Can we assess lung nodule by just looking at it?

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What are pulmonary nodules?

- Pulmonary nodule is a small round or oval-shaped growth in the lung
- Nodule can be caused by infections and non-infectious diseases
- Nodules are typically smaller than 3cm in diameter
- Larger nodules likely represent cancer

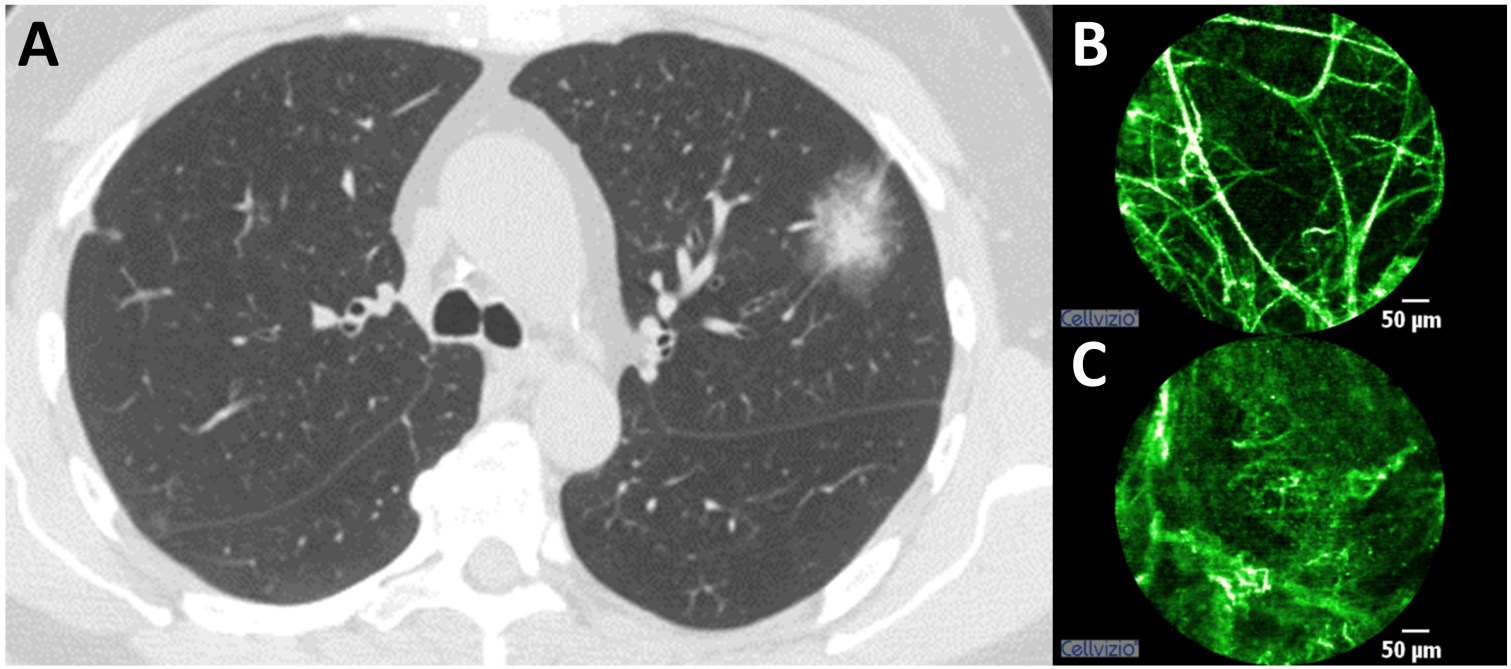
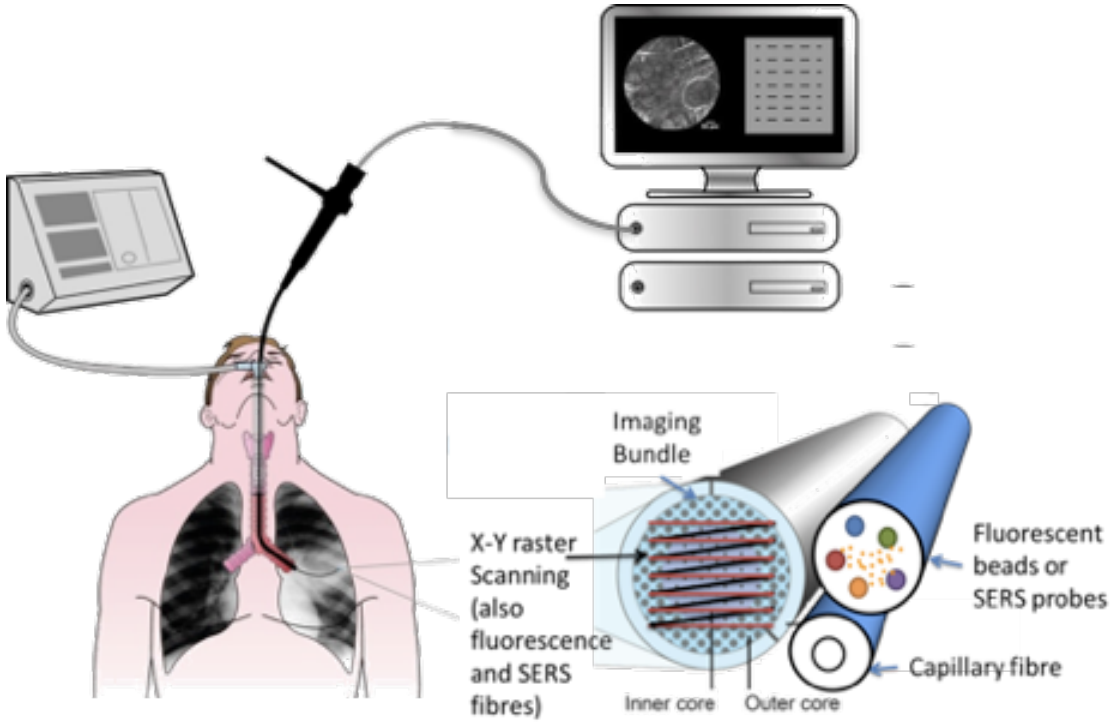


Figure: (a) CT scan demonstrating pulmonary nodule, (b) normal elastin structure, (c) abnormal elastin structure at nodule. Abnormal structure can be benign or malignant.

FCFM: How does it work?



Fibered Confocal Fluorescence Microscopy

- Fiber optic imaging cable is inserted to the distal lung through a bronchoscope
- Imaging is performed by counting emitted photons through fibre optic
- Smartprobe (chemical compound) is delivered to make bacteria fluoresce

Hypothesis

- Can we predict if a solitary pulmonary nodule is benign or malignant from autofluorescence-based pulmonary optical endomicroscopy?
- We did not notice any immediate benefit.

Dataset

- 91 patients: 25 malignant causes and 66 benign causes
- FCFM videos with 16795 on-target frames in total, 159 on an average
- 12 demographic and clinical variables, and benign/malignant assessment
  1. age: in years
  2. sex: male 0, female 1
  3. smoker: nonsmoker 0, smoker 1
  4. smoking-pack-years: number of cigarettes pack smoked per day times number of years smoked
  5. extra-thoratic-cancer: no 0, yes 1
  6. family-history-of-cancer: anyone in family has lung cancer? no 0, yes 1
  7. nodule-size: diameter of nodule in mm
  8. emphysema: shortness of breath? no 0, yes 1
  9. spliculation: nodule has ragged edge?, no 0, yes 1
  10. number-of-nodules:
  11. upper-lobe: nodule appear in the upper lobe? no 0, yes 1
  12. nodule-type: is solid? no 0, yes 1
- The risk on malignancy can be computed from these variables using established risk calculators, i.e., Swensen et al. and McWilliams et al.

Subjective Analysis

- Can clinician do it?

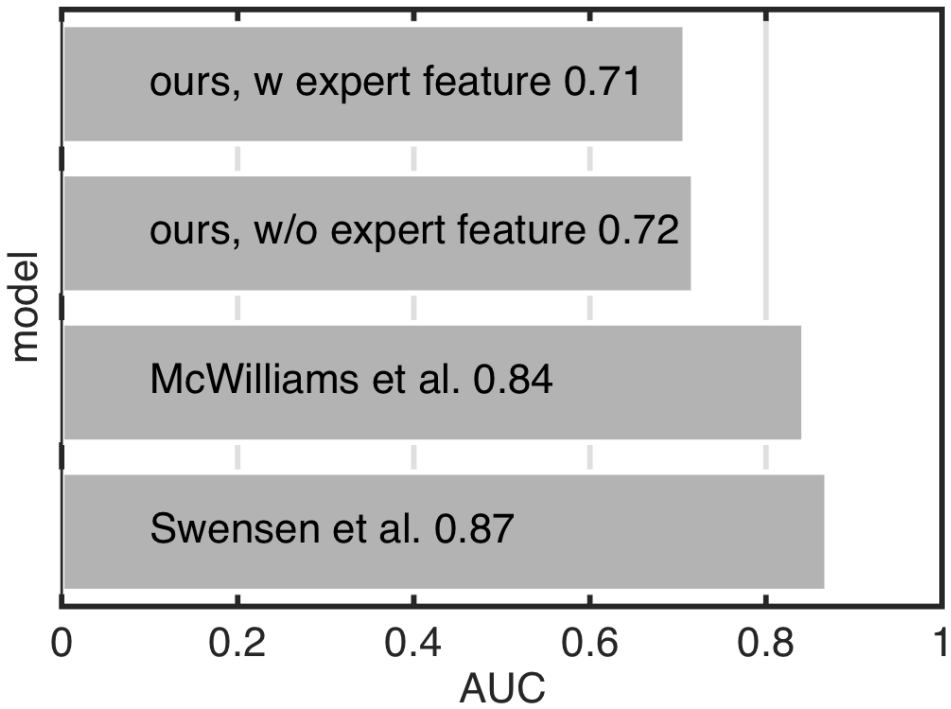


Figure: Comparison of existing models using clinical and demographic features, versus models trained on our patient cohort either with or without using expert annotation as feature.

Subjective Analysis

- Do the frames look different?

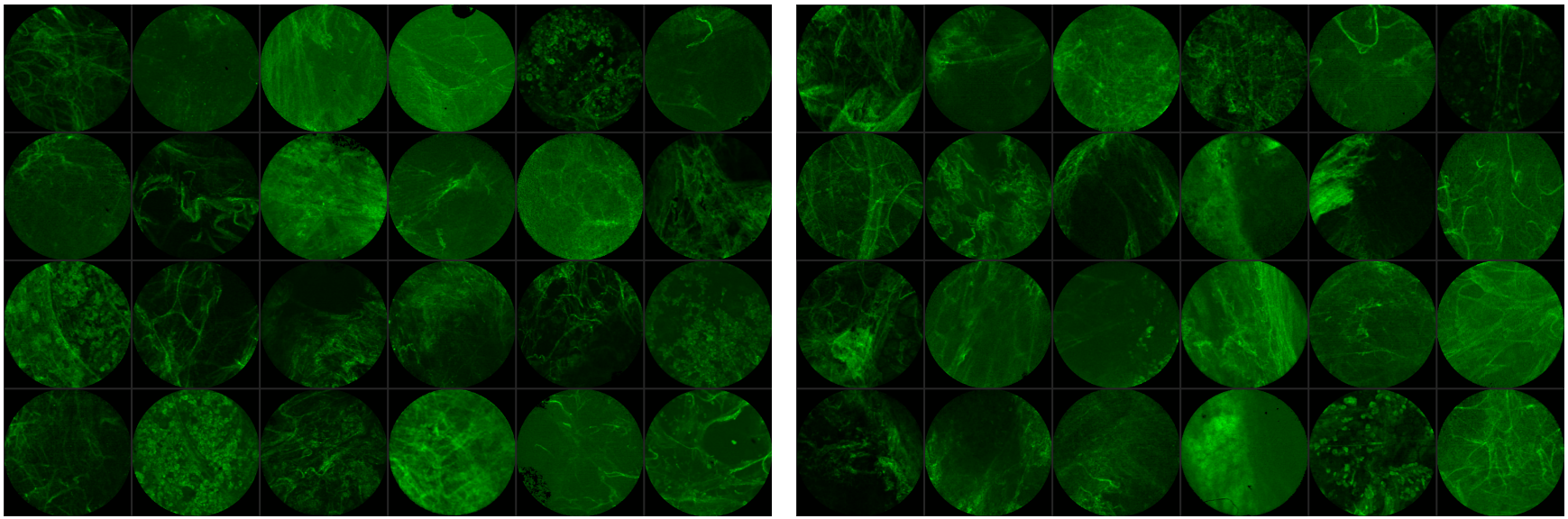


Figure: Benign versus malignant medoid frames

Objective Analysis

1. Extract imaging features from each frame and take average over a video,
   1. Local Binary Patterns, 80 features
   2. Scale Invariance Feature Transformation, 1024 features
   3. Scattering Transformation, 1401 features
2. Build a classifier using cross-validation
   1. ℓ_1 regularized Logistic Regression, linear
   2. Gaussian Process Classification, nonlinear
   3. Random Forest, nonlinear
3. Combine result $(y \mid x_1)$ with existing calculators $(y \mid x_2)$ using α-integration

$$p(y = 1 \mid x_1, x_2) = cm_\alpha(p(y = 1 \mid x_1), p(y = 1 \mid x_2)).$$

   1. $\alpha = -1$ arithmetic mean,
   2. $\alpha = 1$ geometric mean,
   3. $\alpha = \inf, -\inf$ min and max.
4. Evaluate area under ROC curve

Performance

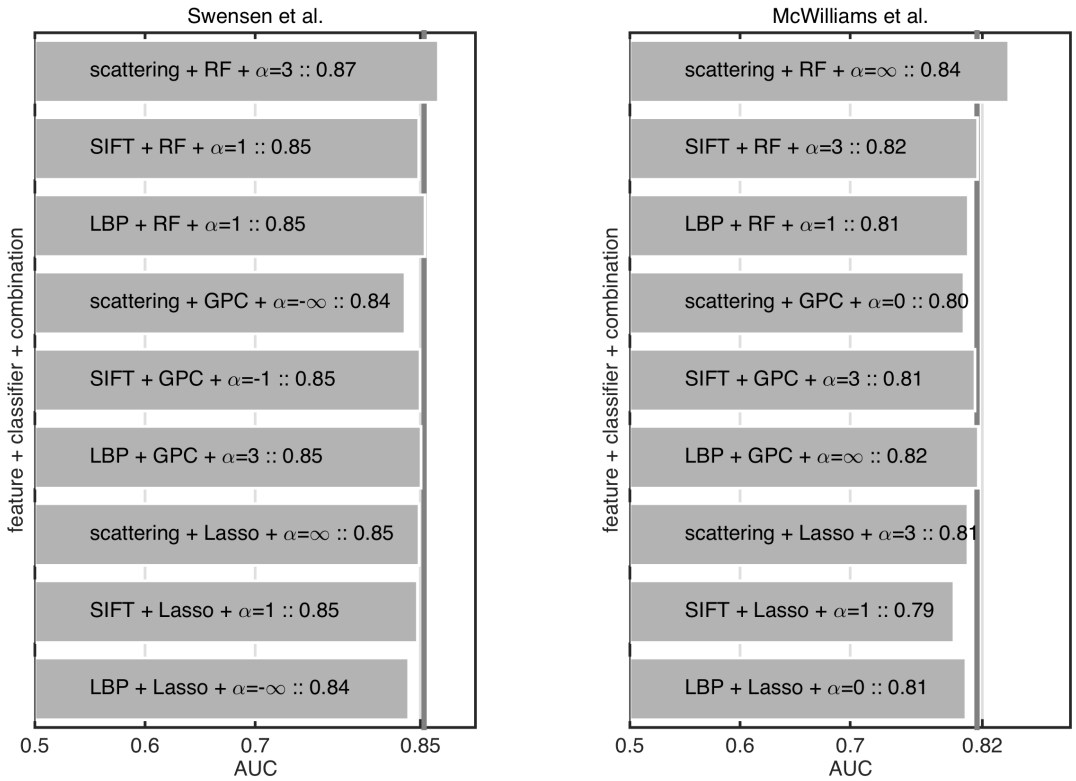


Figure: Comparison of different feature extraction and classification methods with best classifier combination strategy on predicting benign versus malignant nodule when combined with existing models based on clinical and demographic information (left) Swensen et al. (right) McWilliams et al. The vertical line represents performance using only the existing model without imaging information.

Why does this *not* work?

- A prospectively collected database, but is a retrospective analysis
- Imaging modality includes motion artefacts
- Bias for the length of time imaging an abnormal area
- Lack of sufficient contrast for manual assessment
- Variation in dynamic ranges for appropriate comparison
- imaging field of view is small compared to the nodule size, i.e., 600 microns
- analyse images irrespective of smoking status

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Assessing the utility of autofluorescence-based pulmonary optical endomicroscopy to predict the malignant potential of solitary pulmonary nodules in humans

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Solitary pulmonary nodules are common, often incidental findings on chest CT scans. The investigation of pulmonary nodules is time-consuming and often leads to protracted follow-up with ongoing radiological surveillance, however, clinical calculators that assess the risk of the nodule being malignant exist to help in the stratification of patients. Furthermore recent advances in interventional pulmonology include the ability to both navigate to nodules and also to perform autofluorescence endomicroscopy. In this study we assessed the efficacy of incorporating additional information from label-free fibre-based optical endomicrosopy of the nodule on assessing risk of malignancy. Using image analysis and machine learning approaches, we find that this information does not yield any gain in predictive performance in a cohort of patients. Further advances with pulmonary endomicroscopy will require the addition of molecular tracers to improve information from this procedure.