CNN-powered Wheat Disease Detection

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GitHub

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The wheat industry

Worth **$200 billion** USD – and growing.

Wheat Market Report Scope

Report Attribute	Details
Market size value in 2024	USD 202.01 billion
Revenue forecast in 2030	USD 270.88 billion
Growth rate	CAGR of 4.28% from 2024 to 2030

The world’s food

Wheat is a worldwide source of food.

Wheat consumption today

With a massive production volume of 750 million tons per year, wheat is now a staple food for around 35% of the world’s population.[4],[5] Of this production volume, nearly 70% is used for human consumption, with 20% reserved for animal feed and the rest used for other purposes such as biofuel production.[5] To get to this point, the Green

Disease and pests

The cost is enormous.

NIFA AUTHORS

Lori Tyler Gula, Senior Public Affairs Specialist

Between 20% to 40% of global crop production is lost to pests annually. Each year, plant diseases cost the global economy around $220 billion, and invasive insects around $70 billion, according to the Food and Agriculture Organization of the United Nations. Weeds are another significant biotic constraint on global food production.

Disease and pests

Wheat rust

Aphid bugs

Billion dollar losses + Global food losses = A very important problem to solve

$

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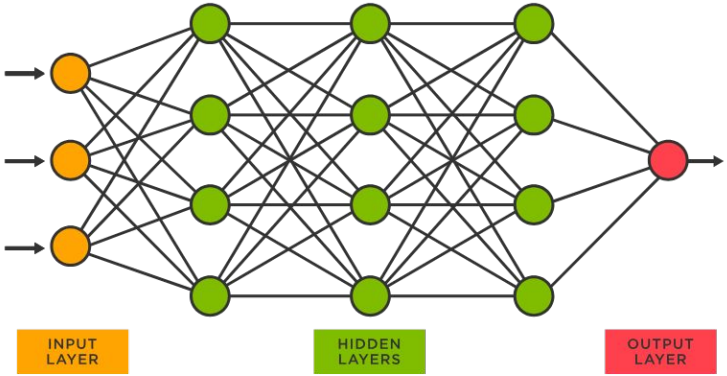
Our project: wheat disease detection

Disease image



CNN

Treatment recommendation

Treatment recommendations

Based on model output → lookup corresponding treatment in table.

	Disease	Recommended treatments	Source links
0	Aphid	Imidacloprid seed treatment; Foliar insecticid...	https://onlinelibrary.wiley.com/doi/full/10.10...
1	Black Rust	Triazole fungicides (e.g., tebuconazole); Stro...	https://www.cropscience.bayer.us/articles/cp/w...
2	Blast	Tebuconazole + Pyraclostrobin; Azoxystrobin + ...	https://ageconsearch.umn.edu/record/312377 | h...
3	Brown Rust	Tebuconazole; Azoxystrobin + Tebuconazole mixt...	https://extension.uga.edu/publications/detail....
4	Common Root Rot	Seed treatment fungicides (fludioxonil, pyracl...	https://extensionpubs.unl.edu/publication/g199...
5	Fusarium Head Blight	Prothioconazole + Tebuconazole (Prosaro); Pydi...	https://site.extension.uga.edu/turnerab/2022/0...
6	Leaf Blight	Chlorothalonil; Mancozeb	https://hort.extension.wisc.edu/articles/home-...
7	Mildew	Triadimenol seed treatment; Azoxystrobin folia...	https://plantpathology.ca.uky.edu/files/ppfs-a...
8	Mite	Dimethoate; Pyrethroids (lambda-cyhalothrin)	https://extension.colostate.edu/topic-areas/in...
9	Septoria	Propiconazole; Azoxystrobin	https://cropprotectionnetwork.org/encyclopedia...
10	Smut	Tebuconazole seed treatment; Difenoconazole se...	https://eupdate.agronomy.ksu.edu/article_new/u...
11	Stem fly	No effective chemical control; use cultural pr...	https://efotg.sc.egov.usda.gov/references/publ...
12	Tan spot	Tebuconazole; Trifloxystrobin	https://extensionpubs.unl.edu/publication/g429...
13	Yellow Rust	Prothioconazole + Azoxystrobin (Trivapro); Teb...	https://site.extension.uga.edu/turnerab/2022/0...

Pest Management Science

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Research Article | Full Access

Effects of imidacloprid and clothianidin seed treatments on wheat aphids and their natural enemies on winter wheat

Peng Zhang, Xuefeng Zhang, Yunhe Zhao, Yan Wei, Wei Mu, Feng Liu

First published: 07 August 2015 | https://doi.org/10.1002/ps.4090 | Citations: 51

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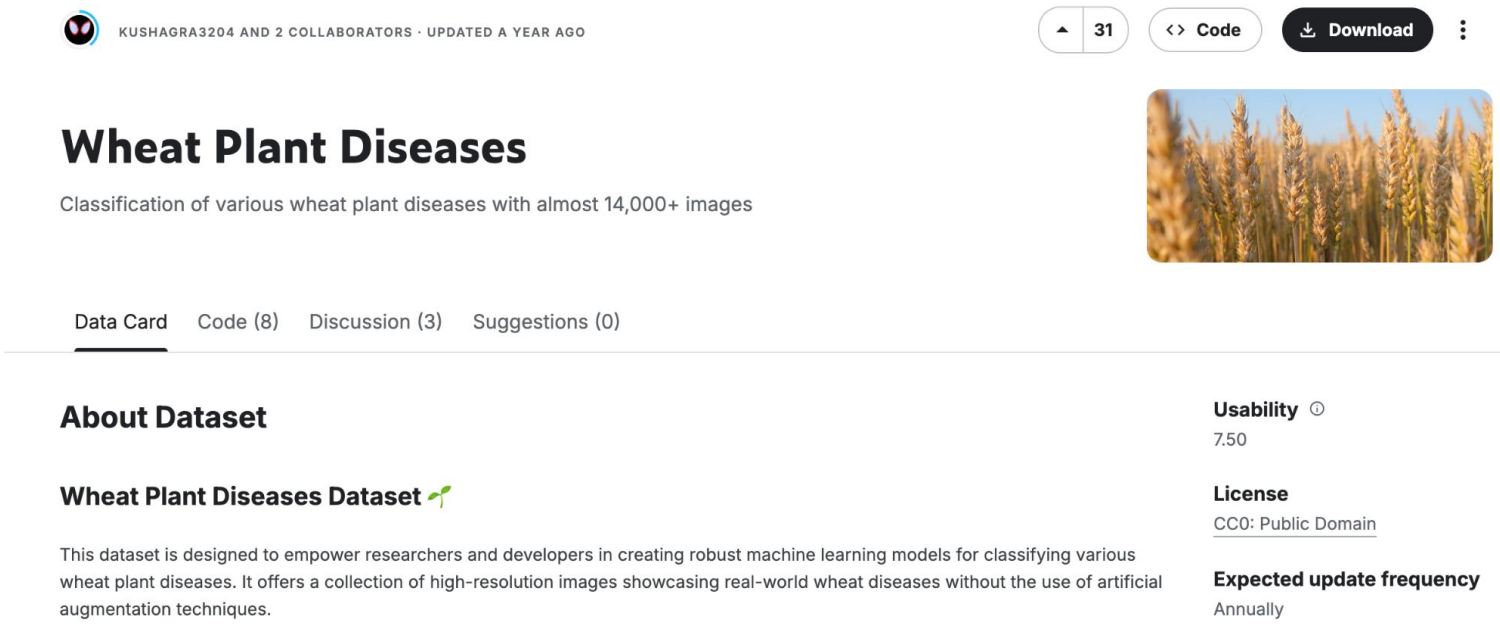
Abstract

BACKGROUND

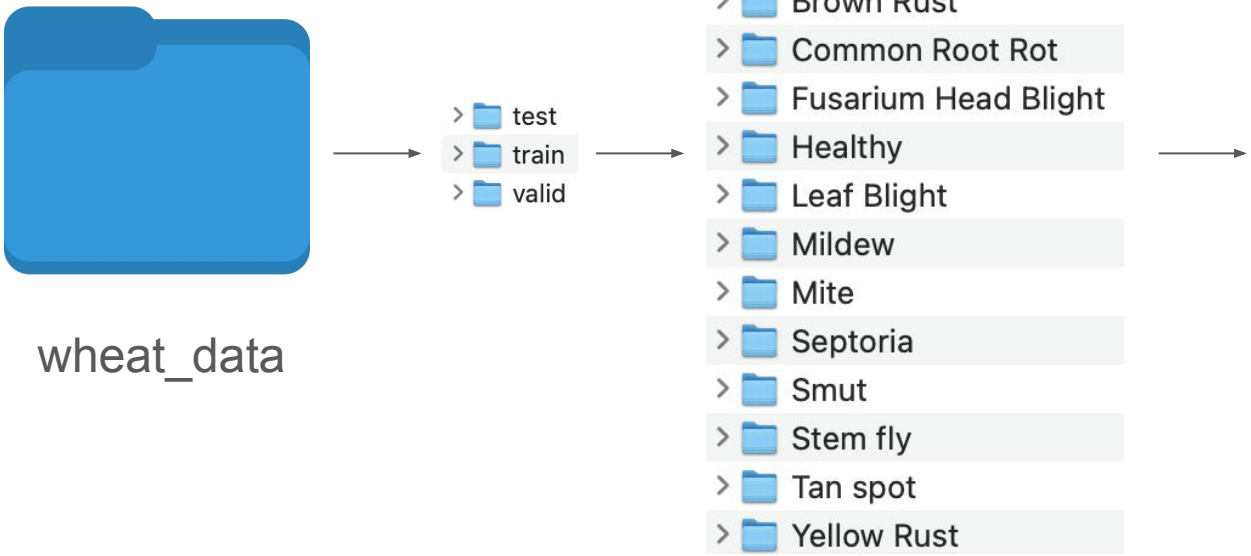
Wheat aphid (Hemiptera: Aphididae) is one of the major pests of winter wheat and has posed a significant threat to winter wheat production in China. Although neonicotinoid insecticidal seed treatments have been suggested to be a control method, the season-long efficacy on pests and the impact on their natural enemies are still uncertain. Experiments were conducted to determine the efficacy of imidacloprid and clothianidin on the control of aphids, the number of their natural enemies and the emergence rate and yield of wheat during 2011–2014.

Kaggle

Dataset can be found here.



The data



wheat_data

14 disease classes, 1 healthy class.

We trained 3 CNNs and compared their performance

- ResNet18
- MobileNetV2
- Customized CNN

ResNet18

A good baseline for image recognition.

Changed output layer to match our 14 disease classes and 1 healthy class.

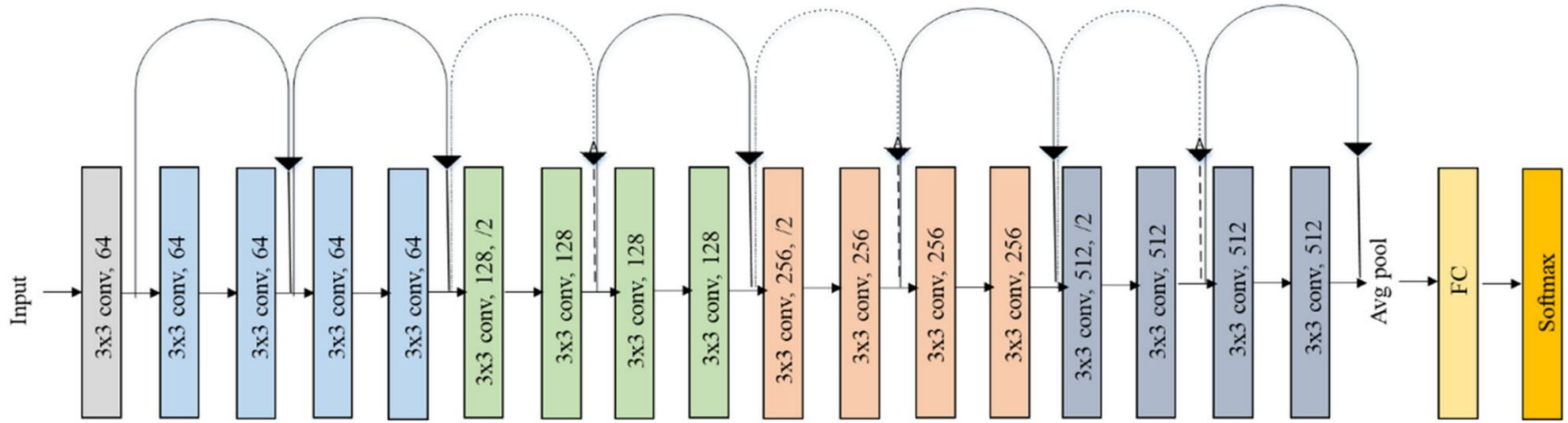
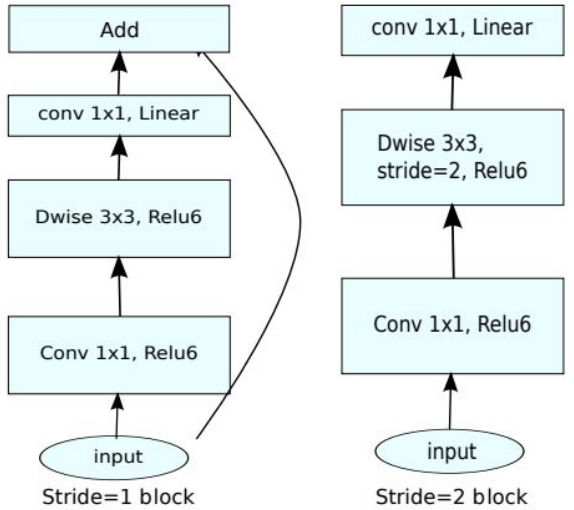


Fig. 2 Original ResNet-18 Architecture

MobileNetV2

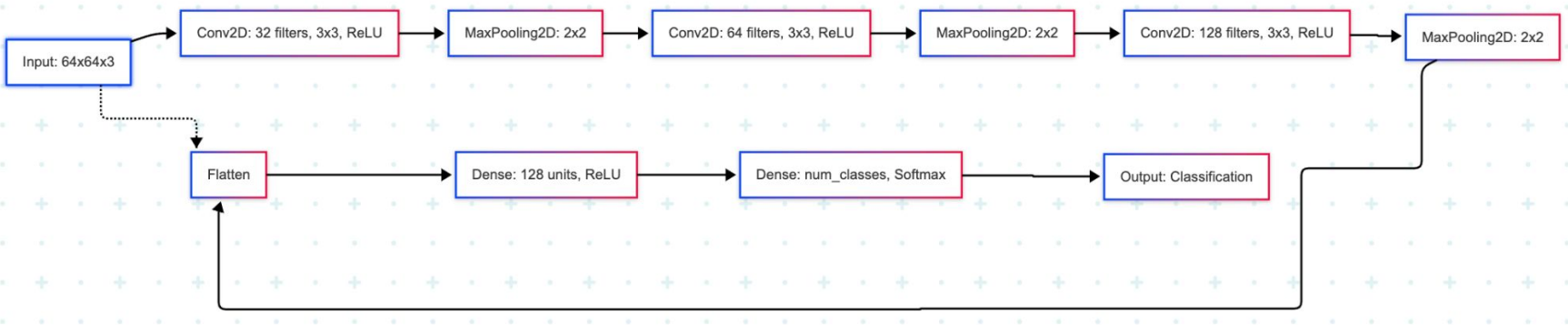
- Used for classification, object detection
- Use inverted residual block to reduce the number of parameters and computational cost.



Customized CNN

A homemade CNN from the ground up.

- Uses simple convolutions, no residual connections.
- Standard convolutions increase computational cost per layer.
- Overall relatively fast but less robust for complex patterns.



Training setups

Model	**ResNet18**	**MobileNetV2**	**Customized CNN**
Layers	18	53	8
Loss	Cross-Entropy	Cross-Entropy	Cross-Entropy
Optimizer	Adam	Adam	Adam
Learning Rate	0.0001	0.0001	0.001
Epochs	20	5	30
Early Stopping?	Yes	No	No

Early results

Model	**ResNet18**	**MobileNetV2**	**Customized CNN**
Test set accuracy	92.40%	68.4%	90.27%
Average test class precision	0.952	0.677	0.917
Average test class recall	0.924	0.704	0.903
Average F1 score	0.908	0.681	0.885

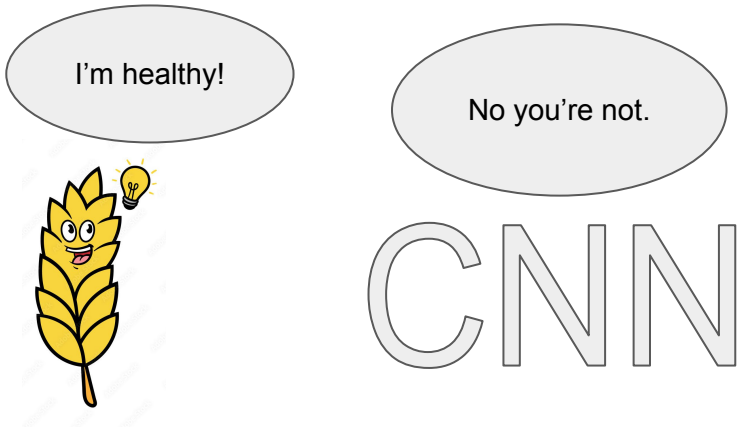
Compare the performance of CNNs

- ResNet18 and the Customized CNN have a better performance on the classification.
- MobileNetV2 has a lower accuracy because it is lightweight with limited capacity, and has a weaker feature extraction ability.
- ResNet18 has more complex patterns and residual blocks, which captures richer and deeper representation.

Issues

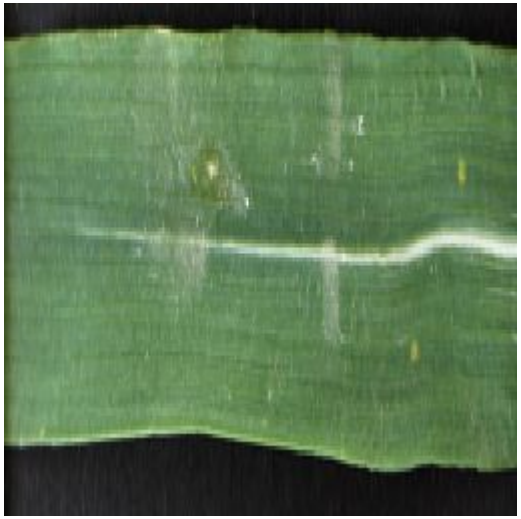
Model is great at predicting disease – but struggles with healthy wheat

	Class	Accuracy (%)	Correct	Total
0	Aphid	96.0	48	50
1	Black Rust	96.0	48	50
2	Blast	100.0	50	50
3	Brown Rust	100.0	50	50
4	Common Root Rot	100.0	50	50
5	Fusarium Head Blight	98.0	49	50
6	Healthy	10.0	5	50
7	Leaf Blight	96.0	48	50
8	Mildew	98.0	49	50
9	Mite	96.0	48	50
10	Septoria	100.0	50	50
11	Smut	100.0	50	50
12	Stem fly	100.0	50	50
13	Tan spot	96.0	48	50
14	Yellow Rust	100.0	50	50



Healthy or Disease?

The difference between healthy and diseased wheat is not always clear.



Healthy

Mildew

Possible Solutions

1. Data augmentation
2. Class balancing
3. Loss Reweighting (higher penalty for incorrect healthy classification)

Data augmentation, class rebalancing, custom loss results

It is difficult for image recognition models to detect an absence of disease!

Class	Accuracy (%)	Correct	Total
Aphid	76.0	38	50
Black Rust	56.0	28	50
Blast	88.0	44	50
Brown Rust	30.0	15	50
Common Root Rot	90.0	45	50
Fusarium Head Blight	62.0	31	50
Healthy	6.0	3	50
Leaf Blight	70.0	35	50
Mildew	78.0	39	50
Mite	60.0	30	50
Septoria	92.0	46	50
Smut	92.0	46	50
Stem Fly	78.0	39	50
Tan Spot	48.0	24	50
Yellow Rust	100.0	50	50

Original

Class	Accuracy (%)	Correct	Total
Aphid	66.0	33	50
Black Rust	46.0	23	50
Blast	96.0	48	50
Brown Rust	24.0	12	50
Common Root Rot	78.0	39	50
Fusarium Head Blight	42.0	21	50
Healthy	6.0	3	50
Leaf Blight	48.0	24	50
Mildew	54.0	27	50
Mite	30.0	15	50
Septoria	84.0	42	50
Smut	78.0	39	50
Stem Fly	74.0	37	50
Tan Spot	40.0	20	50
Yellow Rust	98.0	49	50

New

Further research and final thoughts

- More images for healthy wheat
- Powerful architecture ex. EfficientNetB3
- Add attention mechanism, focus on disease patterns

Thank you!