AG2PI SEED GRANT - PROJECT FINAL REPORT

PROJECT NAME	Event-Based Plant Phenotyping using Deep Learning: Algorithms, Tools and Datasets

PROJECT PRINCIPAL INVESTIGATOR	TODAY'S DATE	PROJECT START DATE	DATE OF COMPLETION
Sruti Das Choudhury	06/30/2023	1/1/2022	4/30/2023
TEAM MEMBERS (co-PI, co-I, personnel)		COLLABORATORS	
Ashok Samal, Srinidhi Bashyam, Yufeng Ge		Ranga Raju Vatsavai	

ACCOMPLISHMENTS

Please provide a short summary of the conclusions (both successes and failures) made from your project. Include a description of how this project will provide benefits to the agricultural genome to phenome community and, possibly, to a broader audience. You should include both qualitative and quantitative details, as necessary, to support your conclusions. Include a short accomplishment statement in non-technical language and do not include names.

This is not a technical report. Please keep to no more than 6-8 sentences (e.g., 1-2 sentences per point, above).

We publicy released three datasets, i.e., UNL Maize Emergence Dataset (UNL-MED), FlowerPheno and FruitPheno, to spur research in event-based plant phenotyping analysis. We believe that these datasets will serve instrumental role in the giant leap of event-based plant phentoyping research by letting acees to image datasets to the researchers across globe who typically do not have the infrastructure to generate them.
The three novel algorithms are publoshed in the premier open access journals, one is under review and two others are in preparation.
The publicly released iPlantSeg+tool will enable the borader community with no or limited knowledge in image processing to interactively segment the desired plant or its components to compute phenotypes. A virtual workshop was also conducte to educate people on its usage. In summary, the research outcome includes open-access journal publications, inviteed talks and poster presentations in national and international conferences, conducting workshops, releasing multiple datasets and a software tool.

(HINT: You can expand sections as necessary by pulling down on the square in the lower right corner of each box)

Products

Please list any products from this project. This may include (but not limited to) publication, concept/white paper, workshop, conference presentation, website, publicly available data or pipelines, etc. Reminder: you are required to make your prodcuts available to the broader stakeholder community using standard USDA practices, open source, FAIR, or other models. Metrics may include number of participants or times accessed, etc. Include links to recordings, DOI, etc. when possible. For presentations and posters, provide authors, date, location and presentation title.

ACTIVITY / PRODUCT	DESCRIPTION (include URL, if applicable)	OUTCOME / METRICS
Publication 1	FlowerPhenoNet: Automated Flower Detection from Multi-View Image Sequences Using Deep Neural Networks for Temporal Plant Phenotyping Analysis *Remote Sens.* 2022, *14*(24), 6252	Authors: 6 Article views: 973 Citations: 2 https://doi.org/10.3390/rs14246252
Publication 2	EmergeNet: A novel deep-learning based ensemble segmentation model for emergence timing detection of coleoptile Front. Plant Sci., 03 February 2023 Sec. Technical Advances in Plant Science Volume 14 - 2023	Authors: 5 Total views and downloads: 704 https://doi.org/10.3389/fpls.2023.1084778
Publication 3	Drought stress prediction and propagation using time series modeling on multimodal plant image sequences Front. Plant Sci., 09 February 2023 Sec. Technical Advances in Plant Science Volume 14 - 2023	Total views and downloads: 796 https://doi.org/10.3389/fpls.2023.1003150
Publication 4	Current Challenges and Future of Agricultural Genomes to Phenomes in the U.S. (Under review)	Authors: 10+ Submitted in Genome Biology
Publication 5	iPlantSeg+: An interactive segmentation tool for phenotyping (in preparation)	Authors: 3 To be submitted in The Plant Methods journal by 31st July, 2023
Publication 6	FruitPhenoNet: Fruit Detection From Hyperspectral Imagery Using Deep Neural Networks For Temporal Plant Phenotyping Analysis (In preparation)	Authors: 3 To be submitted in the Computers and Electronics in Agriculture journal (impact factor: 6.757) by September 2023
Dataset Release 1	UNL-Maize Emergence Dataset (UNL-MED) https://plantvision.unl.edu/dataset	The dataset is intended to spur research in emergence time detection of coleoptile and tracking its growth using deep learning

Dataset Release 2	FlowerPheno Dataset https://plantvision.unl.edu/dataset	The dataset is intended to spur research in deep learning-based flower detection and flower phenotyping analysis.
Dataset Release 3	FruitPheno Dataset https://plantvision.unl.edu/dataset	The dataset is intended to spur research in deep learning-based fruit detection and fruit phenotyping analysis.
Software Tool Release	iPlantSeg+ Tool Available at: https://plantvision.unl.edu/software	The tool enables users automated and interactive segmentation of plant images or the components of the plants, and compute holistic phenotypes that are automatically stored in a database.
Workshop	Segmentation Techniques and Challenges in Plant Phenotyping: Introducing the iPlantSeg+ Tool Virtual AG2PI workshop	Demonstration of a software tool for image segmentation, applied to plant phenotyping. Link to recording: https://www.ag2pi.org/workshops-and-activities/workshop-2023-03-14/
Invited Talk	Future of Temporal Plant Phenotyping based on AI-driven Time Series Modeling, Lightning talk at AG2PI & NIFA workshop "Thinking Big: Visualizing the Future of AG2PI", Iowa, USA, September 2022.	https://www.ag2pi.org/workshops-and-activities/conference-2022-09-09/
Poster Presentation 1	HyperStressPropagateNet: Time Series Modeling for Drought Stress Propagation in Plants using Hyperspectral Imagery.	Authors: Sruti Das Choudhury, Sinjoy Saha, Anastasios Mazis, Ashok Samal, Tala Awada In North American Plant Phenotyping Network (NAPPN) Annual Conference, St. Louis, Missouri, February 2023.
Poster Presentation 2	Sruti Das Choudhury, Ashok Samal, Tala Awada, FlowerPhenoNet: Automated Flower Detection from Multi-view Image Sequences using Deep Neural Networks for 2D and 3D Temporal Plant Phenotyping Analysis.	7th International Plant Phenotyping Symposium (IPPS7), Wageningen, Netherlands, September 2022.
Poster Presentation 3	Sruti Das Choudhury, Vincent Stoerger, Xiijan Fan, Ashok Samal, FruitPhenoNet: Automated Fruit Detection based on Analyzing Time-series Visible Light and Hyperspectral Imagery for Temporal Fruit Phenotyping using Deep Neural Networks.	7th International Plant Phenotyping Symposium (IPPS7), Wageningen, Netherlands, September 2022.

Audience

With whom has this work been targeted to and shared? Please describe how this project and its products have been disseminated to a community of interest. Include any outreach activity or information sharing as well as training or professional development opportunities provided in this project.

The products of ths project has been targeted to and shared with the students, researches and practitioners in the emerging field of techncal advances in plant phenotyping. The prducts included open access journal publications and also software tool (iPlantseg+) and public datasets which has been disseminated from our website: https://plantvision.unl.edu/

Outreach activities: AG2PI workshop on iPlantSeg+ tool, international research trainee: Sinjoy Saha, AAnkit Das from University of Calcutta (India);
Paid student workers from UNL: Yves Cedric Tamwo and Kunjan Theodore Joseph.
The outcome of the research was included in my pre-session short course teaching at the UNL: Computer Vision and Artificial Intelligence Applications in Agricultural Science and Natural Resources (NRES 498/898) Spring 2023

CONTINUATION OF WORK

Next steps

How do you/your team plan to continue moving this project forward? Include how AG2PI can assist in your forward momentum.

We are preparing to submit two manuscripts based on the outcome of the project: a software paper based on iPlantSeg+ tool and FruitPhenoNet.
We are working on improving the iPlantSeg+ tool with added functionalities.
We are working on a fruit harvesting and fruit sorting robot to move forward with the fruit phenotyping part of the project.

AG2PI seed grants are helpful to assit in the forward momentum.