Segmentation - Diagnosis - Risk Prediction of Breast Cancer in MRI

Lukas Hirsch MSc, Andy Huang PhD, Liz J. Sutton MD, Lucas C. Parra PhD

Grove School of Engineering - City College of New York

Summary achievements

Using a large data set we designed and trained deep neural networks to help radiologists in the tasks of segmentation of cancer in breast MRI, diagnosis of cancer and forecasting of cancer development within a year in healthy exams.

- **Large data set available:** We have trained several algorithms supervised with 14,000 patients and over 60,000 exams
- **Radiologist level performance in of segmentation of breast cancer tissue:** Dice score of 0.88 in a set of 250 images.
- **State of art performance diagnosis:** AUC-ROC=0.94 on 6,000 exams.
- 27% of exams can be omitted from reading without losing a single cancer.
- 25% of BI-RADS 4,5 can be correctly omitted from biopsy.
- **Interpretability of diagnosis results:** Model architecture allows for visualization of slices containing high-risk lesions and region within slice leading to the decision.
- **Proposal of clinical pipeline for individual risk screening adjustment:**
- 78% of early detected cancer a year earlier.
- 33% of early diagnosed cancer a year earlier.
- 25% of exams can be scheduled a year later without increasing the rate of cancer misses.

Segmentation performance equivalent to trained radiologists

Large data set available: We trained a volumetric convolutional neural network (CNN) supervised with 2,000 segmentated images of cancer and over 60,000 images of healthy breasts, from a data set containing over 14,000 patients from a screening population followed over 12 years.

Radiologist level performance in segmentation of cancer: Four independent radiologists segmented the same 250 images to evaluate inter-subject variability. To compare individual performance with the network; the network segmentation and each radiologist are compared against a consensus segmentation from the other three radiologists. The network performs within the range of all four.
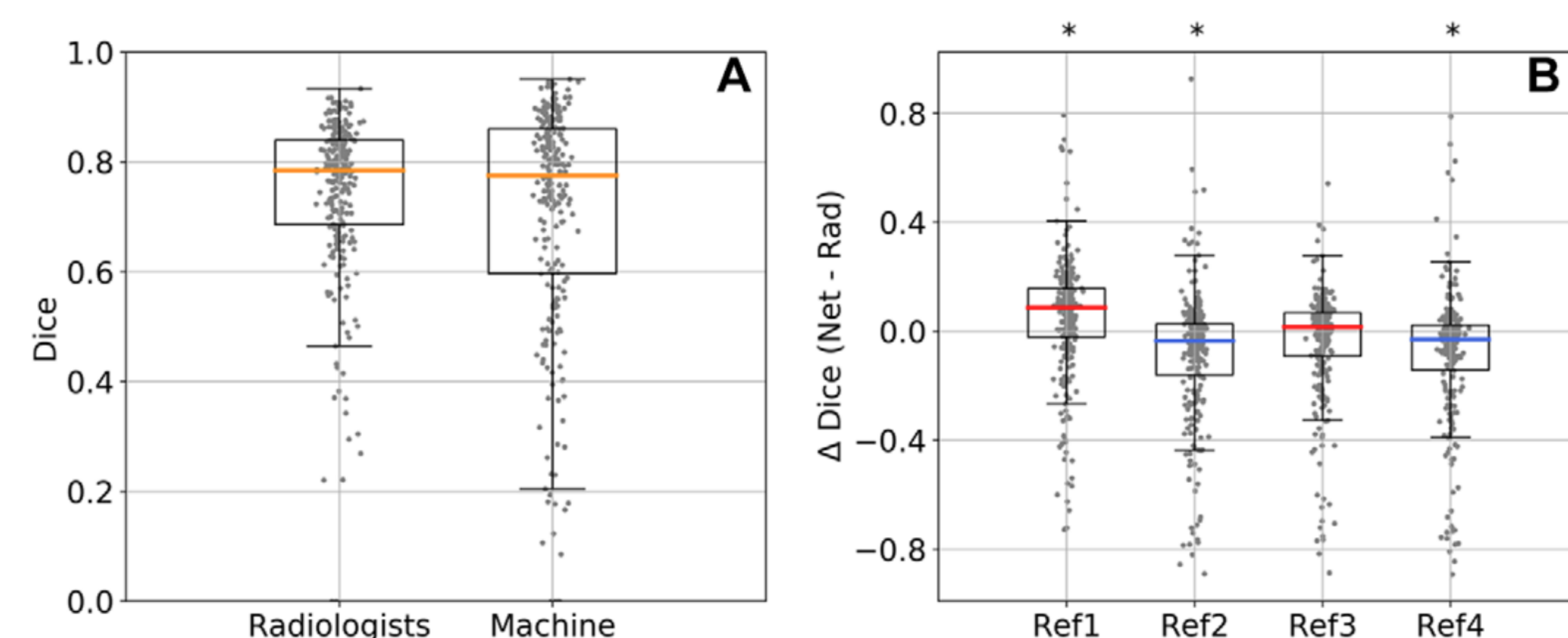

Example segmentation from all four radiologists (R1–R4) for a given section, and the model segmentation probabilities.
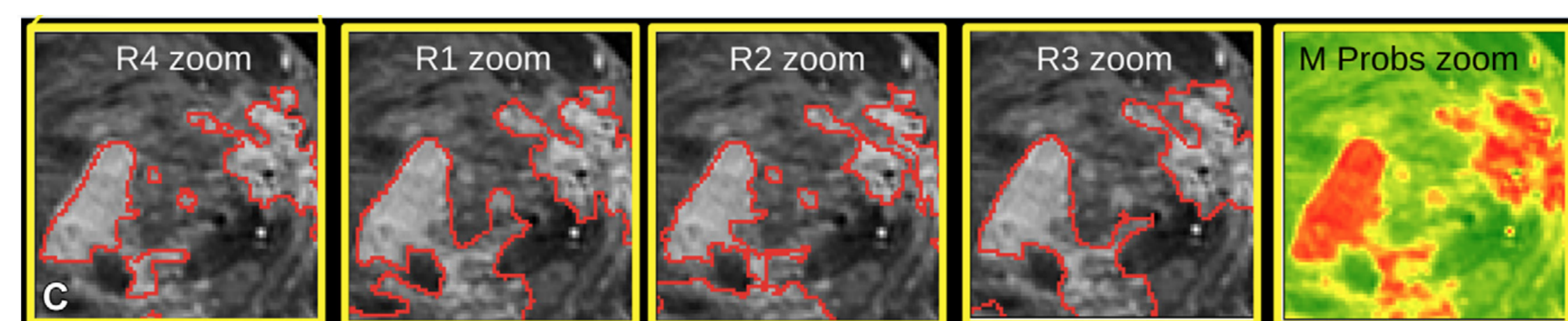

State of art performance on Diagnosis

We trained a deep convolutional neural network to predict whether an MRI slice contains cancerous tissue. The slice picked by radiologists showing the index lesion (segmented slice on the horizontal axis) is highly correlated with the slice selected by the network as containing the highest probability of malignancy. Precision-Recall curve for healthy scans that might not require a reading by a radiologist.
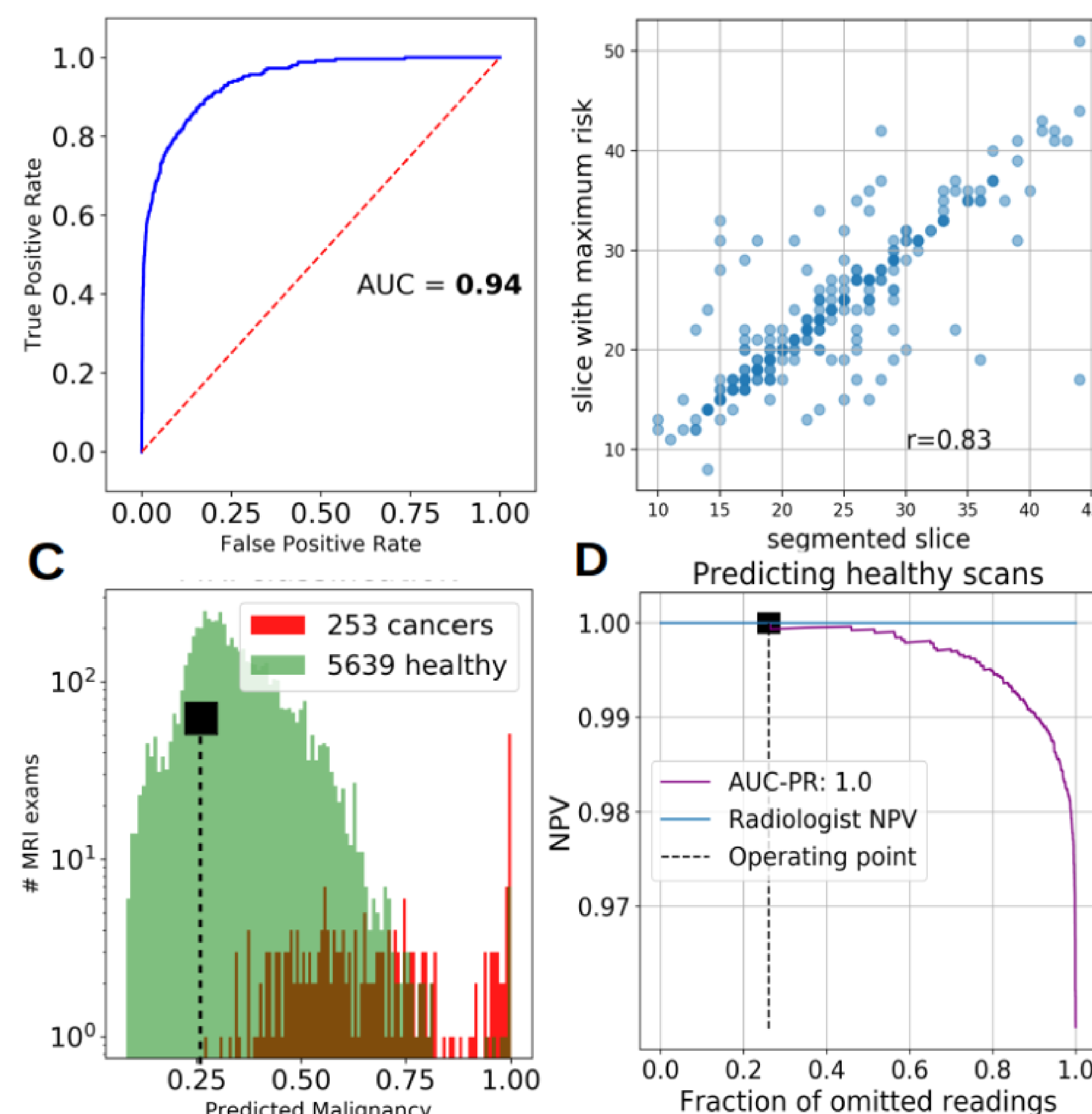

The field of view of the network corresponds to the full sagittal view of a scan, so **we can visualize which regions in the input contribute to the classification output of the network**. Using GradCAM, we compute the sensitivity to the input for the activation of the output unit in the network corresponding to the positive class. This sensitivity, displayed as a heat-map, could serve as guide in an abbreviated reading by a radiologist.
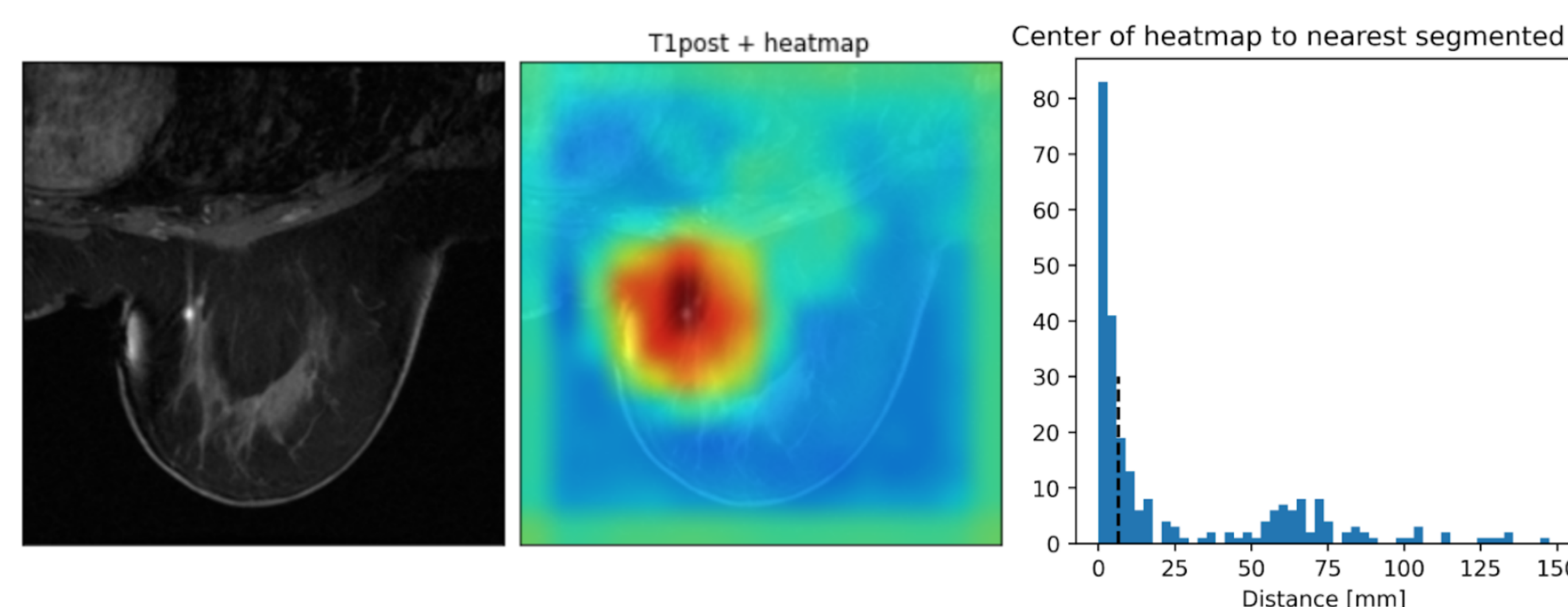

Risk prediction of cancer development on healthy patients

The proposed workflow integrates traditional radiologist's BI-RADS assessments and the AI predicted risk. Higher-risk patients are referred to the radiologist to evaluate suspicious lesions identified by the AI to consider possible biopsy. Medium-risk patients are asked to return for regular follow-up MRI. Lower risk patients can extend the interval of the next scheduled MRI, after confirmation with the radiologist.
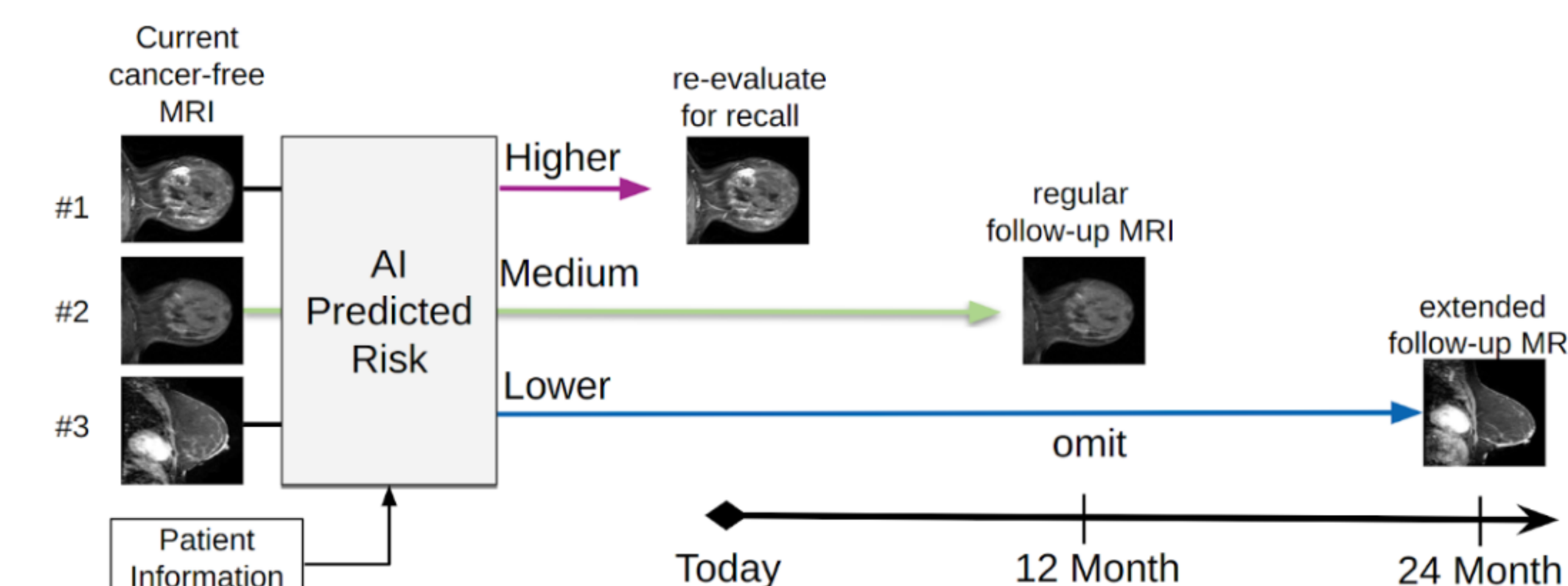
A segmentation network extracts regions of concern from a breast MRI, which have a high likelihood of being part of a cancerous lesion.
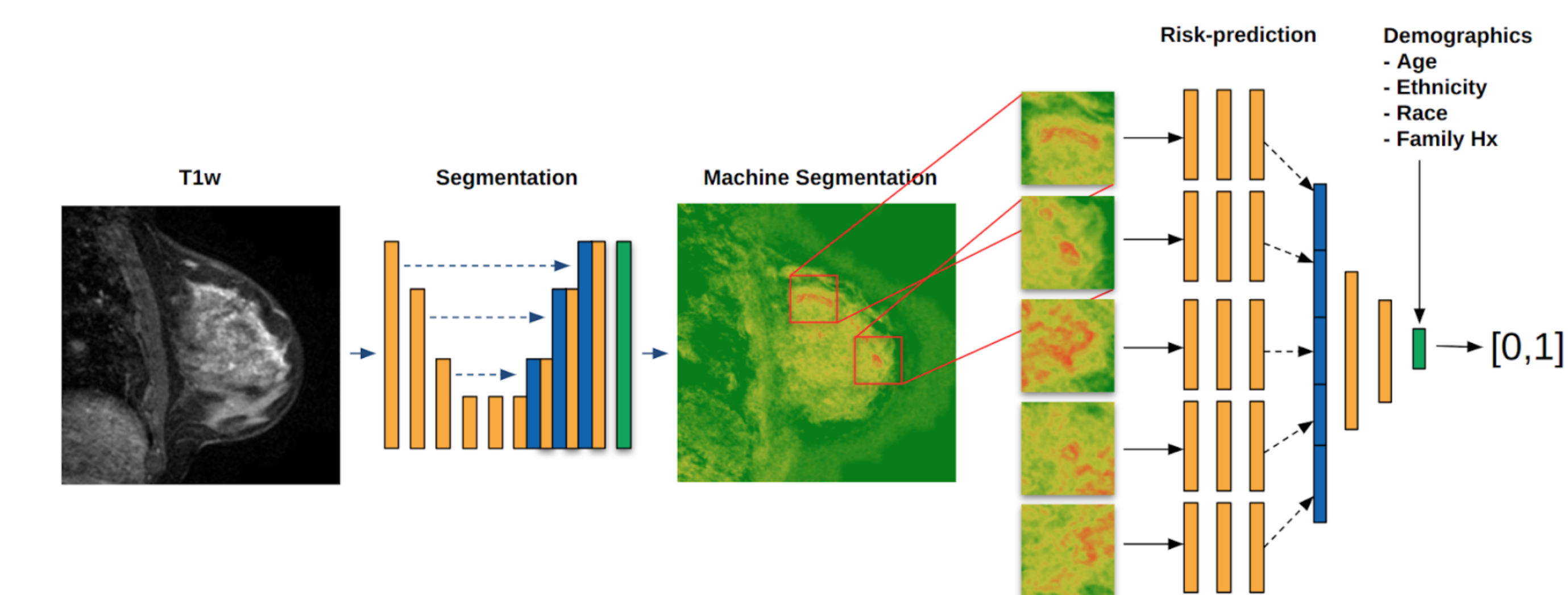
We suggest that instead of a fixed one-size-fits all schedule, the radiologist could adjust the time for the next follow-up, using a numerical risk score estimated by the machine based on the current cancer-free MRI exam.