

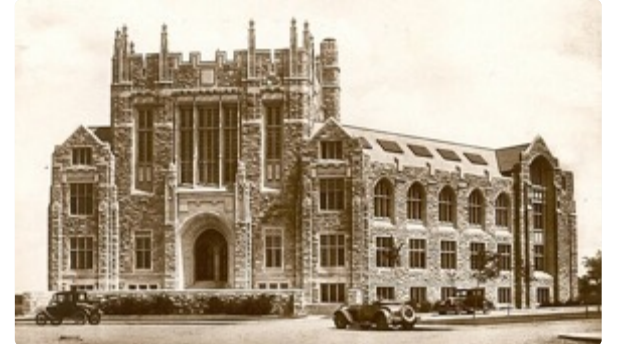
# Computational Agriculture: An Opportunity for Saskatchewan



Ian Stavness

Professor, Computer Science  
University of Saskatchewan

[Ian.Stavness@usask.ca](mailto:Ian.Stavness@usask.ca)



College of Agriculture and Bioresources  
Advancements in Agricultural Research Seminar Series  
January 31, 2024

# Computational Agriculture

People

Data

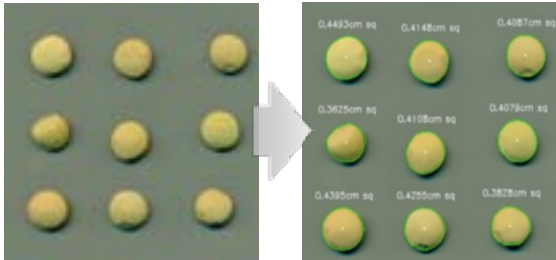
Opportunities



# Computational Agriculture

## Seed scale

*seed phenotyping,  
provenance*



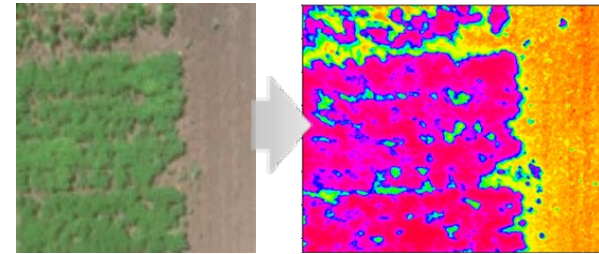
## Plant scale

*identifying plants,  
estimating traits*



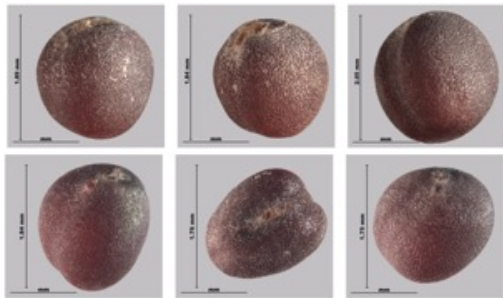
## Field scale

*crop health,  
precision management*



## Global scale

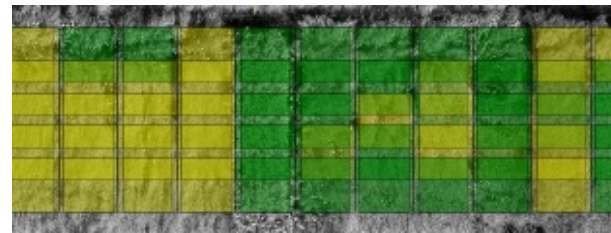
*yield prediction,  
price forecasting*



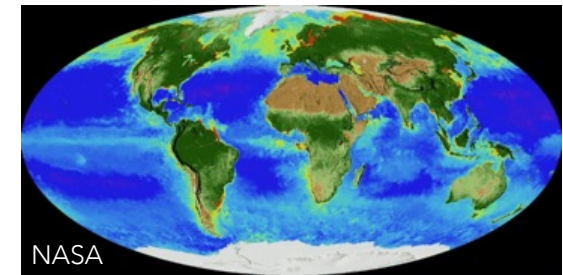
*automated seed  
inspection, grading*



*early disease  
detection*



*crop damage,  
crop insurance*



*weather prediction,  
logistics*

# Plant Phenotyping and Imaging Research Centre (P<sup>2</sup>IRC)



**Flagship 1:**  
Breeding for  
Yield Stability



**Flagship 2:**  
Mobilizing Root-  
Soil-Microbiome



**Flagship 3:**  
Deep Learning  
for Phenomics

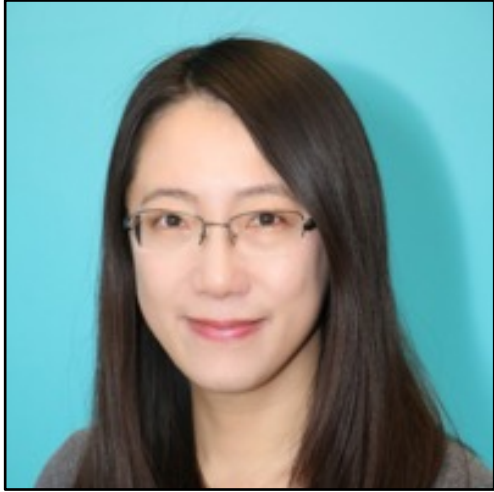


**Flagship 4:**  
Field Imaging for  
Phenotyping



# CompAg in Saskatchewan

## *Comp Sci Researchers in Agriculture*



Lingling Jin (Univ. Saskatchewan)

- Bioinformatics, Genomics, Plant imaging

Abdul Bais (Univ. Regina)

- Crop Imaging/Analysis



Jordan Ubbens (NRC, Saskatoon)

- Deep learning, Genomics/Phenomics





# CompAg in the Prairies

## *Comp Sci Researchers in Agriculture*



Chris Henry (Univ. Manitoba)

- Crop Imaging/Analysis

Farhad Maleki (Univ. Calgary)

- Artificial Intelligence in Ag



# CompAg in Saskatchewan

## *Innovative Companies*


- PrecisionAI
- Nutrien Ag Solutions
- Nuseed Canada
- Local tech companies (Siemens, Calian, Draganfly, etc.)

*Supported by Saskatchewan's Agtech Growth Fund (AGF)*



# What do we need for CompAg?

People + Data





Introduction

People

Data

Discussion



# We need *talented* people

Highly trained and qualified individuals and teams are the most important factor in a project's success

- For *Computational Agriculture*:
  - Specialized skills (Computer + Plant Science)
  - General skills (Communication, Data Management, IP)

# We want *deadly* teams

From our experience with P<sup>2</sup>IRC:

1. the best teams were diverse and open
2. matched Comp Sci and Plant Sci grad students
3. characteristics: enthusiasm, ok being uncomfortable

Example: **the *Canola Counter* team**



# Canola Counter Team



Erik Andvaag  
MSc Computer Science  
[eea299@usask.ca](mailto:eea299@usask.ca)



Kaylie Krys  
MSc Plant Sciences  
[kmk806@usask.ca](mailto:kmk806@usask.ca)  
[@KaylieKrys](https://www.instagram.com/KaylieKrys)

# Canola Counter

The screenshot displays the 'Canola Counter' web application interface. At the top, the title 'Canola Counter' is visible on the left, and 'DemoUser' with a 'Log Out' button is on the right. Below the title bar, the current session information 'DemoFarm1 | DemoField1 | 2023-10-02' is centered, and a 'Map View' button is on the right.

The main interface is divided into several sections:

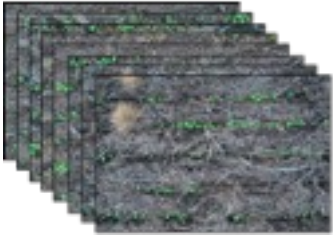
- Left Panel:** Contains a 'Help' button, 'Image 7' with status indicators and a 'Bookmark' button, a 'Save All Changes' button, an 'Active Edit Layer' section with radio buttons for 'Annotation' (selected), 'Region of Interest', 'Fine-Tuning Region', and 'Test Region', and a 'Navigation' section with a list of images (7-13) and 'Previous'/'Next' buttons.
- Center:** A large image of a field with several green canola plants. Blue bounding boxes are drawn around individual plants, and a larger blue rectangle encompasses a region of interest. A scale bar in the bottom right corner indicates '2.05 cm'.
- Right Panel:** Features a 'Model' section with a 'Select' button and the text 'No model selected.', a 'Backend Status' section showing 'Idle' and various fields (Username, Farm Name, Field Name, Mission Date) with 'Last Update' on '2 Oct 2023 14:36:48', a 'Request Predictions' section with buttons for 'Current Image', 'All Images', and 'Full Result', and an 'Annotations' section with 'Upload' and 'Download' buttons.



# Canola Counter workflow

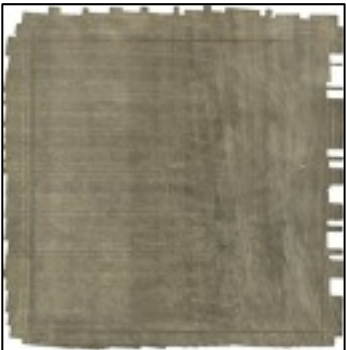
(1) Upload images

*Set of Images*



-- or --

*Orthomosaic*



(2) Annotate images,  
train models, apply models



Model

Backend Status

Predicting  
27%

Username	DemoUser
Farm Name	DemoFarm1
Field Name	DemoField1
Mission Date	2023-10-02

Last Update 22 Nov 2023 14:43:48

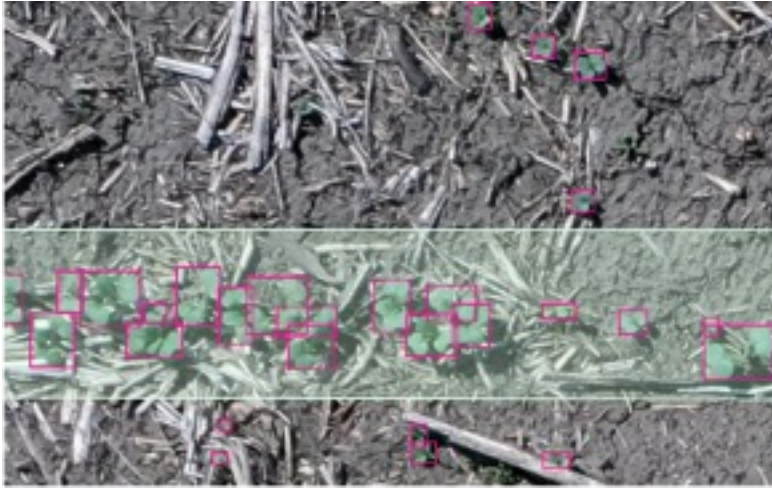
(3) Inspect results and  
download counts



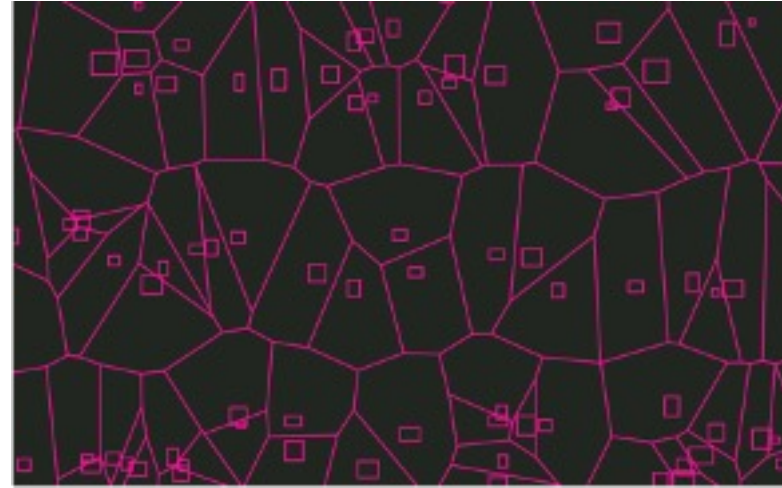
Image Name	Annotated Count	Predicted Count
1	329	332
2	6	7
3	559	555



# Canola Counter *visualizations*



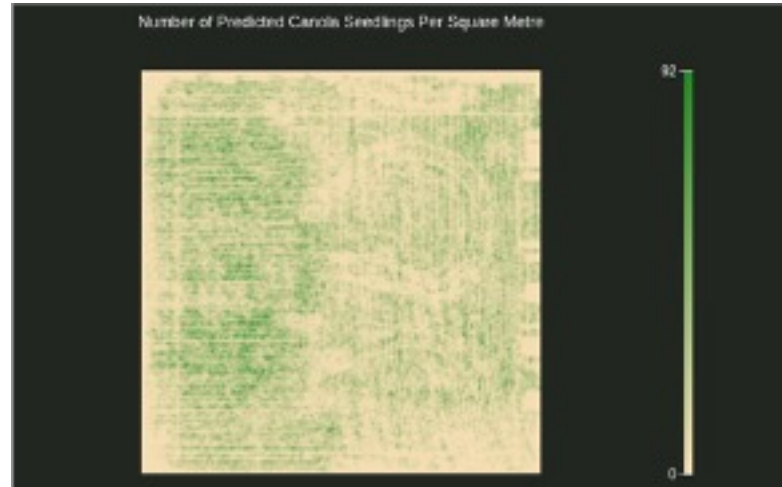
Regions of Interest



Plant Spacing



Vegetation Coverage



Density Maps

# Canola Counter Team



Erik Andvaag  
MSc Computer Science  
[eea299@usask.ca](mailto:eea299@usask.ca)



Kaylie Krys  
MSc Plant Sciences  
[kmk806@usask.ca](mailto:kmk806@usask.ca)  
[@KaylieKrys](https://www.instagram.com/KaylieKrys)

# Trainees want *Saskatchewan* experience

- Prioritize training for the needs of the *Saskatchewan* agriculture sector
- Emphasize hands-on experience:
  - get *CompSci* students in the *Field*
  - get *PlantSci* students on the *Cloud*
- Accelerate careers in academics, government and industry



# NSERC CREATE in Computational Agriculture

*Objective:* Train graduate students at the intersection of Computer Science and Plant Sciences (2024 – 2029)

- New graduate course in Computational Agriculture
  - Cross-Training
  - Team Projects
  - Field Days, Cloud Days, Lab/Facility Tours
- New workshops:
  - AgTech Intellectual Property
  - Managing Agricultural Data
- Professional rotations & internships





# CREATE Team

Curtis Posniak



Adam Carter



Kirstin Bett



Ana Vargus



Maryse Bourgault



Steve Shirtliffe



Crop Breeding

Agronomy

Ian Stavness



Mrigank Rochan



Lingling Jin



Mark Eramian



Carl Gutwin



Deep Learning

Bioinformatics

Imaging & Visualization

# CREATE Partners



*Growing science for life*

**GIFS** | GLOBAL INSTITUTE  
FOR FOOD SECURITY

Nutrien - a Founding Partner



**Agriculture and  
Agri-Food Canada**

Saskatoon  
Lethbridge  
Brandon  
Morden



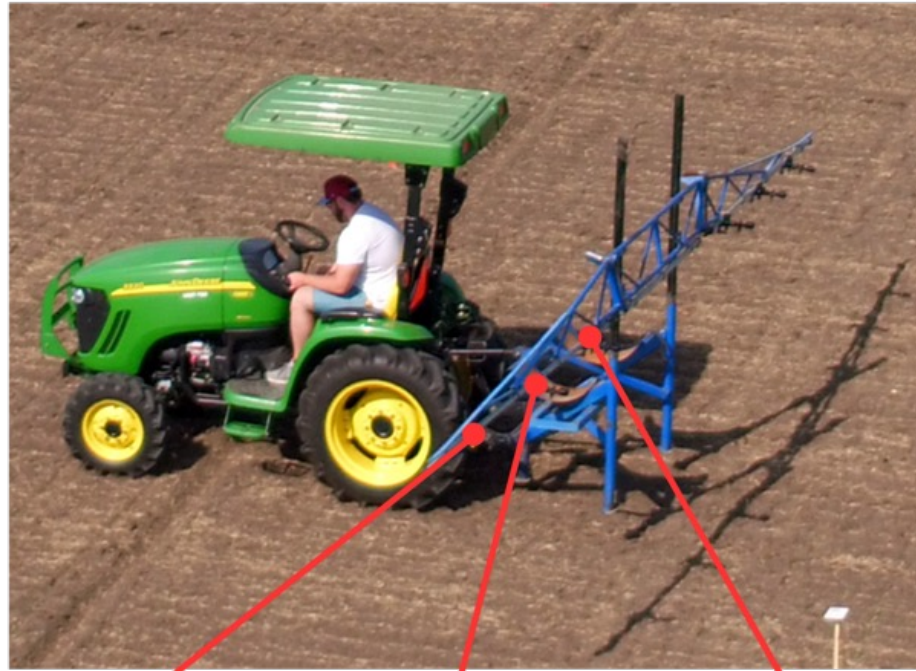
# ProTractor



UNIVERSITY OF  
SASKATCHEWAN

Canada

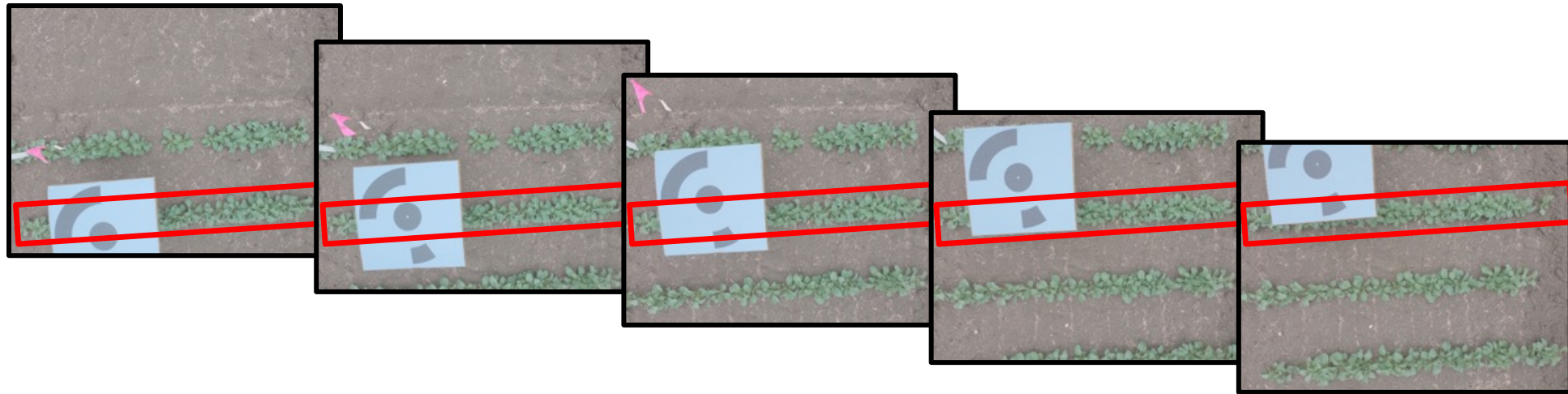
Agriculture and  
Agri-Food Canada

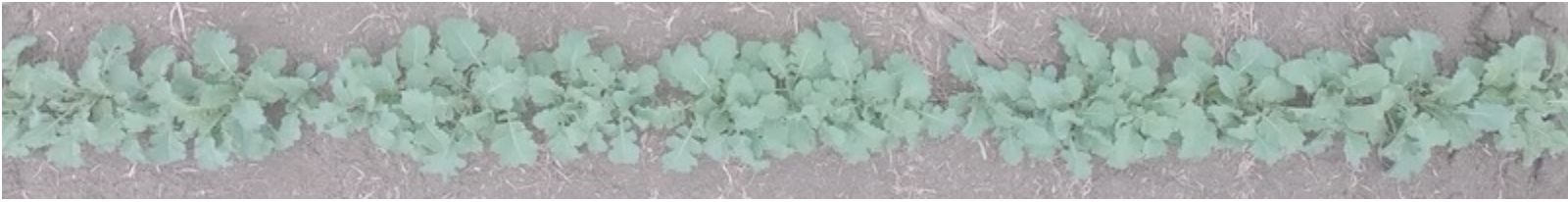
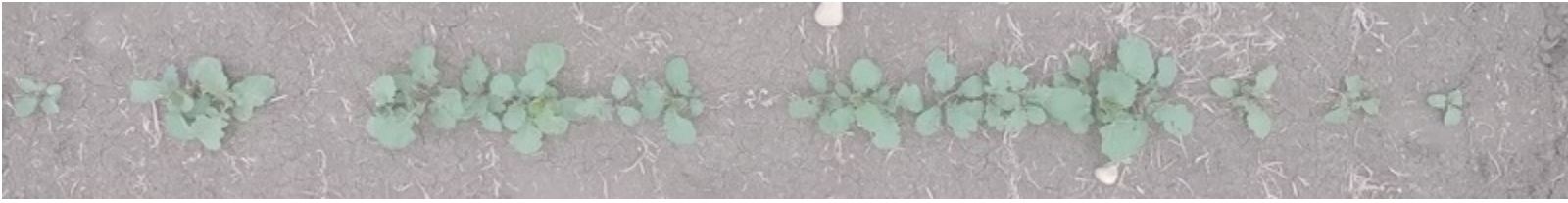


Higgs N, Leyeza B, Ubbens J, Kocur J, van der Kamp W, Cory T, ... Stavness, I. (2019). ProTractor: a lightweight ground imaging and analysis system for early-season field phenotyping. In Proceedings of the IEEE CVPR Workshops (pp. 1-10).



# Row detection





# PlotReel

NUE\_2 · 2019-07-30 · left\_middle\_L1 · range\_1 |  
Selected 0 of 32

Predict Remaining Selection

Scroll Mode:

<

>





# Inspecting plot images

The screenshot displays the P2IRC SysColl web interface. The browser title is "P2IRC | SysColl" and the address bar shows "Secure". The page header includes "P2IRC SysColl" and "STAVNESS, IAN" with a "FEEDBACK" button. The main content area is divided into a left sidebar and a main "Viewers" section.

**Controls**

- Load Trial: (2017) Canola DRIL (5 captu...
- Capture Date: 2017-05-06
- Show/Hide Viewers:
  - Field Viewer
  - Block Viewer
  - Range Viewer
  - Plot Viewer

**Trial Info**

- TestID: 17VN207DRIL
- Name: (2017) Canola DRIL

**Plot Info**

- Plot Number: 7
- Plot Name: DH12075
- Plot Range: 1
- Plot Rows: 9

**Viewers**

The "Viewers" section shows three stacked images of a field plot. The top image is a wide view of the plot with a grid of 39 columns labeled G, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, G. A green vertical line highlights column 7, and a green horizontal line highlights row 1. The middle image is a closer view of the plot, and the bottom image is a close-up of the plants in the highlighted area.



Prof. Carl Gutwin



CompAg

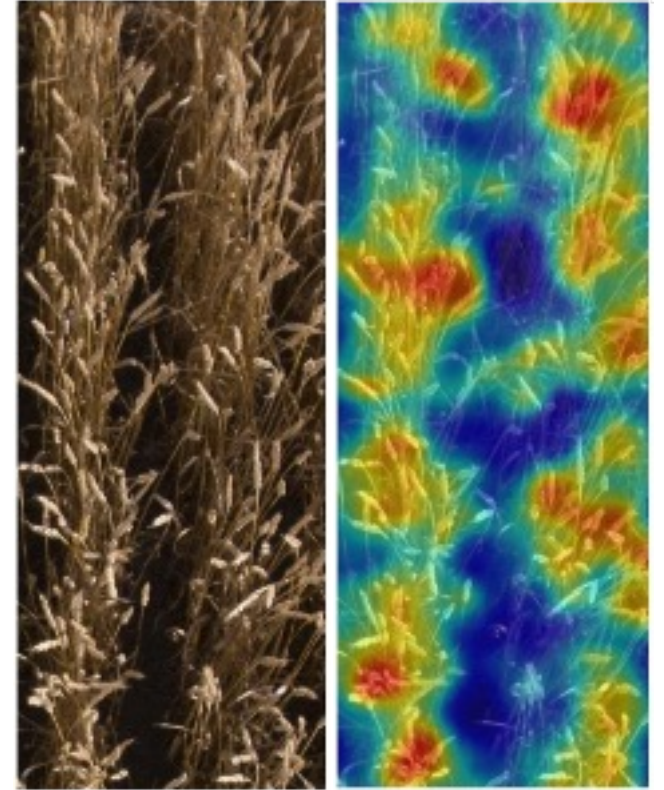
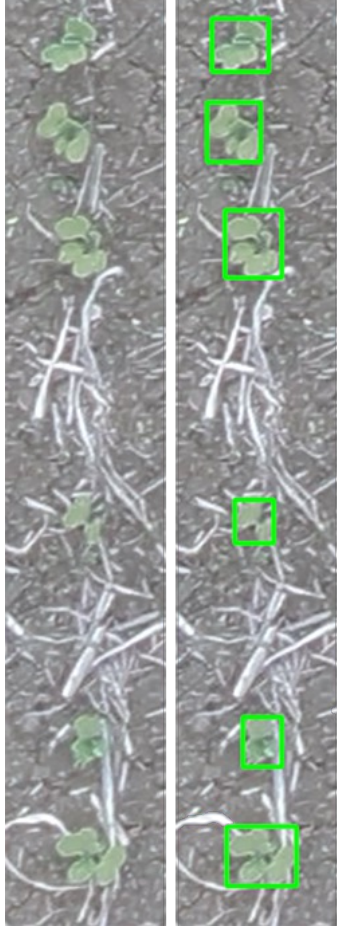
People

Data

Opportunities



# We want *models* that work



# We need *large-scale* datasets

Open Images Dataset V7



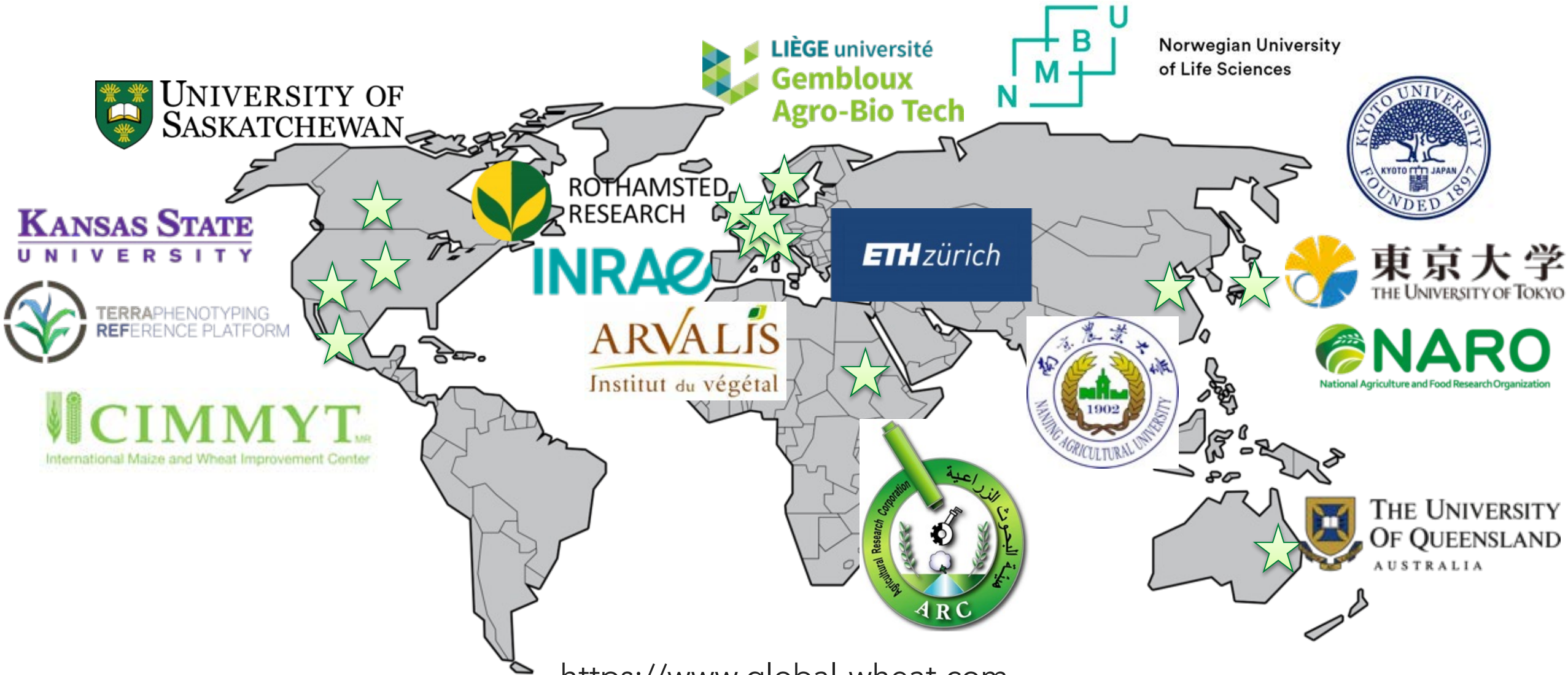
9 Million images

15 Million object boxes on 600 classes

3 Million segmentation masks on 350 classes



# Global Wheat Head Dataset





# Global Wheat Head Dataset



UTokyo\_1



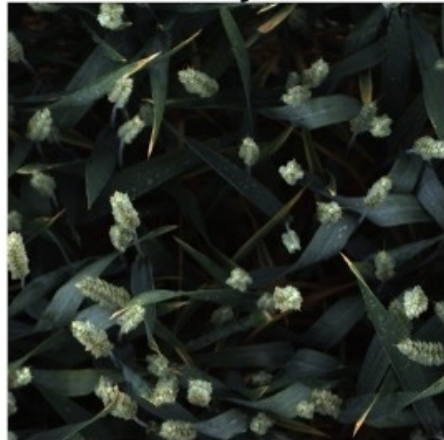
UTokyo\_2



Arvalis\_1



USask\_1



RRes\_1



ETHZ\_1

kaggle

**Global Wheat Detection**

Can you help identify wheat heads using



University of Saskatchewan · 2,245 teams

**AIcrowd** 


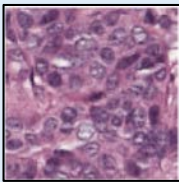
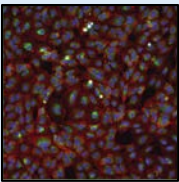
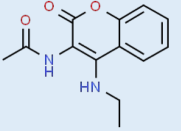




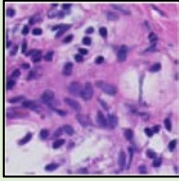
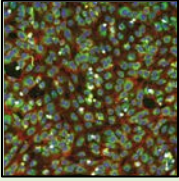
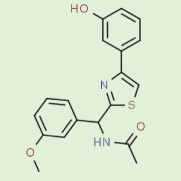
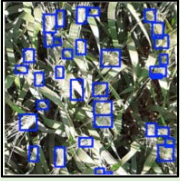




**Global WHEAT  
CHALLENGE 2021**

David E, ... Stavness I, Guo W, (2020). Global Wheat Head Detection (GWHD) dataset: a large and diverse dataset of high resolution RGB labelled images to develop and benchmark wheat head detection methods. Plant Phenomics, Volume 2020, Article ID 3521852.

# WILDS Dataset

in-the-wild distribution shifts spanning diverse data

	Domain generalization					Subpopulation shift	Domain generalization + subpopulation shift			
Dataset	iWildCam	Camelyon17	RxRx1	OGB-MolPCBA	GlobalWheat	CivilComments	FMoW	PovertyMap	Amazon	Py150
Input (x)	camera trap photo	tissue slide	cell image	molecular graph	wheat image	online comment	satellite image	satellite image	product review	code
Prediction (y)	animal species	tumor	perturbed gene	bioassays	wheat head bbox	toxicity	land use	asset wealth	sentiment	autocomplete
Domain (d)	camera	hospital	batch	scaffold	location, time	demographic	time, region	country, rural-urban	user	git repository
# domains	323	5	51	120,084	47	16	16 x 5	23 x 2	2,586	8,421
# examples	203,029	455,954	125,510	437,929	6,515	448,000	523,846	19,669	539,502	150,000
Train example						What do Black and LGBT people have to do with bicycle licensing?			Overall a solid package that has a good quality of construction for the price.	<pre>import numpy as np ... norm=np.____</pre>
Test example						As a Christian, I will not be patronizing any of those businesses.			I "loved" my French press, it's so perfect and came with all this fun stuff!	<pre>import subprocess as sp p=sp.Popen() stdout=p.____</pre>
Adapted from	Beery et al. 2020	Bandi et al. 2018	Taylor et al. 2019	Hu et al. 2020	David et al. 2021	Borkan et al. 2019	Christie et al. 2018	Yeh et al. 2020	Ni et al. 2019	Raychev et al. 2016

<https://wilds.stanford.edu/>



# WILDS Paper

1000+ citations since 2021

The image shows a screenshot of the arXiv website for the paper "WILDS: A Benchmark of in-the-Wild Distribution Shifts". The page header includes the arXiv logo, the category "Computer Science > Machine Learning", and a search bar. The paper title is prominently displayed, followed by the authors' names: Pang Wei Koh, Shiori Sagawa, Henrik Marklund, Sang Michael Xie, Marvin Zhang, Akshay Balsubramani, Weihua Hu, Michihiro Yasunaga, Richard Lanus Phillips, Irena Gao, Tony Lee, Etienne David, Ian Stavness, Wei Guo, Berton A. Earnshaw, Imran S. Haque, Sara Beery, Jure Leskovec, Anshul Kundaje, Emma Pierson, Sergey Levine, Chelsea Finn, and Percy Liang. The abstract text is visible, discussing distribution shifts and the WILDS benchmark. On the right side, there are sections for "Access Paper:" (with links for Download PDF and Other Formats), "Current browse context:" (showing cs.LG), "References & Citations" (with links to NASA ADS, Google Scholar, and Semantic Scholar), "DBLP - CS Bibliography" (with a listing and bibtex link), and "Export BibTeX Citation".

arXiv > cs > arXiv:2012.07421

Search... All fields Search

Help | Advanced Search

Computer Science > Machine Learning

[Submitted on 14 Dec 2020 (v1), last revised 16 Jul 2021 (this version, v3)]

## WILDS: A Benchmark of in-the-Wild Distribution Shifts

Pang Wei Koh, Shiori Sagawa, Henrik Marklund, Sang Michael Xie, Marvin Zhang, Akshay Balsubramani, Weihua Hu, Michihiro Yasunaga, Richard Lanus Phillips, Irena Gao, Tony Lee, Etienne David, Ian Stavness, Wei Guo, Berton A. Earnshaw, Imran S. Haque, Sara Beery, Jure Leskovec, Anshul Kundaje, Emma Pierson, Sergey Levine, Chelsea Finn, Percy Liang

Distribution shifts -- where the training distribution differs from the test distribution -- can substantially degrade the accuracy of machine learning (ML) systems deployed in the wild. Despite their ubiquity in the real-world deployments, these distribution shifts are under-represented in the datasets widely used in the ML community today. To address this gap, we present WILDS, a curated benchmark of 10 datasets reflecting a diverse range of distribution shifts that naturally arise in real-world applications, such as shifts across hospitals for tumor identification; across camera traps for wildlife monitoring; and across time and location in satellite imaging and poverty mapping. On each dataset, we show that standard training yields substantially lower out-of-distribution than in-distribution performance. This gap remains even with models trained by existing methods for tackling distribution shifts, underscoring the need for new methods for training models that are more robust to the types of distribution shifts that arise in practice. To facilitate method development, we provide an open-source package that automates dataset loading, contains default model architectures and hyperparameters, and standardizes evaluations. Code and leaderboards are available at [this https URL](https://wilds.stanford.edu/).

**Access Paper:**

- Download PDF
- Other Formats

[view license](#)

Current browse context:  
cs.LG  
< prev | next >  
new | recent | 2012  
Change to browse by:  
cs

**References & Citations**

- NASA ADS
- Google Scholar
- Semantic Scholar

**DBLP - CS Bibliography**

[listing](#) | [bibtex](#)

Pang Wei Koh  
Henrik Marklund  
Sang Michael Xie  
Marvin Zhang  
Akshay Balsubramani  
...

[Export BibTeX Citation](#)

**Bookmark**

<https://wilds.stanford.edu/>

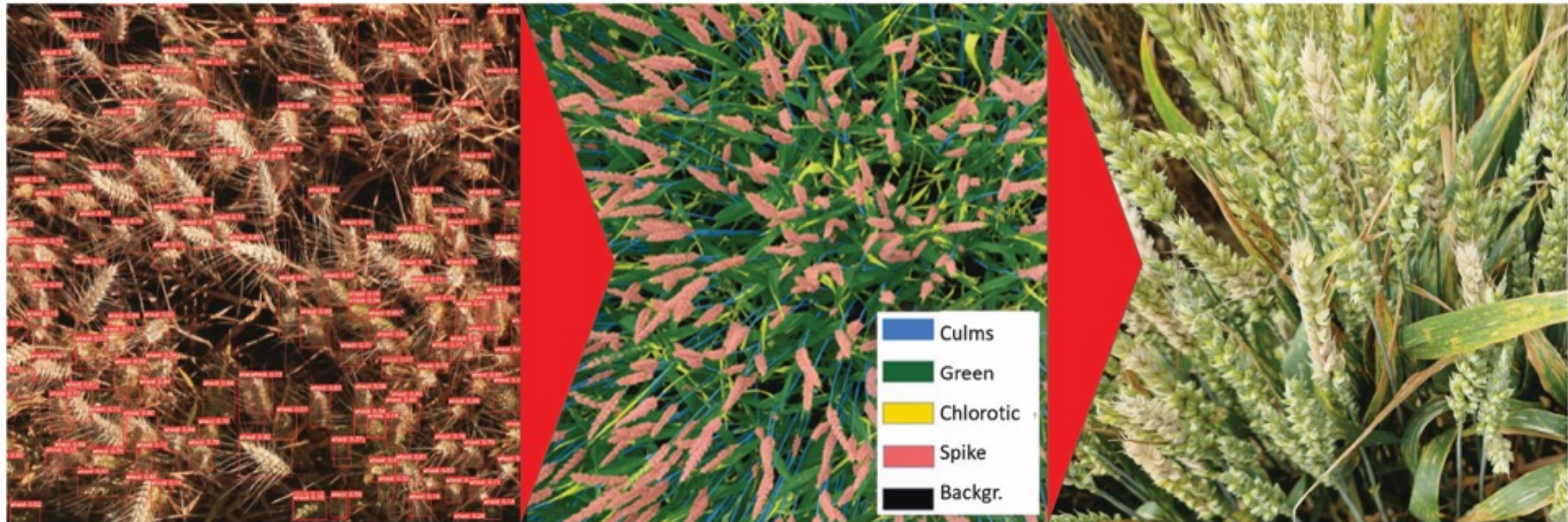
# Future *Global Wheat Datasets*

## Global wheat full semantic segmentation

GWHD

GWSS

GWFB





# Saskatchewan is collecting data

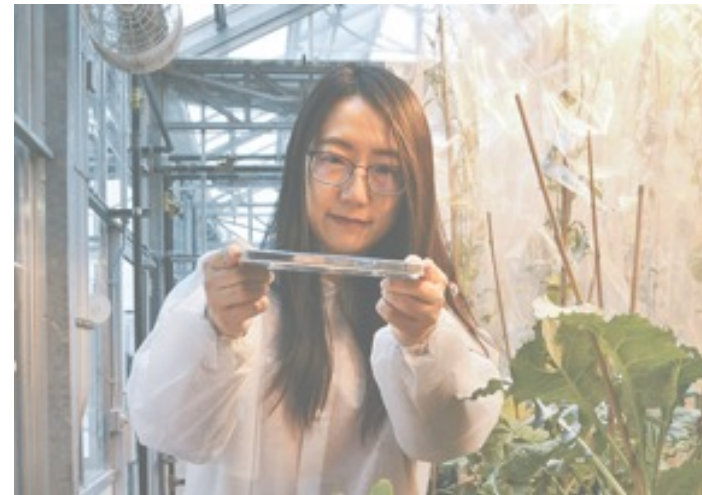
(Noble, UFPS)



(Shirtliffe, Drones)



(Stavness & Vail, Protractor)




(Jin, Smartphones)

*Saskatchewan* needs an Ag data strategy





# We want farm data

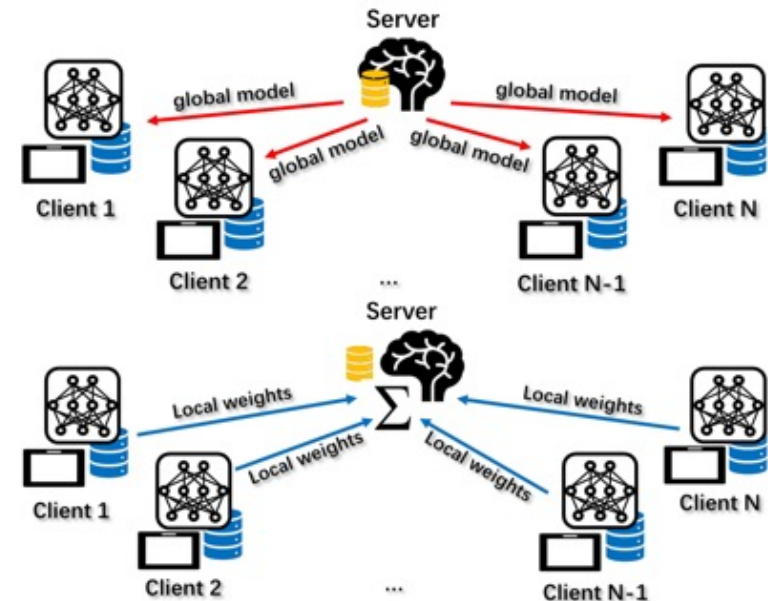
- Ensure data privacy and intended-use
  - Flow benefits to data generators (growers)
  - Reduce costs to store, update, and utilize data
  - Elevate the entire Saskatchewan ag-tech sector
- 

# Data strategy & data sharing

1. Trusted entities



2. Privacy-preserving technology  
e.g. federated-learning



CompAg

People

Data

Compute

Opportunities



# We need *large-scale* compute



(Niagara Cluster, Digital Research Alliance of Canada)



# We need *large-scale* compute

THE WHITE HOUSE



MENU

OCTOBER 30, 2023

FACT SHEET:  
President Biden Issues  
Executive Order on Safe,  
Secure, and Trustworthy  
Artificial Intelligence

 BRIEFING ROOM > STATEMENTS AND RELEASES

# We need *large-scale* compute

The image shows a screenshot of the NSF website's page for the National Artificial Intelligence Research Resource Pilot. The page features a dark blue header with the NSF logo and navigation links. The main content area has a large graphic of a neural network and the title 'National Artificial Intelligence Research Resource Pilot'. Below this is a breadcrumb trail and a paragraph describing the NAIRR. A 'Feedback' button is visible on the right side.

U.S. National Science Foundation

Search NSF

[Find Funding & Apply](#) [Manage Your Award](#) [Focus Areas](#) [News & Events](#) [About](#)

## National Artificial Intelligence Research Resource Pilot

[View image credit & caption](#)

[Home](#) / [Our Focus Areas](#) / [Artificial Intelligence](#) / [National Artificial Intelligence Research Resource Pilot](#)

The National Artificial Intelligence Research Resource (NAIRR) is a vision for a shared national research infrastructure for responsible discovery and innovation in AI.

**On this page**

- [About the NAIRR pilot](#)

Feedback

# We need *large-scale* compute



The screenshot shows the top navigation bar with the logo on the left and the text "Digital Research Alliance of Canada" and "Alliance de recherche numérique du Canada" on the right. A hamburger menu icon is in the top right corner. Below the navigation bar is a breadcrumb trail: "Home / Funding Opportunities". The main heading "Funding Opportunities" is centered and underlined with a yellow line. The main content area contains two paragraphs of text.

**Digital Research Alliance of Canada** | **Alliance de recherche numérique du Canada**

[Home](#) / Funding Opportunities

## Funding Opportunities

**Update as of October 26, 2022:** Funding opportunities are currently being reviewed and prioritized. [Sign up to our newsletter](#) to be alerted when a funding opportunity is launched and continue to visit this webpage for updates.

The Alliance is now recruiting volunteer experts for its Merit Review Committees in preparation for the Alliance's upcoming funding opportunities. For more information and to submit your application, refer to the [Call for Volunteer Experts to sit on the Alliance's Merit Review Committee\(s\)](#).

CompAg

People

Data

Compute

Opportunities





CompAg

People

Data

Compute

Opportunities



# CREATE Opportunities



Department of Computer Science, Department of Plant Sciences

[Home](#) [Training Program](#) [How to Apply](#) [Faculty Members](#) [Featured Projects](#) [Funding Opportunities](#) [Contacts](#)

A wide banner image showing a rural landscape at sunset or sunrise. The foreground is a golden field with several round hay bales. The middle ground shows rolling hills with sparse trees. The sky is a mix of orange, yellow, and dark blue.

NSERC CREATE Computational Agriculture Program

<https://CompAg.usask.ca>  
[Ian.Stavness@usask.ca](mailto:Ian.Stavness@usask.ca)

# Future Directions

Large-scale crop imaging & analysis



(NASA)



# Future Directions

Large-scale crop imaging & analysis



(Phil McLoughlin, USask Biology)





# Future Directions

Radiance field rendering of plant structures



(<https://www.matthewtancik.com/nerf>)

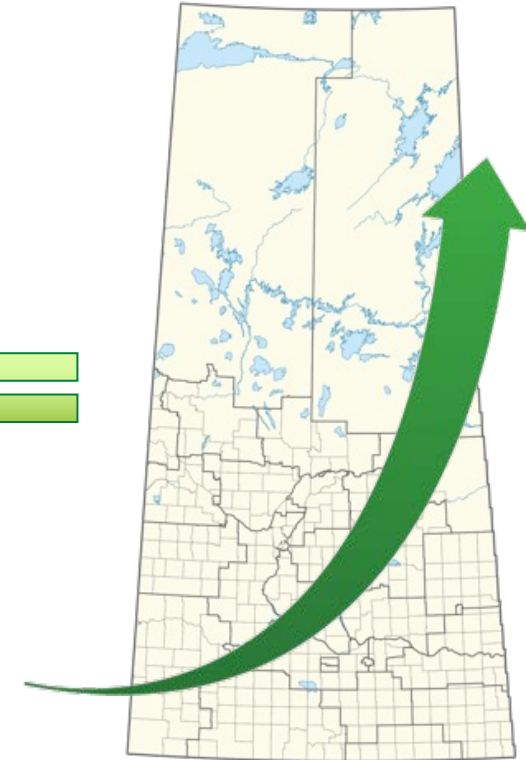
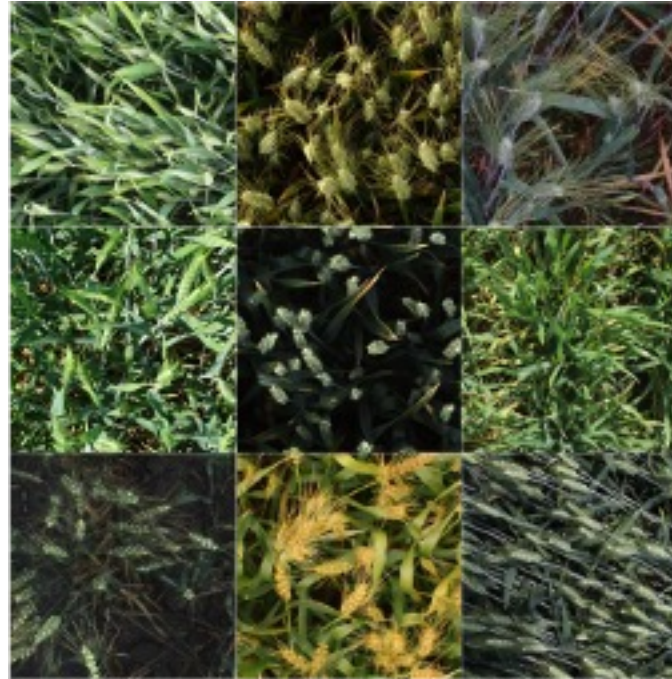
# Future Directions

Plant and crop digital twins



(Mik Cieslak, University of Calgary)

# Summary



We are recruiting Undergrad, MSc and PhD for the CREATE in Computational Agriculture

<https://CompAg.usask.ca>

[Ian.Stavness@usask.ca](mailto:Ian.Stavness@usask.ca)