REU-CAAR: Research Experience for Undergraduates in Combinatorics and AI for Applied Research

William Gasarch-Director
John Dickerson-Co Director
Many Mentors!
Many Students!
Time and Money

1. June 5- August 11 (10 weeks)
   (If on campus then might have you arrive on June 4)
2. $6000 stipend
3. Housing and some Meal Money
4. Excellent student-to-teacher ratio.
5. For more info
   https://www.cs.umd.edu/projects/reucaar/
Activities

1. Research
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2. Learning more discrete math and/or algorithms and/or AI.
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4. Lunches
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6. Sight Seeing in Washington DC (weekend)
7. Research
8. Presentation on Ethics of Research
9. Research
10. Making friends for life! (now possibly with Facebook). (When I first ran the program in 2013 this was novel!)
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The Research

1. At the website is a tab to click for descriptions of the Projects.
2. When you apply you will write a statement. That statement should list which projects you are happy to work on, and for each one (a) why you are interested, and (b) why you are qualified. Advice: Keep it SHORT and pick 3 or 4 projects.
3. Next slides describe THE PROJECTS!
4. The projects range from THEORY to PRACTICE.
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Classical and Quantum Error Correction

**Mentors** Victor Albert and Phillipe Faist
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Prereq Linear Algebra, Quantum Mechanics, Quantum Computing, Quantum Error Correction (two of the three Quantum Prereqs will suffice)
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**Description**
Classic communication uses error correction so that even if a message flips some bits, the original message can be recovered. There are many ways schemes for this.

The project will study both classical and quantum error correction and help build the ErrorCorrectionZoo, a website of classical and quantum error correction schemes.
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Quantum Communication which also needs error correction.
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Improving Machine Translation for Wikipedia

Mentors Marine Carpuat and Eleftheria Briakou.
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**Prereq** Python, Pytorch, Some Deep Learning.
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We will the use what we learn to have Machine Translators that detect and correct errors.
Parallel Algorithms for High-Dimensional Clustering

Mentors Laxman Dhulipala
Parallel Algorithms for High-Dimensional Clustering

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**Prereq** Algorithms, Systems Programming, C and C++
(no knowledge of parallelism required)
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Description

Clustering is taking a dataset and grouping together objects that are similar. This is useful in Machine Learning. Current algorithms can be slow. How to speed them up?
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Parallelism!

We design and implement Parallel algorithms for clustering. We then apply them to known benchmarks and see how they do.
Induced Ramsey Theory

**Mentor** William Gasarch

Let $K_n$ be the graph on $n$ vertices where all vertices are connected. The following is known:

For every coloring of the edges of $K_6$ there is a monochromatic $K_3$.

But what if you color a graph that is NOT $K_6$? For which graphs $G$, when you color the edges of $G$, do you get a monochromatic $K_3$?

More generally find for a graph $H$ a small graph $G$ such that for all 2-colorings of the edges of $G$ you get a monochromatic $H$.

Will learn LOTS of combinatorics! LOTS of Ramsey Theory!
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**Prereq** Combinatorics and Some Ramsey Theory (not alot)
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Fair Decision Making

**Mentor** Furong Huang
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**Prereq** ML, Fairness, Probability, Linear Algebra, Calculus, Reinforcement learning a plus but not required.
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**Description**
Machine Learning is being used in healthcare, finance, hiring, and education. The hope was that this would eliminate bias, but unfortunately it often reinforces it.
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Description
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In this project we will use AI to learn bias patterns missed by humans and hence improve fair ML’s in a dynamic way.
Computational Hilbert Geometry

**Mentor** David Mount and Auguste Gezalyan
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**Prereq** Discrete Math, Algorithms, Programming Skills (no knowledge of computational geometry or Hilbert geometry needed)
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Description The distance you are used to working with is the Euclidean Distance. But there are other distances one can use. These other distances may be useful in Genetics, Probability, Physics, and other fields.
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**Description** The distance you are used to working with is the Euclidean Distance. But there are other distances one can use. These other distances may be useful in Genetics, Probability, Physics, and other fields.

We will explore what happens to Computational Geometry problems when you use a different distance. You will learn Comp Geom and combine Comb Geom with programming.
Using Markov Decision Processes to Mitigate Climate Risk

**Mentor** Aviva Prins
Using Markov Decision Processes to Mitigate Climate Risk

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Prereq Discrete Math, Probability, Algorithms, ML, Numerical Analysis, Mechanism Design, Reinforcement Learning, Fairness. (That’s a long list so it’s okay if you don’t know all of them.)
Using Markov Decision Processes to Mitigate Climate Risk

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In India the farmers are vulnerable to climate risk. Giving them crop advice is crucial.
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**Description**

In India the farmers are vulnerable to climate risk. Giving them crop advice is crucial.

This project will develop tools to actually help them plan. It is in conjunction with a non-profit organization KHEYTI

https://www.kheyti.com/
Activities

1. First week - BEGIN your projects PRONTO!
2. First week - Talks from all the mentors on all the projects.
3. Every Monday - REU lunch. Discussion topics:
   ▶ Grad School
   ▶ Work on Math problems together!
   ▶ Professional Talks
4. Every Wednesday - REU talks
   ▶ From mentors on topics of interest
   ▶ From other people on other topics of interest
5. Every weekday - Work on Project.
6. Field Trip to Washington DC.
7. There will be presentations of the projects.
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Qualifications

2. Knowing how to program.
3. See website for prerequisites for some projects.
4. US Citizenship for NSF funding. But see next point.
5. We have some (not alot!) money for non-citizens.
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How to apply: Goto the website!
Will need:

1. Transcript (including Fall 2022)
2. Statement of Purpose (say which 3 or 4 projects you want to work on, WHY you are interested and WHY you are qualified)
3. Letters of rec. (Letter writers will submit those)
4. Other stuff that is on form
Logistics

1. YOU apply by March 7. Apply EARLIER as we will begin accepting students earlier.

2. WE accept or reject you. Final decisions made by the middle of April (or sooner).

3. If we reject you then... Oh well. (Apply to several programs.)

4. If we accept then you can
- Reject us! This is perfectly fine.
- Accept us! And come!
- Accept and then NOT come. DO NOT DO THIS!
  If you ACCEPT then we look forward to seeing you in June!
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Advice for ANY REU-app, Grad School App

1. Apply Early.
2. Get your personal statement done ASAP.
3. Personal Statement should elaborate on what you want to work on, why you are qualified, and why you’re interested.
4. Apply to many places (REU programs—Google NSF REU to find more programs).
This REU experience was greatly beneficial in expanding my knowledge and experience with machine learning. Dr. Gasarch, the mentors, my team, and the professors were all very supportive and encouraging, and I learned so much from them over the course of the program. The program was a perfect way to explore different research aspects and allow me to get a better idea of how research is conducted. I am very thankful for this experience.
The experience of REU CAAR was excellent. I participated in some research before, yet this is the first time for me to do research in a group, which was great!
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Aside from the research, the lunches and talks were interesting. Thanks to Professor Gasarch, his helper Auguste, and all the mentors. I would recommend it to anyone interested in computer science or mathematics.
Another REU Program at Univ of MD

REU-BRIDGE

1. Most of what I said about REU-CAAR also apply to REU-BRIDGE.

2. REU-BRIDGE website is: https://www.cbcb.umd.edu/summer-internships

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4. Have a great time!

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**Final Takeaway** Apply to REU programs that spark your interest, and consider REU-CAAR and REU-BRIDGE.