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Comparing Classic to State-of-the-Art Image Features: A Clustering Approach Using Local Binary Patterns and ResNet-18 Features for Lung Ultrasound Video Classification

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Introduction/Background

Lung ultrasound (LUS) is a valuable non-invasive tool for diagnosing respiratory diseases, and the use of AI to support LUS interpretation has been proposed. Automatically interpreting LUS data is complex and requires advanced techniques to detect abnormalities like lung consolidations, especially with limited labeled datasets for training AI models. This study explores using Local Binary Pattern (LBP) features and features computed by a ResNet-18 model in an unsupervised learning context to classify LUS video frames in an efficient way.

Methods/Intervention

The study used 178 LUS videos from 200 patients. LBP and ResNet-18 features were extracted from each video frame to capture texture information for distinguishing abnormal from normal lung patterns (Fig. 1). Both feature sets underwent unsupervised clustering using a k-means clustering approach, with k=2, to identify natural data groupings. The effectiveness of the resulting clusters was assessed by calculating the precision in isolating frames that contained lung consolidations, which was determined by comparing the clusters against clinical data on a frame-by-frame basis.

Results/Outcome

The analysis showed that the clustering approach based on LBP features achieved a mean overall precision of 83.72%, and based on ResNet-18 features, 88.73% precision. Visual analysis of the resultant clusters revealed that consolidation frames sometimes appeared to form separate distinct clusters of their own, while in other cases, they were interspersed within either one of the two primary clusters (Fig. 2 & 3). ResNet-18 outperformed LBP features, but the simplicity and efficiency of computing LBP features make them a practical alternative to ResNet-18 features, particularly in resource-limited settings.

Conclusion

Both ResNet-18 and LBP features showed promise as inputs to an unsupervised clustering method for identifying lung consolidations in LUS video frames. Future work will refine these methods to better handle the variability and complexity of medical imaging data by using representative samples from clusters instead of the entire dataset, reducing computational demands and potentially improving generalization by focusing on key data points.

Statement of Impact

This research highlights the potential of traditional and modern techniques in enhancing LUS diagnostics. By addressing current limitations, the study contributes valuable insights into the development of efficient, generalizable AI-based diagnostic tools for respiratory diseases.

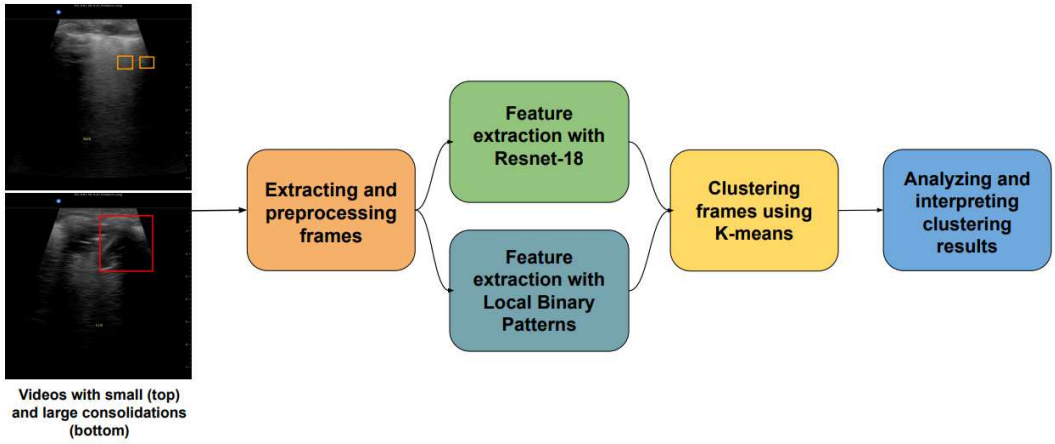

Fig.1: Workflow for LUS Video Frame Classification, starting with the extraction and preprocessing of frames. Features are then extracted using ResNet-18 and Local Binary Patterns (LBP). These features are clustered using K-means to group similar frames, followed by analysis to identify frames with lung consolidations.

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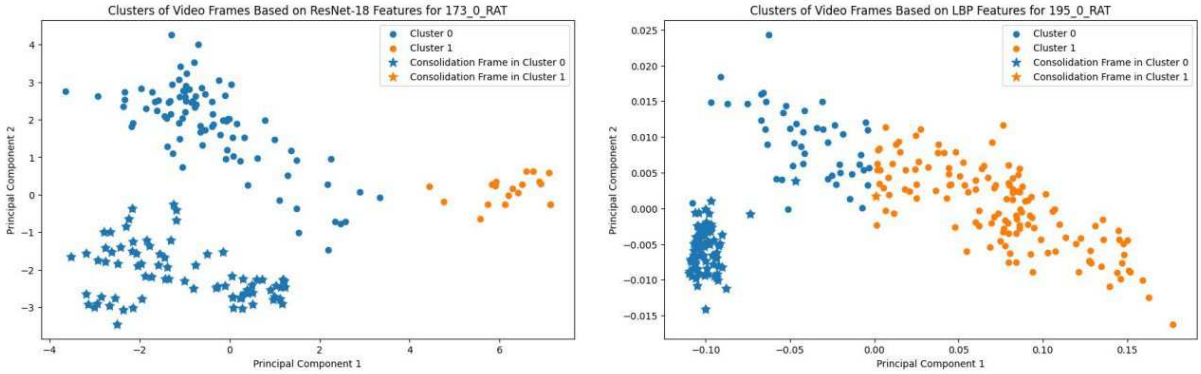

Fig.2: Depiction of instances where consolidation frames formed distinct separate clusters in both ResNet-18 (left) and Local Binary Pattern (right) feature extraction methods.

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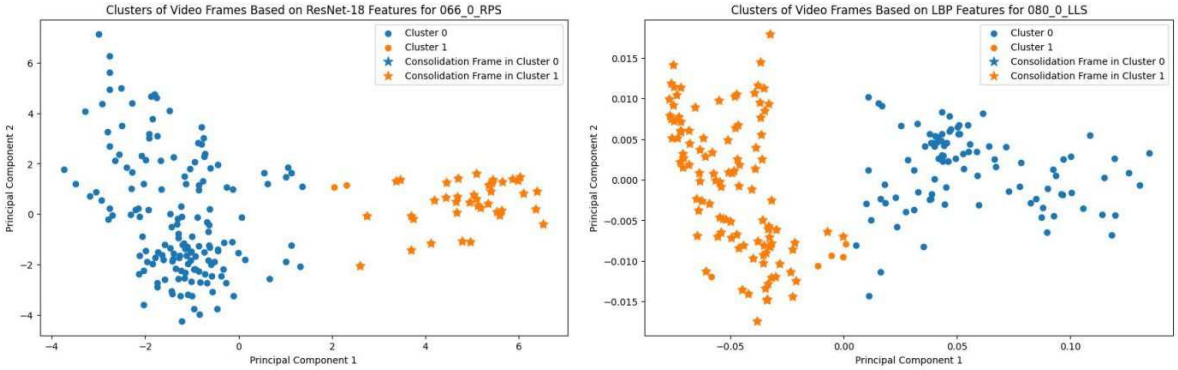

Fig.3: Depiction of instances where consolidation frames were interspersed in either one of the two clusters in both ResNet-18 (left) and Local Binary Pattern (right) feature extraction methods.

Keywords

Lung Ultrasound; Local Binary Pattern (LBP); ResNet-18; Unsupervised Learning; Clustering; Video Frame Classification