Fall 2024 Call for Applications
IEM Undergraduate Research Assistant (URA)

Overview

- The goal of this program is to support IEM undergraduate students to work with IEM faculty to conduct publishable research.
- All IEM undergraduate students can apply.
- Selected URAs are paid $15/hour, up to 10 hours/week over ten weeks.

Research Projects

#	Faculty Contact	Project Title
1	Dr. Austin Buchanan <buchanan@okstate.edu>	Computer Optimization Tool to Assist Redistricting
2	Dr. Akash Deep <akash.deep@okstate.edu> Dr. Srikanthan Ramesh <sri.ramesh@okstate.edu>	Towards Smart 3D Printers: Vibration-assisted Extrusion Printing of Viscous Functional Inks
3	Dr. Guiping Hu <guiping.hu@okstate.edu> Dr. Mohammad Fili <mohammad.fili@okstate.edu>	Identity Cognitive Trajectory Classes using Blood or Brain Biomarkers
4	Dr. Katie Jurewicz <katie.jurewicz@okstate.edu>	Quantifying the Interaction Between Human Operators and AI-Enabled Automation in Aerospace
5	Dr. Katie Jurewicz <katie.jurewicz@okstate.edu>	Using a Systems Engineering Approach to Improve Patient Safety in Labor and Delivery
6	Dr. Srikanthan Ramesh <sri.ramesh@okstate.edu>	Fabrication of Multi-Material Inconel-Copper Parts via Metal Fused Filament Fabrication
7	Dr. Pratima Saravanan <pratima.saravanan@okstate.edu>	A Multi-level Investigation of Factors Influencing Community Health Program Efficacy
8	Dr. Pratima Saravanan <pratima.saravanan@okstate.edu> Dr. Tieming Liu <tieming.liu@okstate.edu>	Feasibility Study of Community Paramedicine for Chronic Disease Management in Rural Oklahoma
9	Dr. Lizhi Wang <lizhi.wang@okstate.edu>	Systematic Integration of Data Sets for Identifying Environmental and Management Factors that Affect the Health and Productivity of Dairy Cows

More details about these projects can be found in the appendix.

Application Process

- Read the project descriptions in the appendix carefully before applying.
- Application should be an email to the faculty that includes (1) your resume, (2) a brief introduction of yourself, and (3) a brief explanation of why you are interested in their particular project.
- One student may apply for multiple projects, and one faculty may receive multiple applications. Faculty can make their selection decisions any time before the deadline of **Monday 09/02/2024**, so please apply early and leave enough time for faculty to get to know you and potentially schedule for an interview.

Expectations and Deliverables for Selected URAs

- Participation in the required kick-off meeting and mid-point meeting
- At least 5 pictures, showing the URA(s) working with the faculty advisor(s) or research group during the project, or presenting research results from the project
- Any additional expectations and deliverables required for individual projects

Timeline

- **08/19/2024**: Application is open.
- **09/02/2024**: Faculty will have selected the URA to work with. Staff will initiate the paperwork for URAs.
- **Week of 09/09/2024**: Kickoff meeting. Exact location, date, and time TBD.
  - 09/09: week 1
  - 09/16: week 2
  - 09/23: week 3
  - 09/30: week 4
  - 10/07: week 5
- **Week of 10/14/2024**: Mid-point meeting. Collect feedback and clarify end-of-semester deliverables. Exact location, date, and time TBD.
  - 10/14: week 6
  - 10/21: week 7
  - 10/28: week 8
  - 11/04: week 9
  - 11/11: week 10
- **11/15/2024**: Due day for end-of-semester deliverables.

Appendix: Project Descriptions

#1

Project title: Computer Optimization Tool to Assist Redistricting

Faculty and email: Dr. Austin Buchanan <buchanan@okstate.edu>

Project description: This project entails the creation of a computer optimization tool to assist in the drawing of political districting plans. Previous research by Dr. Buchanan (paper1, paper2, paper3) has led to various mathematical optimization models (specifically, mixed integer programs or MIPs) to design political districts and districting plans. However, the associated research codes require users to be familiar with Python, MIP modeling, and Gurobi, which lie outside the abilities of the general public. The main deliverable of this project is a user-friendly graphical user interface (GUI), likely built in Python, that can assist non-optimization folks in the design of districting plans. Key to the approach is the code's ability to offer a "menu" of possible districts to choose from. The user should be able to select a district from this menu, the chosen district will be removed from the state, and the process is to be repeated until all districts have been drawn, ultimately yielding a districting plan for the entire state. There are several other features that would ideally be included in the tool as well. This includes the ability to pre-select a portion of the state (e.g., set of counties) for inclusion or exclusion in the next district. Another desired functionality is the ability to perform "halving" rather than "carving". In carving, one district is selected and removed from the state in each iteration. Meanwhile, in halving, the state is divided (nearly) in half in each iteration, until each part is a single district. For example, consider a state like Iowa which has four congressional districts. The user could be shown 10 different ways to divide the state in half—into two "double districts"—each with a population suitable for two districts. After halving the state into two double districts, the user would be shown a menu of ways to halve each double district into single districts. After these final selections, the tool would then export the full, four-district plan as a png file and as a csv file (so that it could be uploaded to popular districting software/websites like https://davesredistricting.org/ for further evaluation and tuning). Dr. Buchanan would also like the URA to come up with a cool name for the computer tool.

Requirements for URA applicants: The URA should have taken IEM 4013 (and liked it too!). The URA should be skilled in Python and have previous experience with Gurobi. Familiarity with GIS, GUI development, and political districting is welcomed, but not required.

Expected research outcome and deliverables: (1) Computer tool (2) User documentation (3) A poster

Requested number of URAs: 1

#2

Project title: Towards Smart 3D Printers: Vibration-assisted Extrusion Printing of Viscous Functional Inks

Faculty name and email: Dr. Akash Deep akash.deep@okstate.edu and Dr. Srikanthan Ramesh sri.ramesh@okstate.edu

Brief project description

The project provides an exciting opportunity for two undergraduate research assistants (URAs) to dive into the intersection of sensors, additive manufacturing, and digital innovation. This is a hands-on project, where the URAs will integrate a vibrating actuator on the nozzle of the 3D printers, control the actuator using Raspberry Pi in real-time, study the effects of induced vibrations on the flow rate, and collaborate with a diverse team of graduate students and faculty in Dr. Deep's and Dr. Ramesh's research group. Throughout the project, the students will gain practical experience in interfacing hardware and software and validating the cyber-physical system. This immersive project not only enhances the technical skills but also exposes them to the exciting intersection of hardware, software, and cutting-edge technologies.

Anticipated job responsibilities:

- Integrate multiple vibrating actuators on 3D printer's nozzle. (Necessary hardware and software are already in place).
- Study the effect of acoustic signals on material deposition.
- Develop comprehensive documentation of the experimental study.
- Coordinate with team (undergraduate, graduate students, and faculty) for project execution and timely updates.
- Present end-of-semester project deliverables.

Join us in this journey to transform traditional 3D printing into a smart intelligent manufacturing system.

Requirements for URA applicants

- Experience in Python [Required]
- Exposure to Linux environments [Preferred]
- Experience with Arduino or Raspberry Pi projects [Preferred]
- Exposure to 3D printers [Preferred]

Expected research outcome and deliverables

At the end of the project timeline, we anticipate the URAs to have successfully achieved the research project goals. Specifically, the expected research deliverables will include: (a) a comprehensive investigation of the relationship between digitally controlled vibration signals and material deposition, (b) successful demonstration of the scripts under different printing conditions, (c) a conference presentation, and (d) pictures, poster, and video as per the URA program's funding requirements.

Requested number of URAs: 2.

#3

Title: Identity Cognitive Trajectory Classes using Blood or Brain Biomarkers

Faculties: Mohammad Fili and Guiping Hu

A. Project Description

Aging is frequently linked to a general decline in cognitive function, but the rate and extent of cognitive changes vary among individuals and are influenced by factors such as genetics, lifestyle, education, and social interactions. While some individuals experience a pronounced decline, others may face a more gradual decrease, and a portion of the population might maintain stable cognitive levels or even show improvement over time. Identifying these differences is crucial for understanding the factors associated with successful aging. Moreover, this analysis can help quantify severe cognitive decline and contribute to the prevention of Alzheimer's disease and dementia. In this study, URA will assist with statistical analysis to model the relationship between cognitive performance and blood or brain biomarkers.

B. URAs and Their Tasks

Task 1 (Cognitive Quantification): Design procedures to quantify cognitive performance from a set of cognition exams over time

Task 2 (Data Preprocessing): Prepare data for analysis and modeling using Python

Task 3 (Exploratory Analysis): Using visualization and statistical tests to understand the relationship between variables

Task 4 (Modeling): Model the relationship between cognitive performance and explanatory variables including blood and/or brain biomarkers

C. Preferred Qualifications

- Some experience in working with Python and popular packages: NumPy, Pandas, Matplotlib.
- Background knowledge in statistics and modeling
- Interest in AI, machine learning, and biomedical applications
- Collaborative and team-oriented mindset
- Commitment and time management
- Ability to present research findings in a clear and organized manner
- Proactive attitude and willingness to contribute to research objectives.

D. Expected Research Outcomes and Deliverables

- Acquire knowledge of research principles and learn about conducting literature reviews.
- Develop research skills through both independent work and collaboration within a team.
- Explore machine learning tools and techniques, along with their practical applications.
- Attain a general understanding of cognitive function.
- Compile a poster by the end of the semester to effectively communicate the outcomes and findings of the research efforts undertaken by the URA.

#4

Project title: Quantifying the Interaction Between Human Operators and AI-Enabled Automation in Aerospace Applications

Faculty and email: Dr. Katie Jurewicz, katie.jurewicz@okstate.edu

Project description: Artificial intelligence (AI), AI-enabled decision aids, and other forms of automation are prevalent in modern complex systems (e.g., military, aerospace, healthcare, manufacturing). The introduction of automation and AI-enabled automation in complex systems require interaction with a human operator, and it has been shown that the use of fully automated systems negatively impacts both Situation Awareness (SA), user performance, and overall system performance. Conversely, manual systems, when employed for prolonged tasks, increase SA but negatively affect both workload and performance. Therefore, there is a need to identify the most appropriate level of automation for human operators that would enhance SA, reduce workload, and ultimately improve performance during human-automation interaction. The purpose of this study is to investigate the factors that contribute to users' preferred level of automation in an automated system and to assess the influence of the reliability of AI assistance on performance during human-AI interaction. Ultimately, we aim to develop a mathematical model that quantifies human behavior of transitioning to a preferred automation level. An experimental study in a flight environment will be conducted, and participants will be asked to perform tasks that are typical for pilots during flight. These tasks include regulating fuel level in a set of primary tanks, responding to call signal at intervals, monitoring the system for malfunction, and controlling the movement of a target around the computer screen with the use of a joystick (tracking task). A secondary screen will simulate an AI agent that provides information about the current level of automation for the tasks being performed on the primary screen. The primary variables of interest to collect are cognitive workload, trust in automation, and task performance. Results from this study will inform how engineers can better design human-AI systems that allow the automation to adapt to the human operator and the contextual environment.

Requirements for URA applicants: The URA is expect to be highly motivated to perform research, available to support data collection, and have a strong math background. There are no course requirements for this position – students with math/stat courses on their resumes are preferred but not required.

Expected research outcome and deliverables: The student is expected to formally disseminate results in the form of a research poster.

Requested number of URAs: 1

#5

Project title: Using a Systems Engineering Approach to Improve Patient Safety in Labor and Delivery

Faculty and email: Dr. Katie Jurewicz, katie.jurewicz@okstate.edu

Project description: Despite its presence as one of the most industrialized countries in the world, the United States (US) experiences one of the highest rates of maternal deaths compared to other modernized countries and was ranked 60th overall in maternal mortality in 2013. Pregnancy-related mortality in the United States has more than doubled from 7.2% to 17.3% between 1987 and 2018. In recent years, the US has experienced an increase of roughly 100 maternal deaths every year from 2018 to 2020. Caesarean births are associated with higher rates of maternal mortality compared to vaginal births. Safety scientists have made several attempts to understand how and why errors occur in complex work systems that lead to adverse events.

The Systems Engineering Initiative for Patient Safety (SEIPS) framework demonstrates the interconnected nature of healthcare work systems. Safe cesarean deliveries depend on the positive influence of each of the work system elements (i.e., person, tasks, tools, organization, environment) within the labor and delivery work system. Several teams of care providers (i.e., obstetricians, nurses, anesthesiologists, and surgical technicians) must communicate and coordinate all of their care activities using a variety of tools under different care environments while adhering to associated policies. Issues within any of the work system elements can lead to adverse patient outcomes. Mismatches between the actual care activities (i.e., work-as-done) and the theoretical care activities (i.e., work-as-imagined) can negatively influence care outcomes through misaligned organizational policies or decisions. Failing to understand the needs of the care providers can lead to ill-informed decisions about device purchases, equipment availability, and environmental designs. The SEIPS 101 tools (e.g., task-tools matrix, journey map, PETT scan) help researchers understand the tasks, tools, people, and care processes within healthcare.

The overall objective of this work is to use a systems engineering approach to understand the labor and delivery work system in order to improve patient safety and clinician resilience. The aims of this work are threefold: (1) model the current labor and delivery care journey, (2) use special cases (e.g., emergencies) to understand how processes change, and (3) determine how care providers resiliently adapt to variation within the work system.

Requirements for URA applicants: The URA is expect to be highly motivated to perform research, and available to support data analysis from the hospital sites. There are no course requirements for this position.

Expected research outcome and deliverables: The student is expected to formally disseminate results in the form of a research poster.

Requested number of URAs: 1

Project Title: Fabrication of Multi-Material Inconel-Copper Parts *via* Metal Fused Filament Fabrication

Principal Investigator: Sri Ramesh, Assistant Professor, School of Industrial Engineering and Management

PI Contact: sri.ramesh@okstate.edu

#6

Research Context

Oklahoma's key industries, oil and natural gas extraction, agriculture, and manufacturing, depend on specialized equipment that often incorporates parts with unique geometries or specific metal alloys, tailored to meet stringent performance requirements. The need for these highly customized components, many of which are legacy parts or no longer available off the shelf, presents a significant challenge for maintaining and repairing industrial machinery. Metal fused filament fabrication (FFF) presents a transformative solution to this challenge. This advanced manufacturing technique allows for the on-demand production of complex, fully dense metal parts by extruding polymer-bound metal powder filaments (Fig. 1 (a-d)). The process is straightforward and adaptable, offering a new avenue for fabricating parts that were previously difficult or impossible to produce using traditional methods. The potential of FFF is particularly exciting when applied to the creation of multi-material or bimetallic parts. These components can combine the properties of different metals. However, the complexity of processing bimetallic parts introduces challeng particularly in managing the different sintering temperatures of the metals involved.

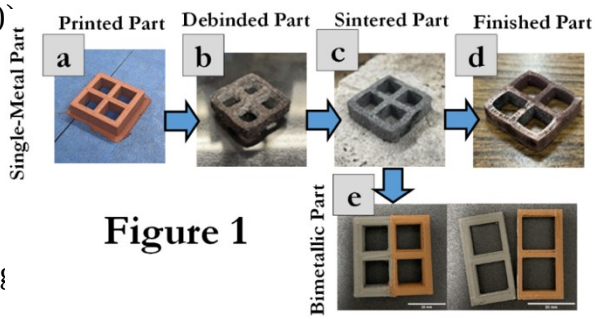

Figure 1

Research Focus

This research project specifically addresses the challenge of interfacial delamination in bimetallic Cu/Inconel 3D-printed parts, a critical issue that arises during the thermal sintering process due to the significant difference in optimal sintering temperatures for copper and Inconel (Fig. 1e). The project aims to develop and optimize thermal debinding and sintering protocols that minimize delamination, ensuring the structural integrity and functional performance of these multi-material components. By conducting systematic experiments to refine sintering parameters, this research seeks to establish standardized post-processing strategies that can be applied not only to Cu/Inconel parts but also to other metal combinations in the future. The outcomes of this study will contribute to advancing the field of metal additive manufacturing, particularly in the production of complex, high-performance bimetallic parts for critical industrial applications.

URA Requirements

- Interest in 3D printing and basic understanding of manufacturing processes.
- Basic coursework in materials science, with a manufacturing course enrolled or completed.
- Willingness to engage in lab-based work and collaborate with graduate student mentors.
- Strong attention to detail and excellent notetaking and book-keeping skills.

Expected Research Outcomes

By the end of the project, the URAs are expected to have,

- Gained practical experience in the 3D printing and thermal processing of bimetallic parts.
- Developed a basic understanding of the challenges related to delamination in multi-material components.
- Worked effectively within a research team, contributing to the optimization of a manufacturing process.

Project Deliverables

- Detailed and organized lab notes documenting experimental procedures and observations.
- A summary report outlining the key findings and contributions to the project.
- Participation in the preparation of a research poster or presentation summarizing the project's results.

Number of Students Needed for the Project: 1

#7

A Multi-level Investigation of Factors Influencing Community Health Program Efficacy

Faculty: Dr. Pratima Saravanan, Assistant Professor, School of Industrial Engineering and Management, Oklahoma State University (pratima.saravanan@okstate.edu)

Project Description: Preventable health conditions among Oklahomans are in a dire situation. Oklahoma leads the nation in the prevalence of heart disease. As such, Oklahoma is a major contributor to the nation's preventable medical spending exceeding $1 billion annually. These metrics provide strong evidence that Oklahoma must accelerate efforts to focus not only on preventing obesity but treating it more aggressively. Physical inactivity and poor nutrition contribute to a variety of chronic diseases and conditions that negatively impact quality of life including obesity. Community-based health programs have the potential to improve health outcomes by increasing physical activity and improving dietary behaviors. However, the long-term success and sustainability of such programs depend on overcoming barriers at multiple levels: individual, community, and program. The goal of this project is to identify pertinent barriers and facilitators to widespread community program efficacy at the individual, community, and program levels. By taking a social-ecological approach, this project will generate knowledge to inform the development and implementation of maximally effective and sustainable community-based health programs in our state. The outcome of this investigation will inform our team's ultimate objective to build reliable machine-learning models that can predict the efficacy of community-based programs.

Requirements for URA applicants: The undergraduate research assistant (URA) is expected to complete Collaborative Institutional Training Initiative (CITI training) modules, which are mandatory for conducting human-subject research. The URA will work closely with the faculty to collect, curate, and analyze the data.

Expected research outcome and deliverables: A poster that summarizes the research project must be presented at the OSU Annual Undergraduate Research Symposium.

Requested number of URAs: 2

#8

Project title: Feasibility Study of Community Paramedicine for Chronic Disease Management in Rural Oklahoma

Faculty and email: Dr. Pratima Saravanan (pratima.saravanan@okstate.edu) and Dr. Tieming Liu (tieming.liu@okstate.edu)

Project description: According to the Rural Health Information Hub (2023), despite the many positive attributes and assets associated with working and living in rural communities, many rural American population groups experience significant health disparities. These disparities are often characterized by indicators such as higher incidence of disease and/or disability, higher mortality rates, lower life expectancies, and higher rates of chronic pain. Rural risk factors for health disparities include geographic isolation, lower socioeconomic status, higher rates of health risk behaviors, limited access to healthcare specialists and preventive health education. In Oklahoma, a rural area with health disparity is Delaware County. It is ranked 54th out of 77 counties for health factors including health behaviors, clinical care, and social and economic factors. Twenty-one percent of the population describe their health as fair or poor (nearly double the US average), with heart disease being the leading cause of death, the obesity rate is 40%, and 15% have type II diabetes. The goal of this research study is to determine the potential for a community paramedicine program to improve the overall health of residents in Delaware County by providing person-centered health care in rural areas of the county, thereby reducing hospitalizations, improving chronic disease management, and providing efficient and timely referral to community services.

Requirements for URA applicants: The undergraduate research assistant is expected to complete Collaborative Institutional Training Initiative (CITI training) modules, which are mandatory for conducting human-subject research. The CITI training is expected to be 3-4 hours long. The URA is expected to attend all team meetings with key stakeholders, assist in data collection and interviews at Delaware County, and help with data analysis.

Expected research outcome and deliverables: (1) A final presentation to the stakeholders

Requested number of URAs: 1

Project title: Systematic Integration of Data Sets for Identifying Environmental and Management Factors that Affect the Health and Productivity of Dairy Cows

#9

Faculty and email: Dr. Lizhi Wang <lizhi.wang@okstate.edu>

Project description: In the past couple of decades, "[t]he U.S. dairy sector has undergone substantial structural change characterized by a shift to larger and fewer dairy operations concentrated in fewer States" [1]. In the meantime, productivity in the U.S. dairy sector grew at an annual rate of 2.99% for large farms with more than 1,000 milk cows, which was four times faster than small operations [1]. The structural change, coupled with climate change and ever improving labor-saving technology, made dairy production increasingly vulnerable to environmental conditions and management practices [1]. The impact of environmental conditions and management practices on the health and productivity of dairy cows has been the topic of scientific research for many decades [2, 3, 4, 5]. However, most studies have focused on one or a few factors, and few have attempted to examine the impact of all measurable factors as well as their complex interactions on the physiology of dairy cows. Data analytics offers a promising approach to understanding lactation biology and physiology from systemic and holistic perspectives [6, 7]. This project will prepare systematically integrated data sets from dairy cow farms in order to identify the environmental and management factors that affect the health and productivity of dairy cows. This project has four tasks:

- **Task 1: Literature review.** We will conduct a thorough review of existing literature at the interaction of data science and animal physiology (especially for dairy cows).
- **Task 2: Farm visits.** We will visit a milk farm to understand their farm operations.
- **Task 3: Data integration.** We will clean, process, impute, and reorganize the raw data from farm operations into systematically integrated data sets.
- **Task 4: Statistical analysis, visualization, and documentation.** We will conduct data analytics based on the integrated data sets and design visualizations to illustrate the relationship between environmental and management factors and productivity.

[1] Njuki, Eric. "US dairy productivity increased faster in large farms and across southwestern states." *Amber Waves: The Economics of Food, Farming, Natural Resources, and Rural America* 2022 (2022).
[2] Phipps, A. J., et al. "Survey of bovine colostrum quality and hygiene on northern Victorian dairy farms." *Journal of Dairy Science* 99.11 (2016): 8981-8990.
[3] Tančin, V., Š. Mikláš, and L. Mačuhová. "Possible physiological and environmental factors affecting milk production and udder health of dairy cows: A review." *Slovak journal of animal science* 51.1 (2018): 32-40.
[4] Tucker, Cassandra B., et al. "Effects of shelter and body condition on the behaviour and physiology of dairy cattle in winter." *Applied Animal Behaviour Science* 105.1-3 (2007): 1-13.
[5] Tančin, V., Š. Mikláš, and L. Mačuhová. "Possible physiological and environmental factors affecting milk production and udder health of dairy cows: A review." *Slovak journal of animal science* 51.1 (2018): 32-40.
[6] Giordano, J. O., et al. "Symposium review: Use of multiple biological, management, and performance data for the design of targeted reproductive management strategies for dairy cows." *Journal of Dairy Science* 105.5 (2022): 4669-4678.
[7] Bouallegue, Mahdi, and Naceur M'Hamdi. "Mathematical modeling of lactation curves: A review of parametric models." *Lactation in farm animals-biology, physiological basis, nutritional requirements, and modelization* 1 (2020): 1-20.

Requirements for URA applicants: The URA is expect to have the interest and skill sets to contribute to all four tasks.

Expected research outcome and deliverables:
(1) A report that summarizes the literature in the environmental and management effects on the health and productivity of dairy cows. (2) A poster that presents results of data visualization and data analysis.

Requested number of URAs: 1