Progress report on the coordinated innovation network for advancing computer vision in precision livestock farming

J. P. Steibel[1,*], T. Brown-Brandl[2], G. J. M. Rosa[3], J. M. Siegford[4], E. Psota[5], M. Benjamin[4], D. Morris[4], J. R. R. Dorea[3] and T. Norton[6]
[1]*Iowa State University, Ames, IA 50011, USA*
[2]*University of Nebraska-Lincoln, Lincoln, NE 68583, USA*
[3]*University of Wisconsin-Madison, Madison, WI 53706, USA*
[4]*Michigan State University, East Lansing, MI 48824, USA*
[5]*PIC North America, Hendersonville, TN 37075, USA*
[6]*Catholieke Universiteit Leuven, Leuven, Belgium*
[*]Corresponding author: Juan P. Steibel, steibelj@iastate.edu

Abstract

Advancing computer vision (CV) applications in livestock is key to accelerate the on-farm adoption of precision livestock farming (PLF). Our group is executing a five-year project funded by the National Institute of Food and Agriculture (NIFA) of the USDA to: 1) advance CV applications in PLF, 2) attract top talent from engineering, computer science and animal science to PLF, and 3) create a synergetic network of professionals working to solve pressing issues in PLF. Among the outputs of this project are the delivery of recorded and archived webinars on current topics related to CV, the release of reference and benchmarking datasets to facilitate the development and validation of CV tools in PLF, and the creation of analytical challenges based on the published datasets. In this presentation we explain current and planned activities of our network. Specifically, we will summarize the outcomes of the CV webinars delivered up convening the USPLF meeting, the status on available and planned data recording and annotation and current analytical challenges. We also present opportunities for members of the global PLF community to be involved in those activities.

Keywords: computer vision, animal behavior, data sharing.

Introduction

While the potential of precision livestock farming (PLF) to increase profitability and productivity of livestock production systems, on-farm adoption of PLF remains limited. Two limiting factors that impede the adoption of PLF outside the dairy industry are 1) the cost of the technology relative to the value of commodity animals and their products and 2) the limited capacity of the current knowledge base (developers and engineers) in livestock agriculture to develop and implement PLF.

A low-cost, non-invasive technology that holds great promise for further advancing PLF is computer vision (CV). CV enables task automation by using computers to extract and interpret important features of a physical system from digital images or videos.

There are currently several interdisciplinary groups developing CV applications for specific PLF purposes. However, there are some acknowledged limitations to the described approach of in-house data generation and analysis for CV in PLF. One is the lack of appropriately trained human resources to develop CV algorithms. Second, research groups with ample experience in CV are not attracted to work in animal agriculture due to lack of awareness of the grand challenges for CV in PLF. Moreover, for existing collaborations, specific datasets are collected, used, and archived without being shared with other researchers and analysts. Thus, the level of solution validation is often limited because the generated CV algorithms are not benchmarked against common datasets. Thus, creating reference datasets and distributing datasets among a broader

research community, can contribute to 1) advancing CV applications in PLF, 2) attracting top talent from engineering, computer science, data science, and animal science to PLF, and 3) creating a synergetic network of professionals working to solve pressing issues in PLF.

Our consortium received funding from the U.S. National Institute of Food and Agriculture to address the described needs through pursuing the following goals:

Objective 1: Generate reference datasets and benchmarking data for facilitating the development of computer vision applications that address key challenges in precision livestock farming.

Objective 2: Build a coordinated innovation network of stakeholders, researchers, and students to develop computer vision applications in precision livestock farming.

Materials and methods

Coordinated Innovation Network (CIN)

Coordinated Innovation Networks are projects funded by the U.S. Institute for Food and Agriculture (NIFA 2021). A CIN fosters creation of communities that address bottlenecks in critical areas by bringing together experts from different disciplines to identify innovative and synergistic solutions. The CIN in this project promotes collaboration among researchers in computer vision and precision livestock farming.

Five institutions (see names and affiliation of coauthors) participate in this project represented by at least one co-principal investigator (co-PI). Each broad objective of the project has several sub-objectives led by members of the co-PI team (Figure 1).

Results and discussion

The CIN on computer vision for precision livestock farming started in 2021, and in this section, we report its ongoing activities.

Review of publicly available data

A review of publicly available data suitable for application of CV in livestock is underway. A total of 20 datasets have been identified, 11 correspond to cattle, 9 to pigs. A preliminary report is being presented in this conference.

A repository of data shared by our group and other group has been created at the Open Science Framework website: https://osf.io/4fv2c/.

Published data

Members of the CIN are generating and analyzing data in the context of objective 1. One dataset with short video episodes of pigs competing for feeder space has been shared (https://osf.io/wa732/). And a companion GitHub site with analysis code has been published (https://github.com/jun-jieh/AgonisticPigBehav/).

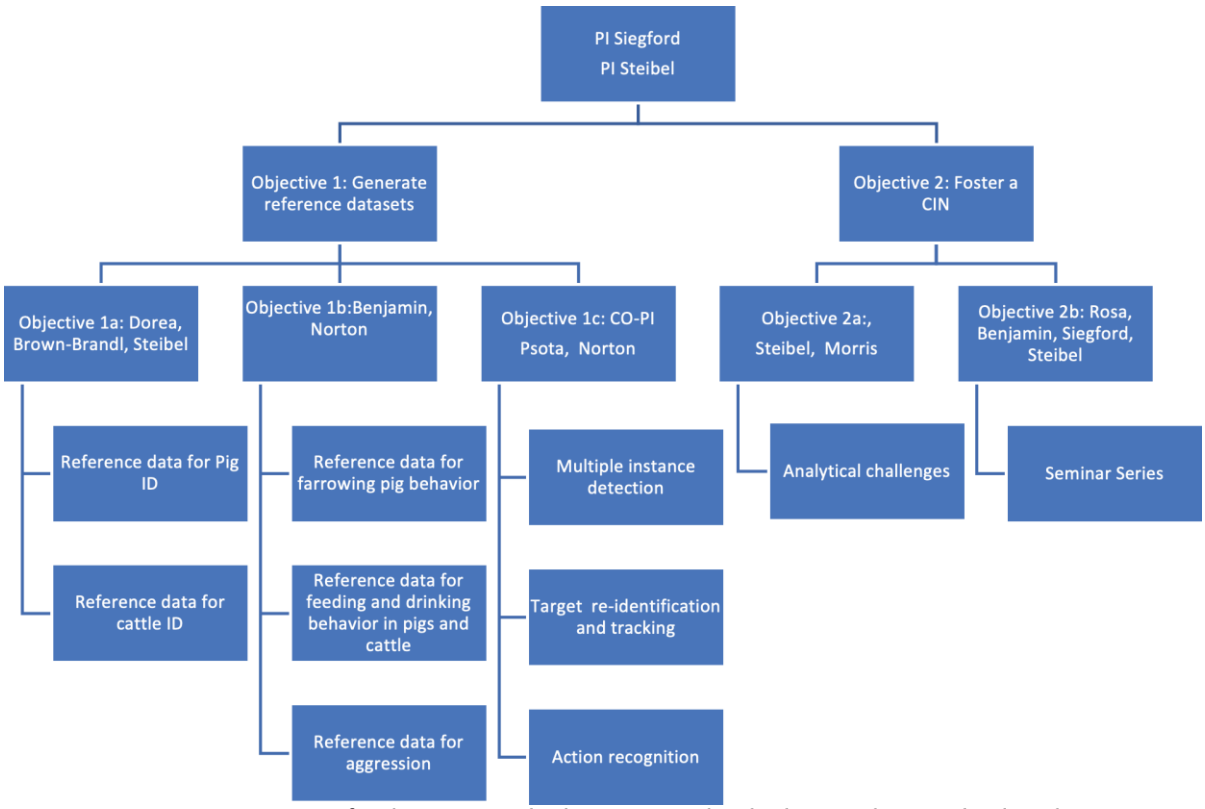

Figure 1: Management structure for the project sub-objectives. Each sub-objective has two leaders that represent different institutions and different disciplines.

Webinar series

The webinar series started in January 2022. The first edition included an introductory presentation and small group discussions (10 groups of n= 6 to 8 persons per group assigned at random), where participants were asked what research and instructional topics in CV applied to precision livestock farming they would like to see featured in the series.

A total of 102 participants attended the webinar and 75 participants from 10 groups contributed to the discussion. For the question on research topics there were 30 suggestions from nine groups. As specific topics, long-term tracking and animal identification were the most requested topics (n=4 each). As general topics, data management and integration of hardware and software were mentioned the most times by group participants. Each group also requested seminars addressing a wide variety of applications of computer vision in livestock systems, including the use of drones in animal husbandry, feed use, and measuring climate-change relevant phenotypes (Figure 2).

Suggested research topics for webinars of computer vision in PLF
Drones in animal husbandry
Continuous Tracking, Identifycation and Phenotyping
Commercially available applications
Group-level production and welfare indicartos
Climate change relevant phenotyping
Current issues faced by the industry
Poultry Behavior
Feed use and feeding behavior
Behavior as management indicator

Figure 2: Suggested applications of computer vision in PLF by webinar participants.

Five groups proposed eleven instructional topics (Table 1) that were grouped into 6 categories. The most requested instructional webinars were: computer vision programming, computer vision pipelines and data integration.

Table 1: Requested instructional topics for future webinars and workshops.

Group	Textual Comment	Assigned Category
1	Programing on CV languages (like for example python)	Programming
2	Review of basic CV libraries and a replicable example with code and data	
1	About Connecting CV algoritms with RFID from electronic feeders	Data integration
3	Integrating video data with other sources (i.e., production, vet, genetic, etc)	
3	Best practices of video equipment, video storage, video communications	Best practices
4	Animal identification and re-identification - full day workshop	Animal ID
4	Tutorial on practical semi-automatic or automatic CV examples	CV pipelines
4	Concrete practical applications of hybrid CV on specific PLF topics	
4	Comparison of 2D vs. 3D vs. other spectral CV-based approaches to solve the same PLF problem	
5	CV Pipeline: from data collection, data mgmt, model specification, model fitting for estimation and prediction purposes.	
5	Tutorial on image data storage systems	Data management

The second webinar of the series focused on animal identification. It was attended by 75 participants. Two short seminars were delivered. Dr. Eric Psota presented: "How do we know who is who?" and Dr. Joao Dorea presented: “Challenges and opportunities of cattle identification through CV systems”.

An exit poll of this webinar was immediately responded to by 32 respondents, of which 23 identified themselves as interested in using computer vision for animal identification, seven respondents were already using computer vision and two were not considering using computer vision for animal identification. Also, important information about the intended use of CV for animal identification by webinar participants was collected, for instance: in which environment (production farm, research farm or laboratory) and for which species participants envisioned using CV for identification.

In March, Dr. Silvia Zuffi delivered a webinar on "Modeling Animals in 3D for Shape and Pose Estimation from Images". It was attended by 65 participants. And in April Dr. Daniel Berckmans presented a webinar titled "Precision Livestock Farming: where we are, where to go?" with 72 participants in attendance.

Recording of these webinars are available online:

https://mediaspace.msu.edu/channel/Computer+Vision+in+Precision+Livestock+Farming/232477

633/ The webinar series will resume in January 2022.

Opportunities for the PLF community to participate

There are multiple ways in which the community of researchers interested in computer vision and precision livestock farming can participate in this coordinated innovation network.

For Objective 2a, community members are welcome to participate in challenges by submitting solutions or they can work with the CIN team to generate challenges around existing data. For Objective 2b, in addition to attending seminars and contributing to post-seminar discussions, researchers in the field of computer vision and precision livestock farming are encouraged to propose and co-organize webinars consisting of presentations and unconference activities.

Conclusions

Precision Livestock Farming holds the hope to enhance animal welfare and profitability; however, the development and the adoption of PLF systems has been slowed by many factors. This paper presents a coordinated innovation network that addresses critical challenges in computer vision applied PLF. The team provides opportunities to learn about the needs of the industry to develop a set of easily accessible webinars with presentations made by leaders in the PLF area, along with opportunities for interactions. These webinars have been well attended, 65 to 102 participants at each event. In addition, the publicly available reference datasets are being developed for students and researchers to use to develop skills, knowledge, and abilities in image processing applications for PLF tool development.

Acknowledgments

This project is funded by NIFA Award 2021-67021-34150.

References

NIFA (2021) Data Science for Food and Agricultural Systems FAQ. *https://nifa.usda.gov/resource/dsfas-faq/*.