would like to acknowledge the 2018 Summer Undergraduate Research Program for the amazing experience opportunity. Professor Pamarti for giving us great experience to do this important research, and Shi Bu daily lab supervisor for guiding us through this project and answering all of our questions in making this a fun learning experience for us.
Diamond as an output coupler for chip-scale terahertz external cavity quantum cascade lasers

External cavity quantum cascade lasers are an integral source of terahertz radiation. However, heat removal from the devices is critical in order to achieve continuous wave operation. We introduce a chip-scale output coupler for a quantum cascade vertical external cavity surface emitting laser (QC-VECSEL) through a 500 um thick synthetic polycrystalline diamond plate. This design brings two primary benefits: a method of dissipating heat from the laser’s bias region and a mechanically stable output coupler with no need for alignment. The diamond is mounted directly on top of the metasurface, replacing an existing design involving an externally mounted quartz output coupler. Initial electromagnetic simulations indicate acceptable high reflectance at a resonant lasing frequency of 3.4 THz and a bandwidth of about 140 GHz. Thermal simulations will be conducted to predict the expected improvements in operating temperature and heat dissipation for the VECSEL’s metasurface. Possible areas of concern include high threshold current and increased thermal losses due to an adjusted ridge geometry that features a high fill factor.

VECESL Coupled with Diamond

Candidate Active Region

Possible area for quantum well

Possible area for quantum well

Active region

Vegetable region

Diamond

Au Plating

MQW

ActiveRegion

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The VECSEL is fabricated from a hybrid evaporation design (VECEL), which has a maximum current density of about 3000 A/cm². Given a ridge height of 0.45 µm, the minimal bias region diameter was chosen to be 1.2 µm. This provides a peak current of 6.6.A.

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Filter Behavior Verification and Characterization Utilizing Analog to Digital Converter and Digital Signal Processing

Electronic filters are utilized almost everywhere. However, while integrated filters are demanded in modern high-complexity systems, for them to be truly useful, we need to fully characterize them with great precision. While such characterization and testing may appear to be straightforward, many difficulties arise in practice. For example, such characterization needs to be fast and accurate, with multiple aspects being measured simultaneously. Measurement equipment non-idealities, such as noise and non-linearity, had to be addressed with careful consideration. Our utilization of an Analog to Digital Converter (ADC) enabled an automated process with high precision, as the ADC’s output could be processed digitally for better handling of various error sources. Our use of an ADC in addition to signal generators and MATLAB algorithms allowed us to automate the process of verifying the accuracy of a filter’s intended behavior; this process allowed us to extract properties such as magnitude and phase, some of the most important parameters to our interest. These now characterized filters can be utilized in more complex integrated systems for various communication applications. For example, the aim from the automated, precise characterization of filters will allow the building of a hybrid filter bank - which would consist of tens of filters - to achieve signal reconstruction with much less difficulty, which is key to realizing a wideband frequency-channelized ADC for high-dynamic-range and low-power applications.

Spectral Leakage

Spectral leakage is when the discrete frequency spectrum is not zero for frequencies not of importance. This is important because of the periodicity of the spectrum. If the spectrum is not periodic, then this will result in non-zero spectral leakage, which will be present in the measured spectrum. Therefore, it is necessary to use a Fast Fourier Transform (FFT) which can be used to extract spectral leakage. The spectral leakage is a function of the signal and the number of periods, which in turn determine the processed frequency content of the signal. If the signal is not periodic, then the spectral leakage will be present in the measured spectrum.

Utilization of MATLAB Algorithms and Power Combiner to Extract Amplitude and Relative Phase

The amplitude of the signal was calculated with the use of the FFT function in MATLAB. The power combiner was used for calculating the power of the signal. The power combiner allows both signals to be separated and calculated with one set of data.

Conclusions and Future Work

Looking forward, the algorithm developed will allow for the accurate verification and characterization of the fast March filter in the lab. Additionally, the algorithm will be used for developing a wideband frequency-channelized ADC that can be used for low-power and high-speed applications. This will be a common research direction in the field of signal processing, where the characterization of the filter quality and performance will continue to be an area of high interest.

Acknowledgments

This work was supported by the Fast Track to Success Summer Scholarship Program. It has also been supported and much gratitude is given to Professor Pamarti as well as all the undergraduate students who have participated in the project. Abbas Bakhshandeh is supported by the Graduate Undergraduate Scholars Program at the Henry Samueli School of Engineering at UCLA.
Rodent Path Reconstruction using Hippocampal Rate Coding

The goal of this project is to use neural spike readings from a rat to determine its position in an enclosure. The spike readings are taken from several neurons in the hippocampus, a part of the brain that is associated with spatial memory. The spike readings are condensed into spike rates for each neuron, which are believed to hold information about the stimulus (the rat's position). The spike rate of each neuron is modeled as a Poisson process with an unknown parameter that is a function of the stimulus. A neural network is used to determine the parameter for every neuron at every position in the enclosure. Different sets of features from the stimulus can be used as the input to the neural network. The parameters of the neural network are designed to minimize the error in the reconstructed path. Some of the decoding algorithms that have been explored in this project include one-shot decoding, greedy decoding, Viterbi decoding, and adaptive decoding. A high-performance decoder could possibly be adapted to improve brain-machine interfaces.

Decoding Methods

- **One-Shot Decoder**
  - Selects position that is within a fixed distance of the previous position
  - \( q_{i+1} = \arg \max (\ell(x_{i+1}) + \lambda \ell(z_{i+1})) \)

- **Greedy Decoder**
  - Selects position that is within a fixed distance of the previous position
  - \( q_{i+1} = \arg \max (\ell(x_{i+1}) + \lambda \ell(z_{i+1})) \)

- **Viterbi Decoder**
  - Selects path with maximum likelihood out of all possible paths
  - \( D_{i+1} = \arg \max (\ell(x_{i+1}) + \lambda \ell(z_{i+1})) \)

- **Adaptive Decoder**
  - Selects position that is within a variable distance of the previous position
  - \( q_{i+1} = \arg \max (\ell(x_{i+1}) + \lambda \ell(z_{i+1})) \)

Future Work

- Explore more decoding algorithms
- Try out different neural network architectures for encoding
- Try out new feature extractions for encoding
- Select different combinations of neurons to use

Results

- Viterbi decoding performs the best, but at the cost of running time
- Adaptive decoding slightly improves the greedy decoder, but not the Viterbi decoder
- Performance decreases as the testing interval moves away from the training interval
- Decoders perform better when trained on future intervals rather than past intervals
- All of these decoders can be in existence, with the Viterbi decoders requiring a delay
- One-shot decoding performs the worst, showing that more sophisticated decoding algorithms can improve performance
A High-Speed, Low-Cost, and Compact Optical Delay Stage for Terahertz Time-Domain Spectroscopy Systems

Terahertz Time-Domain Spectroscopy (THz-TDS) is an application of the terahertz band of the electromagnetic spectrum with advanced capabilities in chemical identification, material characterization, and nondestructive material analysis. Recent developments in THz emitter and detector technology have established improved signal-to-noise ratios within these systems, increasing the viability of THz-TDS in commercial applications. However, the weight and speed of these systems are also limited by a component known as the delay stage, a mechanical device used to vary laser optical path length. The focus of our research has been to create a miniaturized, high-speed delay stage to address this need.

While laboratory delay stages offer sub-micron accuracies, these systems are often large and expensive due to the extra functionality they provide. We have opted to explore alternative mechanisms to achieve compact and cost-effective designs that suit our application. Utilizing 3D printing and machining, we have created prototype stages using crank and crank-inspired mechanisms that achieve recirculation frequencies of 10.4 Hz (as compared to 1.2 Hz by a laboratory stage). Through comparisons of THz-TDS results between a laboratory stage and our stages in the clarity and accuracy of absorbed THz waves measured through air, we have also been able to classify the efficacy of each iteration of our device. Looking at areas other than performance, our stages are lighter (211 g to 17 kg) and cheaper (about $200 to $10k) as well.
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 attain 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.
Analyzing and Quantifying Laser Beam Quality Using the Knife Edge Technique to Calculate the M² Factor

A laser beam is created by photons bouncing between two mirrors. The transverse modes are described by the distribution of the intensity along the radial direction. An ideal laser beam only has one mode and has an intensity beam profile described by a Gaussian function; however, real lasers are not ideal and typically osculate in the lowest and possibly higher-order modes. To quantify the beam quality of a laser, the knife edge technique is used to measure the total irradiance in the transverse direction. The MATLAB curve fitting calculates the M² factor in the transverse directions.

The knife edge technique uses a converging lens to focus on the beam and makes a series of stopped measurements with a knife-edge in two different transverse directions at and around the lens's focus where the beam radius is minimized. This allows the calculation of the beam's spot size, the radius of the beam containing the majority of the power, by measuring the transmitted power with the shift of the knife in the transverse directions. By analyzing the behavior of the beam radius across the optic axis, the divergence of the beam is characterized.

The small M² values were most likely due to diffraction effects from the experimental setup and the knife edge artifacts. Several mirrors were used to reflect the beam before detecting the irradiance. Altering the experimental setup or changing the knife edge made the setup more repeatable. The MATLAB curve fitting calculates the M² factor in the radial direction. An ideal laser beam only has one mode and has an intensity beam profile described by a Gaussian function; however, real lasers are not ideal and typically osculate in the lowest and possibly higher-order modes. To quantify the beam quality of a laser, the knife edge technique is used to measure the total irradiance in the transverse directions. The MATLAB curve fitting calculates the M² factor in the transverse directions.

With the labview program, the knife edge makes stepped movements in the transverse directions, taking and storing the detector's irradiance measurements in a file along with x, y, and z positions of the knife. The apparatus holding the knife is then moved to a different z position and the process repeats. The user can decide to repeat this process at a different z position, moving the knife until it is in position for another set of measurements and the program loops again for the transverse directions in the new z position.

To ensure the program made at least five measurements within one Rayleigh length and at least five outside, the z measurements spanned several millimeters with the step size determined from the Rayleigh length. The user function was written to wash out finite effects of diffraction. The 10-90% criteria for the beam waist was then used to determine the waist location. It defined the waist size as the width where 10-90% of the total irradiance was measured. Curve fitting was then used to find the location along the z axis. The program pauses until the user indicates the next z position where the knife edge will be moved. The apparatus holding the knife is then moved to a different z position, moving the knife until it is in position for another set of measurements and the program loops again for the transverse directions in the new z position.

We would like to thank the National Science Foundation for providing funding for our undergraduate research. We would also like to extend our thanks to the UCLA Electrical Engineering Fast Track to Success Program and UCLA Samuel Engineering Staff for its support and encouragement. This project was completed during Summer research and academic studies.
Implementing Kinematic Prediction via Physics-Guided Neural Networks

Physics-guided neural networks (PGNNs) are crucial for modeling resistive behaviors in real-life scenarios ranging from vehicle tracking to aerial trajectories. In prior papers, bounding box construction for videos would entail construction for every individual frame, hindering progress in terms of speed-up without significant computational power. This paper aims to bridge the divide between image and video object detection, utilizing kinematic priors to predict the motion of objects via the incorporation of affine transformations and perspective consideration (horizontal, side-to-side, overhead, etc.). Approaches based on optical flow algorithms and tubulet architectures are considered, and blended with physics-based learning (right) without physics-based learning (left) and with physics-based learning (left) (above).

Future Plans

The proposed physics model performs with high confidence values in the ideal scenarios created within the dataset. Improvements such as higher efficiency rates, faster processing times, greater accuracy rates, and improved motion predictions for accounted complexities such as occlusions, lighting, and camera motion are expected to be open-source for future development.

Implications of current model:

- Inability to account for changing acceleration hindering progress in terms of speed up without significant computational power.
- Inability to predict object motion with occlusions.
- The added complexity of object occlusion was captured for the purpose of modeling realistic difficulties in object detection and motion prediction.

Applications:

- Gait-Crime, Defense Industry
- Autonomous Drones, Movement Prediction

References


Preliminary Results

Figure 1: Bottle detection without physics-based learning (left) and with physics-based learning (right).

The physics-based model results indicate significant increases in the accuracy of the model when compared with simply the Faster R-CNN framework. Faster R-CNN with physics-based machine learning increases the confidence of object detection and reduces classification errors for objects.

Figure 2: Bounding box construction for videos would entail construction for every individual frame, hindering progress in terms of speed-up without significant computational power.
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 detrending 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.

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.

Background

- Location has been done in outdoor 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.

Results

- 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.
- the overall loudness is much quieter compared to outside.
- however, there is still numerous sounds occurring.
- 22 kHz is louder; the area is quite large, but there is still some reverberations.
- the hallway is very quite;
- there isn’t that much ambient noise either.
- however, the 22 kHz is the loudest here; the most reverberations of any location.

Conclusion and Future Works

- Utilize a variety of mobile sensors with time synchronisation 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

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.
Competitive Cation Exchange Behavior of Simulated Wastewater Streams Using Zeolites and Cation Exchange Resins for CO₂ Mineralization

Sodium based zeolites and resins, often used for gas adsorption and water softening processes, are proposed to be used to induce a pH shift required for CO₂ mineralization using a CO₂ - rich stream. These materials initiate a Na⁺ / H⁺ exchange, which increases alkalinity, forming carbonate ions (CO₃²⁻) for mineralization. Produced water, a waste stream rich in calcium and sodium ions, is proposed for mineralization (to produce calcium carbonate) and for the regeneration of materials. However, produced water streams also contain other polyvalent cations that could potentially compete with Na⁺ for exchange sites and inhibit regeneration. This research explores the competitive exchange of common ions found in produced water on various zeolites and exchange resins that may inhibit regeneration capacities. Ion exchange capacities and kinetics in single component systems using synthetic zeolites 13X and 4A, along with organic resins TP-207 and TP-260 were studied using calcium, magnesium and iron ions for exchange. Various concentrations of ions in solution over time were analyzed through inductively coupled plasma optical emission spectroscopy (ICP-OES). Dual component exchange capacities were further examined to determine competitive exchange behavior using fixed sodium concentration and varying calcium, magnesium and iron concentrations to simulate the concentrations within produced water streams.
Implementing Kinematic Prediction via Physics-Guided Neural Networks
Brian Chap, Lucas He, Irfan Syed
Guangyuan Zhao, ... Achuta Kadambi

GRADUATE STUDENT DAILY LAB SUPERVISOR
Guanyang Zhou
DEPARTMENT
Electrical and Computer Engineering


Towards Data-Driven Autonomous Drones Movement Prediction

Lucas He
First Year
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Physics-Based Object Temporal Localization Via Video Segmentation

The field of object detection has seen much advancements over the past years, especially in videos with the implementation and improvements of architectures such as Optical Flow, Tubelets, and Temporal Action Localization. However, such methods are still limited in their speed, efficiency, and accuracy, with the current fastest method running at an average of two frames per second. Thus, we propose the usage of the Physics Guided Neural Network (PGNN) to aid this task. By specifically tailoring this to detection of cars we hope to produce a naive form of detection that can track and solve transformations (i.e. scale, shear, and direction) of cars as they travel down a road. Using segmentation, we would then be able to establish instances of the cars as apply a physics model and determine each object’s trajectory based on the previous frames of the object’s path. The application of the physics model will serve to reduce the computational requirements of previous methods and allow for a more accurate prediction of an object’s temporal location.
Ultrafast Real-Time Dynamics of Frequency Microcomb Transitions

Temporally stabilized optical solitons, also known as self-sustaining nonlinear pulses at a mid-infrared frequency, confined in a microcavity driven by a continuous-wave laser has attracted tremendous attention due to its fascinating spectral and temporal features and corresponding intriguing cavity dynamics. A real-time ultrafast oscilloscope characterization system demonstrates the dynamics in the microcavity with picosecond resolution and a 500 picosecond recording length over each frame. However, the recording length is limited by the sampling rate due to the restricted memory depth of the oscilloscope during data acquisition. To bypass this complication, time lens was used to stretch the timescale of the waveform without adding distortion or noise. After finding the optimum recording length and temporal resolution, a Kerr frequency comb is generated in the microcavity with a laser which is then sent through optical fibers to the oscilloscope to be studied. We were then able to record the mode-locking formation and the transitions between different soliton states during the formation process. The real-time observations of the ultrafast optical dynamics provides new physical insight for ultrafast phenomena that happens in the microcavity.

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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. Typcially, 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 significan 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.

Results

- 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

Background

- the overall loudness is much quieter compared to outside
- however, there is still numerous sounds occurring
- 22 kHz is louder; the area is quite large, but there is still some reverberations
- the hallway is very quite
- there isn’t that much ambient noise either
- however, the 22 kHz is the loudest here; the most reverberations of any location

Methods

- Recorded 800, three-second audio clips at 4 different locations
- Sample Set A – 400 samples with an 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

Conclusion and Future Works

- Utilize a variety of mobile sensors with time synchronisation 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
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 kindergarteners.

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.

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)

References

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.

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

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.

Timeline of Trial
Stimulus
Cursor position
Random
Reaction
Movement endpoint

Coding
Random dot stimulus is generated with Python, primarily based on the Psychopy toolbox. We modified the code of the Resulaj lab, based on the one presented in Resulaj’s paper. Stimulus will be implemented on LCR/RES machine to collect real-time data every millisecond of the cursor’s position.

References

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 Sharrazin Raiz for their guidance throughout the program.
Design of Cyclic Redundancy Check (CRC) for Tail-Biting Convolutional Codes

 Reliable transmission of data requires channel codes that can correct errors introduced by the channel and/or detect that a received or decoded sequence is not valid. Convolutional encoders can correct errors in a distorted received sequence by using the Viterbi algorithm to find the closest codeword to the received sequence. Cyclic redundancy check (CRC) codes can detect whether the convolutional codeword identified by Viterbi decoding corresponds to a valid message. While both CRCs and convolutional codes have been developed in the past, they have been designed independently even though they are not independent when used together. For zero-terminated convolutional codes (ZTCCs) that are terminated by a final sequence of inputs that drives the encoder to the zero state, our research group has designed CRCs that are optimal for a given ZTCC. Tail-biting convolutional codes (TBCCs) avoid the overhead caused by ZTCCs and therefore can achieve higher rates with essentially the same performance. Rather than using additional input symbols to drive the final state to zero, TBCCs enforce the constraint that the starting state is the same as the final state. Our research is directed towards developing CRCs that are optimal for a given TBCC.

Materials and Methods

- The group of professors and students involved in a communication systems laboratory at a university.
- The lab is primarily focused on research and teaching.
- The lab's current projects and research areas.
- The lab's technology and equipment.
- The lab's collaborations and partnerships.
- The lab's achievements and impact.

Conclusions & Future Work

- Overall, our experiment with the algorithm was successful in improving error detection.
- The algorithm's performance can be further enhanced by incorporating additional data or using different error correction codes.
- Future work could include investigating the performance of the algorithm in different scenarios or considering how it can be integrated into existing systems.

References

- Cyclic redundancy check (CRC) algorithms and their applications.
- Tail-biting convolutional codes and their properties.
- Simulation results and analysis.
- Experimental setup and methodology.
- Impact of the algorithm on system performance.

Acknowledgments

- We would like to thank the National Science Foundation and the Department of Electrical and Computer Engineering Department for providing funding for our research project.
- Special thanks to [Professor's name] for providing guidance and support throughout our research and learning process.
Background

THz-waves pose as a method of increasing the viable range of electromagnetic frequencies used for spectroscopy. The goal of this experiment is to use a Support Vector Machine (SVM) algorithm to identify materials given their absorption of mm-waves. SVMs classify data by determining an optimal hyperplane which acts as a separation boundary between different categories of data. An SVM algorithm was used since it can effectively distinguish between complex sets of data, such as the various material absorptions, with much greater success than a human could. Given new test data after training, higher training accuracy is required for consistent accurate classifications of objects.

Materials and Methods

Signal power received by the circuit was measured in the presence and absence of an object. Absorption for each object was calculated by taking the difference in power with and without the object. The SVM algorithm drew decision boundaries to differentiate the different materials’ absorption data.

Conclusion/Future Works

Conclusion:

From absorption spectra measurements, a Support Vector Machine Algorithm can be trained to predict the material obstructing the signal with 95% accuracy. Given new test data after training, higher training accuracy is required for consistently accurate classifications of objects.

Future Works:

Using other machine learning algorithms to separate absorption data and determine if other algorithms prove more accurate in predicting materials.

Create new absorption data to determine if other factors besides material type and thickness affect absorption.

Running these tests with a new set of materials to provide more data and materials for machine learning algorithms to classify.

References


Acknowledgements

We would like to thank the UCLA Summer Undergraduate Research Program for this research opportunity and the ECE Dean’s Department for funding the experience. We would also like to thank Professor Babakhani for providing the opportunity to work in his lab as well as Babak Jamali for his support and guidance throughout the program.
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 measuring glucose and lactate with high accuracy and sensitivity. The initial sensor tests showed that the applied heat causes changes in sensor readings, which will be addressed in future studies.

Microfluidic Device

- CAD to 3D Device Fabrication: A combination of laser cutting and 3D printing technology allows rapid and low-cost prototyping of microfluidic devices.
- Laser Cut & Pinch Valve Design: Laser-cut fabricated pinch valves are used to control fluid flow through microfluidic channels.
- Thermoresponsive Hydrogel Valves: thermoresponsive hydrogel valves are used as valves which can be opened and closed by applying heat.
- Laser-cut Fabrication: Laser-cut microfluidic channels are used to control fluid flow through electrochemical sensors.
- Electrochemical Sensor Arrays: Electrochemical sensors for glucose and lactate detection are integrated with mobile devices.

Electrochemical Sensors

- Glucose Oxidase Enzyme with Stabilizer: Glucose oxidase enzyme with stabilizer is immobilized on the electrode surface.
- Lactate Oxidase Enzyme with Stabilizer: Lactate oxidase enzyme with stabilizer is immobilized on the electrode surface.
- Gold Chromium Layer: A gold chromium layer is used to enhance the electrical conductivity of the device.
- Oxidized Platinum Layer: An oxidized platinum layer is used to improve the electrocatalytic activity of the device.
- PPD Layer for Filtering: Poly(N-isopropylacrylamide) (PNIAP) is used as a thermoresponsive hydrogel to filter sodium lactate from sweat.
- Polyvinyl Chloride (PVC): Polyvinyl chloride (PVC) is used as a tape-based channel to facilitate fluid flow.

Future Work

- To achieve improved detection accuracy and sensitivity within the human body range (10.00-16.00 mEq/L), additional integration and optimization of the device are needed.
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Acknowledgement

This study was funded by Dr. Gregory Polk's NSF grant for Wireless Health Institute and the Transfer Student Support Program (TSSRP) at UCLA. The authors would like to thank UCLA’s Interconnected and Integrated Bioelectronics Laboratory (IIBL) for their support.
**Effect of Hyaluronic Acid Molecular Weight on CD44 Clustering**

The regeneration of tissue after spinal cord injury (SCI) has proven difficult as a result of the complex pathophysiology at the injury site. One biomolecule that plays an important role in the wound healing response is hyaluronic acid (HA), a long-chain polysaccharide in the extracellular matrix. It is known that HA signals cells to directly influence the inflammatory response in a molecular weight-dependent manner. One possible explanation for this effect is that different molecular weights of HA bind differentially to the CD44 receptor to induce varying levels of clustering. A model cell line, human embryonic kidney (HEK293T), was transduced with CD44 overexpression lentiviral vectors and treated with HA of varying molecular weights. CD44 clustering was characterized using both fluorescent resonant energy transfer (FRET) and Western blotting assays. Measurements of receptor clustering levels were made using HEK293T cells infected with two different viruses, CD44-YPet and CD44-CyPet, which promote expression of the CD44 receptor coupled to the YPet and CyPet fluorophores, respectively, which are well established FRET pairs. To quantify expression of clustered and unclustered CD44 via Western blotting, the crosslinker bis(sulfosuccinimidyl)suberate (BS3) was used to preserve the CD44 receptors clustered in the cell membrane prior to cell lysis. Both FRET and Western blot analysis demonstrated that CD44 receptors in the presence of HA undergo greater clustering. Furthermore, data suggests that increasing molecular weight of HA may correspond with higher levels of CD44 clustering, although additional experimental repeats are required for verification.

**Materials and Methods**

- **Objectives:**
  - Examine the effects of varying molecular weights of hyaluronic acid on CD44 clustering
  - Create a model cell line for CD44 overexpression via lentiviral transduction
  - Characterize CD44 clustering through fluorescent resonant energy transfer (FRET) and Western blotting

- **Background and Motivation:**
  - Spinal cord injury (SCI) has a devastating condition that causes muscle weakness, paralysis, severe pain, and permanent death.
  - Lack of treatment options due to incomplete understanding of the complex pathophysiology of the glial scar and disruption of the extracellular matrix (ECM).

- **Experimental Setup:**
  - FRET efficiency depends on the spectral overlap and distance between the donor and acceptor fluorophores.
  - FRET and Western blot analysis were conducted to measure changes in expression levels of the integrin.

- **Conclusions and Future Directions:**
  - Future directions include receptor clustering on cells that subdues expression (i.e., NSCs, HUVECs, etc.) to examine the relevance of CD44 clustering on cellular bioactivity, proliferation, and differentiation.

**Acknowledgements**

I would like to thank Josh Karam, Lali Ratul, Jesse Song, Ameera Lee, and all of the members of the lab for their contributions as well as the Institutional Review Board and the National Institute for funding this project.
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 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.

Ideas and Principles

- 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.

Timeline of Trial

- Stimulus position
- Random dot stimulus presented with Python, properly tested with the Psychopy GUI.
- Stimulus position and the number of trials are based on the one presented in Resulaj’s paper.
- Stimulus will be implemented on LiCURSE machine to collect real-time data every millisecond of the cursor’s position.

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.

Coding

- Random dot stimulus is generated with Python, properly tested with the Psychopy GUI.
- Image of the random dot motion.
- Schematic of the monitor viewed during experimental session.

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.

References


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 Harmes and Muhammad Shariat Raz for their guidance throughout the program.
Design of Flexible, Wireless Surface Electromyography System

According to the CDC in every 7,250 males are affected by Duchenne and Becker muscular dystrophy, a disease that affects muscle strength and leads to muscle degeneration. Surface Electromyography (EMG) is a non-invasive method used to measure muscle activity that can help in the diagnosis and treatment of musculoskeletal diseases such as muscular dystrophy. Typical Surface Electromyography machines are often bulky, rigid, and heavy which makes them difficult to use in a clinical setting, and it means they cannot be used as wearable devices. In addition, these systems are open single-channel systems which limit the spatial and temporal information that the system can gather, making readings incomplete. To help solve these issues, a full multi-channel electromyography system that is lightweight, flexible, and wireless will be integrated on FlexTrate™, a flexible electronic platform based on Fan-Out Wafer Level Packaging (FOWLP).

The surface EMG will take advantage of FlexTrate™ to integrate a variety of different integrated circuit (IC) dies such as amplifiers, passive components, and a Bluetooth Low Energy (BLE) chip as well as electrodes to detect the EMG signal. For wireless communication, the Nordic nRF52840 BLE module is used for low power consumption. In addition, the system will be implemented on a thin, lightweight, and flexible substrate that can be used easily in a clinical setting.

System Design

Surface EMG on FlexTrate™ Layout

In the figure below, we see the simple layout and size (EMS) system. Total system thickness will be less than 1 mm and weigh approximately 10 g.

System Design

Verification of Wireless Communication

Cross Correlation of a Sinusoid from a Signal Generator and an EMG Electrode

The pre and post processed signal is filtered through a 60 Hz notch filter. Correlation Coefficient is calculated on the right.

References/Acknowledgements

Spin-polarized Electrons by Photoionization with Intense Ultrashort Lasers

High-energy spin-polarized electrons are important for the investigation of pathways in high-energy collisions. However, generation of such electrons is difficult using conventional methods. Photoionization is a very common phenomenon that shows potential to provide a simpler way to produce spin-polarized electrons. Developments in laser technology have made it possible to create extremely high intensity light, which leads to various ionization processes. Multiphoton ionization involves the transfer of energy from multiple photons to an electron in order to surpass the ionization potential. Tunneling ionization occurs when higher field strength and lower frequencies allow the laser to be treated as an electric field which changes the shape of the potential barrier and allows the electron to escape through tunneling. The rates of ionization in these regimes have been described by several theories developed by Landau, Keldysh, ADK, PPT, and Barth and Smirnova. Different models of ionization rates were compared in order to find the areas in which they can be used to accurately describe ionization. The incorporation of magnetic and angular momentum quantum numbers into ionization rates allows for selective ionization of spin-polarized electrons, leading to predictions of up to 30% spin polarization. This may open a new avenue for the generation of high-energy, spin-polarized electrons in combination with the laser wakefield acceleration technique.
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 precision that analog circuits can operate while still being able to result in a desirable behavior.

Background

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 precision that analog circuits can operate while still being able to result in a desirable behavior.

Acknowledgements

We would like to thank everyone who has supported us throughout this journey. We have met and worked with remarkable and wonderful people like Professor Greg Pottie, Kartik Ahuja, and William Herrera for their contributions to our academic and career growth. This content was written by Canadian organizations like NSERC, TSSR, NSF and the Mitacs Program.
Automated Speech Database Organization

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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.

Methods

• Processing of audio transcripts was unifed 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.
  • $(\text{\text{1}}) (A \backslash d) (d) $ matches timestamps of the form $(\text{1}) dd$.
  • $(\text{\text{1}}) (A \backslash d) (d) $ handles transcription and the notation of private information for removal.

• This open-source package for Natural Language Processing aided in identifying private information within files, decreasing manual work.

Design: Text Processing

Variants

• “/ Regular [Ex] pression/”

NumPy

Design: Audio Processing

Deliverables

• A web database layout was designed and accompanied with documentation using content data from the designed processing methods.
  • User interface was created for labeling and cutting audio. It decreases manual work by giving the user extra features.
  • Jumps to audio containing private info or the beginning of certain tasks

Figure 2: Model of template-based recognition

Conclusion and Future Work

• Final database will serve in research for a number of diverse applications.
  • Child academic, speech recognition
  • Child speech and language
  • Recognition and classific
  • Using for polyphonic processing in all speech datasets

References


Figure 3. Study of use of transcribed information: the large dataset can be used when training machine learning models.

Figure 4. Flowchart of template-based recognition.

Input data

Processing Filter

Training Filter

Task

Jump to audio containing private info or the beginning of certain tasks

Acknowledgments to the UCLA Wireless Health Institute, UCLA ECE Fast Track Program, and the NSF for their continuous support financially, and otherwise, for multimodal research.

Automated Speech Database Organization

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GRADUATE STUDENT DAILY LAB SUPERVISOR

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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.
Distributed Quantization for Classification Tasks

When using quantization schemes for distributed classification, the goal is not to reconstruct quantized data perfectly; rather, it is to create a quantization approach such that the classifier maintains the accuracy it had before the large, high-precision data was quantized. If a communication quality constraint exists between different devices in the system, then the number of bits that can be used in our quantization approach is further limited. In applications, such as brain-machine interface and Google Cloud Internet of Things, there is a pretrained classifier that resides in a central node in a communication network, where it receives unclassified data that is distributedly generated. In the case of brain-machine interface, sensors are distributed on a subject’s body, and thus, high-precision features are generated from these body parts. This data is then classified for an actuator to carry out some action. Previously published solutions present a greedy algorithm that uses a recursive binning technique to quantize the data. We propose a more efficient, adaptable quantization approach implemented with neural networks. This approach achieves approximately the same accuracy as the greedy algorithm on an sEMG dataset with lower time complexity.
Absorption Spectroscopy Using Millimeter-Wave and Sub-Terahertz Frequencies

Sensing and retrieving data from millimeter-wave and sub-terahertz frequencies are useful for many different applications including faster data transmission in wireless communication and enhanced resolution in imaging systems. In this frequency regime, broadband systems are also useful for spectroscopy and detecting different absorption frequencies of gas molecules. A comb-based method can be used to enhance bandwidth to include these frequencies and coherent detection techniques can be used to implement a receiver that can detect them. Integrated circuits designed using this method exhibit improved bandwidth, and detection resolution as well as reduced power consumption compared to current CMOS wideband coherent receivers. One specific use for these transmitter and receiver circuits is absorption spectroscopy where the power of the signal generated by the transmitter is measured after it passes through a specific material and is recorded by the receiver. A support vector machine (SVM) algorithm can then be trained with the absorption data of multiple materials to identify a new material given its absorption data collected from the receiver. SVMs are machine learning models that can classify data by determining an optimal hyperplane which acts as a separation boundary between different categories of data. An algorithm that utilizes SVMs is quite effective when it comes to distinguishing between complex sets of data since it is able to determine boundaries in the data that may not be the most obvious to the human eye.

Conclusion/Future Works

- Given new test data after training, higher training accuracy is required for consistently accurate classifications of objects.
- Future Works:
  - Using other machine learning algorithms to separate absorption data and determine if other algorithms prove more accurate in predicting materials
  - Create new absorption data to determine if other factors besides material type and thickness affect absorption
  - Run these tests with a new set of materials to provide more data and materials for machine learning algorithms to classify

Acknowledgements

We would like to thank the UCLA Summer Undergraduate Research Program for this research opportunity and the ECE Dean’s Department for funding the experience. We would also like to thank Professor Babakhani for providing the opportunity to work in his lab as well as Babak Jamali for his support and guidance throughout the program.

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Millimeter-Scale Electroplated Multilayer Magnetic Shielding

Many devices that rely on atomic spectroscopy, like gyroscopic sensors and atomic clocks, require magnetic shielding to function as intended because of interference by external magnetic fields. Although no known material is able to stop a magnetic field, high permeability materials are able to effectively redirect magnetic field lines, creating protected regions of low magnetic field strength. Current methods of magnetic shielding involve inserting a sheet of high permeability material on a circuit board underneath a device or wrapping a region in a sheet of the high permeability material. In this project, we fabricate high performance chip-scale magnetic shields by electroplating alternating layers of nickel-iron alloy, which has a high relative permeability, and copper, which has a low relative permeability, onto a cylindrical shell. By alternating layers of high and low permeabilities, we minimize the influence of the demagnetization field, achieving a higher ability to redirect magnetic field lines. To test the shields, we use an electromagnet to generate a magnetic field and a magnetometer to measure the magnetic field inside the shield. We record the shielding factor of the shield, which is defined as the ratio of the external magnetic field strength to the internal magnetic field strength. Successful millimeter-scale shielding would allow for effective chip-scale implementation of devices that would function in external magnetic fields while conserving space.

Results

Experimental Results

We demonstrate the magnetic shielding effect by COHERENT Multipurpose small scale cryogenic demagnetization shield is commercialized by a number of magnetic shields. We measure magnetic flux density and shielding factor of spherical and cylindrical magnetic shields using an electromagnet and a magnetometer.

Acknowledgements

We would like to acknowledge the UCLA Summer Undergraduate Research Program, the UCLA Electrical and Computer Engineering Department, the National Science Foundation, the Amazon and Technology Education, and the City of Los Angeles for funding this project.
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 STM3c electronics 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.

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 STM3c electronics 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 moving along the path
- Sensors and Internet of Things (IoT) can provide real-time monitoring and feedback about training performance
- 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 STM3c electronics SensorTile utilizing only the onboard accelerometer module (LSM6DSM)

State Machine Design

- Objective: Design and improve the performance of a state machine algorithm on a STM3c electronics SensorTile utilizing only the onboard accelerometer module (LSM6DSM)

Signal Processing

- Accelerometer data could possibly be used to identify two-dimensional gait cycles and 3D human motions
- However, high frequency noises can degrade the performance of the state machine algorithm
- Low-pass filter with a cutoff frequency of 5 Hz reduces high frequency noises and improves the performance of the state machine algorithm

Conclusions

- Accelerometer data can be used to identify two-dimensional gait cycle and 3D human motions
- 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
- The system can also be used to identify two-dimensional gait cycles and 3D human motions

Acknowledgements

- National Science Foundation (Grant no. 1560483)
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- UCLA Wireless Health Institute
- UCLA Transfer Student Summer Research Program
- UCLA Henry Samueli School of Engineering and Applied Science Summer Undergraduate Research Program
- UCLA Henry Samueli School of Engineering and Applied Science Summer Undergraduate Research Program

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
- The system can also be used to identify two-dimensional gait cycle and 3D human motions
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Gait Recognition Using SensorTile – A State Machine Approach

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Electrical and Computer Engineering
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.

Developing the Design Tool

Develop prototypes of mechanically powered paddleboat design
Motorized boat and integrated electronics into design
Finalized boat template and 2D structure on RoCo

Introduction

Problems with Existing Robotics Kits
Expensive
Middle- and high-school age group
Limited hands-on design
Built prototypes of mechanically powered paddleboat 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

Student Design Process

Design in web-based app by inputting parameters
Print and cut out template
Fold and assemble boat, test effects of chosen parameters

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)

References
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.

Methods

- **/ RegularExpression/NumPy**: Design: Text Processing

  - Processing of audio transcripts was unfurled in multiple ways.
  - To extract task completion data for documentation.
  - To identify private information.
  - As a guiding tool when labeling and cutting audio.
  - To map the output of phoneme prediction.
  - To implement Text Processing

- **/ RegularExpression/NumPy**: Design: Audio Processing

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

  - User interface was created for labeling and cutting audio. It decreases manual work by giving the user certain features.
  - Switch between textual and audio analysis (Figure 4) of child interviews.

Conclusion and Future Work

Deliverables

- User database was used in research for a number of diverse applications.
- Child speech analysis and recognition.
- Child speech analysis and recognition.
- Using Python to generate the models for preliminary processing of all speech datasets.

References


Design of Cyclic Redundancy Check (CRC) for Tail-Biting Convolutional Codes

Reliable transmission of data requires channel codes that can correct errors introduced by the channel and/or detect that a received or decoded sequence is not valid. Convolutional encoders can correct errors in a distorted received sequence by using the Viterbi algorithm to find the closest codeword to the received sequence. Cyclic redundancy check (CRC) codes can detect whether the convolutional codeword identified by Viterbi decoding corresponds to a valid message. While both CRCs and convolutional codes have been developed in the past, they have been designed independently even though they are not independent when used together. For zero-terminated convolutional codes (ZTCCs) that are terminated by a final sequence of inputs that drives the encoder to the zero state, our research group has designed CRCs that are optimal for a given ZTCC. Tail-biting convolutional codes (TBCCs) avoid the overhead caused by ZTCCs and therefore can achieve higher rates with essentially the same performance. Rather than using additional input symbols to drive the final state to zero, TBCCs enforce the constraint that the starting state is the same as the final state. Our research is directed towards developing CRCs that are optimal for a given TBCC.
Using Physics-Based Machine Learning to Track Objects

Physics-guided neural networks (PGNNs) are crucial for modeling realistic behaviors in real-life scenarios ranging from vehicle tracking to aerial trajectories. In this research, we propose a framework that implements kinematic prediction via Physics-Guided Neural Networks using a physics-based machine learning approach. The proposed method aims to enhance accuracy by merging regional convolutional neural networks (R-CNN) and physics-guided models. Using video segmentation methods, it uses a physics-guided neural network to classify, detect, and track objects. A self-made dataset created with ideal scenarios involving linear motion such as object drops and throws is the testing framework for the physics-guided model. The dataset contains scenarios involving the complexity of object occlusion for future development of the prediction model to increase accuracy in realistic, occluded situations. Classification and motion tracking of objects through predicted patterns rely on physics-based learning. By predicting trajectories in later frames based on kinematic calculation in earlier frames within the video, the model is able to detect and track the target object and increase accuracy. PyTorch 1.0 is the framework used for developing this platform and the code will be open source for future development.

**Tracking Objects Using Physics-Guided Neural Networks**

Incorporating physics into neural networks, known as physics-guided neural networks (PGNN), has been explored for object detection and tracking. The proposed method aims to enhance accuracy by merging regional convolutional neural networks (R-CNN) and physics-guided models. Using video segmentation methods, it uses a physics-guided neural network to classify, detect, and track objects. A self-made dataset created with ideal scenarios involving linear motion such as object drops and throws is the testing framework for the physics-guided model. The dataset contains scenarios involving the complexity of object occlusion for future development of the prediction model to increase accuracy in realistic, occluded situations. Classification and motion tracking of objects through predicted patterns rely on physics-based learning. By predicting trajectories in later frames based on kinematic calculation in earlier frames within the video, the model is able to detect and track the target object and increase accuracy. PyTorch 1.0 is the framework used for developing this platform and the code will be open source for future development.

**Physics-Based Model**

<table>
<thead>
<tr>
<th>Frame</th>
<th>Bounding box coordinates</th>
<th>Class labels</th>
<th>Confidence probabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frames 1 and 2</td>
<td>Calculate Euclidean distances between bounding boxes of the same class</td>
<td>Identify the shortest distance between bounding boxes of the same class (velocity)</td>
<td>Use kinematic equations to predict locations of future bounding boxes.</td>
</tr>
<tr>
<td>Frames 2 and 3</td>
<td>Remove “camera motion” if all subjects are in the same class</td>
<td>Find the change in velocity between pairs of frames (acceleration)</td>
<td>For next 17 frames</td>
</tr>
<tr>
<td></td>
<td>The endpoint of a bounding box (above) was used to calculate distance</td>
<td>The ground truth is close to the predicted bounding box, increase confidence probabilities.</td>
<td>In ground truth is far from the predicted bounding box, decrease confidence probabilities.</td>
</tr>
</tbody>
</table>

**Regional Convolutional Neural Networks**

**Dataset**

Applications of physics-based calculations on the Faster R-CNN framework were tested on a self-made dataset of videos that captured optimal scenarios, including drops, throws, and object rolling on surfaces to model the effects of gravity, friction, and object motion. The added complexity of object occlusion was captured for the dataset of modeling realistic difficulties in object detection and tracking.

**Future Plans**

The proposed physics model performs with high confidence values in the ideal scenarios captured within the dataset. Expectations for future improvements include higher efficiency rates, faster processing times, greater accuracy in detecting and tracking objects, and the ability to account for changing acceleration and object motion. Applications for physics-based machine learning may include self-driving vehicles, defense systems, autonomous drones, and movement prediction.

**References**

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Electrical Engineering  
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Optimization of Delay Stage of Terahertz Time-Domain Spectroscopy System

Terahertz time-domain spectroscopy (THz-TDS) allows us to analyze materials using pulses of terahertz radiation created by a femtosecond laser. Materials are analyzed based on their absorption patterns of the THz radiation. In the laboratory system, the detector receives pulses of THz radiation along with optical light pulses. The optical light path length is shifted by a delay stage which enables analysis of materials over a time domain and frequency domain.

Our goal is to miniaturize and improve the delay stage to convert the large laboratory system into a mobile, commercial device. The previous delay stage utilizes linear motion; a platform with mirrors accelerates back and forth to alter the path length of the radiation. Our main focus is designing a smaller prototype that relies on rotational acceleration to decrease the loss of speed from linear acceleration and deceleration.

Once a full prototype has been designed, it is tested in the laboratory setup and compared with previous data for accuracy. The frequency domain results of THz-TDS can be analyzed and used to determine chemical composition. When testing for accuracy, the Fourier graphs and THz pulses of our delay stage are directly compared with those of the laboratory stage. Our first test displayed broadening and shifting in the Fourier transformed waves which both indicate a worsened accuracy. However, the new delay stage works at almost double the frequency of the old one (2.2 Hz compared to 1.2 Hz) and only weighs 861 grams.

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Sub-micrometer Precision Optical Delay Stage for Synchronization of Ultrafast Laser Pulse

As laser systems produce shorter and shorter pulses to push the limits of ultrafast and high field science, the requirements for precision timing and optical synchronization in the lab have increased accordingly. The coordination and control of the relative time delay between ultrafast pump and probe laser pulses is required to resolve short lived physical events. Time and space are intimately connected for light, and on picosecond and femtosecond time scales, errors and uncertainties in the optical path length on the order of micrometers and nanometers can drastically degrade the time resolution of measurements in the laboratory. We have implemented an optical delay stage powered by a DC servo motor and controlled by a LabVIEW program. To evaluate the accuracy of positioning two laser pulses, we study the stage’s accuracy and repeatability in creating an optical path length delay with a HeNe laser Michelson interferometer. The pointing stability and reproducibility of the spatial beam profile after the stage is also determined. Understanding of the stage’s precision will enable us to perform picosecond pump-probe experiments, or synchronize ultrafast laser pulses using cross-correlation.

Pointing Stability Experimental Setup

- The assembled delay stage was translated by a DC motor, which can control the path length of the optical delay with a pump
- A LabVIEW program controls the motor and collects data from an x-y position in either single shot or continuous shot
- We measured the delay stage both at rest and field to determine the pointing stability of a CO2 helium-neon (HeNe) laser beam +0.1 nm
- We repeated the experiment introducing a HeNe laser to determine the optical delay of the two interfering beams

Methods

- We assembled a delay stage, translated by a DC motor, which can control the path length of the optical delay with a pump
- A LabVIEW program controls the motor and collects data from an x-y position in either single shot or continuous shot
- We measured the delay stage both at rest and field to determine the pointing stability of a CO2 helium-neon (HeNe) laser beam +0.1 nm
- We repeated the experiment introducing a HeNe laser to determine the optical delay of the two interfering beams

Conclusions

- We measured the position of the interferometer, and determined the total accuracy and precision of measurements in the lab. The delay stage is accurate to within +0.1 nm, which is significantly better than the optical delay stage of a CO2 helium-neon laser beam.

References

Millimeter-Scale Magnetic Shielding

Devices that rely on atomic spectroscopy, such as nuclear magnetic resonance gyroscopes and atomic clocks, are strongly affected by external magnetic fields. Thus, in order to miniaturize these devices while maintaining precision, small-scale magnetic shields must be developed to properly redirect magnetic field lines away from the enclosed devices. The purpose of our research is to fabricate and test potential shield designs. Based on previous research, we determined that the optimal design would consist of concentric cylinders of alternating high permeability and low permeability material. By alternating layers, we partially prevented adjacent ferromagnetic material from reducing the magnetization of that layer. Moreover, multilayer shielding allowed us to mitigate the effects of magnetic saturation, as a single layer of magnetic material would reach saturation more quickly, limiting the shield’s ability to generate an opposing field. We conducted our research by simulating potential shield designs in COMSOL Multiphysics, developing an appropriate test setup to assess the effectiveness of our shields, and fabricating shields to test. For our test setup, we generated a magnetic field using an electromagnet and measured the magnetic flux density using a printed circuit board with a magnetometer mounted at its tip; shielding factor was determined by taking the ratio of external to internal magnetic field. Shields were fabricated by electroplating alternating layers of permalloy and copper.

Results & Discussion

When an external magnetic field \( B_{\text{ext}} \) is applied, a strong enough opposing field \( B_{\text{int}} \) is established to shield the enclosed device from the external field. The magnitude of the shield depends on the permalloy material used; the effectiveness of the permalloy layer depends on the field norm of the applied field. When the shield contains multiple layers of permalloy and copper, the magnetic material is prevented from demagnetizing each other, and the overall shielding factor increases. As the layers increase in number, the magnetic material is able to maintain higher shielding factors for the multilayer shield. Our research serves primarily to test and advance potential shield designs.

Conclusion and Future Work

Our simulations and test results imply that our multilayered cylindrical design produces an optimal shielding factor in a commonly used plan design. When using layers of high and low permeability material produced a higher shielding factor than a single layer of the same diameter, inner radius, and material. By applying different magnetic fields and measuring \( B_{\text{int}} \), we found that the cylindrical design had higher shielding factors overall, with the permalloy layer at a much closer size when measuring \( B_{\text{int}} \) compared to the plan design. In the future, we plan to fabricate and test the effectiveness of different geometries and configurations for improving overall shielding factor using these devices.

References


Acknowledgements

We thank the author and the Laboratory for providing the facilities for this work to make this possible.
Miniaturized magnetic shielding for chip-scale atomic devices

Atomic devices such as atomic clocks and nuclear magnetic resonance (NMR) gyroscopes are excellent for taking measurements because of their well-defined quantum properties. The miniaturization of atomic devices would allow for them to be combined with phones and wearables, which allow for extremely precise, low power positioning systems. However, such devices must be extremely well-isolated against external interference, such as a magnetic field, to preserve their accuracy. For example, atomic clocks need to be shielded to prevent magnetic fields from interfering with the energy spectrum of atoms and to maintain the clock’s frequency. Recent efforts have been made to miniaturize chip-scale atomic devices. But to further scale down the size of atomic devices, smaller magnetic shields must be fabricated to accommodate the compact environment inside electronic devices. In this research, the magnetic behavior of a flat piece of Permendur and a cylinder of Permalloy was measured to study the shape-dependency of magnetic shields as well as their effectiveness to attenuate an external magnetic field. The results of this research would provide insights for the optimal design of a miniaturized magnetic shield.

Introduction

- Atomic devices are ideal for time keeping using high defined quantum states.
- However, these devices have minimal external shielding, such as magnetic fields in a laboratory or home.
- Materials with high permeability provide an alternate path for magnetic field lines to travel through.
- Materials with high saturation (e.g., Permalloy) provide an alternate path for magnetic field lines to travel through.

Methods

- Two wire shielded coils were used to show differences between cylinders and pieces of plate.
- Shielding factor \( \frac{B}{B_{unshielded}} \) was calculated.
- The magnetic field is generated by moving direct current through a coil.


table

<table>
<thead>
<tr>
<th>Cylinder</th>
<th>Plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permendur</td>
<td>Permendur</td>
</tr>
<tr>
<td>106.3</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Discussion

- Saturation effects are apparent for the Permalloy cylinder after 8000µT E-field in Fig. 11 where the plot from linearity. This is confirmed by a decrease in the shielding factor after 7000µT E-field in Figure 8 also suggests the saturation of 60FeCo, which in turn reduces another previous work. The saturation is given in the table above, in the point at which the shielding factor is less than that of the cylindrical shield. Permeability \( \mu \) is a way to determine the magnetic behavior of a material.
- Based on the use mappings, the Permalloy cylinder is able to maintain the magnetic flux density to nearly zero inside its shielded region in both x and z direction. This is consistent with the two coils of Cylindrical simulations.

Conclusion

- The Permalloy cylinder has a higher measurement factor than the Permendur plate.
- Saturation effects are apparent for the cylindrical shield but not for the flat piece.
- Cylindrical shape in a more effective design.

Acknowledgements

References

Computing Channel Capacity using the Blahut-Arimoto Algorithm

The maximum rate at which information can be reliably transmitted over a communication channel is the channel capacity, usually represented in units of bits per channel use. The ability to compute the capacity of any discrete memoryless channel based on its statistical description is a powerful and fundamental result of information theory. Broadly speaking, the noisier a channel, the lower its capacity.

Mathematically, the channel capacity is the maximum mutual information between the input and output of the channel, where the maximum is taken over possible input distributions. My research is focused on developing tools to identify the mutual-information-maximizing input distribution for a channel and consequently its capacity. As an initial project, I have implemented the Blahut-Arimoto algorithm, which finds the capacity-achieving distribution for any discrete memoryless channel with a finite input alphabet.

For many practical channels, the input alphabet is not finite. For example, even a simple amplitude shift keying system has an uncountably infinite number of possible amplitudes. Furthermore, there are practical communication systems where the optimal input distribution turns out to be asymmetric, such as on-off keying over an additive white Gaussian noise channel. My future research is directed towards identifying the optimal input distributions in these cases and developing practical encoders that can approximate those optimal input distributions.

Results

My implementation works for discrete memoryless channels with a finite input alphabet. Undergraduate Research Program for their financial support, and for this opportunity to pursue research.

Conclusions and Future Work

All results converge to the correct theoretical values, validating my implementation of the Blahut-Arimoto algorithm. Future work aims at extending this approach to memoryless channels with a finite input alphabet.

My immediate next project is to find the optimal input distribution given any average power constraint on an on-off keying channel with additive Gaussian noise.
If you would like to find out more about the Summer Undergraduate Research Program, please contact Director William Herrera:

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