Curriculum Vitae

Prahalada Rao

Associate Professor
Mechanical and Materials Engineering
University of Nebraska-Lincoln
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Lab Website: https://engineering.unl.edu/lamps/
Google Scholar: Prahalada Rao - Google Scholar

Summary of Accomplishments

Research Accomplishments	
Funding Record	
External (Federal Funding)	$2,011,838 (My Share); $2,822,082 (Total) Obtained funding from National Science Foundation, Department of Energy, and Department of Defense.
Industry	$25,000
Internal	$10,000
Publications	56 peer-reviewed journal papers published, including 2 best paper awards. 1 peer-reviewed journal papers accepted pending revisions. 4 peer-reviewed journal papers under review. 20+ peer-reviewed conference proceedings published.
Students Graduated	3 Ph.D.'s graduated; 6 ongoing Ph.D.'s 2 MS students graduated (1 ongoing)
Notable Awards and Recognition	Society of Manufacturing Engineers (SME) - Yoram Koren Outstanding Young Manufacturing Engineer Award (2017), SME Outstanding Reviewer Award (2018), NSF Career Award (2018), University of Nebraska-Lincoln - College of Engineering Research and Creative Activity Award (2019).

Teaching and Pedagogy	
Courses Taught	MECH 321 – Statistics and Data Analytics (required undergraduate course) MECH 422 – Industrial Quality Control MECH 498/898 – Additive Manufacturing (AM) MECH 499/899 – Metallurgy and Processing Science of Additive Manufacturing. MECH 492/892 – Data-driven Engineering
Instructor rating	4.3 average over 5.
Teaching Grants	$268, 000
Undergraduates Advised	7 UG with 2 continuing for Ph.D.

Section 1 Education and Employment History

Section 1.1 Education History

Doctor of Philosophy
Industrial Engineering and Management
Oklahoma State University, Stillwater, Oklahoma.
December 2008 – August 2013.

Master of Science
Industrial Engineering and Management
Oklahoma State University, Stillwater, Oklahoma.
August 2003 – August 2006.

Bachelor of Engineering
Production Engineering (First Class)
Victoria Jubilee Technical Institute (VJTI), Bombay University, India.
August 1999 – May 2003.

Section 1.2 Employment History

University of Nebraska-Lincoln.
Associate Professor, August 2020 – Present
Assistant Professor, August 2016 – August 2020.
Mechanical and Materials Engineering

Binghamton University (State University of New York).
Assistant Professor (Tenure-track)
System Science and Industrial Engineering
August 2014 – August 2016.

Virginia Polytechnic Institute and State University (Virginia Tech).
Post-Doctoral Research Associate
Grado Department of Industrial and Systems Engineering
August 2013 – August 2014.

Section 2 Research Accomplishments

Section 2.1 Publications

The following subscripts indicate students under my supervision.
1: Undergraduate student. 2: Master's student.
3: Ph.D. student graduated under my supervision at University of Nebraska-Lincoln (UNL).
3: Ph.D. student graduated from Binghamton University. 4: Postdoctoral researcher.*

Section 2.1.1 Peer reviewed journal publications

1. A. Ramalho, T.G. Santos, B. Bevans[3], Z. Smoqi[3], **P. Rao**, J.P. Oliveira,

   Effect of contaminations on the acoustic emissions during wire and arc additive manufacturing of 316L stainless steel,

   Additive Manufacturing, Volume 51, 2022
   doi: 1016/j.addma.2021.102585.
   Collaboration with NOVA University, Lisbon, Portugal.

2. S. Ramesh, O. Harrysson, **P. Rao**, A. Tamayol, D. R. Cormier, Y. Zhang, I. V. Rivero
   Extrusion bioprinting: Recent progress, challenges, and future opportunities
   Bioprinting, Volume 21, 2021
   doi:1016/j.bprint.2020.e00116.
   Collaboration with North Carolina State, Rochester Institute of Technology, and Connecticut.

3. S. Gerdes[3], S. Ramesh, Azadeh Mostafavi, A. Tamayol, I. V. Rivero, **P. Rao**

   Extrusion-based 3D (Bio)Printed Tissue Engineering Scaffolds: Process–Structure–Quality Relationships

   ACS Biomaterials, Science and Engineering, 2021, 7, 10, 4694–4717
   doi: 10.1021/acsbiomaterials.1c00598
   Collaboration with Rochester Institute of Technology and University of Connecticut.

4. K. D. Cole, A. Riensche[3], **P. Rao,**

   Discrete Green's functions and spectral graph theory for computationally efficient thermal modeling

   International Journal of Heat and Mass Transfer, Volume 183, Part B, February 2022, 122112.
   doi: /10.1016/j.ijheatmasstransfer.2021.122112

5. R. Yavari[3], A. Riensche[3], E. Tekerek, L. Jacquemetton, H. Halliday, M. Vandever, A. Tenequer, V. Perumal, A. Kontsos, Z. Smoqi[3], K. Cole, **P. Rao**,

   Digitally twinned additive manufacturing: Detecting flaws in laser powder bed fusion by combining thermal simulations with in-situ meltpool sensor data

   Materials & Design, Volume 211, 2021, 110167.
   Special Issue: In-line metrology, design optimization and material development in additive manufacturing, pp :109229
   doi: 10.1016/j.matdes.2021.110167.
   Collaboration with SigmaLabs, Drexel University, & Navajo Technical University

6. R. Yavari[3], Z. Smoqi[3], A. Riensche[3], B. Bevans[3], H. Kobir[2], H. Mendoza, H. Song, K. Cole, **P. Rao**
   Part-Scale Thermal Simulation of Laser Powder Bed Fusion Using Graph Theory: Effect of Thermal History on Porosity, Microstructure Evolution, and Recoater Crash.
   Materials & Design, Volume 204, 2021, 109685
   Special Issue: In-line metrology, design optimization and material development in additive manufacturing, pp :109229
   doi: 10.1016/j.matdes.2021.109685.
   Collaboration with Edison Welding Institute

7. R. Yavari[3], R. Williams, A. Riensche[3], P. A. Hooper, K. D. Cole, L. Jacquemetton, H. Halliday, **P. Rao**
   Thermal Modeling in Metal Additive Manufacturing using Graph Theory – Application to Laser Powder Bed Fusion of a Large Volume Impeller.
   Additive Manufacturing. Volume 41, 2021,
   Doi:10.1016/j.addma.2021.101956
   Collaboration with Imperial College London, Sigma Labs, Inc, and Navaho Technical University.

8. R. Salary, J. Lombardi, D. Weerawarne, **P. Rao**, and M. Poliks
   A Computational Fluid Dynamics (CFD) Investigation of Pneumatic Atomization, Aerosol Transport and Deposition in Aerosol Jet Printing (AJP) Process.
   Journal of Micro- and Nanomanufacturing, Volume 9, Issue 1: 010903 (16 pages)
   doi: 10.1115/1.4049958
   Collaboration with Binghamton University and Marshall University

9. R. Chen, **P. Rao**, Y. Liu, E. Reutzel, H. Yang.
   Recurrence Network Analysis of Design-quality Interactions in Additive Manufacturing
   Additive Manufacturing (In-press, January 2021)
   doi: 10.1016/j.addma.2021.101861
   Collaboration with Penn State and NIST.

10. Z. Smoqi[3], J. Toddy, H. Halliday, J. E. Shield, and **P. Rao**.
    Process-Structure Relationship in the Directed Energy Deposition of Cobalt-Chromium Alloy Coatings.
    Materials and Design, Volume 197, January 2021.
    Special Issue: In-line metrology, design optimization and material development in additive manufacturing, pp :109229.
    doi: 10.1016/j.matdes.2020.109229
    Collaboration with Navajo Technological University

11. H. Yang, **P. Rao**, T. Simpson, Y. Lu, P. Witherell, A. R. Nassar, E. Reutzel, and S. Kumara
    Six-sigma Quality Management of Additive Manufacturing.
    Proceedings of the IEEE Volume: 109, Issue: 4, April 2021
    doi: 10.1109/JPROC.2020.3034519
    Collaboration with NIST and Penn State

12. J. Liu, J. Zheng, **P. Rao**, and Z. Kong.
Machine learning–driven in situ process monitoring with vibration frequency spectra for chemical mechanical planarization.
International Journal Advanced Manufacturing Technology, 111, 1873–1888 (2020).
doi:/10.1007/s00170-020-06165-1
Collaboration with Auburn University and Virginia Tech.

13. A. C. Gaikwad[3], B. Giera, G.M. Guss, J-B Forien, M. J. Matthews, and **P. Rao**.
Heterogeneous Sensing and Scientific Machine Learning for Quality Assurance in Laser Powder Bed Fusion – A Single-track Study.
Additive Manufacturing, December 2020, Volume 36, pp. 101659
doi:/10.1016/j.addma.2020.101659
Collaboration with Lawrence Livermore National Laboratory

14. R. Yavari[3], R.J. Williams, K. Cole, P. Hooper, and **P. Rao**.
Thermal Modeling in Metal Additive Manufacturing using Graph Theory: Experimental Validation with In-situ Infrared Thermography Data from Laser Powder Bed Fusion.
ASME Transactions, Journal of Manufacturing Science and Engineering,
142(12): 121005, 2020.
doi: 10.1115/1.4047619.
Collaboration with Imperial College, London

15. J. Williams[3], **P. Rao**, A. Samal, M. Johnson.
Paired Trial Classification: A Novel Deep Learning Technique for MVPA.
Frontiers of Neuroscience, Volume 14, Issue 47, April 2020.
doi: 10.3389/fnins.2020.00417
Collaboration with Center for Brain, Biology, and Behavior – UNL.

16. R. Salary, J.P. Lombardi, D. L. Weerawane, M.S. Tootooni[3], **P. Rao**, M. Poliks.
A Sparse Representation-based Classification (SRC) Approach for Near Real-time Functional Monitoring of Aerosol Jet-Printed Electronic Devices.
ASME Transactions, Journal of Manufacturing Science and Engineering
142(8): 081007, 2020.
doi:/10.1115/1.4047045
Collaboration with Binghamton University and Marshall University.

17. K. Cole, R. Yavari[3], and **P.Rao**.
Computational heat transfer with spectral graph theory: Quantitative verification,
International Journal of Thermal Sciences. Volume 153, July 2020.
doi: 10.1016/j.ijthermalsci.2020.106383

18. S. Gerdes[3], A. Mostafavi, S. Ramesh, A. Memic, I. Rivero, **P. Rao**, and A. Tamayol.
Process-Structure-Quality Relationships of 3D Printed PCL-Hydroxyapatite Scaffolds,
Tissue Engineering (Part A), (Accepted, in-press, available online).
doi: 10.1089/ten.TEA.2019.0237
Collaboration with Rochester Institute of Technology and UConn Medical School.

19. A.C. Gaikwad[3], R. Yavari[3], M. Montazeri[3], K. Cole, L. Bian, and **P. Rao**.
Toward the Digital Twin in Metal Additive Manufacturing – Integrating Thermal Simulations, Sensing, and Analytics to Detect Process Faults.
IISE Transactions, Volume 52, Issue 11, pp. 1204-1217
doi: 10.1080/24725854.2019.1701753
Article highlighted in the Oct. 2020 Issue of the Industrial Engineer Magazine.
Collaboration with Mississippi State.

20. A.C. Gaikwad[3], F. Imani, H. Yang, E. Reutzel, and, **P. Rao**.
Prediction of Thin Wall Build Quality in Laser Powder Bed Fusion using Deep Learning of In-Situ Images, ASTM Journal of Smart and Sustainable Manufacturing Systems
3 (1), pp. 98-121, 2019.
doi:10.1520/SSMS20190027
Collaboration with Penn State Applied Research Laboratory.

21. M. Montazeri[3], A. Nassar. C. Stutzman, **P. Rao**.
Heterogeneous Sensor-based Condition Monitoring in Directed Energy Deposition, Additive Manufacturing, Volume 30, December 2019, 100916.
doi.org/10.1016/j.addma.2019.100916
Collaboration with Penn State Applied Research Laboratory by Dr. Nassar.

22. M. Amini, S.I. Chang, and **P. Rao**.
A Cybermanufacturing and Artificial Intelligence Framework for Laser Powder Bed Fusion (LPBF) Additive Manufacturing Process.
Manufacturing Letters, 21, pp. 41-44, 2019.
doi:10.1016/j.mfglet.2019.08.007
Collaboration with Kansas State University

23. M. Roy, R. Yavari[3], C. Zhou, O. Wodo, and **P. Rao**.
Prediction and Experimental Validation of Part Thermal History in Fused Filament Fabrication Additive Manufacturing Process.
ASME Transactions, Journal of Manufacturing Science and Engineering
141(12), pp. 121001-10, 2019.
doi: 10.1115/1.4045056
Collaboration with University of Buffalo (SUNY)

24. M. Montazeri[3], A. Nassar, A. Dunbar, and **P. Rao**.
In-Process Monitoring of Porosity in Additive Manufacturing Using Optical Emission Spectroscopy Signals.
IISE Transactions (Manufacturing and Design), Volume 52(5), 2019.
doi: 10.1080/24725854.2019.1659525
Collaboration with State Applied Research Laboratory.

25. R. Yavari[3], K. Cole, and **P. Rao**.
Thermal Modeling in Metal Additive Manufacturing using Graph Theory.
ASME Transactions, Journal of Manufacturing Science and Engineering
2019, Vol. 141, pp. 0710071-20.
doi: 10.1115/1.4043648

26. J. Lombardi, R. Salary[3], D. Weerawarne, **P. Rao**, M. Poliks.
Image-Based Closed-Loop Control of Aerosol Jet Printing Using Classical Control Methods
ASME Transactions, Journal of Manufacturing Science and Engineering
141(7), 071011-20, 2019.
doi: 10.1115/1.4043659
Collaboration with Binghamton University and Marshall University

27. L.J. Rhodes, M. Rios, J. Williams[3], G. Quiñones, P. Rao, V. Miskovic.
The Role of Low-Level Image Features in The Affective Categorization of Rapidly Presented Scenes
PLoS ONE 14(5): e0215975, 2019 .
doi: 10.1371/journal.pone.0215975
Collaboration with Center for Brian Biology and Behavior – UNL and Binghamton University.

28. F. Imani, B. Yao, R. Chen, **P. Rao**, H. Yang.
Joint Multifractal and Lacunarity Analysis of Image Profiles for Manufacturing Quality Control (Technical Brief)
ASME Transactions, Journal of Manufacturing Science and Engineering,
141(4), 044501-08, 2018.
doi: 10.1115/1.4042579.
Collaboration with Penn State.

29. J. Williams[3], P. Dryburgh, A. Clare, **P. Rao**, and A. Samal.
Defect Detection and Monitoring in Metal Additive Manufactured Parts through Deep Learning of Spatially Resolved Acoustic Spectroscopy Signals.
ASTM Journal of Smart and Sustainable Manufacturing
Vol. 2(1), 204-226, 2018.
doi/10.1520/SSMS20180035
Collaboration with Nottingham University

30. J. Liu, C. Liu, Y. Bai, Z. Kong, **P. Rao**, and C. Williams.
Layer-wise Spatial Modeling of Porosity in Additive Manufacturing.
IISE Transactions, Volume 51, 2019 - Issue 2:
Additive Manufacturing Special Issue,
Article Highlighted in January 2019 issue of the Industrial and Systems Engineer Magazine.
doi:/10.1080/24725854.2018.1478169
Collaboration with Virginia Tech.

31. F. Imani, A. Gaikwad[2], M. Montazeri[3], **P. Rao**, H. Yang, E. Reutzel. *Process Mapping and In-Process Monitoring of Porosity in Laser Powder Bed Fusion Using Layerwise Optical Imaging*
ASME Transactions, Journal of Manufacturing Science and Engineering,
140(10), 101009-23, 2018.
doi: 10.1115/1.4040615
Collaboration with Penn State Applied Research Lab.

32. X. Wang, M. Sealy, R. Williams, **P. Rao**, Y. Guo.
Stochastic Modeling and Analysis of Spindle Energy Consumption During Hard Milling.
ASME Transactions, Journal of Manufacturing Science and Engineering,
140(6), 060801-14, 2018.
doi.org/10.1115/1.4040728

33. M. Montazeri[3] and **P. Rao**.
Heterogeneous Sensor-based Build Condition Monitoring in Laser Powder Bed Fusion Additive Manufacturing Process using a Spectral Graph Theoretic Approach.
ASME Transactions, Journal of Manufacturing Science and Engineering,
140(9), 091002-18, 2018.
doi: 10.1115/1.4040264

34. M. Montazeri[3], R. Yavari[3], **P. Rao**, P. Boulware.
In-process Monitoring of Material Cross-Contamination Defects in Laser Powder Bed Fusion.
ASME Transactions, Journal of Manufacturing Science and Engineering,
140(11), 111001-20, 2018.
doi: 10.1115/1.4040543
Collaboration with Edison Welding Institute, Ohio.

35. M. Sealy, G. Madireddy, R. Williams, **P. Rao**, M. Toursangsaraki.
Review Article - Hybrid Processes in Additive Manufacturing.
ASME Transactions, Journal of Manufacturing Science and Engineering,
Vol. 140(6), pp. 060801-14, 2018.
doi:10.1115/1.4038644.

36. H. Sun, **P. Rao**, Z. Kong, X. Deng and R. Jin.
Functional Quantitative and Qualitative Models for Quality Modeling in a Fused Deposition Modeling Process.
IEEE Transactions, Automation Science and Engineering,
Vol. 15(1), pp. 393-403, 2018.
doi: 10.1109/TASE.2017.2763609.
Collaboration with Virginia Tech

37. M. S. Tootooni[3], **P. Rao**, C-A. Chou, Z. Kong.
A Spectral Graph Theoretic Approach for Monitoring Multivariate Time Series Data from Complex Dynamical Processes.
IEEE Transactions, Automation Science and Engineering
Vol.15(1), pp.127-144, 2018.
doi: 10.1109/TASE.2016.2598094
Collaboration with Virginia Tech

38. M. Khanzadeh, **P. Rao**, R. Jafari-Marandi, B. K. Smith, M. Tschopp, L. Bian.
Characterizing the Geometric Accuracy of Additively Manufactured Components Using Self-Organizing Maps.
ASME Transactions, Journal of Manufacturing Science and Engineering,
Vol 140(3), pp. 031011- 031023, 2017.
doi: 10.1115/1.4038598
Collaboration with Mississippi State and Army Research Lab.

39. M. Aboutaleb, M. Tschopp, **P. Rao**, L. Bian.
Accelerated Multiobjective Optimization of Part Geometric Accuracy in Additive Manufacturing (AM).
ASME Transactions, Journal of Manufacturing Science and Engineering,
Vol. 139(10), pp. 101001 – 101014, 2017.
doi: 10.1115/1.4037319
Collaboration with Mississippi State University

40. R. Salary[3], J. Lombardi, **P. Rao**, M. Poliks.
Aerosol Jet Printing (AJP) of Flexible Electronic Devices: Online Monitoring of Functional Electrical Properties Using Shape-from-Shading (SfS) Image Analysis.
ASME Transactions, Journal of Manufacturing Science and Engineering,
Vol. 139(10), pp. 101010 – 101023, 2017.
doi:10.1115/1.4036660
Collaboration with Binghamton University

41. M.S. Tootooni[3], A. Dsouza[2], R. Donovan[1], **P. Rao**, Z. Kong, P. Borgesen.
Classifying the Dimensional Variation in Additive Manufactured Parts from Laser-Scanned 3D Point Cloud Data using Machine Learning Approaches.
ASME Transactions, Journal of Manufacturing Science and Engineering,
Vol. 139(9), pp. 091005 – 091019, 2017.
doi: 10.1115/1.4036641
Collaboration with Virginia Tech

42. M.S. Tootooni[3], C. Liu, D. Roberson, R. Donovan[1], **P. Rao**, Z. Kong, S.T.S. Bukkapatnam.
Online Non-contact Surface Finish Machining using Graph-based Image Analysis.
SME Journal of Manufacturing Systems,
Vol. 41, pp. 266-276, October 2016.
doi: 10.1016/j.jmsy.2016.09.007.
Collaboration with Virginia Tech

43. R. Salary[3], J. Lombardi, M.S. Tootooni[3], R. Donovan[1], **P. Rao**, M. Poliks, P. Borgesen.
Computational Fluid Dynamics Modeling and Online Monitoring of Aerosol Jet Printing.
ASME Transactions, Journal of Manufacturing Science and Engineering,
139(2), pp. 021015-021036, October 2016.
doi:10.1115/1.4034591

44. J. Liu, Omer F. Beyca, **P. Rao**, Z. Kong, and S. Bukkapatnam.
Dirichlet Process Gaussian Mixture (DPGM) Models for Real-Time Monitoring and its Application to Chemical Mechanical Planarization.
IEEE Transactions, Automation Science and Engineering,
Vol. 14(1), pp. 208-221, 2017.
doi: 10.1109/TASE.2016.2599436.
Collaboration with Virginia Tech

45. **P. Rao**, Z. Kong, C. Duty, R. Smith, V. Kunc, and L. Love.
Assessment of Dimensional Integrity and Spatial Defect Localization in Additive Manufacturing (AM) using Spectral Graph Theory.
ASME Transactions, Journal of Manufacturing Science and Engineering,
138(5), pp. 051007, 2015.
doi: 10.1115/1.4031574
Collaboration with Oak Ridge National Laboratory.

46. O. Beyca, **P. Rao**, Z. Kong, S. Bukkapatnam, and R. Komanduri.
Heterogeneous Sensor Data Fusion Approach for Real-time Monitoring in Ultraprecision Machining (UPM) process using non-parametric Bayesian clustering and evidence theory.
IEEE Transactions, Automation Science and Engineering,
13(2), pp.1033-1044, 2016.
doi: 10.1109/TASE.2015.2447454

47. **P. Rao**, J. Liu, D. Roberson, and Z. Kong, and C. Williams.
Online Real-time Quality Monitoring in Additive Manufacturing Processes using Heterogeneous Sensors.
ASME Transactions, Journal of Manufacturing Science and Engineering.
137(6), pp. 061007, 2015.
doi: 10.1115/1.4029823.
Collaboration with Virginia Tech.

48. K. Bastani, **P. Rao**, and Z. Kong.
An Online Sparse Estimation-based Classification (OSEC) Approach for Real-time Monitoring in Advanced Manufacturing Process from Heterogeneous Sensor Data.
IIE Transactions, Quality and Reliability Engineering,
48(7), pp. 579-598, 2016.
doi: 10.1080/0740817X.2015.1122254
Best Paper Award,
Invited talk at IISE Conference, 2018.
Article highlighted in the June 2016 (Volume 48, Number 9) Issue of the Industrial and Systems Engineer (ISE) Magazine.

49. **P. Rao**, S. Bukkapatnam, O. Beyca, Z. Kong, K. Case, and R. Komanduri.
A Graph-Theoretic Approach for Quantification Of Surface Morphology and Its Application To Chemical Mechanical Planarization (CMP) Process.
IIE Transactions, Quality and Reliability Engineering,
47(10), pp. 1-24, 2015.
doi: 10.1080/0740817X.2014.1001927
Best Paper Award (Honorable Mention)
Invited talk at IISE Conference, 2017.
Article highlighted in the September 2015, (Volume 47, Number 6) issue of the Industrial Engineer Magazine (now called Industrial and Systems Engineer).

50. **P. Rao**, S. Bukkapatnam, O. Beyca, Z. Kong, and R. Komanduri.
Real-time Identification of Incipient Surface Morphology Variations in Ultraprecision Machining Process.
ASME Transactions, Journal of Manufacturing Science and Engineering,
136(2), pp. 021008, 2014.
doi: 10.1115/1.4026210

51. **P. Rao**, M. Bhushan, S. Bukkapatnam, Z. Kong, S. Byalal O. Beyca, A. Fields, and R. Komanduri.
Process-Machine Interaction (PMI) Modeling and Monitoring of Chemical Mechanical Planarization (CMP) Process Using Wireless Vibration Sensors.
IEEE Transactions, Semiconductor Manufacturing,
27(1), pp. 1-15, 2014.
doi: 10.1109/TSM.2013.2293095

52. S. Bukkapatnam, **P. Rao**, W-C. Lih, N. Chandrashekeran, and R. Komanduri.
Process Characterization and Statistical Analysis of oxide CMP on a Silicon Wafer,
Applied Physics (A), 88(4) pp. 785-792, 2007.
doi: 10.1007/s00339-007-4082-x

53. S. Bukkapatnam, **P. Rao**, and R. Komanduri.
Experimental Dynamics Characterization and Monitoring of MRR in Oxide Chemical Mechanical Planarization (CMP) Process.
International Journal of Machine Tools and Manufacture,
48(12-13), pp.1375-1386, 2008,.
doi:10.1016/j.ijmachtools.2008.05.006.

54. Wen-Chen Lih, S. Bukkapatnam, **P. Rao**, N. Chandrasekharan, R. Komanduri.
Adaptive Neuro-Fuzzy Inference System Modeling of MRR and WIWNU in CMP Process with Sparse Experimental Data.
IEEE Transactions, Automation Science and Engineering,
5(1), pp. 71 -83, 2008.
doi: 10.1109/TASE.2007.911683

55. S. Bukapatnam, R. Komanduri, H. Yang, **P. Rao**, W.C. Lih, M. Malshe, L.M. Raff, B. Benjamin, and M. Rockley.
Classification of Atrial Fibrillation Episodes from Sparse Electro-Cardiogram Data.
Journal of Electrocardiology,
41(4), pp. 292-299, 2008.
doi:10.1016/j.jelectrocard.2008.01.004

56. J.M, Govardhan, S. Bukkapatnam, Y. Bhamare, **P. Rao**, and V. Rajamani.
Statistical analysis and design of RFID systems for monitoring vehicle ingress/egress in warehouse environments.
International Journal of Radio Frequency Identification Technology and Applications,
1(2), pp. 123-146, 2007,
doi: 10.1504/IJRFITA.2007.013140

Section 2.1.2 Numbered list peer reviewed journal publications accepted for publication

1. J. Severson, R. Yavari, A. Reinsche, K. Cole P. Rao Thermal Modeling of Directed Energy Deposition Additive Manufacturing using Graph Theory, SME Journal of Manufacturing Processes (Accepted with Minor Revisions).
2. Z. Smoqi, A. Gaikwad, B. Bevans, M.H. Kobir, J. Craig, A-A. Haj, A. Peralta, Prediction of Porosity in Laser Powder Bed Fusion using Physics-informed Meltpool Signatures and Machine Learning, Journal of Materials Processing Technology (Conditionally accepted, pending Major Revisions, January 2022),

Section 2.1.3 Peer reviewed journal publications submitted under review

3. Z. Smoqi, B. D. Bevans, J. Craig, A. Abu-Haj, B. Roeder, B. Macy, J. E. Shield, **P. Rao**, *Closed-loop Control of Meltpool Temperature in Directed Energy Deposition Additive Manufacturing Using a Co-axial Two-wavelength Pyrometer*,
   Materials and Design (Revisions Required)
   Collaboration with Stratonics, Inc.
4. A. Gaikwad, T. Chang, B. Giera, N. Watkins, S. Mukherjee, A. Pascall, D. Stobbe, P. Rao, *In-process Monitoring of Droplet-on-Demand Liquid Metal Jetting Additive Manufacturing using Machine Learning*, Journal of Intelligent Manufacturing (Under Review).

5. H. Kobir, B. Bevans, R. Yavari, L. Castro, A. Riensche, *Thermomechanical Modeling in Additive Manufacturing using Graph Theory – Prediction of Recoater Crash*, Progress in Additive Manufacturing (Under Review).

Section 2.1.4 Books and book chapters

1. P. Rao.
   Chapter 6: Process Monitoring and Control, in *Laser-based Additive Manufacturing of Metal Parts - Modeling, Optimization, and Control of Mechanical Properties*, Eds. Linkan Bian, Nima Shamsaei, and John Usher, CRC Press, Taylor and Francis Group, ISBN: 978-1-4987-3998-6 Publication Date: August 16, 2017.

2. B. Khoda, T. Benny[2], P. Rao, M. Sealy, C. Zhou.
   Chapter 8: Applications of Laser-based Additive Manufacturing, in *Laser-based Additive Manufacturing of Metal Parts - Modeling, Optimization, and Control of Mechanical Properties*, Eds. Linkan Bian, Nima Shamsaei, and John Usher, CRC Press, Taylor and Francis Group, ISBN: 978-1-4987-3998-6 Publication Date: August 16, 2017. Number of Pages: 46.

3. P. Rao, R. Komanduri, and S. Bukkapatnam
   Sensor-based Modeling and Monitoring of Chemical Mechanical Polishing, VDM Verlag, ISBN 978-3-639-03564-3. December 3, 2008.

Section 2.1.5 Peer reviewed conference proceedings.

1. Yavari, Reza[3], Richard Williams, Cole, Kevin D., Paul Hooper and **Rao, Prahalad**.
   Thermal modeling in metal additive manufacturing using graph theory: experimental validation with in-situ infrared thermography data from laser powder bed fusion.
   Paper#: MSEC2020-8433
   Proceedings of the ASME 2020 15th International Manufacturing Science and Engineering Conference MSEC2020 June 22-26, 2019, Cincinnati, OH, USA. V001T01A028; 10 pages.
   doi: 10.1115/MSEC2020-8433

2. Yavari, Reza[3], Cole, Kevin D., and **Rao, Prahalad.**
   A Graph Theoretic Approach for Near Real-Time Prediction of Part-Level Thermal History in Metal Additive Manufacturing Processes. Paper #: MSEC2019-2875
   Proceedings of the ASME 2019 14th International Manufacturing Science and Engineering Conference. Volume 1: Additive Manufacturing; Manufacturing Equipment and Systems; Bio and Sustainable Manufacturing. Erie, Pennsylvania, USA. June 10–14, 2019. V001T01A030.
   doi:10.1115/MSEC2019-2875

3. Yavari, Reza[3], Severson, Jordan[2], Gaikwad, Aniruddha[3], Cole, Kevin, and **Rao, Prahalad.**

   Predicting Part-Level Thermal History in Metal Additive Manufacturing Using Graph Theory: Experimental Validation With Directed Energy Deposition of Titanium Alloy Parts.
   Paper #: MSEC2019-3034
   Proceedings of the ASME 2019 14th International Manufacturing Science and Engineering Conference. Volume 1: Additive Manufacturing; Manufacturing Equipment and Systems; Bio and Sustainable Manufacturing. Erie, Pennsylvania, USA. June 10–14, 2019. V001T01A038.
   doi: 10.1115/MSEC2019-3034

4. Gaikwad, Aniruddha[3], Imani, Farhad, **Rao, Prahalad**, Yang, Hui, and Reutzel, Edward.

   Design Rules and In-Situ Quality Monitoring of Thin-Wall Features Made Using Laser Powder Bed Fusion. Paper #: MSEC2019-3035

   Proceedings of the ASME 2019 14th International Manufacturing Science and Engineering Conference. Volume 1: Additive Manufacturing; Manufacturing Equipment and Systems; Bio and Sustainable Manufacturing. Erie, Pennsylvania, USA. June 10–14, 2019. V001T01A039.
   doi: 10.1115/MSEC2019-3035

5. Roy, Mriganka, Yavari, Reza[3], Zhou, Chi, Wodo, Olga, and **Rao, Prahalad.**

   Modeling and Experimental Validation of Part-Level Thermal Profile in Fused Filament Fabrication. Paper # MSEC2019-2897

   Proceedings of the ASME 2019 14th International Manufacturing Science and Engineering Conference. Volume 1: Additive Manufacturing; Manufacturing Equipment and Systems; Bio and Sustainable Manufacturing. *Erie, Pennsylvania, USA. June 10–14, 2019. V001T01A031.*
   doi: 10.1115/MSEC2019-2897

6. Salary, Roozbeh Ross, Lombardi, Jack P., Weerawarne, Darshana L., **Rao, Prahalad K**., and Poliks, Mark D.
   A State-of-the-Art Review on Aerosol Jet Printing (AJP) Additive Manufacturing Process. Paper # MSEC2019-3008.
   Proceedings of the ASME 2019 14th International Manufacturing Science and Engineering Conference. Volume 1: Additive Manufacturing; Manufacturing Equipment and Systems; Bio and Sustainable Manufacturing. *Erie, Pennsylvania, USA. June 10–14, 2019. V001T01A035.*
   doi: 10.1115/MSEC2019-3008

7. M. Reza Yavari[3], Kevin D. Cole, **Prahalada Rao**.

   Design Rules for Additive Manufacturing – Understanding the Fundamental Thermal Phenomena to Reduce Scrap

   Proceedia Manufacturing, Volume 33, 2019, Pages 375-382.
   Global Conference on Sustainability in Manufacturing, Lexington, Kentucky, October 2nd – 4th, 2018. Lodging, and conference registration for Prahalada Rao was sponsored by a National Science Foundation travel grant.
   doi: 10.1016/j.promfg.2019.04.046

8. J. Lombardi, R. Salary, D. Weerawarne, **P. Rao**, M. Poliks.

   In-situ Image-Based Monitoring and Closed-Loop Control of Aerosol Jet Printing. Paper # MSEC2018-6487

   46th Proceedings of the North American Manufacturing Research Institution (NAMRI) of SME/2018 Manufacturing Science and Engineering Conference (MSEC) of the ASME, June 18th-June 22nd, Texas A&M University, College Station, TX, 2018, pp. V001T01A039; 10 pages.

   doi:10.1115/MSEC2018-6487

9. F. Imani, B. Yao, R. Chen, **P. Rao**, H. Yang.

   Fractal pattern recognition of image profiles for manufacturing process monitoring and control. Paper # MSEC2018-6523,

   46th Proceedings of the North American Manufacturing Research Institution (NAMRI) of SME/2018 Manufacturing Science and Engineering Conference (MSEC) of the ASME, June 18th-June 22nd, Texas A&M University, College Station, TX, 2018, pp. V003T02A003; 10 pages.
   doi:10.1115/MSEC2018-6523

10. P. Mehta, **P. Rao**, Z. Wu, V. Jovanovic, O. Wodo, M. Kuttolamadom.

    Smart manufacturing: a state-of-the-art review in context of conventional and modern manufacturing process modeling, monitoring and control. Paper # MSEC2018-6658,

    46th Proceedings of the North American Manufacturing Research Institution (NAMRI) of SME/2018 Manufacturing Science and Engineering Conference (MSEC) of the ASME, June 18th-June 22nd, Texas A&M University, College Station, TX, 2018, pp. V003T02A008; 21 pages.
    doi:10.1115/MSEC2018-6658.

11. M. Montazeri[3], R. Yavari[3], **P. Rao**, P. Boulware.

    In-Process Monitoring of Material Cross-Contamination in Laser Powder Bed Fusion Paper # MSEC2018-6470,

    46th Proceedings of the North American Manufacturing Research Institution (NAMRI) of SME/2018 Manufacturing Science and Engineering Conference (MSEC) of the ASME, June 18th-June 22nd, Texas A&M University, College Station, TX, 2018, pp. V001T01A037; 10 pages.
    doi:10.1115/MSEC2018-6470

12. F. Imani, A. Gaikwad[2], M. Montazeri[3], H. Yang, **P. Rao**.

    Layerwise In-process Quality Monitoring in Laser Powder Bed Fusion.

    Paper # MSEC2018-6477,46th Proceedings of the North American Manufacturing Research Institution (NAMRI) of SME/2018 Manufacturing Science and Engineering Conference (MSEC) of the ASME, June 18th-June 22nd, Texas A&M University, College Station, TX, 2018, pp. V001T01A038; 14 pages.
    doi:10.1115/MSEC2018-6477

13. M.S. Tootooni[3*], A. Dsouza[2], R. Donovan[1], **P. Rao**, Z. Kong, P. Borgesen.

    Assessing The Geometric Integrity Of Additive Manufactured Parts From Point Cloud Data Using Spectral Graph Theoretic Sparse Representation-Based Classification Paper # MSEC2017-2794,

    45th Proceedings of the North American Manufacturing Research Institution (NAMRI) of SME/2017 Manufacturing Science and Engineering Conference (MSEC) of the ASME, June 4th-June 8th, University of Southern California, Los Angeles, CA, 2017, pp. V002T01A042; 13 pages.
    doi:10.1115/MSEC2017-2794

14. R. Salary, J. Lombardi, **P. Rao**, M. Poliks.

    Additive Manufacturing (AM) of Flexible Electronic Devices: Online Monitoring Of 3d Line Topology In Aerosol Jet Printing Process Using Shape-From-Shading (SfS) Image Analysis, Paper # MSEC2017-2947,

    45th Proceedings of the North American Manufacturing Research Institution (NAMRI) of SME/2017 Manufacturing Science and Engineering Conference (MSEC) of the ASME, June 4th-June 8th, University of Southern California, Los Angeles, CA, 2017. pp. V002T01A046; 11 pages.
    doi:10.1115/MSEC2017-2947

15. M. S. Tootooni[3*], M. Fan, R. Sivasubramony[2], C.-A. Chou, V. Miskovic, and **P. Rao**.

    Graph Theoretic Compressive Sensing Approach for Classification of Global Neurophysiological States from Electroencephalography (EEG) Signals,

    in Lecture Notes in Computer Science, Vol 9919, 2016, pp. 42-51. doi: 10.1007/978-3-319-47103-7_25. *Brain Informatics and Health: International Conference, BIH 2016,* Omaha, NE, USA, October 13-16, 2016 Proceedings. Online ISBN: 978-3-319-47103-7.
    doi: 10.1007/978-3-319-47103-7_5

16. M. Fan, M.Tootooni[3*], R. Sivasubramony[2], V. Miskovic, **P. Rao**, C-A. Chou.

    Acute Stress Detection Using Recurrence Quantification Analysis of Electroencephalogram (EEG) Signals.

    in Lecture Notes in Computer Science, Vol 9919, 2016, pp. 252-261. doi: 10.1007/978-3-319-47103-7_25. *Brain Informatics and Health: International Conference, BIH 2016*, Omaha, NE, USA, October 13-16, 2016 Proceedings. Online ISBN: 978-3-319-47103-7. doi: 10.1007/978-3-319-47103-7_25

17. R. Salary, J. Lombardi, M. Tootooni[3], R. Donovan[1], **P. Rao**, M. Poliks.

    In-situ Sensor-based Monitoring and Computational Fluid Dynamics Modeling of Aerosol Jet Printing Process. Paper # MSEC2016-8535,

    44th Proceedings of the North American Manufacturing Research Institution (NAMRI) of SME/2016 Manufacturing Science and Engineering Conference (MSEC) of the ASME, June 27th-July 1st, Blacksburg, VA, 2016, pp. V002T04A049; 13 pages.
    doi:10.1115/MSEC2016-8535.

18. **P. Rao,** Z. Kong, C. Duty, R. Smith.

    Three Dimensional Point Cloud-based Dimensional Integrity Assessment for Additive Manufactured Parts using Spectral Graph Theory. Paper # MSEC2016-8516,

    44th Proceedings of the North American Manufacturing Research Institution (NAMRI) of SME/2016 Manufacturing Science and Engineering Conference (MSEC) of the ASME, June 27th-July 1st, Blacksburg, VA, 2016. pp. V002T04A048; 14 pages.
    doi:10.1115/MSEC2016-8516

19. **P. Rao**, Z. Kong, S. Bukkapatnam, O. Beyca, K. Case, R. Komanduri.

    Quantification of Ultraprecision Surface Morphology using an Algebraic Graph Theoretic Approach. Paper # NAMRC 43-65 *Hoken Symposium*,
    43rd Proceedings of the North American Manufacturing Research Institution (NAMRI) of SME, *Proceedia Manufacturing*, June 8th – June 12th, Charlotte, NC, 2015. Volume 1, 2015, Pages 12-26.
    doi.org/10.1016/j.promfg.2015.09.025

20. **P. Rao**, J. Liu, D. Roberson, Z. Kong.
    Sensor-based Online Fault Detection in Additive Manufacturing, Paper # MSEC 2015-9389

    43rd Proceedings of the North American Manufacturing Research Institution (NAMRI) of SME, June 8th – June 12th, Charlotte, NC, 2015. pp. V002T04A010; 13 pages.
    doi:10.1115/MSEC2015-9389.

Section 2.1.7 Invited talks or keynote speeches.

1. Invited Talk: M4AM: *Modeling, Monitoring, Materials, and Machine Learning for Flaw-free Additive Manufacturing*. University of Cincinnati, OH. 02/12/2021, Host: Dr. M. Jog.
2. Invited Talk: M4AM: *Modeling, Monitoring, Materials, and Machine Learning for Flaw-free Additive Manufacturing*. Florida International Univ.. 01/12/2021. Host: Dr. A. Agarwal
3. Invited Talk: *The Digital Twin in Additive Manufacturing*: *Thermal Modeling, Sensing, and Analytics for Zero Part Defects in Additive Manufacturing*.
   International Virtual Conference on Innovations in Advanced Materials Processing, Vellore Institute of Technology, India, 06/24/2020
4. *The Digital Twin in Additive Manufacturing*: *Thermal Modeling, Sensing, and Analytics for Zero Part Defects in Additive Manufacturing*,
   Industrial and Systems Engineering, Texas A&M, February 7th, 2020. Sponsor: Dr. Satish Bukkapatnam
5. *Smart Additive Manufacturing: Modeling, Sensing, and Analytics for Zero Part Defects.*
   Oak Ridge National Laboratory. December 10th, 2019. Sponsor: Dr. Scott Smith.
6. *Ultrafast Thermal Simulation in Additive Manufacturing,*
   General Electric Global Research Center, Edge and Controls Conference (Invited Talk). Niskayuna, NY, September 11th, 2019. Sponsor: Dr. Subhrajit Roychowdhury
7. *The Digital Twin in Additive Manufacturing*: *Thermal Modeling, Sensing, and Analytics for Zero Part Defects in Additive Manufacturing*,
   Mechanical and Nuclear Engineering, Rensselaer Polytechnic Institute.
   September 13th, 2019. Sponsor: Dr. Johnson Samuel.
8. *Ushering the Digital Twin in Metal Additive Manufacturing,*
   International Young Scientist Forum on Smart Manufacturing and Artificial Intelligence, Northwestern Polytechnic University, Taicang, China, July 12th, 2019. Sponsor: Dr. Min Xia.
9. *Correct-as-you-Build in AM – Fixing Part Defects Inside the Machine*,
   Optomec Inc., December 4th, 2018. Sponsor: Mr. Tom Cobb and Mrs. Karen Manley.
10. *Integrating In-Process Sensing, Big Data Analytics, and Modeling for Zero Part Defects in Smart Additive Manufacturing,*
    University of Michigan, September 14th, 2018, Sponsor: Dr. Judy Jin.
11. *Additive Manufacturing (AM/3D Printing) – Fiction, Fantasy, or Fact.*
    September 6th, 2018. Total Manufacturing Company. Sponsor: UNL Industry Relations
12. *Additive Manufacturing (AM/3D Printing) – Fiction, Fantasy, or Fact.* August, 16th 2018. Dell Technologies, Roundrock Austin Texas, Sponsor: Dr. Mario Cornejo
13. *Invited Webinar: Smart Additive Manufacturing*. October 9th, 2018. Sponsor: Dr. Linkan Bian on behalf of Institute of Industrial Engineers, Manufacturing and Design Division.
14. *Big Data Analytics in Additive Manufacturing*, Kansas State University. March 28th, 2018. Sponsor: Dr. Dong Lin
15. *The Unusual Effectiveness of Spectral Graph Theory for Quality Assurance in Additive Manufacturing*. Foundations of Accuracy Control for Additive Manufacturing Workshop , University of Southern California. February 8th, 2018. Sponsor: Dr. Qiang Huang.

16. *Graph Theoretic Signal Processing - Application to Additive Manufacturing and Neurophysiology***,** Virginia Tech. February 27th, 2018. Sponsor: Dr. James Kong
17. *Big Data Analytics in Additive Manufacturing*, Iowa State University. February 21st, 2018. Sponsor: Dr. Iris Rivero.
18. *Invited Talk: Qualify-as-you-build A Paradigm for Sustainability in Additive Manufacturing (AM) through Big Data Analytics***.** Emerging Researcher Showcase, 2017 International Forum on Sustainable Manufacturing, Institute of Sustainable Manufacturing, University of Kentucky. December 7th-8th, 2017. Sponsor: Travel, lodging, and conference registration was funded through a NSF Travel Grant. Invited by: Dr. Fazleena Badurdeen and Dr. I.S Jawahir.
19. *Big Data Analytics in Additive Manufacturing*, National Institute of Standards and Technology. November 14th, 2017. Sponsor: Dr. Brandon Lane
20. *Graph Theoretic Sensor Fusion Application to Additive Manufacturing and Neurophysiology*. October 12th, 2017. Pennsylvania State University, Sponsor: Dr. Hui Yang
21. *Towards Certify-as-you-build in Aerosol Jet Printing (AJP): Process Modeling, Online Monitoring, and Quality Assurance*. April 21st, 2016, North Dakota State University, Sponsor: Dr. Om Prakash Yadav
22. Invited Webinar: In-process Quality Assurance in Additive Manufacturing. April 4th, 2017. Sponsor: Dr. Z. Kong on behalf of Institute of Industrial Engineers, Quality Control and Reliability Engineering Division.
23. *Graph Theoretic Sensor Fusion and its Application to Additive Manufacturing and Neurophysiology*, University of Kentucky (Spring 2016), Sponsor: Dr. I.S. Jawahir.
24. *Graph Theoretic Sensor Fusion and its Application to Additive Manufacturing and Neurophysiology*, University at Buffalo (Fall 2015, Spring 2016), Sponsor: Dr. Chi Zhou, Dr. Ann Bizantz.
25. *Graph Theoretic Sensor Fusion and its Application to Additive Manufacturing and Neurophysiology*, Texas Tech University (Spring 2016), Sponsor: Dr. Han-Chou Zhang
26. *Graph Theoretic Sensor Fusion and its Application to Additive Manufacturing and Neurophysiology*, Kansas State University (Spring 2016), Sponsor: Dr. Bradley Kramer
27. *Graph Theoretic Sensor Fusion and its Application to Additive Manufacturing and Neurophysiology*, University of Iowa (Spring 2016), Sponsor: Dr. Yong Chen
28. *Graph Theoretic Sensor Fusion and its Application to Additive Manufacturing and Neurophysiology*, University of South Florida (Spring 2016), Sponsor: Dr. Tapas K. Das
29. *Invited Webinar: Additive Manufacturing: Capabilities, Research Challenges and Process Monitoring*. Presented with Dr. Alaa Elwany. Feb. 25th, 2016. Sponsor: Institute of Industrial Engineers, Quality Control and Reliability Engineering Division.

Section 2.1.8 Numbered list (in reverse chronological order) of Other Publications

1. Short Article- Newsletter for the Manufacturing and Design Division of the IISE, Additive Manufacturing – Research Opportunities for Industrial Engineers, Fall 2018. URL.
2. *The final step toward quality in additive manufacturing* – Industrial and Systems Engineer Magazine, April 2019, Volume 51, Number 4. URL

Section 2.2 Research Funding

Section 2.2.1 Internally Funded Research Grants.

Summary Table of Internal Funded Projects.

Project Title	*Sponsor*	*Role*	*Dates*	*Total Amount*	*Percentage Attributable to me*
Magnetic Abrasive Finishing (MAF) of Metal 3D Printed Parts	Layman Fund NU Foundation	PI	05/01/2017 to 04/30/2019	$10,000	100%

1. Project ID 45228: Magnetic Abrasive Finishing (MAF) of Metal 3D Printed Parts

   Sponsor: Layman Fund
   Agency Class: NU Foundation
   PI: Prahalada Rao
   Co-PI: None
   Requested Amount: $10,000
   Cost Share: $0
   Current Awarded Amount: $10,000
   Current Awarded Period: 05/01/2017 - 04/30/2018
   Official WBS Number(s): 2611230166001
   Amount Attributable to me: $10,000 (100%)

Short one paragraph description.

Abstract: This work proposes an approach to polish complicated geometries through a novel process called Magnetic Abrasive Finishing. The key idea is to use a magnetically-active abrasive slurry to reach the inside of parts created using additive manufacturing.

Section 2.2.2 Externally Funded Research Grants

For each project a short, one paragraph description of the project is provided after the table

Project Title	Sponsor	Role (PI or Co-PI)	Dates	Total Amount	Percentage Attributed to me
PFI TT: PFI-TT: Ultrafast Thermal Simulation of Metal Additive Manufacturing	National Science Foundation	PI	06/15/2021 06/14/2023	250,000	100%
STTR: Intelligent Additive Manufacturing - Metals. Phase 1	Office of Naval Research	PI	06/08/2020 12/08/2020	$9,996	100%
Understanding the thermal physics and metallurgy of big area additive manufacturing.	Department of Energy	PI	09/01/2020 08/31/2023	$670,000	50%
AI Institute: Planning: AI-enabled Secure and Responsive Smart Manufacturing	National Science Foundation	PI	09/01/2020 08/31/2021	$49,951	100%
RII Track-4: Understanding the Fundamental Thermal Physics in Metal Additive Manufacturing and its Influence on Part Microstructure and Distortion.	National Science Foundation	PI	02/01/2020 to 01/31/2022	$148,629	100%
MRI: Acquisition of an X-Ray Computed Tomography System at the University of Nebraska-Lincoln for Advancing Multidisciplinary Research and Education in the Great Plains Region.	National Science Foundation	Co-PI (I was the main writer, and initiator for this award)	09/01/2018 to 08/31/2020	$562,803	20%
A Novel DLP 3D Printer Optimized for Ceramics and Metals	Tethon3D, Omaha, Nebraska Nebraska Department of Economic Development	Co-PI	08/01/2018 to 01/31/2020	$50,000	50%

Project Title	Sponsor	Role (PI or Co-PI)	Dates	Total Amount	Percentage Attributed to me
CAREER: Smart Additive Manufacturing - Fundamental Research in Sensing, Data Science, and Modeling Toward Zero Part Defects	National Science Foundation	PI	04/01/2018 to 09/30/2023	$508,000	100%
Supplement: NSF INTERN: CAREER: Smart Additive Manufacturing - Fundamental Research in Sensing, Data Science, and Modeling toward Zero part defects.	National Science Foundation	PI	10/01/2019 to 04/01/2020	$35,895	100%
Supplement: NSF INTERN: CAREER: Smart Additive Manufacturing - Fundamental Research in Sensing, Data Science, and Modeling toward Zero part defects.	National Science Foundation	PI	09/01/2019 to 03/01/2020	$35,836	100%
Big Data Analytics Supplement to NSF CAREER	National Science Foundation	PI	04/01/2020 to 03/31/2021	$70,000	100%
CPS: Medium: Cyber-Enabled Online Quality Assurance for Scalable Additive Bio-Manufacturing	National Science Foundation	PI	09/01/2017 to 08/31/2021	$208,000	100%
Biosensor Data Fusion for Real-Time Monitoring of Global Neurophysiological Function	National Science Foundation	PI	04/27/2016 to 08/31/2019	$222,970	100%
External Funding	$2,011,838 (My Share) $2,822,082 (Total)				

1.
2. Project ID 51677: STTR: Intelligent Additive Manufacturing - Metals
Lead PI (UNL): Dr. Prahalada Rao
Requested Period: 06/08/2020 - 12/08/2020
Sponsor: R3 Digital Sciences Inc
Funding Agency: DOD-Office of Naval Research
Submitted On: 02/05/2020
Requested Amount: $9,996
Cost Share Requested: $0
Amount Attributable to me: 100%
Percentage F&A Credit: 100%

Abstract

The objective of this work is to detect AM defects using in-situ sensor data. The UNL commitment to this project is to characterize the samples received by the industry sponsor using X-ray Computed Tomography.

3. AI Institute: Planning: AI-enabled Secure and Responsive Smart Manufacturing

Funding Agency: National Science Foundation
Lead PI (UNL): Dr. Prahalada Rao
Requested Period: 09/01/2020 - 08/31/2022
Submitted On: 01/21/2020
Requested Amount: $50,000
Cost Share Requested: $0
Amount Attributable to me: 100%
Percentage F&A Credit: 100%

Abstract

Propelled by emerging technology, such as 3D printing, high-fidelity sensing, artificial intelligence, and networking, advanced manufacturing is on the cusp of a Fourth Industrial revolution, captured by the term Industry 4.0 or Smart Manufacturing. Given its potential to reinvigorate American industry, Smart Manufacturing is explicitly designated as a research priority area in the 2014 White House Report on Advanced Manufacturing. However, challenges abound in realizing the smart manufacturing paradigm.

Rapidly reconfigurable production systems envisaged in smart manufacturing are inherently tied to acquisition of large amounts of continuous streaming data from machines and automated robots on the shop floor, as well as from entities dispersed in the supply-logistics chain, using heterogeneous sensors. The data has to be transmitted over wireless channels with tight latency and security guarantees, and seamlessly coupled with real-time analysis to allow precise trouble-shooting, coordination, and monitoring. The inescapable conclusion is that to enable smart manufacturing, a tight integration – and, in fact, cross-layer optimization – of manufacturing technologies, robotics and control, networking protocols such as 5G, and machine learning paradigms such as inference on the edge is needed. If ably harnessed, such seamless integration of manufacturing, data, analytics, control, and network

will fundamentally alter the landscape of manufacturing. Achieving this vision is the goal of the institute envisaged in this planning grant.

4. Understanding the Thermal Physics and Metallurgy of Metal Big Area Additive Manufacturing

Funding Agency: Department of Energy
Lead PI: Dr. Prahalada Rao
Requested Period: 09/01/2020 - 08/31/2023
Submitted On: 05/21/2020
Requested Amount: $670,000
Cost Share Requested: $0
Amount Attributable to me: 50%
Percentage F&A Credit: 50%

Abstract

The research goal of this EPSCoR-DOE partnership is to mitigate defects in parts made using a new type of additive manufacturing (AM) process called metal Big Area Additive Manufacturing (m-BAAM). To realize this goal, the PIs will detect and correct defects in the part as it is being printed by combining fundamental knowledge of the thermal physics and metallurgy of m-BAAM with in-process sensor data.

Developed at the DOE-funded Manufacturing Demonstration Facility at Oak Ridge National Laboratory, the m-BAAM process involves one or more robots working together to produce a part by fusing metal wire layer-by-layer using arc welding. The process can print large metal parts such as turbine blades, which is not possible using other AM processes. In addition, m-BAAM production rates are more than ten times faster than other AM processes while requiring one-tenth of the material cost.

Despite their potential to become a critical force multiplier in the energy generation industry, m-BAAM parts may fail to print accurately due to retention of heat and uneven cooling. Overheating and anomalous cooling rates in turn can cause inconsistencies in the microstructure, leading to sudden failure when used in safety-critical applications. In other words, flaw formation in m-BAAM parts is governed by the *thermal history* – intensity and spatial distribution of heat inside the part during printing. The thermal history is a complex function of the part shape and process settings such as welding energy, path taken by the welding torch for deposition (tool path), wire feed rate, among others.

Consequently, to ensure consistent part quality, it is essential to understand, predict, and control the causal effect of process parameters and part shape on thermal history. Existing proprietary finite-element based computational tools to predict thermal history are relatively slow, expensive, and require expert knowledge. Thus, developing fast, inexpensive, accurate, and easy to use thermal simulation tools and establishing automated process correction to prevent flaws are urgent priorities for m-BAAM researchers.

To address these needs, the PIs will realize three objectives:

1. Predict the temperature distribution of m-BAAM parts using the graph theory approach, which predicts the thermal history of AM parts ten times faster than finite element models and with an error of less than 10 percent.
2. Predict microstructure of m-BAAM parts using the temperature distribution and cooling rate estimated using graph theory coupled with the metallurgical phase transformation behavior of the material.
3. Correct process faults in m-BAAM using model-based feed-forward control.

By using knowledge of the fundamental thermal physics, as opposed to trail-and-error empirical studies, this work will accelerate the time-to-market of m-BAAM parts, which are envisioned to become a critical force multiplier in the manufacturing and energy infrastructure of the nation.

5. RII Track-4: Understanding the Fundamental Thermal Physics in Metal Additive Manufacturing and its Influence on Part Microstructure and Distortion.

Funding Agency: NSF
Lead PI: Dr. Prahalada Rao
Requested Period: 02/01/2020 - 01/31/2022
Submitted On: 03/21/2019
Requested Amount: $148,629
Cost Share Requested: $0
Amount Attributable to me: 100%
Percentage F&A Credit: 100%
Abstract

This is an EPSCor NSF Track-4 Fellowship grant. Only two proposals are allowed per university. The objective of this fellowship is to test the hypothesis that the instantaneous spatiotemporal distribution of temperature generated in a metal AM part as it is being deposited layer-upon-layer is predicted by invoking the novel theory of heat dissipation on planar graphs (spectral graph theory) with an accuracy comparable to existing finite element techniques but within a fraction of the computation time (less than 1/10th). To realize this objective, this fellowship provides the PI access to the Open Architecture Laser Powder Bed Fusion metal AM system at the Edison Welding Institute (EWI). This system has eight different sensors and allows the in-situ measurement of thermal signatures at scales ranging from 5 micrometer to 400 micrometers.

Access to this unique apparatus will allow the my group to measure the instantaneous temperature distribution in a part and track changes in its shape with unprecedented precision. Using data obtained from experiments on the open architecture metal AM system at EWI, the PI will: (1) explain and an quantify the causal factors governing the temperature distribution in metal AM parts and link it to part quality; (2) achieve near real-time prediction of the temperature distribution, which will significantly reduce the experimental tests needed to optimize the part geometry and process parameters; and (3) establish the digital twin concept for qualification of metal AM parts by augmenting in-situ sensor data with physical process models. This work will result in experimentally validated, physics-based tools to aid rapid optimization of process settings and part geometry, which in turn will shorten time-to-market for AM parts and reduce scrap rates by up to 80%.

6. MRI: Acquisition of an X-Ray Computed Tomography System at the University of Nebraska-Lincoln for Advancing Multidisciplinary Research and Education in the Great Plains Region.

Funding Agency: NSF
Lead PI: Dr. Joseph Turner
Co-PI: Dr. Prahalada Rao, Dr. Jeffrey E. Shield,
Dr. Yong-Feng Lu, Dr. Jinying Zhu
Requested Period: 08/01/2019 - 07/31/2021
Submitted On: 01/22/2019
Requested Amount: $562,803
Cost Share Requested: $241,202
Amount Attributable to me: N/A.
Percentage F&A Credit: 20% (split equally amongst 5 PIs)
This is an NSF Major Research Instrumentation Grant. Only two proposals are allowed per university. Please contact Dr. Joseph Turner, and Dr. Jeffrey Shield, who will attest to my yeoman role in writing a major part of the grant, streamlining the focus areas, scoping the equipment, getting external reviews, followed by multiple rounds of revisions.

Abstract

This Major Research Instrumentation (MRI) award supports the acquisition of an X-ray Computed Tomography (XCT) instrument at the University of Nebraska-Lincoln (UNL) that will enable new fundamental research on next-generation manufactured components. Performance demands on future components in nearly all fields associated with national security and wellbeing – whether aerospace, infrastructure, or biomedical – will require the use of new designs that take advantage of the latest advances in materials and manufacturing. In order to understand, model, and exploit these cutting-edge manufacturing processes in depth, foundational quantitative information of a component is necessary with respect to external and internal geometry, surface characteristics, and the presence of flaws, such as voids. The XCT is critical for this need because of its inherent nondestructive approach to analyzing the functional and safety-critical aspects of a sample. This award directly benefits materials engineering research conducted by more than 100 faculty, staff researchers, graduate students, and undergraduate students at UNL. In addition, placement of the instrument in a shared research core facility ensures its accessibility to academic and industry researchers across the Great Plains region.

The XCT will provide fundamental insight into the 3D internal and external structure of a wide range of organic and inorganic materials from centimeter to micrometer scales. The information obtained from XCT analysis will advance understanding of the process-structure relationship in several multi-disciplinary domains, including 1) additive manufacturing for which the process-material interactions during manufacturing are studied with respect to the quality of the final part; 2) material science for laser-engineered functionalized surfaces for which surface characteristics from laser-processing are quantified relative to their impact on phenomena such as hydrophobicity and anti-icing; , and 3) materials for next-generation infrastructure for which structural components made from concrete and steel are studied with respect to their aging and sustainable manufacturing.

7. A Novel DLP 3D Printer Optimized for Ceramics and Metals

Sponsor: Tethon3D, Omaha, Nebraska.
Funding Agency: Nebraska Department of Economic Development
Dates of Project: 08/01/2018 - 07/31/2019
Lead PI: Bai Cui, Ph.D.
Co PI: Prahalada Rao, Ph.D.
WBS Number(s): 2611230213001
Sponsor Amount: $50,000
Cost share amount: $0
Total Amount: $50,000
Amount Attributable to me: $25,000 (50%)

Abstract

The objective of this work is to design, build and test a prototype digital mask projection stereolithography-based additive manufacturing machine for Tethon 3D. The printer is made specifically optimized for ceramic and metal-impregnated ceramic resins. Tethon 3D will develop a preliminary design of the printer hardware and software, substantially build the prototype and will co-assemble the functional prototype with help of Dr. Bai Cui and Dr. Prahalada Rao.

Dr. Bai Cui's Tasks

1. Define the resin vat heater settings by resin viscosity tests
2. Define UV curing depth and timing duration
3. Test the prototype

Dr. Prahalada Rao's Tasks

1. Design the printer monitoring sensor for temperature
2. Design the printer visual monitoring and QC sensor
3. Test the prototype

8. CAREER: Smart Additive Manufacturing - Fundamental Research in Sensing, Data Science, and Modeling Toward Zero Part Defects

Funding Agency: National Science Foundation
Dates of Project: 04/01/2018 - 03/31/2023
PI: Prahalada Rao, Ph.D.
WBS Number(s): 2511230054001
Sponsor Amount: $500,000
Cost share amount: $0
Total Amount: $500,000
Amount Attributable to me: $500,000 (100%)

Abstract

Smart Manufacturing strives to monitor every aspect of the manufacturing enterprise - from the individual machine-level to the factory-level - using data gathered from multiple sensors. Resulting efficiencies can reduce product defects and manufacturing costs by over 25 percent. When coupled with Additive Manufacturing, Smart Manufacturing promises to transform U.S. industry. For example, 20 pounds of raw material are currently required to make a one-pound part for the aerospace industry using subtractive machining. Additive Manufacturing can reduce this so-called buy-to-fly ratio of 20:1 to 2:1, while simultaneously reducing lead time from six months to one week. Despite these advantages, industries are hesitant to adopt Additive Manufacturing due to process inconsistency - parts may have undetected defects, such as porosity, that make them unsafe for use in mission-critical applications.

A potential solution to this problem is a concept called Smart Additive Manufacturing, which melds the ideas of Smart Manufacturing with Additive Manufacturing. Through this Faculty Early Career Development Program (CAREER) award, in-process sensor data will be utilized to understand the mechanisms of defect formation occurring during the Laser Powder Bed Fusion Additive Manufacturing process. Advanced data analysis approaches that incorporate the new fundamental understanding of defect evolution will be leveraged to realize a robust correct-as-you-build methodology. This foundational work will find application across many manufacturing sectors including aerospace and defense. The award will also facilitate a discovery-based learning approach to engage learners in hands-on exploration of Additive Manufacturing at multiple levels. A research collaboration with Navajo Technical University will be initiated to further broaden project impact and train the advanced manufacturing workforce of the future.

8.1 Supplement to CAREER: Smart Additive Manufacturing - Fundamental Research in Sensing, Data Science, and Modeling Toward Zero Part Defects
NSF 18-102 Dear Colleague Letter: Non-Academic Research Internships for Graduate Students (INTERN) Supplemental Funding Opportunity

Funding Agency: National Science Foundation
Dates of Project: 08/15/2019 - 02/15/2020
PI: Prahalada Rao, Ph.D.
Form WBS Number (from page 4): 2511230054001
WBS Number(s): 2511230054003
Sponsor Proposal Number: CMMI 1934022
Sponsor Amount: $35,836
Cost share amount: $0
Total Amount: $35,836
Amount Attributable to me: $35,836 (100%)

Abstract

This supplement award to my CAREER grant is for my Ph.D. student Mr. Reza Yavari to complete a 6 month-long internship at Edison Welding Institute (EWI), Columbus, Ohio. The intent to carry out hands-on experiments and obtain real-world experimental data on EWI's sensor instrumented laser powder bed fusion (LPBF) apparatus.
The grant pays the student's stipend and lodging at EWI. My student and I wrote a formal 3-page proposal with support of Mr. Paul Boulware, Senior Engineer at EWI. The proposal.

There are two proposed activities for the project.
Activity 1. Hands-on training on the laser powder bed fusion (LPBF) setup at EWI and calibration of sensors.
Mr. Boulware will train Reza to operate EWI's unique Open Architecture LPBF platform and establish a standard procedure to acquire and store the data from the various sensors in the machine.

Activity 2. Acquisition of in-situ thermal and metrology data to understand the link between process parameters, part geometry, heat distribution, and metal AM part quality.
Activity 2 is the key to the success of the research objective and is centered on experiments to be conducted on the LPBF platform at EWI. At the end of Activity 2, in-situ thermal and optical data will be acquired for 45 samples built with titanium alloy Ti6Al4V, an important metal in the aerospace and biomedical industries.

8.2. Supplement to CAREER: Smart Additive Manufacturing - Fundamental Research in Sensing, Data Science, and Modeling Toward Zero Part Defects
NSF 18-102 Dear Colleague Letter: Non-Academic Research Internships for Graduate Students (INTERN) Supplemental Funding Opportunity

Funding Agency: National Science Foundation
Dates of Project: 10/01/2019 - 04/01/2020
PI: Prahalada Rao, Ph.D.
Form WBS Number (from page 4): 2511230054001
WBS Number(s): 2511230054003
Sponsor Proposal Number: CMMI 1933868
Sponsor Amount: $35,895
Cost share amount: $0
Total Amount: $35,895
Amount Attributable to me: $35,895 (100%)

Abstract

This supplement award to my CAREER grant is for my Ph.D. student Mr. Aniruddha Gaikwad to complete a 6 month-long internship at Lawrence Livermore National Laboratory (LLNL). The intent to facilitate the work of Dr. Brian Giera at LLNL and learn state-of-the-art machine learning techniques for monitoring of additive manufacturing processes. The grant pays the student's stipend and lodging at LLNL My student and I wrote a formal 3-page proposal with support of Dr. Brian Giera.

During this internship Anirudha will work closely with Dr. Brian Giera to conduct experiments on the custom-built AM apparatus at LLNL which has been instrumented with multiple expensive sensors, such as pyrometers and high-speed imaging cameras. Data from this high-resolution sensing system, which is not available at any other academic institution in the U.S.

Further, Aniruddha work on the implementation of his approach on the Integrated Additive-Subtractive Manufacturing (IASM) hybrid AM machine which currently being developed at LLNL. Currently, my group is collaborating on a project with Dr. Brain Giera to develop computer vision and machine learning algorithms to monitor the quality of single-tracks made using laser powder bed fusion AM process. The computational facilities at LLNL (for physical modeling), and the opportunity to acquire data through practical experimentation would provide the student with a well-rounded expertise in AM, which would be invaluable for his future career in AM industry.

9. CPS: Medium: Cyber-Enabled Online Quality Assurance for Scalable Additive Bio-Manufacturing
Funding Agency: National Science Foundation
Dates of Project: 09/01/2017 - 08/31/2021
PI: Prahalada Rao, Ph.D.
Co-PI: None
WBS Number(s): 2511230053001
Sponsor Amount: $208,000
Cost share amount: $0
Total Amount: $208,000
Amount Attributable to me: $208,000 (100%)

Abstract

Close to one million lives could be saved each year in the United States alone by organ transplantation if a sufficient number of organs were available, potentially preventing 35% of all deaths in the nation. In contrast, due to critical shortages of organs, only about 28,000 organ transplants are performed each year, with a waiting list of 120,000 people. A promising potential solution to this shortage is the high quality and production-scale 3D printing of human organs by bio-additive manufacturing (Bio-AM). However, as articulated in the 2016 NSF workshop on Additive Manufacturing for Healthcare, the current use of Bio-AM is impeded by poor organ quality, resulting in part from inadequate process monitoring and lack of integrated process control strategies. As a result, despite enormous strides, it is still not possible to scale Bio-AM to the stringent quality standards mandated for organ transplants. The goal of the project is to reliably produce viable 3D printed biological constructs (mini-tissues). The central approach is to couple in-situ heterogeneous sensor-based monitoring and real-time closed-loop process control approaches for ensuring the reliable printing of biological constructs.

The work involves the following four objectives: (1) using experimentation and modeling to understand the causal effect of process-material interactions on specific Bio-AM defects, (2) employing sensors to detect incipient defects during printing, (3) diagnosing the root causes of detected defects by analyzing sensor data using real-time decision-theoretic models, and (4) preventing propagation of defects through closed-loop process control.

The investigation will contribute: (1) fundamental understanding of the causal bio-physical process interactions that govern the quality of printed biological tissue constructs through empirical investigation and sensor-based data analytics, (2) new mathematical models for predicting the layer quality by taking into consideration the complex and dynamic tissue maturation phenomena, (3) real-time and computationally efficient decision-making for accurate classification of defects from sensor data, and (4) a two-stage, real-time, closed-loop quality control approach for preventing propagation of defects by executing smart corrective actions during the printing process.

10. Biosensor Data Fusion for Real-Time Monitoring of Global Neurophysiological Function
Funding Agency: National Science Foundation
Sponsor: N/A
Dates of Project: 04/27/2016 - 08/31/2019
PI: Prahalada Rao, Ph.D.
Co-PI: None
WBS Number(s): 2511230047004
Sponsor Amount: $225,970
Cost share amount: $0
Total Amount: $225,970
Amount Attributable to me: $225,970 (100%)

Abstract
Real-time detection of acute changes in neurophysiological state, such as epileptic seizures, lapses in cognitive ability, acute stress, etc., can ultimately serve to prevent accidents in high-risk occupations that require unwavering focus. Such professions include hazardous cargo trucking, heavy machinery operation, security and defense, air traffic control, etc. Indeed, technology for acquiring rich biosensor data streams that capture brain function, e.g., electroencephalography, are becoming increasingly portable and noninvasive. These developments present an opportunity for implementing not only real-time monitoring, but also providing pre-emptive alerts (e.g., smart phone displays), which can be used to indicate degradation in physiological states.

This research has direct applications in biomedical settings - for instance, epilepsy, is one of the most common neurological disorders afflicting over 50 million people worldwide, including 3 million people in the U.S. In about 25 percent of these patients, epileptic seizures are not controlled using available medications. Being able to detect (or predict) the onset of epileptic seizures would significantly enhance the patient's quality of life. In a proof-of-concept study, the novel analytical approaches by the research team detected the onset of epileptic seizures within 2.5 seconds. In contrast, existing approaches have a detection delay exceeding 7 seconds. From a broader perspective, the findings of this research can transform the status quo in real-time monitoring of neurophysiological function. The multidisciplinary research team will strive to provide state-of-the-art research and training opportunities for a diverse group of students that bridges the gap from engineering to the life and brain sciences.

The research team will develop a sensor data fusion approach based on graph theoretic topological mapping to combine data acquired from multiple biosensors for neurophysiological change point detection. Unlike existing approaches, which rely on complex signal pre-processing, the graph theoretic approach eschews these computationally demanding steps and is therefore more viable in a practical setting. The research team will exploit this framework using a data library of high-resolution neurophysiological recordings acquired from end users in realistic settings that induce shifts in global functional states (e.g., acute stress, cognitive exhaustion, and fatigue and so on). The research team will integrate automated decision-making approaches in the overall schema to synthesize the information and provide easily interpretable feedback to the end user (e.g., displays on a smart device). Furthermore, the PIs will customize biosensors to accommodate the patient's lifestyle.

Section 2.3 Other (Non-Research) Funding Record

Project Title	*Sponsor*	*Role*	*Dates*	*Total Amount*	*Percentage Attributable to me*
Advanced Manufacturing Summer Institute (Continuing Grant, Funding Renewed)	Department of Energy	*PI*	01/01/2019 to 12/31/2019	$137,573	*50%*
Advanced Manufacturing Summer Institute	Department of Energy	*PI*	03/01/2018 - 08/31/2018	$118,000	*50%*
Funding for Teaching Activities				$127, 786 (my share) Co-PI: Dr. Jeff Shield $255, 573 (total)	

1. Project ID 46591: Advanced Manufacturing Summer Institute
(Continuation, Funding Renewed)
Funding Agency: Department of Energy
Sponsor: American Indian Higher Education Consortium
Dates of Project: 01/01/2019 - 12/31/2019
PI: Prahalada Rao, Ph.D.
Co-PI: Jeffrey E. Shield, Ph.D.
WBS Number(s): 2611230194001
Cost share amount: $0
Total Amount: $137,573
Amount Attributable to me: $68,786 (50%)

Dates of Project: 06/01/2018 - 08/31/2018
Cost share amount: $0
Total Amount: $118,000
Amount Attributable to me: $59,000 (50%)

Abstract.
The PIs propose a Summer Institute for Advanced Manufacturing (AMSI) under the aegis of American Indian Higher Education Consortium (AIHEC), Navajo Technical University (NTU), and University of Nebraska-Lincoln (UNL). The 8-week summer institute held at UNL trained 20 students from tribal institutions affiliated with the AIHEC.

The goal is to induce a rigorous understanding of design, manufacturing, programming, and quality assurance in the specific context of advanced manufacturing. Specifically, the idea is to use additive manufacturing (AM)/3D printing of drones and autonomous vehicles (robots) as a conduit to build these concepts. The summer institute will be guided by Dr. Jeff Shield and Dr. Prahalada Rao (UNL); and Mr. Harold Scott Halliday (NTU)

Section 2.4 Research Patents and Awards

Section 2.4.1 Numbered list of Patents, including title, list of all inventors, date of publication and patent number

1. Simulating Heat Flux in Additive Manufacturing.
   Assignees: R. Yavari, K. Cole, P. Rao, Patent Filed September 13th, 2019.
   Application Number 62/730876
2. Thermal Modeling of Additive Manufacturing using Graph Theory. Assignees: J. Severson, R. Yavari, P. Rao, K. Cole, Patent Filed October 2020, Application Number 63/090,617
3. Thermal modeling of additive manufacturing using progressive horizontal subsections, Patent Filed July 1, 2020, Assignees: R. Yavari, K. Cole, P. Rao. Application Number 63/147,674
4. Systems and methods for combining thermal simulations with sensor data to detect flaws and malicious cyber intrusions in additive manufacturing, Patent Filed: 9/20/2021 Assignees: R. Yavari, P. Rao, K. Cole, A. Riensche, Application Number 63/242,860.
5. Thermal modeling of additive manufacturing using discrete green's functions and spectral graph theory for computationally efficient thermal modeling, Provisional Patent Filed, 9/21/2021, Assignees: R. Yavari, P. Rao, K. Cole, A. Riensche.

Section 2.4.2 Numbered list of all National and International Research Awards and Recognition

1. Best Paper Award, with K. Bastani and Z. Kong, IISE Transactions, 2018 for paper entitled, *An Online Sparse Estimation-based Classification (OSEC) Approach for Real-time Monitoring in Advanced Manufacturing Process from Heterogeneous Sensor Data*. IIE Transactions, Quality and Reliability Engineering, 48(7), pp. 579-598, 2016.

2. Best Paper Award (Honorable Mention), 2017, with K. Case, Z. Kong, S. Bukkapatnam, O. Beyca for paper entitled *A Graph-Theoretic Approach for Quantification Of Surface Morphology and Its Application To Chemical Mechanical Planarization (CMP) Process*. IIE Transactions, Quality and Reliability Engineering, 47(10), pp. 1-24, 2015.

3. Society of Manufacturing Engineers, Yoram Koren Outstanding Young Manufacturing Engineer Award, 2017

4. Finalist, IISE Manufacturing and Design Division's Young Investigator Award, 2016

Section 2.4.3 Numbered list of all Regional and Local Research Awards and Recognition

1. UNL Faculty Research and Creative Activity Award, 2019
2. Nominated by Oklahoma State University for the Institute of Industrial and Systems Engineers (IISE) Pritsker Dissertation Award, 2014

3. Department Nominee, University-wide Dissertation Award, Oklahoma State University, 2014
4. Finalist, IIE, John L. Imhoff graduate fellowship, 2010
5. Outstanding Research Assistant, Alpha Pi Mu, Oklahoma State University chapter, 2009
6. Finalist, IIE Graduate thesis (Master's) award, 2007

Section 3 Student Advising

Section 3.1 PhD Students

Section 3.1.1 PhD students supervised to completion

1. Mohammad Montazeri
   Co-supervisor: None.
   Dissertation Title: Smart Additive Manufacturing: In-Process Sensing and Data Analytics for Online Defect Detection in Metal Additive Manufacturing Processes.
   Percentage Funding provided by me: 100%
   Defense Date: 30th Aug. 2019 at 11 am, location Nebraska Hall W131.
   Current Employment: Novartis, Cambridge, MA

2. Mohammad Samie Tootooni, Ph.D.
   Degree completed at Binghamton University.
   Co-supervisor: None.
   Dissertation Title: Sensor Based Monitoring of Multidimensional Complex Systems Using Spectral Graph Theory.
   Percentage Funding provided by me: 100%
   Defense Date: June 21st, 2016 (Binghamton University).
   Current Employment: Tenure-track Assistant Professor at Loyola University, Chicago

3. Roozbeh Salary, Ph.D.
   Degree Completed at Binghamton University
   Primary Supervisor: Dr. Mark Poliks
   I was the co-supervisor for Roozbeh, but had to relinquish my role after moving to UNL. However, we published 3 papers between 2016-2019.
   Percentage Funding provided by me: 0%
   Graduation Date: June, 2018 (Binghamton University).
   Current Employment: Tenure-track Assistant Professor in Engineering Division at Marshall University, West Virginia.

Section 3.1.2 PhD students currently in progress.

1. Ben Bevans
   Percentage Funding provided by me: 100%
   Expected Graduation Date: August 2023.
2. Alexander Reinsche
   Percentage Funding provided by me: 100%
   Expected Graduation Date: August 2023.
3. M. Reza Yavari
   Admitted to Candidacy, 22nd August, 2019.
   Percentage Funding provided by me: 100%
   Expected Graduation Date: May 2021.
4. Leandro Castro
   Expected Graduation Date: August 2022
5. Aniruddha C. Gaikwad
   Admitted to Materials Science Ph.D. program, December 2018.
   Percentage funding provided by me: 100%
   Expected Graduation Date: December 2021.
6. Samuel E. Gerdes
   Admitted to Materials Science Ph.D. program, August 2019.
   Percentage funding provided by me: 100%
   Expected Graduation Date: December 2022.
7. Ziyad Smoqi
   Admitted to Materials Science Ph.D. program, August 2019.
   Percentage funding provided by me: 50%.
   Rest of the funding by MME department TA-ship.
   Expected Graduation Date: May 2021.
8. Jacob Williams
   Ph.D. study with me in August 2017.
   Funding terminated in December 2018.
   Co-supervisor: Dr. Ashok Samal, Computer Science.
   Percentage Funding provided by me: 100% (August 2017 – December 2018)
   Expected Graduation Date: N/A.

Section 3.2 MS Students (Thesis Option)

1. Aniruddha Gaikwad (University of Nebraska-Lincoln)
   Design Rules for Additive Manufacturing.
   Admitted to Materials Science Ph.D. program, January 2019.
   Percentage funding provided by me: 100%
   Graduation Date: M.S. Thesis Defended January, 23rd, 2019.
2. Jordan Severson (University of Nebraska-Lincoln)
   Thermal Modeling in Directed Energy Deposition using Graph Theory
   Percentage funding provided by me: 100%.
   Thesis Defense Date: May 2020.
   Graduation Data: April 2020
   Currently with Boeing, St. Louis.
3. Ashley D'Souza (Binghamton University)
   Thesis Title: Experimental Evolutionary Optimization of Geometric Integrity in Fused Filament Fabrication Additive Manufacturing Process (Binghamton University)
   Percentage Funding provided by me: 100%
   Graduation Date: May 3rd, 2016
   Current Employment: Manufacturing Engineer at AMETEK Haydon Kirk Motion Solutions, Waterbury, Connecticut, CT.

Section 3.3 Undergraduate Students

1. Ben Bevans, Mechanical Engineering, University of Nebraska, Funded through UNL UCARE. Spring 2017 – Current. John Woollam Scholar 2019.
2. Grant King, Mechanical Engineering, University of Nebraska, University of Nebraska, Funded through UNL UCARE and NSF REU supplemental funding ($8,000). Spring 2017 – Present. John Wollam Scholar 2019.
3. Sam Gerdes, Biosystems Engineering, University of Nebraska, University of Nebraska, Funded through UNL UCARE and NSF REU supplemental funding ($8,000). Spring 2017 – August 2019.
4. Joseph Broadway, Mechanical Engineering, University of Nebraska, Funded through UNL UCARE. Spring 2018 – Spring 2019.
5. August McLenehan, Mechanical Engineering, University of Nebraska, Funded through UNL UCARE. Summer 2018.
6. Emily Curtis, Mechanical Engineering, University of Nebraska. Fall 2016.
7. Ryan Donovan, Mechanical Engineering, Binghamton, Funded through NSF REU supplemental funding ($5,000). Credit Hours: N/A. 2015-2016.

Section 4 Service

Section 4.1 Journal Editorships or Associate Editorships

1. Scientific Advisory Board, Additive Manufacturing, Modeling Systems and 3D Prototyping, 10th Applied Human Factors and Ergonomics Conf., July 24th – 28th, 2019 Washington DC.
2. Associate Editor, Transactions of the Institution of Industrial and Systems Engineers, Journal of Quality and Reliability, August 2018 – Present
3. Associate Editor, Transaction of the Institution of Industrial and Systems Engineers, Journal of Design and Manufacturing, January 2019 – Present
4. Associate Editor, International Journal of Rapid Manufacturing, August 2014-Present
5. Associate Editor, International Journal of Rapid Manufacturing, Special Issue, Cyber Manufacturing -Emerging Frontiers in Sensing, Modelling and Control.
6. Member of the Editorial Review Board, Journal of Manufacturing Systems, Society of Manufacturing Engineers. Summer 2017 – Summer 2019.

Section 4.2 Numbered list of selection Journals for which papers were reviewed

1. Transactions of the American Society of Mechanical Engineers, Journal of Manufacturing Science and Engineering
2. Transactions of the Institute of Industrial and System Engineers, Journal of Quality and Reliability; and Journal of Manufacturing and Design
3. Transactions of the Institute of Electrical and Electronics Engineers (numerous journals), including Transactions of Automation Science and Engineering; Semiconductor Manufacturing; Sensors.
4. Additive Manufacturing Journal
5. Society of Manufacturing Engineers (SME), Journal of Manufacturing Systems; and Journal of Manufacturing Processes.
6. Materials and Design
7. Materials Science and Engineering (A)

Section 4.3 Leadership Positions in International and National Organizations

1. Symposium Organizer, Quality Assurance in Additive Manufacturing − Sensing, Analytics, and Control, ASME, Manufacturing Science and Engineering Conference, Since 2014.
2. Symposium Organizer, Cyber physical Systems, Advances in Cyber Physical Systems − Stochastic Modeling, and Sensor Networks in Advanced Manufacturing, ASME Manufacturing Science and Engineering Conference, Since 2014
3. Session Organizer, Big Data Analytics in Additive Manufacturing, Solid Freeform Fabrication Symposium, Since 2018.
4. Referee, Best Paper Competition, Institute of Industrial and Systems Engineers Annual Conference, Since, 2015.
5. Organizer, Best Paper Competition, Quality, Statistics, and Reliability (QSR) Division, Institute for Operations Research and Management Science World Meeting, Houston, Texas, 2017.
6. Invited Panelist, Future Academician Session, Quality, Statistics, and Reliability (QSR) Division, Institute for Operations Research and Management Science World Meeting, Houston, Texas, 2017.

7. Referee, Best Paper Competition, Quality, Statistics, and Reliability (QSR) Division, Institute for Operations Research and Management Science World Meeting, Nashiville, TN, 2016.
8. Panelist and Referee, Best Student Paper Competition, Quality, Statistics, and Reliability (QSR) Division, Institute for Operations Research and Management Science World Meeting, Philadelphia, PA, 2015.
9. Track Organizer, Quality and Reliability Engineering, Institute of Industrial and Systems Engineers, 2015, Nashville, TN.

Section 4.4 Leadership Positions in Regional and Local Organizations.

1. Invited Guest Speaker and Science Fair Judge, Greater Nebraska Science and Engineering Fair (GNSEF), Nebraska City High School, Saturday, March 25, 2017. Sponsor: Dr. Pam Rademacher (GNSEF Director).

Section 4.5 Memberships in Professional Organizations

1. American Society of Mechanical Engineers (ASME, Since 2014)
2. Institute of Industrial and Systems Engineers (IISE, Since 2003)
3. Institute for Operations Research and Management Science (INFORMS, Since 2005)

Section 4.6 Numbered list of Research Review panels and dates of service

1. Invited Panelist and Presenter, National Science Foundation, Workshop on Smart Manufacturing Systems, Cyber Physical Systems Conference, Organizers: Drs. K. Barton and M.Sibin. Washington DC, Nov. 16th, 2018.
2. Panelist for Proposal Review, National Science Foundation, Division of Cyber Physical Systems, July 2018
3. Panelist for Proposal Review, National Science Foundation, Advanced Manufacturing, July 2020.
4. Proposal review Panelist for Department of Energy and NASA, Fall 2020
5. Panelist for Proposal Review, National Science Foundation, Service Manufacturing and Operations Research (SMOR), now called Operations Engineering (OE), July 2016.
6. Panelist for Proposal Review, National Science Foundation, Summer 2020
7. Ad-hoc Panelist for European Research Foundation, Summer 2020.
8. Young Reviewers' Panel, ASME MSEC, 2015, Charlotte, NC.

Section 4.7 Numbered list of leadership positions on internal committees.

1. Organizing Committee: Great Plains Additive Manufacturing Symposium. May 2018.
2. Biomedical Engineering Tenure-track Faculty Search Committee 2018-2019, requested and permitted to be excused from duties due to health-related reasons.
3. Spring 2020 search committee for Mechanical and Manufacturing track-track faculty position.
4. Spring 2020 search committee for Electrical and Computer Engineering track-track faculty position in robotics and automation, systems integration.

Section 4.8 Other Service Accomplishments

1. Faculty Adviser for VEXRobotics Student Group (Since 2017)
2. Faculty Adviser WarGamers Club (Since 2017)

Section 5 Other Accomplishments

Section 5.1 Professional Development

- Listed in Academic Keys Who's Who in Engineering Academia, 2015
- Invited to attend the Junior Faculty Colloquium: IISE, Nashville, TN, 2015
- Invited to attend the Future Academician Colloquium: INFORMS, Phoenix, AZ, 2012
- ASQ Certified Quality Process Analyst (CQPA), 2005
- APICS Certified in Supply Chain Management (CSM) - Module I, 2004

List of References

1. **Dr. Satish T.S. Bukkapatnam**
   Rockwell International Chair Professor
   Industrial and Systems Engineering
   Texas A&M University, College Station, TX 77843
   satish@tamu.edu; cell: 405-412-4021

2. **Dr. Zhenyu (James) Kong**
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   Grado Department of Industrial and Systems Engineering
   Virginia Polytechnic Institute and State University
   Blacksburg, VA 24061
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   office: 540-231-9762; cell: 405-334-8574

3. **Dr. Kenneth E. Case**
   Emeritus Regents Professor, Member of National Academy of Engineering
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   Oklahoma State University
   Stillwater, OK 74075
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4. **Dr. Soundar Kumara**
   Allen E. Pearce and Allen M. Pearce Professor of Industrial Engineering
   Industrial and Manufacturing Engineering
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5. **Dr. Iris Rivero**
   Professor and Head
   Department of Industrial and Systems Engineering
   Kate Gleason College of Engineering
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6. **Dr. Chad E. Duty**
   Associate Professor
   Mechanical, Aerospace and Biomedical Engineering, College of Engineering
   University of Tennessee
   Knoxville, TN 37996
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7. **Dr. Kevin D. Cole**
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   Department of Mechanical and Materials Engineering
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