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Repeatability of FDG PET/CT based radiomic features using wavelet and Laplacian of Gaussian filters

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accurately adjusted relative to the fixated animal head. The collimator was optimized by Monte Carlo (FLUKA) based beam simulation in water and on CT scans. Doses were weighted by LEM I and IV model predictions. Lateral and depth dose distributions in the original collimation geometry were validated by combined dosimetry with gafchromic films and ionization chambers.

Results

Placement of animals and collimators is rapid, precise and easily reproducible. The entrance field exhibits a lateral dose fall off x80-x20= 0.3 mm (oxygen) to 1.1 mm (protons), see also Fig. 1a. We obtain highly pristine Bragg peaks with very low ion beam energies of 48.12, 50.57, 88.83 and 103.77 MeV/u for protons, helium, carbon and oxygen ions respectively, requiring range shifting by 11.15, 12.59, 10.93 and 10.78 mm PMMA for a residual range R80 of 4 mm. The Bragg peaks are highly similar in beam direction for all ion types (distal dose fall off z80-z20= 1.24±0.02 mm and peak width w80 = 2.15±0.01 mm), only protons show a slightly wider peak (2.51 mm) and a steeper fall off (1.11mm), see Fig. 1b. Very high LET variations can be achieved. Dosimetric film measurements show a dose homogeneity of ±2.0%.

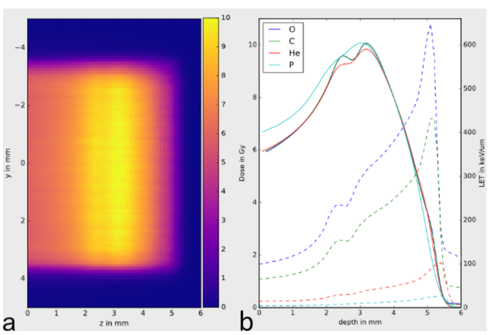

Fig. 1: Dose distribution obtained by Monte Carlo simulation in water. a) Projected dose distribution for He Ions. b) Depth-dose curves (solid lines) and depth-LET curves (dotted lines) for the four studied ion types.

Conclusion

We have shown that conformity of dose distributions between highly different ion types is achievable. The proposed setup allows a detailed examination of biological effects at the distal end of the Bragg peak, thus providing valuable in-vivo data of high RBE irradiation.

EP-1939 Repeatability of FDG PET/CT based radiomic features using wavelet and Laplacian of Gaussian filters

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Purpose or Objective

Pre-processing of medical images prior to radiomics feature analysis is an important step which is often under-analyzed or documented. One aspect is the use of filtering, which has sometimes been applied to yield (more) significant correlations [1]. Here we analyze the value of a filtering process in terms of repeatability of radiomics features in a prospective scan-rescan study of non-small cell lung cancer (NSCLC) patients [2]. Furthermore, we report how the features depend on the applied filtering.

Material and Methods

We compare the repeatability of 51 radiomic features, extracted from unfiltered and filtered images, using 8 commonly applied wavelet and 10 Laplacian of Gaussian (LoG) filters. 19 patients were included in a previously published study of both free-breathing PET/CT and deep inspiration breath hold PET/CT. Both breathing modalities were repeated a few days apart without any active therapy in between to form a scan-rescan study [2]. CT images were discretized in 64 bins with saturation thresholds at ±465 Hounsfield Units [HU]. The PET images were converted into square root SUV maps, and discretized in 64 bins with saturation thresholds at √SUV=±3.2. For the computation of the features, a Matlab radiomics package was used, originally developed by Martin Vallieres [3], although several adjustments to the original script were introduced. Repeatability of the features was based on Pearsons intraclass correlation coefficient (ICC), and the dependence between features with different filters was assessed with Spearmans rank correlation coefficient.

Results

Most features were found to be more robust on original scan than features based on commonly used, LoG or wavelet filters, cf. Figure 1. On CT, the average ICC for the LoG-based features was 0.91±0.12, 0.81±0.30 for the wavelet-based, and 0.92±0.10 for the unfiltered. The ICC differences across the different filters were consistent between PET and CT. Features extracted from images based on the same filter type, were found to be highly correlated, as shown in figure 2.

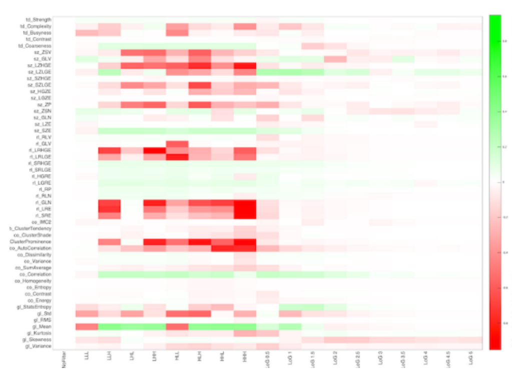

Figure 1: Comparison of repeatability of filter-based features to un- filtered. The values of the heatmap are produced by subtracting the ICC (Pearson) of the filtered features from the unfiltered ones, on CT.

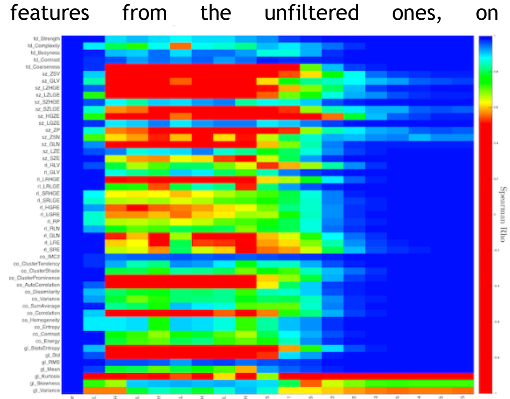

Figure 2: Spearman's rank correlation between features obtained from differently filtered images, in relation to unfiltered, on CT.

Conclusion

Most of the investigated radiomic features were found to be more robust without the use of any image filters.

Because of the high dependence across features extracted from images based on the same filter type, the number of redundant features may be reduced in future studies.

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EP-1940 Impact of respiratory motion on the robustness of 18F-FDG PET/CT radiomic features

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Purpose or Objective

We investigate the repeatability of 18F-FDG PET/CT radiomic features, based on scans obtained in deep inspiration breath-hold (DIBH) and free breathing (FB) in a prospective scan-rescan study of patients with non-small-cell lung cancer (NSCLC) [1].

Material and Methods

18F-FDG PET/CT scans from 19 NSCLC patients were analyzed. DIBH and FB scans were obtained twice, a few days apart, with the same fixation in a prospective study without any active treatment between scans [1]. CT images were discretized in 64 bins with saturation thresholds at ±465 Hounsfield Units [HU]. The PET images were converted into square root SUV maps, and discretized using a fixed bin width of 0.03����√(g/ml). For the computation of the features, a Matlab radiomics package was used, originally developed by Martin Vallieres [2], although several adjustments to the original script were introduced. The evaluation of the feature repeatability was based on Fisher's intraclass correlation coefficient(ICC).

Results

Breathing modality (FB or DIBH) affected the value of many features. However, DIBH vs. FB have negligible impact on the repeatability, as long as the respiratory patterns are not interchanged. The results on the repeatability of the most stable, and least codependent features, are shown in table 1, while the mean effect is shown in figure 1. Additionally, CT-based features were found to be more stable as compared to PET-based features.

CT

Features	DIBH	FB	Mixed
sh volume	0.992	0.995	0.993
gl Variance	0.965	0.976	0.906
co Entropy	0.950	0.970	0.873
co Correlation	0.910	0.919	0.869
rl LRHGE	0.982	0.993	0.695
sz GLN	0.980	0.984	0.962
sz SZHGE	0.936	0.968	0.916
td Complexity	0.949	0.905	0.912
td Strength	0.966	0.956	0.983

PET

Features	DIBH	FB	Mixed
sh volume	0.989	0.993	0.994
sh solidity	0.939	0.741	0.692
co Entropy	0.934	0.947	0.902
co Homogeneity	0.905	0.933	0.884
co Variance	0.838	0.864	0.841
rl RP	0.876	0.946	0.856
rl SRLGE	0.887	0.933	0.907
sz SZLGE	0.948	0.854	0.694
td Strength	0.935	0.873	0.811

Table 1: Feature ICC (Fisher) values, calculated from DIBH and FB scans on PET and CT, of the most stable and least codependent features. "Mixed" corresponds to interchanged patterns, where the ICC is calculated between one day of DIBH and one of FB.

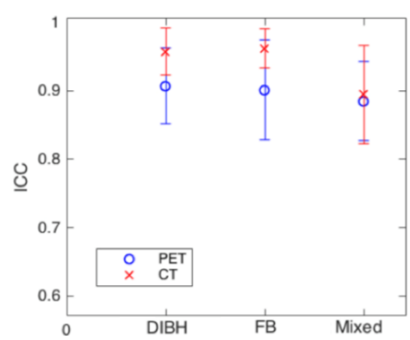

Figure 1: Mean ICC comparison of the features extracted from different respiratory patterns and imaging modalities (shown in table 1), where the errorbars represent ±one standard deviation. "Mixed", corresponds to interchanged patterns, where the ICC is calculated between one day of DIBH and one day of FB.

Conclusion

The majority of feature values are affected by the use of different respiratory patterns. When it comes to feature robustness, our data found no support to choose DIBH over FB. To maximize feature reproducibility upon multiple scannings, it is advisable to maintain a consistent respiratory pattern.

References

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EP-1941 MRI-based radiogenomics analysis of 1p/19q codeletion in grade II and III gliomas

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