Form B: IGEM-HERC Full Proposal Cover Sheet

Idaho State Board of Education

PROPOSAL NUMBER: (to be assigned by HERC)	TOTAL AMOUNT REQUESTED: $95,656
Proposal Track (select one): ● Proof of Concept	

TITLE OF PROPOSED PROJECT: **AI Based Quality Control for Potato Harvesting**	
SPECIFIC PROJECT FOCUS: Artificial Intelligence and Machine Learning Human-Environment Interaction	
PROJECT START DATE: 08/01/2024	PROJECT END DATE: 07/31/2025
NAME OF INSTITUTION: Idaho State University	DEPARTMENT: Mechanical and Measurement & Control Engineering
ADDRESS: 921 S 8th Avenue, Pocatello, ID 83209	
E-MAIL ADDRESS:	PHONE NUMBER:

NAME:	TITLE:	SIGNATURE:	
PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR	Marco Schoen	Marco Schoen Digitally signed by Marco Schoen DN: cn=Marco Schoen, o=ISU, ou=MMCE, email=schomarc@isu.edu, c=US Date: 2024.03.15 14:05:42 -06'00'	
CO-PRINCIPAL INVESTIGATOR	Mary Hofle	Mary Hofle Digitally signed by Mary Hofle DN: cn=Mary Hofle, o, ou, email=hoflmary@isu.edu, c=US Date: 2024.03.15 14:24:55 -06'00'	

NAME OF PARTNERING COMPANY:	COMPANY REPRESENTATIVE NAME:
SIGNATURE:	

Authorized Organizational Representative	NAME: Dave Harris	SIGNATURE: [signature]

1. Name of primary Idaho public institution Idaho State University

2. Project Title AI Based Quality Control for Potato Harvesting

3. Name and project-related credentials of Principal Investigator directing the project

   - Marco Schoen, Ph.D., P.E., Professor of Mechanical and Measurement & Control Engineering, Director of the Measurement and Control Engineering Research Center (MCERC) at ISU.
   - Mary Hofle, P.E., Senior Lecturer of Mechanical and Measurement & Control Engineering, Program Director for Mechanical Engineering at ISU.

4. Name and project related credentials of other key personnel (key project team members)

   - Ken Bosworth, Ph.D., P.E., Professor of Mechanical and Measurement & Control Engineering, Graduate Program Director for MCE at ISU.

5. Project objective(s) and total amount requested

Hollow heart, as well as any defect in a potato crop, can be devasting to farmers. Hollow heart is not a disease but is a physiological disorder. It is affected by external factors such as temperature, soil moisture, plant density, and others [1].

We propose to conduct research that leads to a system that is capable of non-destructive detection and subsequent removal of potatoes affected by hollow heart and other abnormalities that may result in an entire shipment of potatoes being rejected at points of inspection [2]. The novelty of the proposed research is to develop and use an AI classification system for identifying hollow heart in potatoes. Three methods will be used to collect the data for AI training; 1. a vision/vibration enhanced based method, 2. Spectroscopy [4], and 3. an acoustic based method (ultrasound) [4]. One potato at a time will be used to gather a "data point" which consists of the measurements from the above three sensing systems. These data will be manually verified to establish whether the potato is "good" (no hollow heart) or "bad" (hollow heart). The data collected and the corresponding engineered AI features will also be evaluated using several multivariate classification statistic packages to be used as a benchmark for the AI classification system. The proposed research is the first step, TRL3, "Proof of Concept", for the project, that being the successful identification of hollow heart in potatoes using AI classification. Development of this system will lead to the next level, TRL4 with further research being performed to develop a bench scale system to automatically move potatoes through the data collection and AI classification systems. In the long view, information gathered from such as system will be used to create a feedback loop to the farmer to improve overall potato quality.

The objectives for the proposed research and development are as follows:

i. Establish the "best" data collection method(s), features, and feature enhancement methods.
ii. Establish an accurate AI classification system using the data from (i), benchmarking with standard multivariate statistics.

These objectives involve collaborations between the investigators and segments of the potato industry, farmers, processors, and equipment manufacturers. Undergraduate and graduate student researchers will also be an important element of the project. The students will be involved in all aspects of the project. Enhanced learning will be gained by the students working with the investigators and being immersed in research that will aid an industry. By working with the collaborators the students will get a better understanding of issues faced by the industry.

The expected results of the research are to show “proof of concept” that an appropriate data collection/processing and AI classification system can detect potatoes affected by hollow heart. We fully expect to achieve this goal within the specified project time.

Total budget amount requested: $95,656 for 1 year

6. Resource commitment

The research team has established a list of Idaho industries who have expressed interest in this project (see support letters). During the first project phase, we have planned three visits with these entities to validate, consult, obtain field data and to receive feedback.

7. Specific project plan and timeline (1-3 years, depending on proposal track)

The proposed one-year project fits into the proof-of-concept track. The PI’s plan to develop a prototype system to perform non-destructive evaluation of hollow heart in potatoes. The following plan describes milestones, and tasks to achieve TRL3 - “Proof of Concept”.

Milestone 1: 1 Month

a) Hire students for research and review project scope.
b) Identify system requirements for each data collection method and purchase components.
c) Identify AI system hardware requirements and purchase.

Milestone 2: 2 Months

a) Establish criteria for data collection and potato Feature Enhancement System (FES).
b) Set up database to track each potato experiment results based on 2.a.
c) Receive and set up each data collection system.
d) Test each data collection system operation/integration.
e) Acquire a supply of potatoes from growers/industry partners.
f) Begin development of AI algorithms and simulation environment for FES.

Milestone 3: 3 Months

a) Develop testing protocol for data collection. Establish the number of potatoes for initial validation.
b) Perform preliminary “data point” collection experiment, one potato at a time using a 20-pound sample of potatoes for each test based on 3.a above.
c) Manually cut and inspect each potato, after processing through all three methods for each experiment, to identify “good” or “bad”.
d) Update database.
e) Use multivariate classification packages to evaluate responses from 3.c and validate results based on manual inspection.
f) Evaluate process and make necessary adjustments/improvements.
g) Perform feature engineering based intended AI approaches.
h) Continue development of AI classification algorithm and FES.
i) HERC update report submitted.

Milestone 4: 3 Months

a) Continue testing 20-pound samples of potatoes as described in b, c, d, e, and f of milestone 3 above to collect a sufficient amount of data to train AI classification system.
b) Evaluation feature performance with selected AI algorithms and finalize AI

classification system and corresponding FES.
c) Preliminary testing of AI classification system and FES with validated data from milestone 3 and 4a.
d) Compare AI results with standard statical methods used.
e) Evaluate process results and make necessary changes/improvements.

Milestone 5: 3 Months

a) Establish the "best" data collection method(s), feature extraction method(s), and FES based on results for milestone 4.
b) Using AI system, FES, and "best" data scheme, perform data -processing and AI classification on large number of 20-pound potato samples.
c) Use "best" data collection and processing scheme for evaluation using multivariate classification statistics and compare to AI system results.
d) Manually inspect samples and compare to results.
e) Evaluate and compile all results into technical paper(s).
f) HERC final report.

Future achievement of TRL levels:

TRL4:

- With success of TRL 3 further research will be performed to develop a bench scale system to automatically move potatoes through the "best" data collection, FES, and AI classification systems. Demonstrate bench-scale process to industry partners to assist in evaluation of system. Make any changes that may be needed.

TRL5:

- Hands off demonstration and evaluation of prototype reflecting actual potato processing based on a segment of the potato industry, farmers, processors, and equipment manufacturers. Evaluate system for any changes that may be needed.

8. Potential economic impact

The proposed project may lead to an array of products and possible services that will benefit potato growers, processors, and shippers. Considering that North America is one of the leading potato producers in the world with approximately 1.3 million acres of potatoes, of which 310,000 acres are in Idaho. Current statistical measures to be used as specified by USDA require 1% of each lot to be examined at the market and for lots less than 300 packages a minimum of three samples must be provided, [5]. However, if defects are found, additional samples are inspected with tighter tolerances applied to the defect. Currently, there are nine (9) licensed fresh potato processors operating (Basic American Foods, Dickinson Frozen Foods, Idaho Pacific Corporation, Idahoan Foods, J.R. Simplot, Lamb Weston, McCain Foods, Potato Products of Idaho, and Rite Stuff Foods, [6]) and 20 licensed fresh shippers in Idaho, [6]. Approximately 785 potato growers/producers were active in 2022 in Idaho, of which approximately 300 were considered commercial growers (having more than 20 acres of potato each season). In 2022, the total value of Idaho potatoes sold was $1.4 billion, [7], while shrinkage and loss were estimated to be 6,895,000 hundredweight (cwt). Assuming an average cost of $12.5 per cwt, the loss is estimated to be $86 million/year. One of the loss factors is the occurrence of hollow heart. Potato farming is considered a high input crop and it is speculated according to an Idaho Farm Bureau Federation report, [8] that the drop in acreages (25,000 fewer acres than in 2021) for potato farming is indicative of farmers moving to less risky crops such as wheat and barley. Reducing the risk of loss may help with the current trendline of reduced potato acreage in Idaho.

The proposed prototype system has the potential to improve the quality of potatoes produced in Idaho by developing and using an AI based quality control system. This may reduce the loss estimates for potatoes, as a more precise testing can be employed. In addition, the system to be developed has the potential to be used by potato growers during harvest, by potato processing plants prior to processing operations, or by potato shippers for their quality control measures. Besides Idaho, there is a substantial global market for a system that can handle a large throughput rate and accurately detect defects such as hollow heart. Additionally, an array of small AI based quality control units deployed over a sizeable farming territory can keep track of geospatial information along with quality information. This type of data allows for an AI-based land management systems as a separate product.

If the proposed prototype is successful, we anticipate to work with local industry in developing these types of products. After testing the prototype of the AI based quality control system in the field (meeting TRL 5), the development of an AI based large scale land management system for potato quality control will be accomplished, meeting TRL6. This benchmark will allow us to cooperate with companies such as Idaho Steel, Spudnik or L2 in order to develop a production ready system, meeting TRL7. We believe this is possible within the next four years.

9. Criteria for measuring success

Project Metrics:

a) Comparison of preliminary “data point” collection experiment with manual verification of potatoes: the defect was correctly categorized “good” (no hollow heart) or “bad” (hollow heart present. Expectation – over 95% correctly identified using multivariate classification statistics.

b) Preliminary testing of AI classification system and FES with validated data: the defect was correctly categorized “good” (no hollow heart) or “bad” (hollow heart present). Compare AI results with standard statistical methods used. Expectation – sensitivity (recall) and specificity over 95%.

c) Final testing of AI classification system and FES with large number of 20-pound potato samples. Compare AI results to evaluation from multivariate statistics method. Manually process potatoes to compare results from both evaluations. Expectation – sensitivity & specificity over 95%.

d) In 2022, Idaho produced 121 million hundredweight (cwt) of potatoes. It has been suggested that the incidence of hollow heart in processed potatoes can vary between 3 to 15% [1], resulting in 3.6 to 18 million hundredweight of potatoes being affected. Identifying and removing these affected potatoes by growers (300 commercial growers in Idaho), shippers (20 in Idaho), and processors (9 in Idaho) may require a large number of the developed AI based quality control systems. At the end of the proof-of-concept stage, we anticipate to have at least two farmers and one shipper engaged in our project.

10. Anticipated development challenges/barriers

Challenge: initial identification of graduate student and training for details of project: PI's will assume most of the work until graduate and undergraduate students are properly trained for the tasks and works proposed.

Challenge: Not meeting statistical metrics for listed milestones: PI's have been developing alternative AI approaches that will be investigated in the event that the planned approaches don't meet the statistical threshold values for success.

In the case of insufficient personnel funds for proposed work: The department will allow for hiring career path intern to supplement the student researchers in order to accomplish all proposed tasks.

11. Budget

The project anticipates to form a research team that consists of the two PIs, one unpaid consultant, one graduate student, and three undergraduate students. To develop and evaluate all three testing methods, undergraduate students will be engaged to generate data (raw data, processed data, and artificial data) construct the testing devices and instrumentation. The graduate student in collaboration with the PIs and the consultant will work on data processing, feature engineering, and AI algorithm development. The budget seeks funding for the acquisition of the required instrumentation including computational resources, the physical setup of the proof of concept systems, and interaction with the industry.

Budget Summary

LINE ITEM REQUEST	**JUSTIFICATION**	**TOTAL REQUEST**
Personnel (salary and fringe)	Two PIs with partial summer support ($5,000+fringe), one graduate student ($22,800+fringe) including tuition and fees, and three undergraduate students ($3 x $8,970 + fringe)	$61,924
Equipment	1 computer with GPU ($3,700), one laptop for station ($1,800), ultrasonic system ($10,200)	$15,700
Travel	3 field trips with six researchers	$600
Participant Support	Tuition and fees for graduate student ($11832)	$11,832
Other Direct Costs	Materials and supplies	$5,600
		$95,656

FORM D: IGEM-HERC Full Proposal Budget Sheet

Track (select one): *Innovation*
PI First & Last Name: Marco Schoen, Mary Hofle
Project Title: AI Based Quality Control for Potato Harvesting
Milestone description (if applicable *Enter milestone number and/or brief description here*

Insert more rows in each section, as needed. *Copy/paste cell formulas, as needed.* *See cell notes for additional information.*
Do not remove or hide rows. *Shaded areas have preset formulas.*

Personnel								
Name	FTE (opt)	Months	Base Salary	Salary Request	Fringe Rate	Other Ben Rate	Fringe Request	Total
Marco Schoen	9	0.5279	$113,661.00	$5,000.14	0.097		$485.01	**$5,485.15**
Mary Hofle	9	0.6945	$86,404.00	$5,000.63	0.097		$485.06	**$5,485.69**
Graduate Student		1	$22,800.00	$22,800.00	0.025		$570.00	**$23,370.00**
Undergraduate Student		1	$8,970.00	$8,970.00	0.025		$224.25	**$9,194.25**
Undergraduate Student		1	$8,970.00	$8,970.00	0.025		$224.25	**$9,194.25**
Undergraduate Student		1	$8,970.00	$8,970.00	0.025		$224.25	**$9,194.25**
								$61,923.59

Equipment			
Item Description	Units	Unit Cost	Total
Workstation	1	$3,700.00	**$3,700.00**
Laptop	1	$1,800.00	**$1,800.00**
Ultrasonic testing system	1	$10,200.00	**$10,200.00**
	1		**$0.00**
	1		**$0.00**
	1		**$0.00**
			$15,700.00

Travel						
Tentative Date(s)	# persons	Total days	Transit cost/ person	Lodging/ day	Meal per diem	Total
Field trips - local	6	3	$100.00			**$600.00**
						$0.00
						$0.00
						$0.00
						$0.00
						$0.00
						$600.00

Participant Support			
Description	# persons	Cost/ Stipend	Total
Tuition and Fees for Grad.St.	1	$11,832.00	**$11,832.00**
			$0.00
			$0.00
			$0.00
			$0.00
			$11,832.00

Other Direct Costs			
Item	Units	Cost	Total
Materials/ Supplies	1	$5,600.00	**$5,600.00**
Publication Charges	1		**$0.00**
Consultants (add consultant travel here)	1		**$0.00**
Computer Services	1		**$0.00**
Subcontract 1	1		**$0.00**
Subcontracts 2			**$0.00**
Other (list specifics if over $1,000)	1		**$0.00**
Other	1		**$0.00**
Other	1		**$0.00**
Other	1		**$0.00**
			$5,600.00
		TOTAL DIRECT COST REQUEST	**$95,655.59**

12. Budget justification – Clearly describe and justify the purpose of each item in the budget.

Personnel: the two PI's request summer support in the amount of $5,000 each. In addition, one graduate student will be dedicated to this project and the student's tuition and fees for two semesters as well as the summer are requested in the amount of $11,832. The graduate student will receive a stipend reflecting a 19-hour work week at $24/hour for 50 weeks. Three undergraduate students will be employed on an hourly basis, each making $19.5/hour for 10 hours per week for 46 weeks.

Fringes: the faculty fringe rate for summer is 9.7% amounting to $485 for each faculty. The students fringe rate is 2.5% for the year and amounts to $1,243.

Travel: The research team plans to consult with local industry and requests funding for domestic travel (via car) to processors, chippers, fryers, and farmers among others, estimating travel costs of $600.

Equipment: For the AI system development and training, we request funding to purchase a computer with adequate processing power (GPU) and a laptop computer for the student's work: $3,700 + $1,800 = $5,500. For the prototype a small conveyor system will be purchased ($500), and a high-speed camera ($800). The vision testing and control system is supplemented by developing an ultrasonic evaluation system in the amount of $10,200. For the acoustic approach, we anticipate to construct a simple acoustic drop-chamber with dedicated microphone and noise cancelling DAQ in the amount of $1,900.

Materials and Supply: Utilizing the existing shaker table and dSPACE controller, for the prototype assembly we request $2,100 in order to construct the entire system.

13. Project management (see next page)

IGEM-HERC

Project Title: AI Based Quality Control for Potato Harvesting

PI: Marco P. Schoen, Co-PI: Mary M. Hofle

Duration: 12 Months

■ = Milestone | = Original Task Duration | = Original HERC Update | X = Completed Task | X = Completed HERC Update | = Schedule Adjustment | X = Completed Schedule Adj

	Task	Month	1	2	3	4	5	6	7	8	9	10	11	12
1.0	**Personnel Organization and Project Scope Review**													
1.1	Hire students for research and review project scope.													
1.2	Identify system requirements for each data collection method and purchase components.													
1.3	Identify AI system hardware requirements and purchase.													
2.0	**Data Collection System**													
2.1	Establish criteria for data collection.													
2.2	Set up database to track each potato experiment results based on (a).													
2.3	Receive and set up each data collection system.													
2.4	Test each data collection system operation/integration.													
2.5	Acquire a supply of potatoes from growers/industry partners.													
2.6	Begin development of AI algorithms.													
3.0	**Initial Data Collection**													
3.1	Develop testing protocol for data collection. Establish the number of potatoes for initial validation.													
3.2	Perform preliminary “data point” collection experiment, one potato at a time using a 20-pound sample of potatoes for each test based on a) above.													
3.3	Manually cut and inspect each potato, after processing through all three methods for each experiment, to identify “good” or “bad”.													
3.4	Update database.													
3.5	Use multivariate classification packages to evaluate responses from (c) and validate result based on manual inspection.													
3.5	Evaluate process and make necessary adjustments/improvements.													
3.6	Perform feature engineering based on intended AI approaches													
3.7	Continue development of AI classification algorithm.													
3.8	HERC update report submitted.													
4.0	**Preliminary Validation Testing**													
4.1	Continue testing 20-pound samples of potatoes as described in b), c), d), e), and f) of milestone 3 above to collect a sufficient amount of data to train AI classification system.													
4.2	Finalize AI classification system.													
4.3	Preliminary testing of AI classification system with validated data from milestone 3 and 4.1.													
4.4	Compare AI results with standard statistical methods used.													
4.5	Evaluate process results and make necessary changes/improvements.													
5.0	**Establish "Best" Overall System**													
5.1	Establish the “best” data collection method(s) based on results for milestone 4.													
5.2	Using AI system and “best” data collection scheme, perform data collection and AI classification on large number of 20-pound potato samples.													
5.3	Use “best” data collection scheme data for evaluation using multivariate classification statistics and compare to AI system results.													
5.4	Manually inspect samples and compare to results.													
5.5	Evaluate and compile all results into a final technical paper.													
5.6	HERC final report													

14. Additional institutional and other sector support

We have established support from industry to pursue this project. In particular, Spudnik's CEO and the director of operations (see support letter) have great interest in this type of product development. In addition, we have the support from a number of other potato related company, such as McCain Foods, Tompson Farms, Lamb Weston, Southern Fabrication, and Barracuda Engineering. This is in addition to local farmers who will help facilitate data collection. ISU regional role in supporting the industry is part of the mission for the Department of Mechanical and Measurement & Control Engineering, as well as the Measurement and Control Engineering Research Center (MCERC) where this project will be housed.

15. Future funding

The objective of the proposed work and the associated requested funding from HERC is to get fundamentally sound research outcomes to meet the proof-of-concept stage. With such outcomes, we will have the opportunity to pursue a multipronged funding approach: continued fundamental research through NSF and a product development type path by applying for funding through the United States Department of Agriculture (USDA), as well as the subsequent HERC initiatives.

The USDA's Agriculture and Food Research Initiative (AFRI) encompasses the Sustainable Agricultural Systems (SAS) initiative, which invites proposals under its Coordinated Agricultural Project (CAP) program and Strengthening Coordinated Agricultural Project (S-CAP) grants program. Specifically, the SAS-FASE grants aim to target enhancements in food supply, facilitating economic rejuvenation, innovative approaches addressing contemporary needs, improve rural prosperity, and strengthened food and nutrition security. Geared towards large, integrated, transdisciplinary projects, the program focuses on confronting significant obstacles in fostering sustainable food and agricultural systems through research efforts.

References:

[1] K.C. Watts and L.T. Russell, "A Review of Techniques for Detecting Hollow Heart In Potatoes," Canadian Agricultural Engineering, 27, No. 2, 1985.
[2] Index of Official Visual Aids for Potatoes (POT-L-1) (July 2017), SCI Division Inspection Series Crops Inspection Division, USDA.
[3] Imanian, Kamal, Razieh Pourdarbani, Sajad Sabzi, Ginés García-Mateos, Juan Ignacio Arribas, and José Miguel Molina-Martínez. "Identification of internal defects in potato using spectroscopy and computational intelligence based on majority voting techniques." Foods 10, no. 5 (2021): 982.
[4] Solos Jivanuwong, "Nondistructive Detection of Hollow Heart in Potatoes using Ultrasonics," Thesis, Biology, Virginia Polytechnic Institute and State University, May 1998.
[5] USDA Potatoes – Shipping Point and Market Inspection Instructions, April 2012
[6] https://idahopotato.com/directory/processors, last accessed March 2024.
[7] https://www.agproud.com/articles/58402-idaho-annual-potato-summary-2022, last accessed March 2024.
[8] https://www.idahofb.org/news-room/posts/idaho-farmers-plant-25-000-fewer-potato-acres-in-2022/, last accessed March 2024.

Full Proposal Appendices

Appendix A: Facilities and Equipment

This project will be housed at the Measurement and Control Engineering Research Center (MCERC). The MCERC maintains seven research laboratories, and is housed at ISU's Engineering Research Complex, which contains three additional laboratories. The facilities of the MCERC are available for the proposed research. The proposed research will make use of some key equipment that is part of the Dynamic Systems and Intelligent Control Research Laboratory. This laboratory contains

- one small shaker table (40-lb)
- one dSPACE controller
- one PolyTec Inc. model PSV-300-F Scanning Laser Doppler Vibrometer and data processing software
- one vibration isolation table
- Agilent Technologies 35670A 4-channel dynamic signal analyzer
- various vibration sensing equipment
- several power amplifiers (Quansar)
- embedded systems platforms (various manufacturers), 3D printers, 3D scanners, VR and AR equipment, function generators, oscilloscopes among various measurement equipment.

The other laboratories offer additional support, in particular the Robotics Research Laboratory which contains two robot manipulators (ABB IRB-120 robot and UR-5 robot); three robotic hands: Barrett hand, Robotiq 2-finger gripper and lab-made Scott hand; a reprogrammable NI controller; 3D printers; tabletop drills; a multi -camera motion capture studio with five video cameras, two RGB-D cameras and a ZED mini stereo camera; National Instruments data acquisition equipment; robot controllers and other experiments. In addition, desktop computers and laptop computers with software for design, sensing and control: SolidWorks©, Matlab©, LabVIEW© and Mathematica©, among others.

Other MCERC research laboratories that serve in aid to the projects include:

- Jet Engine and Wind Tunnel Research Laboratory: Contains a Westinghouse J-34 jet engine and a 2-ft non-circulating wind tunnel, along with various flow visualization equipment, two high speed cameras, and high-speed pressure DAQ system.
- Controls Research Laboratory: This laboratory contains one Piksi Multi Evaluation kit which is a multi-band, multi-constellation RTK GNSS receiver that provides centimeter-level accuracy. Two Piksi Multi L1/L2, G1/G2, B1/B2, E1/E5b and SBAS GNSS Modules, two Evaluation Boards, two high-quality survey-grade GNSS antennas, two high-performance, industrial 2.4 GHz FreeWave® radios with effective ranges up to 15 kilometers (~10 miles). Access to multiple satellite constellations improves availability, reliability and range between base and rover. A bare-bones rover mobile platform. One tabletop drill, 2 research laptops and 1 desktop computer with software for design, sensing and control*: SolidWorks©, Matlab©, and LabVIEW©*. We are in the process of procuring a RPLIDAR A3M1 360° Laser Range ScannerLiDAR for the mobile platform. 1 programmable custom waveform power supply. 4 Tektronix oscilloscopes.
- Offices and Meeting Space: The MCERC has an array of student offices for PhD and MS students, as well as office space for graduate students in each of the laboratories. In addition, it has a conference room where seminars can be organized for small groups.

Appendix B: Biographical Sketches

IDENTIFYING INFORMATION:

NAME: Schoen, Marco

POSITION TITLE: Professor

PRIMARY ORGANIZATION AND LOCATION: Idaho State University, Pocatello, Idaho, United States

Professional Preparation:

ORGANIZATION AND LOCATION	DEGREE (if applicable)	RECEIPT DATE	FIELD OF STUDY
Old Dominion University, Norfolk, Virginia, United States	PHD	05/1997	Engineering Mechanics
Widener University, Chester, Pennsylvania, United States	MENG	05/1993	Mechanical Engineering
Fachhochschule Nordwestschweiz, Muttenz, Not Applicable, N/A, Switzerland	BS	11/1989	Mechanical Engineering
Gewerbeschule Baselland, Liestal, Not Applicable, N/A, Switzerland	Other training	04/1982 - 04/1986	Design Engineering

Appointments and Positions

2008 - present	Professor, Idaho State University, Pocatello, Idaho, United States
2015 - present	Director - Measurement and Control Engineering Research Center (MCERC), Idaho State University, Pocatello, Idaho, United States
2022 - 2023	Chair, Idaho State University, Department of Mechanical Engineering, Pocatello, Idaho, United States
2021 - 2022	Visiting Researcher, Leibniz University, Hannover, Not Applicable, N/A, Germany
2011 - 2012	Visiting Research Professor, Chinese Academy of Science, Beijing, Not Applicable, N/A, China
2010 - 2013	Chair, Idaho State University, Department of Mechanical Engineering, Pocatello, Idaho, United States
2008 - 2013	Graduate Program Director, Idaho State University, Pocatello, Idaho, United States
2007 - 2007	Visiting Researcher, Norwegian University of Technology, Trondheim, Not Applicable, N/A, Norway
2003 - 2015	Associate Director, Idaho State University, Measurement and Control Engineering Research Center (MCERC), Pocatello, Idaho, United States
2001 - 2008	Associate Professor, Idaho State University, Pocatello, Idaho, United States
1999 - 2001	Director, Indiana Institute of Technology, Applied Research Center, Fort Wayne, Indiana, United States
1998 - 2001	Associate Professor, Indiana Institute of Technology, Department of Mechanical Engineering, Fort Wayne, Indiana, United States
1997 - 1998	Assistant Professor, Lake Superior State University, Sault Ste. Marie, Michigan, United States

1994 - 1997	Research and Teaching Assistant, Old Dominion University, Norfolk, Virginia, United States
1992 - 1993	Research and Teaching Assistant, Widener University, Chester, Pennsylvania, United States
1990 - 1991	Mechanical Engineer, Habasit Inc, Reinach, Not Applicable, N/A, Switzerland
1986 - 1986	Design Engineer, Buss Inc., Pratteln, Not Applicable, N/A, Switzerland
1982 - 1986	Design Engineer Apprentice, Buss AG, Pratteln, Not Applicable, N/A, Switzerland

Products

Products Most Closely Related to the Proposed Project

1. Schoen M, Oettinger M, Mimic D. Deep and Machine Learning-based Methods for Defect Classification in Jet Engines. 2023 Intermountain Engineering, Technology and Computing (IETC). 2023 Intermountain Engineering, Technology and Computing (IETC); ; Provo, UT, USA. IEEE; c2023. Available from: https://ieeexplore.ieee.org/document/10152188/ DOI: 10.1109/IETC57902.2023.10152188
2. Jaman G, Monson A, Chowdhury KR, Schoen MP. System Identification and Machine Learning Model Construction for Reinforcement Learning Control Strategies Applied to LENS System. Intermountain Engineering Technology and Computing Conference (IEEE); 2022 May; Orem, Utah, US.
3. Schoen MP, Lee J. Application of System Identification for Modeling the Dynamic Behavior of Axial Flow Compressor Dynamics. International Journal of Rotating Machinery. 2017 May 07; 2017:14. Available from: https://doi.org/10.1155/2017/7529716
4. Mahmud A, Heidari O, Schoen MP. sEMG based Real-Time Motion Classification using Virtual Reality and Artificial Neural Networks. Journal of Electrical Engineering and Automation. 2022 December; 4(4):241-256. DOI: https://doi.org/10.36548/jeea.2022.4.003
5. Schoen M, Lee J. Application of System Identification for Modeling the Dynamic Behavior of Axial Flow Compressor Dynamics. International Journal of Rotating Machinery. 2017; 2017:1-14. Available from: https://www.hindawi.com/journals/ijrm/2017/7529716/ DOI: 10.1155/2017/7529716

Other Significant Products, Whether or Not Related to the Proposed Project

1. Schoen MP. Dynamic Compensation of Smart Sensors. " IEEE Transaction of Instrumentation and Measurement. 2007 September 17; 56(5). Available from: 10.1109/TIM.2007.895626
2. Schoen MP. A Simulation Model for the Primary Drying Phase of the Freeze-Drying Cycle. International journal of pharmaceutics. 1995 February 14; 114(2):159-170. Available from: https://doi.org/10.1016/0378-5173(94)00234-V
3. Schoen MP, Hoover RC, Chinvorarat S, Schoen GM. System Identification and Robust Controller Design using Genetic Algorithms for Flexible Space Structures. J. Dyn. Sys., Meas., Control.. 2009 March 19; 131(3):031003 (11 pages). Available from: https://doi.org/10.1115/1.3072106
4. Rafiee J, Rafiee MA, Prause N, Schoen Marco P. Wavelet basis functions in biomedical signal processing. Expert Systems with Applications. 2011 May; 38(5):6190--6201. Available from: https://www.sciencedirect.com/science/article/pii/S0957417410012881 DOI:

https://doi.org/10.1016/j.eswa.2010.11.050

5. Schoen M, Hals J, Moan T. Wave Prediction and Robust Control of Heaving Wave Energy Devices for Irregular Waves. IEEE Transactions on Energy Conversion. 2011 June; 26(2):627-638. Available from: http://ieeexplore.ieee.org/document/5706439/ DOI: 10.1109/TEC.2010.2101075

Synergistic Activities

1. Text book: Marco P. Schoen, Introduction to Intelligent Control Systems and Machine Learning using Matlab, Cambridge University Press, January 2024, ISBN 9781316518250
2. Founding Chair of the Model Identification and Intelligent Systems Technical Committee of the Dynamic Systems and Controls Division / ASME (2005-2008).
3. Developed and directed the Applied Research Center (ARC) at Indiana Institute of Technology, focusing in all areas of engineering, particular in Controls, Energy systems, Autonomous and Biomedical systems.
4. Director of the Measurement and Control Engineering Research Center (MCERC) at ISU: Developed infrastructure including research laboratories and initiated collaborative multi-institutional research programs.
5. Recipient of Idaho State University Distinguished Teacher Award for the academic year 2018-2019.

Certification:

When the individual signs the certification on behalf of themselves, they are certifying that the information is current, accurate, and complete. This includes, but is not limited to, information related to domestic and foreign appointments and positions. Misrepresentations and/or omissions may be subject to prosecution and liability pursuant to, but not limited to, 18 U.S.C. §§ 287, 1001, 1031 and 31 U.S.C. §§ 3729-3733 and 3802.

Certified by Schoen, Marco in SciENcv on 2024-03-12 12:07:03

IDENTIFYING INFORMATION:

NAME: Hofle, Mary M

POSITION TITLE: Senior Lecturer

PRIMARY ORGANIZATION AND LOCATION: Idaho State University, Pocatello, Idaho, United States

Professional Preparation:

ORGANIZATION AND LOCATION	DEGREE (if applicable)	RECEIPT DATE	FIELD OF STUDY
Quality Assurance Auditing in Industrial Settings, Gilbert/Commonwealth Training Institute, Reading, Pennsylvania, United States	Other training	03/1991 - 03/1991	Quality Assurance Auditing
QUALPRO, Logan, Utah, United States	Other training	04/1988 - 04/1988	Experimental Design Techniques for Upgrading Existing Processes
Rensselaer Polytechnic Institute, Troy, New York, United States	MS	12/1984	Industrial and Management Engineering
Rensselaer Polytechnic Institute, Troy, New York, United States	MS	05/1984	Mechanical Engineering
University of Akron, Akron, Ohio, United States	BS	05/1982	Mechanical Engineering

Appointments and Positions

2011 - present Senior Lecturer, Idaho State University, Department of Mechanical and Measurement & Control Engineering, Pocatello, Idaho, United States

2013 - present ME Undergraduate Program Director, Idaho State University, Department of Mechanical Engineering, Pocatello, Idaho, United States

2016 - 2017 Chair, Department of Mechanical Engineering, Idaho State University, Department of Mechanical Engineering, Pocatello, Idaho, United States

2012 - 2015 Chair, Department of Mechanical Engineering, Idaho State University, Department of Mechanical Engineering, Pocatello, Idaho, United States

2005 - 2009 Chair, Department of Mechanical Engineering, Idaho State University, Department of Mechanical Engineering, Pocatello, Idaho, United States

2002 - 2011 Associate Lecturer, Department of Mechanical Engineering, Idaho State University, Department of Mechanical Engineering, Pocatello, Idaho, United States

1996 - 2002 Instructor, Mechanical Engineering, Idaho State University, College of Engineering, Pocatello, Idaho, United States

1992 - 1996	Adjunct Instructor, Mechanical Engineering, Idaho State University, College of Engineering, Pocatello, Idaho, United States
1992 - 1996	Adjunct Instructor, Operations Management, Idaho State University, College of Business, Pocatello, Idaho, United States
1990 - 1992	Certified Lead Auditor, Baltimore Gas and Electric - Calvert Cliffs Nuclear Power Plant, Lusby, Maryland, United States
1987 - 1990	Manufacturing Engineering Manager, Bourns Networks, Inc, Logan, Utah, United States
1985 - 1987	Associate to Senior Manufacturing Engineer, Bourns, Logan, Utah, United States

Products

Products Most Closely Related to the Proposed Project

1. Bodily PM, Griffith ID, Hofle M, Heidari O, Lama S, Conlin A, Christiansen A, Moore D, Wilson K, Sebastian A, Schoen M. Automating Predictive Maintenance for Energy Efficiency via Machine Learning and IoT Sensors. CAINE 2021, 34th International Conference on Computer Application in Industry and Engineering, Virtual Conference. 2021 October.

Other Significant Products, Whether or Not Related to the Proposed Project

1. Sterbentz DM, Prasai S, Hofle M, Walters T, Lin F, Li J, Bosworth K, Schoen M. System Identification within the Tip Region of an Axial Compressor Blade Passage. Journal of Thermal Science. 2016 March.
2. Sterbentz DM, Prasai S, Hofle M, Walters T, Lin F, Li J, Bosworth K, Schoen M. System Identification and Modeling of the Dynamics within an Axial compressor's Blade Passage,. Proceedings of the International Symposium on Experimental and Computational Aerothermodynamics of Internal Flows Genoa, Italy. 2015 July.

Synergistic Activities

1. Avista Grant, August 2020 – August 2021, "Automating Predictive Maintenance for Energy Efficiency via Machine Learning and IoT Sensors". Equipment setup and sensor implementation to test equipment to failure to acquire data for machine learning and predicting maintenance, Co-PI.
2. Automating Predictive Maintenance for Energy Efficiency via Machine Learning and IoT Sensors", Paul M. Bodily, Isaac D. Griffith, Mary Hofle, Omid Heidari, Safal Lama, Avery Conlin, Andrew Christiansen, Delaney Moore, Kellie Wilson, Anish Sebastian, and Marco Schoen. CAINE 2021, 34th International Conference on Computer Application in Industry and Engineering, Virtual Conference, October 11 – 13, 2021
3. Baltimore Gas and Electric Calvert Cliffs Nuclear Power Plant, Quality Assurance Engineer, Certified Lead Auditor responsible for auditing and performance evaluation of areas critical to the power plant operation and safety.
4. Bourns Networks, Inc, responsible for the implementation of product designs to the production floor, including equipment design and process development, capital equipment budgets, project development and implementation, and statistical process control (SPC) development and implementation.
5. CEERI Industrial Assessment Center conducted on behalf of the US Department of Energy,

2011-2013. ISU Department of Mechanical Engineering was a participant in the assessment center. Conducted energy conservation/efficiency studies for local industries.

Certification:

When the individual signs the certification on behalf of themselves, they are certifying that the information is current, accurate, and complete. This includes, but is not limited to, information related to domestic and foreign appointments and positions. Misrepresentations and/or omissions may be subject to prosecution and liability pursuant to, but not limited to, 18 U.S.C. §§ 287, 1001, 1031 and 31 U.S.C. §§ 3729-3733 and 3802.

Certified by Hofle, Mary M in SciENcv on 2024-03-14 16:23:56

Appendix C: Senior Personnel

Dr. Ken W. Bosworth is currently a Full Professor in the Dept. of ME and M&CE at ISU, and has served as ME. Dept. Chair, and is the current Director of the MCE Graduate Program, housed within the ME and M&CE Department. Previously he was Chair of the Computer Department at ISU, and also a faculty member in the Dept. of Mathematics and Statistics at ISU. His PhD is in Applied Mathematics, from Rensselaer Polytechnic Institute (1984). His research interests include non-parametric and semi-parametric data fitting, mathematical modeling of complex systems, and system identification. He has taught graduate level courses in Engineering Modeling (ME), System Identification (MCE), Multivariate Statistical Analysis (Math & Stats.), Numerical Analysis (ME), Signal and Image Processing. (CS), and Neural Networks (CS), with these being relevant to this proposal. He has directed 8 PhD students, and over 20 MS students as major advisor while at ISU. His role in this project will be to advise and consult with the PI's on multivariate statistical classification algorithms, machine learning (neural networks), and image and signal processing.

Appendix D:

See support letters from Spudnik Equipment Company LLC and Barracuda Engineering LLC below.

Spudnik Equipment Company LLC
584 W 100 N
PO Box 1045
Blackfoot, ID 83221

Idaho State Board of Education
Higher Education Research Council
650 West State Street, third Floor
Boise, ID 83702

March 2024

To Whom It May Concern:

I am writing on behalf of Spudnik Equipment Company in support of Idaho State University's grant proposal to the Higher Education Research Council (HERC) entitled "AI Based Quality Control for Potato Harvesting." We strongly support this grant application and the focus on artificial intelligence-based potato defect detection research.

As an organization with more than 60 years of experience in the potato industry, Spudnik has developed machinery for every stage of production and transportation for the potato industry. A system that automatically detects, in a non-destructive fashion, defects in potatoes – such as hollow heart – could greatly benefit our industry.

Through this letter, we acknowledge that the research team from Idaho State University (Marco Schoen and Mary Hofle) has the opportunity to consult with us on the planned research tasks in terms of our experience dealing with defective potatoes.

If you have any questions, please feel free to contact us.
Sincerely,

Rainer Borgman
CEO
rainer.borgmann@Spudnik.com
208 680 2469

GaryDee VanOrden,
Director of Operations
Garydee.vanorden@Spudnik.com
208 680 9209

208-681-7527
Kurt@barracudaeng.com
KURT SCOTT P.E.

Higher Education Research Council
650 West State Street, third floor
Boise, ID 83702

To Whome It May Concern,

I am writing on behalf of BarraCuda Engineering LLC in support of Idaho State University's grant proposal to the Higher Education Research Council (HERC) entitled "AI Based Quality Control for Potato Harvesting." We strongly support this grant application and the focus on artificial intelligence-based potato defect detection research.

As an organization we support the next generation of automation in food processing and receiving lines. A system that automatically detects, in a non-destructive fashion, defects in potatoes – such as hollow heart – could greatly benefit our industry.

Through this letter, we acknowledge that the research team from Idaho State University (Marco Schoen and Mary Hofle) has the opportunity to consult with us on the planned research tasks in terms of our experience dealing with defective potatoes.

If you have any questions, please feel free to contact me.

Warm regards,

Kurt W. Scott M.S.P.E
OWNER BARRACUDA ENGINEERING LLC