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***Research article***

**Development of a nomograph integrating radiomics and deep features based on MRI to predict the prognosis of high grade Gliomas**

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**Appendix**

***Appendix A1***

Appendix A1 contains the 107 radiomics features that were extracted using PyRadiomics. They are subdivided into the following classes:

**First Order Statistics (18 features)**

1. 10Percentile

2. 90Percentile

3. Energy

4. Entropy

5. Interquartile Range

6. Kurtosis

7. Maximum

8. Mean Absolute Deviation

9. Mean

10. Median

11. Minimum

12. Range

13. Robust Mean Absolute Deviation

14. Root Mean Squared

15. Skewness

16. Total Energy

17. Uniformity

18. Variance

**Shape-based (2D and 3D) (14 features)**

1. Major Axis Length

2. Minor Axis Length

3. Elongation

4. Mesh Volume

5. Voxel Volume

6. Surface Area

7. Sphericity

8. Maximum2DDiameter (Slice)

9. Maximum2DDiameter (Column)

10. Maximum2DDiameter (Row)

11. Maximum3DDiameter

12. Flatness
13. Least Axis Length
14. Surface Volume Ratio

**Gray Level Co-occurrence Matrix (24 features)**

1. Autocorrelation
2. Cluster Prominence
3. Cluster Shade
4. Cluster Tendency
5. Contrast
6. Correlation
7. Difference Average
8. Difference Entropy
9. Difference Variance
10. Inverse Difference
11. Inverse Difference Moment
12. Inverse Difference Moment Normalized
13. Inverse Difference Normalized
14. Informational Measure of Correlation 1
15. Informational Measure of Correlation 2
16. Inverse Variance
17. Joint Average
18. Joint Energy
19. Joint Entropy
20. Maximal Correlation Coefficient
21. Maximum Probability
22. Sum Average
23. Sum Entropy
24. Sum Squares

**Gray Level Run Length Matrix (16 features)**

1. Gray Level Non-Uniformity
2. Gray Level Non-Uniformity Normalized
3. Gray Level Variance
4. High Gray Level Run Emphasis
5. Long Run Emphasis
6. Long Run High Gray Level Emphasis
7. Long Run Low Gray Level Emphasis
8. Low Gray Level Run Emphasis
9. Run Entropy
10. Run Length Non-Uniformity
11. Run Length Non-Uniformity Normalized
12. Run Percentage
13. Run Variance
14. Short Run Emphasis
15. Short Run High Gray Level Emphasis
16. Short Run Low Gray Level Emphasis

**Gray Level Size Zone Matrix (16 features)**

1. Gray Level Non-Uniformity
2. Gray Level Non-Uniformity Normalized
3. Gray Level Variance
4. High Gray Level Zone Emphasis
5. Large Area Emphasis
6. Large Area High Gray Level Emphasis
7. Large Area Low Gray Level Emphasis
8. Low Gray Level Zone Emphasis
9. Size Zone Non-Uniformity
10. Size Zone Non-Uniformity Normalized
11. Small Area Emphasis
12. Small Area High Gray Level Emphasis
13. Small Area Low Gray Level Emphasis
14. Zone Entropy
15. Zone Percentage
16. Zone Variance

**Neighbouring Gray Tone Difference Matrix (5 features)**

1. Busyness

2. Coarseness

3. Complexity

4. Contrast

5. Strength

**Gray Level Dependence Matrix (14 features)**
1. Dependence Entropy
2. Dependence Non-Uniformity
3. Dependence Non-Uniformity Normalized
4. Dependence Variance
5. Gray Level Non-Uniformity
6. Gray Level Variance
7. High Gray Level Emphasis
8. Large Dependence Emphasis
9. Large Dependence High Gray Level Emphasis
10. Large Dependence Low Gray Level Emphasis
11. Low Gray Level Emphasis
12. Small Dependence Emphasis
13. Small Dependence High Gray Level Emphasis
14. Small Dependence Low Gray Level Emphasis

***Appendix A2***

Kernel size of each layer of 3D-ResNet50.

|  |  |
| --- | --- |
| layer name | 3D-ResNet50 |
| conv1 | 7×7×7, 64, stride 2 |
| conv2\_x | 3×3×3 max pool, stride 2 |
| $$\left[\begin{matrix}1×1×1,&64\\3×3×3,&64\\1×1×1,&256\end{matrix}\right]×3$$ |
| conv3\_x | $$\left[\begin{matrix}1×1×1,&128\\3×3×3,&128\\1×1×1,&512\end{matrix}\right]×4$$ |
| conv4\_x | $$\left[\begin{matrix}1×1×1,&256\\3×3×3,&256\\1×1×1,&1024\end{matrix}\right]×6$$ |
| conv5\_x | $$\left[\begin{matrix}1×1×1,&512\\3×3×3,&512\\1×1×1,&2048\end{matrix}\right]×3$$ |
| max pooling | max pool, 2048-d fc |

1×1×1, 3×3×3 and 7×7×7 in the table are the size of the convolution kernel; 64, 128, 256, 1024 and 2048 are the number of channels output after each convolution; The network structure contained in each square bracket is a “bottleneck” building block，take conv3\_x for example as shown in Fig. 1.



**Figure 1.** A “bottleneck” building block for 3D-ResNet50. Bottleneck is designed to reduce the number of parameters. Considering the cost of calculation, the calculation of the residual block is optimized, that is, the convolutional layer is designed to be 1x1x1 + 3x3x3 + 1x1x1. First, the dimension is reduced by the convolution kernel of 1x1x1, and the result is input to the intermediate layer, and then restored under the convolutional layer of 1x1x1, which not only maintains the accuracy but also reduces the amount of calculation. The first 1x1x1 convolution reduces the 512-dimensional channel to 128 dimensions, and then recovers the 512 dimensions by 1x1x1 convolution at the end.

***Appendix A3***

**The details of the R-packages used in the research**

**1. Formula:**

**Description** Infrastructure for extended formulas with multiple parts on the right-hand side and/or multiple responses on the left-hand side (see).

**Depends** R (>= 2.0.0), stats

**License** GPL-2 | GPL-3

**NeedsCompilation** no

**2. ggplot2:**

**Description**

A system for 'declaratively' creating graphics, based on ``The Grammar of Graphics''. You provide the data, tell 'ggplot2' how to map variables to aesthetics, what graphical primitives to use, and it takes care of the details.

**Depends** R (>= 3.2)

**Imports** digest, glue, grDevices, grid, gtable (>= 0.1.1), isoband, MASS, mgcv, rlang (>= 0.3.0), scales (>= 0.5.0), stats, tibble, withr (>= 2.0.0)

**Suggests** covr, dplyr, ggplot2movies, hexbin, Hmisc, knitr, lattice, mapproj, maps, maptools, multcomp, munsell, nlme, profvis, quantreg, RColorBrewer, rgeos, rmarkdown, rpart, sf (>= 0.7-3), svglite (>= 1.2.0.9001), testthat (>= 2.1.0), vdiffr (>= 0.3.0)

**Enhances** sp

**License** GPL-2 | file LICENSE

**3. glmnet:**

**Description** Extremely efficient procedures for fitting the entire lasso or elastic-net regularization path for linear regression, logistic and multinomial regression models, Poisson regression, Cox model, multiple-response Gaussian, and the grouped multinomial regression. There are two new and important additions. The family argument can be a GLM family object, which opens the door to any programmed family. This comes with a modest computational cost, so when the built-in families suffice, they should be used instead. The other novelty is the relax option, which refits each of the active sets in the path unpenalized. The algorithm uses cyclical coordinate descent in a path-wise fashion, as described in the papers listed in the URL below.

**Depends** R (>= 3.6.0), Matrix (>= 1.0-6)

**Imports** methods, utils, foreach, shape, survival

**Suggests** knitr, lars, testthat

**License** GPL-2

**VignetteBuilder** knitr

**Encoding** UTF-8

**4. grid:**

**Description** grid adds an nx by ny rectangular grid to an existing plot.

**5. Hmisc:**

**Description** Contains many functions useful for data analysis, high-level graphics, utility operations, functions for

computing sample size and power, importing and annotating datasets, imputing missing values, advanced table making, variable clustering, character string manipulation, conversion of R objects to LaTeX and html code,

and recoding variables.

**Depends** lattice, survival (>= 3.1-6), Formula, ggplot2 (>= 2.2)

**Imports** methods, latticeExtra, cluster, rpart, nnet, foreign, gtable, grid, gridExtra, data.table, htmlTable (>= 1.11.0), viridis, htmltools, base64enc

**Suggests** acepack, chron, rms, mice, tables, knitr, plotly (>= 4.5.6), rlang, plyr

**License** GPL (>= 2)

**LazyLoad** Yes

**6. lattice:**

**Description** A powerful and elegant high-level data visualization system inspired by Trellis graphics, with an emphasis on multivariate data. Lattice is sufficient for typical graphics needs, and is also flexible enough to handle most nonstandard requirements.

**Depends** R (>= 3.0.0)

**Imports** grid, grDevices, graphics, stats, utils

**Suggests** KernSmooth, MASS, latticeExtra

**Enhances** chron

**LazyLoad** yes

**LazyData** yes

**License** GPL (>= 2)

**7. rms:**

**Description** Regression modeling, testing, estimation, validation, graphics, prediction, and typesetting by storing enhanced model design attributes in the fit. 'rms' is a collection of functions that assist with and streamline modeling. It also contains functions for binary and ordinal logistic regression models, ordinal models for continuous Y with a variety of distribution families, and the Buckley-James multiple regression model for right-censored responses, and implements penalized maximum likelihood estimation for logistic and ordinary linear models. 'rms' works with almost any regression model, but it was especially written to work with binary or ordinal regression models, Cox regression, accelerated failure time models, ordinary linear models,the Buckley-James model, generalized least squares for serially or spatially correlated observations, generalized linear models, and quantile regression.

**Depends** R (>= 3.5.0), Hmisc (>= 4.3-0), survival (>= 3.1-12), lattice, ggplot2 (>= 2.2), SparseM

**Imports** methods, quantreg, rpart, nlme (>= 3.1-123), polspline, multcomp, htmlTable (>= 1.11.0), htmltools, MASS, cluster, digest

**Suggests** boot, tcltk, plotly (>= 4.5.6), knitr, mice, rmsb

**License** GPL (>= 2)

**8. survival:**

**Description** Contains the core survival analysis routines, including definition of Surv objects, Kaplan-Meier and Aalen-Johansen (multi-state) curves, Cox models, and parametric accelerated failure time models.

**Depends** R (>= 3.4.0)

**Imports** graphics, Matrix, methods, splines, stats, utils

**LazyData** Yes

**LazyLoad** Yes

**ByteCompile** Yes

**License** LGPL (>= 2)

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