Supplementary Materials

Definition of radiomics features

Table. Feature categories used in this study.

Feature classes	**Representative features**
Shape-based	Voxel Volume, Surface Area, Sphericity, ….
First Order Statistics	Energy, Entropy, Mean, ….
GLCM	Autocorrelation, Joint Average, Cluster Shade, ….
GLDM	Small Dependence Emphasis, Large Dependence Emphasis, Dependence Non-Uniformity
GLRLM	Short Run Emphasis, Long Run Emphasis, Run Length Non-Uniformity, ….
GLSZM	Small Area Emphasis, Large Area Emphasis, Size-Zone Non-Uniformity, ….
NGTDM	Coarseness, Contrast, Complexity, ….
Wavelet	-
Sequential features	-

GLCM = Gray Level Co-occurrence Matrix, GLDM = Gray Level Dependence Matrix, GLRLM = Gray Level Run Length Matrix, GLSZM = Gray Level Size Zone Matrix, NGTDM = Neighboring Gray Tone Difference Matrix.

I. Spatial domain features

Spatial domain features comprise Shape-based, First Order Statistics, texture

(GLCM, GLDM, GLRLM, GLSZM, NGTDM) features. Definition of these features was listed elsewhere (https://pyradiomics.readthedocs.io/en/latest/features.html). Wavelet features were extracted for each first order features and texture features after applying wavelet filtering to the original images, yielding 8 decompositions per level (LLL, LLH, LHL, HLL, LHH, HLH, HHL, HHH).

II. Sequential features

Sequential features were mainly composed of two parts, including the rate of enhancement of features and some time-varying curve based features. Sequential features were extracted based each spatial domain feature except for the common shape features. Here dyn_0, dyn_1, dyn_2 and dyn_3 represent the mask phase, first enhanced phase, second enhanced phase and third enhanced phase, respectively.

Feature enhancement rate

Feature enhancement rate is the rate of change of features between each two phases during contrast enhancement, which is defined as:

$$Enh(dyn_{\mathrm{i}}, dyn_{\mathrm{j}}) = \frac{dyn_{\mathrm{j}} - dyn_{\mathrm{i}}}{dyn_{\mathrm{i}}}$$

here DYN_{i} represents the feature value of the former phase, and DYN_{j} represents the feature value of the later phase. $Enh(dyn_0, dyn_1)$, $Enh(dyn_1, dyn_2)$, $Enh(dyn_2, dyn_3)$, $Enh(dyn_0, dyn_3)$ were calculated in this study (totally 3348 features).

Time-varying curve based features

Time-varying curve based features indicate the mean, variance, skewness,

kurtosis and entropy of the time-varying curves (totally 3348 features).

1. Mean

$$mean(DYN = [dyn_1 ... dyn_N]) = \frac{1}{N}\sum_{i=1}^{N} dyn_i$$

2. Variance

$$variance(DYN = [dyn_1 ... dyn_N]) = \frac{1}{N-1}\sum_{i=1}^{N} (dyn_i - \overline{DYN})^2$$

3. Skewness

$$skewness(DYN = [dyn_1 ... dyn_N]) = \frac{1}{N}\sum_{i=1}^{N} \left[\frac{dyn_i - \overline{DYN}}{\sigma}\right]^3$$

4. Kurtosis

$$kurtosis(DYN = [dyn_1 ... dyn_N]) = \left\{\frac{1}{N}\sum_{i=1}^{N} \left[\frac{dyn_i - \overline{DYN}}{\sigma}\right]^4\right\} - 3$$

here $N = 4$ corresponds to 4 DCE phases, $\sigma = \sqrt{Var(dyn_1 ... dyn_N)}$ is the distribution's standard deviation.