The Summer Undergraduate Research Program (SURP) provides an intensive summer research experience in a wide range of engineering and physical science fields. Undergraduate students from all walks of life participate in research with UCLA Samueli School of Engineering faculty to gain real-world lab experience.

Due to the COVID-19 pandemic that is still affecting us this summer, SURP has had to transition the program into a remote learning environment for many of its scholars. Despite this challenge, SURP’s many scaffolding resources and social events have still been able to occur and students were able to:

- Conduct 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 Summary of Project.
- Gain a competitive advantage for engineering graduate schools.
- Learn how you can impact your community as an engineer.

This year, a record 66 undergraduate students were selected to join the 2021 SURP cohort, spread out across 31 faculty in 6 engineering departments. We are happy to announce 64% of these are women, 20% are underrepresented minorities, and many are first generation and low income students. SURP is involved with ongoing efforts in fostering a more diverse, equitable and inclusive community at UCLA Samueli Engineering.

Creating new knowledge is a very difficult yet important task, and these high-performing students have done an outstanding job working through the rigors of academic research. These students should be very proud of all that they have accomplished in a short time this summer. I encourage you to explore our publication and learn about all the cutting-edge knowledge that is being created here.

Sincerely,

Dr. Jayathi Murthy
Ronald and Valerie Sugar Dean
Analyzing the Effectiveness of Social Robots in Children’s Speech Assessments

FACULTY ADVISOR
Abeer Alwan

DAILY LAB SUPERVISOR
Alexander Johnson

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ABSTRACT
Speech recognition devices have vastly transformed people’s way of life, as everyone knows of “hey google” and “Alexa,” but there are greater possibilities with such systems including improving the early education of children. Many children are behind in their reading and speech acquisition skills, a direct result of lack of exposure to vocabulary and oral skills. While other companies have created intelligent tutoring systems, they do not possess the ability to pick up on the acquisition of children. In order to determine the success of a young child interacting with a social robot, a series of tasks were completed and recorded with an instructor, child and the robot JIBO. These sessions were analyzed to quantify patterns in interactions such as boredom, excitement, and frustration. The data concluded that boredom and prompts from the instructor occurred most often, showing that young children struggle the most with staying focused during the long tasks. The more interactions from the instructor, the longer the sessions lasted since they kept the children on track, but it was found only 18.7% of the recordings were a child speaking. It’s suggested the tasks be shortened so that there can be more success in the students completing all of the tasks to be recorded and analyzed for future sessions. Social robots can be used in classrooms, clinic offices and even at home to develop learning at a young age that is most beneficial for the future.

Results & Discussion
Quantifying Patterns (by hand):
A transcription of all tasks and interactions from the instructor were the most frequent patterns that occurred.

Quantifying Patterns (with code):
A function was used to go through transcriptions and calculate the occurrences of exact phrases showing instructor interjections.

Results

Conclusions

Analyzing the transcripts both by hand and with code was insightful in hoping how students interacted with JIBO, situations where JIBO could not successfully move the session along, as well as the trend of prompts by instructor increasing the length of the session.

Students mostly struggled with the exploration tasks because they were complex. In future work, the participants may benefit from more support from the robot. This is demonstrated in the data where it was found that only 18.7% of the transcriptions included the robot speaking.

A suggestion for future experiments is to adjust the length so that the students can engage and complete the tasks. It is important for them to finish the tasks successfully in order to collect data more specific to the articulation of children, after their interaction with JIBO the robot is improved.
Printable Robotic Boat Swarms with Actuation and Sensing Capabilities

FACULTY ADVISOR
Ankur Mehta

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ABSTRACT
The design and development of robotic devices remains limited to those with considerable time, funds, and technical expertise. Our goal is to increase the accessibility of robotics so that the average person can design and create their own robotic boats. We set out to provide a variety of boat hull morphologies with three new actuation capabilities: a propeller, paddlewheel, and rudder. After designing the 2D layout of these origami-inspired boats, we implemented them in the Robot Compiler (RoCo) framework for generating foldable robotic designs, thus allowing a user to add any actuation capability to any boat hull by setting parameters in code. I then used a paper cutter to cut out inexpensive thin plastic sheets into foldable boats with actuators driven by continuous rotation servos and DC motors. I found that the propeller produces fast linear motion, the paddlewheel enables motion that is linear and rotational, and the rudder adds more precise steering capabilities. In order to test my boats’ autonomous capabilities such as following a colored object, I integrated my boats with OpenMV cameras and inertial measurement units (IMUs), which provided basic feedback-controlled movement. I found that given this relatively small set of tools and materials, it's possible to generate a wide variety of robotic boats. This work establishes a foundation for the community at large to rapidly, easily, and inexpensively create novel types of robotic boats.
Expanding Human-Computer Interaction via Object Recognition Implemented into a Hand Signal Actuated Robotic Arm (SARA)

FACULTY ADVISOR

Xiang ‘Anthony’ Chen

DAILY LAB SUPERVISOR

Jiahao Li

DEPARTMENT

Electrical and Computer Engineering

ABSTRACT

Human-computer interaction (HCI) has advanced the efficacy of a multitude of sectors such as communication and consumerism. However, there exists a gap where most HCI research is conducted to improve quality in industrial aspects rather than personal aspects. Our research extends HCI to improve quality of life by designing and implementing a hand signal response AI into a six degree of freedom (6DoF) robotic arm. We call this our hand signal actuated robotic arm, SARA. An implementation of forward kinematics (FK) and inverse kinematics (IK) in python allows the robotic arm to actuate in response to complex hand signals, made possible via our hand recognition software. This software presents a real-time object-tracking process that recognizes hand signals by finger landmark mapping. A rule classifier distinguishes different variations of raised fingers. To confirm mechanical actuation and limitations, we developed a simulator in MATLAB using a virtual robotic arm that parallels SARA. Our research ultimately produced a design that, when implemented, gives SARA the capability to react to diverse hand signals independently. Qualitative demos conducted with a variety of hand signals validated our research design and implementation. A set of thirty-two hand signals was displayed to SARA that resulted in successful actuation in accordance with the simulator. The application of this design aims to assist individuals with physical limitations, making HCI more personal. The success of implementing a hand signal response AI makes the interaction with a robotic arm intuitive, ultimately expanding the scope of HCI to enhance the human experience.

Figure 1: shows the relationship between joint angles and the position of the end-effector.

Figure 2: shows the relationship between the DH parameters and the position of the Effector.

Figure 3: shows the relationship between the DH parameters and the rotation matrix.

Mathematical Methods

DH Parameters

\[ \begin{align*}
A_0 &= \\
A_1 &= \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1 
\end{bmatrix} \\
A_2 &= \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1 
\end{bmatrix} \\
A_3 &= \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1 
\end{bmatrix} \\
A_4 &= \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1 
\end{bmatrix} \\
A_5 &= \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1 
\end{bmatrix} \\
A_6 &= \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1 
\end{bmatrix}
\end{align*} \]

Inverse Kinematics (IK)

The mathematical process that allows us to find the joint angles from the X, Y, and Z coordinates of the end-effector. The DH parameters consist of four factors:

\[ \begin{align*}
\text{DH Parameters} &= \begin{bmatrix}
a_1 & \theta_1 & a_2 & \theta_2 \\
da_3 & \theta_3 & a_4 & \theta_4 \\
0 & 90 & a_5 & \theta_5 \\
0 & 0 & a_6 & \theta_6 
\end{bmatrix}
\end{align*} \]

Forward Kinematics (FK)

The mathematical process that allows us to find the position of the end-effector via FK. The DH parameters consist of four factors:

\[ \begin{align*}
\text{DH Parameters} &= \begin{bmatrix}
a_1 & \theta_1 & a_2 & \theta_2 \\
da_3 & \theta_3 & a_4 & \theta_4 \\
0 & 90 & a_5 & \theta_5 \\
0 & 0 & a_6 & \theta_6 
\end{bmatrix}
\end{align*} \]

Results

To confirm mechanical actuation and limitations, we developed a simulator in MATLAB using a virtual robotic arm that parallels SARA. This was written with the help of Peter Corke’s Robotic Toolbox.

Objective

Our research extends HCI to improve quality of life by designing and implementing a hand signal response AI into a six degree of freedom (6DoF) robotic arm. What sets this robotic arm apart from other AI driven robotic arms is the hand recognition software. This software presents a real-time object-tracking process that recognizes hand signals by finger landmark mapping. A rule classifier distinguishes different variations of raised fingers. Qualitative demos conducted with a variety of hand signals enhanced our design. In-lab qualitative demos conducted with a variety of hand signals validated our research design and implementation. Actuation was observed, recorded, and measured. The data obtained was compared to the original parameters.

Conclusion

In this research, we successfully implemented a hand signal actuated robotic arm, SARA. Our research utilizes advanced techniques and technologies to enhance the quality of human-computer interaction. Our research also demonstrates the potential for machines to read and react to human emotions.

References


Acknowledgements

We would like to thank Professor Chen for providing us the opportunity to do research (SURP). We also would like to thank Nick Li for offering us guidance and knowledge throughout our time with him. Lastly, we would like to express gratitude towards Will Herrera and the SURP Staff for their hard work in ensuring our success.
Origami Webapp User Interface & Integration of New Designs

Jaehoon Song, Ankur Mehta, The Laboratory for Embedded Machines and Ubiquitous Robots

SUMMER UNDERGRADUATE RESEARCH PROGRAM

ABSTRACT
The Origami Design App is a web application that can view, compile, and change the parameters of robots along interfaces. UCLA’s LEMUR originally designed this webapp as a means to make robot compiling easier for those that lack the engineering or the programming background. I integrated some of the functionalities such as being able to view necessary component files when inputting a subcomponent into a html form by using a PATH method. This is significant because a user could potentially compile a robot easier or faster than using the standard RoCo application. I also edited some of the existing user interface such as editing the style of transitioning buttons with css files to provide the user with optimal visual experience. For the future, I plan to conduct a user study to observe that the changes I have implemented have benefited the Origami Design App and prove that the changes within the user interface were successful. I also plan to implement the functionality to combine components along interfaces which will most likely reduce the time that a user needs to spend in order to design a robot.

INTRODUCTION
The Origami Design App is a web application that can view, compile, and change the parameters of robots along interfaces. UCLA’s LEMUR originally designed this webapp as a means to make robot compiling easier for those that lack the engineering or the programming background. I integrated some of the functionalities such as being able to view necessary component files when inputting a subcomponent into a html form by using a PATH method. This is significant because a user could potentially compile a robot easier or faster than using the standard RoCo application. I also edited some of the existing user interface such as editing the style of transitioning buttons with css files to provide the user with optimal visual experience. For the future, I plan to conduct a user study to observe that the changes I have implemented have benefited the Origami Design App and prove that the changes within the user interface were successful. I also plan to implement the functionality to combine components along interfaces which will most likely reduce the time that a user needs to spend in order to design a robot.

RESULTS & DISCUSSION

User Interface

CSS Statements:
- Used for general styling and layout
- Bigger and aligned transition buttons

RoCo Interface:
- Used for displaying styling and layout buttons
- Display user contact on the web browser

HTML and Jinja was used to inherit templates:
- Used delimiters to inherit the navigation bar
- Used html tags to create an easily navigable builder option which directs to the builder page

MODELING

Web Interface Interaction

RoCo Robot Compiler
- Standard RoCo application is a set of python scripts
- Component files that the webapp uses are generated here

RoCo Library
- Library that contains pre-built/newly built component models
- Contains a python script
- Loads the model that was sent

Jinja
- Used Jinja as a templating engine, I was able to:
  - inherit templates
  - Used python codes on html
  - Used delimiters to fetch the user input

User Interface

CSS Statements:
- Used for general styling and layout
- Bigger and aligned transition buttons

RoCo Robot Compiler
- Used for displaying styling and layout buttons

JavaScript:
- Used for displaying styling and layout buttons

Python:
- Used for displaying styling and layout buttons

Python Scripts:
- Used delimiters to inherit the navigation bar
- Used html tags to create an easily navigable builder option which directs to the builder page

Model:
- Used Jinja as a templating engine, I was able to:
  - inherit templates
  - Used python codes on html
  - Used delimiters to fetch the user input

Jinja Template:
- Used for rendering designs from thumbnails

Results & Discussion

- Easier robot compiling for those that lack the engineering or the programming background
- Plan to implement combining components along the interface
- New Interface Design

Models

MODELS

name

name

name

Acknowledgements

- Dr. Ankur Mehta, UCLA LEMUR
- William Herrera, Summer Undergraduate Research Program
- Grace Hwang, Shawk Jasti, Jillian Pantog, Sudarshan Seshadri, Marisa Duran, Shahrul Kamil Hassan, and Ankur Mehta
- NSF REU
A Personalized Approach to Federated Learning


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Abstract

Federated learning, a machine learning technique, has been gaining popularity as a method of protecting user data privacy for modern-day devices while still providing a great user experience by only sending model updates to the server instead of exchanging sensitive data. However, utilizing a singular global model is extremely restricting as the data is exceedingly diverse, which limits the global model from maximizing performance for each individual client. This heterogeneously distributed data across multiple clients is the primary motivation in utilizing personalized versions of federated learning. In this research, we implement algorithms that use personalized federated learning techniques such as clustering clients and utilizing temporary models for communication. Various hyperparameters - batch size, local communication rounds, number of clients - are adjusted to maximize the algorithm’s accuracy levels. The algorithms are implemented using PyTorch (a machine learning library developed by Facebook’s AI Research Lab) and both trained and tested using the CIFAR-10 image dataset. Using random heterogeneously distributed data, the algorithms converge to higher accuracy levels through these personalization techniques when compared to traditional federated learning algorithms.

Materials and Methods

Implement personalized federated learning algorithms

- Personalized techniques (client clustering and utilizing temporary models) will result in algorithms converging to higher accuracy levels.

Results and Discussion

- FedAvg Model
- pFedMe Model
- FedFomo Model
- Client Model (IID)

<table>
<thead>
<tr>
<th>Problem</th>
<th>FedAvg Model</th>
<th>pFedMe Model</th>
<th>FedFomo Model</th>
<th>Client Model (IID)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Rate</td>
<td>73%</td>
<td>79%</td>
<td>77%</td>
<td>74%</td>
</tr>
<tr>
<td>Regularization</td>
<td>79%</td>
<td>74%</td>
<td>79%</td>
<td>79%</td>
</tr>
</tbody>
</table>

Conclusions

- Personalized federated learning algorithms allow for models to outperform traditional federated learning algorithms when using non-IID data. Future implementation of other personalized algorithms such as FedFomo will further showcase the advantages of personalization techniques.

These techniques are key components within future machine learning applications (autonomous vehicles, traffic predictions, etc.) as they increase the performance of machine learning models on heterogeneous datasets while eliminating data security risks within the cloud.

Acknowledgements

I would like to thank Kaan Özkara and Suhas Diggavi for their guidance and resources throughout this project. I would also like to thank NSF (REU) for their funding and the UCLA Summer Undergraduate Research Program (SURP) for this research opportunity.

References


Reinforcement Learning in an Imperfect Information Game

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SUMMER UNDERGRADUATE RESEARCH PROGRAM
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ABSTRACT
Reinforcement learning (RL) has been a growing subset of machine learning with increasing success and promise - but it has just begun to be used in complex, multiplayer environments and games. An agent learns in a complex environment through trial and error, beginning from fully random trials and finishing with sophisticated actions. We apply RL to the imperfect information game known as Liar’s Dice, which presents a challenging mix of two-player dynamics and partial information to explore. The game forces players to call bluff and doubt opponents while reading others’ potential actions. Implementing reinforcement learning to imperfect information games allows us to find successful strategies and models in dynamic Markov Decision Processes (MDPs) environments that require sequential decision making. Utilizing both Python and MATLAB, we employed the popular Q-learning method of RL to train agents that begin with random actions or to use a combination of fixed strategies against others. An agent employing Q-learning improved its win rate from 50% to only 65% within 1,000,000 episodes against a simple agent. On the other hand, an agent that made decisions based on various fixed strategies available increased its win rate from 11% to 77.7% with 100,000 episodes. Those varying speeds demonstrate the difficulty of learning and the variability of Q-learning in a game with partial information. In future work, we may compare counterfactual regret minimization and more state-of-the-art RL algorithms, which would expand our understanding of various methods of a partially observable, dynamic environment such as Liar’s Dice. By studying this game, we hope to one day broaden our results to the education space, a similar Markov process where individuals also make decisions sequentially. Using intervention tools such as quizzes and lectures, the interactions between students and instructors may be refined to improve student learning outcomes.

KEY TERMS
Q-Learning Algorithm
SARSA

TOOLS
Reinforcement Learning Bot

A Reinforcement Learning Bot

Part 2: RL Bots’ Performance

Naive
Ag Honest
Ag Prob
Ag Mixed
Ag

Figure 1: By playing 25 games, we may evaluate the strengths and weaknesses of each bot. A human can beat the naive and honest agents easily, but has more difficulties against the probabilistic agent. Against the mixed agent, the optimal strategy is to randomized between all mixed strategies. A human can beat the probabilistic agent

Figure 2: To find optimal strategies and models in dynamic Markov Decision Processes (MDPs), environments that require sequential decision making, we employed the popular Q-learning method of RL to train agents that begin with random actions. We apply RL to the imperfect information game known as Liar’s Dice, which presents a challenging mix of two-player dynamics and partial information to explore. The game forces players to call bluff and doubt opponents while reading others’ potential actions. Implementing reinforcement learning to imperfect information games allows us to find successful strategies and models in dynamic Markov Decision Processes (MDPs) environments that require sequential decision making.
SURP is an umbrella program that administers and scaffolds summer undergraduate research opportunities within UCLA Samueli Engineering. SURP participating sub-programs include National Science Foundation (NSF) Research Experience for Undergraduates (REU) Sites, Samueli Research Scholars (SRS) Program, Faculty-funded grants, and Electrical and Computer Engineering Fast Track Program.

William Herrera, the director of SURP, is also director of UCLA Samueli Engineering’s Undergraduate Research and Internship Program (URP/UIP) during the academic year. URP/UIP is committed to helping you find research/internship opportunities. Our Peer Advisors are trained to help you with any questions and concerns you may have, and appointments are available on our website.

For any questions about these resources, please reach out to us at urp@seas.ucla.edu and uip@seas.ucla.edu, or scan the QR code on the next page to get to our website.

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