ACR AI-LAB for Radiology: an overview

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intelligent processing of visual information

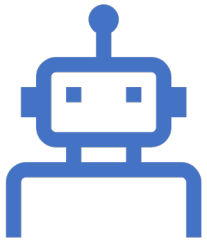
- image processing
- medical image analysis
- computer vision
- human vision
- artificial intelligence
- machine learning
- deep learning

Disclosures

I have no conflicts of interest related to the material discussed in this talk.

Disclaimer

I am not associated with the American College of Radiology (ACR), its Data Science Institute (DSI), or NVIDIA.



AI in Radiology

Radiologists and AI

WIRED Artificial Intelligence, Real Smarts

BUSINESS | CULTURE | DESIGN | GEAR

KLINT FINLEY BUSINESS 10.27.15 6:00 PM

ROBOT RADIOLOGISTS WILL SOON ANALYZE YOUR X-RAYS

"It's quite obvious that we should stop training *radiologists*"
-- Geoffrey Hinton
(2016)

ANNALS OF MEDICINE APRIL 3, 2017 ISSUE

A.I. VERSUS M.D.

What happens when diagnosis is automated?

By Siddhartha Mukherjee

ELSEVIER

Journal of the American College of Radiology

Volume 13, Issue 12, Part A, December 2016, Pages 1415–1420

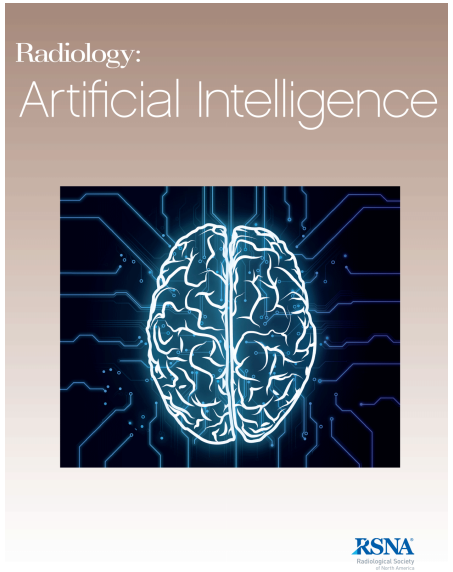
Original article

The End of Radiology? Three Threats to the Future Practice of Radiology

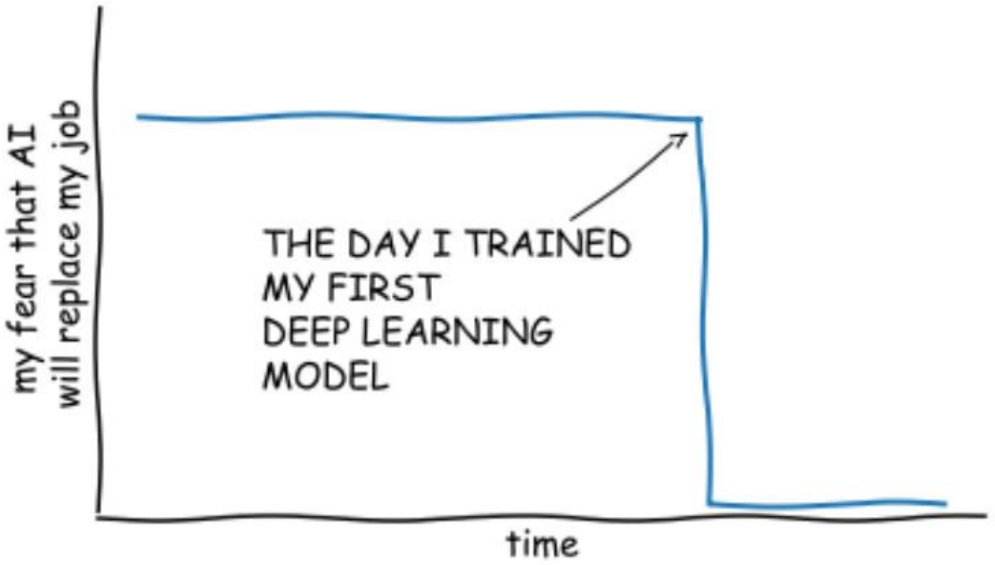
Katie Chockley, BA[a], Ezekiel Emanuel, MD, PhD[a]

The AI in Radiology community today

- Open challenges with publicly available datasets
- New journals, e.g., RSNA's *Radiology: Artificial Intelligence*



- Doctors who code!



"Fear of AI" by Felipe Kitamura

Felipe Kitamura
@FelipeKitamura Follows you

The AI in Radiology community today

- Development of ML curriculum for radiologists


ARTICLE IN PRESS

OPINION

The Need for a Machine Learning Curriculum for Radiologists

Monica J. Wood, MD, Neil A. Tenenholtz, PhD, J. Raymond Geis, MD, Mark H. Michalski, MD, Katherine P. Andriole, PhD

"Rather than succumb to fear and skepticism, future radiologists must be equipped with a working knowledge of ML to leverage the tools as they are deployed."

Quote: Wood et al. (2018)

The AI in Radiology community today

- Partnerships and alliances
- Hackathons
- Hands-on training (SIIM, EuSoMII)
- AI-LAB (ACR DSI)


ACR AI-LAB™
ENTER
DATA SCIENCE
INSTITUTE™
AMERICAN COLLEGE OF RADIOLOGY
ACR®
AMERICAN COLLEGE OF
RADIOLOGY

AI-LAB

- A data science toolkit designed by the American College of Radiology's Data Science Institute (DSI) to

  "democratize AI by empowering radiologists to develop algorithms at their own institutions, using their own patient data, to meet their own clinical needs."

https://ailab.acr.org

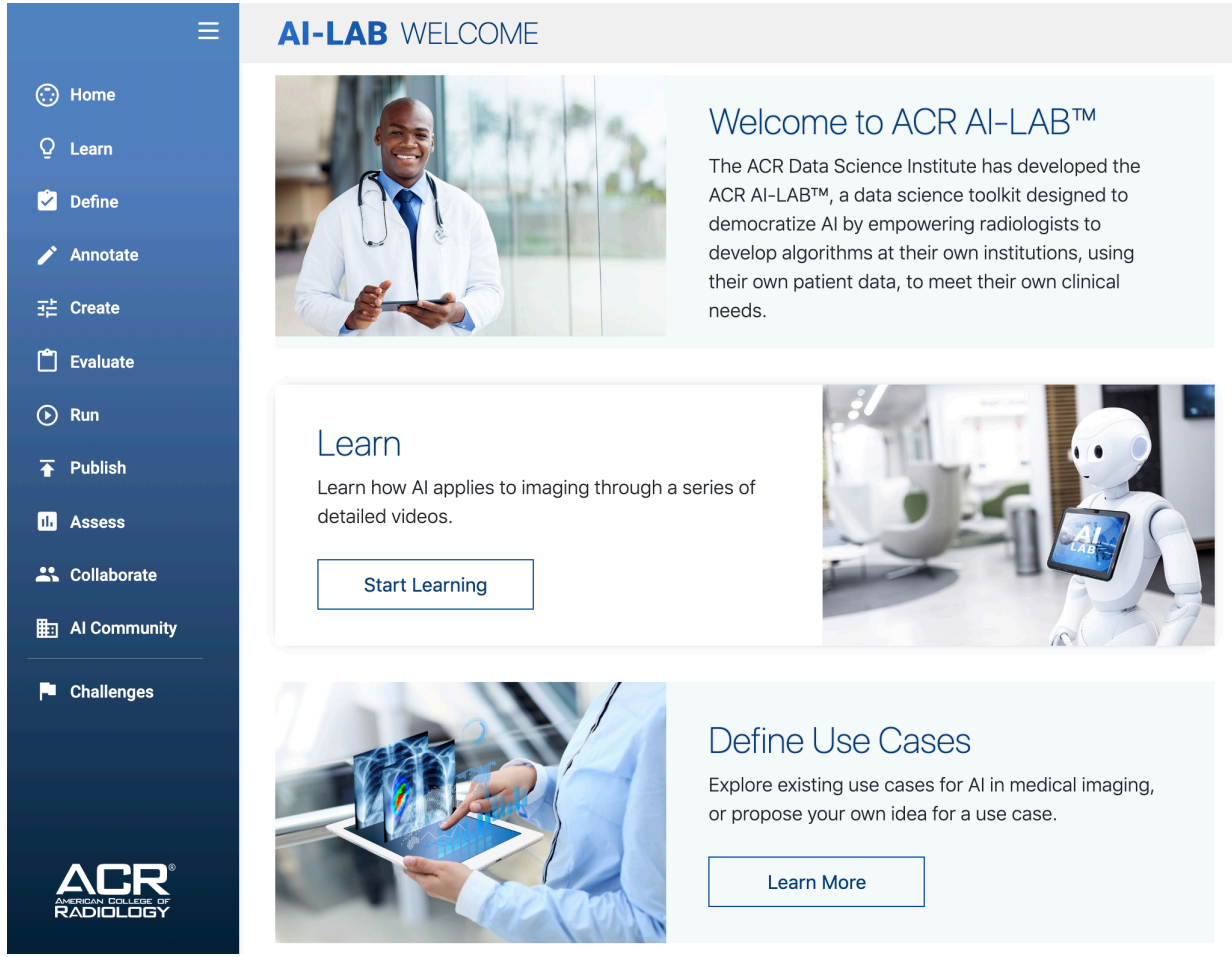
Hands-on assignment (example)

AI-LAB: Hands-on Assignment (example)

- **Learning objectives:**
  - Get acquainted with the growth of AI and Deep Learning applications in radiology (and medicine as a whole)
  - Learn fundamental concepts associated with the end-to-end workflow of typical AI Deep Learning solutions
  - Practice with real-world problems, datasets, and performance evaluation metrics **without having to write code**

AI-LAB: Hands-on Assignment (example)

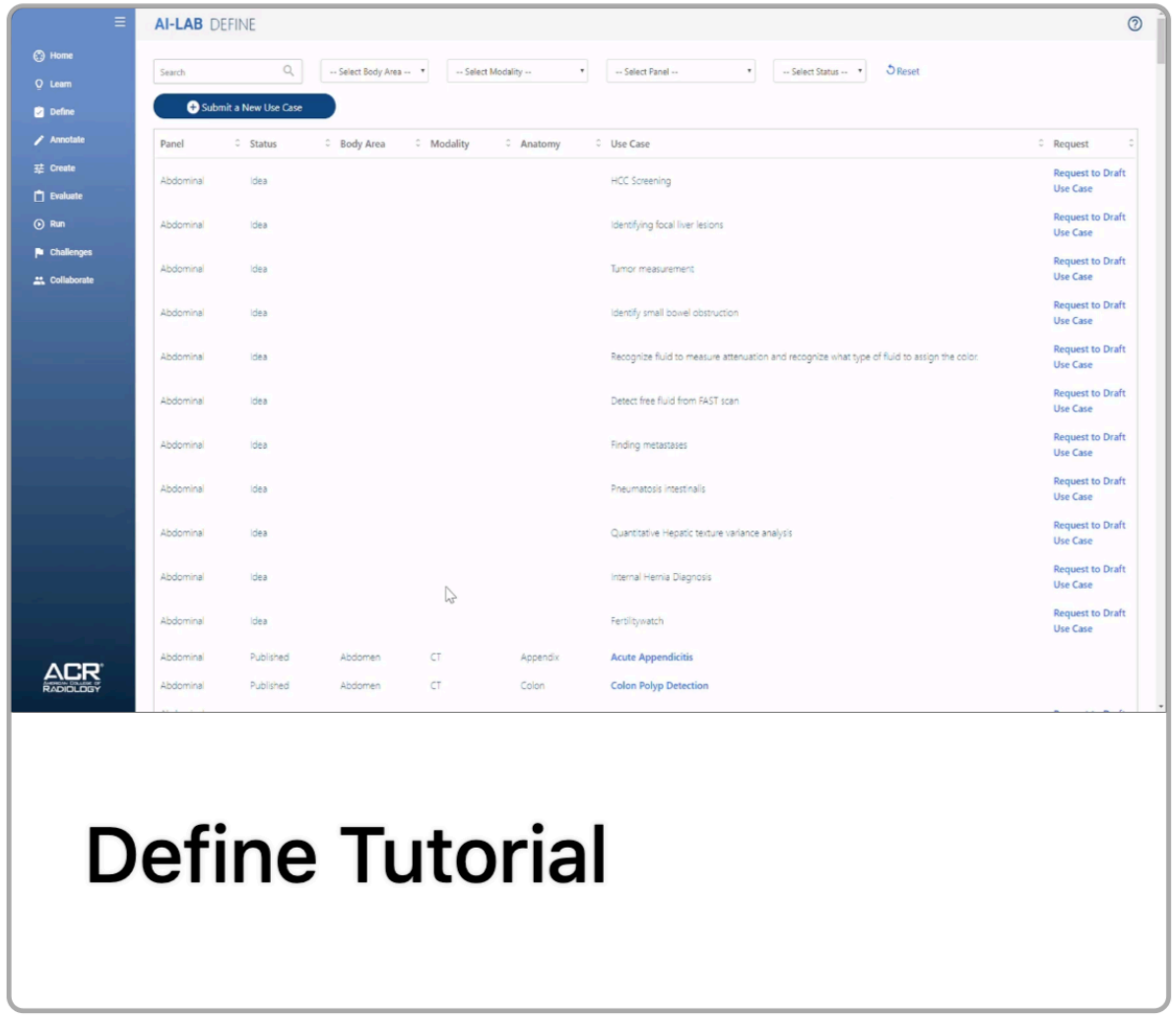
- **Steps / structure:**
  - Follow the flow of the site
    - Define
    - Annotate
    - Create
    - Evaluate
    - Run
    - Publish
    - Assess
  - Learn important concepts along the way
    - Watch videos
    - Answer questions
  - Play / interact / try different things!
  - Reflect upon your learning experience and draw meaningful conclusions



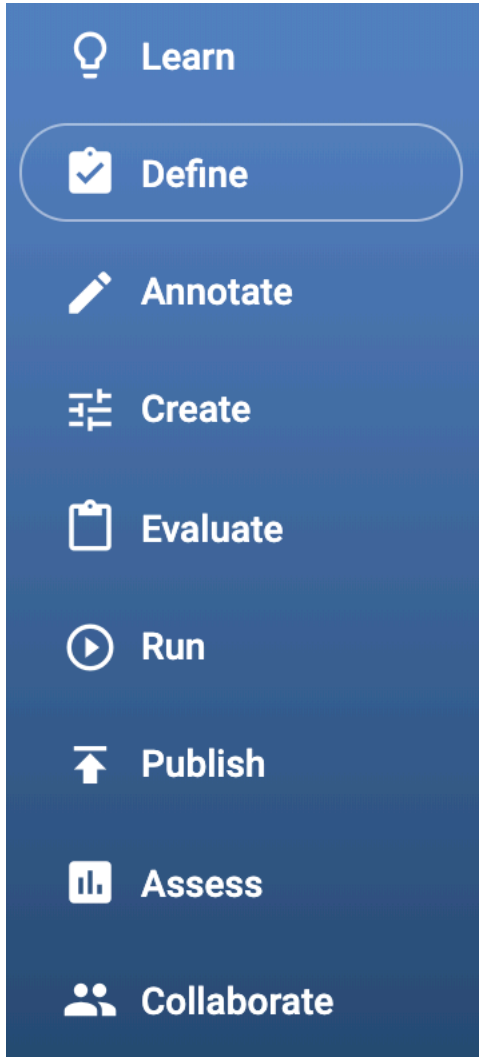
- Learn
- Define
- Annotate
- Create
- Evaluate
- Run
- Publish
- Assess
- Collaborate

How can data scientists help radiologists?

- Learn
- Define
- Annotate
- Create
- Evaluate
- Run
- Publish
- Assess
- Collaborate



Define Tutorial



AI-LAB DEFINE

Search | breast | MAM | -- Select Panel -- | -- Select Status --

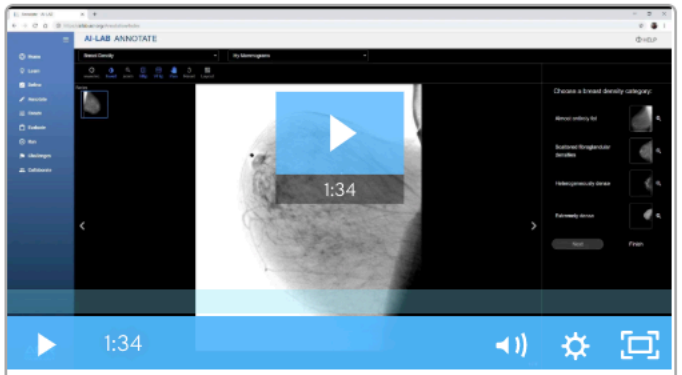
Reset | Submit a New Use Case

Panel	Status	Body Area	Modality	Anatomy	Use Case	Request
Breast Imaging	Published	breast	MAM	breast	Classifying Suspicious Microcalcifications	
Breast Imaging	Published	breast	MAM	breast	Breast Density	
Breast Imaging	Review	breast	MAM	breast	High Risk Lesion Classification (FEA)	
Breast Imaging	Review	breast	MAM	breast	High Risk Lesion Classification (LN)	

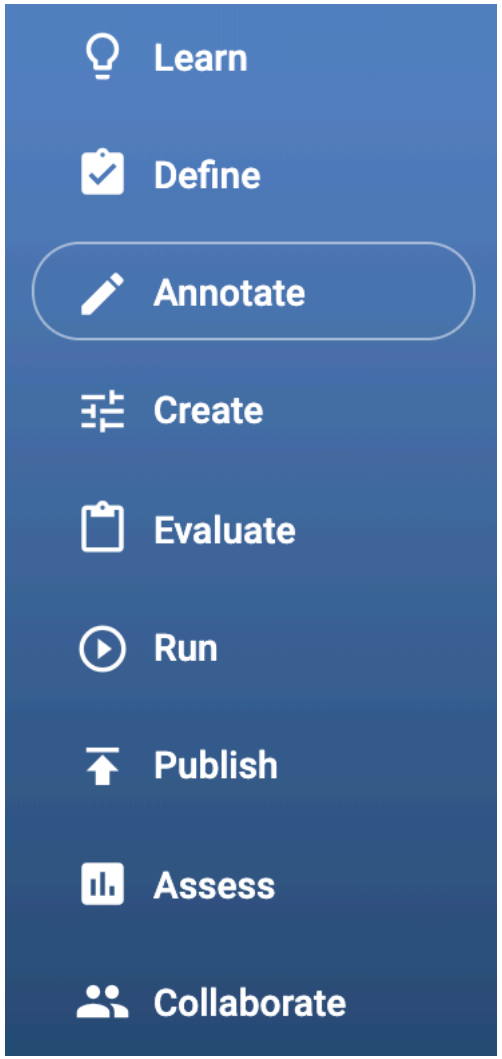
- Learn
- Define
- Annotate
- Create
- Evaluate
- Run
- Publish
- Assess
- Collaborate

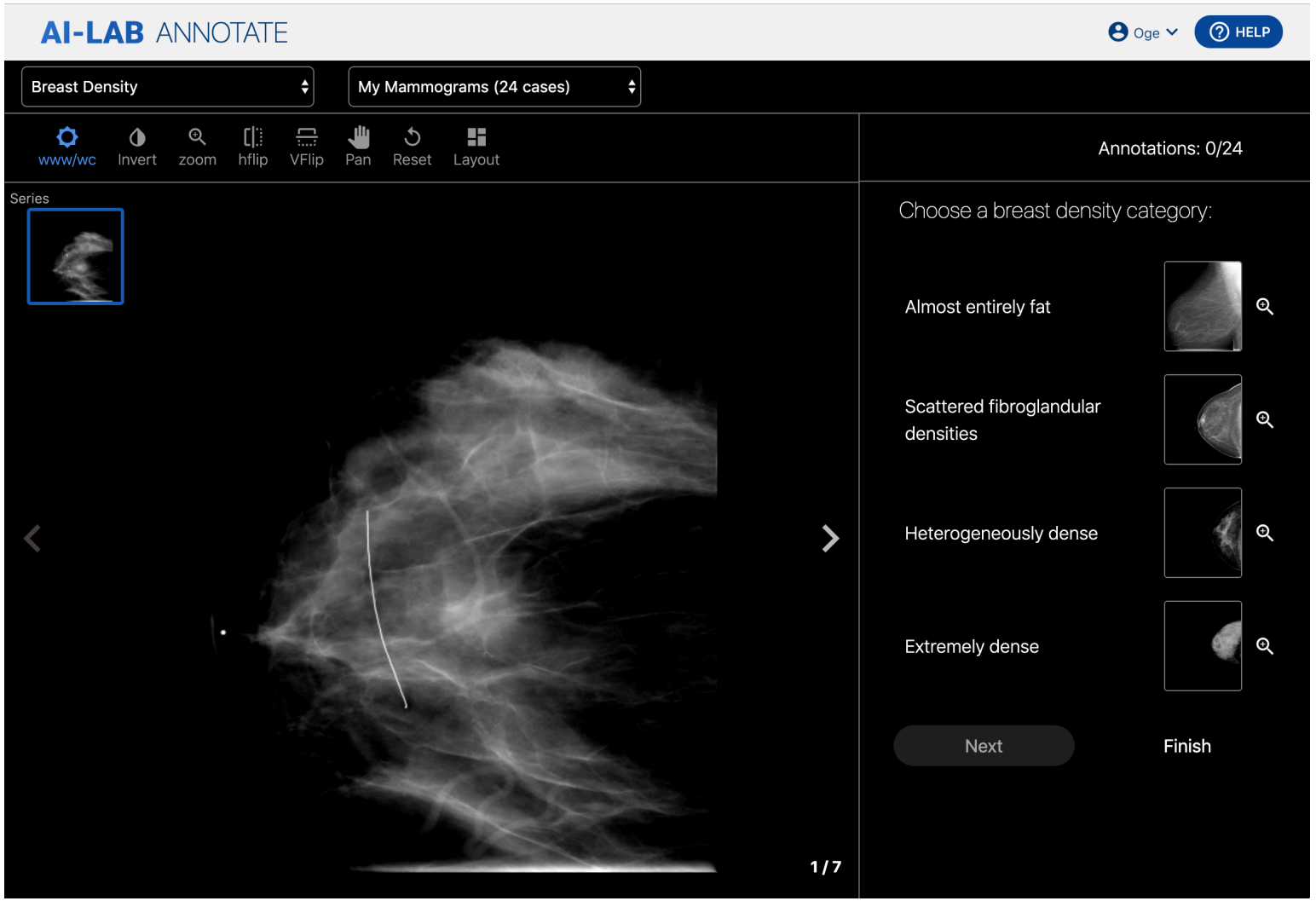
Annotate

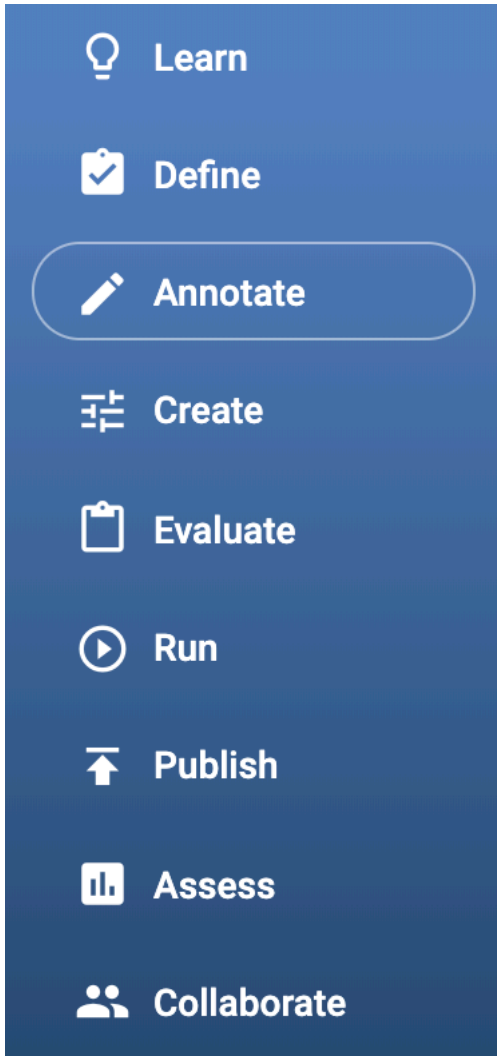
Annotate



Annotate Tutorial


Learn
Define
Annotate
Create
Evaluate
Run
Publish
Assess
Collaborate


AI-LAB ANNOTATE
Oge
HELP
Breast Density
My Mammograms (24 cases)
www/wc
Invert
zoom
hflip
VFlip
Pan
Reset
Layout
Annotations: 0/24
Series
Choose a breast density category:
Almost entirely fat
Scattered fibroglandular densities
Heterogeneously dense
Extremely dense
Next
Finish
1 / 7



Congratulations, you have completed 22/24 annotations! Annotating cases is an essential task in building AI models and is very similar to what you do every day as a radiologist - you are assigning “ground truth” to an image. Soon, you will be able to use annotated data sets developed here to create your own AI models.

OK

- Learn
- Define
- Annotate
- Create
- Evaluate
- Run
- Publish
- Assess
- Collaborate

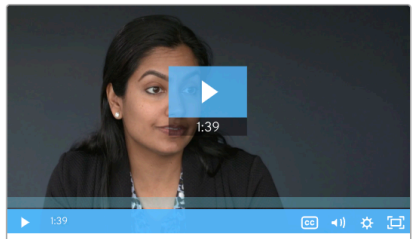
AI-LAB LEARN

Oge | HELP

Create

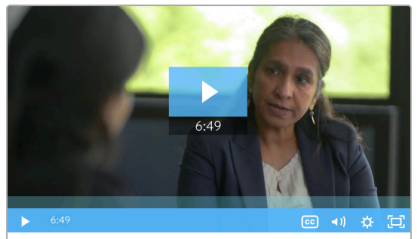
Architecture

Overfitting



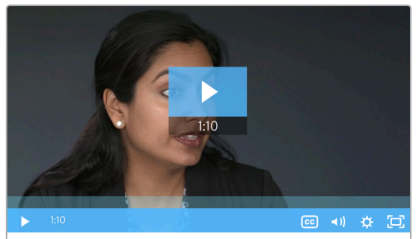
Cost function

Epochs

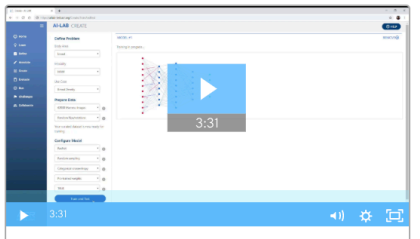


Pre-processing

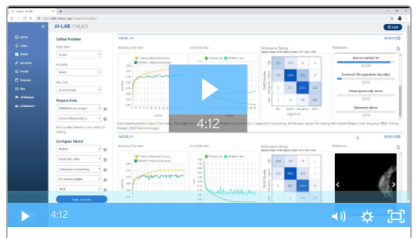
Confusion Matrix Details vs. Accuracy



Kappa

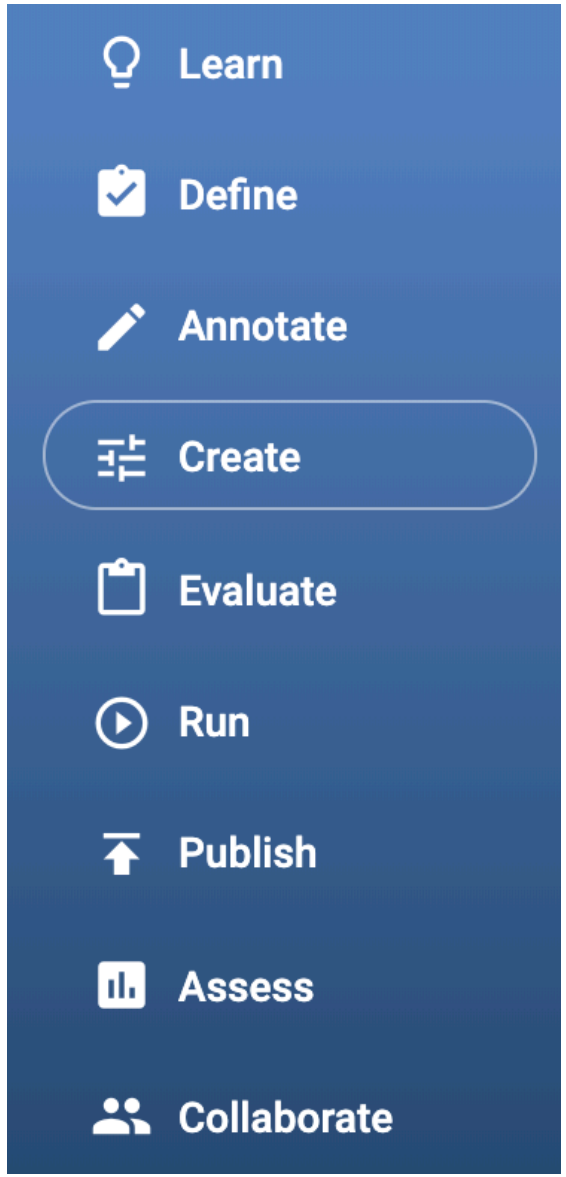


Create Tutorial: Part1



Create Tutorial: Part2

Equal Sampling



AI-LAB CREATE

Define Problem

Body Area

Breast

Modality

MAM

Use Case

Breast Density

Prepare Data

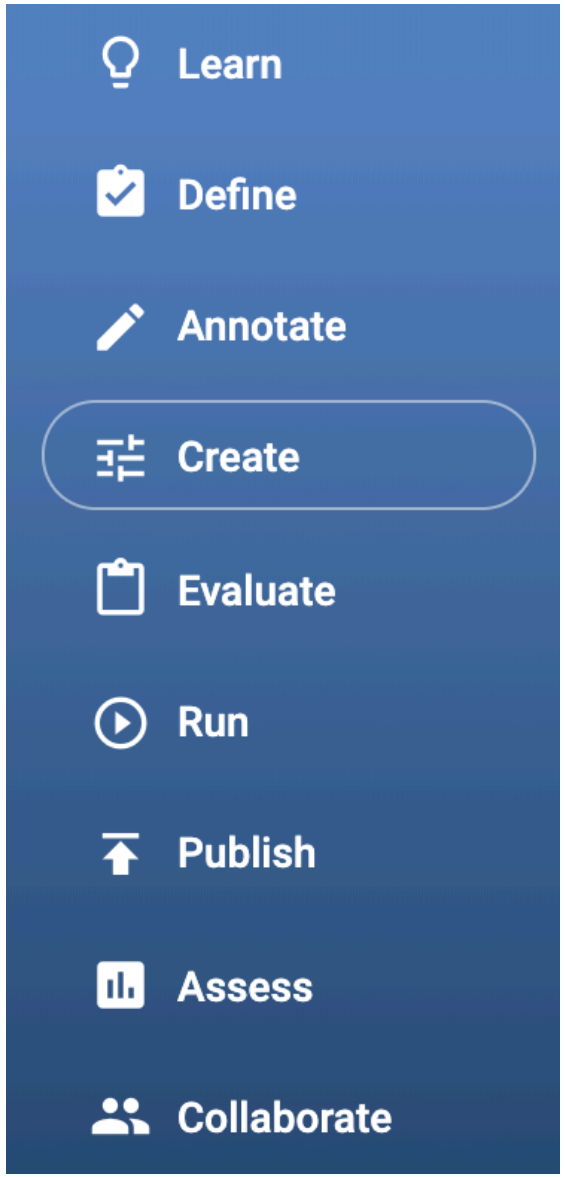
Training Data

62000 Mammo images

Augmentation

None

Start Preprocessing



Preprocessing complete

Configure Model

Architecture

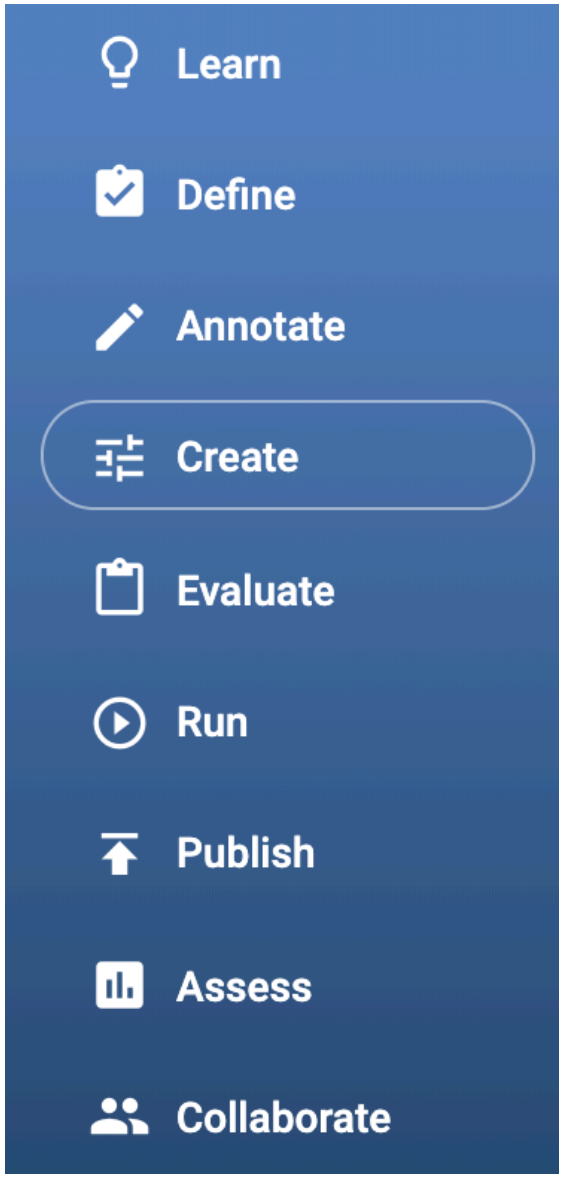
Sampling Method

Loss Function

Pre-training

Early Stopping

Train and Test



Configure Model

Architecture

ResNet

Sampling Method

Equal class ratios

Loss Function

Categorical-crossentropy

Pre-training

Pre-trained weights

Early Stopping

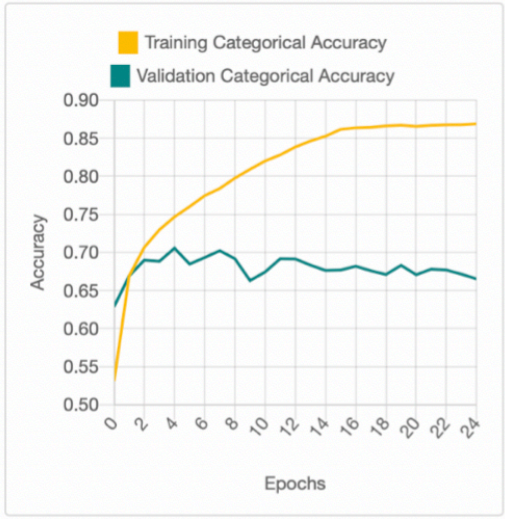
TRUE

Train and Test

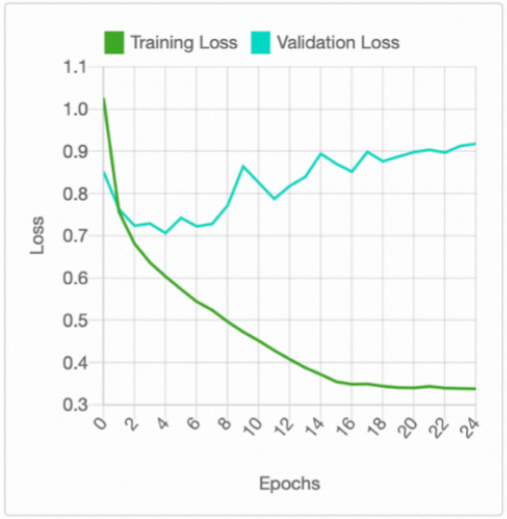
MODEL #1

SAVE

Accuracy Overview



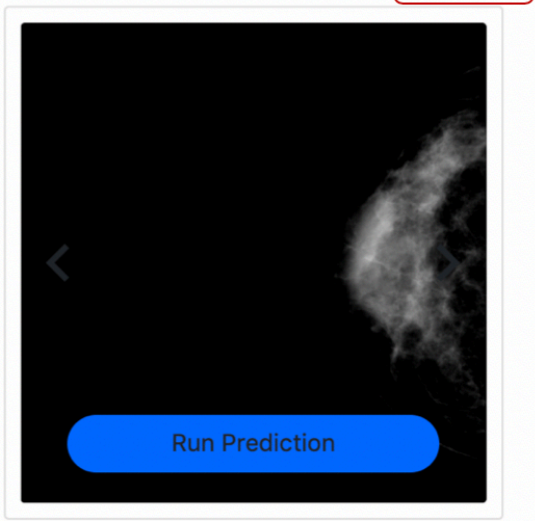
Loss Overview



Performance Testing

Kappa (4 class) = 0.66, Kappa (2 class) = 0.71, AUC = 0.94

Predictions



Data Sampling Method: Equal Class Ratios, Data Augmentation: None, Loss Function: Categorical Crossentropy, Architecture: resnet, Pre-training: Pre-trained Weights, Early Stopping: TRUE, Training Dataset: 62000 Mammo images

- Learn
- Define
- Annotate
- Create
- Evaluate
- Run
- Publish
- Assess
- Collaborate

Predictions

Predictions

Almost entirely fat

0.00%

Scattered fibroglandular densities

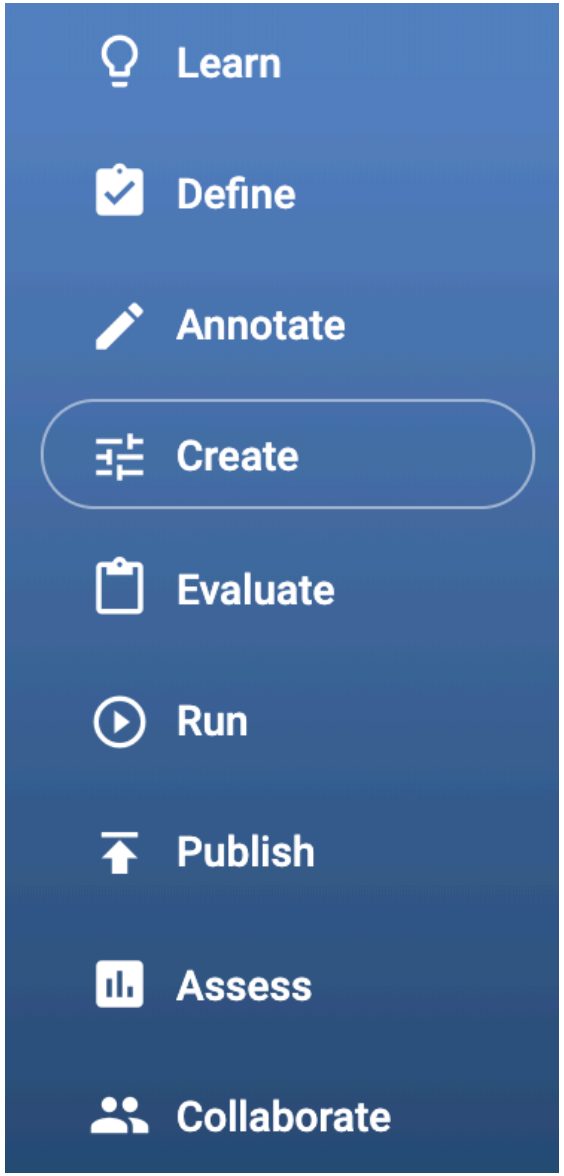
0.00%

Heterogeneously dense

16.00%

Extremely dense

83.00%



Define Problem

Body Area

Breast

Modality

MAM

Use Case

Breast Density

Prepare Data

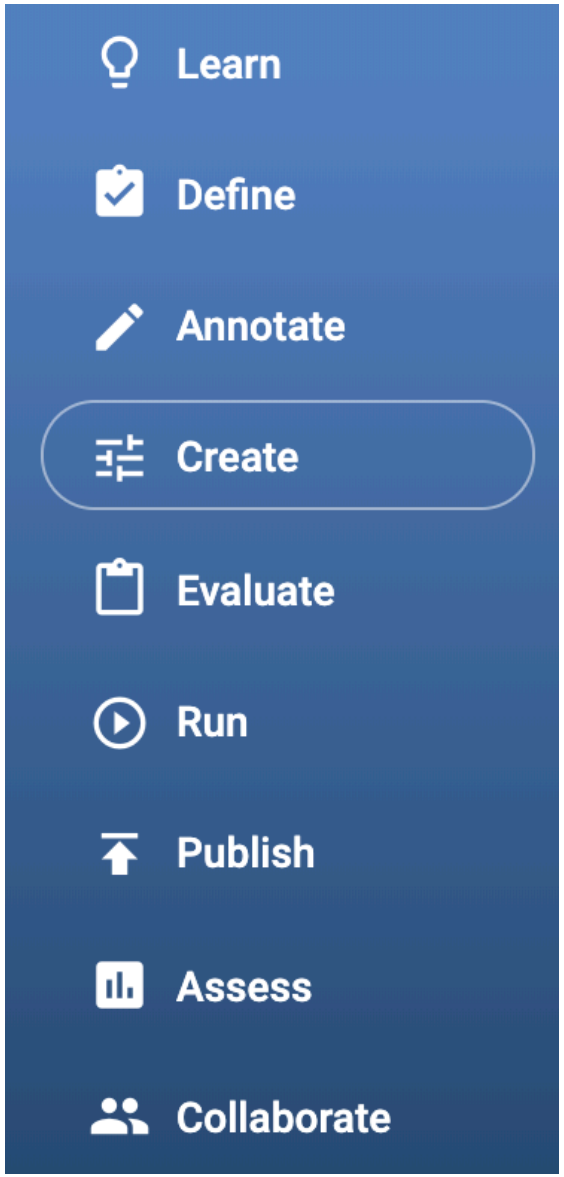
Training Data

62000 Mammo images

Augmentation

Random flips/rotations

Start Preprocessing



Configure Model

Architecture

ResNet

Sampling Method

Equal class ratios

Loss Function

Categorical-crossentropy

Pre-training

Pre-trained weights

Early Stopping

TRUE

Train and Test

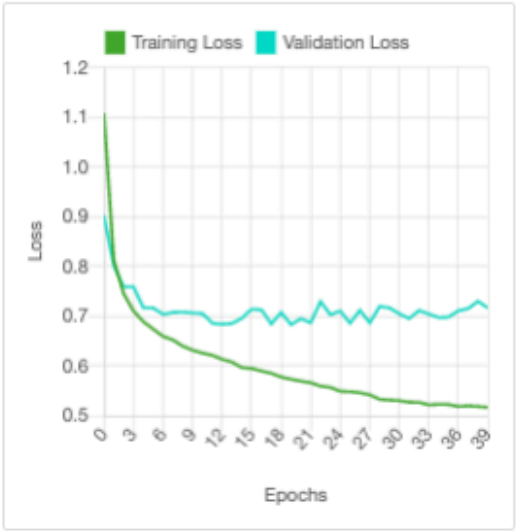
- Learn
- Define
- Annotate
- Create
- Evaluate
- Run
- Publish
- Assess
- Collaborate

MODEL #2

SAVE

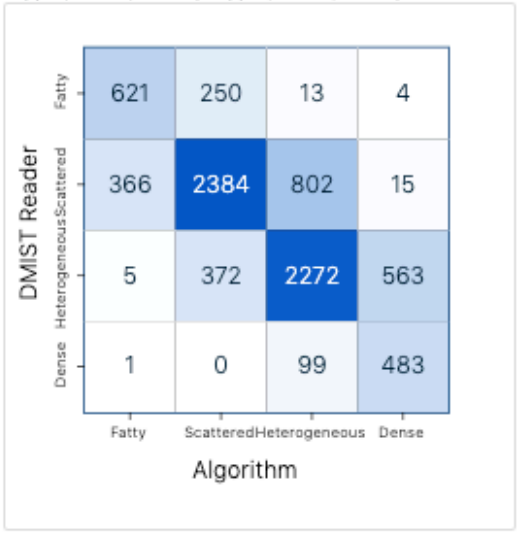
Accuracy Overview

Loss Overview

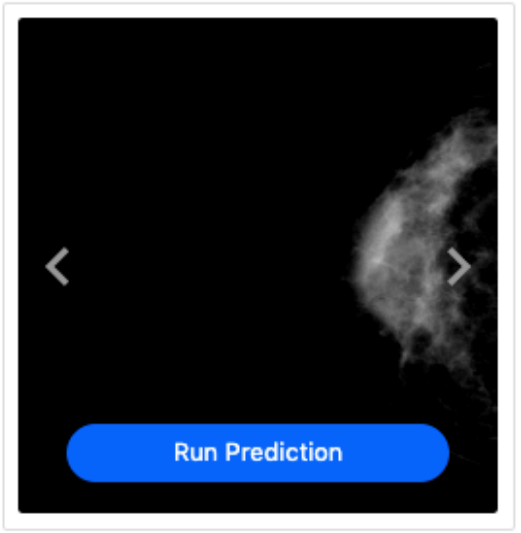


Performance Testing

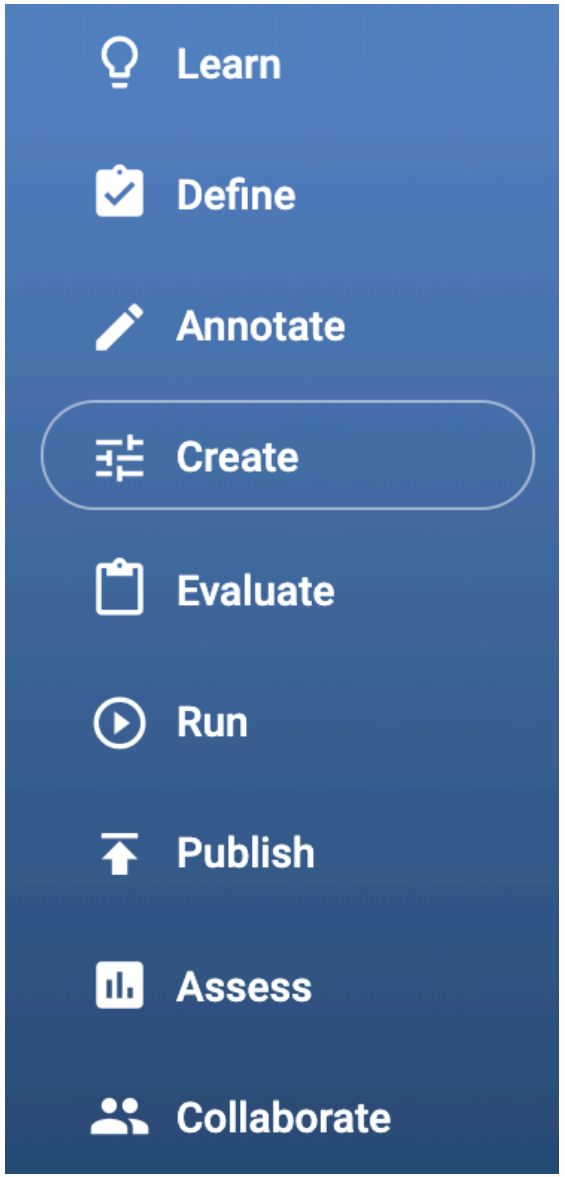
Kappa (4 class) = 0.65, Kappa (2 class) = 0.71, AUC = 0.94



Predictions



Data Sampling Method: Equal Class Ratios, Data Augmentation: Random Flips/Rotations, Loss Function: Categorical Crossentropy, Architecture: resnet, Pre-training: Pre-trained Weights, Early Stopping: TRUE, Training Dataset: 62000 Mammo images



Configure Model

Architecture

Inception

Sampling Method

Equal class ratios

Loss Function

Categorical-crossentropy

Pre-training

Pre-trained weights

Early Stopping

TRUE

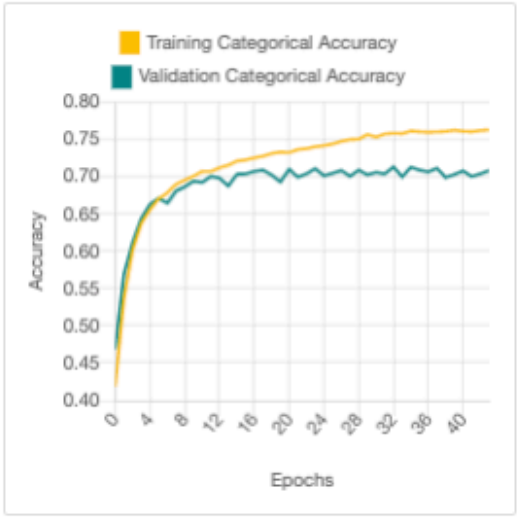
Train and Test

- Learn
- Define
- Annotate
- Create
- Evaluate
- Run
- Publish
- Assess
- Collaborate

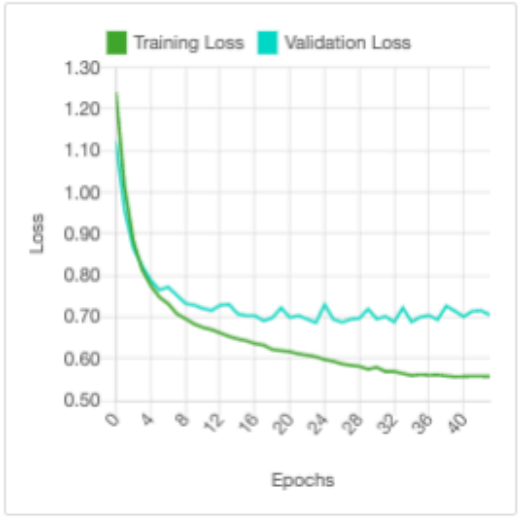
MODEL #4

SAVE

Accuracy Overview

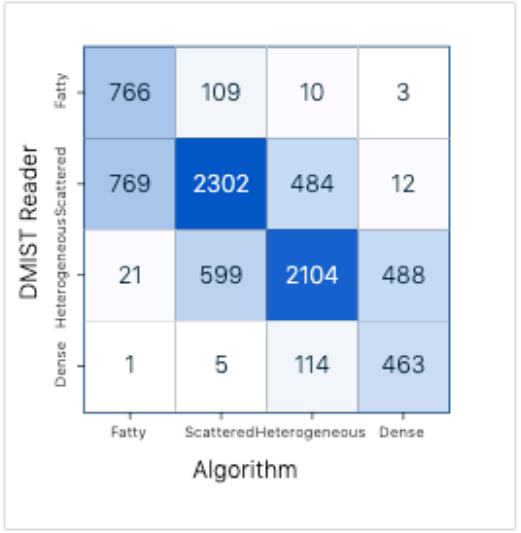


Loss Overview



Performance Testing

Kappa (4 class) = 0.65, Kappa (2 class) = 0.72, AUC = 0.94



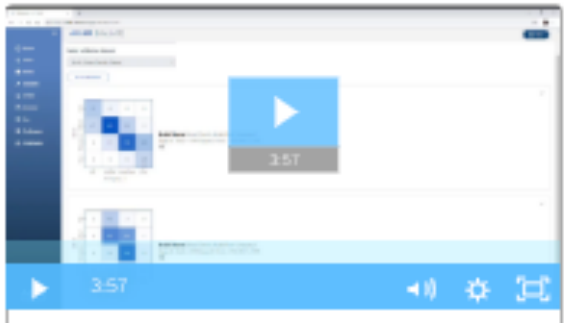
Predictions

Data Sampling Method: Equal Class Ratios, Data Augmentation: Random Flips/Rotations, Loss Function: Categorical Crossentropy, Architecture: inception, Pre-training: Pre-trained Weights, Early Stopping: TRUE, Training Dataset: 62000 Mammo images

- Learn
- Define
- Annotate
- Create
- Evaluate
- Run
- Publish
- Assess
- Collaborate

Evaluate

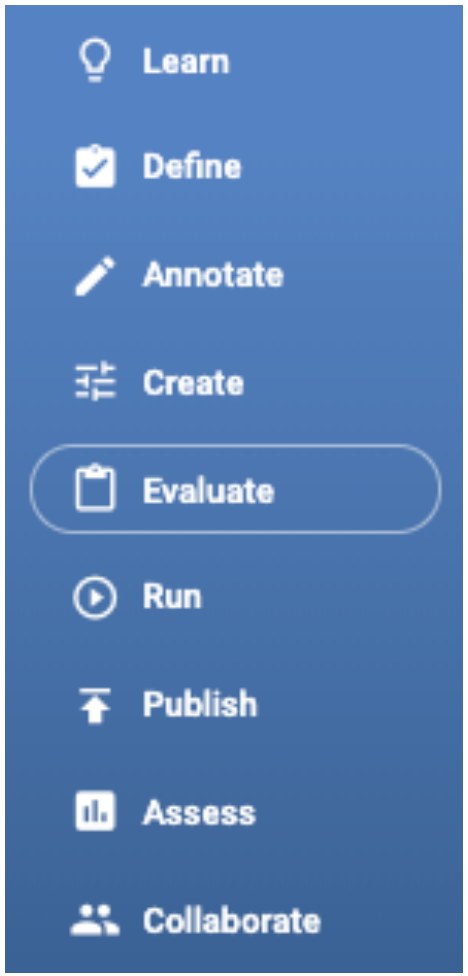
Transfer learning



Evaluate Tutorial

Instructions

1. Select an AI use case.
2. Select a validation data set.
3. Click on the models you want to evaluate, you may click on more than one.
4. Click EVALUATE MODELS to view the test results.
5. Click SHOW MODELS to change your selections.



Use Case

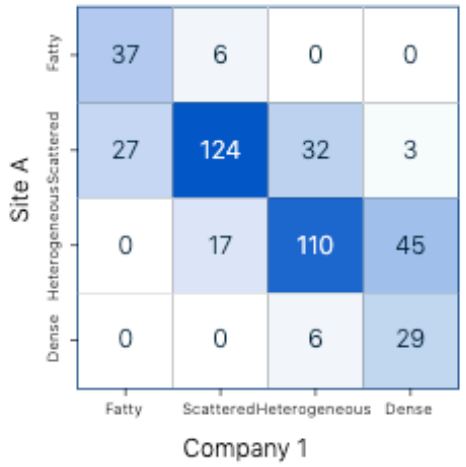
Breast Density

Validation Dataset

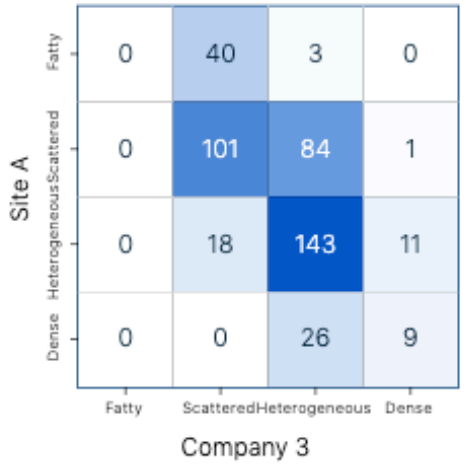
Site A - Breast Density Dataset

Model Name	Evaluate Models
☑ Breast Density Model from Company 1	
☐ Breast Density Model from Company 2	
☑ Breast Density Model from Company 3	
☐ Breast Density Model from Company 4	

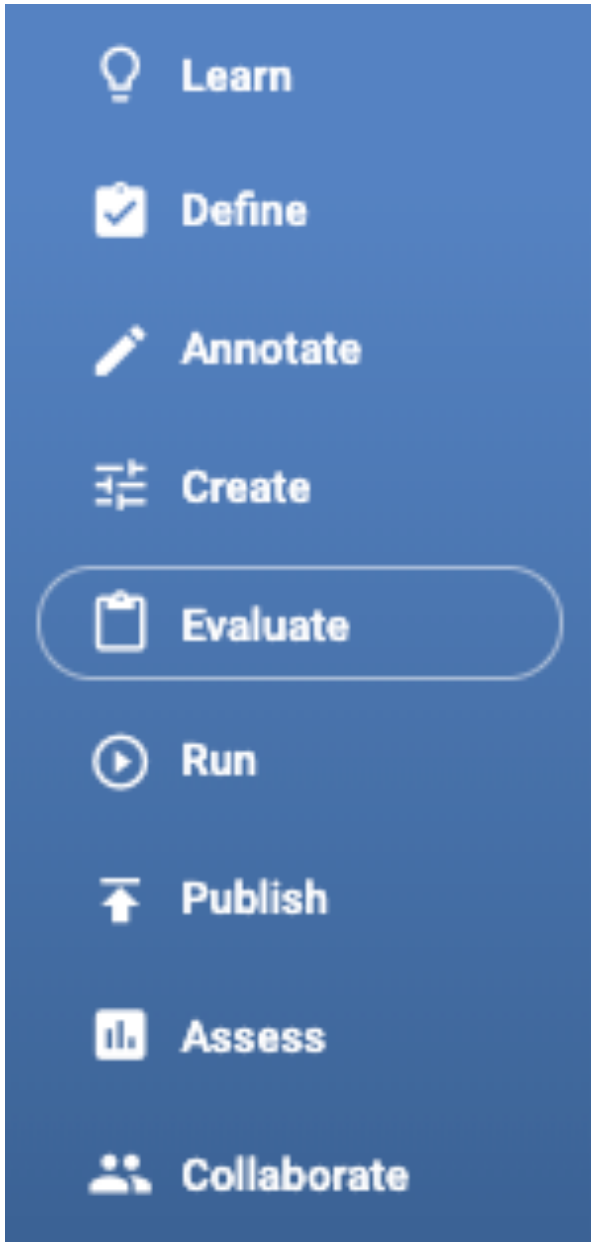
- Learn
- Define
- Annotate
- Create
- Evaluate
- Run
- Publish
- Assess
- Collaborate



Model Name: Breast Density Model from Company 1
Kappa (4 class) = 0.66 Kappa (2 class) = 0.76 AUC = 0.95



Model Name: Breast Density Model from Company 3
Kappa (4 class) = 0.41 Kappa (2 class) = 0.52 AUC = 0.89



AI-LAB EVALUATE

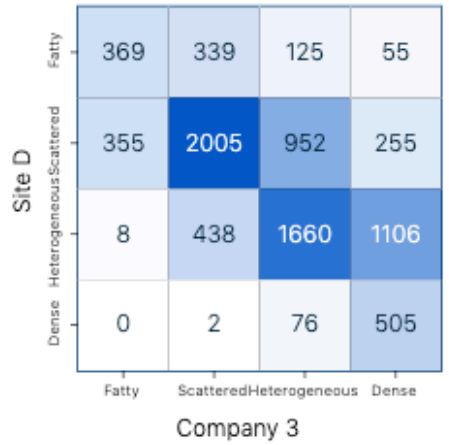
Use Case
Breast Density

Validation Dataset
Site D - Breast Density Dataset

Model Name
☑ Breast Density Model from Company 1
☐ Breast Density Model from Company 2
☑ Breast Density Model from Company 3

- Learn
- Define
- Annotate
- Create
- Evaluate
- Run
- Publish
- Assess
- Collaborate

Model Name: Breast Density Model from Company 1
Kappa (4 class) = 0.13 Kappa (2 class) = 0.25 AUC = 0.71

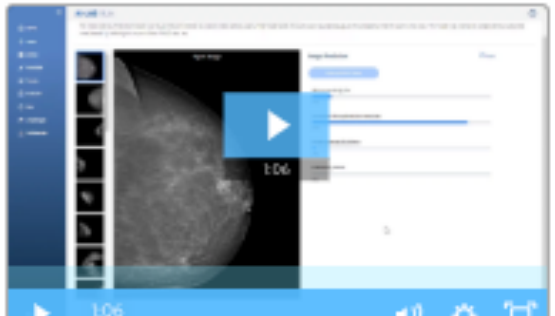


Model Name: Breast Density Model from Company 3
Kappa (4 class) = 0.46 Kappa (2 class) = 0.56 AUC = 0.89

- Learn
- Define
- Annotate
- Create
- Evaluate
- Run
- Publish
- Assess
- Collaborate

Run

Inference



Run Tutorial

Instructions

1. Select an AI use case.
2. Select a model to run.
    a. Click MORE DETAIL to view more information about the model.
3. Select a prepopulated image.
4. Click RUN PREDICTION to view the model's output.
5. Click RESET or select another prepopulated image to run another prediction.

- Learn
- Define
- Annotate
- Create
- Evaluate
- **Run**
- Publish
- Assess
- Collaborate

AI-LAB RUN

HELP

Use Case: Breast Density

Model: Breast Density Model from Company 4

Image Prediction

RUN PREDICTION

Almost entirely fat
11%

Scattered fibroglandular densities
87%

Heterogeneously dense
2%

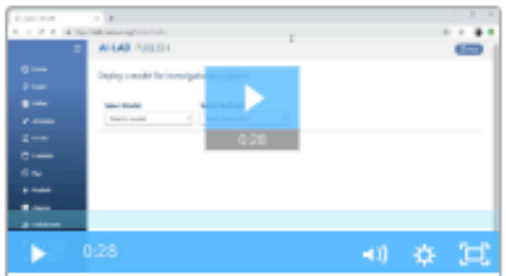
Extremely dense
0%

Report Text

There are scattered areas of fibroglandular density.

- Learn
- Define
- Annotate
- Create
- Evaluate
- Run
- Publish
- Assess
- Collaborate

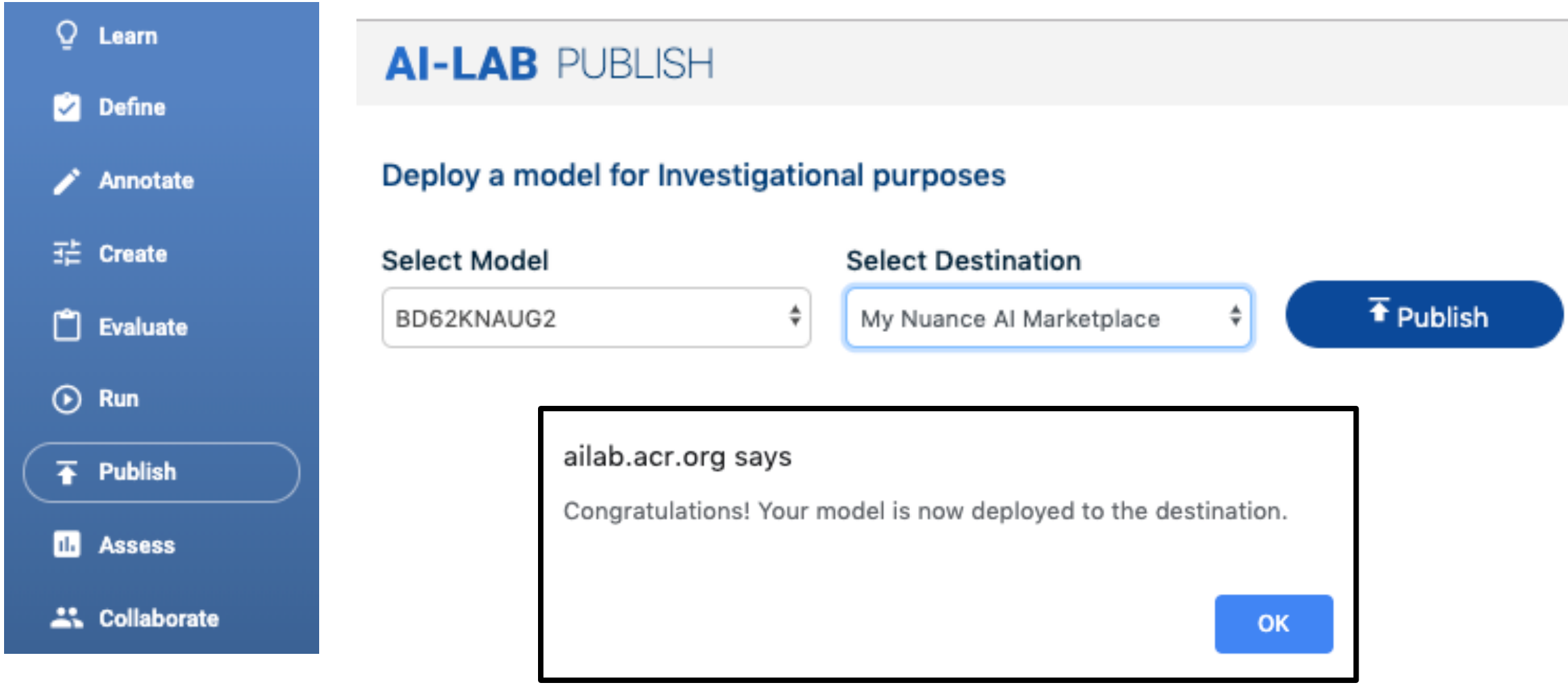
Publish



Publish tutorial

Instructions

1. Select an AI use case.
    a. If there are no available models, go to the create page, create a model, and save it.
2. Select a destination to publish your model to.
3. Click PUBLISH. This will send your model to the destination.


Learn
Define
Annotate
Create
Evaluate
Run
Publish
Assess
Collaborate
AI-LAB PUBLISH
Deploy a model for Investigational purposes
Select Model
BD62KNAUG2
Select Destination
My Nuance AI Marketplace
Publish
ailab.acr.org says
Congratulations! Your model is now deployed to the destination.
OK

- Learn
- Define
- Annotate
- Create
- Evaluate
- Run
- Publish
- Assess
- Collaborate

Assess

Assess tutorial

Instructions

1. Select an AI use case.
2. To view just one model at a time, select a model from the drop down list.

- Learn
- Define
- Annotate
- Create
- Evaluate
- Run
- Publish
- Assess
- Collaborate

AI-LAB ASSESS

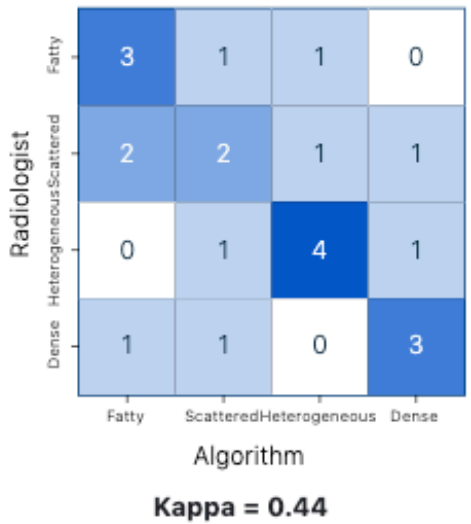
Oge | HELP

Use Case

Breast Density

Models

Model Name: **BD1KNAUG1**



Kappa = 0.44

Model Name: **BD62KNAUG2**

Kappa = 0.64

- Learn
- Define
- Annotate
- Create
- Evaluate
- Run
- Publish
- Assess
- Collaborate

Bonus

AI-LAB
Under the hood

AI-LAB Reference Architecture Framework*

- The document that defines the reference architecture framework for AI-LAB.
- “AI-LAB is aimed to be used by hospitals, clinics and imaging centers seeking to create, assess, experiment with, and leverage AI algorithms within their institution.”
- The document also provides supporting literature for infrastructure sizing, solution evolution, and other considerations.
- Intended audience: hospital IT analysts and architects, program managers and leadership, healthcare software vendor architects, platform specialists, and IT system purchasing.

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*Available online at: https://www.acrdsi.org/-/media/DSI/Files/PDFs/AI-LAB-Reference-Architecture-Framework.pdf?la=en

Concluding remarks

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