## Additional file 1

**Category: Intensity Histogram**

| Variable | Description | Parameters |
|---|---|---|
| Inter Quartile Range | The interquartile range of the occurence probability values in the histogram. | N/A |
| Kurtosis | Measure the peakedness of the occurence probability values in the histogram. | N/A |
| Mean Absolute Deviation | The mean absolute deviation of the occurence probability values in the histogram. | N/A |
| Median Absolute Deviation | The median absolute deviation of the occurence probability values in the histogram. | N/A |
| Percentile | Percentiles of the occurence probability values in the histogram. | Percentile=5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95; |
| Percentile Area | Percentiles of values in the accumulative histogram. | Percentile=5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95; |
| Quantile | Quantiles of the occurence probability values in the histogram. | Quantile=0.025 0.25 0.5 0.75 0.975; |
| Range | Measure the range (Max Value -Min Value) of the occurence probability values in the histogram. | N/A |
| Skewness | Measure the asymmetry of the occurence probability values in the histogram. | N/A |

**Category: shape**

| Variable | Description | Formula | Parameters |
|---|---|---|---|
| Compactness 1 | N/A | (Volume)/(sqrt(pi)*(Surface Area)^(2/3)) | N/A |
| Compactness 2 | N/A | 36*pi*(Volume^2)/((Surface Area)^3) | N/A |
| Convex | 1. Measure the proportion of the pixels in the convex hull that are also in the region.<br>2. Refer to MATLAB "regionprops (Mask, 'Solidity')" for details | 1. Compute convex value in 2D slice-by-slice. Convex=regionprops (2DMask, 'Solidity')<br>2. Compute the mean of convex value among the slices. | N/A |
| Convex Hull Volume | The mean volume of the 2D convex hulls that are the convex envelopes of each slice's binary mask. | N/A | N/A |
| Convex Hull Volume3D | 3D volume of the convex hull that is the convex envelope of binary mask. | N/A | N/A |
| Mass | Mass caculation is only meaningful to CT images. | N/A | N/A |
| Max3D Diameter | Max3DDiameter= largest pairwise Euclidean | N/A | N/A |

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|---|---|---|---|
| | distance between voxels on the surface of the tumor volume. | | |
| Mean Breadth | MeanBreath=Integral of mean curvature | N/A | N/A |
| Number of Objects | N/A | N/A | N/A |
| Number of Voxel | The number of voxels treating the edge voxels differently. | N/A | Edge Voxel Fraction=0.5; |
| Orientation | 1. Measure the angle between the x-axis and the major axis of the ellipse in 2D.<br>2. Refer to MATLAB "regionprops (Mask, 'Orientation')" for details | 1. First, compute orientation value in 2D slice-by-slice. Orientation=regionprops(2D Mask, 'Orientation')<br>2. Then, compute the mean of orientation value among the slices. | N/A |
| Roundness | 1. Measure how much the binary mask is close to circle in 2D.<br>2. Refer to MATLAB "regionprops(Mask, 'Eccentricity')" for details | 1. First, compute roundness value in 2D slice-by-slice. Roundness=1-regionprops(2DMask, 'Eccentricity')<br>2. Then, compute the mean of roundness value among the slices. | N/A |
| Spherical Disproportion | N/A | N/A | N/A |

| | | | |
|---|---|---|---|
| Sphericity | N/A | N/A | N/A |
| Surface Area | The surface area of the binary mask. | N/A | N/A |
| Surface Area Density | Surface Area Density == Surface Volume Ration in Hugo's paper below. | (surface area of the binary mask)/(volume of the binary mask). | N/A |
| Volume | The physical volume treating the edge voxels differently. | N/A | Edge Voxel Fraction =0.5; |
| Voxel Size | The physical voxel size. | N/A | N/A |

**Category: Gray Level Cooccurence Matrix 25**

| Variable | Description |
|---|---|
| Auto Correlation | Auto Correlation =-333-1, -333-4, -333-7, 0-1, 0-4, 0-7, 45-1,45-4,45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Cluster Prominen | Cluster Prominen= -333-1, -333-4, -333-7, 0-1, 0-4, 0-7, 45-1,45-4,45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Cluster Shade | Cluster Shade= -333-1,-333-4,-333-7,0-1,0-4,0-7,45-1, 45-4, 45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Cluster Tendendcy | Cluster Tendendcy=-333-1,-333-4,-333-7,0-1,0-4,0-7, 45-1, 45-4,45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Contrast | Contrast=-333-1,-333-4,-333-7, 0-1, 0-4, 0-7, 45-1, 45-4, 45-7, 90-1,90-4,90-7,135-1,135-4,135-7, |
| Correlation | Correlation=-333-1,-333-4,-333-7, 0-1, 0-4, 0-7, 45-1, 45-4, 45-7, 90-1,90-4,90-7,135-1,135-4,135-7, |
| Difference Entropy | Difference Entropy=-333-1,-333-4,-333-7, 0-1, 0-4, 0-7, 45-1, |

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|---|---|
| | 45-4,45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Dissimilarity | Dissimilarity=-333-1,-333-4,-333-7, 0-1, 0-4, 0-7, 45-1, 45-4, 45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Energy | Energy=-333-1,-333-4,-333-7, 0-1, 0-4, 0-7, 45-1, 45-4, 45-7, 90-1,90-4,90-7,135-1,135-4,135-7, |
| Entropy | Entropy=-333-1,-333-4,-333-7, 0-1, 0-4, 0-7, 45-1, 45-4, 45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Homogeneity | Homogeneity=-333-1,-333-4,-333-7, 0-1, 0-4, 0-7, 45-1, 45-4, 45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Homogeneity2 | Homogeneity2=-333-1,-333-4,-333-7,0-1, 0-4, 0-7, 45-1, 45-4,45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| InformationMeasureCorr1 | InformationMeasureCorr1=-333-1,-333-4,-333-7,0-1, 0-4, 0-7,45-1,45-4,45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| InformationMeasureCorr2 | InformationMeasureCorr2=-333-1,-333-4,-333-7,0-1, 0-4,0-7,45-1,45-4,45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Inverse Diff Moment Norm | Inverse Diff Moment Norm=-333-1,-333-4,-333-7,0-1, 0-4, 0-7,45-1,45-4,45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Inverse Diff Norm | Inverse Diff Norm=-333-1,-333-4,-333-7,0-1,0-4,0-7, 45-1,45-4,45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Inverse Variance | Inverse Variance=-333-1,-333-4,-333-7,0-1,0-4,0-7,45-1, 45-4,45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Max Probability | Max Probability=-333-1,-333-4,-333-7, 0-1, 0-4, 0-7, 45-1, 45-4, 45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Sum Average | Sum Average=-333-1,-333-4,-333-7, 0-1, 0-4, 0-7, 45-1, 45-4, 45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Sum Entropy | Sum Entropy=-333-1,-333-4,-333-7, 0-1, 0-4, 0-7, 45-1, 45-4, |

| | |
|---|---|
| | 45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Sum Variance | Sum Variance=-333-1,-333-4,-333-7, 0-1, 0-4, 0-7, 45-1, 45-4, 45-7,90-1,90-4,90-7,135-1,135-4,135-7, |
| Variance | Variance=-333-1,-333-4,-333-7, 0-1, 0-4, 0-7, 45-1, 45-4, 45-7,90-1,90-4,90-7,135-1,135-4,135-7, |

**Category: Gray Level Run Length Matrix 25**

| Variable | |
|---|---|
| Gray Level Non uniformity | Gray Level Non uniformity=-33,0,90 |
| High Gray Level Run Empha | High Gray Level Run Empha=-33,0,90 |
| Long Run Emphasis | Long Run Emphasis=-33,0,90 |
| Long Run High Gray Level Empha | Long Run High Gray Level Empha=-33,0,90 |
| Long Run Low Gray Level Empha | Long Run Low Gray Level Empha=-33,0,90 |
| Low Gray Level Run Empha | Low Gray Level Run Empha=-33,0,90 |
| Run Length Non uniformity | Run Length Non uniformity=-33,0,90 |
| Run Percentage | Run Percentage=-33,0,90 |
| Short Run Emphasis | Short Run Emphasis=-33,0,90 |
| Short Run High Gray Level Empha | Short Run High Gray Level Empha=-33,0,90 |
| Short Run Low Gray Level Empha | Short Run Low Gray Level Empha=-33,0,90 |