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-LAB[1], 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

Hands-on Assignment

Instructions:

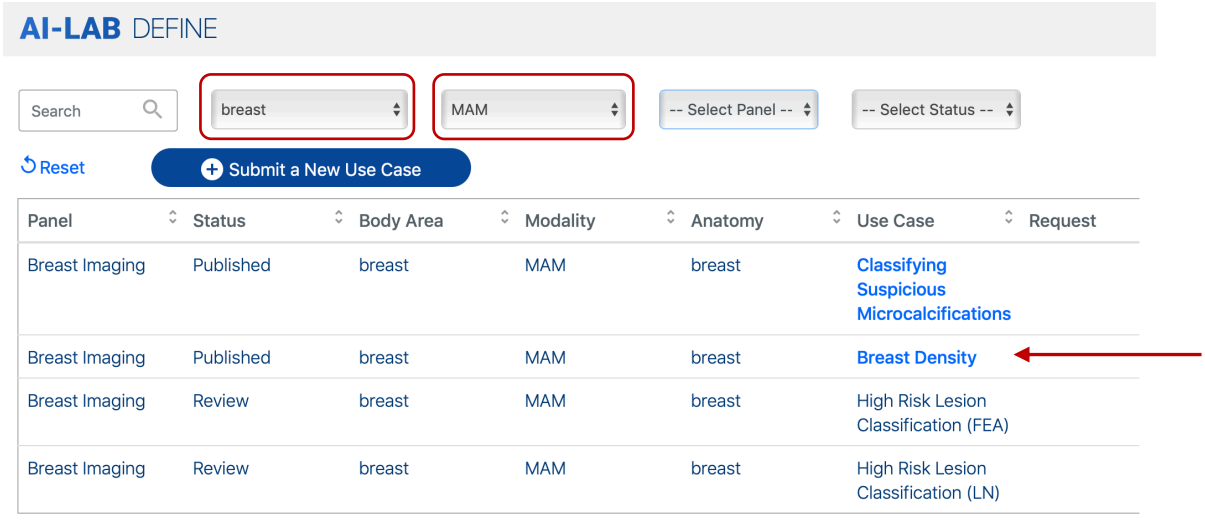
- Document all your findings, steps, conclusions, lessons learned, insights, etc. in your **report** *(think of it as a "lab notebook")*
- **Add your answers to the numbered questions in your report.**

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.



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

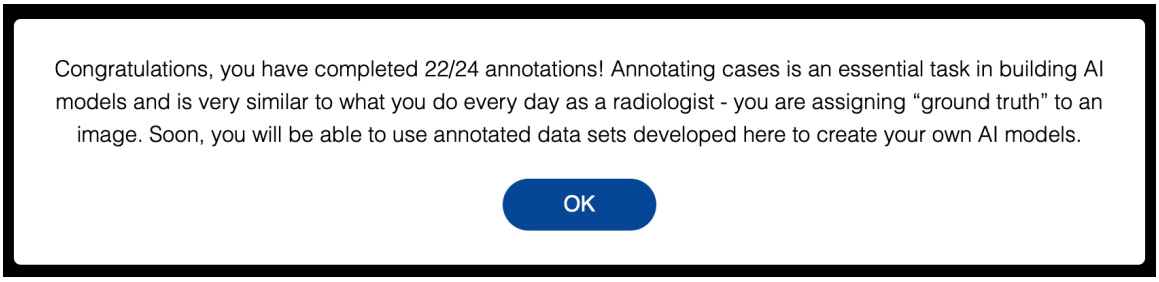
Part 2: Annotate

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?

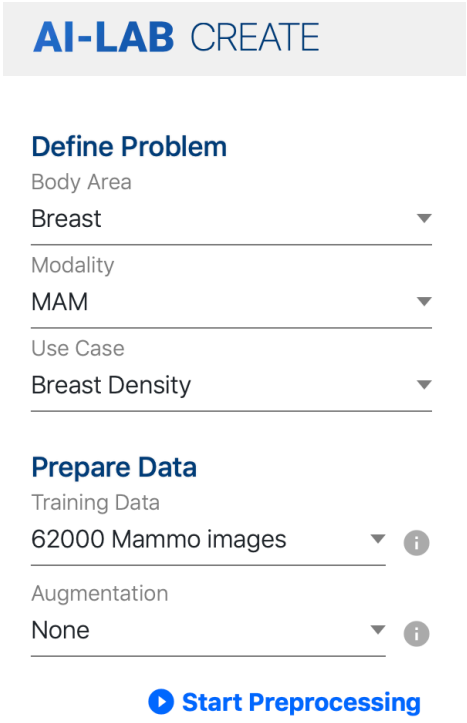
QUESTION 7: Define *(image) data augmentation* in your own words.

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

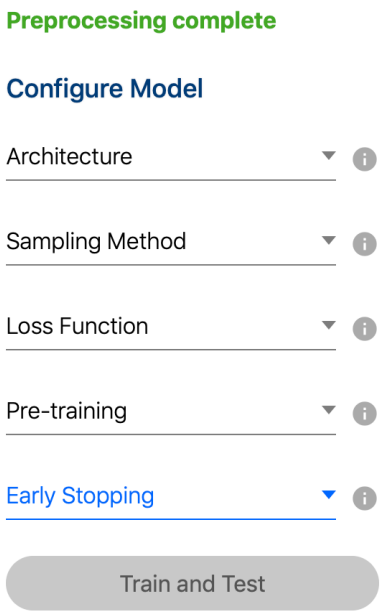
QUESTION 9: Define *equal sampling* in your own words.

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

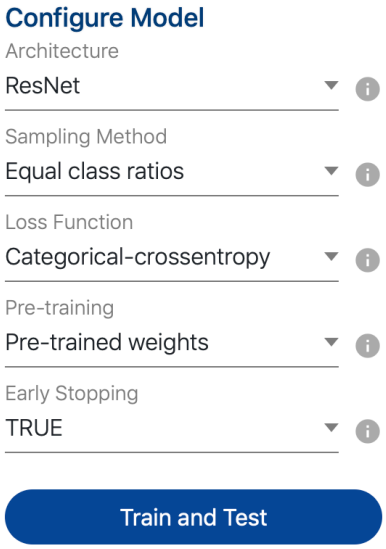
16. Select the options from the dropdown lists as per the screenshot below and click on "Start Preprocessing".



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



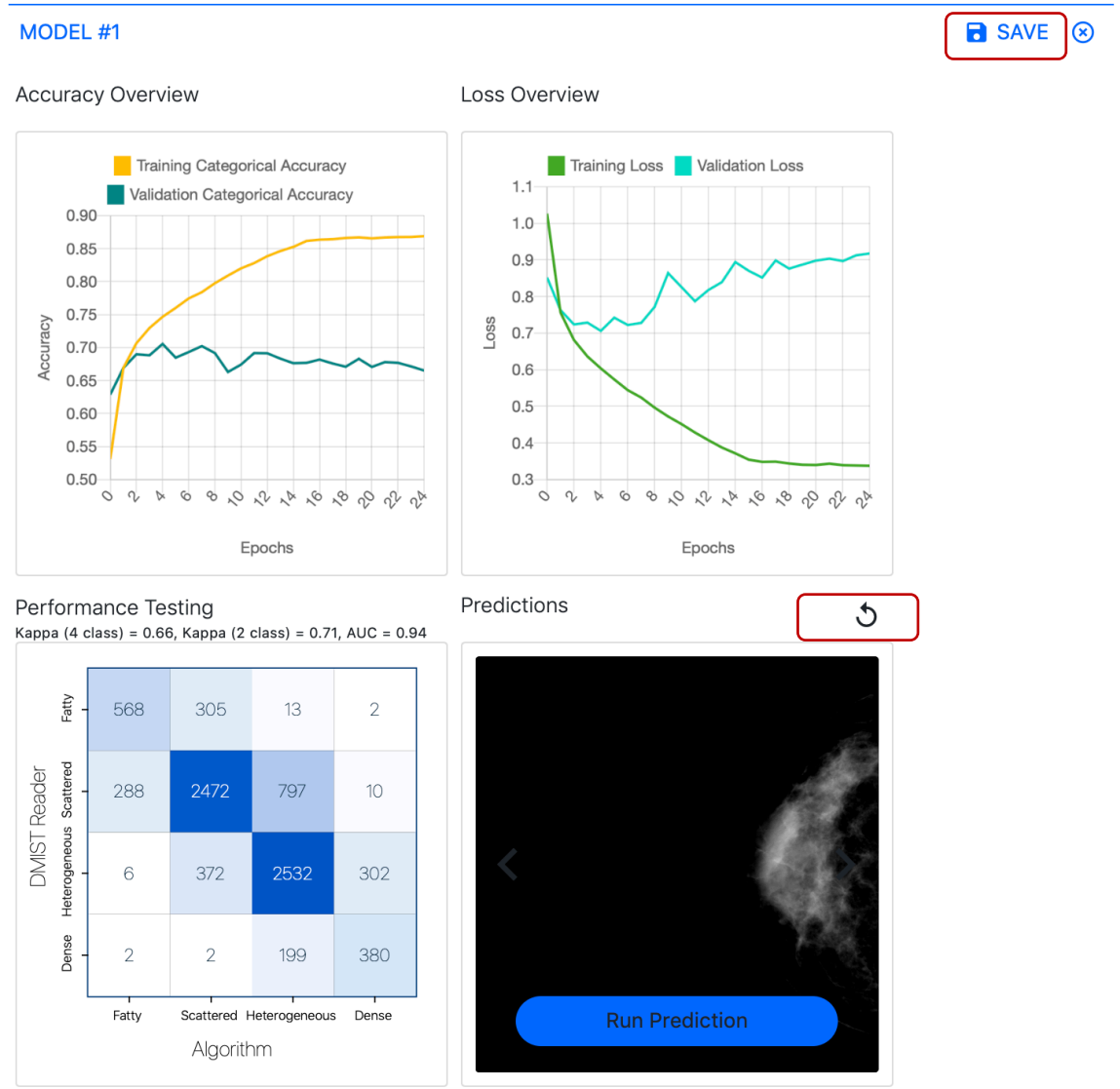
18. Select architecture, etc. as per the screenshot below and click the "Train and Test" button:



19. After a few seconds[2], 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!



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.

21. 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.

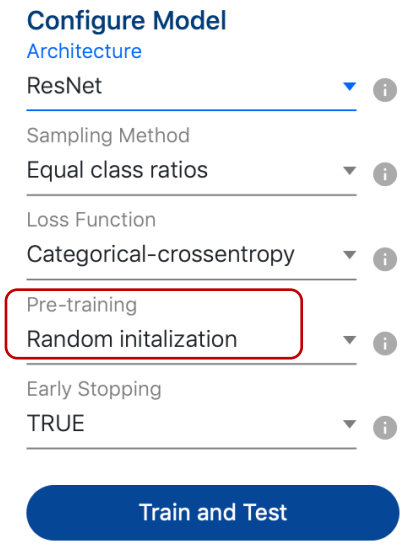
24. After a few seconds, you should see the curves and confusion matrix for your second model. Take some time to explore them in detail.

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.



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.

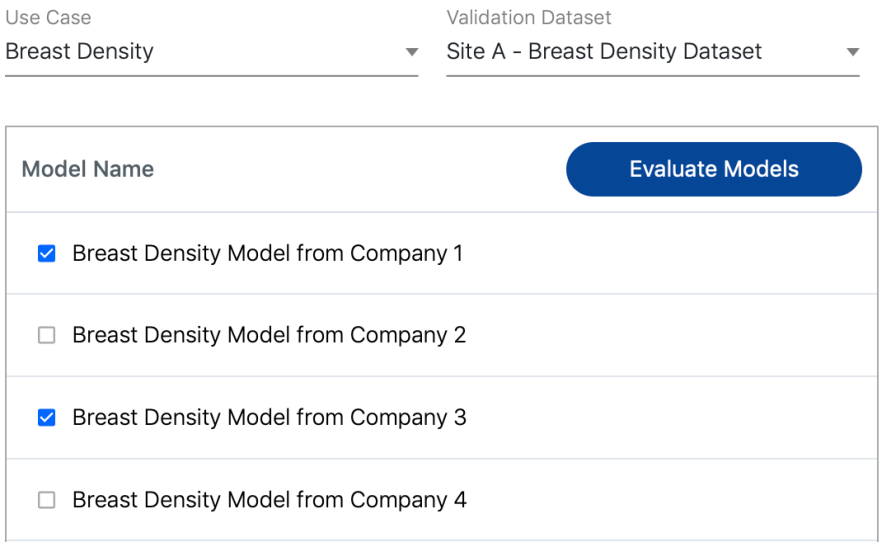
32. Select your best performing model and document its parameters and performance indicators (screenshots are fine).

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.



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 (form 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.

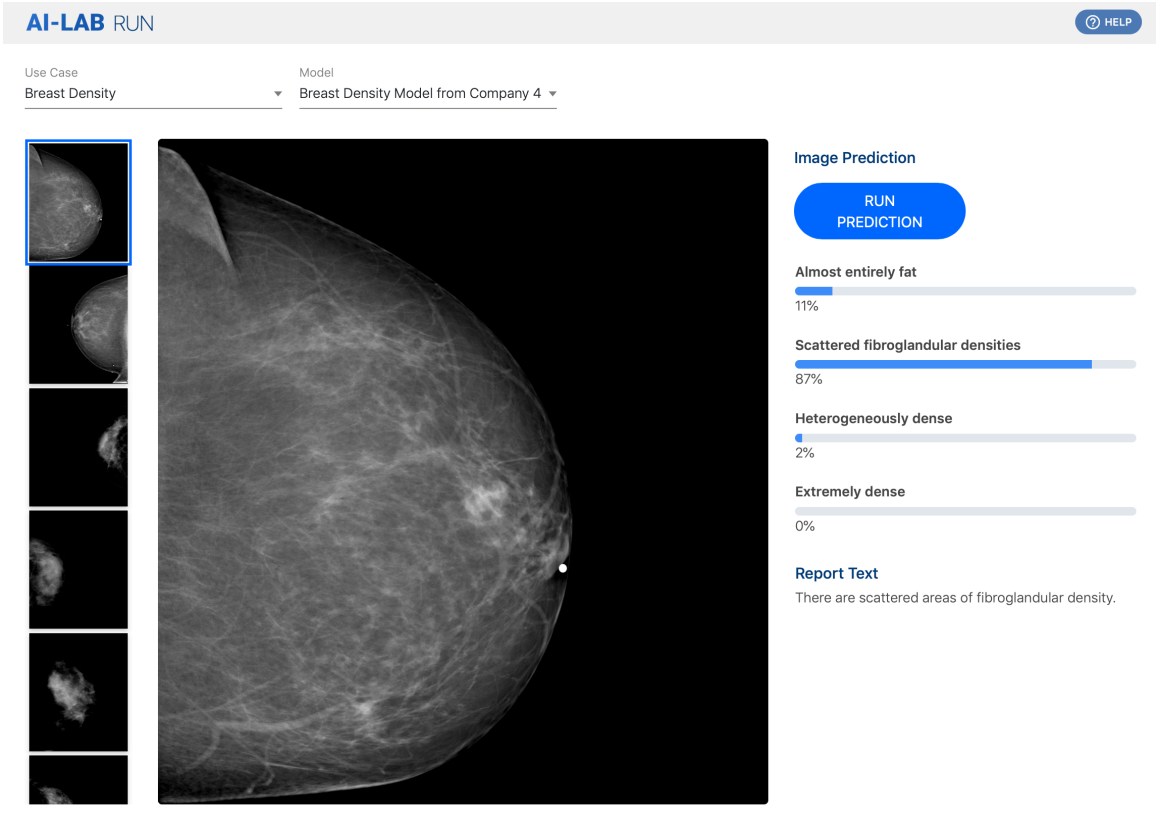
Part 5: Run

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!).



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) Publish[3] 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.