Academic Year 2020/21 MURI Research Projects

Below are the **MURI** projects to which full-time IUPUI undergraduate students pursuing their first degree can apply. If you want to be considered for one or more of the projects please update your CV/resumé and make sure it lists your contact email, current GPA, your major and minor, your year of study (first year, sophomore etc.), previous research experiences as well as your skill sets. Note, you are not expected to meet all the skills described for each project. When you have decided on the project(s) follow the application link below. You will be asked to enter some demographic information and to upload your CV. Your CV/resumé will then be forwarded to the corresponding project mentor(s).

To apply for a spot on a MURI team please **click here**

If you are accepted to a MURI team please know that you are required to work on the project for 25h/month from October 1 through April 30. In addition, you are **required** to attend the Student Research Orientation Day, which is tentatively scheduled for September 27, 2020 (time and location TBA).

Deadline for application is September 17, 2020. You can apply for a position on more than one project. However, you will be eligible to work on only one project. Once you have been accepted to a project please inform the mentors of other projects to which you have applied. Note that project mentors may decide to close applications for their respective project prior to that deadline once they have assembled their project team.

1. **Research and Development of 3D Bioprinters**

3D bioprinting is the utilization of 3D printing techniques to combine biomaterials and/or cells to fabricate biomedical parts that maximally imitate natural tissue characteristics. The objectives of this research project are to (1) develop a customized extrusion-based 3D bioprinter with mechanical extrusion system, and to (2) understand the process-property-performance relations in 3D printed biomaterials.

For students majoring in: Mechanical Engineering, Chemistry, Physics, Computer Science, Electrical Engineering

Required skill set: Mechanical design, electrical system design, materials synthesis, modeling and simulation.

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2. **Effect of natural fibers in the mechanical properties of starch-based plastic**

In this project, students will learn how to make bio-based plastic from potato starch and study the effects of adding natural fibers (straw, hemp, and banana peel) to the bio-based plastic.

For students majoring in: Students from all disciplines and majors are invited to apply. In previous projects, students from STEAM disciplines (Science, Technology, Engineering, Arts, Mathematics) have participated. This include Mechanical Engineering, Chemistry, Biology, Physics, Geology, Energy Engineering, Biomedical Engineering, among others.

Required skill set: Students are required to do experimental work preparing bio-based plastic from potato starch. They are expected to constantly review literature through databases available at the IUPUI library, perform mechanical and chemical characterization, write bi-weekly reports, prepare and deliver formal presentations, contribute to a journal or conference publication, and contribute to the content of the project's website (https://sites.google.com/view/makesomeplastic/home).

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3. Computational and Experimental Support for 3D Bioprinting

This project "Computational and Experimental Support for 3D Bioprinting" will train and provide practice to the undergraduate students in addressing the needs of this interdisciplinary technology of tissue engineering. Conditions permitting, the students will also be introduced to additive manufacturing (3D printing), as the preparatory step to bioprinting. The project makes intensive use of computer-assisted design of tissues and organs, and of virtual simulations of basic cellular processes.

For students majoring in: Biomedical Engineering, Computer Sciences or Engineering, Electrical or Mechanical Engineering, Physics, Pre-Med or Biology.

Required skill set: Some basic programming experience for one-two students Basic laboratory training for the others.

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4. **Data Analysis & Development To Support Push Notifications for Just-in-time Learning**

Do you have an interest in design, writing, development, or education? Do you desire to use your skills (or learn new skills) in computer programming, IT, technical writing, graphic design, or user experience design? EASEL is a project focused on conducting research in mobile software development. The 2020-2021 MURI Research Team will conduct research focused on experiential learning, just-in-time learning, user experience design, and REACT Native development to build on previous iterations of EASEL (Education through Application-Supported Experiential Learning). EASEL is a mobile platform designed to support students in all types of field-based experiences (such as interviews, internships, etc.). If selected, you and your peers will have an opportunity to learn about forming appropriate research questions and then participating in software design, research, and development to explore answers to those questions.

For students majoring in: Computer Information Technology, Computer Science, Mathematics, Technical Communication, Computer Graphics Technology, and/or Informatics/New Media.

Required skill set:

- Computer Information Technology & Computer Science students: Software development focused on Swift and Object-C, problem solving, Computer Programming (Javascript).
- Mathematics: Statistical analysis of previous study data.
- Computer Graphics Technology, Technical Communication, or Informatics/New Media Students: Human-computer interface design or interaction, graphic design, UX or usability testing knowledge and/or experience.
- Education students: personalized learning, secondary education, STEM education

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5. **Investigating the link between soundscape and noise levels of themed attractions to the experience of staff and customers.**

Themed entertainment spaces such as theme parks and museums created carefully crafted experiences which aim to transport customers out of their reality and immersing them into worlds outside their normal day to day experiences. Much development has been done by large themed entertainment companies and designers to create visual experiences that border on true and full immersion where the customer becomes a part of the story. As these experiences become more connected with multimedia experiences that use visual technology such as 3D projection, virtual reality, multi-device touch, and stereoscopic video experiences, music has also been incorporated into the background. However, the soundscape of an experience should not just include music, but also encompass good overall acoustic design that enhances the experience of the customer and staff.

The underlying goal of the research would be to establish a body of research that would better inform the creation of attractions in the future by providing sound measurements and questionnaire results from customers and staff about their experiences. This will be an interdisciplinary experience that fuses engineering, the arts, experimental design, statistics, and design with high profile locations that they can experience their research in. The project will include various themed attraction venues throughout the fall and spring semester in and around Indianapolis.

For students majoring in: Music Technology, Computer Graphics Technology.

Required skill set: Ideally, four students will be needed for this project. One student is expected to have a music technology / acoustics background for acoustic measurements. A second student is expected to have a themed attraction / CGT background to relate the sound to themed attractions. A third student is expected to have a strong experimental design and statistics background for the staff questionnaire survey. Lastly, a fourth student is expected to have a design or engineering background in order to study noise sources and analyze the acoustic signals.

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6. MXene qubits

Nanomaterials and nanotechnology are an essential part of our modern and future life. Nanotechnology covers almost all areas from creating faster and smarter devices that can work without the need for batteries to space travel and curing deadly diseases. In this project, students will be creating novel nanomaterials and understanding how fabrication and synthesis conditions can affect the final product's structural, optical, and electronic properties and potentially lead to scientific breakthroughs and discoveries of advanced solid-state devices.

This project involves hands-on work with high-temperature furnaces, wet-chemistry labs, centrifuges, and ultra-high-speed mixers. Students will use different elemental powders such as hafnium, titanium, molybdenum, tungsten, aluminum, carbon to fabricate two-dimensional nanomaterials. By utilizing organic chemistry knowledge, the surface of these two-dimensional nanomaterials with be modified to enhance their solubility and mechanical properties. Students will use electron microscopy, x-ray diffraction, UV-visible, and NMR spectroscopy to analyze the novel nanomaterials.

For students majoring in: MEE, Chemistry, Chemical Engineering

Required skill set: Communication

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7. Developing Novel Approaches to Thin Film Microscopic Image Analysis

New technological devices are being developed in our lab by combining atomically thin layers in a stacked heterostructure. The result is a device with unique electrical and magnetic properties, and these devices have applications in spintronics, nanotechnology, and quantum materials. When creating these devices, the various fabrication steps require precise characterization with various methods, including Atomic Force Microscopy (AFM). The AFM data is an image with two channels (phase and topology) that must be further analyzed to determine the layer's properties. Standard AFM data processing uses statistical measures common to all image processing techniques. Novel image processing techniques such as image classification, semantic segmentation algorithms and genetic algorithms have all been used to analyze physical data. Image classification and semantic segmentation algorithms are machine learning applications with the potential to distinguish between two different materials or material-phases, while genetic algorithms are capable of analyzing crystallographic phase data in 3D. These techniques are not typically implemented in the standard preprocessing of AFM images, as they require a priori knowledge of the material.

Therefore, we propose two main goals: 1) the automation of preprocessing techniques to improve accuracy and workflow by implementing known physical parameters (material specific preprocessing) and 2) an exploration of novel image processing techniques with the capability of extracting information from an AFM dataset above and beyond the ISO measures since a priori knowledge is available to us.

For students majoring in: Physics, Electrical Engineering, Chemistry, Computer Science, Mechanical Engineering, Informatics.

Required skill set: General chemistry, introductory physics, or equivalent; Experience programming in Matlab, Python, or MS Excel.

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8. Distance Learning 3D Printed Project for Engineering Coursework

The need for distance learning has significantly increased. This project entails learning NX CAD software, creating a Stirling Engine, and designing lesson plans for use in Engineering Coursework. Stirling engines use cyclic compression and expansion of air. Many miniature designs exist, and we are looking to create pathways to teach students how to create their own designed engines.

Skills needed would be able to learn CAD software, creativity in making parts, and the ability to share your knowledge both orally and written. If you are interested in improving any of these skills, you should consider applying for this project. The PIâ€™s have many years" experience working with student researchers. We are looking for student researchers that have any major or class status to do this project.
For students majoring in: Computer Science, Informatics, Art History, Classical Studies

For students majoring in: Mechanical Engineering, Electrical Engineering

Required skill set: CAD 3D printing group communications

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9. Great Marble Map of Rome Project

The Great Marble Map of Rome (GMMR) is one of the best known, yet least understood, artifacts from the ancient Roman world. Targeted studies of the map however, remain rare and sporadic due to the physicality of the map fragments themselves. Technological revolutions have improved access to the map by producing high quality, accurate, scalable 3D digital scans of all existing GMMR fragments. MURI students will pilot the design, construction, and population of the GMMR database and website, primarily through preparing 3D models of the scanned GMMR fragments.

For students majoring in: Computer Science, Informatics, Art History, Classical Studies

Required skill set: Familiarity with database management software or an ability to learn; familiarity with basic art historical research or an ability to learn

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10. Artificial Retina

Vision impairment affects millions worldwide. Currently, there is no treatment option to restore vision in age-related macular degeneration, which is the leading cause of blindness, particularly in the US. There is also no sustainable cure in hereditary macular dystrophies, which results in photoreceptor loss (e.g., retinitis pigmentosa). Researchers at Indiana University propose to develop and test an artificial neurosensory retina that interfaces directly with functional retinal ganglion cells (RGCs) through nerve-exciting electric fields exhibited from gold nanoparticles when they are exposed to light wavelengths matching their resonant frequency. Gold nanoparticles exhibit a positively charged field once excited by a resonant frequency-matching wavelength.

For students majoring in: Chemistry, Biomedical Engineering, Electrical Engineering, Physics, Mechanical Engineering

Required skill set: Cleanroom work fabrication of nanoparticles optics voltage probing.

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11. Mapping the Oratory of Fredrick Douglass

The goal of this research project is to use the different research methodologies employed by two different disciplines, History and Spatial Humanities, to analyze samples of the large body of speeches by Frederick Douglass, a runaway Maryland slave who rose to become the most influential African American of the nineteenth century. The research will be looking for geographical patterns, both chronologically and thematically, in Douglass's public speaking tours. The project aims to explore: (1) how did the geographical patterns of Douglass's speaking change over the course of over five decades of public life? (2) in what ways did the subject matter of Douglass's public speeches change in different geographical locations? (3) how did the demographic composition of Douglass's audiences change in different geographical locations and how did that affect his speech themes? (4) were there different geographical patterns in Douglass's public speaking when he spoke as a reformer and when he spoke as a paid lecturer? and (5) How did Douglass's speaking itinerary expose the racial practices of 19th century America? Preliminary results indicate that the answers to these questions are obtainable, but more data is required to come to substantive conclusions.

For students majoring in: History, Geography, Africana Studies, Informatics.

Required skill set: Ability to read and research nineteenth century printed and written documents; ability to encode and enter data onto electronic software; and ability to critical analyze findings of data analysis.

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12. Nanovision

This MURI project aims to take the first steps towards developing a virtual reality (VR) or augmented reality (AR) environment for nanoscience and nanotechnology. This system will make its focus on the mix of education with play to expose children to the names, appearance, and basic scientific facts of nanoscience and nanotechnology. By creating a VR or AR environment, we can bridge the gap between higher education and the public about one of the exciting and relevant topics of our internet-of-things life.

The student team will conduct a review of the literature on nanotechnology by reviewing books, lectures, recent journal articles, and state-of-the-art technologies that are available to the public. They will prepare comprehensive PowerPoint slides in a format that can be translated to designing the environment based on the literature reviewed. This will be done to validate the scientific and engineering aspects of the work. The team will then design and develop the environment, including various educational models based on the literature.

For students majoring in: Computer Information and Graphics Technology, Mechanical & Energy Eng., Biomedical Eng., Electrical and Computer Eng., Technology Leadership and Communication, Engineering Technology, Biology, Chemistry, Physics, Computer and Information Science

Required skill set: Able to conduct a literature search and gather information about nano, Basic knowledge in nanoscience and nanotechnology or expertise in graphic design and app development

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