**Introduction**

Emphysema manifests as a component of chronic obstructive pulmonary disease (COPD), which is expected to be the third most common cause of death in 2020. Animal models such as elastase-induced emphysema mice have been used to study COPD. In this context, a method for a reliable quantification of emphysema lesions is required to evaluate the stage of the disease and the effect of treatments. The second moment of the equivalent diameter variable ($D_2$) has shown a robust behaviour in emphysema quantification since it does not depend on the shape of the airspace and is sensible to a heterogeneous distribution of them. However, the value of $D_2$ by itself does not provide information about the degree of emphysema severity.

**Data**

All experimental protocols involving animal manipulation were approved by the University of Navarra Experimentation Ethics Committee. Lung lobe sections (H&E stained) from control and emphysema-treated mice were obtained using an automated Axioplan 2ie Zeiss microscope (Carl Zeiss, Jena, Germany). Each slide was initially acquired with a Plan-Neofluar objective (numerical aperture NA = 0.035, magnification 1.25x, pixel resolution 3.546 μm/pixel). The images of fourteen lung sections were available for the present study: 12 training images (6 control and 6 treated) and 2 test images (1 control and 1 treated). A total of 399 patches (751x751 pixels) were extracted from the training sections: 190 from normal ($N$) and 209 from emphysematous ($E$) tissue areas of control and treated mice, respectively.

**Methods**

Given a lung lobe image, semi-automatic segmentation based on morphological operators was applied to identify parenchyma pixels. Subsequently, a 751x751 window was centred on each pixel and the corresponding value of $D_2$ was computed. A Bayesian approach was used to map a $D_2$ value onto a probability index indicating emphysema severity. The posterior probability of being emphysematous was obtained as $p(E|D_2) = p(D_2|E)p(E)/p(D_2)$, where $p(D_2) = p(D_2|E)p(E) + p(D_2|N)p(N)$. The density functions $p(D_2|E)$ and $p(D_2|N)$ were obtained from samples in the training set using the Parzen’s method.

**Results**

Figures 1 and 2 show the emphysema map of the two lung sections in the test set (higher intensity corresponds to higher probability of emphysema). The percentage of parenchyma labelled as emphysematous, i.e., $p(E|D_2) > 0.5$, was 17.9% and 83.3% for the control and the treated mice, respectively.

**Conclusion**

The proposed method could serve as an objective tool for the evaluation of emphysema severity in the context of COPD study.


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Fig. 1: Left: Original lung lobe section from a control mouse. Centre: Segmented lung for the identification of parenchyma pixels. Right: Emphysema map using the proposed Bayesian inference approach.

Fig. 2: Left: Original lung lobe section from a treated mouse. Centre: Segmented lung for the identification of parenchyma pixels. Right: Emphysema map using the proposed Bayesian inference approach.