# Yin BAO, Ph.D.

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## *Education*

Ph.D., Agricultural and Biosystems Engineering, Iowa State University (ISU) 2018
- Dissertation: "Automated Plant Phenotyping using 3D Machine Vision and Robotics"

M.S. study in Mechanical Engineering, University of Illinois Urbana-Champaign 2012.08-2012.12

B.E., Mechanical (Vehicle) Engineering, China Agricultural University 2012

## *Professional Experience*

Assistant Professor, Biosystems Engineering Dept., Auburn University (AU) 2019.08 to date
- Appointment: 60% research and 40% teaching

Postdoctoral Research Associate, Ag & Biosystems Engineering Dept., Iowa State University 2018.05-2019.08

Graduate Research Assistant, Ag & Biosystems Engineering Dept., Iowa State University 2013.01-2018.05

## *Research Interests*

AI-based cyber-physical systems for smart agriculture and forestry, and high-throughput phenotyping for phenomics. Specific elements include remote and proximal sensing, computer vision, robotics, and machine/deep learning.

## *Teaching*

Instructor for *AU BSEN 3610/7110 Instrumentation and Controls for Biological Systems* 2020 to date

Instructor for *AU BATM 5120/6120 Agri-Industrial Electronics and Controls (PLC)* 2021 to date

Guest lecturer and lab instructor for *ISU TSM 465 Automation Systems (PLC)* Spring 2016 & 2017

## *Professional Affiliations*

American Society of Agricultural and Biological Engineers (ASABE) 2014 to date

Association of Overseas Chinese Agricultural Biological Food Engineers (AOCABFE) 2014 to date

International Society of Precision Agriculture (ISPA) 2019 to date

American Association for the Advancement of Science (AAAS) 2018 to date

## *Honors & Awards*

2022 ASABE AIM ITSC paper award

2020 New Faces of ASABE

2018 Reverend P. T. Taiganides Award

2018 Iowa State Research Excellence Award
2017 AOCABFE Graduate Leadership and Service Award
2017 First Place AOCABFE Student Paper Competition Award
2017 First Place AOCABFE Student Research Presentation Award
2016 Third Place AOCABFE Student Paper Competition Award
2016 First Place AOCABFE Student Research Presentation Award

## ***Service***

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|---|---|
| Associate Editor for ASABE journals (Machine Systems) | 2022 to date |
| ASABE Robotics Student Design Competition Committee | 2019 to 2021 |
| Secretary of ASABE Robotics Student Design Competition Committee | 2019 to 2020 |
| Board member at-large of AOCABFE | 2020 to 2022 |
| Student Activity Committee Chair of AOCABFE | 2016 to 2017 |
| Associate Editor for AOCABFE IMPACT Newsletter | 2015 to 2017 |

## ***Graduate Students Advised***

1. Puranjit Singh 2023 to date. PhD. Dissertation: TBD
2. Sharif Shabani 2022 to date. M.S. Thesis: TBD
3. Rafael Bidese-Puhl 2019 to date. PhD. Dissertation: TBD
4. Mary Beth Cassity 2021 to date. M.S. Thesis: TBD
5. Kamand Bagherian 2021-2022. M.S. Thesis: *Rapid peanut phenotyping and water quality monitoring using remote sensing and machine learning techniques*. Completed.
6. Nariman Niknejad 2021-2022. M.S. Thesis: *Kinematic Equine Gait Analysis and Phenotyping of Loblolly Pine using 3D Stereo Machine Vision and Deep Learning*. Completed.
7. Vinika Gupta 2020-2021. M.S. Thesis: *Equine Gait Analysis, Body Part Tracking using DeepLabCut and Detectron2 and Biomechanical Parameter Extraction*. Completed.

## ***Patent and Disclosures***

1. Lie Tang, Ji Li, **Yin Bao**, Jian Jin, & Akash Nakarmi (2017). Crop stand analyzer using reflective laser proximity sensors. Patent No.: US9804097B1
2. Yin Bao & Rafael Bidese Puhl. mmWave Radar-based Peanut Mass Flow Sensor. Provisional Application No.: 63/417,343

## ***Manuscripts in Preparation or Review (*correspondence)***

1. Bidese-Puhl, R., **Bao, Y.***, Butts, C., & Mclntyre, J. Mass flow rate sensing using mmWave radar and machine learning towards a peanut yield monitor. *Computers and Electronics in Agriculture*. In preparation.
2. Bagherian, K., Fernandez-Figueroa, E., **Bao, Y.***, Kaye, K., Wilson, A., & Rogers, S. Detecting harmful algal blooms in Lake Okeechobee using MODIS satellite imagery and long-short term memory. *Journal of the ASABE*. In preparation.

3. Bidese-Puhl, R., **Bao, Y.***, Payne, N., Stokes, T., Nadel, R. and Enebak, S.A. In-field pine seedling counting using end-to-end deep learning for inventory management. *Journal of the ASABE.* Under review.
4. Niknejad, N., Caro, J., Bidese-Puhl, R., **Bao, Y.***, & Staiger, E.A. Equine kinematic gait analysis using stereo videography and deep learning: stride length and stance duration estimation. *Journal of the ASABE.* In review.
5. Bagherian, K., Bidese-Puhl, R., **Bao, Y.***, Zhang, Q., Sanz-Saez, A., Dang, P., Lamb, M., & Chen, C.Y. Phenotyping agronomic and physiological traits in peanut using UAV-based hyperspectral imaging and machine learning. *The Plant Phenome Journal*. In review.
6. Niknejad, N., Bidese-Puhl, R., **Bao, Y.***, Payn, K. and Zheng, J. Phenotyping of architecture traits of loblolly pine trees using stereo machine vision and deep learning: stem diameter, branch angle, and branch diameter. *Computers and Electronics in Agriculture*. In review.
7. Gupta, V., West, A., Niknejad, N., Smythe, M., **Bao, Y.***, Brooks, S. and Staiger, E.A. A deep learning-based video processing pipeline for markerless equine kinematic gait analysis. *International Journal of Agricultural and Biological Engineering*. In review.
8. Puppala, N., Nayak, S.N., Sanz-Saez, A., Chen, C.Y., Devi, M.J., Nivedita, N., **Bao, Y.**, He, G., Traore, S.M., Wright, D.A., Pandey, M.K., & Sharmaei, V. Physiological and molecular basis of drought and heat stress tolerance to enhance productivity and nutritional quality of peanuts in harsh environments. *Frontiers in Genetics*. In review.
9. Xiang, L., Gai, J., **Bao, Y.**, Yu, J., Schnable, P., & Tang, L. Field-based robotic leaf angle detection and characterization of maize plants using stereo vision and deep convolutional neural networks. *Journal of Field Robotics*. In review.

***Peer-Reviewed Journal Publications***

1. Xiang, L., Nolan, T., **Bao, Y.**, Elmore, M., Tuel, T., Gai, J., Shah, D., Wang, P., Huser, N., Hurd, A., McLaughlin, S., Howell, S., Walley, J., Yin, Y., & Tang, L. (2021), Robotic Assay for Drought (RoAD): an automated phenotyping system for brassinosteroid and drought responses. *The Plant Journal 107*, 1837-1853. https:/doi.org/10.1111/tpj.15401
2. Zhang, J., **Bao, Y.**, Du, D., Wang, J., & Wei, Z. (2021). OM2S2: on-line moisture-sensing system using multi-frequency microwave signals optimized by a two-stage frequency selection framework. *IEEE Transactions on Industrial Electronics*, 68(11), 11501-11510. https:/doi.org/10.1109/TIE.2020.3032927
3. Qian, K., **Bao, Y.**, Zhu, J., Wang, J., & Wei, Z. (2021). Development of a portable electronic nose based on a hybrid filter-wrapper method for identifying the Chinese dry-cured ham of different grades. *Journal of Food Engineering*, 290, 110250. https://doi.org/10.1016/j.jfoodeng.2020.110250
4. Mantilla-Perez, M., **Bao, Y.**, Tang, L., Schnable, P., & Salas-Fernandez, M. (2020). Towards "smart canopy" sorghum: discovery of the genetic control of leaf angle across layers. *Plant Physiology*, 184(4): 1927-1940. https://doi.org/10.1104/pp.20.00632
5. Zhang, J., Du, D., **Bao, Y.**, Wang, J., & Wei, Z. (2020). Development of multi-frequency swept microwave sensing system for moisture measurement of sweet corn with deep-neural-network. *IEEE Transactions on Instrumentation and Measurement,* 69(9), 6446-6454. https:/doi.org/10.1109/TIM.2020.2972655
6. **Bao, Y.**, Zarecor, S., Shah, D., Tuel, T., Campbell, D., Chapman, A., Imberti, D., Kiekhaefer, D., Imberti, H., Lübberstedt, T., Yin, Y., Nettleton, D., Lawrence-Dill, C., Whitham, S., Tang, L., & Howell, S. (2019). Assessing plant performance in the Enviratron. *Plant Methods*, 15(1): 117. https://doi.org/10.1186/s13007-019-0504-y

7. Breitzman, M., **Bao, Y.**, Tang, L., Schnable, P., & Salas-Fernandez, M. (2019). Linkage disequilibrium mapping of high-throughput image-derived descriptors of plant architecture traits under field conditions. *Field Crop Research*, 244, 107619. https://doi.org/10.1016/j.fcr.2019.107619
8. Xiang, L., **Bao, Y.**, Tang, L., Ortiz, D., & Salas-Fernandez, M. (2019). Automated morphological traits extraction for sorghum plants via 3D point cloud data analysis. *Computers and Electronics in Agriculture*, 62, 951-961. https://doi.org/10.1016/j.compag.2019.05.043
9. **Bao, Y.**, Tang, L., Srinivasan, S., & Schnable, P. (2019). Plant architectural traits characterization for maize using time-of-flight 3D imaging. *Biosystems Engineering*, 178, 86-101. https://doi.org/10.1016/j.biosystemseng.2018.11.005
10. **Bao, Y.**, Tang, L., Breitzman, M., Salas-Fernandez, M., & Schnable, P. (2018). Field-based robotic phenotyping of sorghum plant architecture using stereo vision. *Journal of Field Robotics*, 36(2), 397-415. https://doi.org/10.1002/rob.21830
11. **Bao, Y.**, Shah, D., & Tang, L. (2018). 3D perception-based collision-free robotic leaf probing for automated indoor plant phenotyping. *Transactions of the ASABE*, 61(3), 859-872. https://doi.org/10.13031/trans.12653
12. Salas-Fernandez, M., **Bao, Y.**, Tang, L., & Schnable, P. (2017). A high-throughput, field-based phenotyping technology for tall biomass crops. *Plant Physiology*, 174(4), 2008-2022. https://doi.org/10.1104/pp.17.00707
13. **Bao, Y.**, & Tang, L. (2016). Field-based robotic phenotyping for sorghum biomass yield component traits characterization using stereo vision. *IFAC-PapersOnLine*, 49(16), 265-270. https://doi.org/10.1016/j.ifacol.2016.10.049

### ***Book Chapter***

1. **Bao**, Y., Gai, J., Xiang, L., & Tang, L. (2021). Field robotic systems for high-throughput plant phenotyping: A review and a case study. In: Zhou J., Nguyen H.T. (eds) *High-Throughput Crop Phenotyping. Concepts and Strategies in Plant Sciences*. Springer, Cham. https://doi.org/10.1007/978-3-030-73734-4_2

### ***Conference Papers and Presentations***

1. Bidese-Puhl, R., **Bao, Y.**, Payne, N., Stokes, T., Nadel, R., & Enebak, S. (2022). In-field pine seedling counting using end-to-end deep learning for inventory management. 2022 ASABE Annual International Meeting, July 17-20, Houston, Texas, USA. Received Information Technology, Sensors, and Control Systems (ITSC) Community Paper Award. https://doi.org/10.13031/aim.202200463
2. Bagherian, K., Bidese-Puhl, R., **Bao, Y.**, Zhang, Q., Sanz-Saez, A., Chen, C., & Dang, P. (2022). Phenotyping agronomic traits of peanuts using UAV-based hyperspectral imaging and deep learning. 2022 ASABE Annual International Meeting, July 17- 20, Houston, Texas, USA. https://doi.org/10.13031/aim.202200814
3. Niknejad, N., Caro, J., Bidese-Puhl, R., **Bao, Y.**, & Staiger, E.A. (2022). Estimation of equine stride length and stance duration using stereo 3D videography and deep learning. 2022 ASABE Annual International Meeting, July 17- 20, Houston, Texas, USA. https://doi.org/10.13031/aim.202201204

4. Smythe, M.P., Gupta, V., Staiger, E.A., **Bao, Y.**, & Brooks, S.A. (2021). Using artificial intelligence to analyze horse gait parameters for genomics research in musculoskeletal traits. Journal of Equine Veterinary Science, 100, 103502. https://doi.org/10.1016/j.jevs.2021.103502
5. West, A., Gupta, V., Smythe, M.P., Staiger, E.A., **Bao, Y.**, & Brooks, E.A. (2021). Locomotion pattern analysis using digital video labeling by machine learning. Journal of Equine Veterinary Science, 100, 103604. https://doi.org/10.1016/j.jevs.2021.103604
6. Bidese-Puhl, R., **Bao, Y.**, Sanz-Saez, A., & Chen, C. (2021). Infield peanut pod counting using deep neural networks for yield estimation. 2021 ASABE Annual International Virtual Meeting, July 12-16. https://doi.org/10.13031/aim.202101080
7. Gupta, V., West, A., **Bao, Y.**, Brooks, S.A., & Staiger, E.A. (2021). A video processing pipeline for equine biomechanical parameters extraction and gait analysis. 2021 ASABE Annual International Virtual Meeting, July 12-16. https://doi.org/10.13031/aim.202100942
8. Akter, M., Niknejad, N., **Bao, Y.**, Bidese-Puhl, R., Payn, K., & Zheng, J. (2021). Phenotyping of pine tree architecture with stereo vision and deep learning. 2021 ASABE Annual International Virtual Meeting, July 12-16. https://doi.org/10.13031/aim.202100847
9. **Bao, Y.**, & Tang, L. (2019). Temporal leaf tracking of maize plant using a convolutional neural network. 2019 ASABE Annual International Meeting, July 7-10, Boston, MA, USA.
10. **Bao, Y.,** & Tang, L. (2018). "A robotized multi-sensor perception-driven indoor plant phenotyping system". 2018 ASABE Annual International Meeting, July 29-August 1, Detroit, MI, USA.
11. **Bao, Y.**, & Tang, L. (2018). Plant architectural traits characterization for maize using Time-of-Flight 3D imaging. 2018 ASABE Annual International Meeting, July 29-August 1, Detroit, MI, USA.
12. **Bao, Y.**, Tang, L., & Shah, D. (2017). Robotic 3D plant perception and leaf probing with collision-free motion planning for automated indoor plant phenotyping. 2017 ASABE Annual International Meeting, July 16-19, Spokane, WA, USA. https://doi.org/10.13031/aim.201700369
13. **Bao, Y.**, Tang, L., Schnable, P., & Salas-Fernandez, M. (2016). Infield biomass sorghum yield component traits extraction pipeline using stereo vision". 2016 ASABE Annual International Meeting, July 17-20, Orlando, FL, USA. https://doi.org/10.13031/aim.20162462338
14. **Bao, Y.**, Tang, L., Schnable, P., & Salas-Fernandez, M. (2015). GPU-based parallelization of a sub-pixel high-resolution stereo matching algorithm for high-throughput biomass sorghum phenotyping. 2015 ASABE Annual International Meeting, July 26-29, New Orleans, LA, USA. https://doi.org/10.13031/aim.20152188089
15. **Bao, Y.**, Nakarmi, A., & Tang, L. (2014). Development of a field robotic phenotyping system for sorghum biomass yield component traits characterization. 2014 ASABE Annual International Meeting, July 13-16, Montreal, Quebec, Canada. https://doi.org/10.13031/aim.20141901199

***Invited Speak***

1. "AI for seedling counting and production". 2022 Southern Forest Nursery Management Cooperative Advisory Board Meeting, November 2, 2022. Auburn AL, USA.
2. "Automated pine seedling inventory using machine vision and machine learning". 2022 Joint Annual

Meeting: Southern and Northeastern Forest Nursery Associations, July 19, 2022. Charleston, SC, USA.

3. "Automated seedling inventory". 2021 Southern Forest Nursery Management Cooperative Contact Meeting, July 19, 2021. Online Zoom meeting.
4. "Robotic plant phenotyping". Biological Systems Engineering Department Seminar, University of Wisconsin-Madison. February 24. 2021. Online Zoom meeting.
5. "High-throughput plant phenotyping and its potential for automated seedling inventory". 2020 Southern Forest Nursery Management Cooperative Contact Meeting, July 20, 2020. Online Zoom meeting.
6. "Robotic Plant Phenotyping". 2019 Plant Science Research Symposium, December 17, Auburn, AL, USA
7. "High-Throughput Phenotyping: Plant Architecture". 2019 North Carolina State University Tree Improvement Program Contact Meeting, November 14, Tuscaloosa, AL, USA.
8. "Robotic plant phenotyping". 2019 ASABE Alabama Station Section Meeting, April 12, Auburn, AL, USA.

***Research Grants and Contracts (My contribution: $1,003,763; Total amount: $2,658,978)***

1. An AI-based ground robotic vision system for automated inventory and quality assessment of bareroot seedlings in forest tree nursery production ($548,897). **Yin Bao**, Lie Tang, Scott Enebak, Timothy McDonald. USDA-NIFA AFRI. 2022-2025. **PI**
2. Unmanned aerial systems for determining vegetative establishment on ALDOT construction sites ($199,976). Michael Perez, **Yin Bao**, Wesley Donald. Alabama Department of Transportation. 2022-2024. **Co-PI**
3. Development of a mmWave radar-based peanut yield monitor ($9,658). **Yin Bao**, Christopher Butts. Alabama Peanut Producers Association. 2022. **PI**
4. Evaluating a remote soil moisture sensor for precision cotton irrigation management ($8,000). **Yin Bao**, Brenda Ortiz. Alabama Cotton Commission. 2021-2022. **PI**
5. Continue to improve the accuracy of blueberry yield prediction ($16,529). Sushan Ru, **Yin Bao**, James Spiers. California Blueberry Commission. 2022-2023. **Co-PI**
6. Enabling high-throughput yield prediction for efficient blueberry production ($30,280). Sushan Ru, **Yin Bao**, Elina Coneva, James Spiers, Paul Bartley. California Blueberry Commission. 2021-2022. **Co-PI**
7. Enabling high-throughput yield prediction for efficient blueberry production ($5,000). Sushan Ru, **Yin Bao**, Elina Coneva, James Spiers, Paul Bartley. Southern Region Small Fruit Consortium. 2022. **Co-PI**
8. Utilizing drone to detect herbicide injury and common cotton pests ($8,000). Steve Li, **Yin Bao**. Alabama Cotton Commission. 2021-2022. **Co-PI**
9. Future of peanut maturity assessment: remote sensing, physiology and artificial intelligence ($25,000). Brenda Ortiz, Alvaro Sanz-Saez, Charles Chen, Kris Balkcom, Luan De Oliveira, **Yin Bao**. Alabama Peanut Producers Association. 2021-2022. **Co-PI**
10. Creating a tool for forecasting Harmful Algal Blooms using Earth Observations and Machine Learning to Predict (HELP) high risk surface water sources ($149,546). Stephanie Rogers, **Yin Bao**, Alan Wilson. Alabama Agricultural Experiment Station Interdisciplinary Research Grant Program. 2021-2023. **Co-PI**
11. Developing the AU-Hop Team: Breeding Southeastern-Adapted Hop Varieties with Integrative

Horticultural, Phenotypic, and Genomic Strategies ($149,280). Andre da Silva, **Yin Bao**, Alex Harkess, Alvaro Sanz-Saez, Courtney Leisner. Alabama Agricultural Experiment Station Interdisciplinary Research Grant Program. 2021-2023. **Co-PI**

12. Development of a vision-based robotic seedling counting and geo-mapping system for bareroot pine seedling production ($50,000). **Yin Bao**, Ryan Nadel, Timothy McDonald. Alabama Agricultural Experiment Station Production Agriculture Research Funding Program. 2020-2022. **Co-PI**
13. Effects of environmental conditions in live production on production efficiency and product quality in commercial poultry ($1,307,680). Jeremiah Davis, Jessica Starkey, Charles Starkey, **Yin Bao**, Jesse Campbell. USDA ARS Poultry Research Unit. 2020-2022. **Co-PI**
14. Application of funding toward purchasing new drone-based remote sensing equipment (drone + hyperspectral and multispectral cameras) for AU row crop research ($100,000). Alabama Agricultural Experiment Station Equipment Grant Program. Steve Li, Kathy Lawrence, Katelyn Kesheimer, Scott Graham, Alvaro Sanz-Saez, **Yin Bao**, Tyler Sandlin, David Russell. 2020-2024. **Co-PI**
15. Three-dimensional equine gait analysis using computer vision and deep learning for genomic mapping ($49,800). Elizabeth Staiger, **Yin Bao**, Sonia Moisá, Reid Hanson. Auburn University Intramural Grants Program. 2020-2022. **Co-PI**
16. Development of a low-cost, cable-based mobile crop sensing platform on a center pivot ($5,000). **Yin Bao**. Alabama Agricultural Experiment Station Planning Grant Program. 2019-2020. **PI**

***Education Grant***

1. Development of hands-on trainers in electrical systems and electronic control systems to strengthen electrical problem solving skills in poultry processing plants, feed mills, hatcheries, and on the farm ($31,946). Jeremiah Davis, Jess Campbell, William Batchelor, **Yin Bao**, Dennis Brothers and Kelly Goneke. Alabama Poultry and Egg Association. 2019.

***Grant Panelist and Ad Hoc Grant Reviewer***

- Panelist, USDA-NIFA AFRI Regional Innovations for Climate-Smart Agriculture and Forestry (RICSAF) (2022)
- Panelist, USDA-NIFA AFRI Research and Extension Experiences for Undergraduates (REEU) (2022)
- Panelist, Alabama Agricultural Experiment Station Production Agriculture Research Funding program (2021)
- Ad hoc reviewer, the Hong Kong Jockey Club Equine Welfare Research Foundation Pump-Prime Funding program (2022)

***Technical Reviewer***

- Applied Engineering in Agriculture
- Biosystems Engineering
- Computers and Electronics in Agriculture

- Frontiers in Plant Science
- Plant Methods
- Plant Phenomics
- Precision Agriculture
- Transactions of the ASABE
- Agricultural Water Management

***Media Coverage***

- Spotlight on Agriculture, Alabama Public Television, Season 4 Episode 1. From 40:40 to 44:25. https://video.aptv.org/video/hudsonalpha-oewmz6/