What does AI see? Deep Segmentation Networks discover biomarkers for lung cancer survival

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3D Co-Segmentation UNet

- PET-CT Co-Segmentation UNet (Zhong et al., 2018)
Can deep segmentation network encode features for survival prediction?
Outcome Prediction Framework
96 NSCLC patients with pairs of PET-CT image

In total of 55,296 features were obtained from each of the pre-trained 3D deep segmentation UNet

We discovered approximately 20 features that are highly correlated with cancer survival

Via bootstrapping, the deep-learned features totally outperforms the conventional radiomic approaches
Network Visualization

- Visualizing Latent Neurons

Optimization Problem: \( X^* = \arg \max_x q_i(X|W, b) \)

Gradient Ascent: \( X^{k+1} = X^k + \gamma^k \nabla q_i(X^k|W, b) \)

- \( X^k \): Current solution at \( k \)-th iteration
- \( \gamma^k \): step length
- \( \nabla q_i \): gradients computed using backpropagation

Activation value: \( q_i(X|W, b) \)
Network Visualization

- Visualizing CT UNet Survival-related Neurons

CT

PET
Risk Map

Input: $\mathbf{X}$

Pre-trained segmentation encoder

Feature activation maps

Logistic regression layer

Survival outcome

Death

Survival

$\omega_k = \max \left( \frac{\partial (1 - S(X))}{\partial A_{i,j}^k}, 0 \right)$

Weights: $\omega_i$
Normalization factor: $Z$
Neuron ID: $i, j$
Activation Map ID: $A^k$
Survival probability: $S(X)$

$R(X) = \sum_{m} \omega_k A^k(X)$
Risk Map

- Risk Map Visualization

Patient IA002100
(Survival: 1.13 years)
Possible Correlation with Cancer Progression

a. Axial slice from a primary (pre-therapeutic) CT image

b. Risk map of the CT image

c. Post-therapeutic CT image of the same patient.
Thank You!

Questions?

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