**Texture analysis methodology**

Texture analysis wad applied to the CT images using in-house software (AK, version 3.2.2, GE Healthcare). A region of interest (ROI) was delineated initially around the tumor outline for the 3D ROI area. 396 imaging texture features from the category of histogram, the Grey level co-occurrence matrix(GLCM), the gray level size zone matrix(GLSZM), the gray level Run-length matrix(RLM), and Shape and size based features were finally extracted from one single image **Table S1.**

**Table S1:**

**Summary of radiomic features used in this study**

|  |  |  |
| --- | --- | --- |
| Feature classes | No. of features | 3 representative features |
| Histogram | 42 | FrequencySize, MaxIntensity, MeanValue,… |
| GLCM | 144 | ClusterProminence, ClusterShade, Correlation,… |
| GLSZM | 11 | SizeZoneVariability, HighIntensityEmphasis, IntensityVariability,… |
| RLM | 180 | GreyLevelNonuniformity, HighGreyLevelRunEmphasis, LongRunEmphasis,… |
| Formfactor | 9 | Compactness1, Maximum3DDiameter, Sphericity,… |
| Haralick | 10 | HaraEntroy, contrast, differenceEntropy,… |
| Total | 396 |  |

GLCM= the Grey level co-occurrence matrix, GLSZM =the gray level size zone matrix, RLM= the gray level Run-length matrix

312 features were considered excellent reproducibility with ICC > 0.75 in intra-and interobserver.

First, The general univariate analysis was used to select features.

parameters setted: {'P value for threshold in': 0.05}

num of remained features: 288

remained features:

[['ShortRunLowGreyLevelEmphasis\_angle45\_offset7']

['Correlation\_angle90\_offset1']

['ClusterShade\_AllDirection\_offset4']

['HaralickCorrelation\_angle45\_offset1']

['HighGreyLevelRunEmphasis\_angle135\_offset4']

['ClusterShade\_angle90\_offset4']

['HaralickCorrelation\_angle90\_offset1']

['ClusterProminence\_angle0\_offset7']

['Correlation\_angle45\_offset7']

['ShortRunEmphasis\_AllDirection\_offset1']

['Inertia\_angle90\_offset7']

['GreyLevelNonuniformity\_angle135\_offset7']

['InverseDifferenceMoment\_angle135\_offset4']

['Sphericity']

['Inertia\_angle135\_offset7']

['HaralickCorrelation\_angle90\_offset7']

['ClusterProminence\_AllDirection\_offset7\_SD']

['GLCMEntropy\_angle0\_offset7']

['GLCMEnergy\_AllDirection\_offset4\_SD']

['ShortRunEmphasis\_angle135\_offset7']

['ShortRunHighGreyLevelEmphasis\_AllDirection\_offset1\_SD']

['Inertia\_AllDirection\_offset1']

['ShortRunEmphasis\_angle45\_offset1']

['GreyLevelNonuniformity\_angle0\_offset4']

['GLCMEntropy\_angle0\_offset1']

['Inertia\_AllDirection\_offset7\_SD']

['GreyLevelNonuniformity\_AllDirection\_offset7']

['Correlation\_AllDirection\_offset7\_SD']

['GreyLevelNonuniformity\_angle90\_offset1']

['GLCMEnergy\_angle135\_offset7']

['RunLengthNonuniformity\_angle45\_offset1']

['HighGreyLevelRunEmphasis\_angle45\_offset4']

['InverseDifferenceMoment\_angle45\_offset4']

['ClusterProminence\_angle45\_offset4']

['differenceEntropy']

['ClusterShade\_AllDirection\_offset7']

['HighGreyLevelRunEmphasis\_AllDirection\_offset4']

['HaralickCorrelation\_angle45\_offset4']

['GreyLevelNonuniformity\_angle45\_offset7']

['RunLengthNonuniformity\_angle135\_offset1']

['Inertia\_AllDirection\_offset1\_SD']

['LowGreyLevelRunEmphasis\_AllDirection\_offset7\_SD']

['HaralickCorrelation\_angle0\_offset4']

['Variance']

['FrequencySize']

['ShortRunLowGreyLevelEmphasis\_angle0\_offset7']

['GLCMEntropy\_angle90\_offset1']

['GreyLevelNonuniformity\_angle90\_offset7']

['InverseDifferenceMoment\_AllDirection\_offset4']

['GLCMEnergy\_angle0\_offset1']

['contrast']

['ShortRunLowGreyLevelEmphasis\_angle45\_offset1']

['LongRunHighGreyLevelEmphasis\_AllDirection\_offset7\_SD']

['ShortRunEmphasis\_angle135\_offset4']

['HighGreyLevelRunEmphasis\_angle45\_offset1']

['histogramEntropy']

['Correlation\_angle0\_offset7']

['Correlation\_AllDirection\_offset1\_SD']

['Inertia\_angle0\_offset4']

['LowGreyLevelRunEmphasis\_angle90\_offset1']

['LowGreyLevelRunEmphasis\_angle135\_offset1']

['LowGreyLevelRunEmphasis\_angle45\_offset4']

['GLCMEntropy\_angle135\_offset7']

['ShortRunEmphasis\_AllDirection\_offset7\_SD']

['InverseDifferenceMoment\_AllDirection\_offset7']

['ShortRunEmphasis\_angle0\_offset7']

['sumVariance']

['LongRunHighGreyLevelEmphasis\_angle0\_offset7']

['InverseDifferenceMoment\_angle45\_offset1']

['LowGreyLevelRunEmphasis\_AllDirection\_offset7']

['VolumeCount']

['LowGreyLevelRunEmphasis\_AllDirection\_offset4']

['VoxelValueSum']

['ClusterProminence\_angle135\_offset1']

['GLCMEnergy\_AllDirection\_offset1']

['LongRunHighGreyLevelEmphasis\_AllDirection\_offset1\_SD']

['HaraVariance']

['ShortRunLowGreyLevelEmphasis\_angle90\_offset1']

['LowGreyLevelRunEmphasis\_angle90\_offset7']

['GLCMEnergy\_angle135\_offset1']

['GLCMEnergy\_angle0\_offset7']

['GLCMEntropy\_angle45\_offset7']

['ClusterProminence\_angle45\_offset1']

['LowGreyLevelRunEmphasis\_angle0\_offset7']

['ShortRunLowGreyLevelEmphasis\_angle90\_offset4']

['inverseDifferenceMoment']

['InverseDifferenceMoment\_angle135\_offset1']

['ClusterShade\_angle45\_offset4']

['LowGreyLevelRunEmphasis\_angle45\_offset1']

['ClusterShade\_AllDirection\_offset4\_SD']

['RunLengthNonuniformity\_angle45\_offset4']

['ShortRunEmphasis\_angle90\_offset4']

['Inertia\_angle45\_offset7']

['HighGreyLevelRunEmphasis\_AllDirection\_offset7']

['ClusterProminence\_angle135\_offset7']

['RunLengthNonuniformity\_angle90\_offset7']

['GreyLevelNonuniformity\_angle0\_offset1']

['ClusterShade\_angle90\_offset1']

['SphericalDisproportion']

['LongRunHighGreyLevelEmphasis\_angle0\_offset1']

['VolumeCC']

['ClusterShade\_AllDirection\_offset1']

['Inertia\_angle135\_offset4']

['HighGreyLevelRunEmphasis\_angle90\_offset1']

['Percentile95']

['ClusterProminence\_AllDirection\_offset1\_SD']

['LongRunEmphasis\_AllDirection\_offset1']

['ClusterProminence\_angle135\_offset4']

['GreyLevelNonuniformity\_angle135\_offset1']

['RunLengthNonuniformity\_angle0\_offset4']

['sumEntropy']

['GLCMEntropy\_AllDirection\_offset1\_SD']

['Inertia\_angle0\_offset7']

['Percentile85']

['HaralickCorrelation\_angle135\_offset1']

['HighGreyLevelRunEmphasis\_angle90\_offset4']

['GreyLevelNonuniformity\_angle0\_offset7']

['GLCMEntropy\_AllDirection\_offset4']

['ClusterProminence\_angle0\_offset1']

['GLCMEnergy\_angle0\_offset4']

['ShortRunLowGreyLevelEmphasis\_angle135\_offset7']

['LongRunHighGreyLevelEmphasis\_angle135\_offset1']

['InverseDifferenceMoment\_AllDirection\_offset1']

['RunLengthNonuniformity\_angle0\_offset1']

['ClusterProminence\_AllDirection\_offset4']

['GreyLevelNonuniformity\_AllDirection\_offset7\_SD']

['RunLengthNonuniformity\_angle90\_offset1']

['GLCMEnergy\_angle90\_offset7']

['GreyLevelNonuniformity\_AllDirection\_offset4']

['ShortRunEmphasis\_angle0\_offset4']

['GLCMEnergy\_angle45\_offset4']

['ShortRunLowGreyLevelEmphasis\_angle0\_offset1']

['LongRunHighGreyLevelEmphasis\_angle90\_offset4']

['Correlation\_AllDirection\_offset1']

['InverseDifferenceMoment\_angle135\_offset7']

['Inertia\_angle45\_offset1']

['LongRunHighGreyLevelEmphasis\_angle45\_offset1']

['ClusterProminence\_AllDirection\_offset1']

['HaralickCorrelation\_angle0\_offset7']

['ClusterShade\_angle135\_offset7']

['LongRunEmphasis\_AllDirection\_offset4']

['ShortRunLowGreyLevelEmphasis\_AllDirection\_offset1']

['GLCMEntropy\_angle90\_offset7']

['LongRunHighGreyLevelEmphasis\_AllDirection\_offset4\_SD']

['LongRunEmphasis\_AllDirection\_offset4\_SD']

['LongRunEmphasis\_angle90\_offset1']

['ClusterShade\_angle0\_offset7']

['Correlation\_angle45\_offset1']

['Quantile0.975']

['ShortRunEmphasis\_AllDirection\_offset4\_SD']

['HighGreyLevelRunEmphasis\_angle0\_offset1']

['ShortRunLowGreyLevelEmphasis\_angle135\_offset4']

['HaralickCorrelation\_angle135\_offset4']

['ShortRunEmphasis\_AllDirection\_offset4']

['GreyLevelNonuniformity\_angle45\_offset1']

['ShortRunEmphasis\_angle45\_offset7']

['HaralickCorrelation\_AllDirection\_offset1']

['GLCMEntropy\_angle45\_offset1']

['GLCMEnergy\_angle45\_offset7']

['HighGreyLevelRunEmphasis\_angle45\_offset7']

['Compactness1']

['GLCMEnergy\_angle45\_offset1']

['LowGreyLevelRunEmphasis\_angle135\_offset4']

['HaralickCorrelation\_angle45\_offset7']

['HaralickCorrelation\_AllDirection\_offset4']

['Correlation\_angle135\_offset1']

['LongRunLowGreyLevelEmphasis\_AllDirection\_offset1\_SD']

['LongRunEmphasis\_angle0\_offset1']

['Inertia\_angle0\_offset1']

['LongRunEmphasis\_AllDirection\_offset1\_SD']

['InverseDifferenceMoment\_angle90\_offset4']

['Inertia\_angle135\_offset1']

['stdDeviation']

['LongRunHighGreyLevelEmphasis\_angle90\_offset1']

['HighGreyLevelRunEmphasis\_angle135\_offset1']

['ClusterShade\_angle135\_offset4']

['RunLengthNonuniformity\_angle90\_offset4']

['ShortRunLowGreyLevelEmphasis\_AllDirection\_offset7']

['uniformity']

['ShortRunLowGreyLevelEmphasis\_angle135\_offset1']

['SurfaceVolumeRatio']

['GLCMEntropy\_angle45\_offset4']

['RunLengthNonuniformity\_AllDirection\_offset1\_SD']

['RunLengthNonuniformity\_AllDirection\_offset7']

['ClusterShade\_angle135\_offset1']

['LongRunEmphasis\_angle0\_offset4']

['ClusterProminence\_angle45\_offset7']

['HaralickCorrelation\_AllDirection\_offset7']

['GLCMEnergy\_angle90\_offset1']

['ShortRunEmphasis\_angle90\_offset7']

['Inertia\_AllDirection\_offset4']

['InverseDifferenceMoment\_angle90\_offset1']

['RunLengthNonuniformity\_AllDirection\_offset4']

['ShortRunLowGreyLevelEmphasis\_angle0\_offset4']

['Range']

['GreyLevelNonuniformity\_angle90\_offset4']

['LongRunHighGreyLevelEmphasis\_angle45\_offset4']

['VolumeMM']

['GLCMEnergy\_AllDirection\_offset7']

['LowGreyLevelRunEmphasis\_angle90\_offset4']

['GLCMEntropy\_AllDirection\_offset1']

['GLCMEnergy\_AllDirection\_offset1\_SD']

['InverseDifferenceMoment\_angle0\_offset4']

['AngularSecondMoment']

['InverseDifferenceMoment\_angle45\_offset7']

['LowGreyLevelRunEmphasis\_angle45\_offset7']

['LowGreyLevelRunEmphasis\_angle0\_offset1']

['RunLengthNonuniformity\_angle135\_offset4']

['ShortRunLowGreyLevelEmphasis\_AllDirection\_offset4']

['LongRunHighGreyLevelEmphasis\_angle0\_offset4']

['ShortRunEmphasis\_AllDirection\_offset7']

['HaraEntroy']

['ClusterProminence\_angle0\_offset4']

['ClusterProminence\_AllDirection\_offset7']

['SurfaceArea']

['GLCMEntropy\_AllDirection\_offset7']

['HaralickCorrelation\_angle135\_offset7']

['RunLengthNonuniformity\_angle0\_offset7']

['InverseDifferenceMoment\_angle90\_offset7']

['ClusterShade\_AllDirection\_offset7\_SD']

['GreyLevelNonuniformity\_AllDirection\_offset4\_SD']

['RunLengthNonuniformity\_AllDirection\_offset7\_SD']

['RunLengthNonuniformity\_angle45\_offset7']

['RunLengthNonuniformity\_AllDirection\_offset4\_SD']

['LongRunEmphasis\_angle45\_offset1']

['LongRunHighGreyLevelEmphasis\_AllDirection\_offset4']

['ShortRunLowGreyLevelEmphasis\_angle90\_offset7']

['ShortRunEmphasis\_angle90\_offset1']

['ClusterProminence\_angle90\_offset4']

['HighGreyLevelRunEmphasis\_angle0\_offset4']

['ClusterProminence\_angle90\_offset1']

['GLCMEntropy\_angle135\_offset1']

['ShortRunLowGreyLevelEmphasis\_angle45\_offset4']

['histogramEnergy']

['LowGreyLevelRunEmphasis\_AllDirection\_offset1']

['LowGreyLevelRunEmphasis\_angle0\_offset4']

['HaralickCorrelation\_angle0\_offset1']

['GLCMEntropy\_angle0\_offset4']

['ClusterProminence\_AllDirection\_offset4\_SD']

['LongRunHighGreyLevelEmphasis\_AllDirection\_offset1']

['ShortRunLowGreyLevelEmphasis\_AllDirection\_offset7\_SD']

['GLCMEnergy\_angle135\_offset4']

['HaralickCorrelation\_AllDirection\_offset1\_SD']

['ClusterShade\_angle0\_offset1']

['Inertia\_AllDirection\_offset7']

['InverseDifferenceMoment\_angle0\_offset7']

['GreyLevelNonuniformity\_AllDirection\_offset1\_SD']

['ShortRunHighGreyLevelEmphasis\_AllDirection\_offset7\_SD']

['ShortRunEmphasis\_angle45\_offset4']

['Inertia\_angle90\_offset1']

['ShortRunEmphasis\_angle0\_offset1']

['Correlation\_angle0\_offset1']

['sumAverage']

['RunLengthNonuniformity\_angle135\_offset7']

['ClusterShade\_angle0\_offset4']

['GLCMEnergy\_AllDirection\_offset7\_SD']

['differenceVariance']

['HighGreyLevelRunEmphasis\_angle135\_offset7']

['GreyLevelNonuniformity\_AllDirection\_offset1']

['ShortRunHighGreyLevelEmphasis\_AllDirection\_offset4\_SD']

['HighGreyLevelRunEmphasis\_AllDirection\_offset4\_SD']

['GLCMEntropy\_angle90\_offset4']

['Inertia\_angle45\_offset4']

['GreyLevelNonuniformity\_angle45\_offset4']

['RunLengthNonuniformity\_AllDirection\_offset1']

['HighGreyLevelRunEmphasis\_angle0\_offset7']

['Inertia\_angle90\_offset4']

['HighGreyLevelRunEmphasis\_AllDirection\_offset1']

['Inertia\_AllDirection\_offset4\_SD']

['Correlation\_AllDirection\_offset4\_SD']

['GLCMEnergy\_AllDirection\_offset4']

['ClusterShade\_angle45\_offset1']

['HaralickCorrelation\_angle90\_offset4']

['ShortRunLowGreyLevelEmphasis\_AllDirection\_offset4\_SD']

['ShortRunEmphasis\_angle135\_offset1']

['HighGreyLevelRunEmphasis\_angle90\_offset7']

['LowGreyLevelRunEmphasis\_angle135\_offset7']

['Compactness2']

['Correlation\_AllDirection\_offset7']

['GLCMEnergy\_angle90\_offset4']

['ClusterShade\_angle90\_offset7']

['GreyLevelNonuniformity\_angle135\_offset4']

['Percentile90']

['MaxIntensity']

['ClusterProminence\_angle90\_offset7']

['InverseDifferenceMoment\_angle0\_offset1']

['ClusterShade\_angle45\_offset7']

['GLCMEntropy\_angle135\_offset4']]

Then the least absolute shrinkage and selection operator (LASSO) was applied to select

the most useful features from the primary data.

parameters setted: {'alpha': 0.008957598878169343}

num of remained features: 7

remained features:

['Sphericity']

['Inertia\_angle135\_offset7']

['histogramEntropy']

['Correlation\_angle0\_offset7']

['GLCMEntropy\_angle135\_offset7']

['VoxelValueSum']

['MaxIntensity']