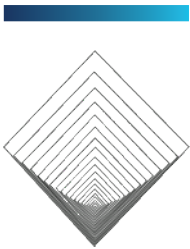




# FHL VIVE CENTER

ANNUAL REPORT 2023





The FHL Vive Center for Enhanced Reality was founded at the University of California, Berkeley in 2017. It was established with generous support from HTC Corporation and the Faith Hope & Love Foundation, which were co-founded by Berkeley alumna Cher Wang and her husband, Wenchi Chen.

The mission of the FHL Vive Center for Enhanced Reality is to sponsor critical fundamental research and high-impact applications in the emerging fields of Virtual Reality, Augmented Reality, and Artificial Intelligence, and at the same time serve as the central hub to facilitate the deployment of disruptive VR, AR, and AI technologies across the Berkeley campus for cross-disciplinary research and education.



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# Leadership Message



Five years in, the FHL Vive Center is growing at a spectacular pace, with dynamic leadership, robust programming, and increasing collaboration and support from key industry sponsors and partners.

In 2023, the Center's Robot Open Autonomous Racing (ROAR) program became the prime lead of the multi-university AI Racing Tech team by assuming ownership of the driverless Dallara AV-21 racecar, which the team drove into place as the top-ranked U.S. team in the Indy Autonomous Challenge. At CES in early 2024, AI Racing Tech was one of only three teams selected to test-drive the brand new Dallara AV-24, now the most advanced automated racecar ever built. The exciting "Sim-to-Real"

competition promises to help advance the science not only of the future of transportation, but of other high-stakes fields demanding critical assurance, from healthcare to aerospace.

Meanwhile, the ROAR Academy, our two-week summer intensive for highschoolers, and ROAR Ambassadors, select high schoolers who embed with the AI Racing Tech team, has helped catapult the STEM careers of hundreds of high-school students from throughout California and as far as Texas since it began in 2021. The online summer program spurred by the pandemic continues to thrive three years later, while we work towards launching an in-person program on campus in the upcoming year.

We benefit tremendously from close collaborations with industry partners. Last spring, a partnership forged with ByteTrade enabled faculty and students to work together on the company's proprietary operating system to advance a vision for Web3 infrastructure. As I write this, we are welcoming BeamNG to our roster of sponsors, which will enrich our efforts with their exceptional vehicle physics and sensor physics technologies.

We are tremendously grateful to our wonderful faculty, students, partners, sponsors, and donors for the success you have brought to FHL Vive in 2023, and we look forward to growing with you, advancing the mission and the science, for the next five years and beyond.

Shankar Sastry  
Founding Director





2023 will be remembered as a great year for the AI industry. The successful commercialization of GPT technologies has shine a bright light on the power of natural languages in representing human knowledge and intelligence in tasks from Turing-passing daily conversations to performing instructions and code writing. At Berkeley, in addition to the concerns about AI safety, the Center leadership is keenly focused on seeking solutions to make accessibility of such rapidly growing AI technologies more equitable for students, researchers, and our industry partners at large. To this end, Shankar and I have spearheaded a prototype project to deploy one of the first GPT teaching assistant programs at Berkeley to answer students' course questions in EE 106/206 (Introduction to Robotics). Instead of relying on external paid GPT services such as OpenAI, this prototype model, codenamed ROAR GPT, is based on a 7B parameter small model, and it has further digested relevant course materials from instructors and student teaching assistants to provide the most accurate learning assistance and document citations. Our goal will be to work closely with the University leadership and interested industry stakeholders to establish safety and privacy-preserving local GPT TA services to as many Berkeley courses as possible.

On the front of AI racing, after two years participating in Indy Autonomous Challenge (IAC) as part of the AI Racing Tech team, we have broadened our commitment to the IAC racing program by becoming the prime owner of the AI Racing Tech team, while continuing expanding our team partnership with the University of Hawaii (the original prime owner), the University of California, San Diego, and Carnegie Mellon University. Built on our strong semi-final win at CES 2023 IAC competition, the team has been selected by IAC to be one of the first three teams to receive vehicle model upgrade to AV-24 model. The new model for 2024 improves the performance from the older AV-21 model on almost all specifications, including a new drive-by-wire solution, top-of-the-line LIDAR and RADAR sensors, and improved CPU performance. We look forward to an exciting new AI racing season in 2024.

Finally, another cornerstone of the Vive Center's research activities is in the AR/VR field. We are thrilled to learn that many of our Center alums have been the core team in Apple that created the latest AR/VR headset known as VisionPro. While we are eagerly waiting for its product launch in 2024, we are encouraged to double our effort and commitment in promoting cross-disciplinary AR/VR research and educational projects at Berkeley. As an example, we are waiting for the approval by the campus to establish a new undergraduate level AR/VR mezzanine course, which will complement the existing graduate level CS 294-137 advanced topics course and potentially triple the number of seats available for Berkeley to offer quality AR/VR courses to all students from different backgrounds and different departments.

I look forward to hearing from our current and potential partners to build a stronger Center program in AI, AR/VR, and Robotics.

Allen Yang  
Executive Director

# Leadership

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## **S. Shankar Sastry**

Founding Director, FHL Vive Center for Enhanced Reality  
Thomas M. Siebel Professor in Computer Science  
University of California, Berkeley



## **Allen Yang**

Executive Director, FHL Vive Center for Enhanced Reality



## **Yi Ma**

Chief Scientist, FHL Vive Center for Enhanced Reality  
Director, HKU Musketeers Foundation Institute of Data Science  
Head, Department of Computer Science, HKU  
Professor, Chair of Artificial Intelligence



## **Shannon Jackson**

Chief Creative Officer, FHL Vive Center for Enhanced Reality  
Cyrus and Michelle Hadidi Professor of Rhetoric and of Theater, Dance and Performance Studies



## **Bjoern Hartmann**

Chief Design Officer, FHL Vive Center for Enhanced Reality  
Associate Professor of Electrical Engineering and Computer Science  
Paul and Judy Gray Alumni Presidential Chair in Engineering Excellence

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# Advisory Board



**Wenchi Chen**

President and CEO of VIA Technologies, Inc.  
Director of HTC



**Cher Wang**

Co-founder and Chairwoman of HTC Corp.  
Chairperson of VIA Technologies, Inc.



**Said Bakadir**

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Qualcomm Inc.



**Mark Liu**

Chairman of Taiwan Semiconductor  
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**Mark Meltzer**

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**Harry Shum**

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and Research, Microsoft Corp.



**Thomas Nesbitt**

Emeritus Associate Vice Chancellor for Strategic  
Technologies and Alliances, UC Davis  
Founding Director, Center for Health and  
Technology, UC Davis Health







## Researchers



**Ruzena Bajcsy**

Professor Emerita of EECS



**Francesco Borrelli**

Professor in Mechanical Engineering  
FANUC Chair in Mechanical Systems



**Luisa Caldas**

Professor of Architecture  
Director of xR Lab



**Lee Fleming**

IEOR Professor  
Emeritus Director, Fung Institute for Engineering  
Leadership



**Richard Hernandez**

Associate Professor of Journalism  
Bloomberg Chair



**Jack McCauley**

Innovator in Residence at Jacobs Hall



**James O'Brien**

Professor of Computer Science



**Ren Ng**

Professor of EECS



**Kathryn Quigley**

Senior Digital Producer  
Lawrence Hall of Sciences



**Koushil Sreenath**

Assistant Professor in Mechanical  
Engineering



**Claire Tomlin**

Professor of EECS  
Charles A. Desoer Chair in College of  
Engineering



**Stella Yu**

Director of Vision at ISCI Vision Group  
Adjunct Professor at UC Berkeley





## VIVE CENTER HIGHLIGHTS



# K-12 STEM Outreach

Amidst the challenges posed by the Covid pandemic, the Vive Center responded with innovation, launching an online ROAR Academy summer program tailored for high school students in grades 10 through 12. This pioneering initiative provided driven individuals with the unique chance to collaborate with esteemed UC Berkeley faculty, researchers, and scientists, immersing themselves in the intricacies of Python programming and introductory autonomous driving algorithms. Topics have expanded to include machine learning, reinforcement learning, and large language models such as GPT.

Over the span of this immersive 10-day program, participants absorbed essential knowledge essential for active involvement in the ROAR Simulation Racing competition, an exclusive venture conducted within a sophisticated software simulation environment. Moreover, attendees seized the opportunity to ascend to the esteemed role of ROAR ambassadors. In this capacity, they assumed leadership roles within their high schools, spearheading the establishment of clubs and fostering research opportunities in collaboration with the center.

Beyond the program's duration, students leveraged their enriched experiences to bolster their academic pursuits and college applications, catalyzing personal growth and paving the way for future success.

After three successful years, the ROAR Academy and Ambassador programs have effectively forged a robust pipeline for K-12 outreach initiatives.

Starting in 2024, the ROAR Academy program will transition to an enriching, in-person summer experience hosted at UC Berkeley. This exciting shift promises participants a more immersive and hands-on learning journey.





## ROAR Academy

The Academy is a rigorous and intensive two-week summer program for high school students who have demonstrated an aptitude for academic and professional careers in science, technology, engineering and mathematics (STEM) subjects. It is designed to help students gain sufficient knowledge in Python programming and its applications to autonomous driving. We continue to adapt our program curriculum to reflect evolving STEM topics such as GPT language models.

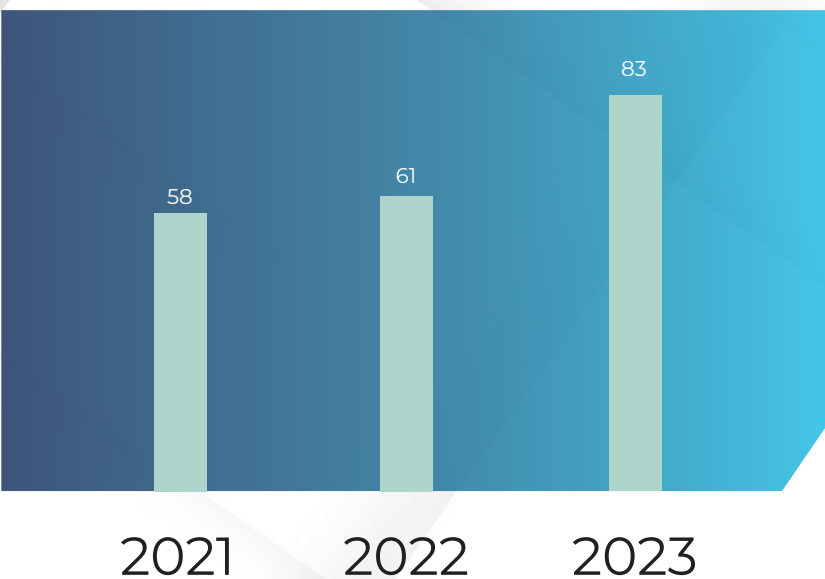
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We are excited to announce for ROAR Academy that starting in 2024, the summer STEM program will be offered in in-person format for our Grades 10 to 12 students to have more opportunities to interact with the Berkeley instructors during its full two-week curriculum. We are also announcing that a one-day short course on the introduction of GPT will be added to the curriculum of ROAR Academy 2024.

- Allen Yang, Executive Director

”

## The Numbers



The ROAR Academy has continued to grow each year increasing the number of students who have been able to attend online through the three sessions.

## ROAR Ambassadors

The Ambassador program was developed to give back to promising high school students who excel in the Academy and participate in the racing simulation competition. It is designed to bring Berkeley ROAR AI Racing, ROAR Research, and ROAR Academy experience to K-12 schools with our technical and financial support. Activities that the ROAR program sponsors include organizing AI and Autonomous Driving seminars, participating in ROAR AI Racing, providing program feedback to us, and potentially becoming an active researcher to help grow the Berkeley ROAR program. Each ROAR ambassador will be directly teamed up with one ROAR faculty member and one graduate student at Berkeley and given a \$2,000 grant.

Furthermore, over the course of three years, the ROAR Ambassador program has awarded \$20,000 in grant support to ten ambassadors. This funding has been instrumental in fostering the development of clubs and programs at their respective high schools, aimed at nurturing students' interest in STEM-related topics.

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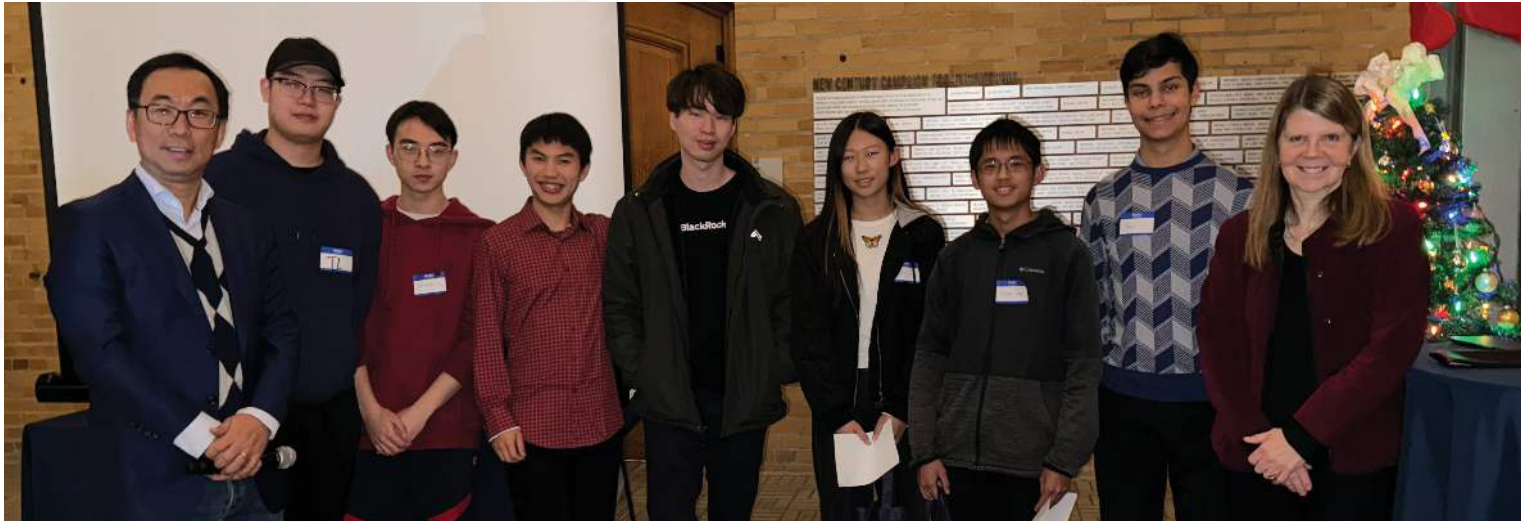
**As our ROAR Ambassadors program entered the third year, we welcome a new class of four Ambassadors to join our ROAR family: Derek Chen from Burlingame High, Mark Menaker from University High, Irvine, CA, Lynna Xu from Sonoma Academy, and Christopher Zhang from the John Cooper School. We also congratulate our first-year alums Aaron Xie and Cameron Shaw for entering their respective college studies. Specifically, Aaron accepted an offer made by Berkeley and currently is a freshman undergraduate researcher starting his research career on the ROAR project.**

**- Allen Yang, Executive Director**

”



# Ambassadors Class of 2024



Meet Derek Chen, a sophomore from Burlingame High School. Derek's passion for innovation led him to attend the 2023 ROAR Academy,

where he honed his skills and competed in Summer 2023 ROAR Racing Competition, winning first place. Beyond ROAR, Derek is an integral member of his school's robotics team, where he continues to push boundaries and explore new frontiers. In his leisure time, Derek enjoys hiking, swimming, and indulging in the strategic depths of chess.



Meet Mark Menaker, a sophomore at University High School in Irvine, CA. Mark excelled in the ROAR Academy and Simulation Racing Series in Summer 2023, winning second place.

Mark is in the enhanced math program at his school, and is involved in math competitions, science fairs, Science Olympiad and Ocean Science Bowl. He has earned President's Volunteer Service Awards for promoting STEM activities in his community. A talented musician, Mark plays tenor saxophone in his school's Wind Ensemble and Marching Band. His enthusiasm and passion for Formula 1 and coding fuels his role as a ROAR Ambassador.



Meet Lynna Xu, a sophomore from Sonoma Academy in Santa Rosa, California. Lynna's passion for technology and innovation led her to

participate in the 2023 ROAR Academy Summer Session, where she delved into the world of coding and simulation racing. Beyond ROAR, Lynna is a seasoned competitor in the VEX Robotics competition, boasting three years of experience and two appearances at the World Championships. In her downtime, Lynna enjoys playing piano and tennis.



Meet Christopher Zhang, a spirited Sophomore hailing from The John Cooper School in The Woodlands, Texas. Christopher's journey with ROAR began in 2021 showcasing his talents and determination. Beyond

the competition arena, Christopher finds joy in spending time with his friends and playing golf.



We extend our heartfelt gratitude to the outgoing class of 2023 ROAR Ambassadors, Aaron Xie, Harris Song, Benny Liu, and Vivian Zhu for their invaluable contributions to the advancement of the ROAR platform and research.

## Ambassadors at Southern California's Walnut High School Represent ROAR



In September 2023, Walnut High School's Robot Open Autonomous Racing (ROAR) Team captivated students with a live simulated racing demo on the Berkeley Major Map, sparking excitement for the competition. This event took place during Walnut High's annual club fair, where the ROAR team showcased their initiative to eager students. Additionally, they actively participated in the local Diamond Bar STEAM Fair, engaging young minds in the community with the Carla interface and sharing insights into the

Berkeley initiative.

What sets Walnut High School's ROAR team apart is its pioneering Ambassador Program, uniquely bridging high school and collegiate students with UC Berkeley remotely. Under the guidance of the Computer Science Club, the team hosts free workshops and classes, empowering aspiring computer scientists to excel in competitions like ROAR. The Walnut High ROAR racing team clinched an impressive second place in the Fall 2023 Simulation Racing Series, just a year into the Ambassador outreach at Walnut High School with Harris Song.

Established to amplify AI and autonomous driving research in local communities, the Ambassador Program pairs each ambassador with a Berkeley faculty member and graduate student. Applications for the upcoming year close on October 13, 2023. For more details, visit <https://roar.berkeley.edu/ambassador-program/>.

Authored by John Yang and Harris Song, Walnut High School ROAR, under the mentorship of Mr. Nick Blackford advising the Computer Science Club. Special thanks to Mrs. Jenny Alegre and Professor Allen Y. Yang, PhD, for their pivotal contributions to the program's inception.



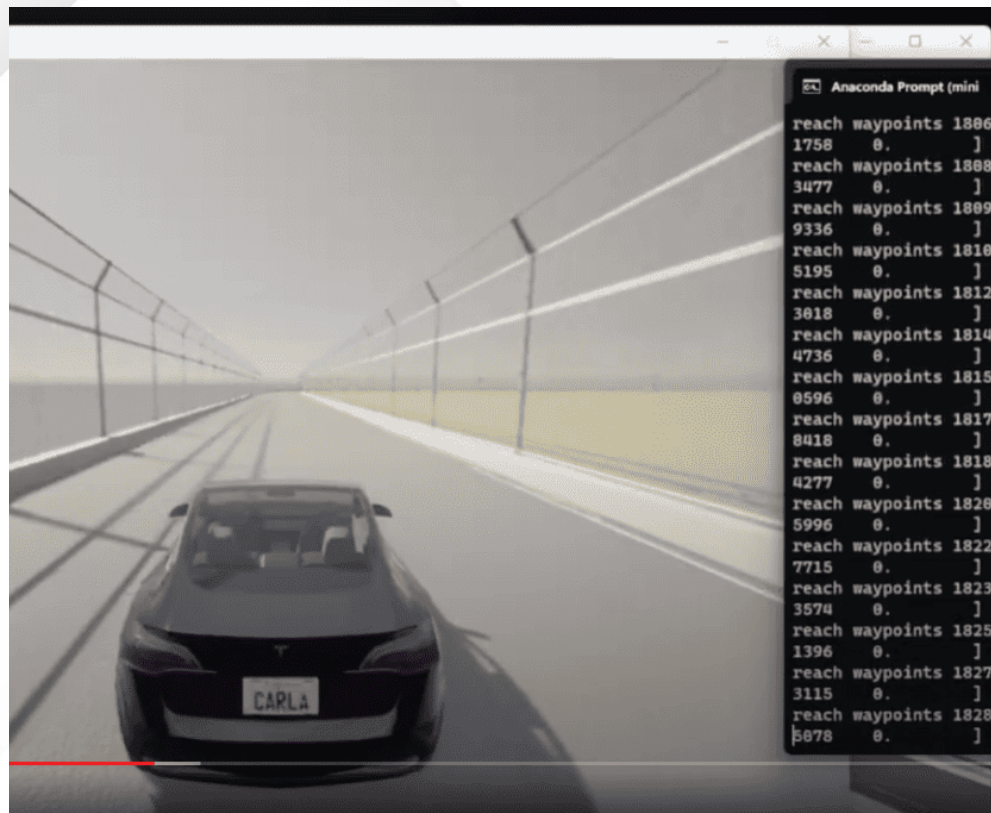
## ROAR Simulation Racing Series

The ROAR Simulation Racing Series stands as a cornerstone in the evolution of autonomous driving algorithms. Leveraging a Python-based racing simulation environment, ROAR empowers participants to unleash their autonomous AI agents on the track. With the absence of physical vehicle hardware, contenders have the freedom to fully train and test their AI algorithms, driving innovation in the field.

Central to ROAR's prowess is its custom-built CARLA map, meticulously crafted to foster research and competition within a simulated urban/suburban setting. The Berkeley Major Map, fashioned using CARLA and Unreal Engine, mirrors the Berkeley campus and its surrounding terrain, capturing the intricate nuances of real-world streets with precision.

In addition to the CARLA server, ROAR users receive essential resources, including an official waypoint list and orthographic occupancy map, to enhance the performance of their autonomous driving agents. These reference files serve as valuable tools for optimization and experimentation.

Looking ahead, Berkeley ROAR Racing is proud to unveil a groundbreaking addition to its virtual circuit lineup: the Monza circuit. This release commemorates the historic milestone of the first-ever Indy AI racing on an F1 road track in Monza, Italy. Built and compiled using the CARLA platform, this virtual model promises an exhilarating new frontier for AI racing enthusiasts worldwide.





# 2023 Simulation Series Winners

## Spring 2023

featured our Berkeley Major Map v1.2.

Grand Prize: Campo Cougar – Aaron Xie, Tristan Needham (Record: 516.9 s)

Second Place: PhastasPhuck – Hin Kit Eric Wong, Elizabeth Hsu (522.15 s)

Third Place: Aadi Dahake (537.85 s)

Special Awards:

Prime Directive (Fastest solution that successfully follows safe on-road traffic rules): Aaron Xie

## Summer 2023

featured our Berkeley Major Map v1.4.

Grand Prize: Derek Chen (Record: 486.2 s)

Second Place: Initial B – Mark Menaker, Arvind Krishna Sivakumar, Saul Statman (490.5 s)

Third Place: Krishay Garg (495.05 s)

## Fall 2023

featured our Monza Map v1.

Grand Prize: Tifosi – Mark Menaker (Record: 356.9 s)

Second Place: Walnut ROAR High – Yuehang Yang, Audrey Han, Gavin Chang, Alex Lin, Brandon Koo (385.2 s)

Third Place: Chowie – Ryan Chow (386.15 s)

# AI RACING TECH

## In the News

01

UC Berkeley to Lead Most Decorated U.S. Autonomous Racing Team

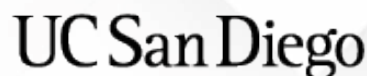
02

UC Berkeley Autonomous Racing Team Sets New Road Course Record

03

UC Berkeley ROAR Racers Among Top Teams to Demo Next-Gen Autonomous Racecars at CES 2024

## AI Racing Tech Partners and Sponsors



TRITON AI  
Autonomous Racing Team



# AI Racing Sponsorship

BENEFITS	TIER 1 FOUNDER	TIER 2 BOARD	TIER 3 PARTNER
Exclusive Naming Rights	✓		
Advisory Board	✓	✓	
Software Commercial License	✓	✓	
Data Sharing and Testing	✓	✓	✓
Student Recruiting	✓	✓	✓
Brand Name Placement	✓	✓	✓
Event VIP Hospitality	✓	✓	✓



Our rigorous research and development projects in the AI, autonomy, and robotics markets offer a wealth of sponsorship opportunities to our partners as market leaders. All partnerships will be governed by a UC Berkeley Industry Partnership Agreement that establishes a formal relationship between the ROAR program and the industrial partners.

The ROAR program offers three tiers of benefits, as highlighted in the table above.

- Founder sponsorship is exclusive to no more than one sponsor. In addition to all the other benefits, our Founder sponsor will have the exclusive right to name the ROAR Racing team. Furthermore, we will offer naming privileges for our research lab spaces dedicated to ROAR program research at UC Berkeley.
- Board sponsorship is ideal for those partners who want to play an active role in shaping the directions of our R&D. This will be governed by an external advisory board, which includes both our Founder and Board sponsors. Another unique benefit offered to Founder and Board members is a non-exclusive, license-free commercial license for any software, experiment data, and simulation environments that the program has developed.
- Partner sponsorship typically includes partners who value co-branding opportunities to allow us to demonstrate their own cutting-edge products in our R&D and also the ability to recruit the best of our students.

We will invite all our industrial partners to participate in our AI Racing competition events on the world stage, and enjoy the best hospitality arrangements offered by us and the event organizers.

For detailed sponsorship information, please contact:  
 Dr. Allen Y. Yang, Executive Director (yang@eecs.berkeley.edu)

# UC Berkeley to Lead Most Decorated U.S. Autonomous Racing Team



The University of California, Berkeley, the world's number one public university, is assuming leadership of the nation's most decorated autonomous racecar team in the Indy Autonomous Challenge (IAC). After more than three years since its start at the University of Hawai'i, the AI Racing Tech Team has risen to prominence for advancing a sophisticated stack of autonomy, AI, and "sim-to-real" technologies under high-stakes, high-speed racing conditions as well as for winning races and setting speed records. As UC Berkeley takes on the role of lead university, the roster of universities, principals, and industry sponsors comprising and supporting the team remains the same.

The transition means that UC Berkeley will assume ownership of the team's Dallara AV-21 racecar, the world's fastest and most advanced autonomous racecar to date, produced in Speedway, Indiana, and valued at more than a million U.S. dollars. From a distance, the classic chassis resembles most modern racecars, but a closer look reveals no driver's seat – instead, the interior is outfitted with cameras, sensors, and specialized hardware that, along with advanced controls, provide 100 percent automation.

"UC Berkeley is excited to lead the charge in this next phase of the team's evolution," says S. Shankar Sastry, faculty director of UC Berkeley's Robot Open Autonomous Racing (ROAR) program, home of the AI Racing Tech Team. "With eyes on the research, we expect big gains for the team this racing season and can't wait to get back out on the track."

The AI Racing Tech Team is made up of a broad coalition of faculty and students in artificial intelligence and robotics at four universities: Carnegie Mellon University, the University of Hawai'i, and the University of California, San Diego, along with UC Berkeley. The team has also attracted industry sponsorships, including



New Eagle LLC, Pratt Miller, ZblueSoftware, ADLINK, Luxonis, HTC Vive, VIA Technologies, Hitch Interactive, and ByteTrade Lab.

This pioneering competition for extreme autonomous robotics signals a transformative era for industries grappling with the challenges of pushing automated systems to the limit and corner cases of design. The race environment mirrors hardware challenges encountered in application domains such as aerospace, defense, and healthcare, which also include expensive equipment, limited access, unknown conditions, and the need for safety and performance assurances.

The team earned its distinctions at the Indy Autonomous Challenge Powered by Cisco at Texas Motor Speedway on November 11, 2022, and at the Autonomous Challenge at CES 2023 at Las Vegas Motor Speedway on January 7, 2023, coming in as the top U.S. team at both competitions. In August, the team set the 1.78-mile Putnam Park Road Course autonomous lap record of 1 minute 27 seconds. The 2024 season for the Indy Autonomous Challenge starts off with an oval race during CES 2024 at the Las Vegas Motor Speedway on January 11, 2024. The rest of the 2024 season will be announced during CES, to include a return in June to Monza, Italy to race at the famous Autodromo Nazionale Monza, so familiar to Formula One fans, next June.

“With a stellar group of enthusiastic students – undergraduate and graduate – along with outstanding faculty expertise, we’re well-positioned to reach for new highs in this season,” says Allen Yang, UC Berkeley Robot Open Autonomous Racing (ROAR) Director, who now assumes the role of Principal Investigator of the AI Racing Tech Team.

The team was founded in 2020 by Gary Passon at the University of Hawai’i, Maui, consisting then of students from his Autonomous Vehicle Technology course. In 2021, the team expanded to include faculty and students from other universities – UC Berkeley, UC San Diego, and Carnegie Mellon University in short order.

“We’ve been able to assemble an amazing group of universities and sponsors collaborating in one of the most technical and challenging international autonomous racing vehicle competitions in the world,” says Passon, who takes on a new role as AI Motorsports Race Principal at UC Berkeley. “Watch for us on the podium at the next IAC competition.”

“The Indy Autonomous Challenge looks forward to continuing to work closely with the AI Racing Tech Team to develop more advanced research projects and to create more opportunities for the automotive industry to strengthen their support of high-speed automation innovations under Berkeley’s leadership, of a team that has already accomplished so much,” says Paul Mitchell, President, Indy Autonomous Challenge.

“The end-to-end precision engineering across hardware and software required to survive this competition is as demanding as running a startup, and the students lead with extraordinary hard work and sacrifice,” adds C.K. Wolfe, Berkeley Engineering alum and ROAR program manager who has been with the team since Berkeley joined in 2021.

# UC Berkeley Autonomous Racing Team Sets New Road Course Record



featured from left to right Allen Yang UCB, Siddharth Saha UCSD, Gary Passon UH, Raymond Song UCSD, Tianlun Zhang UCB, Haoru Xue CMU, Wade Koglin UH, C.K. Wolfe UCB (Photo credit Jordan Esley, Indy Autonomous Challenge)

The AI Racing Tech Team led by UC Berkeley's Robot Open Autonomous Racing (ROAR) program achieved the fastest autonomous lap time ever recorded on the U.S. Road Course track, at 1 minute 27 seconds at the Putnam Park Road Course in Greencastle, Indiana on August 31. The team's custom Dallara AV-21 race car, which is considered the most advanced autonomous car ever built and valued at over a million dollars, broke the previous autonomous course record of 2 minutes 9 seconds.

The performance adds to a long history of successes for the most decorated U.S.-based AI Racing team in the International series of the Indy Autonomous Challenge (IAC), a DARPA-inspired competition designed to encourage the next generation of STEM talent and innovation.

The AI Racing Tech Team's record-setting performance was a triumph of developing novel sim-to-real learning tools and machine learning technologies to optimize the safe performance of an autonomous driving system, adapting in real-time to individual road courses with variations in terrain, configurations, and track characteristics. To put this accomplishment into perspective, the theoretical computational lowest limit for the fully optimized Dallara AV-21 car at Putnam Park Road Course is 1 minute 12 seconds.

"The sim-to-real transfer really pushed us," says S. Shankar Sastry, UC Berkeley professor, ROAR faculty director, and racing team advisor. "You design in-silico, train extensively in simulation, then see how the system behaves under the pressure of competition. Going 150 miles an hour really focuses the mind – and tests the resilience of the algorithms and neuro-symbolic design tools."

The AI Racing Tech Team is made up of artificial intelligence and autonomy researchers and undergraduate and graduate students at four universities: Carnegie Mellon University, the University of Hawai'i, and the University of California, San Diego, in addition to UC Berkeley. Last month's record-setting performance builds on the team's past racing successes, coming in second at the 2022 IAC at Texas Motor Speedway



and third at the Autonomous Challenge at CES 2023 in Las Vegas, in competition with eight other international IAC teams.

This record-setting exercise at Putnam Park serves as a training ground for two upcoming Challenge events: The Oval race at CES 2024 in Las Vegas, NV in January, and in June 2024 at the MIMO Road Course race in Monza, Italy at the famous Autodromo Nazionale Monza so familiar to Formula One fans.

This pioneering competition for extreme autonomous robotics signals a transformative era for industries grappling with the challenges of pushing automated systems to the limit and corner cases of design. The race environment mirrors the hardware challenges encountered in application domains such as aerospace, defense, and healthcare. These challenges also include expensive equipment, limited access, unknown conditions, and the need for safety and performance assurances.

“Extreme robotics needs provably correct performance guarantees, and the AI Racing Tech Team is among the first to deploy and experiment on these theories using full-scale race cars,” says Allen Yang, UC Berkeley FHL Vive Center Executive Director, ROAR Principal Investigator, and UC Berkeley racing team lead.

## UC Berkeley ROAR Racers Among Top Teams to Demo Next-Gen Autonomous Racecars at CES 2024



AI Racing Tech team members navigate the course from their computers as driverless cars compete on the track (CES 2023)

The University of California, Berkeley, Robot Open Autonomous Racing (ROAR) program, together with its multi-university partners comprising the AI Racing Tech team, will serve among three leading international teams to test out the next-gen Indy Autonomous Challenge (IAC) racecar. The updated world's fastest and most advanced autonomous racecar will be unveiled at CES 2024, held January 9-12 in Las Vegas, NV.

Three top racing teams from this year's IAC competition will test out the next-gen model, with its upgraded controls, perception sensors, qualified systems, and other improvements on the original Dallara AV-21 introduced in 2021. The manufacturer's Autonomous Vehicle (AV) series is based on the classic carbon-composite Indy NXT chassis – similar in size, weight, and performance to racecars Indy drivers have driven to victory, with one major distinction: no driver's seat. Instead, the cockpit is outfitted with specialized hardware and high-performance controls to provide complete driverless operation.

This high-stakes "sim-to-real" environment demands extreme autonomous robotics, designed to advance not only the future of automated transportation, but also other industries requiring the highest performance and safety assurances, such as aerospace, defense, and healthcare.

The AI Racing Tech Team is made up of faculty and students in AI and robotics at four universities: Carnegie Mellon University, University of Hawai'i, and University of California, San Diego, as well as UC Berkeley. The team's industry sponsors are HTC Vive, VIA Technologies, ByteTrade Lab, New Eagle LLC, Pratt Miller, ZblueSoftware, ADLINK, Luxonis, AVA Mobility, Point One Navigation, and Hitch Interactive.

"This close collaboration with industry – including hardware and software designers and manufacturers – is an unprecedented opportunity for our students and faculty to be part of the historic development of next-gen hardware and talent," says S. Shankar Sastry, ROAR faculty director and UC Berkeley professor of electrical engineering and computer science. "We look forward to setting new speed records with the advanced model as it rolls out."

"We are thrilled to have the ROAR Program on board as part of the IAC's AI Racing Tech team, paving the way for the future of autonomous driving," says Paul Mitchell, President, Indy Autonomous Challenge. "The team will have a chance to showcase their engineering prowess as they put the next-gen IAC racecar – the world's fastest autonomous racecar – to the test at CES 2024."



# AI Racing Leadership



**S. Shankar Sastry**  
Faculty Director



**Allen Yang**  
PI, ROAR Racing



**Gary Passon**  
Principal, AI Motorsports

## Advisors



**Jack Silberman**  
Triton AI, UCSD



**Francesco Borelli**  
Berkeley MPC Lab



**John Dolan**  
CMU Robotics Institute



**Koushil Sreenath**  
Advisor





# Center Research and Faculty Highlights





# ByteTrade Lab and UC Berkeley Partner on Web 3.0

ByteTrade Lab (“ByteTrade” or the “Company”), infrastructure provider for the decentralized and user-controlled web, and The University of California Berkeley (“UC Berkeley”) DeFi Research Initiative today announced a multi-year industrial partnership to jointly develop advanced decentralized computing and identification technologies.

The partnership combines ByteTrade’s commercial expertise with UC Berkeley’s academic resources, with the goal of accelerating Web3 technologies that can transform how users interact with the internet and financial services.

ByteTrade Labs CEO Dr. Lucas Lu said: “We are excited to partner with Berkeley’s renowned faculty and supremely talented students on building Web3 infrastructure. Our work together will use ByteTrade’s proprietary operating system tech to power projects in decentralized ID, decentralized privacy, and more.”

Dr. Allen Y. Yang, Founding Executive Director of Berkeley FHL Vive Center for Enhanced Reality and the Defi Research Initiative said: “The exponential growth of new technologies such as Web3 has offered opportunities for academia to innovate and also closely tap on the pulse of the industry on its most significant challenges. We are thrilled to bring this partnership with ByteTrade to Berkeley to continue this tradition in technology innovation. I believe the new Web3 computing infrastructure will onboard many suitable research programs to demonstrate its future efficacy and the importance on data privacy.”

ByteTrade was founded in 2022 to enable users to own their data again. To this end, ByteTrade plans to release a Web3 OS in 2023 that uses decentralized edge computing architecture to concurrently solve the consumer data storage, data privacy, and data-sharing bottlenecks, giving end users full control of their own private data.

The DeFi Research Initiative at UC Berkeley was founded in 2021 to promote research and education programs in the intersection of AI, Metaverse, and decentralized technologies such as public blockchains and smart contracts. We believe decentralized technologies will lay the groundwork for connecting the crucial human elements with future metaverse applications.





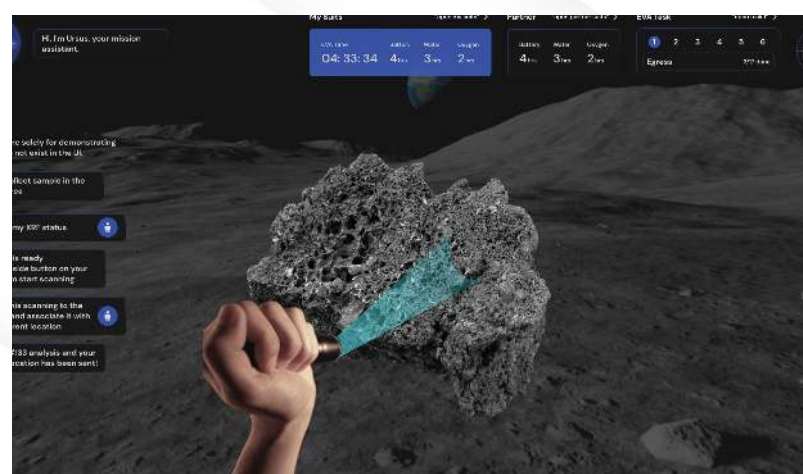
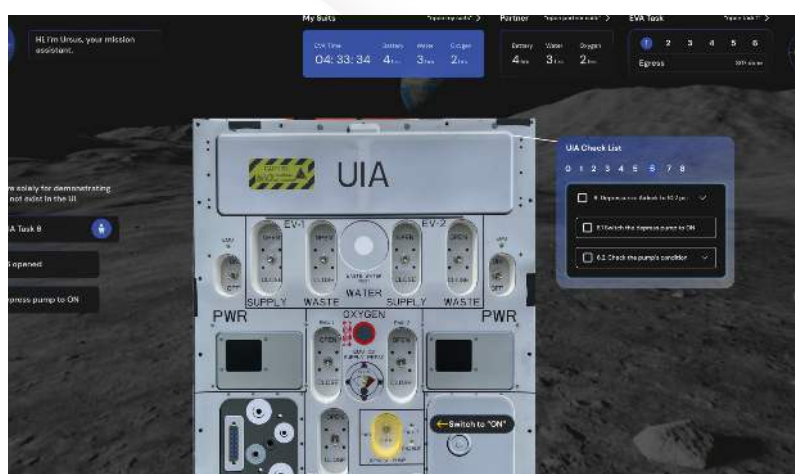
## Space Bear: AR User Interface Integrated with LLM for NASA SUITS Challenge

The Space Bear team is participating in NASA's Spacesuit User Interface Technologies for Students (SUITS) challenge. We were selected to test our design at NASA's Johnson Space Center in Houston in May. The challenge requires teams to design and develop an augmented reality (AR) interface to assist astronauts performing Extravehicular Activity (EVA) on Mars. The interface is designed to help astronauts navigate the Mars surface, perform tasks such as Egress, Ingress, Equipment Diagnosis and Repair, and collaborate with rovers to collect geological samples.

Our approach integrates voice control with LLM into the AR interface, simplifying multiple processes into direct, straightforward voice commands. With Space Bear, astronauts can control the entire user interface, request their biological information, and navigate and drop pins using voice interaction. In addition, the voice assistant can act as a mission assistant, combining visual cues and voice responses to analyze user input with the task library, matching the best solution for the user's needs. Through integration with LLM, astronauts can use natural language, eliminating the need to remember all the queries, for interacting with the AR user interface. This approach not only offers a hands-free solution but also makes the interaction more intuitive and swift.

### UC Berkeley Team at FHL Vive Center:

Erin Fan (UIUX Lead); Yani Shi; Zixun Huang (Algorithm Lead and Graduate Lead); Kathy Zhuang; Xiaowen Yuan; Rui Li; Jackson Gao; Franco Huang; Tianlun Zhang; Yukun Song (HMD Dev Lead), Zoe Zhou; Kai Mohl (Operations Lead and Hardware Lead, Leo Rover); Isaac Gonzalez (LMCC Lead and Undergrad Lead); Rojan Kashani (Hardware Lead, Wearable Devices); Aerial Amparo (Outreach Lead); Allen Yang (Faculty Advisor).



# Robust Digital-Twin Localization via An RGBD-based Transformer Network and A Comprehensive Evaluation on a Mobile Dataset

The potential of digital-twin technology, involving the creation of precise digital replicas of physical objects, to reshape AR experiences in 3D object tracking and localization scenarios is significant. However, enabling robust 3D object tracking in dynamic mobile AR environments remains a formidable challenge. These scenarios often require a more robust pose estimator capable of handling the inherent sensor-level measurement noise. Recognizing the challenges of comprehensive solutions in existing literature, we propose a transformer-based 6DoF pose estimator designed to achieve state-of-the-art accuracy under real-world noisy data. To systematically validate the new solution’s performance against the prior art, we also introduce a novel RGBD dataset called Digital Twin Tracking Dataset v2 (DTTD2), which is focused on digital-twin object tracking scenarios. Expanded from an existing DTTD v1 (DTTD1), the new dataset adds digital-twin data captured using a cutting-edge mobile RGBD sensor suite on Apple iPhone 14 Pro, expanding the applicability of our approach to iPhone sensor data. Through extensive experimentation and in-depth analysis, we illustrate the effectiveness of our methods under significant depth data errors, surpassing the performance of existing baselines.

## Ren Ng named 2023 Optica Fellow



CS Associate Professor Ren Ng has been elected as a 2024 Optica Fellow. Optica (formerly OSA) has inducted 129 members from 26 countries to the Society’s class of 2024 Fellows. Founded in 1916, Optica is a global society that works to advance the science and technology of light. Ng was honored “for pioneering work developing light field cameras, as well as seminal contributions in 3D view synthesis and human visual perception.” Ng was named a Sloan Fellow in 2017 and a Hellman Fellow in 2019, the same year that he received the Jim and Donna Gray Award for Excellence in Undergraduate Teaching of Computer Science.



## Claire Tomlin wins IEEE Mildred Dresselhaus Medal



EECS Department Chair and Professor Claire Tomlin has won the IEEE Mildred Dresselhaus Medal. The medal, named after the late Mildred Dresselhaus, is awarded to individuals who have made exceptional contributions to the fields of science and engineering, significantly impacting the IEEE's areas of focus. The award comprises a gold medal, a bronze replica, a certificate, and an honorarium. The selection process prioritizes individuals with a proven track record of impactful technical advancements, leadership in achieving meaningful goals, and a notable body of work reflected in publications, patents, or other evidence. Tomlin was honored "for foundational work in the design and verification of cyber-physical systems with

applications to safety in autonomous systems."

## Ruzena Bajcsy awarded Berkeley Citation



EECS Professor Emerita Ruzena Bajcsy was awarded the Berkeley Citation, the university's highest honor, at a special event on Tuesday, Sept. 5. The surprise announcement was made at the end of a special event to commemorate The Past and Future of Robotics and Machine Learning Based on 250 Years of Research Experience. Tsu-Jae King Liu, dean of the College of Engineering, presented the award. The Berkeley Citation is awarded to distinguished individuals whose contributions to UC Berkeley go beyond the call of duty and whose achievements exceed the standards of excellence in their fields. Bajcsy, whose storied career spans over 50 years, conducted seminal research in the areas of human-centered computer control, cognitive science, robotics, computerized radiological/medical image processing, and computer vision. Among her numerous awards and firsts, Bajcsy was the first-ever woman to receive a Ph.D. in electrical engineering in the United States. She is renowned for

her intellectual leadership, tireless work ethic, and inspiring approach to research and mentorship. Bajcsy is widely considered the foremost role model of generations of educators and researchers in computer science and engineering.

## Join Us!

With your generosity, the potential of our faculty and students are limitless. for more information on how to support education and innovation initiatives with the Vive Center, please contact:

Allen Yang, Executive Director, [allenyang@berkeleye.edu](mailto:allenyang@berkeleye.edu)

## ROAR Support Fund

The global raace to make vehicles more intelligent, safer, and more environmentally friendly has created a perfect playground for artificial intelligence research in complex, real-world conditions. The Berkeley ROAR program was created by EECS and mechanical engineering faculty to tackle challenging problems, including optimizing AI under extreme conditions (like high speeds and off-road) and collecting real-world data on complex AI systems to design for better performance and lower costs.

Your gift supports innovation and helps raise awareness of breakthrough AI applications by helping our students compete at the highest level of AI racing against the best university teams from around the world. It also supports students who will be future leaders of the growing industry, and helps us host the ROAR Academy, a STEM program for K-12 students.



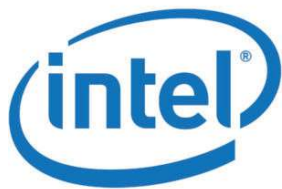
## Your gift makes a difference!

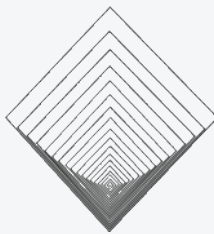






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