INTERIM DEAN’S MESSAGE

The UCLA Samueli School of Engineering’s Summer Undergraduate Research Program (SURP) provides a real-world research experience in a wide range of engineering and physical science fields. Through this program, undergraduate students hailing from diverse backgrounds and experiences have an opportunity to conduct research in our faculty’s laboratories under their supervision.

In 2022, SURP transitioned back to in-person programming after two years of remote sessions. Students in this year’s program have been able to:

- Conduct on-campus research in a cutting-edge field at a world-renowned research institution
- Meet and network with a community of peers who have similar goals and interests
- Create a professional scientific poster and publish a research abstract
- Learn to communicate research outcomes and present a detailed project summary
- Gain a competitive advantage for applying to graduate schools
- Learn how to impact their communities as engineers and scientists

Forty-four undergraduate students were selected to join the 2022 SURP cohort and were mentored by 25 faculty members across six UCLA Engineering departments. UCLA Samueli is committed to fostering a more equitable, diverse and inclusive community. More than 40% of this year’s SURP participants are women, 24% are from underrepresented populations, 20% are first-generation students and 18% of the students are from area community colleges.

Creating new knowledge is a challenging but meaningful endeavor, and these high-performing students have done an outstanding job working through the rigors of scholarly research. They should be very proud of all that they have accomplished in a short time this summer. I encourage you to peruse our brochure and learn about their research.

Sincerely,

Bruce Dunn
Interim Dean

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BRUCE DUNN
Interim Dean
Electrovibration is a principle that revolutionizes the way touchscreens are perceived and interacted with. By applying an oscillating voltage to a screen, electrostatic force is induced between user fingers and the touchscreen, and a wide range of tactile feedback is able to be achieved without the use of any moving parts for superior durability. Additionally, electrovibration can render a richer set of textures than what can be offered by mechanical vibrations. Because of this operating principle, computing devices using electrovibration hold a number of advantages to physical vibration that make it an appealing alternative or addition to its current counterpart. From the lack of wear and tear to increased magnitude and spatial uniformity in tactile feedback, electrovibration induces a perceived sense of friction to sliding fingers that when used in conjunction with physical vibration, allow for a much more immersive experience. Conventionally, designs of electrovibration rely on heuristics that demand experience from the user. Trial and error could also be time consuming. In this project, we propose a toolkit to automate the creation of realistic haptics on conductive materials using electrovibration. Specifically, to use our toolkit, all a user needs is to slide their smartphone with our 3d printed conductive materials using electrovibration. Specifically, to use our proposed toolkit to automate the creation of realistic haptics on conductive materials using electrovibration. Specifically, to use our proposed toolkit to automate the creation of realistic haptics on conductive materials using electrovibration. Specifically, to use our proposed toolkit to automate the creation of realistic haptics on conductive materials using electrovibration. Specifically, to use our proposed toolkit to automate the creation of realistic haptics on conductive materials using electrovibration. Specifically, to use our proposed toolkit to automate the creation of realistic haptics on conductive materials using electrovibration.
Deformable Planar to Spatial Deployable Designs

ABSTRACT

We expect deployable designs to be easy, efficient, and practical to use. Auxetics – elastic geodesic grids in this specific research – can be used as a 2D to 3D deployable design that can form a target curved surface. These grids are built from flat flexible rectangular beams that allow for deformation out of plane, shaping the 3D surface. The structures are relatively simple, cost-efficient, and easy to manufacture. Since elastic geodesic grids require flexible materials to deploy to their 3D state, our objective is to find out what kind of different materials we can use to fabricate them as well as how the materials affect the overall deployment efficiency of the structure. Knowing this, we can determine what surfaces we can and cannot approximate with certain sets of materials. To ensure precise fabrication of the beams and pivot points, we use a laser cutter to create an accurate grid approximation. For future works, we would like to investigate further grid applications such as attaching canvas or membranes over the grids.

GOAL: Find different flexible materials to use in the construction of elastic geodesic grids to see the effect on deployment behavior.
In the 1900s, photographer Eadweard Muybridge rigged 12 consecutive cameras with a tripwire to produce sequential pictures depicting a horse’s motion. These images were monumental in proving that horses amid their gallop are momentarily airborne, but more importantly, they developed the concept known as time-resolved imaging. Today’s frontier in sequential motion photography resides on fundamental questions about quantum dynamics utilizing X-ray free electron lasers (XFELs) to understand interactions between light and matter at the femtosecond scale—a quadrillionth of a second. This is game-changing for our basic understanding of nature’s smallest, fastest, and most elusive constituents that play a fundamental role in chemistry, biology, and quantum physics. High-quality electron beams are at the heart of these unique sources, which currently rely on decades-old technologies, thus hampering their advancement. Our project explores emerging theories in quantum electrodynamics (QED) through vigorous calculations and computer simulations, first proving that our tabletop laser can match the brightness of the Ytterbium laser inherently producing different wavelengths from our electron source, we reach the potential for higher variations of the HCF. The new frontiers of quantum electrodynamics (QED) are unmatched spectral band (wide range of frequencies) through dynamic control of optical properties inside HCF.

A Brighter Future: Next-gen Electron & Photon Probes for Quantum Science Frontiers

ABSTRACT

In the 1900s, photographer Eadweard Muybridge rigged 12 consecutive cameras with a tripwire to produce sequential pictures depicting a horse’s motion. These images were monumental in proving that horses amid their gallop are momentarily airborne, but more importantly, they developed the concept known as time-resolved imaging. Today’s frontier in sequential motion photography resides on fundamental questions about quantum dynamics utilizing X-ray free electron lasers (XFELs) to understand interactions between light and matter at the femtosecond scale—a quadrillionth of a second. This is game-changing for our basic understanding of nature’s smallest, fastest, and most elusive constituents that play a fundamental role in chemistry, biology, and quantum physics. High-quality electron beams are at the heart of these unique sources, which currently rely on decades-old technologies, thus hampering their advancement. Our project explores emerging theories in quantum electrodynamics (QED) through vigorous calculations and computer simulations, first proving that our tabletop laser can match the brightness of the Ytterbium laser inherently producing different wavelengths from our electron source, we reach the potential for higher variations of the HCF. The new frontiers of quantum electrodynamics (QED) are unmatched spectral band (wide range of frequencies) through dynamic control of optical properties inside HCF.

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Optimizing Compacted Biofilter Amendments for Stormwater Treatment in Roadside Soils

ABSTRACT

Transportation infrastructures such as roadways in urban areas contribute to pollution via contaminated stormwater runoff. Implementing soil-based stormwater infrastructure such as biofilters could capture and treat the contaminated runoff. However, required compaction for roadside soil limits biofilter’s infiltration and treatment capacity. The addition of bulking agents such as sand or large aggregates such as expanded shale, clay, and slate (ESCS) can increase the infiltration capacity. However, the quantity of the bulking agent required to achieve the desired infiltration rate is unknown. To estimate the optimal amount of bulking agent, we mixed the soil with two bulking agents, sand (0.6 - 0.85 mm), and expanded shale, clay, and slate (ESCS, < 2.8 mm) with different mixing ratios. Further, we amended the soil-bulking agent mixture with biochar to enhance the contaminant removal performance. The result shows that the biofilter media mixture with 50% (v/v) bulking agents, 25% soil, and 25% biochar, meet the required infiltration rate of 1-5 inch.h⁻¹. Under compaction, ESCS-based media exhibited a 3 times higher infiltration rate than sand. While both compacted biofilter media effectively remove E. coli, biofilter amended with sand relatively higher removal than ESCS-based media owing to greater straining in sand amended biofilters. The results would help develop design guidelines for roadside stormwater treatment systems that require the compaction of filter media.

Materials & Methods

Table 1: Media composition

Table 2: Biofilter media mixture

Table 3: Biofilter media mixture composition

Results

Figure 3. Vegetative stormwater control measures along roadways.

Conclusions

The next steps in this research is to determine the heavy metal and nutrient removal capacity of these compacted media.

References

References

Acknowledgement

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Optimizing Compacted Biofilter Amendments for Stormwater Treatment in Roadside Soils

Background

Improper surface or roadside management and compaction of the available soil materials resulted in infiltration of stormwater and contaminant runoff. Transportation infrastructures such as roadways and side walks are prime locations for stormwater control and contaminant removal. Efficient contaminant removal requires the media to interact with the bacteria more. Therefore, biofilters with high pollutant removal capacity are preferred. Additionally, the biofilter media composition. ESCS and sand are the most effective in removing contaminants.

Hypothesis

Bul комиссионади sand or ESCS, and biochar may dilute the required amount of compaction to achieve the desired infiltration rates. This study will compare the contaminant removal performance of the compacted ESCS-based media with different mixing ratios.

Objective

1. To determine the optimum mixing ratio of soil, biochar, and ESCS for infiltrating stormwater.
2. To compare the contaminant removal performance of the compacted ESCS-based media with different mixing ratios.
3. To evaluate the media’s ability to resist compaction.

Methods

Two mixtures were within the ideal hydraulic conductivity, 1. ESCS, soil, and biochar and 2. sand, soil, and biochar. Both mixtures had the same ratio of soil and biocar meaning the infiltration rate was due to the different grain sizes of ESCS and sand. E. coli inoculated stormwater was simulated in the biofilters with the same ratio of soil and biochar. The ESCS-based mixture did not perform as well as expected under compaction in terms of contaminant removal, and vegetation health.

Moisture content at varying depth was the media blend of sand, soil, and biochar. Both mixtures had the same ratio of soil and biochar. The infiltration rate difference was due to the different grain sizes of ESCS and sand. The equivalent sand-based blend performed magnitudes better, likely due to the lower HC.

Conclusions

The next steps in this research is to determine the heavy metal and nutrient removal capacity of these compacted media.

References


Figure 5: Effluent collected using fecal indicator bacteria (FIB) such as E. coli, at a higher growth rate than expected for non-vegetated comparison. Unfortunatley, the ESCS-based media was not the most effective in removing contaminants and vegetation health.

Figure 8: Hydrolysis of biochar in biofilter media results in pH increase, which contributes to increased vegetative growth and greater infiltration capacity.

Future Work

We aim to determine the heavy metal and nutrient removal capacity of these compacted media.

Acknowledgement

I would like to thank my faculty advisor Prof. Sanjay Mohanty; my daily lab supervisor Tonoy Das; my lab mates Yuhui Zhang and Lisa Thamiz; Sami Research Scholars for awarding me this opportunity; my lab mates Yuhui Zhang and Lisa Thamiz for their guidance and support.


Figure 6: Hydrolysis of biochar in biofilter media results in pH increase, which contributes to increased vegetative growth and greater infiltration capacity.
**Methodology**

Step 1: Divide

- **Results**
  - **numerical stability.**
  - **other developed distributed computation methods with sparse matrix**
  - **numerical precision were not explored here. Future work can employ**
  - **demonstrates improvements in tradeoffs between recovery threshold**
  - **improving over 70% at high levels of sparsity. While this result**
  - **is too massive to handle on one machine. Stragglers, nodes that**
  - **is handled by distributing tasks along worker nodes, as the task**
  - **Big data and its applications require massive amounts of data**
  - **is an illustrative example using A split into 3 rows and 2**
  - **Machine learning and data analytics algorithms, results**
  - **are due to the random generation of matrices**
  - **assumes non-sparse matrix), still has a gap to reach**
  - **are due to the random generation of matrices**
  - **shows new approaches improve upon the worst case (which**

**Introduction and Background**

Big data and its applications require massive amounts of data computed within the timeframe of milliseconds, and they rely on distributed computations. One such element of distributed computations is large matrix multiplications, and this computation is handled by distributing tasks along worker nodes, as the task is too massive to handle on one machine. Stragglers, nodes that don’t finish computations in a timely manner, are bottlenecks for distributed computations. Current solutions mitigating the adverse effect of stragglers inject redundancies in distributed tasks sent to worker nodes, which lowers the recovery threshold, defined as the minimum number of worker nodes needed to recover the result. Here we examine sparsity: the quantity of zero entries in data matrices. Inspiration from previous solutions are applied to lower the recovery threshold when compared to recovery thresholds of non-sparse matrix multiplication. We take advantage of sparsity to directly lower the recovery threshold by compactly packing information from matrices into the shortest possible representation. The results show that improvement in recovery threshold increases as sparsity increases, improving over 70% at high levels of sparsity. While this result demonstrates improvements in tradeoffs between recovery threshold and computation costs, it currently does not account for numerical stability of the algorithms as decimals and errors stemming from finite numerical precision were not explored here. Future work can employ other developed distributed computation methods with sparse matrix multiplications, look into sparsity in multiple matrices, or study the effects of numerical stability.
BreastBot: A Pneumatically Actuated Soft Robot for Breast Localization in Radiotherapy

ABSTRACT

Radiotherapy is a well-established technique for treating malignant and curable diseases. In breast radiotherapy, regions containing cancerous cells are exposed to x-rays to shrink and kill tumors. However, this method of treatment remains unsatisfactory due to crude setups and poor localization techniques that prevent effective normal organ sparing. Overlapping and nearby healthy organs may be unintentionally damaged by radiotherapy in addition to the targeted cancer cells, which results in life-threatening acute and chronic toxicities in breast cancer patients after treatment. To control healthy organ sparing and provide a reproducible setup, this work experimentally develops a pneumatically actuated soft robot to safely isolate the breast from other organs for imaging and treatment using Ecoflex, a silicone elastomer with a low Young’s Modulus. We pneumatically actuate the soft robot by pumping air into a network of air channels embedded within the robot’s body, causing specific sections of walls to expand and press against the breast. This expansion fixes the breast in a treatable position as far away from the patient’s body as possible. The current working internal pressure of the device is around 5-10 kPa, which is at the 10kPa pressure limit. Upon actuation, the thickness of the inner wall pressing against the breast is less than 250µm, which minimizes interference with imaging and unwanted radiation exposure. Each device costs less than 5 USD and 4 hours to manufacture excluding the 3D printed mold, so it is practical to custom fit the robot to each patient and dispose of it after treatment. This work demonstrates a promising future for soft robots in medical applications due to their lightweight, adaptable, reproducible, and inexpensive features.

I. Introduction & Background

In the United States, breast cancer is the second leading cause of cancer-related deaths among women. Although radiotherapy remains the most well-established method of cancer treatment, post-localization techniques and inconsistent setups can lead to life-threatening complications after treatment. There is a strong need to develop a technique that consistently and effectively localize the breast during radiotherapy to minimize radiation risk to healthy cells and maximize breast radiation.

II. Project Objectives

We intend to develop a pneumatically actuated soft robot with embedded air channels that rests around the breast of a patient’s body in the supine position. The robot applies a compressive radial pressure to the breast to push it away from the body for imaging and treatment.

Design Considerations:

- Pneumatically actuated: Achieves motion by inflating air channels (10kPa pressure limit) for an adaptable fit
- Thin walls: Parts of the robot in contact with the patient cannot exceed 250µm for optimal imaging and to minimize radiation exposure.
- Inexpensive: Custom fit to each patient and disposed of after treatment for comfort and sanitation.

Figure 1: (A) Axial CT scan of a patient in the supine position, in which breast localization is difficult due to gravity. (B) The same patient in the prone position, which increases cardiac exposure and decreases radiation exposure.

Figure 4: (A) Scaled down BreastBot with fiber optic channels. Inner and outer walls are 250µm each. (B) Pneumatic actuation of one air channel on scaled down BreastBot around a phantom breast model. The thickness of the inner wall in direct contact with the breast is estimated to be <200µm with no observable pressure difference.

Figure 5: Time series of the internal pressure in an air channel on BreastBot. A pneumatic control system cyclically pumps air in and out of the air channel until it reaches a threshold pressure of 35 kPa, where the pressure is held for 750ms. Pneumatic actuation is achieved with pressures of 5-35 kPa, which can fit within the 10 kPa comfort limit.

Figure 6: For greater positioning control, multiple soft robots are benched on top of each other. A robotic control system and procedural need to be developed before testing on live patients.

III. Materials & Methods

The fabrication process starts with a 3D printed mold. The two precursor parts are degassed and degassed. The two precursor parts are degassed and degassed. The two precursor parts are degassed and degassed.

Figure 3: (A) Cross-sectional view of the air channel. The inner and outer walls are 250µm each. The cross-sectional view of the on the robot’s body.

Figure 2: (A) Axial CT scan of a patient in the supine position, in which breast localization is difficult due to gravity. (B) The same patient in the prone position, which increases cardiac exposure and decreases radiation exposure.

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Figure 4: (A) Scaled down BreastBot with four air channels. Inner and outer walls are 250µm each. (B) Pneumatic actuation of one air channel on scaled down BreastBot around a phantom breast model. The thickness of the inner wall in direct contact with the breast is estimated to be <200µm with no observable pressure difference.

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Figure 2: (A) Cross-sectional view of the air channel. The inner and outer walls are 250µm each. The cross-sectional view of the on the robot’s body.

The soft robot is now ready to be moved. Preciously, we would like to thank Professor Lihua Jin, Professor Ke Sheng, and Boliang Wu for all their guidance and support throughout the work. We also thank the UCLA and all the institutions that supported this work.
Object Tracking Using Event-Based Cameras and Gabor Filters

ABSTRACT

Event-Based cameras measure the timestamps of discrete changes in pixel intensity and therefore have higher temporal resolution and lower energy use than frame-based cameras. This makes them extremely useful for tracking objects moving extremely quickly, such as aircraft. Convolutional neural networks, which are typically used for frame-based object tracking, require too much computation and are too slow for event-based vision. Necessitating the development of specialized tracking algorithms. In this project, we use Gabor Filter convolution on event-based videos. Gabor Filters for detection of object speed and direction. Matching an object's predicted position in the next frame to its actual position in the next frame allows us to track it across multiple frames.

Project Objectives

- Write an algorithm that can track moving objects across a frame using Gabor Filters.
- Develop the algorithm, process and perform action on moving object tracking on an edge detection problem.

Results

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>MOTA</th>
<th>Precision</th>
<th>Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tracktor++</td>
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<tr>
<td>Tracktor</td>
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<td>0.80</td>
<td>0.60</td>
</tr>
</tbody>
</table>

Conclusion

Gabor Filters and event-based cameras are not meant to detect objects. Any bounding box created using our Gabor Filter object tracking pipeline is not meant to perfectly match the object's actual bounding box. Therefore, the MOTA values at the lowest Jaccard Index thresholds, 0.1, are most valuable to us.

References

[1] Voigtlaender, Paul & Krause, Michael & Osep, Aljosa & Luiten, Jonathon & Sekar, Berin & Geiger, Alexander. (2019). "Event-based Vision: A Survey." IEEE Transactions on Pattern Analysis and Machine Intelligence. [2] PETS09-S2L1 dataset of the public Multiple Object Tracking Challenge. The MOTS challenge intentionally includes objects getting close to each other and overlapping each other. Better at being able to track objects in more challenging situations is important for convolutional ML algorithms, our pipeline doesn't utilize machine learning and can't distinguish between overlapping objects. Event-based cameras are most useful for special scenes with very low motion. The MOTA value for our Gabor Filter tracking pipeline will be higher in a dataset that better matches its use case.
DEPARTMENT
Electrical and Computer Engineering

Developing Undulators For Compact and Lower Energy Free Electron Light Sources (FEL)

ABSTRACT
Free Electron Light Sources (FEL) create intense bursts of x-rays that are millions of a billionth of a second long, enabling unprecedented scientific discoveries: capturing the birth of chemical bonds, creating images of biological models, studying diseases, and much more. Access to FELs is limited, however, because there are few FELs in the world; current machines are very expensive (>$1B) and very long (>1km). This project aims to address both of these challenges, and thus increase access, by further developing short-period undulators. The undulator is composed of alternating magnetic fields that transversely accelerate an electron beam as it travels, which generates the x-rays. Shortening the undulator period lowers the required electron beam energy to obtain a given photon wavelength, which in turn reduces the length and cost of the electron accelerator. Conventional undulators used in XFELs have period lengths around 3 cm; we designed undulators with periods of 3 and 6 mm, which would result in an accelerating field length reduction of ~68%. Out of the three designs tested, simple, Halbach, and hybrid, the hybrid has the strongest field and also the highest likelihood of unacceptable field variation due to material inhomogeneities. To address this, we developed a novel method of shimming, or local magnetic field adjustment, that works within tight space constraints. Successful development of such strategies for short-period undulators has the potential to transform the field of light sources: democratizing access to discover the world on an atomic scale.
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Stereo Depth Mapping in YOLO

ABSTRACT
While object detection algorithms are able to accurately report the positions of objects in a scene, there is no sense of 3D space. In contrast, the human brain can create a sense of depth and absolute external space automatically. Current computer vision technologies rely on complex neural networks trained on massive data sets detect objects and navigate. Images are run through hundreds of processing layers, whereas the brain has far less layers and still produces better results. Instead, humans more simply navigate by using visual displacement in their surroundings as they move their eyes and heads to create depth sensations. Our experiments take the concepts of motion parallax and the object detection algorithm, “You Only Look Once” (YOLO), to create an absolute sense of 3D space. Tests were done on various hardware: a flying drone, a quad-camera apparatus, a 2-axis laser engraver, and a dual-camera robotic car. Our findings suggest creating 3D depth sensations from displaced 2D images is possible and could greatly contribute to the advancement of current navigation systems. While our methods prove to be effective, there appears to be underlying variables such as camera technicalities. Future areas of improvement include better algorithm optimization for distant objects to improve accuracy. Additionally, we would like to integrate our technologies into a virtual reality control and feedback system, creating a more immersive experience.

Objective
Design a program that processes 2D images and returns the depths of recognized objects

Materials and Methods

Hardware

EW Yolov3, Laser Engraver, 4 x 16MP cameras attached to Raspberry Pi, Raspberry Pi controlled robotic car, You Only Look Once (YOLO) object detection software

Writing the algorithm

YOLO is an object detection algorithm capable of processing 2D egocentric images at a minimum of 45 fps. With the use of neural networks, the program finds patterns in various regions used to create an absolute sense of depth and allocentric space. YOLO will take in two binocular images and create bounding boxes for each frame, extracting their full 3D coordinates of each object. Using this information, the program can triangulate to calculate the depth of objects in front of a camera. For each hardware setup, camera setup must be known to run accurate predictions.

Re-interpreting algorithm into code
Process images using various hardware

Results

The depth calculated by our algorithm is typically between 30 and 30 percent of the actual distance. While some accuracies are lower than expected, this is likely because the actual distance was lower than expected.

Conclusion
Though not as accurate as LiDAR, our stereo depth algorithm can be applied for a significantly cheaper price. Making it more accessible for a broader range of applications. We believe most of the error to come from poor depth estimation due to the stereo vision differences between the two images.

References


Acknowledgements

We would like to thank the National Science Foundation for funding our project through the UCR Summer Undergraduate Research Program. We would like to thank Professor Arisaka for his encouragement, knowledge, and support. We would like to thank Will Herrera and the SURP facilitators for their guidance throughout the research process.
ABSTRACT

Brain-computer interfaces (BCI) enable humans to control technology, such as prosthetic limbs and computer games, with thoughts. The highest performing BCIs on the market require brain implants that read signals from hundreds of individual neurons, a surgery that can be risky and unaffordable. Electroencephalography (EEG) is a non-invasive alternative used to detect neural activity from one’s scalp using a wearable cap that contains 64 electrodes. When a user imagines performing a physical movement, the electrodes record activity produced by populations of neurons firing in the sensorimotor cortex. We repeatedly trained an EEGNet convolutional neural network of producing an accurate output for a given input. To optimize this decoder, we designed and updated a game in which the cursor on a computer screen moves in a direction that corresponds to a specific thought. The user trains the cursor to move left, right, up, and down by imagining their left hand, right hand, tongue, and feet moving, respectively. To keep the cursor still, the user practices meditative rest by imagining their left hand, right hand, tongue, and feet moving, respectively. To keep the cursor still, the user practices meditative rest by imagining their left hand, right hand, tongue, and feet moving, respectively. To keep the cursor still, the user practices meditative rest by imagining their left hand, right hand, tongue, and feet moving, respectively.

Hypothesis: More training data will improve function parameters and increase validation accuracy to result in better BCI control.

Results from subject #1 reveal an upward trend in validation accuracy as the number of training days increased. The cause for the upward trend can be attributed to using corrective feedback of direction with the game displaying white cursor parameters.

Conclusion

Results from subject #1 reveal an upward trend in validation accuracy as the decoder is provided with increasing long-term closed loop data. The cause for this nonlinearity in validation accuracy is attributed to artifacts that were present from day to day. The cause for the upward trend can be attributed to using corrective feedback of direction with the game displaying white cursor parameters.

Future Directions

• Decoding imagination for 3-D task (robotic arm)
• Implementing other EEG models to improve performance

Acknowledgements

This research was funded by UCLA’s Fast Track to Success undergraduate fellowship in the Electrical and Computer Engineering Department. We would like to thank Will Herrera, Professor Jonathan Kao, Sangjoon Lee, and Johannes Lee for their leadership, guidance and encouragement in the research.

References

Intuitive Gestural Interfaces: Development of Intuitive input controls for complicated XR Engineering Environments.

ABSTRACT

When a designer wants to create a robot to achieve an objective, augmented reality (AR), where a user is embedded in a virtual world, has much promise due to the immersiveness of the designer computer interface and the lower overhead of computation for the creation. My research focuses on making better use of the capacity of communication from the user to the computer by interpreting more motions of the user’s hands, which allows the creator to be more expressive in the scope of robot objectives. I quantified hand gestures into three vectors: the positioning of skeletal points in the hand, the rotation of the palm, and the motion of the center point of the hand. Consulting a movement expert, we were able to create a few gestures that represented the objectives of robot creation. I developed an algorithm to interpret the vectors associated with those gestures to match them to the objectives. To facilitate this match, I developed a function partitioning the vector space to map to each objective. I executed gestures multiple times with slight variations and computed the bounds of the space to create this partition. With my implementation created by refining my algorithm, an engineer with design experience within a few minutes was able to perform interpretable gestures with very little instruction. This implementation will decrease the time to learn the inputs of the augmented reality and either increase the time available to develop more robots or get a final robot out quicker.
Stereo Depth Mapping in YOLO

ABSTRACT

While object detection algorithms are able to accurately report the positions of objects in a scene, there is no sense of 3D space. In contrast, the human brain can create a sense of depth and absolute external space automatically. Current computer vision technologies rely on complex neural networks trained on massive data sets detect objects and navigate. Images are run through hundreds of processing layers, whereas the brain has far less layers and still produces better results. Instead, humans more simply navigate by using visual displacement in their surroundings as they move their eyes and heads to create depth sensations. Our experiments take the concepts of motion parallax and the object detection algorithm, “You Only Look Once” (YOLO), to create an absolute sense of 3D space. Tests were done on various hardware: a flying drone, a quad-camera apparatus, a 2-axis laser engraver, and a dual-camera robotic car. Our findings suggest creating 3D depth sensations from displaced 2D images is possible and could greatly contribute to the advancement of current navigation systems. While our methods prove to be effective, there appears to be underlying variables such as camera technicalities. Future areas of improvement include better algorithm optimization for distant objects to improve accuracy. Additionally, we would like to integrate our technologies into a virtual reality control and feedback system, creating a more immersive experience.

Objective

Design a program that processes 2D images and returns the depths of recognized objects

Materials and Methods

Hardware

- DJI Tello Drone, Laser Engraver
- 4 x 16MP cameras attached to a raspberry Pi
- Raspberry Pi controlled robotic car, You Only Look Once (YOLO) object detection software

Writing the algorithm

We started our research with what we knew about motion parallax. We noticed that we could integrate this concept with triangulation. A rigorous model would allow you to calculate the location of an object by forming triangles to the point of origin from other known points. In this case, we knew points to find the location of an object would be the positions of our cameras.

Results

The depth calculated by our algorithm is typically between 30 and 35 percent of the actual distance. For our test cases, the greatest error percent occurred for close objects, with farther away objects receiving a higher error percent. The quadcams were the most accurate out of all of the used hardware and the robot car being the least accurate out of all the used hardware.

Re-interpret algorithm into code

Process images using various hardware

Conclusion

Through not as accurate as LiDAR, our stereo depth algorithm can be applied for a significantly cheaper price. Making it more accessible for a broader range of applications. We believe most of the error to come from pixel discrepancies with the YOLO algorithm between the two images.

Though not as accurate as LiDAR, our stereo depth algorithm can be applied for a significantly cheaper price. Making it more accessible for a broader range of applications. We believe most of the error to come from pixel discrepancies with the YOLO algorithm between the two images.

References


Acknowledgements

We would like to thank the National Science Foundation for funding our project through the UCLA Summer Undergraduate Research Program. We would like to thank UCLA Physics and Astronomy for their assistance, knowledge, and support. We would like to thank NIRvana and the NIRvana Facilities for their guidance throughout the research process.
Self Assembly of Perovskite Nanocrystals

ABSTRACT

With climate change on the rise and only so limited time to save the earth, sustainability is at the forefront of issues that we need to solve. A viable solution is converting to renewable energy especially solar power, however our current technology has many limitations that make it hard to harness these natural resources. Luminocent solar concentrators are one such device which concentrate sunlight and direct it to the solar cells. Though this technology has been around for a long time, LSC’s are inefficient because a significant amount of sunlight is lost due to isotropic light emissions from the LSC’s. Hence having anisotropic light emission from the solar concentrator plays a major role in determining the effectiveness of the LSC’s and solar cells. This project proposes an idea of orienting light emission (anisotropic) from the LSC’s by forming self-assembled 2-D and 1-D perovskites lattices. This was achieved by non dimensionalizing the formed 3-D perovskite nanocubes to 2-D nano wires or 1-D nanowires (shrinking the dimensionality of the structures would lead to less scattering of the sunlight) through solvent dependent interactions of surface passivating ligands and manipulating environmental conditions such as temperature. Self-assembled superlattices perovskite structures lead to uniform monodisperse layers and optically stable nanocrystals which is required for large scale applications.

Why Halide Perovskite Assemblies?

Halide perovskites have demonstrated extraordinary optical properties. Assembly into organized structures would make them ideal for high efficiency LEDs, quantum light sources (i.e. LED or a solar concentrator) and quantum confinement (i.e. optical properties). The self-assembly of nanocrystals can be achieved by (1) controlled evaporation (2) using air/liquid interfaces (3) solvent dependent normal conditions (4) centrifugation. 

Why Nanocrystals?

Nanocrystals are highly tunable and can be made in a variety of shapes and sizes. They enable stronger interactions of quantum confinement as the size of the nanocrystals decrease. They can exhibit absorption/emission based on their size.

Results

Precursors PbBr$_2$ and Cs$_2$CO$_3$ are injection into PbBr$_2$ solution. Cs$_2$OA is injection into PbBr$_2$ solution. The CsPbBr$_3$ nanowires are centrifuged. The CsPbBr$_3$ nanocubes are dried. The CsPbBr$_3$ nanowires are centrifuged. The CsPbBr$_3$ nanocubes are dried.

Conclusion: The Next Steps

The next steps are to perform other types of self assemblies to create larger range of shapes and angles. We hope to observe very bright and directional emission. We can use the quantum yield and angular emission to calculate how much of the solar spectrum that the nanocrystals are capturing. As a result, we hope to reach a higher efficiency for the LSC device.

References


Designing High-Rank Distance-Spectrum-Optimal CRC polynomials for High-Rate Convolutional Codes

ABSTRACT

5G technology has been enabled by recent advances in coding theory, such as polar codes. However, many applications remain out of reach. Without sufficiently low error-rate and low latency, a class of applications, dubbed “mission-critical” applications due to their strict error and latency requirements, remain out of reach of current wireless communication technology. However, much progress has been made to close this gap. One such area, list-decoding, is a subject of research at Professor Wesel’s Communications Systems Laboratory. It has already been shown that both high-rate and low-rate zero-terminated and tail-biting convolutional codes (ZTCCs and TBCCs) with cyclic-redundancy-check (CRC)-aided list decoding techniques closely approach the random-coding union (RCU) bound for short blocklengths. However, current program implementations have limited our ability to design high-rank CRCs in these papers. In our research, we use software engineering techniques to improve the performance of the current CRC search algorithm and mitigate an important memory-bandwidth bottleneck.

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5G technology has been enabled by recent advances in coding theory, such as polar codes. However, many applications remain out of reach. Without sufficiently low error-rate and low latency, a class of applications, dubbed “mission-critical” applications due to their strict error and latency requirements, remain out of reach of current wireless communication technology. However, much progress has been made to close this gap. One such area, list-decoding, is a subject of research at Professor Wesel’s Communications Systems Laboratory. It has already been shown that both high-rate and low-rate zero-terminated and tail-biting convolutional codes (ZTCCs and TBCCs) with cyclic-redundancy-check (CRC)-aided list decoding techniques closely approach the random-coding union (RCU) bound for short blocklengths. However, current program implementations have limited our ability to design high-rank CRCs in these papers. In our research, we use software engineering techniques to improve the performance of the current CRC search algorithm and mitigate an important memory-bandwidth bottleneck.

Conclusions

While we have seen that the behavior of the CRC polynomials seems to follow patterns across ZTCCs, it is still worth noting how these CRCs may be used within ZTCCs to follow the same trend. This would allow us to utilize CRCs to reduce the memory usage in the future. Future Work

For both cases, increasing CRC rank consistently reduces RCU gap and decoding complexity. If we can expect this benefit to carry-over to other codes, like tail-biting convolutional codes (TBCCs), the performance boost will be a significant one. Conclusions

The CRCs allow us to use a large subset of possible paths in the decoder, which in turn allows us to be more efficient. The CRCs allow us to divide the message into a CRC polynomial and to check for errors. The CRCs also allow us to use software engineering techniques to improve the performance of the current CRC search algorithm and mitigate an important memory-bandwidth bottleneck.

Mathematical Principles

CRCs can be modeled as polynomial functions within a binary Galois field $\mathbb{F}_2$. More precisely, they are modeled as $x^n + x + 1$ over $\mathbb{F}_2$. The message $M$ is divided into $n$ symbols, each symbol being a member of $\mathbb{F}_2$. The message is then encoded by appending a CRC check bit sequence to the end of the message. The result is then transmitted over the channel, where errors may be introduced. The receiver then uses the CRC to verify the integrity of the received message.

References


Future Work

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References

ABSTRACT

New methods of spacecraft propulsion have been continuously studied since the emergence of astrophysics in order to make space travel cheaper and faster, while still collecting data that teaches us more about the universe. Solar sails utilize the momentum of reflected photons to accelerate near the Sun. To effectively accelerate, it must be ultra lightweight and reflect as much light as possible. It should also be made of a material that withstands extreme temperatures close to the sun while passively cooling the spacecraft and that which carries it. This requires a low density material with a low solar absorptivity and high thermal emissivity. Coating an ultrathin metal such as titanium nitride with an inorganic substrate such as carbon or boron nitride nanotube combines the strength and reflectivity of the metal with the thermal emissivity of the substrate, allowing for a material that could make up a functional solar sail. Here I will overview our work on design and fabrication of such thin films. I will show that ~1 micron thick films can be fabricated by solution process methods and transferred onto various substrates for subsequent post processing.

Mission and Goals

Objectives

- Architect a thin film made of inorganic materials to be used as a substrate for solar sails.
- Prove that the films are acceptable solar sail materials by analyzing optical properties and verifying their ability to be transferred onto different substrates.
- Prove that the films can be made production and are low cost.
- Create a method of spacecraft propulsion that uses radiation pressure to achieve unprecedented speeds for deep space exploration.

Requirements

- The sail must be able to get close enough to the Sun to be accelerated to desired velocities, which requires materials with extremely high melting temperatures.
- Materials must withstand extreme temperatures that come with that proximity to the Sun.
- Materials must have enough strength and reflectivity such as metal such as titanium nitride with an inorganic substrate such as carbon or boron nitride nanotube.

Coating Material

Titanium Nitride (TiN)

- Close approach to the Sun is a local Refractory metals (circled in red) offer a small enough perihelion and allow for sufficient sail velocities, which requires materials with extremely high melting temperatures that come with that proximity to the Sun.
- Density is 4.5 g/cm³, lightweight enough to allow for sufficient sail acceleration.
- Refractory metal, strong and heat resistant.
- Requires support from a substrate for structural strength and thermal control.

Substrate Materials

Carbon Nanotube (CNT)

- Density of 2.4 g/cm³, lightweight enough to allow for sufficient sail acceleration.
- High reflectivity, high melting point in order to allow for sufficiently near perihelion of about 2-5 R.Sun.
- Nonrigid substrates are placed onto a 3-D printed PETG frame (lower right).

Results and Conclusions

- I would like to thank Artur Davoyan and Ho-Ting Tung for their continuous guidance on this project and their support.
- I would also like to thank the Vision grant and the National Undergraduate Research Program at UCLA for their ongoing funding.

References

Fracture Mechanics of Liquid Crystal Elastomers

ABSTRACT

Liquid Crystal Elastomers (LCEs) are a type of soft material combining flexible polymer network and rod-like liquid crystals (LCs) that can withstand higher strain than classical elastomers due to the reorientation of LCs. With more applications of LCEs starting to be realized, it will be crucial to understand the fracture mechanics of LCEs so future engineers would be able to prevent possible failures. The purpose of this research is to understand the fracture mechanics of LCEs by investigating the strain and displacement fields and the director rotation around a crack tip. To achieve strain and displacement measurements, we fabricated main-chain monodomain LCEs films with a small edge-crack, and stretched parallel, perpendicular and oblique to the initial director with different angles. The Digital Image Correlation (DIC) method through the Ncorr program on MATLAB was utilized to track the displacement and strain distribution in the LCE samples. The rotation of the director was measured using the optical polariscope method. In general, we found the directors around the crack tip field rotate to be tangential to the crack surface, and the directors at remote regions realigned to the stretching direction. The overall strain and displacement fields match with the simulation where displacement concentration around the crack tip shifts for the specimens with different initial directors. Future work on fatigue cycle and internal concentration around the crack tip shifts for the specimens with displacement fields match with the simulation where displacement regions realigned to the stretching direction. The overall strain and rotate to be tangential to the crack surface, and the directors at remote rotation of the director was measured using the optical polariscope (DIC) method through the Ncorr program on MATLAB was utilized to determine the displacement and strain field around a crack. The overall strain and rotate to be tangential to the crack surface, and the directors at remote rotation of the director was measured using the optical polariscope (DIC) method through the Ncorr program on MATLAB was utilized to determine the displacement and strain field around a crack.

BACKGROUND

LCs are composed of liquid crystal mesogens embedded within the polymer chains. Monodomain nematic elastomer (MNE) has one domain where all mesogens align in one direction. This direction refers to as the director and the Young’s modulus are different based on the angle, Young’s modulus are different based on the angle. This direction refers to as the director. Monodomain nematic elastomer (MNE) has one domain where all mesogens align in one direction. This direction refers to as the director where all mesogens align in one direction. This direction refers to as the director. 

MNE has anisotropic properties, that means the properties such as Young’s modulus are different based on the orientation of LCs.

REFERENCES


RESULTS

Fracture Mechanics of Liquid Crystal Elastomers

INTRODUCTION

Liquid Crystal Elastomers (LCEs) are a category of soft material combining flexible polymer network and rigid liquid crystals (LCs) that can withstand higher strain than traditional elastomers. LCEs can also be actuated in response to light and heat, which makes them useful in various applications. However, the problem is that the fracture mechanics of LCEs are not well studied.

OBJECTIVES

• Determine the displacement and strain field around a crack
• Observe that directors near the crack rotate to be tangential to the crack surface while directors in remote region tend to align with the tensile direction

METHODS AND MATERIALS

Fracture Mechanic of Liquid Crystal Elastomers

I would like to thank Professor Lihua Jin and my Daily Lab Supervisor, Chen Wei, for guidance through the project, and I would like to thank National Science Foundation for funding me to do the research with Summer Undergraduate Research Program at UCLA. I would like to thank Professor Lihua Jin and my Daily Lab Supervisor, Chen Wei, for guidance through the project, and I would like to thank National Science Foundation for funding me to do the research with Summer Undergraduate Research Program at UCLA.

Explored the director rotation in an edge-crack through the DIC analysis and noticed a high strain concentration around the crack tip. Noticeable high strain concentration at or near crack tip. Director near crack rotates to be tangential to crack surface for all orientations. Noticeable high strain concentration at or near crack tip independent of the boundary condition.

Explored the director rotation with the simulation. Director near crack rotates to be tangential to crack surface for all orientations. Noticeable high strain concentration at or near crack tip independent of the boundary condition.

Experimental results match with the simulation, proving underlying theory for fracture mechanics of LCEs.

Successfuly using DIC method to evaluate strain and displacement field and notice high strain concentration at the crack tip for samples of all different orientations.

To observe that directors near the crack rotate to be tangential to the crack surface while directors in remote region tend to align with the tensile direction.

1. Conduct uniaxial tensile test on Tensile Testing Machine (Instron 68SC) with crack length of 3 mm
2. Record the process through camera
3. Use Ncorr (MATLAB) to calculate the displacement and strain field

ACKNOWLEDGEMENTS

Fabrication: Two-stage thiol-acrylate Michael addition photopolymerization (SAMAP) Method

Fig 1. Structure of LCE

Fig 2. Fabrication Process for Monodomain LCE Samples

Fig 3. DIC recording setup on the crack testing machine

Fig 4. DIC Analysis Process

Fig 5. DIC recording setup on the crack testing machine

Fig 6. Vertical Displacement for 30° LCE Sample

Fig 7. Horizontal Displacement for 30° LCE Sample

Fig 8. Strain (Eyy) for 30° LCE Sample

Fig 9. Director Angle Field for 30° LCE Sample

Fig 10. Horizontal Displacement for 30° LCE Sample

Fig 11. Vertical Displacement for 30° LCE Sample

Predicting the strain distribution and director rotation field for samples with 0°, 30°, 45°, 60°, and 90°. Observe high-strain and director rotation independent of the sample as a result of boundary conditions.

Different strain, displacement, and director angle field for samples with 0°, 30°, 45°, 60°, and 90°. Observe high-strain and director rotation independent of the boundary conditions.

Fig. 8 Strain (Eyy) for 30° LCE Sample Fig. 9 Director Angle Field for 30° LCE Sample

Fig. 6 Vertical Displacement for 30° LCE Sample Fig. 7 Horizontal Displacement for 30° LCE Sample

Fig. 10 Horizontal Displacement for 30° LCE Sample Fig. 11 Vertical Displacement for 30° LCE Sample

Fig. 12 Strain (Eyy) for 45° LCE Sample Fig. 13 Horizontal Displacement for 45° LCE Sample

Fig. 14 Vertical Displacement for 45° LCE Sample Fig. 15 Director Angle Field for 45° LCE Sample

Fig. 16 Horizontal Displacement for 45° LCE Sample Fig. 17 Vertical Displacement for 45° LCE Sample

Fig. 18 Strain (Eyy) for 60° LCE Sample Fig. 19 Horizontal Displacement for 60° LCE Sample

Fig. 20 Vertical Displacement for 60° LCE Sample Fig. 21 Director Angle Field for 60° LCE Sample

Fig. 22 Horizontal Displacement for 60° LCE Sample Fig. 23 Vertical Displacement for 60° LCE Sample

Fig. 24 Strain (Eyy) for 90° LCE Sample Fig. 25 Horizontal Displacement for 90° LCE Sample

Fig. 26 Vertical Displacement for 90° LCE Sample Fig. 27 Director Angle Field for 90° LCE Sample

Fig. 28 Horizontal Displacement for 90° LCE Sample Fig. 29 Vertical Displacement for 90° LCE Sample

Fig. 30 Strain (Eyy) for 180° LCE Sample
ABSTRACT

We live in an era of technology and innovation where robots are taking inspiration from nature in order to solve complex problems. However, not everyone has access to these advancements due to the complexity of robot design and manufacturing. By introducing an inexpensive, streamlined, and simplified approach—cut-and-fold robots—we aim to increase the accessibility of bio-inspired robot creation. Our objective is to diversify the functionality of cut-and-fold robots by translating the natural ability of a three banded armadillo to enclose itself. I adapted a two-dimensional cut-and-fold template for an armadillo, which I then sent to a desktop paper cutter to ensure precise fabrication. Prototypes were fabricated using cardstock and thin plastic sheets since they are relatively inexpensive, easily deformable materials. I found that the cardstock better mimicked the rolling motion of an armadillo; the plastic sheets were too rigid. We wanted an easy way to roll and unroll the body, so we implemented a string system by sewing fishing line into its sides. When pulling the fishing line, we could transition the armadillo between its rolled and unrolled state. For future works we would like to explore additional bio-inspired mechanisms. Adapting bio-inspired designs to the cut-and-fold context will aid in making a larger variety of robotic functions more accessible to a general audience.
Comparison between control group of A7R5 smooth muscle cells for 4 hours with a magnetic field of 6 mT show some deformation of mitochondrial and actin structures. 12-well cell culture plates will be hosted within the Helmholtz Coils, and making sure they perform relatively close to our simulations. Finally, cell culture. After building the coils, we will test their efficiency, greater control over the way the magnetic field interacts with a given organism. We also aim to systematize and corroborate or refute the evidence found in previously published experiments. Towards that goal, we are first constructing our own 3-Axes Helmholtz Coils to have greater control over the way the magnetic field interacts with a given cell culture. After building the coils, we will test their efficiency, making sure they perform relatively close to our simulations. Finally, the instrument will be placed inside an incubator. Up to 4 standard 12-well cell culture plates will be hosted within the Helmholtz Coils, and we will observe any changes on them as a function of DC magnetic field strength and exposure times. Preliminary results done with a one-directional Helmholtz coil on Actin, Tubulin, and Mitochondria within smooth muscle cells for 4 hours with a magnetic field of 6 mT show some deformation of mitochondrial and actin structures.

**Introduction**

Quantum biology studies how quantum mechanics can be used to explain the findings of classical mechanics in biological systems. Many animals, such as robins, have magnetoreception, or the ability to detect the Earth’s magnetic field navigation during migration season. However, more research is needed to determine how magnetic fields interact with or affect smaller organisms at the cellular level. We seek to determine how weak magnetic fields are altering the physiology of various types of organisms in many different ways. For example, this is seen in animals that display magnetoreception, which is the ability to detect the Earth’s magnetic field navigation during migration season. We hypothesize that weak magnetic fields are able to alter physiological functions of living organisms.

**Objective**

- Construct a device that allows you to manipulate magnetic fields to varying degrees.
- Determine how weak static magnetic fields affect organisms.
- Corroborate and systematize the current knowledge on the effects of moderate SMFs on living organisms.

**Materials and Methods**

1. Designed and assembled 3-Axis Helmholtz coil out of an acrylic frame and 3D printed feet and a sample holder.
2. Used orthocyclic winding to wrap ~10,000 ft of 22 AWG wire around frame.
3. Created a Faraday Cage out of muntmetal and glyeosil to keep the coils in a room in order to remove any influence of external magnetic fields on the samples.
4. Tested points in the coils to determine the efficiency of the magnetic field compared to simulations.
5. Placed cell samples in coils for periods of time and measured any changes in structure.

**Results and Discussion**

In this preliminary study, using the Helmholtz coil in Figure 4, a similar arrangement shown in Figure 5. As a single axis Helmholtz coil done previously, the 3-Axis Helmholtz coil was being made just to start on the experiments to save time. Out of the 300 samples placed in the magnetic field, there were about 30 or so samples that seemed to be affected by the magnetic field (some of which are shown in Figure 4). These did not seem to be affected. There might have been a potential confounding variable, that being temperature as the wire increased in temperature as more current was passed through them. This could have potentially affected the cells. This could potentially be solved by adding a cooling mechanism in the coil system.

**Conclusion**

Through the experiments conducted, there seems to be some indication that weak magnetic fields alter some physiological functions or structures of cells when they are exposed for a certain period of time. The preliminary results show deformation of cell structure in the actin and mitochondria of smooth muscle cells. Because of the low number of affected cells out of all the batch, there is a possibility that this is due to the increase in temperature of the cells, which can affect the cells. Once the 3-Axis Helmholtz is fully built with the Faraday and possibly a different type of coil, such as a Helmholtz coil, we will be able to perform experiments to determine how weak magnetic fields may affect the cells.

**References and Acknowledgments**

- *Biological Effects of Moderate Static Magnetic Fields* by Mathew Irazabal, Abasalt Bahrami, and Professor Clarice Aiello
  - Department of Electrical and Computer Engineering - University of California, Los Angeles

An additional big thanks to Abasalt Bahrami for providing the images of the preliminary results.
Identification of Embedded Devices via Electromagnetic Emissions

ABSTRACT

Securely identifying an electronic device can be extremely difficult. The majority of current solutions, such as RFIDs or printed barcodes are either too expensive to realistically use at industrial scale, or too easy to spoof and therefore insecure. Due to these limitations, finding an alternative that fulfills both criteria is highly desirable. Electromagnetic emissions have been proven to be unique enough to identify individual devices from one another, and add no extra cost to device manufacturing. However, it has yet to be shown that it is possible to identify devices at extended ranges, especially when such devices do not have wireless transceivers. We show that by analyzing the emanations for common features across device types while still retaining individuality, it is still possible to recover enough data at range (>1 meter) to uniquely identify separate devices. Electromagnetic emissions from several development boards in various states (idle, running a simple program) were obtained using a USRP Software-Defined Radio and GNURadio. This data was then processed in MATLAB, then a machine learning classifier determines the device identification.

Data Analysis and Classification

Machine Learning Classifier

• Random Forest classifier
• Trained on either antenna or probe data collected over various days

Results

Antenna Model Accuracy: 94.8%

Probe Model Accuracy: 91.1%

Machine Learning Classifier

• Random Forest classifier
• Trained on either antenna or probe data collected over various days

Background and Goals

Background

• Electromagnetic Emissions (EME) are a byproduct of a device’s normal operation and are caused by unique variances in device to device.

EME have been used previously to identify devices, however only at extremely nearfield (<1 cm) using a probe to classify devices.

• We have found in previous work that the clock signal from a device is much stronger than other EME.

Research Goals

• Utilize features of the stronger clock signal to extend the range of identification.

• Enables more accurate identification using advanced machine learning algorithms.

Conclusion and Future Work

• At range, it is possible to identify a device using solely its EME with extremely strong accuracy.

• Additional data should be collected to form a more rigorous model and test in alternate environments.

• Future work could explore potential use cases for EME and a rigorous model and test in alternate environments.

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References

Compressing Convolutional Neural Networks on One-Dimensional Datasets via Weight Pool Networks

ABSTRACT

Convolutional neural networks are often used in a variety of classification and prediction models, most commonly in the field of image processing. However, as some of these neural networks become increasingly deep and complex, their requisite computational power and storage size may start to look unviable for resource-constrained devices. Compression techniques such as weight pooling serve to cluster neural network weights together and reduce the number of weights needed to be stored. We specifically used channel-wise weight pooling to allow for groupings on arbitrary 2D filter sizes while minimizing accuracy drop. As this approach has exhibited an adequately low drop in accuracy when run on an image dataset, we applied the same methods to one-dimensional datasets such as DeepSig’s RadioML dataset. Generating weight pools of size 64 allows for 7.6x compression while showing similar levels of accuracy compared to the original network.

Methodology

❖ Background

Conducted training on Speech Commands dataset using 4 convolutional layers

❖ Materials

Speech Commands audio dataset

❖ Objectives

➢ Many neural networks nowadays are too advanced for deployment on resource-constrained devices.

➢ We seek to achieve optimal compression of NNs with minimal accuracy drop in order to reduce requisite computing power or memory.

➢ We would like to minimize the amount of operations needed when running networks along the spatial dimension (channel-wise pooling) on datasets other than image datasets.

➢ Methodology

Conducted trials on Speech Commands dataset using 4 convolutional layers.

➢ We sought to achieve optimal accuracy drop when training on Speech Commands dataset using 4 convolutional layers.

➢ Conducted training on Speech Commands dataset using 4 convolutional layers.

➢ Training using 256 samples per batch.

➢ By stacking filters and pooling weights along the channel-dimension, we can represent each weight with an index to the weight pool’s center instead of storing several weight matrices for each filter.

➢ After 8 channel-wise pooling applying k-means clustering algorithm, there will be 32, 64, 128, or 256 pools of weights:

➢ Trained original neural network while mapping weights to a compressed neural network.

➢ RF dataset can be treated as a very long two-dimensional dataset due to parallelism allowing for operations on weights with their surrounding elements and a particular filter.

➢ Retraining original neural network while integrating weight pool clusters to regenerate a compressed neural network.

➢ Classification accuracy drop for RF dataset is negligible after compression and retraining.

❖ Results

➢ All neural networks were trained until average classification accuracy converged (between 100 and 200 epochs).

➢ Accuracy on both datasets converged at around 80% and remained roughly the same.

➢ Neural network or audio dataset was trained using varying sizes of weight pool sizes (ranging between 32 and 256 groups).

➢ Neural network or RF dataset was trained only using weight pool size of 64.

❖ Conclusions

➢ Classification accuracy drop for RF dataset is negligible after compression and increases in some cases (network trained on 200 epochs).

➢ Accuracy on speech commands classification is larger but still insufficient especially when trained with 64 pool clusters.

➢ Results show that weighting pooling allowed for compression of convolutional neural networks with satisfactory accuracy retention.

➢ Future progress can be found in combining channel-wise weight pooling with other compression techniques to improve accuracy or increase compression ratio.

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Optics research and applications often require accurate and precise measurements of the power, time-of-flight, or spectral content of a laser. Examples of this include lidar, spectroscopy or supercontinuum (SC) generation, a nonlinear optical process in which a short pulse laser experiences extreme spectral broadening after passing through a material. Current data acquisition systems for spectral measurements operate at an acquisition rate of around 1 Hz using a monochromator, photodetector, and oscilloscope. High speed data acquisition systems must be implemented to accurately measure the spectral content of lasers operating at a repetition rate of 1 kHz. We created a mock-up experimental setup with a variable pulse length 656.6 nm diode laser to focus on automating the spectral data collection process. Communication with the oscilloscope and monochromator was accomplished by Python code. We produced an acquisition rate of around 50 Hz, the maximum frequency before the oscilloscope collected repeated values. We tested the data acquisition framework by first mapping the maximum frequency before the oscilloscope collected repeated values. We produced an acquisition rate of around 50 Hz, which can be calculated by

\[
\text{kHz} = \frac{1}{t_{\text{pulse}}} \times \frac{1}{t_{\text{cycle}}}
\]

where \(t_{\text{pulse}}\) is the pulse length and \(t_{\text{cycle}}\) is the cycle time. We can determine the frequency of the data acquisition by dividing the pulse length by the cycle time. We can then use this frequency to control the acquisition rate of the oscilloscope. A 1 µs pulse and 10 Hz rate will produce an acquisition rate of around 50 Hz. This can be concluded by the instructional code sent by the computer to the oscilloscope. A 1 µs pulse will produce an acquisition rate of around 50 Hz. This can be concluded by the instructional code sent by the computer to the oscilloscope.

Automation of High-repetition Rate Spectral Measurement for Use in Research of Infrared Supercontinuum Generation

ABSTRACT

Optics research and applications often require accurate and precise measurements of the power, time-of-flight, or spectral content of a laser. Examples of this include lidar, spectroscopy or supercontinuum (SC) generation, a nonlinear optical process in which a short pulse laser experiences extreme spectral broadening after passing through a material. Current data acquisition systems for spectral measurements operate at an acquisition rate of around 1 Hz using a monochromator, photodetector, and oscilloscope. High speed data acquisition systems must be implemented to accurately measure the spectral content of lasers operating at a repetition rate of 1 kHz. We created a mock-up experimental setup with a variable pulse length 656.6 nm diode laser to focus on automating the spectral data collection process. Communication with the oscilloscope and monochromator was accomplished by Python code. We produced an acquisition rate of around 50 Hz, the maximum frequency before the oscilloscope collected repeated values. We tested the data acquisition framework by first mapping the maximum frequency before the oscilloscope collected repeated values. We produced an acquisition rate of around 50 Hz, which can be calculated by

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Windowed Cauchy Estimation for Multi-State Systems

ABSTRACT

Bayesian state estimators use both noisy measurement data and prior knowledge about the stochastic dynamics of a system to make an inference about the true value of the state. Since 1960, only one estimation scheme in which the dynamic generation of the conditional probability density function given the measurement history is recursive and analytic - the celebrated Kalman filter. A Kalman filter applies Bayesian estimation for linear dynamics over discrete time steps to estimate a state over time. However, the Kalman filter assumes the state to be a normal (Gaussian) distribution, a light tailed distribution, and thus is inadequate for systems with heavy-tailed noise, or those with higher probability of data distributed towards the tails of the probability density function. Thus, the analytic and recursive Cauchy estimator was developed basing the (modeled) process and measurement noises on the heavy-tailed Cauchy distribution. Because the amount of memory and computation required for the Cauchy estimator grows indefinitely with each discrete time step, a sliding window approximation was implemented to ensure an estimator with a fixed amount of computation and memory could be made at any given time step. This windowed Cauchy algorithm was tested on a nonlinear three-state model of a homing missile with radar measurement. When the algorithm was used to estimate the position, relative velocity, and target acceleration of the missile over time, it was found to significantly outperform the Kalman filter, even with smaller window sizes. Because larger window sizes require more computation and memory, different window sizes were tested against each other. Little significant decrease in estimation accuracy was measured at smaller window sizes, thus implying that the windowed Cauchy filter can practically be applied without excessive computational power. Future research will include testing the Cauchy estimator on different applications which are found to have heavy-tailed noise.
Intuitive Environmental Design in Virtual Reality for Robotic Simulation

ABSTRACT

The field of robotics needs simpler tools to create robots, especially for nonexperts, as the complete process is tedious and not user-friendly. A part of testing a robot is evaluating how it will physically interact with an environment through handling an obstacle or traversing certain terrain. With intuitive tools to design a robot's environment, robot creation becomes simpler. Virtual reality provides the best 3-dimensional visualization of real life, which makes for more intuitive design. Using virtual reality I created an easy-to-use tool that allows anyone to design a robotic environment. I developed a simple user interface that allows a user to design terrain 3-dimensionally. The design tool enables spawning, resizing, and placing multiple objects to form an environment that a robot may travel through. The tool extracts a numerical measurement of each object when resizing, allowing for scaled design necessary for practical robotic simulation. Overall, the tool simplifies environmental design and can help those who may not be well versed in robotics. With my simplified environmental design tool, future work involving structural design automation will allow nonexperts to create their own robots.

INTRODUCTION AND BACKGROUND

We need intuitive environmental design tools to simplify robotic design.

RESULTS

Movement: Teleportation based on where player is looking
Spawning Objects: 1. Empty World
Resize Objects: Slider used to resize width, length and height

Front side of objects
Back side of objects

2. Open Menu and Select Object
3. Spawn Object

Regular Spawned Cube
Resized Cube

MATERIALS

Oculus Quest 2
C++ / Blueprint
Unreal Engine 5

CONCLUSIONS AND FUTURE WORK

Current Applications: Freedom in designing environment and visualizing environment
Next Steps: Make structural robotic creation tool to use with environmental design to tool to help simplify robotic design

ACKNOWLEDGEMENTS AND REFERENCES

[References and acknowledgments]

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INTUITIVE ENVIRONMENTAL DESIGN TOOL IN VIRTUAL REALITY FOR ROBOTIC SIMULATION

Bilal Malik, Professor Ankur Mehta
The Laboratory for Embedded Machines and Ubiquitous Robots, Department of Electrical and Computer Engineering, University of California – Los Angeles

Goal: Create an easy-to-use environmental design tool that is intuitive and enables 3-dimensional visualization in virtual reality to simplify robotic simulation and design.
Measuring, Prediction, and Application of Pressure Profiles for Lithium-ion Batteries

ABSTRACT

In this project, we create a setup to measure the pressure profile of eight lithium-ion batteries simultaneously that can be charged at different rates. We then collect cycling and pressure data and use this data to train a machine learning model that can be used for prediction of pressure profiles. This work improves upon the slow constant current-constant voltage protocol needed to use this protocol for complete prevention of lithium plating. Pressure sensing can be used as a physical metric to detect and avoid lithium plating while charging faster.

Results

We were able to create a setup that allows us to measure multiple pressure profiles of cycling batteries simultaneously.

In Figures 3, we compare the prediction pressure profile predictions and are mostly perfect. But this is likely due to the fact that our data is very similar.

Figure 4, which is a plot of the area under the curve for different pressure profiles, shows the performance of our machine learning model compared to the software in loop PID control we are using now.

As shown in Figure 5, our early machine learning pressure profile predictions are nearly perfect, but this is likely due to the fact that our data is very similar.

Discussion and Conclusions

To meet our goals of increasing charging rate, we projected four main phases. In phase A, we setup hardware and collect data. In phase B, we use this data to train a machine learning model that can be used for prediction of pressure values. In phase C, we begin development of a PID control to increase charging speed.

Acknowledgements

I would like to thank Professor Li and my advisor for this opportunity and supporting me throughout the summer. I would also like to thank Professor Li for providing me with this opportunity and supporting me throughout the summer. I would like to thank Professor Li and my advisor for this opportunity and supporting me throughout the summer. I would also like to thank Professor Li for providing me with this opportunity and supporting me throughout the summer. I would like to thank Professor Li and my advisor for this opportunity and supporting me throughout the summer. I would also like to thank Professor Li for providing me with this opportunity and supporting me throughout the summer.

References

Design and Modeling of Application-Specific Caged Hinges

ABSTRACT

Compliant mechanisms are parts or systems of parts that flex and bend to achieve desired motions. They are often manufactured as a single piece, eliminating sliding and rubbing motions between separate components; this significantly reduces wear and friction. As a result, compliant mechanisms require less maintenance and can be designed to have a longer lifespan than dynamically-equivalent, rigid mechanisms. Additionally, compliant mechanisms are incredibly precise, and can maintain this high precision throughout their entire lifespan. Consequently, in fields where maintenance, lifespan, and precision are top priorities, compliant mechanisms may be superior to rigid, over-constrained alternatives. A caged hinge is a particular type of compliant mechanism that permits rotation about one axis via elastic deformation, while remaining strong in tension along that same axis. Caged hinges have applications in industrial robot arms, wind turbines, satellites, and medical devices. However, there is currently no analytical tool to assist in the design of application-specific caged hinges. In this work, we present a model for predicting maximum stress and stiffness.

Our mathematical models have less than a 5% error compared to FEA results. Future work will include optimizing the caged hinge geometry to minimize maximum stress or stiffness. We define 5 geometric parameters for the caged hinge and apply 2 types of loads. We generate a range of model geometries in SolidWorks. Generate Caged Hinge Configurations.

Figure 1: A) Two views of caged hinge. B) Rotated at 20°.

Figure 2: Objective 1: Build Models. Some of the information throughout the text is demonstrated in Figure 2.

Materials and Methods

We define 5 geometrical parameters for the caged hinge and apply 2 types of loads. We generate a range of model geometries in SolidWorks.

Figure 3: Define 5 geometrical parameters for the caged hinge and apply 2 types of loads. We generate a range of model geometries in SolidWorks.

Perform Finite Element Analysis

We perform linear-regression element analysis (FEA) in ABAQUS on 65 mechanisms of different geometries, under varying loads. We then used linear-regression gradient-descent optimizations and simple neural networks to construct a multi-step model. Our model predicts maximum stress within a margin of error of 5% compared to FEA results. Future work includes validating stiffness values and using our model to determine the optimal caged hinge geometry for various prosthetics applications.

Figure 4: A) Building models in MATLAB with extracted FEA data by A. B) Training a neural network to synthesize optimal caged hinges for different geometries, under varying loads. We then used linear-regression gradient-descent optimizations and simple neural networks to construct a multi-step model. Our model predicts maximum stress within a margin of error of 5% compared to FEA results. Future work includes validating stiffness values and using our model to determine the optimal caged hinge geometry for various prosthetics applications.
A communication system, which consists of a transmitter and a receiver, models the process by which the information is sent and received. The transmitted symbols that are generated by a transmitter go through a noisy channel and reach the receiver end. The receiver needs to estimate the transmitted symbols by their noisy version. Claude Shannon developed a theory that determines the maximum rate at which the receiver can reliably estimate the transmitted symbols based on the noisy statistics. To achieve the maximum rate, the transmitted signals need to approximately follow an optimal probability distribution, which can be done through probabilistic shaping. One method for probabilistic shaping is using a distribution matcher that takes a sequence of bits equally likely to be ones and zeros and maps it bijectively to a new sequence of symbols with the desired probability distribution. There are two types of distribution matchers denoted as constant and multi-composition distribution matchers or CCDMs and MCDMs. We coded a CCDM and a MCDM, which is denoted as constant and multi-composition distribution matchers or probability distribution. There are two types of distribution matchers that takes a sequence of bits equally likely to be ones and zeros and maps it bijectively to a new sequence of symbols with the desired probability distribution. There are two types of distribution matchers denoted as constant and multi-composition distribution matchers or CCDMs and MCDMs. We coded a CCDM and a MCDM, which is a union of CCDMs. Two different versions of the MCDM based on a high probability and typical set rule were constructed. We found that MCDMs outperformed CCDMs in both normalized Kuftkab-Leiber (KL) divergence, a measure of how well the desired probability distribution is met, and matching rate, meaning we can send more information using less bits. By applying MCDMs to channels, we can achieve higher transmission rates and better noise correction to increase the efficiency and speed of the internet and communication systems around the world.
Proactive Signal Strength Prediction using a 2D Deep Learning Model

ABSTRACT

An essential tool to furthering dynamic spectrum sharing, which allocates spectrum based on user demand, is knowing the signal strength on particular frequencies and at locations, allowing optimized base station placement for efficient use of the spectrum between many devices in an area. Given the location of existing fixed transmitters and the locations and signal strength of their respective receivers, our goal is to find the signal strength at any point in an area of interest due to a transmitter at any location, but without any active transmission from the transmitter. The path loss model, employing a least squares linear regression, is a traditional method for this problem; however, finding the signal strength in an urban area, because of building obstacles, has a complex pattern of loss, so we attempt to predict that strength through a deep learning model. Specifically, we use a 2D format to feed in as matrices, which is a 2D format, to give the model spatial context.

Previous efforts have used the path loss model: $P_t = P_0 - 10 \log_{10}(d^2)$, where $P_t$ is the signal strength at the receiver, $P_0$ is the signal strength at the transmitter, and $d$ is the distance from transmitter to receiver. However, in varying the transmitters, there is a significant drop in error. After that, the negligible increase in accuracy comes with a significant increase in training computation time.

For both figures, the model was trained for 120 epochs and averaged for 5 runs. Sensors are not static, so spatial interpolation is not used, and we are dependent on the model being well-generalized for values at any location. The U-NET model has, at most, 3 dB lower mean absolute error than the path loss model.

A larger number of receivers is more detrimental to the model’s accuracy than a few number of transmitters. However, in varying the transmitters, there is an optimal number around 40, where there is a significant drop in error. After that, the negligible increase in accuracy comes with a significant increase in training computation time.

The model is tuned mostly through changing the number of receivers sampled per transmitter, transmitters used for training, and epochs.

Conclusions & Prospects

Improving the model:

We can evaluate performance when information of building locations 12 is incorporated in the model as another input.

More, and accurate, training data:

(1) Crowdsourcing signal strength from sensors of existing communication systems

(2) Collecting data through software-defined radios

Significance of predicting signal strength based on dynamic spectrum sharing, by helping the placement of future base stations such that spectrum can be more efficiently allocated to many devices.

Reference

Phonon Modes and Raman Signatures of MnBiTe Magnetic Topological Heterostructure

ABSTRACT

The intersection of magnetism and topological electronic structure in momentum space has gained great interest in the field of condensed matter physics and quantum electronics. There has been great effort in observing magnetic ordering within 2D and quasi-2D materials since their discovery. Novel phenomena such as the anomalous quantum Hall effect, Weyl Fermions and axion insulator phases can be realized in such systems, only that it has proven difficult to engineer well controlled doping concentrations over large areas. MnBi2Te4 and its family MnBi2nTe3n+1 overcome these difficulties as it is easily synthesized into uniform bulk single crystals. Using a laser, photons are directed onto the MnBi2Te4 sample to have its back scattered photons collected and sorted by wavelength within a spectrometer. A charge couple device then detects the number of photons, or intensity, per wavelength to provide a unique signature of the molecule. The Raman signatures of MnBi2Te4 demonstrate the E modes at 27 cm⁻¹, with the newly observed E mode peak measured at 27 cm⁻¹. A 1D scan of the MnBi2Te4 is performed on silicon substrate using a motorized stage to provide a gradient of each material’s intensity across the sample’s surface. With this enhancement of the Raman spectrum to MBT-124, the pronounced change in the vibrational modes will provide a new scope in observing its magnetic ordering when subjected to a range of cryogenic temperature and magnetic field variances.
Revealing Effects of Physiological Stimuli on Neuroepithelial Development in Forebrain Organoids

ABSTRACT

Human brain organoid models create unprecedented opportunities for study of neurological diseases and early neurologic development. Unfortunately, such a promising system often exhibits impaired growth and suboptimal structure in traditional culture due to the insufficient diffusion of oxygen and nutrients within organoids. To improve solute transport and supply, many engineering tools including hyperoxic incubation and fluidic flow have been routinely incorporated in organoid culture. While these physiological stimuli are known to play an equally important role as their chemical counterparts (e.g., growth factors), their impacts on organoid development are relatively undefined. As a result, effectively engineering the culture microenvironment to optimize organoid differentiation remains challenging.

Materials & Methods

We investigated the individual and combined impacts of flow and hyperoxia, two essential solute transport enhancement tools, by culturing forebrain organoids either in static wells or in our unique culture device in both normoxic and hyperoxic environments. The samples were collected at various time points for various characterizations. Compared to the static normoxic control, we found that organoids cultured in flow and hyperoxia had a significant increase in size and neural architecture, with the maximal benefit imparted by both stimuli together (i.e., flow + hyperoxia). We observed that flow led to an enhanced growth of the cortical plate region due to increased mechanotransduction on cells in the periphery, causing the enhanced layer growth.

Cortical plate growth is enhanced by flow. Flow and hyperoxia have additive effects on enhancing organoid growth. These results suggest that the mechanisms by which flow and hyperoxia operate to enhance organoid growth are separate, allowing for additive benefits when performed in combination. Unique metabolic profiles are generated in each condition. When a metabolism assay was run, organoids in all condition consumed similar metabolites, but the level at which they consumed each metabolite was different. Flow and hyperoxia independently shifted the metabolic phenotype to show an increased consumption of several more metabolites than static normoxia, while the flow hyperoxia condition had many more significantly consummed metabolites, displaying a more diversified consumption profile.

Conclusions & Future Directions

We also saw that flow and hyperoxia induced a metabolic change on the organoids, changing the diversity of consumed metabolites. The shifted profiles demonstrated low flow and hyperoxia may cause an up-regulation of other metabolic pathways, increasing organoid growth. Our results suggest that flow and hyperoxia culture produce structurally improved organoids, suggesting the importance of modulating environmental stimulation in organoid differentiation.

References

4. I want to thank my PI Neil Lin along with my graduate student colleagues Nathan Cai, Kathryn Saxton, and Marie Payne. I also want to thank my fellow lab members Marie Payne and Kathryn Saxton.

Acknowledgements
Implementation of AR4JA LDPC Encoding and Decoding Using min*-Algorithm

**ABSTRACT**

Low Density Parity Check (LDPC) codes are linear block codes with high throughput and error-correction capabilities, making them relevant for transmission of information over constrained or noisy transmission channels. Iterative message passing algorithms are used to decode LDPC codes passed between variable nodes corresponding to the received channel bits and check nodes. While Sum-Product Algorithm (SPA) achieves high decoding performance at the expense of high computational complexity, reduced complexity decoding algorithms such as Min-Sum Algorithm (MSA) meanwhile can suffer decoding performance degradation as a tradeoff for simplified computation of outgoing check node messages. By implementing a modified MSA with correction term, also known as min*-algorithm, in a LDPC decoder on both software and hardware, we seek to demonstrate improved decoding performance over MSA with approach performance close to that of SPA.

**Methodology**

An LDPC code of bit length length can be thought of as containing a table of relevant message information, n = k bits of parity check bits, LDPC Code is decoded using iterative message passing algorithm between the variable nodes, which correspond to individual bits of received channel codes, and the k number of check nodes which compute updated LLR's to each of their respective connected variable nodes. The iterative algorithm can be outlined as follows [2]:

1. Initialization variable node (VN) LLR's (Log Likelihood Ratio), more negative = 1, more positive = 0.

2. Check nodes (CN) accumulate incoming LLR's from each VN and calculate outgoing messages for each CN to connected VN's and calculate an updated CN to VN messages.

3. Each VN, if 1, 0, ... calculates its updated total LLR, which is then used to determine whether a tentatively decoded bit at a certain VN is either 0 or 1.

4. Hard decision performed on whether parity check 0-syndrome condition is satisfied.

5. Stopped, Stop iterative passing protocol. Stop if satisfied or maximum number of allowed iterations reached.

**Implementation of AR4JA LDPC Encoding and Decoding Using min*-Algorithm**

**Introduction**

Low-Density Parity Check (LDPC) codes are linear block codes with high throughput and error-correction capabilities, making them useful for transmission of information over constrained or noisy transmission channels, particularly prominent in emerging communications schemes such as 5G NR [1]. Iterative message passing algorithms are used to decode LDPC codes passed between variable nodes corresponding to the received channel bits and check nodes. Sum-Product Algorithm (SPA) achieves high decoding performance at the expense of high computational complexity, while reduced complexity decoding algorithms such as Min-Sum Algorithm (MSA) meanwhile can suffer decoding performance degradation as a tradeoff for simplified computation of outgoing check node messages. By implementing a modified MSA with correction term, also known as min*-algorithm, in a LDPC decoder on both software and hardware, we seek to demonstrate improved decoding performance over MSA with approach performance close to that of SPA.

**LDPC Iterative Decoding Algorithm**

An LDPC code of bit length length can be thought of as containing a table of relevant message information, n = k bits of parity check bits, LDPC Code is decoded using iterative message passing algorithm between the variable nodes, which correspond to individual bits of received channel codes, and the k number of check nodes which compute updated LLR to each of their respective connected variable nodes. The iterative algorithm can be outlined as follows [2]:

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4. Hard decision performed on whether parity check 0-syndrome condition is satisfied.

5. Stopped, Stop iterative passing protocol. Stop if satisfied or maximum number of allowed iterations reached.

**References**


[4] All material from this paper is intended to be used as a supplement to the SPA decoding.

**Methodology (continued)**

As shown in Fig. 2, the min*-implementation of the decoder demonstrates a clear improvement in decoding performance over standard min-sum decoding. The BER for the min*-decoder is consistently lower and decaying more rapidly than the min-sum decoder over the tested SNR-range. We would like to thank Dean Wesel for his guidance and leadership throughout the research process. This research was supported by NSF grants CCF-1116611 and CCF-2039699 through the Summer Undergraduate Research Program at the UCLA Electrical and Computer Engineering Department. Finally, we would like to thank Prof. Lihong Wang, and Cike Qi Tand for their assistance with the technical aspects of our project.
End-to-End Design Process for Cut-and-Fold Modular Robots

**ABSTRACT**

Robot development is a challenging and resource-consuming process requiring the integration of mechanical, electronic, and computational subsystems. In addition, many iterations of designing and testing are required to customize robotic technology to fit individual needs. Our goal is to increase accessibility and streamline the robot development process by using a modular approach to assembly. This would aid introductory-level roboticists in producing simple designs while requiring the integration of mechanical, electronic, and computational components that are relevant to ground locomotion. This database of parts enables designers to realize new robot designs which can be paired with electronics and software to simulate different types of ground locomotion such as rolling, crawling, and walking. We use Robot Compiler (RoCo), a framework for visualizing and generating cut-and-fold robots whose mechanical parts are fabricated as flat sheets of material that can be easily folded into a prescribed 3D form. We compiled a library of modular robotic parts that are relevant to ground locomotion. Our research provides a rapid process that allows users to create a wide variety of simple ground locomotion robots.

**Background**

- Robot development is a challenging and resource-consuming process.
- Requires extensive knowledge and many iterations of designing and testing to customize robotic technology.
- Research Goals:
  - Create library of robotic components that users can select from to create a wide variety of simple ground locomotion robots.

**Key Terms**

- Cut and Fold Robots — mechanical parts fabricated as flat sheets and folded into their 3D form
- Robot Compiler (RoCo) — LEMUR's framework for generating cut-and-fold-robots

**Materials**

- **RoCo Library**
  - Arduino IDE
  - Arduino IDE
- **Design Software**
  - Silhouette Studio
  - Inkscape
- **Laser Cutter**
  - Cameo
  - PET and cardstock
- **Arduino IDE**
  - Jumper wires
  - Servo motors
- **Electronics**
  - Microcontroller

**Discussion**

- **Capabilities**
  - Load-carrying and stability
  - Crawling, walking, and rolling motions
- **Limitations**
  - Thin material weight efficiency
  - Complexity and scale of designs
  - Unstable connections

**References**


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I would like to thank Professor Mehta and the LEMUR Lab as well as the Samueli Engineering Summer Undergraduate Research Program and the Fast Track Program for this research opportunity, and the support and resources throughout this process. I would also like to thank the Office of Naval Research for funding this project.

**STEP 1**

- Select components from library
- Fabricate cutouts and gather electronics
- Fold sheets into intended 3D form
- Connect electronics and attach components

**STEP 2**

- Code shapes
- Measure cutouts and slots
- Scale designs

**STEP 3**

- Fabrication
  - Cut
  - Fold
  - Validate
Utilizing PathFX to Anayze Drug-Gene Associations in Diabetes and Lung Cancer

Anjali Sivanandan, Professor Jennifer Wilson
Department of Bioengineering, University of California – Los Angeles

ABSTRACT

Protein-Protein Interaction (PPI) network methods are an increasingly popular way to predict drug downstream effects. For example, PathFX is a novel algorithm that uses PPI network methods to identify drug pathway associations and drug-related phenotypes. However, these algorithms often predict more drug effects than evidence supports. These predictions can be tested by conducting observational studies in the Electronic Health Record (EHR). However, instead of testing each individual drug-disease prediction in the EHR, it is more practical to test groups of drugs based on shared gene pathways. This study will focus on the specific disease areas of diabetes and lung cancer to illustrate how PathFX can be used to analyze drug-gene and drug-disease associations to identify hypotheses for shared drug-gene pathways. We analyzed PathFX networks for drugs used to treat diabetes and lung cancer. We analyzed the frequency of shared genes and shared phenotypes, and used downstream proteins to cluster treatments drugs. We identified 44 and 34 drugs for diabetes and lung cancer respectively, and found drug network clusters are distinct across cancer pathways had distinct functional categories. We hypothesize that we will be able to distinguish clinical and non-clinical drugs by their downstream pathways and provide a means to reduce PathFX over-prediction. We will later use observational studies in the EHR to test the utility of network-identified clusters and expand this analysis to other disease areas.

Figure 1. Drug clusters are formed based on ATC classification. Drugs are grouped into 5 main disease areas: diabetes, lung cancer, cancer, obesity, and gastroenterology. (a) Diabetes drugs are clustered by all genes from the PathFX known effect pathways. (b) Lung cancer drugs are clustered by all genes from the PathFX known effects pathways.

Figure 2. PathFX predicted drug-gene associations. Figure 3. (a) Diabetes drugs are clustered by all genes from the PathFX known effect pathways. (b) Lung cancer drugs are clustered by all genes from the PathFX known effect pathways.

Figure 2. PathFX predicted drug-gene associations. Wilson et al., Bioinformatics, 2019.

Figure 3. (a) Diabetes drugs are clustered by all genes from the PathFX known effect pathways. (b) Lung cancer drugs are clustered by all genes from the PathFX known effect pathways.

Conclusion

Certain genes are more prominent than others, pointing to hypotheses for drug groups based on gene pathways. ATC drug classification does not necessarily match up with drug clustering based on gene pathway. GO enrichment was used to discover functions associated with network patterns. It was found that both the diabetes and lung cancer pathways had distinct functional categories.

References


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Special thanks to Dr. Jennifer Wilson, the Lab for the Understanding of Network Effects @ UCLA, the UCLA Department of Bioengineering, the Samuel Research Scholars Institute, and the UCLA Summer Undergraduate Research Program.
ABSTRACT

X-ray free-electron lasers (XFELs) produce short, high-energy pulses of X-ray radiation by wigging a beam of relativistic electrons through a magnetic array called an undulator. While these distinctly powerful X-ray pulses enable unprecedented research in a broad range of fields, XFELs are large, cost billions of dollars, and are only able to serve a few experiments at time, resulting in severely limited facility access. So-called “short-period” undulators have the potential to reduce the cost and size of an XFEL; however, these tend to be drastically less efficient than undulators with longer periods. One way to target this inefficiency is by focusing the electron beam as it passes through the undulator. This increases the efficiency of the FEL process, leading to a shorter overall undulator length and higher photon beam power, but previous techniques employing permanent magnets are not tunable and difficult to manufacture and align. We propose using copper current sheets instead, which are both tunable and simple to install. In this experiment, we investigate the practicality of this design through simulation and modeling. Our results illustrate the optimum width of current sheet at 4.75 mm for our chosen gap height of 2.5 mm, creating a “good field” region 2.4 mm wide while maintaining a gradient of 0.25 T/m at a small current density of 1.92 e7 A/m2. The gradient could reasonably be increased by two or three orders of magnitude with larger currents, commensurate with desired gradient levels in upcoming FELs.

Current Sheet Quadrupole Focusing for Short-Period Undulators

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Department of Computer and Electrical Engineering, University of California – Los Angeles

ACKNOWLEDGMENTS

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FUTURE WORK

In this experiment, we demonstrated the possibility of implementing strong focusing using copper current sheets in small-gap undulators. This focusing could improve the efficiency of compact electron accelerators by reducing the required electron beam and therefore good focusing strength. In future work, it may be possible to reduce the electron beam size and therefore good focusing strength. This could improve the efficiency of compact electron accelerators by reducing the required electron beam and therefore good focusing strength.
GroundSight: Floor-Sensing Shoe Wearable for Inferring User Location

ABSTRACT

Real-time location systems (RTLS) are increasingly being used in healthcare and warehouse facilities to monitor the activity of people and equipment. Unlike global positioning, RTLS are a type of local positioning system used for localization within a closed area. Most RTLS use large networks of transmitters and receivers, which can be very expensive to implement. The large overhead and cost make these systems inaccessible to users and smaller facilities with low budgets. Current RTLS solutions also raise privacy concerns with their constant tracking with an emphasis on user privacy.

How to improve localization

• Using a smart wearable to determine position fully on-device without any external support
• Enables low-cost systems and user autonomy

Drawbacks of current solutions

• Lack of affordable and secure user localization methods
• Position tracking and inference tasks should be fully performed by the user without any external support
• Inferred step-detection through low-pass filtering
• Motion-based interrupt

GroundSight: A smart wearable to determine position fully on-device without any external support

Using a smart shoe to determine position fully on-device without any external support enables low-cost systems and user autonomy.

Conclusion

• Inferential step detection through low-pass filtering can be difficult to implement due to noisy issues.
• Classifying floor materials is a viable alternative for low-cost and secure indoor localization.

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3D Printed Liquid Crystal Elastomers

ABSTRACT

Liquid crystal elastomers (LCEs) are soft stimuli-responsive materials that contract along the orientation of the mesogen, called director, upon heating due to a transition from the nematic to isotropic phase. LCE structures can be utilized for applications requiring remote actuation, cyclic actuation and miniaturization. Direct Ink Writing 3D printing allows fabrication of LCE structures with variable spatial orientation and order parameter due to the shear forces acting during the extrusion process. Literature contains various simple 2D LCE structures, such as spiral and radial alignments in disks, which exhibit intriguing shape-morphing capabilities. However, an understanding of complex LCE orientations is yet to be achieved to get extreme shape morphing, snapping and locomotion. In this study, we design structures with complex print patterns by developing custom G-Codes. We prepare a standard LCE ink by mixing the mesogen, RM-82, cross-linker, n-Butylamine, and a photoinitiator, HHMP, and oligomerizing the mixture at high temperatures. To reduce the temperature-dependent viscosity of the ink during printing, we fabricate an in-house syringe heater that uniformly heats the syringe and reduces temperature-dependent viscosity of LCE ink. Higher printing velocities and pressures result in greater shear forces, causing higher actuation shrinkage. We also found that the shrinkage increases with the actuation temperature. More complex shapes such as a disk with spiral print pattern were printed, which actuates from a planar disc to a 3D cone, due to circumferential shrinking and radial expansion. We also computationally simulated bilayer structures that can snap to a new configuration and instantly release energy in this process.
Fingerprinting RF Devices

ABSTRACT

Common methods of radio frequency (RF) device authentication, such as RFID tags, cost time or energy. An ideal authentication scheme identifies transmitters from data collected in situ. We investigate such a scheme here. Due to hardware imperfections, identically manufactured RF devices transmit slightly different signals. We attempt to extract this discrepancy for use as a fingerprint. A dataset was created consisting of data collected from seven transmitters sending WLAN packets to one receiver. Since wireless channels can distort these transmitter fingerprints, we also introduced the effects of seven different channels on the signals. The received short and long training fields were extracted and used as input to train a neural network to classify the transmitters and evaluate the effect on accuracy of the channels. Further work may be aimed towards eliminating channel distortion.

REFERENCES


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Characterization of a Radiative Emitter

ABSTRACT

Materials that passively cool themselves are of particular interest in our society, particularly with the rise of climate change. Since air conditioning actively requires energy to operate and no process is 100% efficient, air conditioning temporarily cools an internal environment at the expense of the world at large. As such, alternative cooling methods are needed that are less energy-intensive. Prior research has demonstrated that materials can be engineered such that cooling methods are needed that are less energy-intensive. Prior research has demonstrated that materials can be engineered such that they experience a net loss of heat to the cold of space. However, this effect requires a clear view of the sky and minimal view of the ground, conditions rarely met in urban environments. In this experiment, we characterized a directional emitter designed to exhibit high emittance in conditions rarely met in urban environments.

INTRODUCTION

By reflecting both sunlight and terrestrial heat, a directional emitter can cool itself when an omnidirectional emitter on a building may absorb more light than it emits. By reflecting both sunlight and terrestrial heat, a directional emitter can cool itself when an omnidirectional emitter on a building may absorb more light than it emits. An object can cool itself by radiating more heat than it absorbs. Typical, omnidirectional emitters, absorb and emit all wavelengths of light. In a hot environment, an omnidirectional emitter on a building may absorb more light than it emits.

THEORY

An object can cool itself by radiating more heat than it absorbs. Typical, omnidirectional emitters, absorb and emit all wavelengths of light. In a hot environment, an omnidirectional emitter on a building may absorb more light than it emits. By reflecting both sunlight and terrestrial heat, a directional emitter can cool itself when an omnidirectional emitter would get hot.

BACKGROUND

Motivation

Climate-change-induced temperature increases will result in greater demand for air conditioning. As conditioning (AC) itself is an unsustainable method of cooling that merely moves heat from inside to outside, a better alternative to AC is needed. Here we test an alternative to traditional AC that operates off of radiative effects. The design uses simple geometric principles and additive manufacturing to create a material with directionally-tuned optical properties.

MATERIALS

Broadband Emitter

Directional Emitter

Phase Two: A large-scale test was then done pitting the Broadband Emitter against a Broadband Emitter. From our phase one data, we find that the Directional Emitter radiates as a function of angle of incident light, plateauing as the angle increases. This should that our idea has promise.

Methodology

Phase One: Using a thermal camera, we took pictures of our sample at various angles. From the thermal data from the pictures, we then calculated the emittance of our Directional Emitter. Phase Two: A large-scale test was then done pitting the Directional Emitter against a Broadband Emitter.

ANALYSIS

From our phase one data, we find that the Directional Emitter radiates as a function of angle of incident light, plateauing as the angle increases. This should that our idea has promise.

Iterating upon this, we proceeded to phase two: large-scale tests. The results of which are seen in Figure 3.

Figure 3: Baseline data from the large-scale setup. Figure 2 of our Broadband Emitter (BE, Blue) is bare to the sky (solid line to the left), whereas the Directional Emitter (DE, Green) is facing the instrument. The Broadband Emitter (BE, blue) was facing the sky for the entire hour-long duration of the test.

DISCUSSION

Phase One: Our data indicated a notable dependence of the emissivity of our sample as a function of azimuthal angle. With higher angles of incidence correlating with greater emissivity, we have also shown that the structure of the directional emitter can be altered to change the angular emissivity.

Future Steps:

From our data from phase two, it is clear that our directional emitter can perform better than a broadband emitter in terms of cooling by 1.3 degrees Celsius. From Figure 3, it is clear that our directional emitter can perform better than a broadband emitter in terms of cooling by 1.3 degrees Celsius. Our data indicated a notable dependence of the emissivity of our sample as a function of azimuthal angle. With higher angles of incidence correlating with greater emissivity, we have also shown that the structure of the directional emitter can be altered to change the angular emissivity.

From our data from phase two, it is clear that our directional emitter can perform better than a broadband emitter in terms of cooling by 1.3 degrees Celsius. From Figure 3, it is clear that our directional emitter can perform better than a broadband emitter in terms of cooling by 1.3 degrees Celsius.

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Adhesion Characterization of Hydrogels For Wound Dressing

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Hydrogels are three-dimensional polymer networks that are crosslinked using various chemical or physical crosslinkers and are attractive candidates for medical applications such as wound dressing and tissue engineering. Gelatin methacryloyl (GelMA) is a widely studied hydrogel for tissue engineering due to its similarity to native extracellular matrices. Methacrylate modification of gelatin allows this hydrogel to be covalently crosslinked upon exposure to ultraviolet light. However, this application has been limited due to its low mechanical strength before crosslinking, leading to undesired flows on wet surfaces. We propose to overcome the low mechanical strength of GelMA by incorporating oppositely charged block polyelectrolytes (bPE) that self-assemble ionically when mixed in aqueous mediums, resulting in hybrid hydrogels with higher mechanical robustness prior to photocuring. To quantify hydrogel's mechanical properties, we built an ASTM F2392 – 04 standard burst pressure apparatus to measure the maximum pressure that hydrogel acquires to burst. We compared the burst pressure of GelMA with varied concentrations as well as block polyelectrolytes supplemented with GelMA (bPE-GelMA) systems in dry and wet environments. The results showed that increasing GelMA concentration from 5 wt.% to 10 wt.% doubled the burst pressure. In underwater environments, GelMA solutions undergo significant declines in burst pressure. The burst pressure of bPE-GelMA system is nearly equal to the burst pressure in dry environments, showing controlled application underwater compared to rapid dilution of GelMA. This work assessed hydrogel applications and relevant mechanical properties in environments that resemble physiological conditions.

References
[1]: Advances in Engineering Hydrogels
[2]: Li et. Al.
If you would like to find out more about the UCLA Samueli Summer Undergraduate Research Program, please contact our team at surp@seas.ucla.edu or visit our website at www.seasoasa.ucla.edu/surp.