MIT Beaver Works Summer Institute

MIT Beaver Works Summer Institute 2023

VIRTUAL HIGH SCHOOL PROGRAM

Draper

Autonomous RACECAR Grand Prix

Autonomous Cognitive Assistant

Remote Sensing

AFOSR
AF Office of Scientific Research

Build a CubeSat

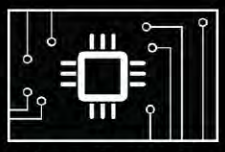
UAS-SAR

Serious Game Design and Development with AI

MITRE Project

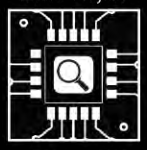
Embedded Security and Hardware Hacking

Data Science for Health & Medicine



Microelectronics and Hardware Development

MITRE Project



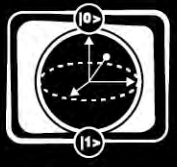
Back To bASICs

Cyber Operations

ONR Autonomous Maritime Engineering Project

Autonomous Underwater Vehicle Challenge

MITRE Project



Quantum Software

AEROASTRO MIT | BEAVER WORKS Lincoln Laboratory | School of Engineering | CSAIL | MIT EECS

LINCOLN LABORATORY Massachusetts Institute of Technology | MITMECHE | Open Learning | School of Engineering

Massachusetts Institute of Technology

MIT Lincoln Laboratory

MIT Lincoln Laboratory / School of Engineering Beaver Works

MIT Beaver Works Summer Institute

Dear Friends, Family, and Engineering Enthusiasts,

This is our 2023 Beaver Works Summer Institute brochure. We are we excited to again offer courses back in-person, and are continuing to provide several of our most popular classes in an online-only format. Our in-person courses will not be residential and as we work with MIT, we will be announcing which programs those will be. We are looking forward to watching our students push themselves beyond expectations and accomplishing great things.

The MIT Beaver Works Summer Institute is a rigorous, world-class STEM program for talented rising high school seniors. BWSI started in 2016 with a single class and has grown exponentially since. The 2022 program featured thirteen project-based, workshop-style courses: Autonomous RACECAR Grand Prix, Autonomous Air Vehicle Racing, Autonomous Cognitive Assistant, Autonomous Underwater Vehicle Challenge, Data Science for Health and Medicine, Build a CubeSat, UAS-Synthetic Aperture Radar (UAS-SAR), Embedded Security and Hardware Hacking, Design of Assistive Technology, Remote Sensing for Disaster Response, Serious Game Design with AI, Cyber Ops, and Quantum Software.

The 2022 MIT Beaver Works Summer Institute was the biggest class ever thanks to the enthusiasm of our students, the dedication of our instructors, and the hard work of our team members. We leaned forward into creating more virtual programs that included more kits to send to students to use as part of their course projects. Courses like Build a CubeSat, and Design of Assistive Technology used kits to help students build and by building learn. It's been incredible to see the engagement and interest in these college-level courses from all the students, the teamwork and community this year was something the students will never forget.

In the coming years, we will integrate new programs into this initiative, and make the summer program content available broadly. We are supporting middle and high school STEM teachers who use our teaching materials to help better prepare their students for college and beyond. We will also help other universities and high schools create similar programs, working to build a network of institutes to collectively improve engineering education worldwide. While we missed seeing students in-person at BWSI in 2022, running virtual courses have helped accelerate the development of a more modular and portable course content that can be shared widely and have a greater impact on our leaders of tomorrow.

Thank you for the continued support of our program.

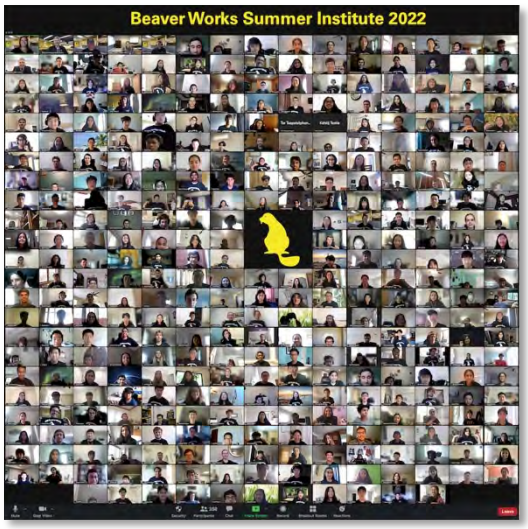
The MIT Beaver Works Summer Institute Staff

What is Beaver Works Summer Institute?

The MIT Beaver Works Summer Institute (BWSI) is a rigorous, world-class STEM program for talented students who will be entering their senior year in high school. The four-week program teaches STEM skills through project-based, workshop-style courses.

BWSI began as a challenge, a challenge to create a program to help students learn professional skills and advanced programming that was not available at the high school level! In 2016, we began with a single course offered to 46 students, a mix of local daytime students and out- of-state residential students. In this course, RACECAR (Rapid Autonomous Complex Environment Competing Ackermann steering), students programmed small robotic cars to autonomously navigate a racetrack, competing in teams.

The positive student reaction to our hands-on learning style led to the expansion of the program to include two new courses in 2017. To make sure students had the STEM background to participate fully in the three courses, the BWSI instructors developed online tutorials that students had to complete as a prerequisite for applying for the summer program. The new courses were Autonomous Air Vehicle Racing and Autonomous Cognitive Assistant. In 2017, 98 students from 49 high schools nationwide enjoyed BWSI.



We continued to grow both adding courses and students after switching to a virtual format in 2020 during the pandemic. In 2022, we offered 13 courses adding more autonomous systems, cyber-security, software and engineering courses. We have over 351 students participating in our program from over 200 high schools. It is one of most diverse group of students yet, with 43% young women. We also were able to support in-person program in on Kwajalein.

Our goals are to continue to find ways to provide project-based learning opportunities where ever possible. We are looking for new courses that motivate students in new areas of autonomous technologies to data science and engineering. We are always looking for collaborators to scale up the program nationally and internationally, offering our curriculum high school STEM teachers. Our vision is a broad network of BWSI-like programs that will help improve engineering education, and toward that goal, we will share our work and ideas with universities and schools worldwide.

Contact us at bwsi-admin@mit.edu for information on how to adopt this program into your school curriculum.

BEAVER WORKS
Lincoln Laboratory | School of Engineering

What is Beaver Works?

Beaver Works is a joint venture between MIT Lincoln Laboratory and the MIT School of Engineering that is envisioned as an incubator for research and innovation. Beaver Works facilitates project-based learning, a hallmark of an MIT education, and leverages the expertise and enthusiasm of MIT faculty, students, researchers, and Lincoln Laboratory staff to broaden partnerships across both institutions.

Beaver Works was created by collaboration *for* collaboration! We're located in Cambridge, Massachusetts, provides these facilities:areas for collaborative brainstorming; workshops and tools for fabricating prototype systems; and space for classroom-style instruction. Beaver Works allows students to address real-world problems and issues, engages students in hands-on learning, and demonstrates an effective strategy for teaching complex engineering concepts.

Beaver Works supports MIT student involvement in a range of research and educational pursuits, including two-semester, course-based capstone projects; joint and individual research initiatives; and Undergraduate Research Opportunities Program internships. Students involved in these projects develop innovative solutions to real-world problems and gain an exceptional experience in hands-on learning from world-class researchers.

In addition to the Summer Institute, Beaver Works is also extending project-based learning opportunities to local K–12 school children and increasing the diversity in STEM. We are part of the rich, outreach ecosystem that exists at both Lincoln Laboratory and MIT.

MIT Beaver Works Summer Institute

2023 Summer Program: Course Overview

The MIT Beaver Works Summer Institute ran the courses below in 2022 and we plan on running them all again, some will continue to be virtual and others will be in-person based MIT policy and space availability for 2023. We will make an official course announcement in early 2023. For more information on each course, see the following pages in this brochure.

Autonomous RACECAR Grand Prix

Beaver Works Summer Institute will offer students, each with its own MIT-designed RACECAR robot, the opportunity to explore the broad spectrum of research inautonomy; learn to collaborate, and demonstrate fast, autonomous navigation in a Mini Grand Prix to ***Move... Explore... Learn...Race!***

Autonomous Cognitive Assistant

Beaver Works Summer Institute will offer students an opportunity to learn about the cutting-edge in machine learning. Cog*Works consists of project-based modules for developing machine learning apps that leverage audio, visual, and linguistic data. Students will work with experts in these fields to learn foundational mathematical, programming, and data analysis skills, which will enable them to create their own algorithms and neural networks from scratch. Ultimately, they will design their own cognitive assistants.

Build a CubeSat

Beaver Works Summer Institute will offer students the opportunity to design, build,and test a prototype CubeSat. Students will explore all the major subsystems of a satellite and get hands on experience with mechanical, electrical, and software engineering. The class will use these new skills to demonstrate a real CubeSat science mission in partnership with scientists from Woods Hole Oceanographic Institution.

Microelectronics and Hardware Development

Beaver Works Summer Institute will offer a brand-new course on microelectronics and hardware development this summer. This course will provide students with an overview of how microchips, PCBs, and hardware systems are made and how they run the world. Students will receive hands-on experience on how to design and implement hardware systems using microcontrollers and develop useful electronics that can impact our daily lives. At the start of the summer, students will receive a basic hardware kit and can ask for additional items to be purchased so they can implement their own unique designs. No prior experience with hardware is necessary, and we encourage novices to participate.

Back To bASICs – MITRE Project

Beaver Works Summer Institute will offer a brand-new course on open source semiconductor design and fabrication this summer. This course will give students a fundamental and working knowledge of **the** building blocks of today's electronic world—knowledge that will benefit the student no matter what they decide to pursue academically. Students will receive hands-on experience on how to design and arrange semiconductors on a nanometer scale to perform a specific function. Students will start with a blank canvas (silicon substrate) and learn how to take a specification through the entire design process—including foundry manufacturability. Once complete, the student's design will be sent to a foundry for fabrication. Six months later we'll host a class reunion and the students will be provided a dev kit with their custom design permanently etched in silicon—a milestone to be treasured for a lifetime!

Cyber Operations

Beaver Works Summer Institute will help students learn and understand cyber security The program will introduce students to techniques for conducting full-spectrum cyber operations from: networking, system administration, cyber threat intelligence, network defense, digital forensics, malware analysis, and additional cybersecurity techniques. The course will culminate a digital field training exercise (FTX) event consisting of several mystery tasks derived from several phases of the course.

Embedded Security and Hardware Hacking – MITRE Project

Beaver Works Summer Institute will cover several cybersecurity topics with a focus on threats that are especially concerning for embedded systems. These topics include cryptography, embedded systems, software security, side-channel analysis, and fault-injection. This background will help prepare students for the summer course, during which they will design and perform security assessments of multiple implementations of an embedded system. They will learn the basics of embedded security and hardware hacking by designing a secure system and performing security assessments of classmates' designs to see who can find and fix the most security flaws.

Medlytics (Data Science for Health & Medicine)

Beaver Works Summer Institute will give students a chance to explore the exciting intersection of data science and medicine. Students will build a solid foundation in the fundamentals of probability and statistics, and learn the basics of coding and machine learning techniques through a series of online teaching modules. During the summer, students will work in groups to gain hands-on experience applying advanced machine learning and data mining to solve real-world medical challenges.

Quantum Software - MITRE Project

Beaver Works Summer Institute will offer students a chance to learn about quantum computing and algorithms. Students will learn fundamentals of quantum mechanics that make qubits unique and important to solving hard computational problems and develop algorithms that make use of qubit properties like superposition and entanglement. Students will be able to use quantum computing simulators to test their ideas andalgorithms and explore the incredible opportunities with this technology.

Remote Sensing for Disaster Response

Beaver Works Summer Institute Remote Sensing program will offer students the opportunity to explore the exciting intersection of data science and disaster response. The program consists of two components: (1) online course from February to May 2023, open to all interested and committed students; and (2) a four-week virtual summer program. During the course, the students will learn to understand the basics of Python, Git, GIS, machine learning, and image processing through a series of online teaching modules. Students will explore real world datasets featuring disaster imagery from both satellites and aerial platforms. Students in this course will develop experience in an area of data science that is poised to play a critical role in understanding our world.

Autonomous Underwater Vehicles Challenge

This course will introduce students to the challenges faced by real-world ocean engineers in designing, building and programming autonomous underwater autonomous vehicles (AUVs). The culmination of the summer course will be an exciting test of true autonomy – the student AUVs will autonomously navigate a simulated underwater obstacle course, applying real-time decision making based on feedback from onboard sensors.

Unmanned Air System – Synthetic Aperture Radar

Beaver Works Summer Institute will introduce students to Synthetic Aperture Radar (SAR) imaging as they build and fly a radar on a small Unmanned Aerial System (UAS) and use it to image scenes around campus. Students will work in small teams alongside their instructors to gain hands-on experience building, integrating, and processing data from a radar to generate SAR images. Teams will compete to create the UAS-SAR capable of producing the clearest images possible.

Autonomous Air Vehicle Racing *(is not being offered this summer in 2023)*

Beaver Works Summer Institute will offer students the opportunity to explore some new areas of research and to design their own autonomous capabilities for UAVs (unmanned aerial vehicles). The students will work in teams to develop algorithms for deployment to an advanced quadrotor, the DJI/Ryze Tello Drone. They will use the Robot Operating System (ROS), popular open-source libraries, and custom algorithms to program the quadrotors to compete in an autonomous navigation event.

MIT Beaver Works Summer Institute

2023 Summer Program

Autonomous RACECAR Remote Challenge

Program Overview

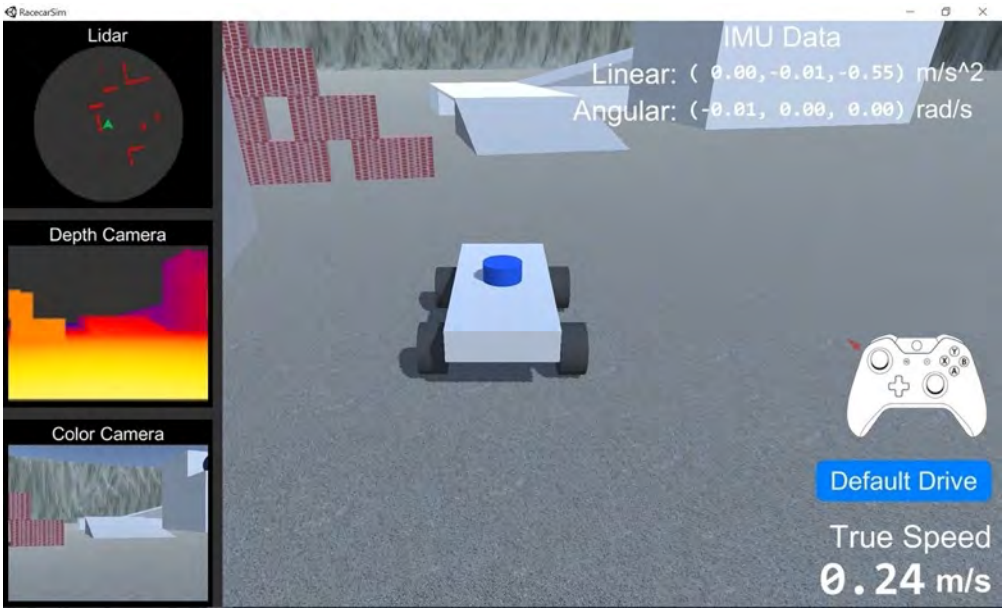
Driverless vehicle technology has been growing at an exponential pace since the DARPA Grand and Urban Challenges pushed the state of the art to demonstrate what was already possible. Commercial interest and aggressive development are being driven by Google, Toyota, Tesla, Continental, Uber, Apple, NVIDIA, and many other companies. There is no single technology or "killer app" available to solve the myriad perception, understanding, localization, planning, and control problems required to achieve robust navigation in highly variable, extremely complex and dynamic environments. This summer, Beaver Works Summer Institute will offer nine teams of five students, each with its own MIT-designed RACECAR (Rapid Autonomous Complex Environment Competing Ackermann steeRing robot, the opportunity to explore the broad spectrum of research in these areas, and learn to collaborate, and demonstrate fast, autonomous navigation in a Mini Grand Prix to ***Move... Explore... Learn...Race!***

This program consists of two components, all virtual: a prerequisite, online course from February to May open to all interested students and an intensive four-week virtual program from July 10 to August 6 for a select group of students. The prerequisite component gives students a background in the basic concepts and tools that will be used during the summer program. Students will learn a rich set of modern tools and techniques used in the world of robotics. Students will also have the opportunity to program a simulated RACECAR in Unity, which will allow them to develop skills and demonstrate the basic concepts without requiring a physical RACECAR.

Completing the prerequisite curriculum will prepare students to cover the topics of Control Systems, Computer Vision, Localization, Planning, and Navigation at a more advanced

level in the virtual summer program. The robotic platform used in the course is the RACECAR Model Nano (RACECAR-MN, which is capable of achieving speeds of 30 mph, utilizing data from real sensors processed with an onboard NVIDIA Jetson Nano embedded computer. The RACECAR-MN is a small-scale, MIT-designed robotic system. Beaver Works will lend out a complete RACECAR-MN hardware kit to students who are accepted into the program, to participate in the virtual RACECAR summer program. Students will receive all of the hardware and materials required to participate in the course from their own homes.

A team of experienced MIT researchers and instructors will give live lectures, covering material on autonomy fundamentals and expanding on advanced topic areas in the lecturers' expertise. A series of graduated exercises, hands-on labs, and weekly challenge demonstrations will be provided to lead students through the process of developing their solutions to the fundamental problems. Additionally, guest lecturers from leading researchers in the computer science, engineering, and autonomous vehicle academic and corporate communities will provide students with insight into emerging trends in these fields. The instructors will be available throughout the program to help with debugging.



RACECAR model navigating simulated Unity level, using synthetic sensor data

Prerequisite Course

The online component for the Autonomous RACECAR course contains important introductory material to provide students with the background required to successfully complete the four-week summer course. The online course will contain all the necessary information for downloading and installing any needed tools or software. This course will prepare students to work through both the introductory and more advanced topics and explore problems specific to autonomous vehicles during the summer portion of the program.

Introduction and Prerequisites

- Installing and running Python
- Installing and using the virtual RACECAR Unity environment
- Overview of the Ubuntu/Linux environment
- Learning the basics of Python programming
- Introduction to the Robot Operating System

Autonomous Vehicles

- Using the RACECAR model in the Unity simulation environment
- Learning about basic control systems and basic perception
- Studying fundamentals of computer vision using the OpenCV library
- Acquiring elementary navigation and planning concepts

Summer Virtual Course

The four-week summer program is based on the BWSI 2020 course, with additional online material that prepares students to begin the summer course at a more advanced level. The curriculum is being expanded this year to emphasize the use of computer vision and machine learning techniques in autonomous navigation.

Each day in the course will consist of a mix of lectures and hands-on projects to reinforce and apply the material. The tentative schedule for each week is listed below:

Week 1: Setup…

- Meet the Instructors and TAs
- Setup your computers for virtual lectures
- Setup your computer to run RACECAR software
- Setup and test your RACECAR-MN

Week 2: Move…

- RACECAR-MN system operation and sensors
- Basic sensing and perception
- Basic motion control and simple obstacle avoidance

Week 3: Explore…

- Color- and depth-image Computer vision techniques
- Visual and inertial navigation
- LiDAR navigation

Week 4: Learn…

- Mapping unknown environments
- Planning paths to achieve goals
- Navigating in dynamic environments

Week 4 (End): Final Project/Competition!
At the end of the program, you will take part in a final project or competition, as facilitated by the instructors. This will give you a chance to expand on what you knowand share what you've learned with your classmates across the country

MIT Beaver Works Summer Institute

2023 Summer Program

Autonomous Cognitive Assistant

Program Overview

Artificial intelligence research has achieved a dramatic resurgence in recent years, as innovation of novel deep learning and other machine learning tools has enabled machine performance surpassing humans in specific cognitive tasks. New records in “machine thinking” seem to be set almost daily. This summer, the BWSI is offering students a chance to learn and use the state-of-the-art machine learning tools in a program called Cog*Works: Build your own Cognitive Assistant. The program will guide students in learning and applying the foundational technologies of artificial intelligence for building cognitive assistants. Students who have successfully completed the online course will be considered for participation in the summer program in which teams of students will leverage professional cognition services (e.g., Amazon Alexa/Echo) and open-source tools in conjunction with their own machine learning tools to develop cognitive systems. The program will be divided into modules during which students will implement and explore algorithms in core areas of natural language processing and machine cognition. These capabilities will be composed to create end-to-end cognitive assistants that will compete against each other at the end of the program.

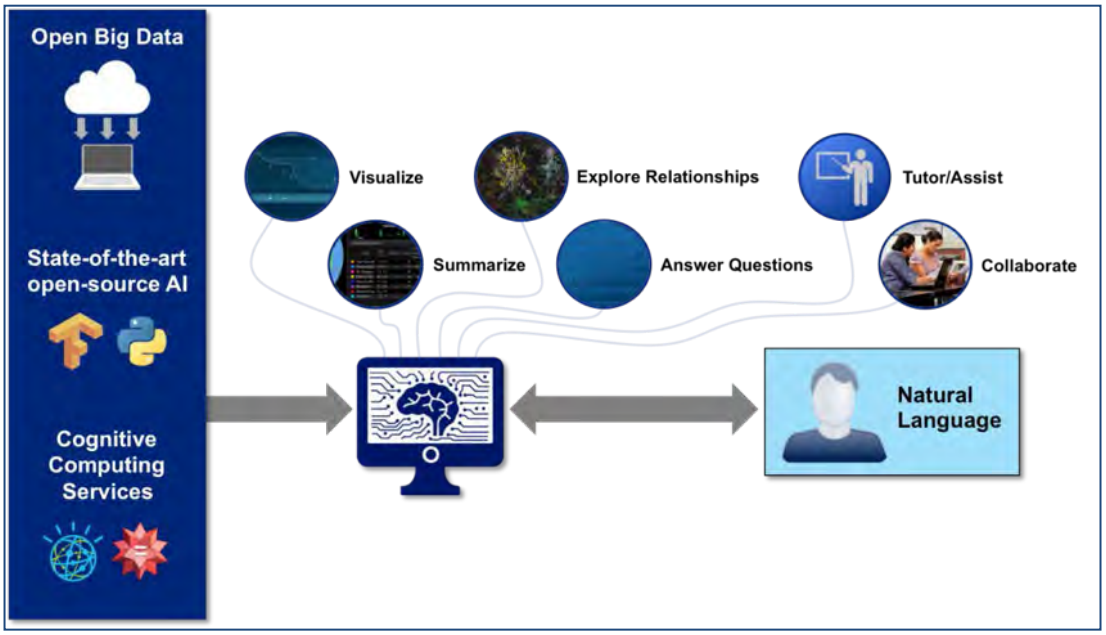
This program consists of two components: (1) online course from February to May 2023, open to all interested and committed students, and (2) a four-week virtual summer program for a small group of students, July 11 to August 7. During the course, the students will be trained to understand the basics of Python, Git, natural language processing, and machine learning through a series of online teaching modules. Students will build services that are both functional and fun. By participating in the online and/or onsite portion of the program, students will develop experience in an area of computer science that is poised to play a critical role in shaping future technologies and applications across many industries.

Online Course

The online component for the Cog*Works course will contain important introductory material that will provide students with the background required to successfully completethe four-week summer course. In addition to the introductory material, the online coursewill include more advanced machine learning–specific material that will enable students to begin exploring problems specific to cognitive assistants.

Online Course Topics

- Essentials of Python
- Python coding exercises
- Essentials of Numpy
- Applied Numpy coding exercises
- Perspectives on Machine Learning
- Introduction to Supervised Learning
- Introduction to Gradient-Based Optimization
- Write your own automatic differentiation code



Summer Course

The four-week summer component of the BWSI Cog*Works course aims to guide students through the process of creating their own cognitive assistants. Daily lectures from course instructors and guest speakers will solidify and expand upon the content from the online portion of the course. Students will collaborate in small groups to complete milestone projectsthat are based on their lecture materials. These projects will allow for creative customizationand enhancements from the students, and weekly awards will be given to the group(s) with the most "interesting" projects. Ultimately, these projects will serve as the components that compose an end-to-end cognitive assistant.

The following is a rough outline for the summer course:

Week 1: Audio

- Python/NumPy/Github review
- Essentials of audio recording and digitization
- Fundamentals of signal processing
- Pattern recognition in audio data
- Audio capstone project

Week 2: Vision

- Introduction to machine learning via linear regression
- Gradient-based learning and automatic differentiation
- Neural networks as universal function approximators
- Dense neural networks
- Convolutional neural networks for image classification
- Vision capstone project

Week 3: Language

- Introduction to natural language processing (NLP)
- Language modeling and comparing documents
- Embedding text in a semantically-meaningful way
- Recurrent neural networks
- Attention-based language models
- NLP capstone project

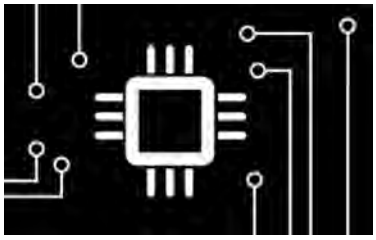
Week 4: Challenges

- Customize your own neural network

MIT Beaver Works Summer Institute

2023 Summer Program

Microelectronics and Hardware Development



Program Overview

The world runs on microelectronics, and they have transformed our modern world. You might have heard about the chip shortage in the news in recent years. But how are these chips made and what makes them so special? And how can we get started in using microchips to create our own unique electronic hardware systems right at home?

This brand-new course for 2023 will introduce students to the fundamentals of hardware system design and show how hardware developers approach problems and think like engineers. Students with no prior experience in hardware are encouraged to participate.

Students will be provided a basic hardware kit and can ask for additional items to be purchased so they can implement their own unique designs. This virtual course will aim to create an opportunity for students to be imaginative with their original hardware designs and enable them to create electronic systems that can impact our lives.

Online Prerequisites

These skills will be covered in the online course:

- Circuit basics
- Digital logic
- Transistor basics
- Arduino IDE (C++)

Summer Course

The objective of the summer is to have students develop their own unique microcontroller-based hardware system. During the first part of the course, the students will learn the fundamentals of using microcontrollers and ensure functionality of the basic kit. During the second part of the course, students will be challenged to come up with their own unique design, and they can request the purchase of additional hardware items to augment their basic kit. This class will also provide supplementary lectures on topics of interest to hardware developers and microelectronics designers & fabricators. These topics may include:

- How semiconductors work and a peek into a modern chip fabrication foundry
- Printed circuit boards and custom design process
- How solar panels work and how they are made
- How lasers, photodiodes, photodetectors, transistors, and other advanced electronic components work and how they are made
- Analog to digital and digital to analog convertor design
- How to analyze and present data

A rough timeline of the summer is as follows:

Week 1: Understand the basics of microcontrollers and storing data

Week 2: Demonstrate successful interface with sensor hardware in the basic kit

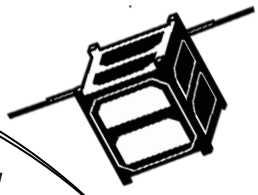
Week 3: Design and implement unique hardware designs by incorporating additional hardware components of the student's choice

Week 4: Continuation of Week 3, culminating in a final presentation

MIT Beaver Works Summer Institute

2023 Summer Program

Build a CubeSat



Program Overview

In 2023, this BWSI course is dedicated to space but grounded in science. The coursewill partner with Woods Hole Oceanographic Institution (WHOI) to tackle a real-world ocean science mission. Based around a 1U CubeSat (10 cm x 10 cm x 10 cm), the four-week course will guide the class through the design trades, assembly, and testing of a CubeSat with an imaging payload. The program will consist of two components. The first is a series of online courses teaching the basics of satellite development coupled with computer-driven exercises that will allow the class to perform key design trades for the mission involving communication, power generation and usage, size, mass, and performance. The four-week summer program will review the key points from the online course and add in lessons on how to handle and test hardware before assembling and testing a working CubeSat prototype. During the summer course, students will work with Lincoln Laboratory staff and MIT graduate students to gain hands-on experience inbuilding a space system.

The progression of miniature electronics coupled with the availability of launch rideshares provides access to space for a wide range of organizations that weren't able to dream of such capability 20 years ago. The advent of the CubeSat standard by Bob Twiggs and Jordi Puig-Suari in 1999 opened up real, achievable access to space for student projects that allows for hands-on development experience for the next generation of scientists and engineers.

Online Course

The online component for the BWSI CubeSat course contains important introductory material toprovide students with the background required to successfully complete the four-week

Introduction and Prerequisites
- Why we go to space?
- Basics of rockets and orbital dynamics (using Systems Toolkit)
- Spacecraft subsystems

Satellite Design Work
- Spacecraft systems design trades
- The space environment
- Satellite engineering tools
- Laboratory safety

Summer Course

The four-week summer component of BWSI CubeSat will focus on building and testing spacecraft hardware. Daily lectures will review the basics with the students, and guest lectures on key spacecraft systems will be given. With hardware kits at home, students will split into teams to get hands-on exposure to hardware testing, assembly, and programming. Students will be mentored by Lincoln Laboratory staff, and MIT faculty and graduate students,and WHOI engineers and scientists.

The following is a rough outline for the summer course:

Week 1: "Space, The Final Frontier" Hardware Basics and Systems Engineering
- Space systems 101
- Basic hardware safety and handling
- Fundamentals of systems engineering

Week 2: Spacecraft Subsystems
- Testing and assembly of all subsystems
- Payloads and camera performance
- Communication and power
- Software, the glue that holds it all together

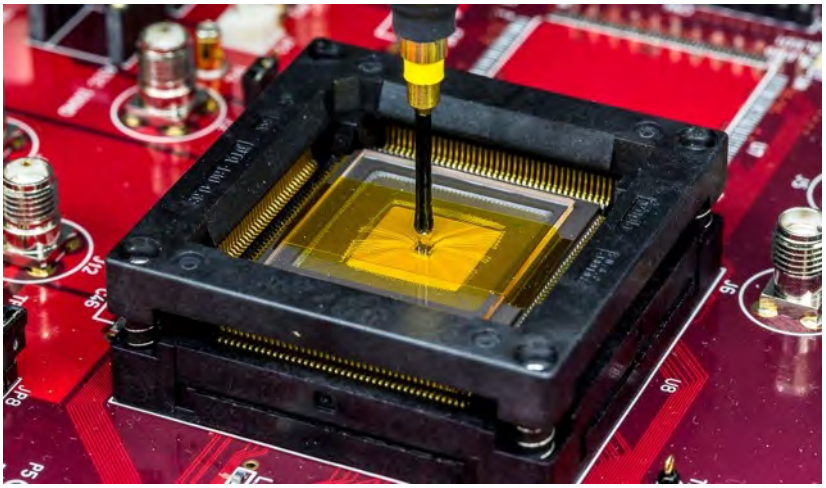
Week 3: "Houston We Have A Problem" Making It All Work Together
- Subsystem integration
- System and software testing
- Mission planning, attitude determination
- Debugging and testing a flight system

Week 4: Test Flights and Analysis
- Final functional testing
- Simulated "flight"
- Evaluate mission performance

BEAVER WORKS
Lincoln Laboratory | School of Engineering

Embedded Security and Hardware Hacking

MITRE Project



Program Overview

Computers long ago moved out from under our desks to being in almost every device in our lives. They can be found in safety-critical systems like automobiles, aircraft, and implanted medical devices, and are increasingly present in our lives with the rise of IoT, edge-computing, and wearables. To maintain our safety and privacy as these embedded computing devices have become a standard part of life, we need to ensure that devices are trustworthy and secure against bad actors. The small size and pervasive nature of these devices means that attackers often have access to the physical device they are targeting. As a result, we must now secure against attacks enabled by physical or proximal access in addition to traditional cyber vulnerabilities.

This course aims to start the education of the next generation of security engineers - teaching fundamental computer engineering in addition to cryptography, cybersecurity, and system security. Topics covered include microcontrollers and device architecture, low-level programming, protocol design, cryptography, software security, and hardware security. A hands-on approach gets students working with hardware during lab exercises. Students will also work in teams to design and build a secure system in an attack and defense style exercise, targeting other team's designs once theirs is completed.

This program consists of two components: an online course from February to May open to all interested students, and a four-week virtual summer program from July 10 to August 6 for a selected students.

Online Course

The online component for the Embedded Security and hardware hacking course containsimportant introductory material to provide students with the background required to successfully complete the four-week summer course.

The online course will consist of the following modules:

- Hardware
- Embedded Software
- Programming in Python
- C programming
- Assembly
- Cryptography Basics

Summer Course

The four-week summer program is based on the MITRE Collegiate eCTF, which challenges teamsof undergraduate and graduate students to design a secure system. Teams of BWSI students willdesign and implement their own secure systems based on a previous eCTF challenge and then hunt for security flaws in other teams' designs. The course will consist of a mix of lectures and hands-on labs and projects that reinforce and apply the material. The detailed topics for each week are listed below:

Week 1: Embedded Software

- Components of embedded systems
- Embedded software security basics

Week 2: Cryptography and Security

- Overview of cryptography and secure design fundamentals
- Introduction of the design challenge

Week 3: Hardware Analysis

- Hardware and interface analysis
- Introduction to side-channel analysis and fault attacks

Week 4: Hack!

- Teams will compete to see who can score the most points – earned by capturing virtual "flags", by demonstrating flaws in the target systems, and by fixing the flaws to secure the system.

MIT Beaver Works Summer Institute

2023 Summer Program

Medlytics

Program Overview

Data mining and machine learning have become ubiquitous in the age of "big data," and for good reason: advanced learning algorithms take advantage of ever-growing compute capacity and vast amounts of data to solve complex problems that can often meet or exceed human ability. These techniques are being embraced in nearly every sector including financial trading, cybersecurity, entertainment, advertising, autonomous vehicles, and of course health and medicine. The increasing adoption of electronic health records, mobile health apps, and wearable technologies continues to generate troves of rich, real-time, high-resolution data. This data is now being used to train algorithms to help physicians build prognostic models, conduct medical image analysis, and improve diagnostic accuracy.

In, the BWSI Medlytics program will offer students the opportunity to explore the exciting intersection of data science and medicine. The program consists of two components: (1) online course from February to May, open to all interested and committed students; and a four-week virtual summer program hosted by MIT for a group of 20-25 students from July 10 to August 6. The online course will help students build a solid foundation in the fundamentals of probability and statistics, and provide an introduction to coding and machine learning techniques through a series of online teaching modules. During the summer, students will work in groups to gain hands-on experience applying advanced machine learning and data mining to solve real-world medical challenges.

Online Course

The online component for the BWSI Medlytics course contains important introductory materialto provide students with the background required to successfully complete the four-week summer course. In addition to the introductory material, the online course will expose students to real-world data and machine learning techniques, and introduce some of the challenges and opportunities of combining the two.

Introduction

- Perspectives on the challenges of working with medical data
- Probability & statistics
- Introduction to coding: Python, Git, Jupyter

Data Science for Health and Medicine

- Defining a patient cohort
- Correlation and regression; noise vs. outliers
- Beginner machine learning: supervised and unsupervised algorithms
- Introduction to time series data analysis

Summer Course

The four-week summer component of Medlytics will take a deep-dive into the application of data analytics to structured data, physiological signals, and medical imagery. Prepared course material, case studies, and small-group projects will expose students to some of the challenges inherent to working with medical data and introduce them to state-of-the-art machine learning tools. Students will compete in weekly challenges and participate in a finalcapstone project from concept proposal to live demonstration.

The following is a rough outline for the summer course:

Week 1: Introduction to Diagnostic Research and Machine Learning

- Research questions, hypotheses and objectives
- Structured data processing and plotting in Python
- Classification evaluation and metrics
- Supervised machine learning
- Clinical Data Challenge 1: Diagnosing Hypothyroidism

Week 2: Signals Processing and Deep Learning

- Introduction to signals processing
- Fourier transforms
- Machine learning for time-series data
- Artificial neural networks
- Clinical Data Challenge 2: Classifying Sleep Stages

Week 3: Image Processing and Advanced Data Analytics

- Computer vision applications in medicine
- Texture classification using convolutional neural networks
- Transfer learning
- Clinical Data Challenge 3: Analyzing Mammograms

Week 4: Capstone Project

In the final week of the course, students will work in teams to propose, design, and demonstrate a health application prototype, leveraging the lessons learned from weeks 1-3.

MIT Beaver Works Summer Institute

2023 Summer Program

Remote Sensing for Disaster Response

https://www.af.mil/News/Article-Display/Article/116782/rescue-center-members-assist-with-saving-330-lives-in-tennessee/

Program Overview

Imagine coordinating a response after the chaos of a hurricane or the challenges of afamine lasting years, these big problems require big data to solve. With airplanes and satellites, we collect mountains of data of affected regions but who looks at this data? How do we turn this data into a physical response? The program's goal is for participants to explore, leverage, and transform open source information and imagery collected from drones, airplanes, helicopters, and satellites to generate actionable intelligence to support a disaster or humanitarian response. Students will be exposed to three main components:

(1) remote sensing modalities and data products,
(2) visualization and analysis technique with AI and machine learning (AI/ML), and
(3) using data for decision making. The program will explore tools and techniques using real world operational data from across the globe.

In 2023, this BWSI Remote Sensing program will offer students the opportunity to explore the exciting intersection of data science and disaster response. The program consists of two components: (1) online course from February to May 2023, open to all interested and committed students; and (2) a four-week virtual summer program. During the course, the students will learn to understand the basics of Python, Git, GIS, machine learning, and image processing through a series of online teaching modules. Students will explore real world datasets featuring disaster imagery from both satellites and aerial platforms. Students in this course will develop experience in an area of data science that is poised to play a critical role in understanding our world.

Online Course

Prior to the virtual summer course, students will be required to complete an online course which contains important introductory material. The online course will give the students a strong foundation required to successfully complete the four-week summer course. In addition to foundational introductory material, the online course includes discussion of different use cases and expose students to real world challenges and applications of the coursework.

Introduction and Prerequisites

Computer Science	AI/ML and Data Science	Real World Data
• Python	• GeoPandas and GIS	• Civil Air Patrol
• Git & GitHub management	• Intro to Deep Learning	• Social Vulnerability
• Machine learning ethics	• Image Processing	• Satellite Imagery

Summer Course

The four-week summer component of aims to guide students through the processing of designing experiments to evaluate primarily text-based content. Daily course material, casestudies, guest lectures, and small-group projects will expose students to challenges across technical domains.

The following is a rough outline for the summer course:

Week 1: Introduction to GIS

- Review of Python fundamentals
- Introduction to pandas, geopandas, geospatial information systems
- Working with open source tools and data

Week 2: Analysis of Geospatial Data

- Introduction to classifiers and data science
- Spatial analysis and networks
- Geospatial data sources and how to work with them

Week 3: Introduction to Image Processing

- Fundamentals of images and metadata
- Multispectral imaging
- Satellite images and analysis
- Deep Learning Image classification

Week 4: Decision Making

- Intro to optimization
- Data-driven decision making
- Final Project: Simulated Hurricane Emergency Management Response Exercise

MIT Beaver Works Summer Institute

2023 Summer Program

Serious Game Design and Development with AI

Program Overview

Combine modern methods in machine learning and game-like modeling to quantitatively analyze socially relevant technology and policy questions. This year's application will be tactical routing for self-driving ambulances. We will build an analysis framework in Python to study the technical, moral, and strategic opportunities that new technologies present to that application. There will also be an emphasis on learning the practical tools and skills for working on a professional software development team.

Historical

Game depicting physical and social influences on infant health circa 1900

Modern

2019 BWSI students participating in hurricane disaster simulation

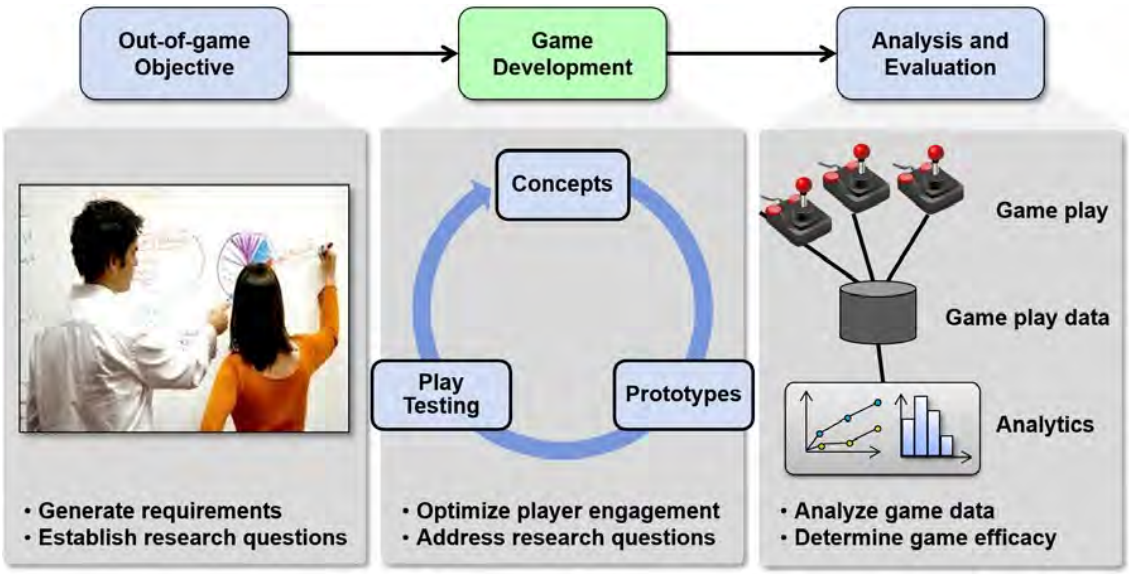
The recent interest in gaming as a method for acquiring data on human-machine interaction,decision making and human factors has helped establish an emerging area of research called“Serious Games”. Examples of Serious Games can include:

- Training for dangerous, expensive, or rare situations
- Evaluation of critical factors in decision making
- Cognitive assessment for injuries and diseases that affect the brain
- Systems analysis

Examples, such as Foldit, a game which adds to the body of bioinformatics knowledge by challenging users to fold proteins, can actually make a significant scientific impact. Output from the game helped scientists understand the inherent structure of a key protease in a viruswhich causes HIV-like symptoms. As personal computing platforms become more prevalent (who, today, doesn’t own a cell phone?) the opportunity to help tackle critical challenges by harvesting the brainpower of millions while generating fun is tantalizing.

The program will consist of a one-month, intensive dive into the key aspects of serious gamingincluding: experimental design, game design, and application development. The course will examine and categorize different types of games, how to extract useful data, an introductionto User Interface design, rules development and play testing.

Students will be provided a basic introduction to Agile management, and coached as they follow the timeline for development. Completing the course will provide students with an understanding of software development, project management, human factors, game design,and technical collaboration as well as the emerging fields of artificial intelligence and seriousgames.



Prerequisites:

- Python

Topics covered in this course:

- Systems modeling
- AI for gaming
- Ethics for AI
- Backend game development
- Game mechanics and input interfaces
- Human systems and user interfaces
- Data logging and data analysis
- Undead domain modelling
- Agile team and software practices

Course Outline:

Week 1

- Overview of serious games and their role in systems analysis and human factors
- Introduction to design of experiments
- Dev team formation
- Agile software development, healthy teams
- Backend software development startsWeek 2
- Backend software development continued
- Explore zombie-based automated medical response architectures
- Role and ethics of AI in game design and development
- Novel game extension to baseline game proposal
- Public health policy overviewWeek 3
- Modeling undead disease propagation
- Novel game extension development
- Human Systems Interfaces, User Interface Design, Visualizing Information,
- Data logging and analysisWeek 4
- Game code finalization
- Run the experiment (play the developed game) with data collection and analysis
- Game debut
- Final presentations and results

Expectations:

Students will focus on coding both a portion of the game back-end as well as self-designed extensions. With the assistance of instructors and Teaching Assistants, participants will learn about how Artificial Intelligence can impact the design of experiments and contrast with natural, human-centric game play. All students will participate in both back-end development, within a game-ready python framework, as well as coding of their own extensions. Introduction to supporting topics, including software development best practices for small teams, how to create user interfaces, bug and issue management, data visualization, public health and disease control, and technical presentation will be included.

Game Theme:

A single player game, which can also be played as by committee, describes the outbreak of a highly-contagious disease threatening a densely populated, urban area. Individuals who have contracted the disease have formed a zombie population which can be categorized into different architypes. These architypes may have different capabilities, propagation models, needs, and goals. The objective of the game will be to explore the efficacy of public health policies designed to deal with traditional disease outbreaks as applied to different infection models, methods and rates. Data analysis, such as the rate of infection compared against the implementation of different human or AI-enabled policy decisions, will provide an opportunity to visualize the results of different decision-making styles in remediating the humanitarian disaster.

MIT Beaver Works Summer Institute

2023 Summer Program

Cyber Operations

Program Overview

Beaver Works Summer Institute offers students a chance to learn and apply cyber security concepts in a pilot course titled Cyber Operations. The program will introduce students to techniques for conducting full-spectrum cyber operations from: networking, system administration, cyber threat intelligence, network defense, digital forensics, malware analysis, and to offensive security. Topics & themes are routinely emphasized in layered repetition. Beaver Works invites Guest Lecturers and Subject-Matter Experts from Industry to collaborate with and to contribute field experience to the world-class education. Students operate both individually and as teams to solve complex problems via the crawl-walk-run methodology. Students are empowered to lead their peers through communication and through shared responsibility & foster comradery. This will culminate a digital field training exercise (FTX) or capstone event consisting of several mystery tasks derived from several phases of the course.

Students are individually assessed based on successful completion of phases and several dimensions (attendance, leadership, teamwork, technical competence, & lecture participation) via GO or NO-GO. The Class is also assessed based on successful majority completion of the phases and may be granted the title of "*Beaver Operator*". Teams have an opportunity to demonstrate their technical-knowledge and to compete for the coveted "Capstone Challenge Coin". Individuals who embody qualities of technical-competence, significant supportive teamwork, and exemplary leadership may earn the mysterious & ultra-rare "Shadow Coin".

MIT Beaver Works Summer Institute

2023 Summer Program

Prerequisites (Technically-Intensive Course)**:**
Python*
Bash (Linux OS)
Ability to Read ASCII/Hex/Binary
**some prerequisites can be waiver-able at the discretion of the Course Instructor & Program-Staff*

Phases:
Pre-Phase 0 – Selection
Phase 0 – NETOPS Fundamentals
Phase 1 – DCO Basic
Phase 2 – DCO Advanced
Phase 3 – Intelligence
Phase 4 – OCO (Offensive Security)
Phase 5 – Capstone
Phase 6 - Recovery

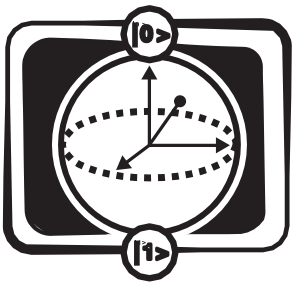
Fall:
Pending course feedback and popularity, Cyber Operations may run in the Fall 2023. Intensity is scaled-down based on available time, academic schedules, and content. Fall is an accelerated survey course in which Phases 0-4 are covered again. Those not selected for Summer are highly-encouraged to apply for this section as well. Phases are subject to change.

Spring:
Pending course feedback and popularity, intensity is scaled-down based on available time, academic schedules, and content as a preparation course for Summer. Emphasis is in Phases 0-2. Phases are subject to change.

MIT Beaver Works Summer Institute

2023 Summer Program

Quantum Computing
MITRE Project



Program Overview

In recent years, there has been an enormous surge of interest in quantum computing. Government, academic, and commercial organizations have spent billions of dollars attempting to create reliable, general-purpose quantum computers. These systems leverage the unusual properties of quantum mechanics to perform computations that could never be performed on conventional computers in our lifetime. Such calculations have a wide range of applications, including:

- Breaking certain cryptographic algorithms
- Engineering new materials
- Simulating how systems behave in extreme environments
- Finding new medicines that target specific diseases
- Building secure transmission channels that cannot be eavesdropped

How do quantum computers accomplish these bold claims? How could we use this technology to tackle our most difficult challenges? And how do programmers like you access it? In this course, we will explore the answers to these questions and help you unlock the ability to write quantum software and simulate quantum algorithms. Students should bring some basic programming experience and an open mind as we delve into a new computing paradigm.

This summer, join the Quantum Revolution and learn how to harness this disruptive technology!

MIT Beaver Works Summer Institute

2023 Summer Program

Prerequisites

The prerequisite knowledge and skills required to excel in the summer course will be covered in online materials available to students between February and June. This portion touches the following topics:

- Complex numbers
- Vectors & Matrices
- Bra-ket and tensor notation
- Digital information
- Endianness
- Digital logic
- Low- end high-level programming
- Software development

Outline

The objective of the summer is to develop the practicable skills needed to implement and study quantum algorithms in software. In the first half of the course, students will learn the fundamentals of quantum computing through live lectures interspersed with coding challenges. During this portion, the following topics are covered:

- Qubits and quantum gates
- Multi-qubit systems
- Quantum circuits
- Quantum protocols
- Quantum algorithms
- Quantum error correction
- Execution on quantum hardware
- Q# and Qiskit programming

In the second half, students will break out into teams of 3-4 to design their own software implementations of a quantum algorithm. Each team will select an algorithm from the literature, work together to understand how it works, develop a quantum program that implements it, verify the correctness with unit tests, analyze the computational resources required to run the program, and finally create a video explaining their work to a general audience.

MIT Beaver Works Summer Institute

2023 Summer Program

Autonomous Underwater Vehicles Challenges

Program Overview

Many of the final frontiers of exploration on Earth are underwater – the deep ocean, water-filled cave systems in the Yucatan Peninsula, and the subglacial lakes of Antarctica. Exploring the farthest reaches of these areas requires underwater piloted or semi-autonomous vehicles. Hydrodynamic pressure, water currents, darkness, curious sea creatures and slimy bacteria make underwater places difficult to navigate. True underwater autonomy is difficult to achieve, and even the most advanced piloted vehicles are frequently lost.

This course will introduce students to the challenges faced by real-word ocean engineers in designing, building and programming autonomous underwater vehicles (AUVs).

The culmination of the course will be an exciting test of true autonomy – the student AUVs will autonomously navigate simulated underwater obstacle course, applying real-time decision making based on feedback from onboard sensors.

Prerequisites

- Python
- Physics (any level)
- Linear algebra (any level)

Course Topics

- Vehicle control
- Sensor integration
- Data analysis
- Image processing
- Autonomy

Summer Course Outline:

Week 1
- Introduction to marine autonomy
- Setting up computing environment
- Foundational tools – Linux Command Line, Vim, C++, Visual Studio Code

Week 2
- Single-vehicle autonomous operations
- Mission analysis
- Writing your own sensor-driven behavior
- Individual project

Week 3
- Multi-vehicle autonomous operations
- Individual challenge problem
- Final challenge team formation

Week 4
- AUV Final Challenge execution

MIT Beaver Works Summer Institute

2023 Summer Program

Unmanned Air System - Synthetic Aperture Radar

Program Overview

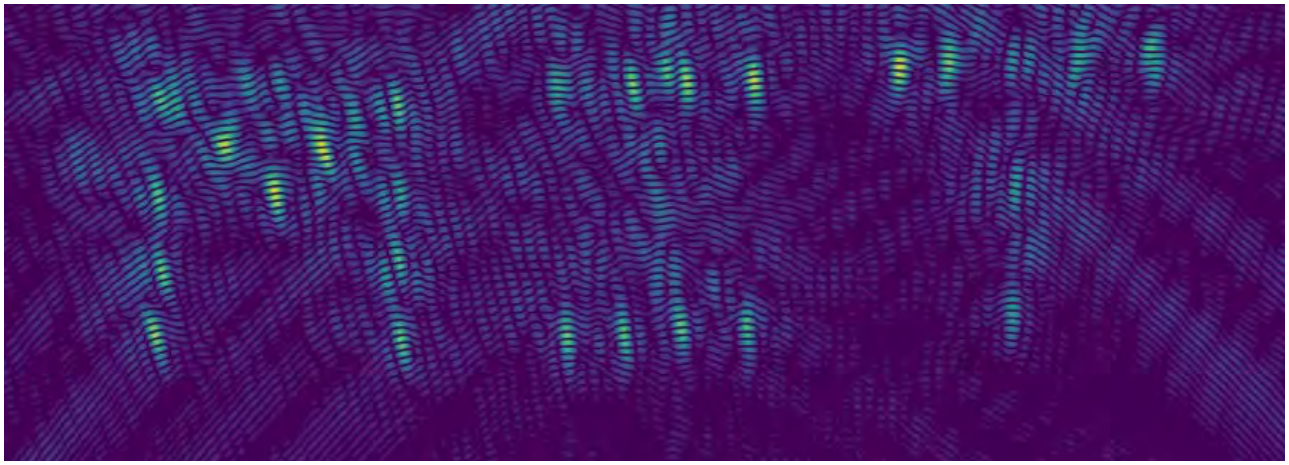
The recent explosion of unmanned air system (UAS) technology coupled with the miniaturization of electronics opens the door to countless applications and missions. UAVs can provide unparalleled views at sporting events, images of structures are not safely accessible to construction workers, and scenic aerial photography, all using low-cost cameratechnology. One can also envision many applications of small UAS-based radar solutions, ranging from day/night autonomous tracking of objects of interest in all–weather conditionsto change detection using radar imaging techniques to search and rescue.

In 2023, the BWSI Unmanned Air System – Synthetic Aperture Radar (UAS-SAR) program will offer students the opportunity to explore the field of radar imaging by simulating a radar on a small UAS and using it to image a virtual world. The program consists of two components: (1) a preparatory course from February to May 2023, open to all interested andcommitted students, and (2) a four-week summer program for a small group of accepted students from July 10 to August 6. The preparatory course will help students build a solid foundation in the fundamentals of radar, basics of Python programming, and collaboration tools such as Git. During the summer, students will work in small teams of 4 – 5 alongside instructors to implement command and control of a commercial radar, develop radar imagingsoftware, conduct simulated data collections, perform data analysis to identify and address problems, and extend their UAS-SAR system w/ novel capabilities.

UAS-SAR System in Operation

MIT Beaver Works Summer Institute

2023 Summer Program



SAR Image of "MIT" formed by Student Team

Online Course

The preparatory component for the BWSI UAS-SAR course contains important introductory material to provide students with the background required to successfully complete the four-week summer program. In addition to the introductory material, the online course will expose students to real-world radar data and UAV motion properties.

Introduction and Prerequisites

- Introduction to Python
- Introduction to Numpy, Matplotlib, and other required Python packages
- Git and GitHub collaboration tools

Radar

- Fundamentals of radar
- Radar system components
- Ranging with a radar
- Doppler effect

Summer Course

The four-week summer component of the UAS-SAR course will feature a mix of lectures from radar experts, team-based system development, and simulation-based experiments with mini-capstone milestones at the end of each week. Lectures w/ active student participation will reinforce basic radar concepts and dive deep into the principles behind radar imaging. Students will conduct simulation-based experiments by defining experiment objectives and plans, executing said plans, and performing analysis on the collected data. They will also learn how to interpret radar imagery in order to assess success and areas for improvement in their systems.

Week 1: Let's Build a Radar

- Python review
- Radar fundamentals review
- Implement radar command and control
- Milestone: Ranging and Doppler experiments w/ show-and-tell

Week 2: Let's Form an Image

- Introduction to SAR imaging
- Implementing SAR via back projection
- Rail-SAR experiments
- Milestone: Best SAR image challenge

Week 3: Up, Up, and Away

- Integration of radar onto UAS
- UAS-SAR data collections
- Refining SAR imaging algorithms
- Milestone: Best UAS-SAR image challenge

Week 4: Best Image

- Teams refine/improve their UAS-SAR
- Team develop novel capabilities for their UAS-SAR
- Teams compete to form the best image of a secret challenge scene

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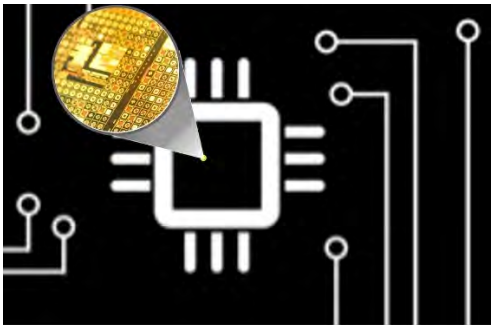
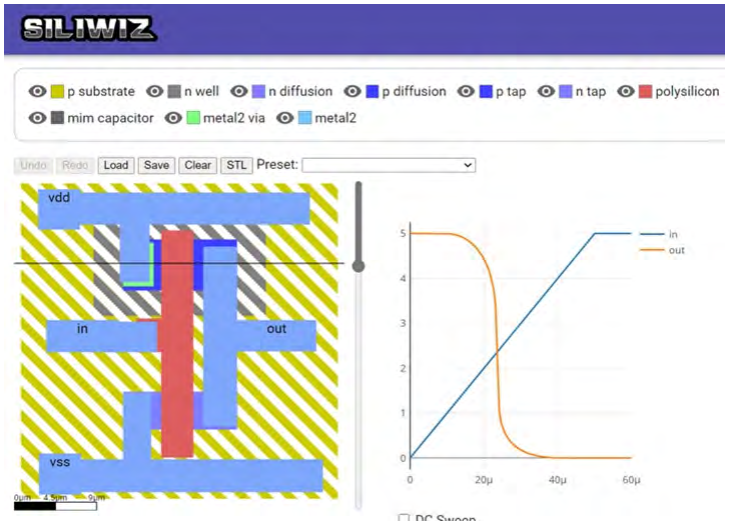
Back To bASICs – New



Program Overview

Beaver Works Summer Institute will offer a brand new course on open source semiconductor design and fabrication this summer. This course will give students a fundamental and working knowledge of the building blocks of today's electronic world—knowledge that will benefit the student no matter what they decide to pursue academically. Students will receive hands-on experience on how to design and arrange semiconductors on a nanometer scale to perform a specific function. Students will start with a blank canvas (silicon substrate) and learn how to take a specification through the entire design process—including foundry manufacturability. Once complete, the student's design will be sent to a foundry for fabrication. Six months later we'll host a class reunion and the students will be provided a dev kit with their custom design permanently etched in silicon—a milestone to be treasured for a lifetime!

There is overlap with the microelectronics course, including basic electronics, but this course will focus more semiconductor theory, MOSFET/CMOS fabrication. Course instruction by industry practitioners with context from academia and government.



This course does not have any prerequisites as part of the application process (other than deep interest in this topic!). The course will begin in June for accepted students with online instruction of tools and software that will be used during the July program. Accepted students will be provided with this information after April 30.

Week 1: Recap of online prerequisites

- Foundational info on PN junctions and depletion region

Week 2: Introduction to TinyTapeout and Makerchip tools

- Introduction to TinyTapeout and TL Verilog,
- Learn about and “dissect” previous designs

Week 3: Introduction to eFabless Tools

- Familiarization exercises and discussion of selected previous designs available online

Week 4: Student Project Development (teams of 3 or 4 students)

- Using commercial tools to design chips leveraging new knowledge
- DRC check and submit for fabrication.

MIT Beaver Works Summer Institute

2023 Summer Program

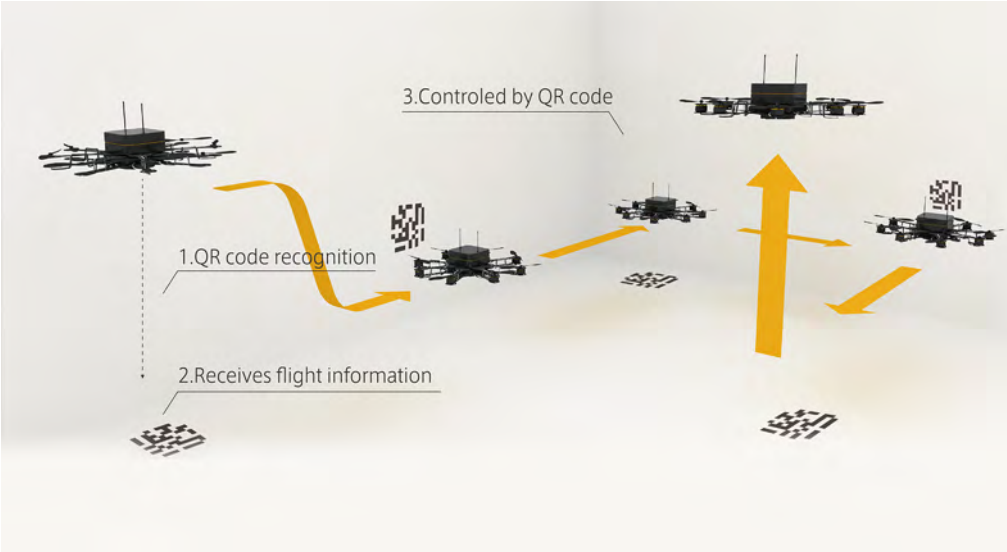
Autonomous Air Vehicle Racing

Autonomous Air Vehicle Racing will not be offered in the summer of 2023

Program Overview

Rapidly expanding unmanned aerial vehicle (UAV) technology has enabled a number of new application areas. The growth in UAV development is evident in the popularity of First-Person View (FPV) drone racing, and interest from companies, like Amazon and others, to develop fully autonomous aerial delivery vehicles. As UAV technologies mature, they open new and exciting areas for potential research. This summer, Beaver Works will offer students the opportunity to explore some of these new areas of research, and to design their own autonomous capabilities for UAVs. The students will work in teams to develop algorithms for deployment of a commercial quadrotor, the DJI/Ryze Tello drone. They will use Python, Robot Operating System (ROS), various open-source libraries, and custom algorithms to program the quadrotors. The summer course will culminate in a final challenge during which the students will apply the knowledge gained from the four-week program's projects and lectures to an autonomous navigation project.

This program consists of two components: an online course from February to May open to all interested students and a four-week summer program at MIT from July 10 to August 6 for a small group of students. The online component gives students a background in the course material, and provides a solid foundation in programming that will be critical when completing the more advanced topics of the summer course. Students will demonstrate basic implementations of control and autonomy after each unit of instruction. These lessons will build upon previous instruction to enable students to develop algorithms so that their quadrotors can autonomously navigate through their homes.



Conceptual UAV QR Navigation

Online Course

The online component for the Autonomous Air Vehicle Racing course will contain important introductory material that will provide students with the background required to successfully complete the four-week summer course. In addition to the introductory material, the online course will include more advanced, quadrotor-specific material so that students can begin to explore problems specific to autonomous aerial vehicles.

Introduction and Prerequisites

- Introduction to quadrotors
- Linear algebra
- Basics of matrix mathematics
- Introduction to probability and statistics
- Computer programming fundamentals

Autonomous Aerial Vehicles

- Flight geometry
- Actuators and control
- State estimation
- Sensing
- Basic control theory
- Computer vision
- Visual motion estimation

Summer Course

The four-week summer program will be structured to provide the students with projects and hands-on exercises. The program will apply and expand upon the online course material, leading to multiple competitive team challenges in autonomous UAV control. Each day the course will consist of a mix of lectures and hands-on projects to reinforce and apply the material. A team of experienced MIT researchers will provide the lectures, covering material that reviews UAV and autonomy fundamentals and expanding on advanced topic areas in the lecturer's expertise. Hands-on projects will enable the students to apply each lecture, working toward a capability for autonomous UAV navigation by using the provided drone and associated equipment. In addition, the course is lining up guest lecturers from among

leading researchers in the computer science, autonomy, and air vehicle academic and corporate communities to provide the students with emerging trends in these fields. Upon completion of the four-week course, the students will have developed an understanding of autonomous systems development; including controls, flight dynamics, navigation, and computer vision.

The summer course extends over three weeks of instruction and hands-on practice and one week of team challenges, culminating in the final UAV racing challenge. The detailed topics for each week are listed below:

Week 1: Quadcopter Basics

- Intro to Unix, Debugging, Git
- UAV Hardware & Safety
- Robot Operating System
- Localization & Reference Frames

Week 2: Computer Vision & Machine learning

- Intro to Computer Vision
- Edge Detection & Color Segmentation
- AR Tags & Intro to Probability
- Machine Learning & Applications in Computer Vision

Week 3: Planning & Control

- Intro to Control Theory
- State estimation
- Navigation and planning

Week 4: Final Challenge

The final week of the course will focus on hands-on team projects in autonomous UAVs and autonomous navigation challenges, leveraging the lessons learned from the first three weeks of the course.

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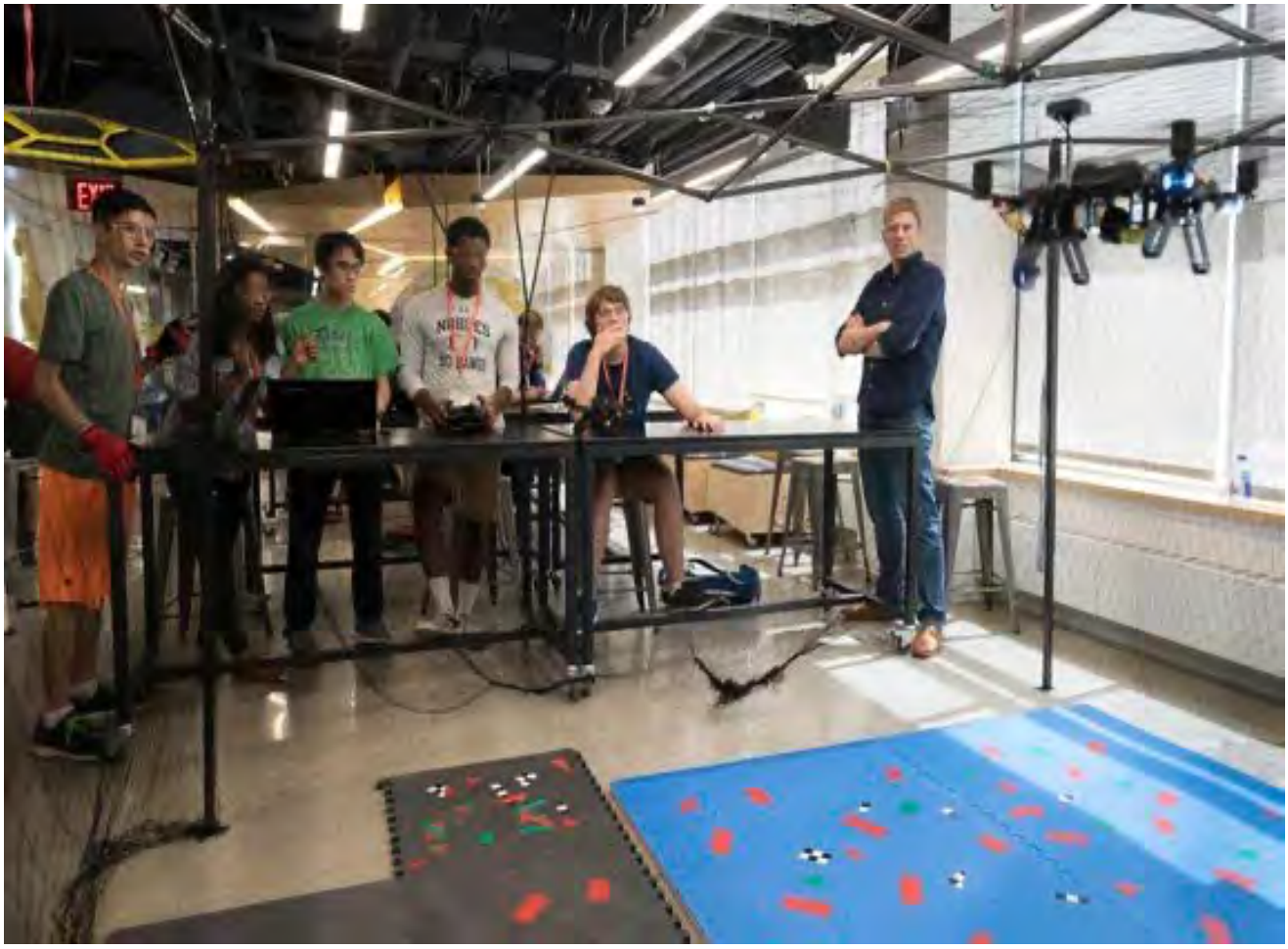

BWSI Online Program Registration Process for High School Student

In 2022, BWSI hosted all our courses virtually, in 2023 some will be in-person

- Autonomous RACECAR Grand Prix
- Build a CubeSat
- Design of Assistive Technology
- Embedded Security and Hardware Hacking
- Medlytics
- Quantum Software
- Back to bASICs – MITRE Project
- Cog*Works: Build Your Own Cognitive Assistant
- Cyber Operations
- Remote Sensing for Disaster Response
- Serious Games Design and Development with AI
- Underwater Autonomous Vehicle Challenge
- Unmanned Air System - Synthetic Aperture Radar
- Microelectronics and Hardware Development

To be eligible to apply to one of these summer programs, you must complete the BWSI Pre-requisite Online Education Program, designed to prepare students for the technically rigorous BWSI summer programs.

To participate in the online pre-requisite course, we have two tracks that can be followed:
For up-to-date links see our website: https://beaverworks.ll.mit.edu/CMS/bw/bwsiapply

Track 1: If you are a Teachers/Parents/Guardian/Mentors (TPGM) you can nominate student(s) with step below:

Step 1 for TPGM - Nominate the student(s) for access to the online course. Do you know a talented student that needs a challenge? This track is for you to nominate them for access. Courses do not open until 1 February - students will not have access until then but register students early so they can be ready to go. Nominations for registration is continuous to 31 March, after that date, students can still be nominated but will only be eligible to take the online courses.

Teachers, prior BWSI students, and teaching assistants (TAs) can also apply for online course access by using the same link that the students use to apply to the online program. After nomination, the student will be sent a link to register themselves for access to the free online course.

Step 2 Student Registration: Are you a student who is interested in these technologies? You can register yourself without a nomination to get online course access. Students will receive their unique ID number after they complete and submit their registration for the online course. Students will also need to self-register on Piazza to be able to participate in the course Q&A forums, all piazza information will be found in the online courses. All online courses will remain open for independent learners, even if they are not accepted into the July program

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Track 2: Students can register themselves for online pre-requisite course access

To register yourself for access to the online course (learn.bwsix.edly.io), see https://beaverworks.ll.mit.edu/CMS/bw/bwsiapply for current link

Once you have completed the form, you will be sent information to enrolling in the online courses.

BWSI Virtual Summer Program Application Process

Application for the BWSI Summer Program is separate from the online course application. The Summer Program application will be available Mid-March 2023, with decisions expected April 30 2023. The selection criteria for the Summer Program include, but are not limited to,

1. Demonstrated technical ability (determined through recommendation by school official andother supporting information, such as test scores, completed coursework, and grades collected in the application).

2. Demonstrated commitment to extracurricular learning via participation and completion of theonline course (participation/progress are tracked by the instructors).

Students must make significant progress in the online course by Summer Program application to ensure that they are ready and well prepared for participation in the BWSI programs. Students may participate in one or more of the online courses to determine which they are interested in, but note that the online courses are time-intensive, and we suggest down selecting to a single course as early as possible.

MIT Beaver Works Summer Institute 2023

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Autonomous Cognitive Assistant

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