MIT Beaver Works Summer Institute

MIT Beaver Works Summer Institute 2021

VIRTUAL HIGH SCHOOL PROGRAM

Autonomous RACECAR Grand Prix

Autonomous Air Vehicle Racing

Autonomous Cognitive Assistant

Remote Sensing

Build a CubeSat

UAS-SAR

Serious Game Design and Development with AI

MITRE Project

Embedded Security and Hardware Hacking

Medlytics

Data Science for Health & Medicine

MITRE Project

A.T.

Assistive Technology

CSIS

CYBERSECURITY FOR SOFTWARE INTENSIVE SYSTEMS

Cyber Security

Autonomous Underwater Vehicle Challenge

Quantum Software

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MIT Beaver Works Summer Institute

Dear Friends, Family, and Engineering Enthusiasts,

The brochure below includes all the information on the 2021 Beaver Works Summer Institute, virtual program! Due to the COVID-19 situation we had to cancel the onsite portion of our program this summer, but we are excited to offer several of our most popular classes in an online only format. We are looking forward this summer to pushing the boundaries of BWSI with our instructors and students. This format will be an important step in making the incredible BWSI content available to broader audiences.

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 2019 program featured ten project-based, workshop-style courses: Autonomous RACECAR Grand Prix, Autonomous Air Vehicle Racing, Autonomous Cognitive Assistant, Data Science for Health and Medicine, Build a CubeSat, UAS-Synthetic Aperture Radar (UAS-SAR), Embedded Security and Hardware Hacking, Designing for Assistive Technology, Remote Sensing for Disaster Response, and Hack a 3D Printer.

The 2020 MIT Beaver Works Summer Institute was a complete success thanks to the enthusiasm of our students, the dedication of our instructors, and the hard work of our team members. We initially planned to offer a dozen high school courses and three middle school classes onsite at MIT campus, but when COVID-19 prevented in person participation many of our instructors were able to quickly revamp their course content for remote instruction. We partnered with many high schools to recruit future engineers to participate in our program, and had the pleasure of working with 178 students from 101 high schools across the country for the seven courses offered this year. We also offered an independent project, piPACT, focused on technology for automated contact tracing of COVID-19 transmission which ran concurrently with the BWSI courses and 175 students from 128 high schools participated.

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 the movement to an online only BWSI this summer was a difficult decision, it will 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

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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 in 2016 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.

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.

In 2018, we grew again. This year, we had eight courses, adding five ones; each new course is developed with a requisite online tutorial. The 2018 class of BWSI boasted 198 young people from 106 high schools from across the country and Puerto Rico.

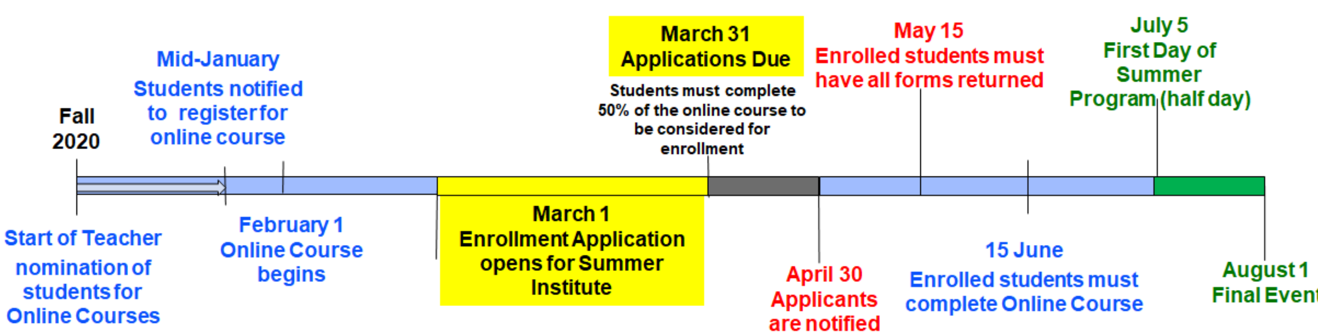
In 2019, we grew yet again and added two new courses to our eight. The 2019 class of BWSI grew to 239 students from 158 high schools across the country and Puerto Rico. As in the previous two years, we have had teams from Massachusetts and outside the United States participate in our RACECAR Grand Prix after they completed the course curriculum on their own.

In 2020, we offered 7 courses and 1 independent project virtually thanks to substantial efforts to shift the onsite program. BWSI partnered with many high schools to recruit future engineers to participate in our program, and had the pleasure of working with 178 students from 101 high schools across the country for the seven courses offered this year.

Expansion in the coming years will focus on developing new courses and working with collaborators to scale up the program nationally and internationally. We will continue to advise high school STEM teachers who want to incorporate the BWSI concepts and materials into their classrooms. 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.

BWSI 2021 Timeline of Program requirements.



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.

The Beaver Works center 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 schoolchildren. Among these offerings have been a robotics workshop for an all-girl FIRST (For Inspiration and Recognition of Science and Technology) LEGO League team, a hands-on camera-building activity for high-school girls, and LLRISE, a one-day workshop on radars for students in middle school.

MIT Beaver Works Summer Institute

2021 Summer Program: Course Overview

The MIT Beaver Works Summer Institute will consist of the following courses. 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 in autonomy; 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.

Assistive Technology

BWSI Assistive Technology will help students develop skill for product design, rapid prototyping, and product testing as they create technology solutions for people living with disabilities. We will tackle real problems faced by collaborating with people who have disabilities in your local community, and learn to work with the end users, stepping through the engineering design process together to come up with personalized, creative solutions.

Cyber Security in Software Intensive Systems

Beaver Works Summer Institute will help students learn and understand cyber security. Through projects and challenges will learn about network security and cryptography, learn how to use a fuzzer in finding and fixing software vulnerabilities, and how create a software service that can survive a disruption, and why social engineering and the usability of software are all parts of Cyber Security.

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 embedded software security, JTAG and UART probing, 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 and algorithms 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 2021, 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.

Serious Game Development with AI

This course will introduce students to the process of game design with the application of Artificial Intelligence to game play. Very specifically, the course will focus on unconventional approaches to understand and address real world problems (e.g., designing a game about zombies to study the effects of public health policies with respect to chemical or biological terrorist threats.) The program will consist of an intensive dive into the key aspects of serious gaming including: experimental design, game design, and application development. The course will examine and categorize different types of games, how to extract useful data, an introduction to User Interface design, rules development and play testing. 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.

Autonomous Underwater Vehicles Challenge

Learn basic hydrodynamics, vehicle control and image recognition. Build a custom underwater vehicle and program it to navigate an obstacle course autonomously.

Tentative Courses: (will be decided by March 2021)

Autonomous Air Vehicle Racing

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 Intel Aero Ready-To-Fly Drone. They will use the Robot Operating System (ROS), popular open-source libraries, and custom algorithms to program the quadrotors to compete in a racing event.

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.

MIT Beaver Works Summer Institute

2021 Summer Program
Autonomous RACECAR Remote Challenge

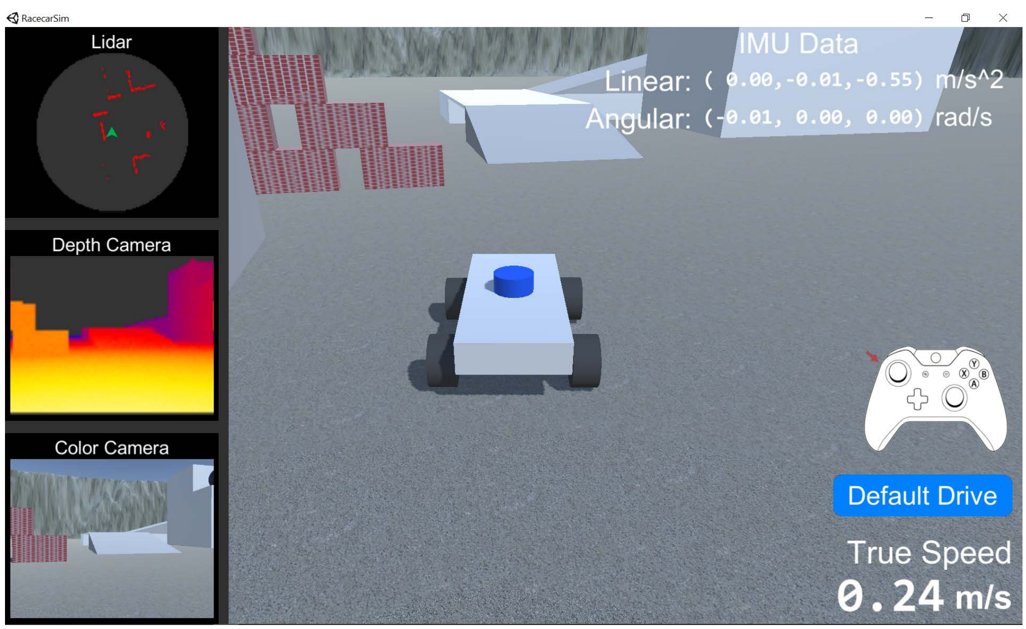
Program Overview

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 5 to August 1 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 know and share what you've learned with your classmates across the country!

MIT Beaver Works Summer Institute

2021 Summer Program
Autonomous RACECAR Remote Challenge
- Field Site Locations

Marshall Islands Program

MIT Lincoln Laboratory field site on the Kwajalein Atoll in the Republic of Marshall Islands (RMI) will host an in-person BWSI mini-RACECAR program for Summer 2021. This program is open to residents of Kwajalein and local RMI high school students.

This in-person program will take place as allowed under local RMI guidance on COVID-19 protocols.

Huntsville, Alabama Program

MIT Lincoln Laboratory Huntsville Field Site in Huntsville, AL will be hosting an in-person / hybrid course for local area students.

The in person program will take place as long if the rules for social distancing due to COVID 10 change. The virtual program will its place if the rules do not change.

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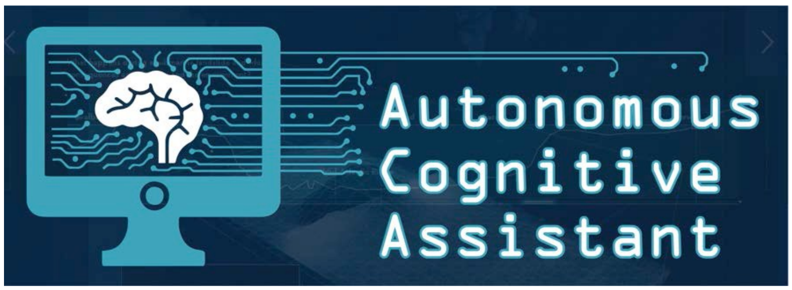
2021 Summer Program
Autonomous Cognitive Assistant



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 2021, open to all interested and committed students, and (2) a four-week virtual summer program for a small group of students, July 5 to August 1. 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

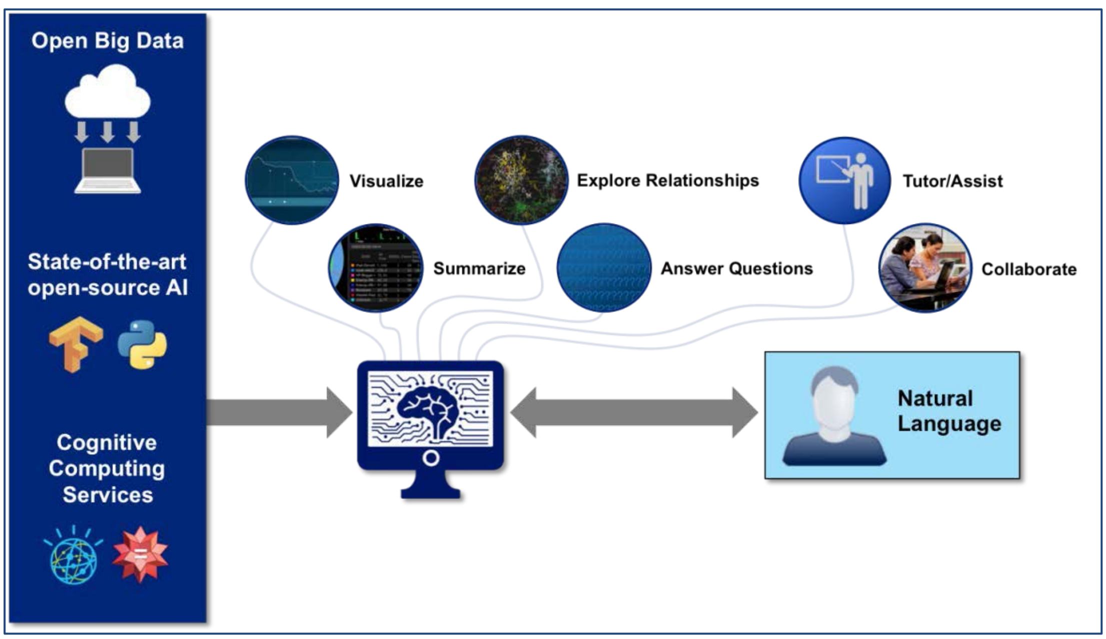
The online component for the Cog*Works course will contain important introductory material that will provide students with the background required to successfully complete the four-week summer course. In addition to the introductory material, the online course will include more advanced machine learning–specific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

Introduction and Prerequisites

- Introduction to Python
- Git & Github management tools
- Perspectives on machine learning

Autonomous Cognitive Assistants

- Advanced NumPy
- Simple image classification with Python
- Introduction to neural networks
- Introduction to Web Services
- Introduction to Microsoft Cortana©, and Amazon Alexa© services



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 projects that are based on their lecture materials. These projects will allow for creative customization and 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
- Audio recording, sampling, and encoding
- Discrete Fourier transforms and their applications
- Pattern recognition in audio data
- Audio capstone project

Week 2: Visual

- Review of machine learning concepts
- Coding your own autograd library
- Training dense neural networks
- CNNs and RNNs
- Visual capstone project

Week 3: Language

- Representing written language numerically
- Document comparison and summarization
- Training a language model
- Training word embedding
- Information retrieval
- NLP capstone project

Week 4: Challenges

- Customize your own neural network

MIT BeaverWorks Summer Institute

2021 Summer Program:
Assistive Technologies (AT)

Program Overview

There are many members of our communities who live with physical and cognitive disabilities, some of whom may be helped by assistive technologies (AT). However, these technologies often need to be customized for the individual, making it difficult to simply use off-the-shelf products. This course will help students develop skills in product design, rapid prototyping, and product testing in a user co-design manner to understand how to produce these kinds of solutions.

We will first go over product design processes and exercises in general, and then bring those skills into the context of working in the assistive technology space. In this class, a "co-designer" is a member of the community who is living with a disability and has an idea for a technology that might improve their quality of living by easing an activity that is frustrating. Using example problems and working with co-designers, we will learn how to conduct interviews to develop product requirements, and how to develop those requirements into prototypes. With early prototypes, we then look at how to iterate over different designs, taking user feedback into account in order to arrive at AT solutions that work well for the end-user.

Online Course

Before the summer course, students will be required to complete an online course introducing assistive technology, product design, and specific technical skills. The course will introduce students to key concepts that will be required on day one. The latter portion of the online course will be an open-ended design activity that will lead students to prepare a co-design proposal that will form the core of their application to BWSI.

The online course will consist of the following modules:

- What is assistive technology?
- Design thinking
- Design processes
- Technical skills development
- Co-design proposal formation activity

Summer Course

The four-week summer component of BWSI AT will give students a chance to use and further develop the skills they learned through the online course and to iteratively improve upon their proposal until it becomes a fully developed and usable prototype. The course will have online lectures, hands-on design exercises, small group technical mentorship, and project management activities culminating with students documenting and developing a custom AT solution for a community member with a disability.

A team of MIT researchers and students will help students through these materials and activities, using previous AT solutions developed at MIT as guiding examples and helping facilitate community member engagement. By the end of this course, students will have developed an understanding of the engineering process that it takes to build an AT solution, be able to identify engineering requirements from user interviews, be able to identify potential solutions and the skills required to implement the solutions, and build their own prototype solutions.

This course is being offered virtually for the first time during summer of 2020 and is being adjusted from the previous in-person offering. The focus of the technology skills component will depend on the needs of each student's project and is subject to change, but may include areas such as computer-aided design, 3D printing, and electronics. Past projects that have come out of a similar MIT class and hackathon have included all-terrain walkers, jackets that can be zipped up with one hand, a device to control smartphones using sip-and-puff breath inputs, and others.

Week 1: Product Design Introduction

Week 1: Proposal to Project Plan

- Overview of the co-design process: beginning to end
- Scoping a project with limited time and resources
- Working with people with different disabilities and cultures
- Interviewing users and identifying requirements
- Rapid prototyping using basic materials
- User testing for iterative improvement
- Agreeing on and articulating project goal (which person doing which activity in which context)

Week 2: Systematic Ideation and User-Testing Prep

- Starting lab notebook to document design
- Searching for off-the-shelf solutions
- Brainstorming ideas
- Examining proposed solutions and required skills
- Build and share low-fidelity proof-of-concept and user-testing plan

Weeks 3: User Testing to Create Prototype

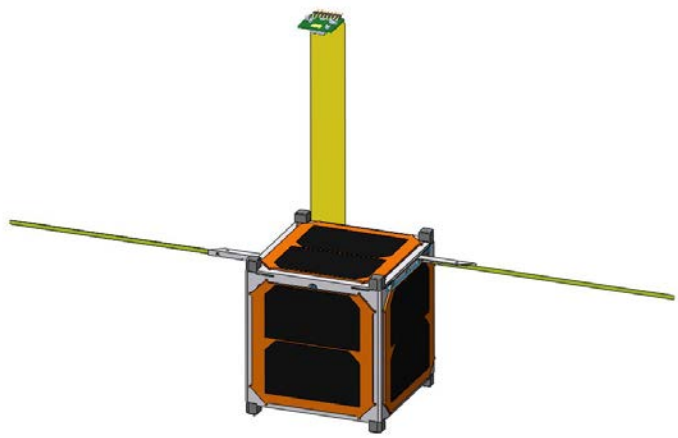
- User testing with low-fidelity prototypes
- Tweak, rebuild, refine, reevaluate
- Incorporate all testing into final design
- Order parts

Weeks 4: Build, Document and Share Prototype

- Build final design
- Prototype testing and evaluation by co-designers
- Finish documentation
- Prepare final report/presentation

MIT Beaver Works Summer Institute

2021 Summer Program
Build a CubeSat



Program Overview

In 2021, this BWSI course is dedicated to space but grounded in science. The course will 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 in building 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 to provide 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

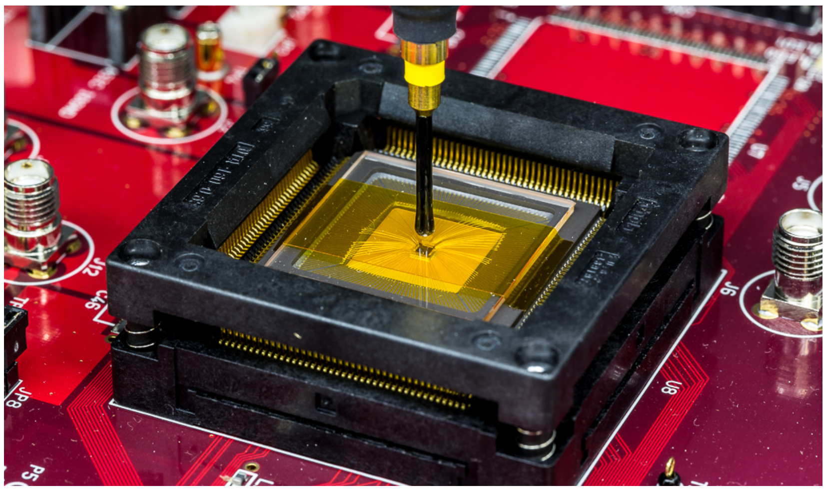
Week 4: Test Flights and Analysis

- Final functional testing
- Simulated "flight"
- Evaluate mission performance

MIT Beaver Works Summer Institute

2021 Summer Program

Embedded Security and Hardware Hacking – MITRE Project



Program Overview

Most of us are aware of our reliance on computers throughout our everyday lives, but what we typically think of as computers (from the servers that run our favorite websites, to our laptops and smartphones) are only the tip of the iceberg. Hidden just beneath the surface is a substantial and diverse group of computers referred to as embedded systems. Although the concept may be unfamiliar to many, embedded systems are pervasive and have existed for decades. They commonly work within larger pieces of technology, performing specific tasks, such as operating one element of a car, medical device, aircraft, or even a musical instrument. Their security affects the security of the larger system. And they are being hacked!

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 5 to August 1 for a select group of students.

The online course will introduce the students to several security topics with a focus on threats that are especially concerning for embedded systems. These topics include embedded software security, JTAG and UART probing, 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.

Online Course

The online component for the Embedded Security and hardware hacking course contains important 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 teams of undergraduate and graduate students to design a secure system. Teams of BWSI students will design 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

2021 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 (2) a four-week virtual summer program hosted by MIT for a group of 20-25 students from July 5 to August 1. 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

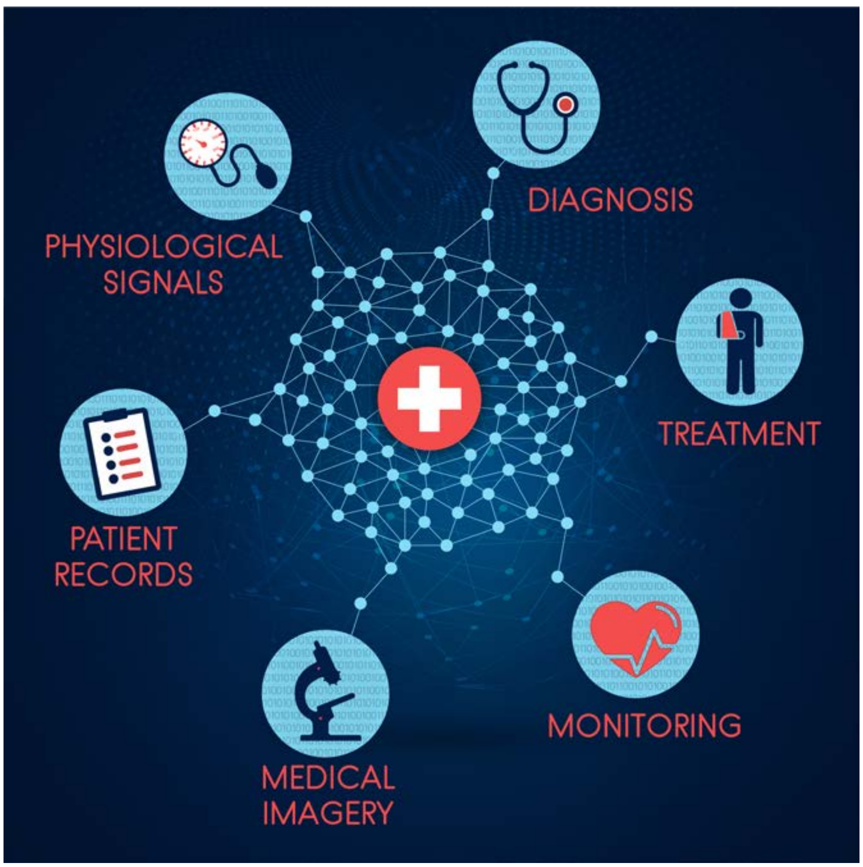
The online component for the BWSI Medlytics course contains important introductory material to provide students with the background required to successfully complete the four-week summer course. In addition to the introductory material, the online course will expose students to real-world data and machine 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 final capstone 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 BeaverWorks Summer Institute

2021 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 a famine 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) feature extraction from raw data, 2) classification via machine learning techniques, and 3) data products for decision makers. The program will explore tools and techniques using real world operational data collected from across the globe.

In, 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, 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
- Getting started with Python
- Git & GitHub management
- Machine learning perspectives

Data Science
- Advanced NumPy
- Simple image classification
- Introduction to Web Services

Real World Data
- Civil Air Patrol
- USGS Landslide Assessment
- Zanzibar Mapping Initiative

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, case studies, 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
- Research questions, hypotheses and objectives
- 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

Week 4: Image Classification and Decision Making
- Classify images based on contents
- Intro to optimization
- Data-driven decision making

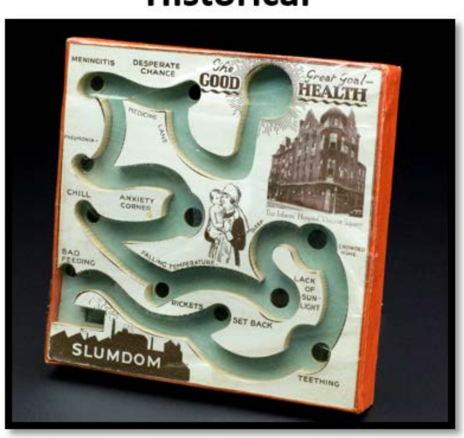
MIT Beaver Works Summer Institute

2021 Summer Program
Serious Game Design and Development with AI

Program Overview

This course will introduce students to the process of game design with the application of Artificial Intelligence to game play. Very specifically, the course will focus on unconventional approaches to understand and address real world problems (e.g., designing a game about zombies to study the effects of public health policies with respect to chemical or biological terrorist threats.)

Historical



Game depicting physical and social influences on infant health circa 1900

Modern

2019 BWSI students participating in hurricane disaster simulation

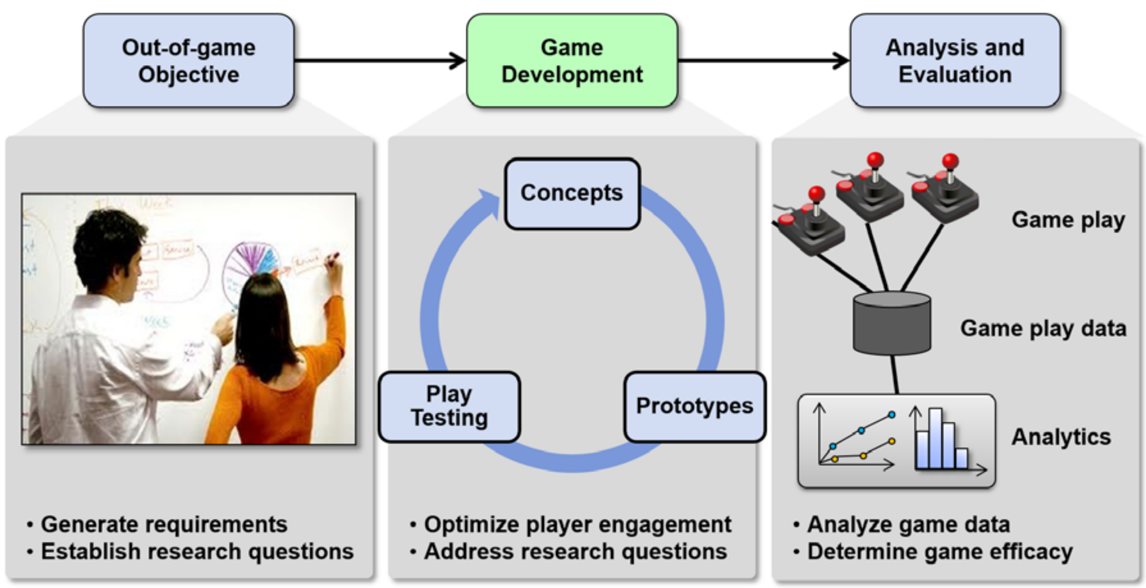
The recent interest in gaming as a method for acquiring data on human-machine interaction, decision making and human factors has helped establish an emerging area of research called “Serious Games”. Examples of Serious Games can include:

- 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 virus which 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 gaming including: experimental design, game design, and application development. The course will examine and categorize different types of games, how to extract useful data, an introduction to 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 serious games.



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 starts

Week 2

- Backend software development continued
- Exploring zombie-based contamination/disease propagation models
- Role and ethics of AI in game design and development
- Novel game extension to baseline game proposal
- Public health policy overview

Week 3

- Modeling undead disease propagation
- Novel game extension development
- Human Systems Interfaces, User Interface Design, Visualizing Information,
- Data logging and analysis

Week 4

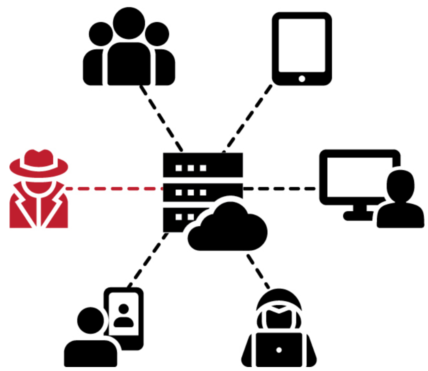
- Game code finalization
- Run the experiment (play the developed game) with data collection and analysis
- Game debut
- Final presentations and results

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

2021 Summer Program
Cyber Security in Software Intensive Systems



Program Overview

Beaver Works Summer Institute will help students learn and understand cyber security. Software is pervasive and everyday reliance on software-intensive systems by individuals, businesses, industries, and governments is only increasing. The many benefits of using software, however, come at a price: the cyber threats are real, and their impacts can be devastating. This course will introduce students to the fundamentals of cybersecurity and then go over real-world cybersecurity threats and students will be challenged to develop ways to mitigate them.

Winter Course

The online component for the Cybersecurity of Software Intensive Systems course runs from January to May and is open to all interested students. It contains important introductory material to provide students with the background required to successfully complete the four-week summer course. The following modules will be covered.

- The Bascis of Cybersecurity
- Programming in Python
- Programming in C
- Assembly
- Basics of Computer Networking
- Basics of Cryptography
- Introduction to Usable Security

Summer Course

The four-week summer program runs from beginning to end of July for a select group of students, and it is focused on a study of a distributed system providing a service to common users like you. The course will consist of a mix of lectures and hands-on exercises that reinforce and apply the material. Teams of BWSI students will design and implement their own aspects of this system to address typical cybersecurity threats that services encounter in real life. Each team will be given an opportunity to assess other teams' designs. The following is the outline for the summer course:

Course Outline

Week 1: Distributed Systems

- Distributed system fundamentals
- Dependability
- Design challenge introduction

Week 2: Cybersecurity Fundamentals

- Network security
- Applied cryptography

Week 3: Vulnerability Assessment

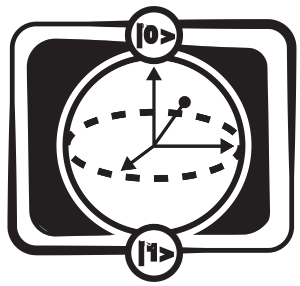
- Bug classes
- Fuzzing
- Reverse engineering

Week 4: Human Aspects of Cybersecurity

- Social engineering and usable security
- Finalize design and assessments

MIT Beaver Works Summer Institute

2021 Summer Program
Quantum Software − 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 comutations 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.

Online prerequisites

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

- Complex numbers
- Dirac (Bra-Ket) notation
- Basic linear algebra (vector and matrix math)
- Principles of classical computing
  - Binary numbers
  - Digital logic
  - Logic gates
  - Machine instruction
  - High-level programming languages
- Basic development with strongly-typed languages
- The Visual Studio Integrated Development Environment

Summer Course

The objective of the summer is to implement real quantum algorithms in quantum software. Students will learn the fundamentals of quantum computing through short lectures followed by coding challenges. During the fourth week, they will break out into teams to design their own software implementations of a quantum algorithm.

Week 1: Recap of online prerequisites and Intro to Quantum Concepts

- Qubits
- Superposition
- The Bloch sphere
- single-qubit gates
- Q#

Week 2: Fundamentals of Quantum Computing notationLO

- Quantum circuit diagrams
- The Quirk tool
- Qubit registers
- Complex multi-qubit superpositions
- Multi-qubit gates
- Entanglement
- Quantum interference

Week 3: Quantum Algorithms

- Toy algorithms (DJ, Simon)
- Quantum error correction
- Quantum communication
- Amplitude amplification (Grover's)
- Integer factorization (Shor's)

Week 4: Algorithm Implementation

- Teams will implement a quantum algorithm from its original paper in source code
- Correctness of the implementations should be verifiable, and it should efficiently use quantum hardware resources
- Students will present their work at the end of the week
- Team with the most efficient implementation will be the winner!

MIT Beaver Works Summer Institute

2021 Summer Program
Autonomous Underwater Vehicles

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 course materials will be organized into four modules:

- Module 1: Get Your Feet Wet: Get familiar with your UUV kit and tools
- Module 2: Get Your Bearings: Undersea sensing and sensor integration
- Module 3: Refine Your Stroke: Hydrodynamics and fin design
- Module 4: Explore the Undersea World: Autonomous operations

The culmination of the course will be an exciting test of true autonomy – the student AUVs will autonomously navigate an underwater obstacle course.

<u>Prerequisites</u>

- Python
- Physics (any level)

Course Topics

- Hydrodynamics/aerodynamics
- Vehicle control
- Sensor integration
- Data analysis
- Image processing
- Autonomy

Summer Course Outline:

Week 1
- Build Sea Glide vehicle kits
- Customize and build (3D print) fins and rudders
- Verify vehicle control models (how fast the vehicle travels in one direction, how the vehicle responds to turning a rudder or fin)
- Event 1: First swim

Week 2
- Sensor integration
- Review data and image processing concepts
- Integrate sensor processing algorithms into vehicle controller
- Event 2: Sensor-adaptive swim

Week 3
- Introduce types of challenges on course
- Develop autonomy algorithms (use data collected to make automatic decisions)
- Integrate autonomy processing into vehicle control
- Plan and program autonomy options
- Event 3: Obstacle field walkthrough for sensor calibration

Week 4
- Debug final autonomy logic by navigating examples of challenge course obstacles (e.g. navigate to and drive through suspended hoop)
- Event 4: Final Challenge!

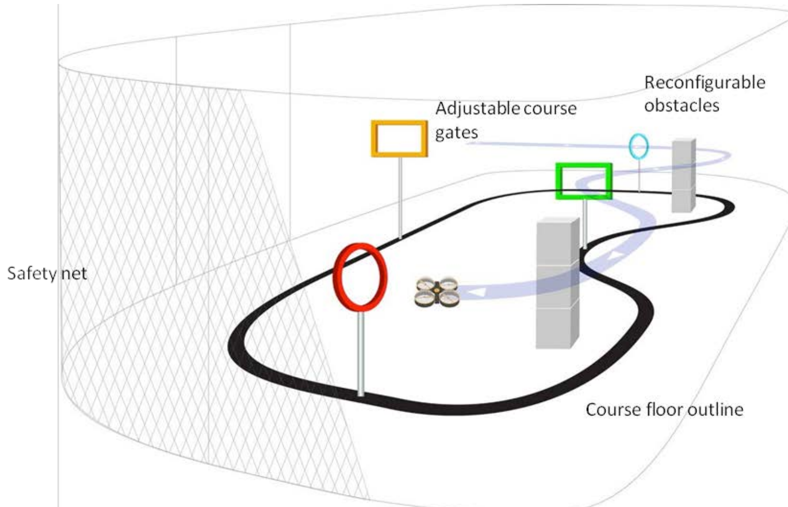
MIT Beaver Works Summer Institute

2021 Summer Program:
Autonomous Air Vehicle Racing *(Tentative)*

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 on a commercial quadrotor, the Intel Aero Ready-to-Fly Drone. They will use the Robot Operating System (ROS), various open-source libraries, and custom algorithms to program the quadrotors. The summer course will culminate in a competition at which the students will apply the knowledge gained from the four-week program's projects and lectures to a series of racing challenges.

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 5 to August 1 for a small group of students. The online component gives students a background in the course material, and provides a solid mathematical foundation 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 a quadrotor can autonomously navigate a UAV racecourse designed for the summer program.



Conceptual UAV Race Course

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

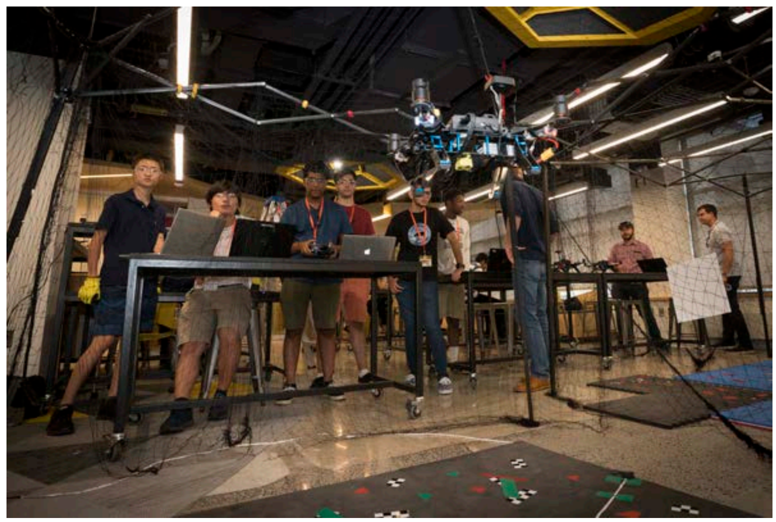
Summer Course

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 racing by using the provided drone and associated experimentation 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 course extends over four 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: Flight

- Quadrotor design
- Quadrotor dynamics
- Quadrotor components



Week 2: Vision

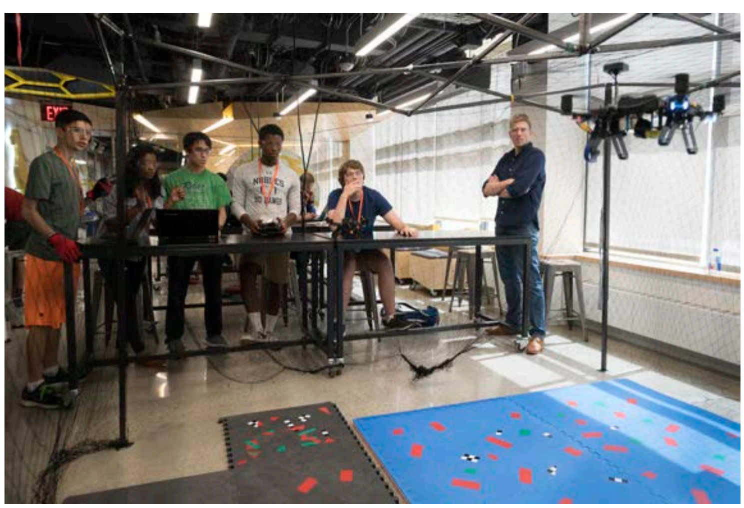
- Image formation
- Edge detection
- Image filtering
- Object detection

Week 3: Control

- Control systems
- State estimation
- Navigation and planning

Week 4: Racing Challenges

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



MIT Beaver Works Summer Institute

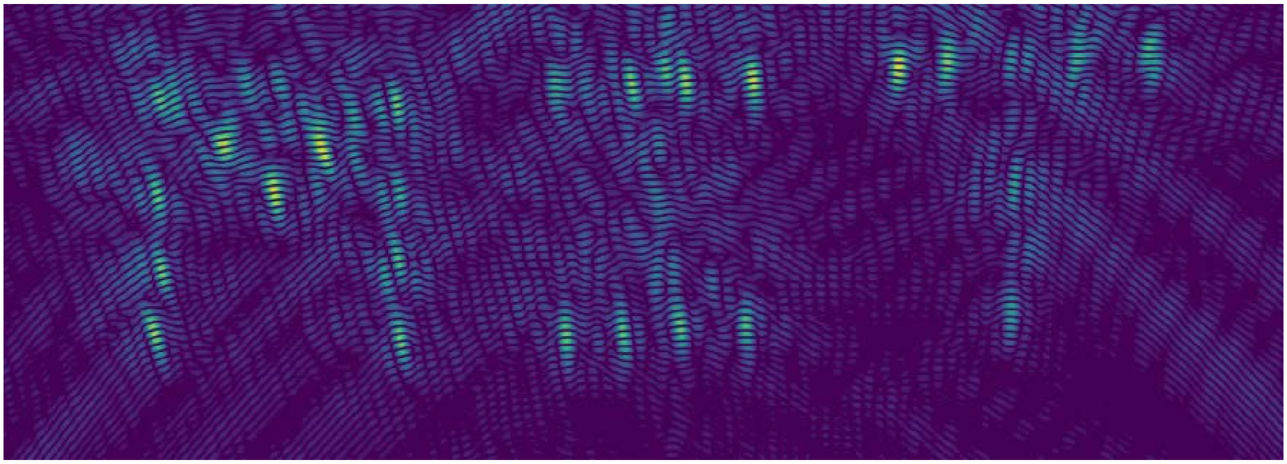
2021 Summer Program:
Unmanned Air System - Synthetic Aperture Radar *(Tentative)*

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 camera technology. 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 conditions to change detection using radar imaging techniques to search and rescue.

In 2021, 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 2021, open to all interested and committed students, and (2) a four-week summer program for a small group of accepted students from July 5 to August 1. 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 imaging software, 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



SAR Image of "MIT" formed by Student Team

<u>Online Course</u>

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

<u>Summer Course</u>

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 backprojection
- 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

BWSI Online Program Application Process for High School Student

The Beaver Works Summer Institute is pleased to announce our program offerings for virtual program for summer 2021. The following programs will be offered:

- Autonomous RACECAR Grand Prix
- Build a Cubesat
- Designing for Assitive Technologies
- Embedded Security and Hardware Hacking
- Medlytics
- Quantum Software
- Autonomous Air Vehicle Racing*
- Cog*Works: Build Your Own Cognitive Assistant
- Cyber Security in Software Intensive Systems
- Remote Sensing for Disaster Response
- Serious Games Design and Development with AI
- Underwater Autonomous Vehicle Challenge
- Unmanned Air System - Synthetic Aperture Radar*

To apply to one of these summer programs, you must complete the BWSI Online Education Program, designed to prepare students for the technically rigorous BWSI summer programs. To participate in the online course, a student must submit the following:

1. A nomination by a school technical point of contact (POC), typically a STEM teacher or school administrator familiar with the student's schoolwork and technical abilities. For step by step on the application process go to https://beaverworks.ll.mit.edu/CMS/bw/bwsiapply The nomination form for the teacher/recommender can be found at https://mit-bwsi.formstack.com/forms/bwsi_nomination_onlinecourse_2021

2. The application form for the student will be sent to them once the request comes in from the teacher/recommender. Once we receive your application if your application is approved, the student will receive an email containing a user ID and password as well as instructions on how to access the online course website.

Teachers, prior BWSI students, and teaching assistants (TAs) can also apply for online course access by using the same BWSI online course request link and filling out the form.

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 April 2021, with decisions expected Mid May 2021. The selection criteria for the Summer Program include, but are not limited to,

1. Demonstrated technical ability (determined through recommendation by school official and other 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 the online course (participation/progress are tracked by the instructors).

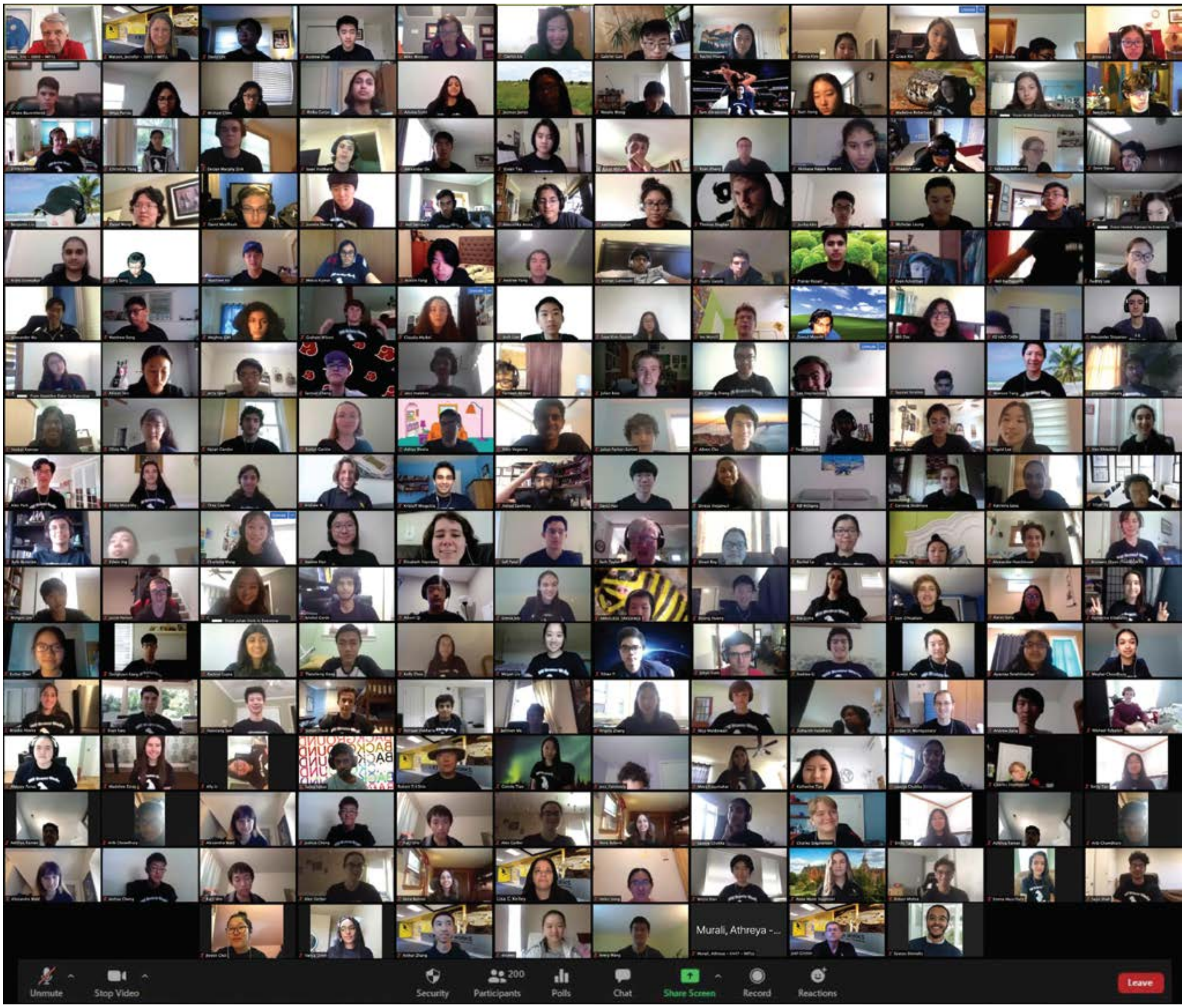
Students must make significant progress in the online course by Summer Program application to ensure that they are ready and well prepared for participation in the BWSI programs. Students may participate in one or more of the online courses to determine which they are interested in, but note that the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

*** Tentative course - decision on course will be in March 2021**

BEAVER WORKS
Lincoln Laboratory | School of Engineering

MIT Beaver Works Summer Institute

Class of 2020



MIT Beaver Works Summer Institute 2020

VIRTUAL HIGH SCHOOL PROGRAM

Autonomous RACECAR Grand Prix

BAE Systems Project
Autonomous Cognitive Assistant

Raytheon Intelligence & Space Project
Medlytics
Data Science for Health & Medicine

Sierra Nevada Corp Project
Build a CubeSat

piPACT
A BWSI Independent Project

MITRE Project
Embedded Security and Hardware Hacking

Remote Sensing

Serious Game Design and Development with AI

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