Description of hepatic HCC lesions using persistent homology

Ecole doctorale Sciences Pour l'Ingénieur

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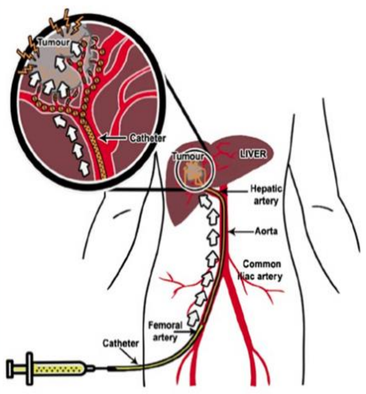
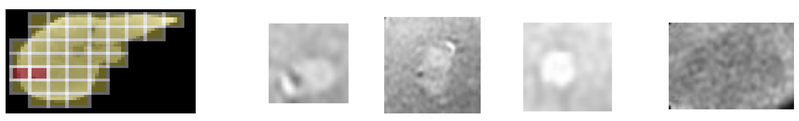
INTRODUCTION

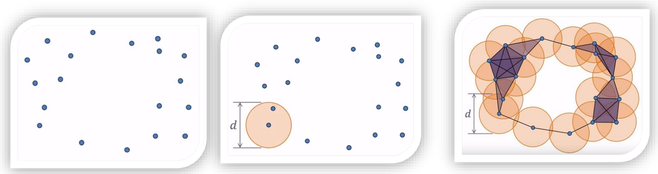


- Our research group focuses on the computer evaluation of tumoral response
- For hepatic diseases, in particular HCC (HepatoCellular Carcinoma)
  - 5th cause of cancer in the World (500,000 new cases / year)
  - 3rd cause of death by cancer in the World

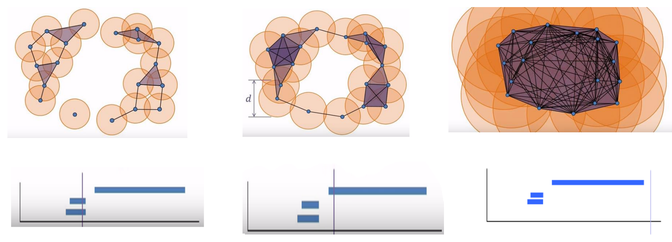


METHOD : PERSISTENT HOMOLOGY (PH)

- A popular tool in topological data analysis.
- Algebraic tool for discerning topological features (holes, graph) of data.

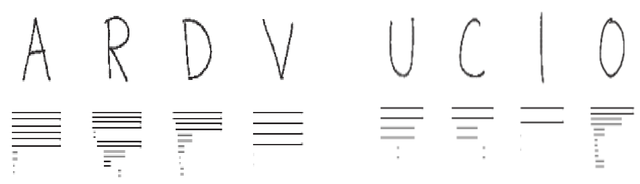


- Persistent



- Shape analysis : holes representation using thickness, breadth [Aldo et al., 2016].

- Shape analysis : topological invariant [Anne Collins et al., 2004].



APPLICATION TO MEDICAL IMAGE PROCESSING

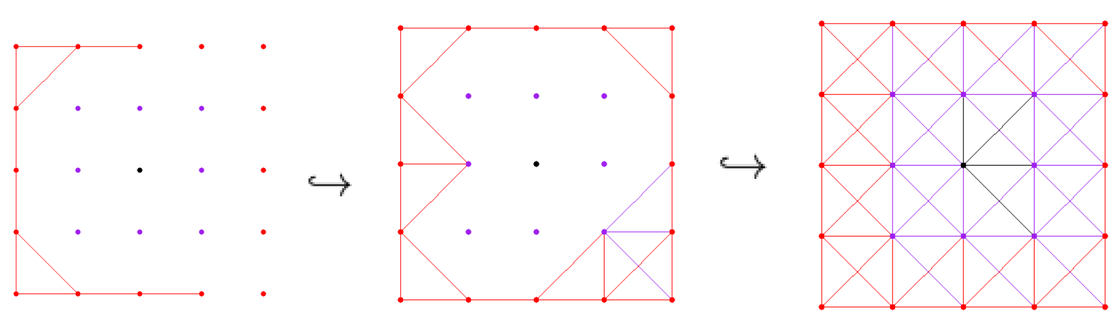
- Framework for hepatic lesions [Adcock et al.,2014]

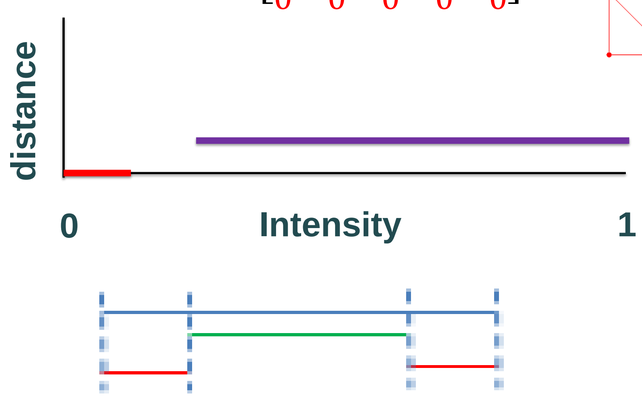
Image I

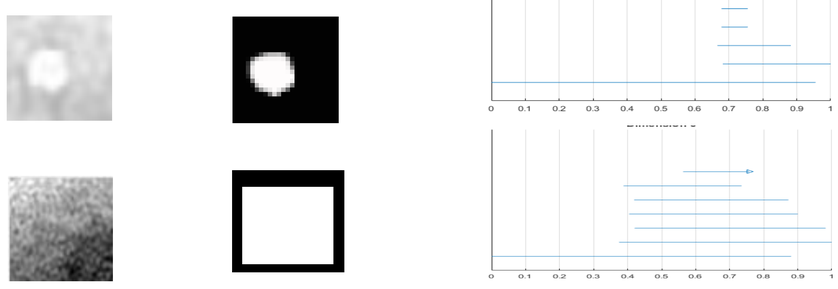
$$I = \begin{bmatrix} 0.1 & 0.12 & 0.13 & 0.14 & 0.15 \\ 0.16 & 11 & 10 & 12 & 0.17 \\ 0.18 & 13 & 14 & 15 & 0.19 \\ 0.2 & 9 & 16 & 17 & 0.21 \\ 0.22 & 0.23 & 0.24 & 0.25 & 0.26 \end{bmatrix} \qquad BW = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

- the distance from the lesion border to each pixel
- pixel intensity (ranked in ascending order)
- Barcode
- metric $\delta(I, J) = |I \cup J - I \cap J|$

$$distance = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 2 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

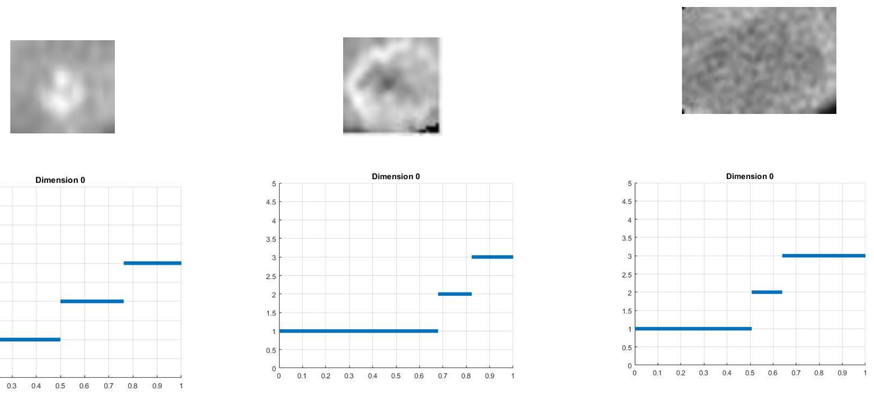




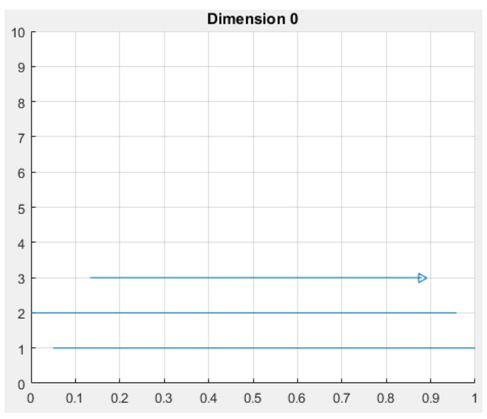


RESULTS

- Database : 10 000 patchs of healthy tissu / 100 patchs of lesion.
- Persistence for lésion



- Persistence for healthy tissu



CONCLUSION

- This framework may be complementary to the standard techniques currently in use.
- Extract topological features to compute the persistence can improve the result.
- Useful for segmentation of tumor.
- This framework is flexible enough to be used in a variety of contexts.

BIBLIOGRAPHY

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[3] Aldo Gonzalez-Lorenzo, Alexandra Bac, Jean-Luc Mari, Pedro Real. Two Measures for the Homology Groups of Binary Volumes, International Conference on Discrete Geometry for Computer Imagery (DGCI 2016), Apr 2016, Nantes, France. Lecture Notes in Computer Science, 9647, pp.154-165, 2016