# Stable Airway Center Tracking for Bronchoscopic Navigation

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## 1. Introduction

Bronchoscopists use X-ray fluoroscopy to guide bronchoscopes to the lesion to be biopsied without any kind of incisions. Reducing exposure to X-ray is important for both patients and doctors but alternatives like electromagnetic navigation require specific equipment and increase the cost of the clinical procedure.

We propose a guiding system based on the extraction of airway centers from intra-operative videos. Such anatomical landmarks could be matched to the airway centerline extracted from a pre-planned CT to indicate the best path to the lesion. We present an extraction of lumen centers from intra-operative videos based on tracking of maximal stable regions of energy maps.

## 2. Methods

Lumen centres are computed using likelihood maps [1] with maximum values at candidate centres. Unlike [1], we use a bank of anisotropic Gaussian filters with different orientations and scales to model non-circular lateral bronchi and small distal levels.

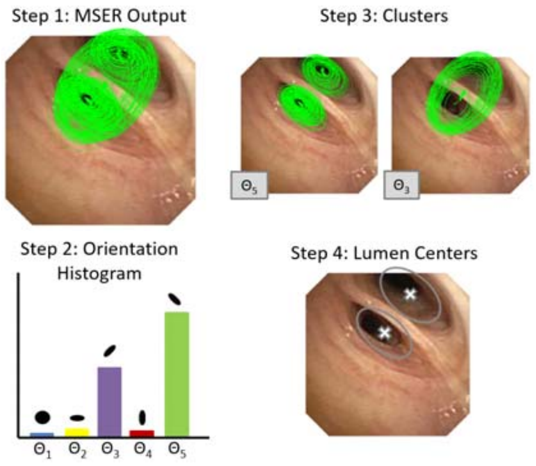


**Fig.1:** Mulsti-scale Extraction of Lumen Centers.

To compute local maxima consistent across scales and orientations, we use stable extremal regions (MSER, [2]) in a multi-scale scheme (Fig.1). A set of MSER elliptical regions are extracted from each likelihood map (Fig.1, step1). To endow stability across filters, MSER regions are split according to their orientation using a histogram (Fig.1, step2). For each orientation, regions are sorted by their area and grouped into N clusters (Fig.1, step3). The union of all ellipses in each cluster defines a set of N regions that are filtered using an inclusion criteria. The overlapping between regions is computed and those having maximum overlap are selected. The collection of centroids for all valid regions are the lumen centres for each frame (Fig.1, step4). Finally, MSER candidates are tracked using a modified Kalman filter using null velocity in state vectors

## 3. Results

To test the quality of our approach we have analyzed 3 ultrathin bronchoscopy videos performed for the study of peripheral pulmonary nodules at Hospital de Bellvitge. For each video, we considered one proximal (up to $6^{th}$ division) and one distal (above $6^{th}$) fragments. For each fragment, we selected 10 consecutive frames sampled every 50 frames. Such frames were annotated by 2 clinical experts to set false detections and the position of missed centres. The intersection of the two annotated point sets is our ground truth used to compute precision (Prec) and recall (Rec) for each set of consecutive frames. These scores are taken for all such sets in distal and proximal fragments for a statistical analysis.

Table1 reports Prec and Rec confidence intervals at proximal and distal levels. We always have a 100% of precision and a recall over 86%, with non-significant differences between distal and proximal levels (p-val >.4 for a Wilcoxon test).

| | Proximal | Distal |
|---|---|---|
| Prec | [1.00,1.00] | [1.00,1.00] |
| Rec | [0.86, 1.00] | [0.87, 0.95] |

**Table1:** Precision and Recall confidence intervals

## 4. Discussion & Conclusion

We have presented an airway lumen extraction from videobronchoscopy. Results indicate high performance at proximal and distal levels. Such promising results encourage a use in a navigation system to explore the benefits of using video information for guidance to peripheral nodules.

## References

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[2] Matas, J., Chum, O., Urban, M., & Pajdla, T. (2004). Robust wide-baseline stereo from maximally stable extremal regions. ImaVis, 22(10), pp. 761-767.