

Effect of pre-processing on radiomics features estimation from computed tomography imaging in patients with rectal cancer.

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Radiomics: Images Are More than Pictures, They Are Data

"high-throughput extraction of **quantitative features** that result in the conversion of images into *mineable data* and the subsequent analysis of these data for decision support." a

^aGillies RJ et al. Radiomics: Images Are More than Pictures, They Are Data. doi:10.1148/radiol.2015151169



Deng, J. (Ed.), Xing, L. Big Data in Radiation Oncology. doi:10.1201/9781315207582

Images:

Computed tomography images of 20 representative patients with **rectal cancer**, undergoing preoperative radiotherapy.

Gross tumor volume manually segmented by a radiation oncologist



CT acquisitions: Scanner

Acquisition type Tube voltage Tube load Slice thickness Pixel size Matrix

GE LightSpeed RT16 Helical 120 kVp 140-170 mAs 5 mm 0.82-1.27 mm 512×512

105 **features** divided into 7 classes:

14 shape

18 first-order

22 Gray Level Co-occurrence Matrix (glcm)



14 Gray Level Dependence

Matrix (gldm)

16 Gray Level Run Length Matrix (glrlm)

- 16 Grav Level Size Zone Matrix (glszm)
- - 5 Neighbouring Grav Tone

Difference Matrix (ngtdm)

Features estimation with varying image pre-processing:

- Resampling:
 - 6 isotropic voxel sizes: 1, 1.3, 1.6, 1.9, 2.2, 2.5 mm
 - 10 interpolation algorithms: BSpline (BS), BlackmanWindowedSinc (BL), CosineWindowedSinc (CWS), Gaussian (G), HammingWindowedSinc (HWS), LabelGaussian (LG), LanczosWindowedSinc (LWS), Linear (L), NearestNeighbor (NN), WelchWindowedSinc (WWS)
- Quantization of gray-levels:
 - 6 binwidths: 3, 4, 5, 6, 7, 8 HU

4 analyses:

- Effect of interpolation algorithm for different voxel sizes
- 2 Effect of binwidth for different voxel sizes
- 3 Effect of voxel size for different binwidths
- effect of voxel size for different interpolation algorithms

Statistical analysis

- Intraclass Correlation Coefficient (ICC): two-way mixed effects model, single rater, absolute agreement
- Coefficient of Variation $COV = \frac{\sigma}{|\mu|}$

1) ICC values related to the effect of interpolation algorithm for different voxel sizes



Features are divided into **4 reliability classes** (poor, moderate, good, excellent) according to ICC values.

2) ICC values related to the effect of binwidth for different voxel sizes







d) girim



GrayLeveNonUniformity

HighGrand evenPautE motossis

LongBunHintGravLevelEmphasis

LongRunLowGrast.evelEmphasis

RunLerothNonUniformityNormalized

ShortBucklinhGraul avail[mobasis

ShortRunLowGrayLevelEmphasis

LowGrayLeve/RunEmphasis

RunLengtNonUniformity

LongBunEmphasis

RunEntropy

RunPercentage Burblariance

ShortRunEmphasis

GrayLove/Nor/UniformityNormalized GrayLove/Noriance



g) ngtdm









Radiomics Study description Results Conclusion

3) ICC values related to the effect of voxel size for different binwidths











d) girim











e) glszm





Radiomics Study description Results Conclusion

4) ICC values related to the effect of voxel size for different interpolation algorithms

a) shape



b) first order



e) alszm

GravLeveNorUniformity



g) ngtdm



f) aldm











d) airim



Radiomic features median COV

shape	1	2	3	4
Elongation	0,0	0,0	1,2	1,2
Flatness	0,0	0,0	1,3	1,3
LeastAxisLength	0,0	0,0	1,0	1,0
MajorAxisLength	0,0	0,0	0,6	0,6
Maximum2DDiameterColumn	0,0	0,0	1,1	1,1
Maximum2DDiameterRow	0,0	0,0	0,8	0,8
Maximum2DDiameterSlice	0,0	0,0	0,9	0,9
Maximum3DDiameter	0,0	0,0	0,8	0,8
MeshVolume	0,0	0,0	1,7	1,7
MinorAxisLength	0,0	0,0	0,6	0,6
Sphericity	0,0	0,0	2,8	2,8
SurfaceArea	0,0	0,0	3,1	3,1
SurfaceVolumeRatio	0,0	0,0	2,8	2,8
VaxelValume	0,0	0,0	1,6	1,6
first order	1	2	3	4
10Percentile	50,5	0,0	9,6	9,8
90Percentile	6,5	0,0	0,9	0,8
Energy	0,6	0,0	97,1	97,1
Entropy	3,1	11,8	0,6	0,6
InterquartileRange	8,4	0,0	2,3	2,4
Kurtosis	23,2	0,0	21,8	18,8
Maximum	18,3	0,0	6,5	6,3
MeanAbsoluteDeviation	6,4	0,0	2,1	1,9
Mean	11,0	0,0	1,4	1,4
Median	6,8	0,0	1,0	1,2
Minimum	20,1	0,0	20,0	18,0
Range	16,3	0,0	14,8	14,3
RobustMeanAbsoluteDeviation	7,7	0,0	1,7	1,7
RootMeanSquared	0,3	0,0	0,0	0,0
Skewness	15,5	0,0	12,3	10,3
TotalEnergy	0,6	0,0	1,5	1,5
Uniformity	10,0	30,6	1,3	1,4
Variance	14,6	0,0	7,8	7,0

Note:

1) Effect of interpolation algorithm

- 2) Effect of binwidth
- 3) Effect of voxel size
- 4) Effect of voxel size

glem	1	2	3	4
Autocorrelation	27,9	69,8	31,2	30,4
JointAverage	16,0	34,4	16,5	15,8
ClusterProminence	36,2	132,6	40,6	39,2
ClusterShade	26,6	104,4	30,4	27,2
ClusterTendency	12,6	70,8	13,2	11,9
Contrast	22,0	70,5	25,6	24,9
Correlation	20,7	0,4	29,8	28,1
DifferenceAverage	14,5	35,0	12,7	12,6
DifferenceEntropy	6,5	14,0	5,6	5,5
DifferenceVariance	22,1	70,1	27,1	26,1
JointEnergy	39,8	55,0	7,7	8,3
JointEntropy	4,8	12,3	1,3	1,2
Incl	36,1	7,3	24,7	23,8
Imc2	8,3	6,0	7,4	7,0
ldm	17,7	23,0	9,3	9,9
ldmn	0,1	0,0	0,2	0,2
ld	12,2	16,2	6,4	6,8
ldn	0,6	0,0	1,0	1,0
InverseVariance	11,9	20,1	6,8	6,8
MaximumProbability	46,2	52,2	7,8	8,7
SumEntropy	2,4	10,1	1,6	1,5
SumSquares	14,1	70,7	7,2	6,7
girim	1	2	3	4
GrayLevelNonUniformity	5,9	25,3	94,1	93,7
GrayLevelNonUniformityNormalized	8,0	29,0	1,4	1,6
GrayLeveNariance	13,0	68,3	8,1	7,4
HighGrayLevelRunEmphasis	28,3	70,0	31,4	30,4
LongRunEmphasis	26,0	13,6	10,1	10,5
LongRunHighGrayLevelEmphasis	30,5	56,0	38,6	41,8
LongRunLowGrayLevelEmphasis	73,0	52,6	43,2	40,5
LowGrayLevelRunEmphasis	47,6	40,5	51,4	49,2
RunEntropy	2,6	6,8	2,4	2,4
RunLengthNonUniformity	11,4	11,2	90,6	90,1
RunLengthNonUniformityNormalized	7,4	7,0	4,0	3,9
RunPercentage	5,1	4,3	2,6	2,6
RunVariance	65,8	40,9	35,2	35,2
ShortRunEmphasis	4,0	3,0	1,8	1,8
ShortRunHighGrayLevelEmphasis	29,3	72,8	31,1	29,8
ShortRunLowGrayLevelEmphasis	44,4	38,4	52,6	51,4

Operate information (%) 28.6 13.0 8.4.5 8.4.5 Operate information (%) 13.0 4.0.4 13.0 4.0.4 13.0 Operate information (%) 13.0 4.0.4 13.0 4.0.4 13.0 Operate information (%) 7.2.1 8.0.5 14.0.4 13.0 4.0.4 13.0 Lapportarging conterprises 14.0 13.0 4.0.4 14.0 14.0 Lapportarging conterprises 14.0 14.0 14.0 14.0 14.0 Discript conterprises 14.0 14.0 14.0 14.0 14.0 Discript conterprises 2.3 4.0.4 14.0 <th>glszm</th> <th>1</th> <th>2</th> <th>3</th> <th>4</th>	glszm	1	2	3	4
Operate/allocation/monitage 4.6 2.0 4.0 1.0 Operate/allocation/monitage 2.4 4.0 1.0 1.0 Np/Operate/Descriptions 2.4 7.0 3.0 1.0 Np/Operate/Descriptions 2.4 7.0 3.0 1.0 1.0 Np/Operate/Descriptions 4.1 4.0 4.0 4.0 1.0 Lappolate/Adjotacy.ent/Operate 4.1 4.0 4.0 4.0 1.0 Descriptions 4.0 4.0 4.0 7.0 7.0 Descriptions 2.0 4.0 7.0 7.0 7.0 Des	GrayLevelNonUniformity	25,6	13,6	58,5	56,6
Oper-Control 130 44.0 51.0 51.0 May Oper-Control 27.0 80.0 15.4 130.0 Laponeutgrouteringsias 72.0 80.0 15.4 130.0 Laponeutgrouteringsias 15.2 15.0 15.5 15.6 15.6 Laponeutgrouteringsias 15.2 15.5 15.6 15.5 15.0 Balzoneutoringsime 15.0 15.5 15.6 15.6 15.6 Balzoneutoringsime 15.0 15.6 15.0 15.0 15.0 Balzoneutoringsime 13.0 4.8 15.0 15.0 15.0 Balzoneutoringsime 13.0 4.8 15.0 15.0 15.0 Balzoneutoringsime 13.0 4.0 15.0 15.0 15.0 Scheinering 24.0 30.0 16.0 15.0 15.0 Scheinering 25.0 25.0 25.0 25.0 15.0 Scheinering 25.0 25.0 25.0 25.0 25.0	GrayLevelNonUniformityNormalized	8,6	23,2	6,7	6,3
NAME NAME NAME NAME NAME Lappowerspring EA SA SA SA SA Balacebreichemense EA SA	GrayLevelVariance	19,9	49,4	16,0	13,9
Laponetaryionsi 72.1 89.0 79.4 89.0 Laponetaryionsi 14.2 15.5 16.4 14.4 Laponetaryionsi 14.2 15.5 16.4 14.4 Laponetaryionsi (Sampa Carlowsing) 15.2 15.5 16.4 14.2 Balzonetarionsimplemita 23.0 4.4 15.3 15.3 15.4 Balzonetarionsimplemita 23.0 4.4 15.3 15.4 15.3 Balzonetarionsimplemita 23.0 4.4 23.5 15.4 23.6 15.4 Balzonetarionsimplemita 23.0 4.8 23.5 15.4 23.6 15.4 Zondreange 23.4 3.0 15.4 23.6 15.4 23.6 15.4 23.6 15.4 23.6 15.4 23.6 15.4 23.6 15.4 15.4 23.6 15.4 15.4 15.4 15.4 15.4 15.4 15.4 15.4 15.4 15.4 15.4 15.4 15.4 15.4 15.4	HighGrayLevelZoneEmphasis	30,4	73,0	31,8	31,0
Lappokarding/conjunctimpions 64.1 55.0 16.5 14.6 15.2 14.6 15.2 14.6 15.2 14.6 15.2 14.6 15.2 14.6 15.2 <th15.2< th=""> 15.2 15.2 <t< td=""><td>LargeAreaEmphasis</td><td>72,1</td><td>89,9</td><td>139,4</td><td>138,8</td></t<></th15.2<>	LargeAreaEmphasis	72,1	89,9	139,4	138,8
Lippolarazing configuration 110.2 111.5 112.0 <th1< td=""><td>LargeAreaHighGrayLevelEmphasis</td><td>64,1</td><td>55,9</td><td>146,5</td><td>146,4</td></th1<>	LargeAreaHighGrayLevelEmphasis	64,1	55,9	146,5	146,4
Landbardschörengensis 40,4 47,5 47,5 48,4 48,1 48,	LargeAreaLowGrayLevelEmphasis	105,2	115,5	124,0	126,2
Backbackschlominy 927 45.6 92.4 82.0 Backbackschlomine 2.8 4.8 1.9 7.4 <td< td=""><td>LowGrayLevelZoneEmphasis</td><td>49,4</td><td>47,5</td><td>48,7</td><td>46,0</td></td<>	LowGrayLevelZoneEmphasis	49,4	47,5	48,7	46,0
BiaDavidentiformity 22.6 4.5 7.4 5.7 Biadbaselignity 23.0 7.4 8.7 7.4 Biadbaselignity 45.0 7.4 8.7 7.4 Biadbaselignity 45.0 7.4 8.7 7.4 Biadbaselignity 45.0 7.6 8.4 8.5 9.4 Zondhronzing 4.5 7.4 8.0 9.6 7.4 Zondhronzing 7.4 2.8 8.6 9.6 7.4 Zondhronzing 7.2 7.2 8.6 7.7 7.0 Dependencelinichantemento 6.8 7.8 7.0 7.0 7.0 Dependencelinichantemento 6.8 7.0	SizeZoneNonUniformity	39,7	45,5	52,4	52,0
Bandbackgi/optice/section 223 44 74 <th< td=""><td>SizeZoneNonUniformityNormalized</td><td>22,6</td><td>8,5</td><td>12,5</td><td>13,7</td></th<>	SizeZoneNonUniformityNormalized	22,6	8,5	12,5	13,7
Binal basel (b) c)	SmallAreaEmphasis	32,9	4,4	6,7	7,4
Bandback-deck-deckpoint 50.8 64.9 65.9 64.2 Sconferrego 26.4 30.0 50.9 64.2 Sconferrego 26.4 30.0 50.9 64.2 Sconferrego 26.4 30.0 10.0 10.0 Sconferrego 27.7 2.0 4.0 30.0 10.0 10.0 Sconferrego 27.7 2.0 4.0 4.0 30.0 10.0	SmallAreaHighGrayLevelEmphasis	45,3	78,4	29,9	30,3
Zuedimoping 45 8.0 8.0 8.0 8.0 Zuenheurings 7.4 8.0 8.0 16.2 Zuenheurings 7.4 8.0 16.2 16.2 gene 1 2.5 8.6 3.7 Dependencificity/montp 2.6 8.8 8.4 8.1 Dependencificity/montp 2.6 8.8 8.4 8.1 Dependencificity/montp 2.6 8.8 8.4 8.1 Dependencificity/montp 2.8 8.8 8.4 8.1 Dependencificity/montp 1.8 7.0 7.1 7.2 7.8 Dependencificity/montp 1.8 7.0 7.0 7.5 7.6 7.5 7.6 7.5 7.5 7.5 7.5 7.5 7.6 7.5 7.6 7.5 7.6 7.5 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6 7.6	SmallAreaLowGrayLevelEmphasis	50,8	45,8	53,5	54,4
Zondramspin 24.4 83.0 82.9 84.8 Zondrams 7.4 8.0 16.0 16.0 Zondrams 7.7 2.8 6.0 16.0 Dependencification 2.7 2.8 8.0 16.0 Dependencification 2.8 8.0 8.0 17.0 12.0 Dependencification 10.0 3.00 9.0 12.0 12.0 Operadoncification 10.0 3.00 12.0 12.0 12.0 Operadoncification 10.0 3.00 12.0 12.0 12.0 Operadoncification 10.0 12.0 12.0 12.0 12.0 Operadoncification 10.0 12.0 12.0 12.0 12.0 12.0 Operadoncification 12.0 12	ZoneEntropy	4,5	3,6	6,3	6,0
Zavakukanen 74.8 90.1 90.2 94.2 gelm 1 2 3 4 gelm 1 2.5 3.6 3.7 Departischick/momp 26.8 7.84 4.84 8.18 Departischick/momp 26.8 7.84 4.84 9.24 Departischick/momp 62.8 4.84 4.84 9.24 Operatischick/momp 62.8 4.84 8.18 9.27 9.24 Operatischick/momp 62.8 4.80 9.27 9.25 9.26 9.71 9.24<	ZonePercentage	29,4	38,0	25,9	26,4
gém I Z S 4 Dependencification 2.7 2.8 8.4 8.4 Dependencification 2.8 8.4 8.4 8.4 Dependencification 1.8 3.8 9.7 9.7 9.2 Dependencification 1.8 3.8 9.4	ZoneVariance	74,8	90,3	140,6	140,2
gén 1 2 3 4 Departure dirito d'antimitation d'antination d'antimitation d'antimitation d'antination d'an					
Dependencification 2.7 2.8 8.3 8.4 8.4 Dependencification 2.8 8.4 8.4 8.4 Dependencification 2.8 8.4 8.4 8.4 Dependencification 2.8 8.4 8.4 8.4 Dependencification 1.8 3.80 8.4 8.4 Dependencification 1.8 3.80 8.4 7.4 Dependencification 1.8 3.80 8.4 7.4 Dependencification 1.8 3.8 8.4 7.4 Dependencification 1.8 3.8 8.4 9.4 Dependencification 1.8 3.4 3.2 2.2 1.4 Dependencification 1.8 3.4 <td>gldm</td> <td>1</td> <td>2</td> <td>3</td> <td>4</td>	gldm	1	2	3	4
Dependencision/montportane 28.6 78.6 64.6 81.2 Dependencision/montportane 62.8 43.0 70.7 71.2 Dependencision/montportane 62.8 43.0 70.7 72.7 Opsicambinity/montportane 15.8 70.0 70.8 70.4 Opsicambinity/montportane 15.8 70.0 70.4 70.4 Upsignet/montportane 57.1 47.4 70.4 70.4 Upsignet/montportane 57.1 47.4 70.4 70.4 Upsignet/montportane 57.1 47.4 70.4 70.4 70.4 Upsignet/montportane 58.1 30.3 70.4 70.4 70.4 70.4 Statisficame/montportane 18.8 30.3 70.4 70.4 70.4 70.4 70.4 Statisficame/montportane 18.8 30.4 70.4 70.4 70.4 70.4 70.4 70.4 70.4 70.4 70.4 70.4 70.4 70.4 70.4 70.4 70.4	DependenceEntropy	2,7	2,5	3,6	3,7
Dependencipitariando 28.6 28.4 21.7 12.1 Dependencipitaria 28.6 28.0 21.7 24.2 Objectivativitaria 10.8 28.0 21.7 24.2 Objectivativitaria 10.8 28.0 21.8 7.1 Mp/Objectivativitaria 28.0 68.0 21.4 28.4 UsepSpeanoracity/Objectifytation 21.6 48.0 23.2 23.2 DepEndence/objectifytation 21.6 48.0 23.2 23.2 DemEndence/objectifytation 13.4 23.0 23.2 23.2 DemEndence/objectifytation 13.4 23.4 23.4 23.4 DemEndence/objectifytation 13.8 23.0 23.2 23.2 DemEndence/objectifytation 13.8 23.0 23.2 23.4 DemEndence/objectifytation 23.6 23.6 23.4 23.4 DemEndence/objectifytation 23.6 23.6 24.0 24.0 DemEndence/objectifytation 23.6 23.6 24.	DependenceNonUniformity	20,6	26,8	84,6	83,8
Dependencipation 62.8 40.0 97.0 94.20 Opsignetification 16.5 70.6 70.7 70.7 Opsignetification 16.5 70.6 70.6 70.4 70.4 Opsignetification 17.1 47.4 70.6 70.6 70.6 Upsignetification 17.1 47.4 70.6 70.6 70.6 Upsignetification 18.0 84.0 25.0 70.6 70.6 Upsignetification 18.8 30.2 20.0 80.1	DependenceNonUniformityNormalized	20,6	26,8	12,7	13,6
Oracle and Microsoftwine (MI) 100 90	DependenceVariance	62,8	40,9	21,7	24,2
Object-Methylanica 14.5 70.8 71.8 7.1 7.1 7.1 7.1 Melliong Leeffgrand 16.0 84.0 <td< td=""><td>GrayLevelNonUniformity</td><td>10,0</td><td>30,6</td><td>97,1</td><td>97,0</td></td<>	GrayLevelNonUniformity	10,0	30,6	97,1	97,0
High Graph contemporation 280 69.0 69.1 9.0 89.0 9.0	GrayLevelVariance	14,5	70,8	7,8	7,1
LapsQberndericPhysiks 97,1 42,4 82,6 42,4 LapsQberndericPhysiks 18,8 43,6 52,2 52,8 LapsQberndericPhysiks 18,8 43,6 52,9 52,8 BiniLDspondericPhysiks 13,8 33,8 23,8 43,4 34,4 BiniLDspondericPhysiks 13,8 33,8 12,8 34,4 34,4 BiniLDspondericPhysiks 12,8 14,8 13,4 34,4 34,4 BiniLDspondericPhysiks 12,8 14,8 13,8 32,6 14,7 34,4 BiniLDspondericPhysiks 12,8 14,8 14,8 34,8	HighGrayLevelEmphasis	28,0	69,8	31,4	30,4
LagsDappenderset/producet/producet/ Landpopenderset/conducet/ Landpopenderset/conducet/ Landpopenderset/conducet/ BraitDappenderset/producet/ BraitDappenderset/producet/ BraitDappenderset/ Dappenderset/ Landpopenderset/ L	LargeDependenceEmphasis	57,1	42,4	26,4	27,9
Lagnolgeneration-on-on-fore-difference 94.0 84.0 85.0 98.1 Dandga electrifyeria 81.8 33.8 23.8 23.8 23.8 Bandlopendendifference 13.8 33.8 23.8 23.4 34.4 Bandlopendendifference 23.8 13.8 33.8 23.8 13.4 Bandlopendendifference 23.8 14.8 13.8 33.4 34.4 Bandlopendendifference 23.8 14.8 13.8 34.4 34.4 Bandlopendendifference 1 2 2 2.4 14.8 14.5 <	LargeDependenceHighGrayLevelEmphasis	55,1	19,6	47,5	50,2
Londary development 45.8 40.2 5.0 42.1 BirdExperidencifyEnd 14.0 30.2 2.9 2.1 BirdExperidencifyEnd 4.1 10.4 31.4 3.4 BirdExperidencifyEnd 4.1 10.4 31.4 3.4 BirdExperidencifyEnd 4.1 10.4 31.4 3.4 BirdExperidencifyEnd 4.2 3.6 4.1 4.5 BirdExperidencifyEnd 4.2 5.0 4.1 4.5 Bayman 4.2 3.6 5.7 5.1 Constance 2.8 3.6 4.2 5.0 4.1 Constance 2.8 3.6 4.2 5.0 4.2 Constance 2.1 4.0 4.2 4.0 4.0 4.0 Serupin 2.1 4.2 4.0 4.0 4.0 4.0	LargeDependenceLowGrayLevelEmphasis	98,0	84,3	25,2	25,8
Binal ComponentifyInteals 01.8 03.8 03.9 02.9 02.11 Binal ComponentifyInteals 01.6 01.4 01.5 01.6 01.5 01.6 01.5 01.6 01.5 01.6 01.4 01.5 01.4 01.5 01.4 01.5 01.6 01.5 01.6 01.5 01.6 01.5 01.6 01.5 01.6 01.5 01.6 01.5 01.5 01.6 01.5 01.6 01.6 01.5 01.6 01.6 01.6 01.6 01.6 01.6 01.6 01.6 01.6 01.6 01.6 01.6 01.6 01.6 01.	LowGrayLevelEmphasis	45,8	40,2	51,0	49,1
BindExpediences/philos/LevelEmpaise 41.1 102.4 11.4 12.4 12.4 multidepediences/philos/LevelEmpaise 23.8 23.6 24.5 25.6 27.4 mpdin 1 2 3 4 20.6 51.8 51.8 51.8 51.8 51.8 51.8 51.8 52.8	SmallDependenceEmphasis	31,8	33,3	22,9	23,1
Smithopeninocdex/Graphene/Entrophane 22.6 14.2 0.7 0.7 rg/mm 1 2 0.4 1 2 0.4 Baryness 42.2 0.5 0.57 51.8 0.2 0.5 0.2 0.5 0.2	SmallDependenceHighGrayLevelEmphasis	46,1	102,4	31,4	31,4
regidem 1 2 3 4 Baryness 482 50.4 51.7 51.8 Coursenance 22.4 5.5 6.5 6.5 Complashy 54.2 6.5 6.5 2.2.4 Contrast 22.1 4.3 42.7 4.5 Sworgh 27.2 5.8 31.8 20.2	SmallDependenceLowGrayLevelEmphasis	23,6	14,3	67,9	67,6
region 1 2 3 4 Busyness 42.2 50.6 51.7 51.8 Conseners 28.8 0.5 61.1 66.5 Complexity 34.2 80.8 25.9 22.4 Contract 23.1 84.5 40.7 45.6 Simuph 31.7 63.8 10.8 20.1					
Burynesa 46,2 50,6 51,7 51,8 Contraress 22,8 0,5 68,1 68,5 Complexity 34,2 69,8 22,4 0,8 Contrast 22,1 48,3 40,7 48,5 Swingth 37,2 51,8 31,8 20,2	ngtdm	1	2	3	4
Coarsensis 22.8 0.5 68.1 68.5 Complexity 34.2 89.8 25.9 22.4 Contrast 23.1 46.3 40.7 48.5 Strength 37.2 51.8 31.8 32.0	Busyness	48,2	50,6	51,7	51,8
Complexity 34.2 89.8 25.9 22.4 Contrast 23.1 48.3 49.7 48.5 Strength 37.2 51.8 31.8 32.0	Coarseness	22,8	0,5	68,1	68,5
Contrast 23,1 48,3 49,7 48,5 Strength 37,2 51,8 31,8 32,0	Complexity	34,2	89,8	25,9	22,4
Strength 37,2 51,8 31,8 32,0	Contrast	23,1	48,3	49,7	48,5
	Strength	37,2	51,8	31,8	32,0

Conclusion



The estimation of radiomics features in rectal cancer from CT imaging appreciably **depends on pre-processing**, in terms of *resampling voxel size*, *interpolation algorithm* and *quantization binwidth*.

- **ICC analysis** shows that more than half of the radiomic features have *poor* or *moderate* reliability,
- A number of features with good ICC values (ICC >0.75) presents a median COV>25%

Image pre-processing effect should be taken into account when planning a clinical study, comparing results from different studies and performing multicentric studies.