RIT

2019 PROVOST'S LEARNING INNOVATIONS GRANTS
CALL FOR PROPOSALS

The **Provost's Learning Innovations Grants** (PLIG) program was developed to broaden and enrich the learning experience of RIT students by funding faculty-initiated projects that enhance student learning. Managed by the Innovative Learning Institute (ILI), this program has been designed to:

- Better support dissemination of individual faculty learning to the wider faculty population
- Integrate funding with Institute priorities
- Support the scholarship of teaching and learning

I. ELIGIBILITY

All full-time RIT faculty (tenured, tenure-track, visiting, lecturers, etc.) are eligible to apply.

II. GRANT TYPES

There are two types of grants—Exploration and Focus—for PLIG 2019. Full details are available on the Grants Types page of the PLIG website (www.rit.edu/plig).

III. USE OF GRANT FUNDS

Provost's Learning Innovations Grants for 2019 may range from $1,000-$5,000.

Examples of the use of PLIG funds include:

- Course release (reasonable, actual replacement costs for faculty members removed from teaching)
- Development of new technology-based learning tools and/or environments
- Technologies or equipment required that are not normally provided by the department/college
- Resources for research design and consultation, data collection and aggregation, instrument development and/or purchase, secure data storage, data analysis, and report generation
- Travel to support research activity and/or meet with potential funding sources

IV. PLIG TIMELINE AND TASKS

The grant timeline assumes that most recipients will use the Spring 2019 and/or Summer 2019 term(s) to plan and develop their PLIG-funded project for delivery or implementation during the Fall 2019, Spring 2020, and/or Summer 2020 term(s). The full timeline, including grantee tasks, is available on the PLIG website.

V. SELECTION COMMITTEE AND EVALUTION CRITERIA

Applications for PLIG funds are evaluated by the PLIG selection committee according to the following criteria:

- *Utility* (solves a defined problem; has potential to benefit many courses/faculty)
- *Creativity* (is a novel approach or application; represents a new paradigm)
- *Efficacy* (uses an evidence-based approach; impact to student learning and/or the student experience can be demonstrated)

The criteria are further defined, illustrated, and explained in the Proposal Evaluation section of the PLIG website.

VI. QUESTIONS

Please email plig@rit.edu with any questions about the PLIG process.

(*Examples of previously funded projects are available in the Previous Awards section of the PLIG website).*

RIT

2019 PROVOST'S LEARNING INNOVATIONS GRANTS

APPLICATION

INSTRUCTIONS

1. Complete this Application Form and save as "Lastname_Firstname_APP" (*using your name*).
2. Ask your Department Head to complete the Department Head Certification, scan and save as, "Lastname_Firstname_SIG" (*using your name*).
3. Email all documents to plig@rit.edu, ***no later than 11:59pm ET, January 21, 2019.***

If you have any questions about completing this application, please contact Michael Starenko at 585-475-5035 or mssetc@rit.edu.

APPLICANT INFORMATION

This application is for a (please select *one* type of grant):

☐ **Exploration Grant**

X **Focus Grant – Active Learning Across All Course Modes**

Principal Applicant Name: Yunbo "Will" Zhang

Faculty Title: Assistant Professor **Email**: ywzeie@rit.edu **Phone:** 475-5571
(Full-time only)

College: KGCOE **Department:** Industrial & Systems Engineering

Department Head Name: Iris Rivero **Email**: ivreie@rit.edu

Others involved in the project (if any): ____________

Project Name: An Augmented-Reality based Learning Environment for Manufacturing Laboratories

Total Funds Requested (*as calculated on the budget worksheet on the next page*): $5000
(requests of $1,000 to $5,000 will be considered)

BUDGET

Complete the table below to calculate your budget

- The total shown on this worksheet must match the "Total funds requested" in the Applicant Information section on page 1 of this application form.
- If awarded, additional funds will be provided to cover any benefits and ITS expenses associated with the salary budget requested.
- Note that any equipment or other materials purchased with grant funds are the property of your department and revert to the department after your project is completed

Personnel	Purpose/Justification	Amount
Full-time Faculty/Staff		
Adjuncts, Part-time Faculty/Staff, Summer Salary		
Student Workers, Graduate Assistants		
	Personnel Total	**$ 0.00**
Equipment	**Purpose/Justification**	**Amount**
HTC VIVE Pro Virtual/Augmented Reality System and accessories	For carrying out the project.	1745
MSI VR ONE 7RE-065US laptop	For project development and demonstration in the conference.	2199
Cable extension	For extending the working range of the AR device	56
	Equipment Total	**$ 0.00**
Travel	**Purpose/Justification**	**Amount**
Conference	Project Dissemination	1000
	Travel Total	**$ 0.00**
Other (*Specify*)	**Purpose/Justification**	**Amount**
	Other Total	**$ 0.00**
Total Award Requested		**5000**

STATEMENT OF UTILITY (two pages maximum)

Using the evaluation criteria outlined in the Proposal Evaluation section of the PLIG website, please provide an overview of the project you are proposing, including:

- Project objectives
- An explanation of the teaching/learning problem(s) it is designed to address
- An explanation of the significance of the project to student outcomes and/or the student experience.
- A brief description of how the project integrates with activity already underway at RIT in a priority area and/or how this approach has been successfully used at RIT already.

Project Summary:

The main object for this project is to investigate, develop, and assess an Augmented-Reality (AR) based learning environment for the laboratories of manufacturing courses. AR techniques sense the 3D information of the physical environment, and enrich the physical environment by overlaying virtual objects in real-time. It benefits the students' learning by providing them with the perception of the spatiality, the dimensionality, and the geometry of the physical world, and the flexible and intuitive interactions. Based on these new affordances, this proposed AR based learning environment enables students to actively explore the environment and manufacturing systems, and learn how to operate manufacturing systems through a simulation tool.

Objective:

The objectives of this proposed project are as follows:

1. To design and implement a set of interaction tools on a head-mounted (HMT) AR device for the user to interactively conducting environment exploration, virtual annotation, and virtual operation.
2. To design and implement the multi-view image based Artificial Intelligence (AI) algorithms on the HMT AR device for recognizing manufacturing systems and machine parts in the laboratory environment.
3. To assess the effectiveness of the proposed AR system and providing insight for future AR based learning systems, we plan to conduct a comprehensive user study by testing the system in the ISEE-140 Materials Processing class, and collecting students' qualitative and quantitative evaluation.

Problems in Current Teaching/Learning:

Active learning approaches are widely studied and implemented in the U.S. institutions of higher education. In contrast to the traditional instruction based teaching-learning paradigm, students actively explore the field of the course, understand the topics, seek questions, and figure out their own solutions, instead of passively receiving the knowledge from an expert [1]. However, in the laboratories of manufacturing courses, the instruction based learning style is still dominant. There are several problems for the adoption of active learning. First of all, lab sessions for manufacturing courses involving hands-on activities, highly rely on the prior experience from the expert. The safety and cost are also concerns for the active learning to be implemented in the laboratories. It is neither safe nor cost effective for the inexperienced students to explore in laboratories and operation manufacturing systems without instruction. For example, students in the lab session of ISEE-140 materials processing are required to complete a motion assembly using aluminum as the materials. They need to cut the materials using the linear or circular saw, mill the parts, and machine them using mill and lathe machines under the instruction from a technician with more than 30 years' experience. Students are not allowed to perform any activities prior to the expert's instruction due to possible misoperation and danger.

Current teaching-learning paradigm for manufacturing courses also lacks the support for the upcoming revolution of Smart Manufacturing. Smart Manufacturing, also known as "Industrial 4.0", is referred to as the "New Industrial Revolution" by *The Wall Street Journal* in 2018 [2]. In the context of the Smart Manufacturing, the traditional manufacturing is evolving rapidly towards more automation and intelligence. As a result, the environment of manufacturing plant will be no longer like what we set up in the laboratories sessions. Nevertheless, our teaching-learning environment for the laboratories remains the same as decades ago. It is necessary to update our teaching-learning environment for preparing our students to face the future opportunities and challenges

Integration to RIT and Broader Impact:

RIT has its name for encouraging students to gain hands-on experience from the learning. The proposed AR system enables the active learning of manufacturing courses' lab sessions by providing students with the AI based physical environment exploration, AR supported intuitive interaction, and the in situ simulation for machine operation. With this system, the learning of lab sessions in manufacturing courses has more engagement of students without raising cost or safety issues. The proposed system also showcases how the integration of emerging techniques including AR, AI and geometric processing would change the way of traditional teaching-learning mode, and improving students learning efficiency and experience.

We plan to integrate the proposed system into multiple manufacturing courses offered at RIT. Some courses includes: ISEE 140 Materials Processing, ISEE-741 Rapid Prototyping and ISEE-740 Design for Manufacture and Assembly. These courses all include lab sessions and currently have the similar limitations with implementing active learning. We plan to initially incorporate our system as a testing module in the lab sessions of these courses for collecting the both qualitative and quantitative evaluation from the students.

In the long run, this project will be part of the ongoing effort in developing a series of Smart Manufacturing courses in the institutes of higher education in United States. In order to prepare our students for the new trend, it is essential for educator of higher education to update the existing courses by introducing new teaching-learning paradigm and emerging technologies. The proposed project aims to inspire the educators in the manufacturing area by showcasing how the new technologies would change the old laboratories teaching-learning. In addition, this project is also possible to be incorporated with some outreach activities, namely, the K-12 STEM education or the engineering education for general public. We believe that this project will broadly impact the manufacturing educations, and situate RIT as the leading role in the future industrial revolution.

Reference:

[1] Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998). Active learning: Cooperation in the college classroom. Interaction Book Company, 7208 Cornelia Drive, Edina, MN 55435.

[2] Mims, C. (2018). Inside the New Industrial Revolution. The Wall Street Journal. Url: https://www.wsj.com/articles/inside-the-new-industrial-revolution-1542040187.

STATEMENT OF CREATIVITY (three paragraphs maximum)

Provide a brief description of how this is a novel approach, or a new application of an existing mode or model of teaching and learning, and/or research about how teaching and learning represents a new paradigm.

AR has been widely explored to assist users in assembly process by providing virtual guidance. Virtual instructions were overlaid in the view of user's AR headset [3], while corresponding virtual CAD models were displayed around physical objects [4]. Different interaction metaphors were adopted in the AR-based assembly process, including a virtual interactive tool [5] or bare hand for assembly guidance [6]. By integrating Radio-frequency identification (RFID) into each of the construction modules, a real-time tracking and monitoring was enabled for assembly guidance [7].

Moreover, AR has been investigated for interacting with robots. TouchMe [8] adopted AR to control the mobile robots. Leveraging AR with robots, researchers have achieved human-robot collaboration for object manipulation [9] and object pick and place [10]. AR has also been used for simulation of manufacturing process. Different manufacturing processes, including metal casting [11] and CNC machining [12], have been simulated in AR environment for verifying process plan, reducing material cost, and training novice mechanist.

These existing works explored the possibilities of AR in the manufacturing, yet, there are still some unsolved problems. The integration of AR and AI techniques are still under development. Existing works cannot provide a robust object recognition in the setup of manufacturing facilities. Another unsolved question is the interaction design for AR environment in manufacturing. A question needs to answer is: what will be the appropriate interactions for this AR environment in manufacturing with more intuitiveness, and higher efficiency? One of the objective of the proposed project is to integrate a multi-view based object recognition method to the AR device for robust environment exploration. We would also conduct a comprehensive user study to get feedback from the users for designing and improving our user interaction and the user interface.

Reference:

[3] Henderson, S. J., & Feiner, S. K. (2011, October). Augmented reality in the psychomotor phase of a procedural task. In Mixed and Augmented Reality (ISMAR), 2011 10th IEEE International Symposium on (pp. 191-200). IEEE.

[4] Makris, S., Pintzos, G., Rentzos, L., & Chryssolouris, G. (2013). Assembly support using AR technology based on automatic sequence generation. CIRP Annals-Manufacturing Technology, 62(1), 9-12.

[5] Yuan, M. L., Ong, S. K., & Nee, A. Y. C. (2008). Augmented reality for assembly guidance using a virtual interactive tool. International Journal of Production Research, 46(7), 1745-1767.

[6] Wang, X., Ong, S. K., & Nee, A. Y. C. (2016). Multi-modal augmented-reality assembly guidance based on bare-hand interface. Advanced Engineering Informatics, 30(3), 406-421.

[7] Zhang, J., Ong, S. K., & Nee, A. Y. C. (2011). RFID-assisted assembly guidance system in an augmented reality environment. International Journal of Production Research, 49(13), 3919-3938.

[8] Hashimoto, S., Ishida, A., Inami, M., & Igarashi, T. (2011, November). Touchme: An augmented reality based remote robot manipulation. In 21st Int. Conf. on Artificial Reality and Telexistence, Proc. of ICAT2011.

[9] Frank, J. A., Moorhead, M., & Kapila, V. (2016, August). Realizing mixed-reality environments with tablets for intuitive human-robot collaboration for object manipulation tasks. In Robot and Human Interactive Communication (RO-MAN), 2016 25th IEEE International Symposium on (pp. 302-307). IEEE.

[10] Ishii, K., Takeoka, Y., Inami, M., & Igarashi, T. (2010, September). Drag-and-drop interface for registration-free object delivery. In RO-MAN (pp. 228-233).

[11] Watanuki, K., & Hou, L. (2010). Augmented reality-based training system for metal casting. Journal of mechanical science and technology, 24(1), 237-240.

[12] Zhang, J., Ong, S. K., & Nee, A. Y. (2010). Development of an AR system achieving in situ machining simulation on a 3-axis CNC machine. Computer Animation and Virtual Worlds, 21(2), 103-115.

STATEMENT OF EFFICACY (two pages maximum)

Provide a brief description of the experiment/research design, methodology, and methods of data collection and analysis you will use to gauge efficacy.

In this proposed project, an AR environment will be designed and implemented for active learning in laboratories of manufacturing courses. The AR environment enables students' engagement in the teaching-learning in the lab sessions by allowing them to explore the environment and manufacturing systems, and perform virtual operation simulation prior to the actual operation of the machine.

There are 5 phases of this project:

1. Establishing the AR platform: we will build up a head-mounted AR platform with interaction tools ready on a HTC VIVE Pro AR device. The object tracking and registration will be done in this stage as well. This will be done based on a recent paper from the PI, which is about an AR based manual data input interface for numerical control manufacturing systems [13].
2. Integration of multi-view based object recognition: we will be reviewing the literature and figuring out the best of state-of-art AI algorithm for multi-view object recognition. Based on our findings, we will implement it on our AI platform.
3. Data input and training: the AI algorithm requires the input of geometric information of both the environment as well as the manufacturing systems. These information with proper manual annotation will be used to train the AI algorithm.
4. Testing & assessment: the AR environment will be tested by PI and the student researchers. The purpose for the testing is to check the possible problems and bugs in our system. After the testing, we plan to assess the AR system in the lab session of ISE-140 Materials Processing. We plan to evaluate our system through both quantitative and qualitative methods. The students will be required to complete a set of tasks designed by us, and provide their evaluation. Then, there will be an open-ended session for the student to use the AR system without restrictions, and again they will evaluate the system. The PI has extensive experience in human-computer-interaction, and published several papers with the quantitative and qualitative evaluation [14, 15].
5. Dissemination: we plan to submit a paper to SME North American Manufacturing Research Conference or ASME International Design Engineering Technical Conferences & Computers and Information in Engineering Conference to announce our work to the researchers and practitioners in mechanical engineering and manufacturing engineering.

Details about the quantitative and qualitative assessment:

- Two stages of the assessment: we plan to assess our system through two stages: in the first stage, each of the students will be asked to complete a set of standard tasks which are designed by us. Afterwards, an online survey will be taken by the student to evaluate the usability of our system. Then, the students will be asked to explore the manufacturing environment and virtual operate the manufacturing systems on their own, and there is no restriction for them. Once they finish it, an interview will be conducted to find out their qualitative evaluation to our system.
- The survey and questionnaire: we plan to use the Standard Usability Scale (SUS) [16] as the first part of our survey to evaluate the usability of our system. We also include some questions in the survey, such as how do the students think of our system, which part they like, which part they don't like in the system, and etc.
- Interview: To better capture the qualitative evaluation of our system, we also plan to interview each of the students after the stage 2 of the assessment. We would like to ask the students about their experience of learning in the lab session using the AR system. We will encourage students to share what they learned, what questions they found, and how they solved the question.

Reference:

[13] Zhang, Y., & Kwok, T. H. (2018). Design and Interaction Interface using Augmented Reality for Smart Manufacturing. Procedia Manufacturing, 26, 1278-1286.

[14] Liu, M., Zhang, Y., Bai, J., Cao, Y., Alperovich, J. M., & Ramani, K. (2017, May). WireFab: Mix-Dimensional Modeling and Fabrication for 3D Mesh Models. In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (pp. 965-976). ACM.

[15] Yoon, S. H., Zhang, Y., Huo, K., & Ramani, K. (2016, October). TRing: Instant and Customizable Interactions with Objects Using an Embedded Magnet and a Finger-Worn Device. In Proceedings of the 29th Annual Symposium on User Interface Software and Technology (pp. 169-181). ACM.

[16] Brooke, J. (1996). SUS-A quick and dirty usability scale. Usability evaluation in industry, 189(194), 4-7.

ADDITIONAL CONSIDERATIONS

Please address these questions, if needed.

Will your project require assistance for extensive or unusual media, multimedia, simulation, and/or software development? If so, please explain?

None will be required.

All courses offered by RIT must be accessible to students with disabilities, according to Section 504 of the Rehabilitation Act of 1973 and Title II of the Americans with Disabilities Act of 1990 (rit.edu/studentaffairs/disabilityservices/info). Is your proposed teaching approach accessible to all students, with reasonable accommodation? If not, please explain.

Yes, there is no issue for any student to access.

RIT abides by the Family Educational Rights and Privacy Act of 1974 (FERPA), which prohibits instructors from making students' identities, course work, and educational records public without their consent (rit.edu/xVzNE). Will any data gathering or sharing for your project raise any FERPA issues? If so, please explain.

No, all the data will be collected anonymously. We will also follow any instruction of RIT's office of compliance and ethics.

DISSEMINATION AGREEMENT

By completing this grant application, I agree to provide the materials and services described here, in support of disseminating what is learned from this project to the RIT community.

I also agree to return all/a portion of the funds that I receive for this project to RIT if I fail to complete or provide the materials described here:

- Full Project Plan (*including roles and responsibilities, milestone dates, and pertinent project details*)
- Preliminary Findings report (*may include experiment/study design, lessons learned, initial data collection, and/or literature review summary*)
- Participation in an ILI/TLS Preliminary Findings Roundtable dissemination event (*share and discuss your preliminary findings with your PLIG cohort*)
- Final Summary of Findings (*including data collection, lessons learned, implications for further study, and which may be in the form of an article abstract, conference presentation outline, or short report*)
- Final budget accounting (*reconciliation of budget provided with your application and the actual project expenses)*
- Participation in an ILI/TLS PLIG Showcase dissemination event (*present a poster or other display at the annual Showcase*)

By submitting this application, I accept this agreement. YZ *(applicant, please initial here)*

TIMELINE AND TASKS

Please indicate any variances to the planned PLIG 2019 schedule as described in the above Dissemination Agreement and the reasons for this variance. *If you do not intend to deviate from the schedule, you may leave this section blank.*

Task	Date	Proposed Variance and Reason
Full Project Plan submitted to TLS	August 16, 2019	
Preliminary Findings report submitted to TLS	January 10, 2020	
Participation in an ILI/TLS Preliminary Findings Roundtable dissemination event	February, 2020	
Summary of Final Findings report submitted to TLS	August 21, 2020	
Final Budget Accounting report submitted to TLS	August 21, 2020	
Participation in an ILI/TLS PLIG Showcase dissemination event	November 2020	

DISSEMINATION PLAN (*optional*)

Provide details about the journals, conferences, shows, or other external vehicles with strong potential for dissemination of your results (in addition to the ILI/TLS Preliminary Findings Roundtable and PLIG Showcase dissemination events). Include supporting documentation, such as preliminary interest or acceptance, with your application, if available. *(Please note that special consideration will be given to proposals that have a defined opportunity for external dissemination, such as an academic journal or professional conference.)*

We plan to submit a paper to SME North American Manufacturing Research Conference or ASME International Design Engineering Technical Conferences & Computers and Information in Engineering Conference to announce our work to the researchers and practitioners in mechanical engineering and manufacturing engineering.

RIT

DEPARTMENT HEAD CERTIFICATION

I support this PLIG application and verify that the principal applicant is a full-time faculty member in good standing in my department.

Principal Applicant Name: Yunbo "Will" Zhang

Department Head Name (PRINT): Iris Rivero **Email:** ivreie@rit.edu

Department Head Signature: [signature] **Date:** 1/30/19.

NOTE: When signed, please scan and email with your Application Form to: plig@rit.edu