

CAP 6635 – Artificial Intelligence – Dr. Marques

Hands-on Assignment

AI and Deep Learning are making great strides in radiology (and medicine, in general). In this “fun” assignment (no coding necessary), you will learn more about how to navigate the entire workflow of applying AI and deep learning to radiology cases.

Goal: Learn the main concepts, steps, and workflow of AI in radiology, using the newly released AI-LAB¹, 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.”



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.**

Reference links:

- <https://ailab.acr.org> (main site)
- <http://news.mit.edu/2019/using-ai-predict-breast-cancer-and-personalize-care-0507> (for context)

¹ <https://ailab.acr.org>

Instructions:

- Document all your findings, steps, conclusions, lessons learned, insights, etc. in your **report** (*think of it as a “lab notebook”*)
- **Add your answers to the numbered questions in your report.**

Procedure:

1. Go to <https://ailab.acr.org> and click the ‘Enter’ button.
2. (OPTIONAL) Spend some time learning more about ACR, DSI, and the AI-LAB.
3. Click on the ‘Learn’ button (left-hand-side menu) – or go to <https://ailab.acr.org/Learn/Index> (AI-LAB LEARN module) directly.
4. Watch the “How can data scientists help radiologists?” (3-min) video.
5. (OPTIONAL) Watch other short videos above the “Define” heading on that page.

Part 1: Define

6. Watch the “Define Tutorial” (2-min) video.
7. Go to AI-LAB DEFINE (<https://ailab.acr.org/Define/Index>) and select Breast | MAM (mammogram). You should see the screen below.

The screenshot shows the AI-LAB DEFINE web application. At the top, there is a search bar with the word "breast" and dropdown menus for "MAM" and "Panel". Below the search bar are buttons for "Reset" and "Submit a New Use Case". The main area displays a table of use cases. The first row is highlighted with a red arrow pointing to the "Request" column, which contains the text "Classifying Suspicious Microcalcifications". The second row has a red arrow pointing to the "Request" column, which contains the text "Breast Density". The third and fourth rows have "Request" columns containing "High Risk Lesion Classification (FEA)" and "High Risk Lesion Classification (LN)" respectively. The table has columns for Panel, Status, Body Area, Modality, Anatomy, Use Case, and Request.

| 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) | |

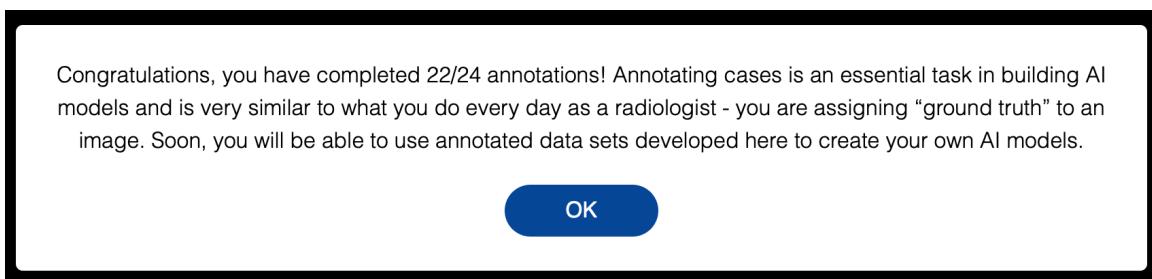
8. Click on the “Breast Density” link and glance through the linked document (to get a sense of jargon, scope, and context).

Part 2: Annotate

9. Go back to the AI-LAB LEARN page and watch the two videos below the “Annotate” heading on that page.
10. Go to AI-LAB ANNOTATE (<https://ailab.acr.org/Annotation/Index>) and select Breast Density | My Mammograms (24 cases).



11. Spend some time exploring the navigation and visualization options and getting a sense for the data – and the radiologist’s job at interpreting it.
12. Try to annotate a few of the 24 images, just to get a sense of the task of annotating / proving “ground truth”. When you press ‘Finish’ you should see a message like this:



Part 3: Create

13. Go back to the AI-LAB LEARN page and watch the 10 short videos below the “Create” heading on that page.
14. Answer the questions on the next page (in your report).

QUESTION 1: True or False: There is a lot of “trial and error” involved in getting a (predefined) model to work the way you expect.

QUESTION 2: Define *overfitting* in your own words.

QUESTION 3: Define *cost function* in your own words.

QUESTION 4: Define *epoch* in your own words.

QUESTION 5: Define *confusion matrix* in your own words.

QUESTION 6: What are some of the tasks/operations typically involved in the *pre-processing* stage?

QUESTION 7: Define *(image) data augmentation* in your own words.

QUESTION 8: Define *kappa* (score) in your own words.

QUESTION 9: Define *equal sampling* in your own words.

15. Go to AI-LAB CREATE (<https://ailab.acr.org/Create/TrainAndTest>). Now we can start the most fun part!

16. Select the options from the dropdown lists as per the screenshot below and click on “Start Preprocessing”.

The screenshot shows the AI-LAB CREATE interface. At the top, it says "AI-LAB CREATE". Below that is a "Define Problem" section with dropdown menus for "Body Area" (set to "Breast"), "Modality" (set to "MAM"), and "Use Case" (set to "Breast Density"). Under "Prepare Data", there are dropdown menus for "Training Data" (set to "62000 Mammo images") and "Augmentation" (set to "None"). At the bottom is a blue button labeled "Start Preprocessing" with a play icon.

Define Problem

Body Area
Breast ▾

Modality
MAM ▾

Use Case
Breast Density ▾

Prepare Data

Training Data
62000 Mammo images ▾ ⓘ

Augmentation
None ▾ ⓘ

Start Preprocessing

17. After a few seconds, you should see a message “Preprocessing complete” and a new set of dropdown lists:

Preprocessing complete

Configure Model

Architecture ▾ ⓘ

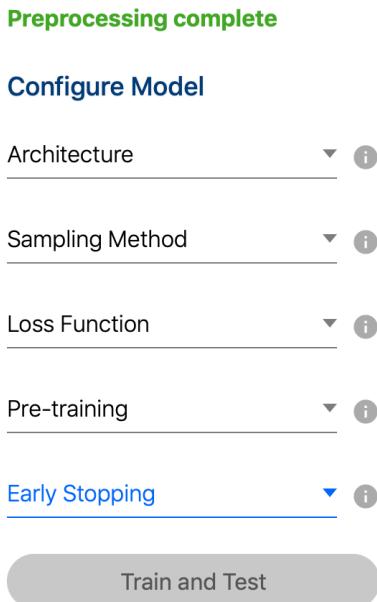
Sampling Method ▾ ⓘ

Loss Function ▾ ⓘ

Pre-training ▾ ⓘ

Early Stopping ▾ ⓘ

Train and Test



18. Select architecture, etc. as per the screenshot below and click the “Train and Test” button:

Configure Model

Architecture
ResNet ▾ ⓘ

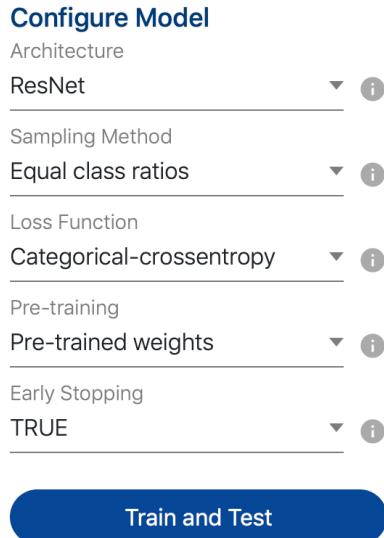
Sampling Method
Equal class ratios ▾ ⓘ

Loss Function
Categorical-crossentropy ▾ ⓘ

Pre-training
Pre-trained weights ▾ ⓘ

Early Stopping
TRUE ▾ ⓘ

Train and Test



19. After a few seconds², you should see the screen on the top of next page. Take some time to explore it in detail.

20. **Save** the model (the system will give it a name, automatically).

² This is a simulation. In practice, this step could take minutes, hours, or even weeks!

MODEL #1

SAVE

Accuracy Overview



Loss Overview

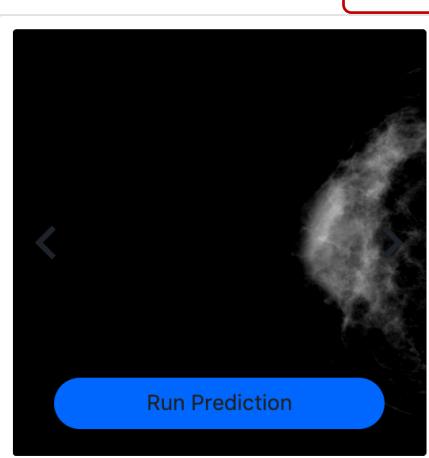


Performance Testing

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

| | | Fatty | Scattered | Heterogeneous | Dense | |
|--------------|---------------|-----------|-----------|---------------|-------|--|
| | | Algorithm | | | | |
| DMIST Reader | Fatty | 568 | 305 | 13 | 2 | |
| | Scattered | 288 | 2472 | 797 | 10 | |
| | Heterogeneous | 6 | 372 | 2532 | 302 | |
| | Dense | 2 | 2 | 199 | 380 | |

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

QUESTION 10: Does the model seem to be suffering from overfitting? How did you come to that conclusion (whether you answer yes or no)?

QUESTION 11: Which two classes are more likely to be misclassified by the model? Does that match your intuition (as a lay person)?

Hint: Go back to the AI-LAB ANNOTATE (<https://ailab.acr.org/Annotation/Index>) module and see how the images from those classes usually look like.

- Click the *Run Prediction* button (and repeat it a few times, using the refresh image icon).

22. Go back to the dropdown options on the left and make a single change: under *Augmentation*, choose “random flips/rotations” and click on “Start Preprocessing”.
23. After receiving the **Preprocessing complete** message, configure your model again using the same parameters as in step 18 above and click the “Train and Test” button.
24. After a few seconds, you should see the curves and confusion matrix for your second model. Take some time to explore them in detail.
25. **Save** the model (the system will give it a name, automatically). This will be your second model (so far).

QUESTION 12: How does model 2 compare to model 1 in terms of AUC?

QUESTION 13: How does model 2 compare to model 1 in terms of overfitting?

26. Go back to the dropdown options under **Configure Model** and change them as follows and click the “Train and Test” button.

Configure Model

Architecture

ResNet

Sampling Method

Equal class ratios

Loss Function

Categorical-crossentropy

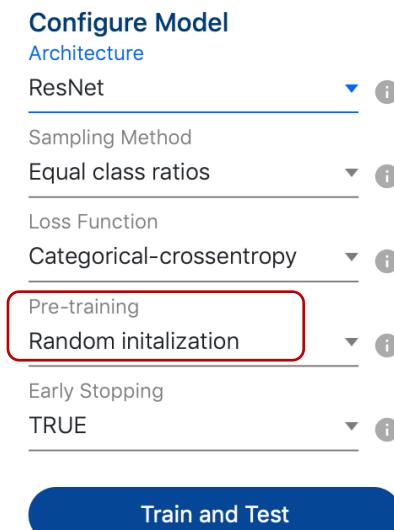
Pre-training

Random initialization

Early Stopping

TRUE

Train and Test



27. After a few seconds, you should see the curves and confusion matrix for your second model. Take some time to explore them in detail.
Hint: Pay special attention to the learning curves!
28. **Save** the model (the system will give it a name, automatically). This will be your third model (so far).

QUESTION 14: How does model 3 compare to model 2 in terms of AUC?

QUESTION 15: Can you explain why the learning curves for this model are so dramatically different than the previous two?

29. Go back to the dropdown options under **Configure Model** and change them any way you want and click the “Train and Test” button.
30. **Save** the model (the system will give it a name, automatically). This will be your fourth model (so far). Document all the options for this model (*Architecture, Sampling Method, ..., Early Stopping*).
31. (OPTIONAL) Repeat steps 29 and 30 as many times as you want, for as many (meaningful) variations as you would like to compare.
32. Select your best performing model and document its parameters and performance indicators (screenshots are fine).

Part 4: Evaluate

33. Go back to the AI-LAB LEARN page and watch the two videos below the “Evaluate” heading on that page.

QUESTION 16: Explain *transfer learning* in your own words.

34. Choose options as per screenshot below and click on **Evaluate Models** button.

| | |
|---|-------------------------------------|
| Use Case | Validation Dataset |
| Breast Density | ▼ Site A - Breast Density Dataset ▼ |
| | |
| Model Name | Evaluate Models |
| | |
| <input checked="" type="checkbox"/> Breast Density Model from Company 1 | |
| | |
| <input type="checkbox"/> Breast Density Model from Company 2 | |
| | |
| <input checked="" type="checkbox"/> Breast Density Model from Company 3 | |
| | |
| <input type="checkbox"/> Breast Density Model from Company 4 | |

35. Make a note (screenshots are fine) of which model performed best.

36. Repeat steps 34 and 35, but this time choosing a different site (Site D) to compare the same two models (from hypothetical companies 1 and 3).

QUESTION 17: What are the main differences between what you saw in step 35 and step 37? What can you conclude from this brief experiment?

37. (OPTIONAL) Repeat steps 34 and 35, but this time using some models that you created earlier (Part 3) for different companies and record the most interesting findings.

Part 5: Run

38. Go back to the AI-LAB LEARN page and watch the two videos below the “Run” heading on that page.
39. Try your hand at this module by selecting the options in the screenshot below and click on the Run Prediction button.
40. Repeat the step above for other images whose thumbnails after on the left-hand side of the screen.
41. (OPTIONAL) Repeat this process for other models (including your own models from Part 3!).

AI-LAB RUN

Use Case: Breast Density Model: Breast Density Model from Company 4

The screenshot shows the AI-LAB RUN interface. On the left, there is a vertical stack of six small thumbnail images of mammograms, with the top one highlighted by a blue border. To the right of these thumbnails is a large, detailed grayscale mammogram of a breast. In the top right corner of the main window, there is a blue button labeled "RUN PREDICTION". To the right of this button is a section titled "Image Prediction" containing four horizontal bars representing different density categories. The categories and their percentages are: "Almost entirely fat" (11%), "Scattered fibroglandular densities" (87%), "Heterogeneously dense" (2%), and "Extremely dense" (0%). Below this section is another titled "Report Text" which contains the text: "There are scattered areas of fibroglandular density."

| Density Category | Percentage |
|------------------------------------|------------|
| Almost entirely fat | 11% |
| Scattered fibroglandular densities | 87% |
| Heterogeneously dense | 2% |
| Extremely dense | 0% |

Report Text
There are scattered areas of fibroglandular density.

Part 6: Publish

42. Go back to the AI-LAB LEARN page and watch the short video below the “Publish” heading on that page.

43. (OPTIONAL) Publish³ one or more of your models.

Part 7: Assess

44. Go back to the AI-LAB LEARN page and watch the short video below the “Assess” heading on that page.

45. Compare several models for breast density prediction and choose the one with highest Kappa. Take a screenshot of it and add to your report.

Part 8: Wrap it up

46. (OPTIONAL) Go back to the AI-LAB LEARN page and watch the “Saliency maps” video below the “Bonus” heading on that page.

47. Prepare your **report**, with all relevant plots, code snippets, numerical values and – most importantly – your insights and lessons learned.

³ This is currently a mockup.