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Enhancing Radiomics in Shoulder US: The Impact of Image Pre-Processing

Radiomics, the extraction of quantitative features from medical images, has gained prominence in diagnostic and prognostic modelling, particularly in CT and MRI. However, its application in ultrasound imaging, especially in musculoskeletal (MSK) imaging, remains limited due to the inherent variability of ultrasound acquisition. Factors such as operator dependency and variations in imaging settings present challenges in ensuring reproducible radiomic features. The variability in image acquisition can significantly impact the consistency of extracted data, which is essential for the clinical utility of radiomics in ultrasound.

In the context of shoulder ultrasound, the assessment of calcific tendinopathy can benefit from improved feature reproducibility. A recent study published in the *Journal of Imaging Informatics in Medicine* investigates whether commonly used image pre-processing techniques can enhance the reliability of radiomic features, with the aim of improving the quality of ultrasound-based analyses.

The Role of Image Pre-Processing in Ultrasound Radiomics

Ultrasound imaging is widely used for evaluating shoulder pathologies, but the absence of standardised intensity values presents difficulties in achieving consistent radiomic feature extraction. Unlike CT or MRI, where intensity values are inherently standardised, ultrasound images can vary significantly depending on the machine settings, operator technique and probe used. Pre-processing techniques aim to mitigate this issue by enhancing image contrast and standardising intensity distributions. Three pre-processing methods—Histogram Equalisation, Standard Contrast-Limited Adaptive Histogram Equalisation (CLAHE) and Advanced CLAHE—were assessed for their impact on the reproducibility of radiomic features in shoulder ultrasound. Each method offers distinct advantages, with Advanced CLAHE incorporating a dynamically calculated tile grid size to balance contrast enhancement with noise reduction. By applying these techniques to ultrasound images of rotator cuff calcifications, the study evaluates their effectiveness in improving the stability of radiomic features and ensuring more reliable data extraction.

Evaluating Reproducibility of Radiomic Features

The study retrospectively analysed ultrasound images from 84 patients with rotator cuff calcifications. A total of 849 radiomic features were extracted from manually segmented calcifications, and their reproducibility was assessed using the intraclass correlation coefficient (ICC). The results showed that pre-processing significantly influenced the reliability of features, with Advanced CLAHE yielding the highest ICC values, followed by Standard CLAHE and Histogram Equalisation.

The analysis demonstrated that Advanced CLAHE led to more consistent radiomic features across different images, reducing the effect of imaging variability. Wavelet-transformed features, particularly those within the Grey Level Co-occurrence Matrix (GLCM) and Grey Level Run Length Matrix (GLRLM) subgroups, demonstrated robust reproducibility across all pre-processing methods. These features showed less sensitivity to changes in image contrast and intensity variation, making them reliable markers for radiomic analysis. In contrast, shape-based features exhibited lower reproducibility, highlighting the limitations of structural measurements in ultrasound radiomics. Shape features, which depend heavily on the clarity of object boundaries, were more affected by imaging inconsistencies, making them less stable in comparative analysis.

Impact on Clinical and Research Applications

Enhancing the reproducibility of radiomic features in ultrasound imaging has significant implications for clinical and research applications. Reliable radiomic features can improve the consistency of diagnostic assessments, enabling more accurate classification of calcifications based on texture and intensity characteristics. This, in turn, may facilitate the development of automated radiomics-based models for diagnosing and monitoring musculoskeletal conditions. Improved reproducibility means that results obtained from radiomic analyses can be generalised more effectively across different imaging settings, allowing clinicians to make data-driven decisions with greater confidence. Additionally, the findings underscore the importance of selecting appropriate pre-processing methods to ensure robust feature extraction.

Given the variations in ultrasound imaging protocols, standardising pre-processing approaches could contribute to the broader adoption of radiomics in musculoskeletal ultrasound. Ensuring reproducibility in radiomic features is particularly critical for integrating radiomics into clinical workflows, where consistent and interpretable data are essential for decision-making. The ability to extract stable and meaningful features from ultrasound images could advance the use of AI-driven diagnostic models, which rely on high-quality input data for accurate predictions.

The study demonstrates that image pre-processing plays a critical role in improving the reproducibility of radiomic features in shoulder ultrasound. Among the techniques evaluated, Advanced CLAHE proved the most effective in enhancing feature reliability. The ability to achieve higher consistency in radiomic feature extraction through pre-processing can help improve diagnostic accuracy and prognostic assessments in ultrasound imaging. These findings reinforce the necessity of pre-processing in ultrasound-based radiomics and provide a foundation for future research aimed at optimising imaging protocols. Standardising pre-processing techniques may lead to enhanced reliability in radiomic analyses, benefiting both clinical applications and research initiatives.

By improving the reproducibility of radiomic features, ultrasound radiomics can become a more viable tool for musculoskeletal imaging, particularly in assessing calcific tendinopathy. Future studies could explore additional pre-processing techniques and their effects on different anatomical structures, further advancing the potential of radiomics in ultrasound imaging. As the field progresses, the integration of pre-processing methods into routine workflows could enhance the role of radiomics in precision medicine, ensuring more reliable and reproducible imaging analysis.

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