False positive reduction in lung nodule computer-aided detection based on 3D ranklet transform

Matteo Masotti, Todor Petkov

Medical Imaging Group, Department of Physics, University of Bologna

Viale Berti-Pichat 6/2, 40127, Bologna, Italy

1. Objective

Development and evaluation of a novel 3D technique, based on 3D ranklet transform, for the reduction of false positives affecting computer-aided detection of lung nodules in computed tomography (CT) images

2. Introduction

In a typical lung nodule computer-aided detection system:

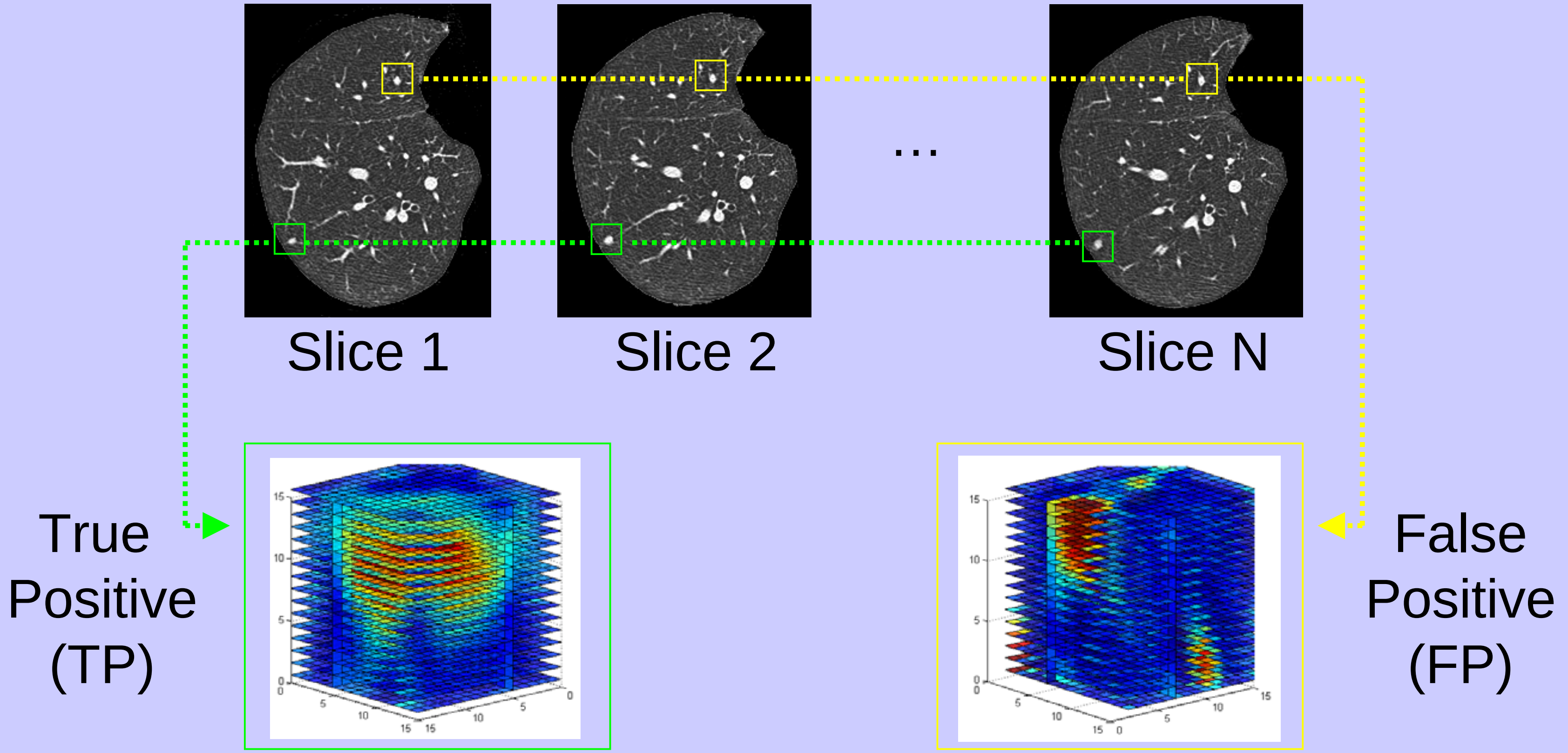
- ❖ A first pre-screening stage is aimed at achieving high nodule detection sensitivity at the expense of a large number of false positives

- ❖ False positives are then reduced by a second false positive reduction stage

In this work, 3D ranklet coefficients are proposed as classification features in combination with a support vector machine (SVM) classifier for false positive reduction

3. Methods :: 3D Nodule Candidates

2D nodule candidates found on segmented lung areas from contiguous sections of a CT scan are merged to form 3D nodule candidates:



4. Methods :: Ranklet Transform

3D nodule candidates are submitted to 3D ranklet transform. As for the 2D case (see references [1,2]), the resulting ranklet coefficients are:

- ❖ Non-parametric: 3D ranklet transform deals with voxels' ranks rather than with their gray-level intensity values; i.e., given (v_1, …, v_N) voxels, the intensity value of each v_i is replaced with the value of its order among all the other voxels (Fig. 1)

- ❖ Multi-resolution and orientation-selective: Ranklet coefficients are calculated at different resolutions and orientations (i.e., vertical, horizontal, and diagonal) by means of a suitable stretch and shift of the 3D Haar wavelet supports used for their computation (Fig. 2)

5. Methods :: Ranklet Transform

$$\begin{pmatrix} 55 & 99 & 25 & 153 \\ 26 & 75 & 92 & 200 \\ 21 & 64 & 88 & 154 \end{pmatrix} \longrightarrow \begin{pmatrix} 4 & 9 & 2 & 10 \\ 3 & 6 & 8 & 12 \\ 1 & 5 & 7 & 11 \end{pmatrix}$$

(a) (b)

Fig. 1: 3D ranklet transform deals with voxels' ranks rather than with their gray-level intensity values. Here, the 2D equivalent is shown: intensity values of an image (a) and corresponding ranks (b)

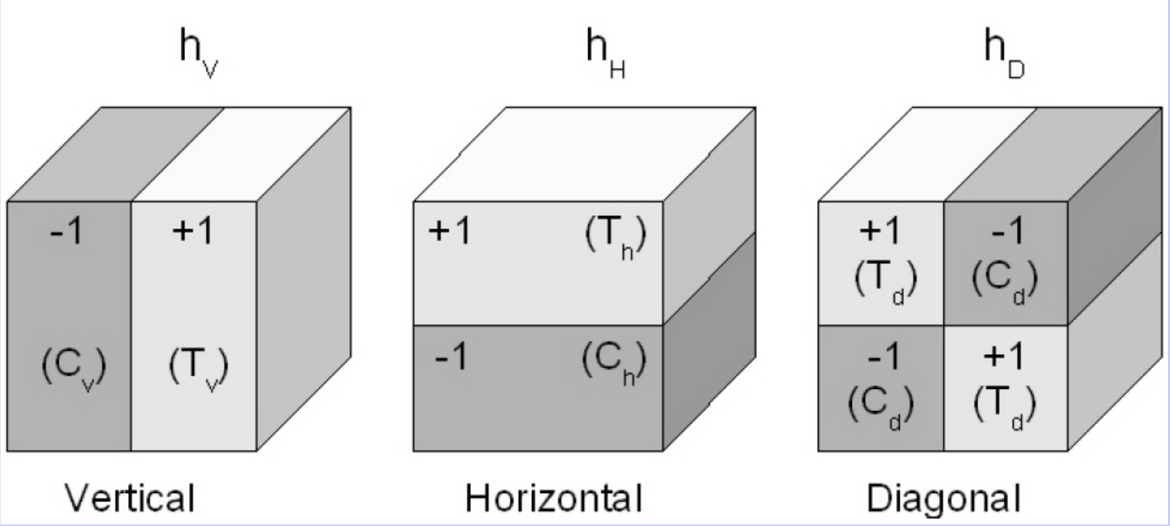


Fig. 2: 3D Haar wavelet supports used for computing ranklet coefficients

6. Methods :: SVM classification

3D nodule candidates encoded by means of 3D ranklet transform are classified as TPs or FPs by a previously trained SVM classifier

7. Results :: Data

Evaluation of the proposed approach is performed on data consisting of CT scans provided by European Institute of Oncology (IEO) with:

- ❖ section thickness of 1 mm
- ❖ nodule dimension ranging from 2.5 to 5 mm

In particular:

- ❖ 25 3D nodules are extracted using the ground truth annotations provided by experienced radiologists
- ❖ 1048 3D non-nodules are randomly extracted from the segmented lung volume of healthy cases

8. Results :: Evaluation

Due to the limited number of available nodules, a leave-one-out scheme is adopted for evaluation purposes, thus achieving:

- ❖ 96% sensitivity (i.e., 24/25 nodules correctly classified as healthy tissue)

- ❖ 1% false positive fraction (i.e., 11/1048 non-nodules misclassified as nodular tissue)

Classification performances reached by the proposed approach seem to be encouraging and incorporation into a larger computer-aided detection system for decreasing the number of FPs definitely is worthy of deeper investigations

9. References

[1] Masotti, M., *A ranklet–based image representation for mass classification in digital mammograms*, Tech. Rep. 930, University of Bologna, Department of Physics, March 2005

[2] Angelini, E.; Campanini, R.; Iampieri, E.; Lanconelli, N.; Masotti, M.; Petkov, T.; Roffilli, M., *A ranklet-based CAD for digital mammography,* Proceedings of the International Workshop of Digital Mammography, Manchester, 2006, In Press

10. Further Information

Please, contact masotti@bo.infn.it. More informations on ranklets can be obtained at http://www.bo.infn.it/~masotti.

Medical Imaging Group at Department of Physics, University of Bologna: http://www.bo.infn.it/mig/.