A mixed-effects model approach to digital image analysis

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Statistics and histopathology
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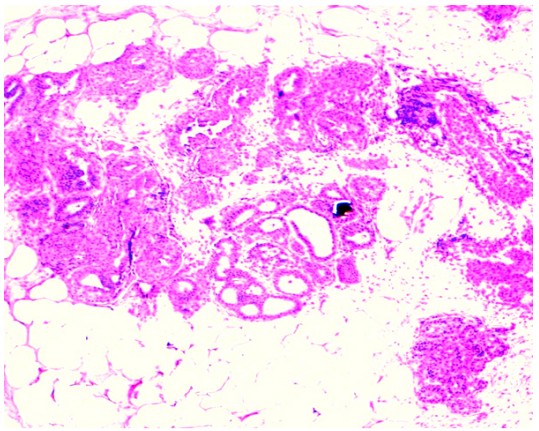
Histopathological images

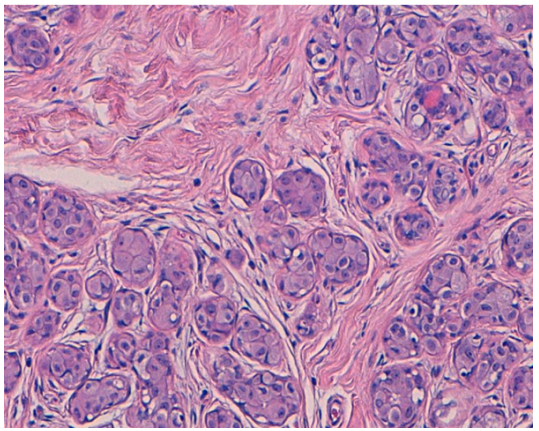
Standard clinical practice

- cancer detection
- cancer classification

What to avoid

- inter-operator variability

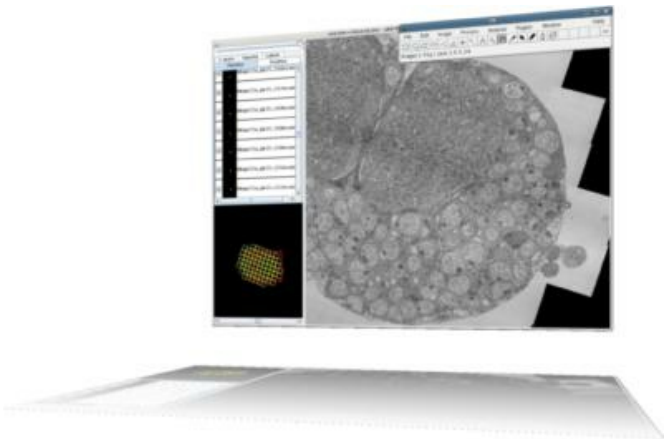




Digital images 1/2

Manipulation softwares

- commercial products
  - ...
- open-source products
  - ...
  - Fiji
  - ...



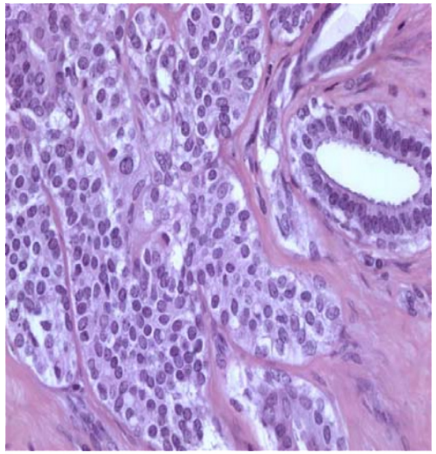
Digital images 2/2

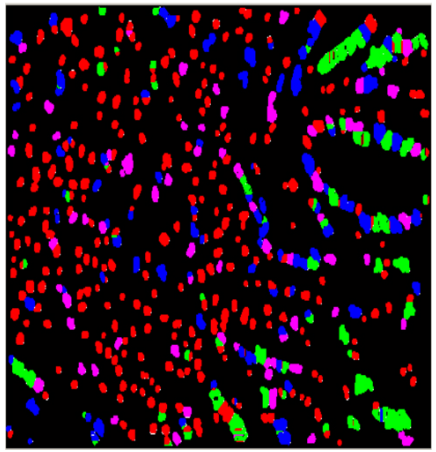
Difficulties in *expert systems*

- low-level information
  - pixel values
- high-level information
  - relationships pixel/object
- domain-specific information
  - histo structures relationships

Milestones

- Dalle et al., IEEE-EMBS, 2008.
- Singh et al., IJEST 3(5), 2011.





Available computational techniques

Probabilistic / statistical approaches

- ...
- scoring methods
- bayesian classifiers
- neural networks
- ...

Our proposal

- mixed-effects models

What are mixed-effects models

Fixed effects + random effects

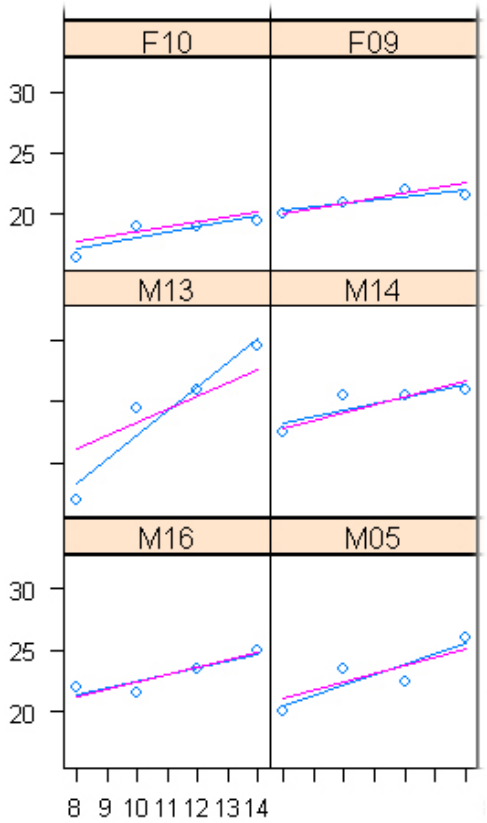
- repeated measures data
- longitudinal data
- hierarchical / clustered data

$$y_{ij} = \mu + b_i + \epsilon_{ij}$$

One of the advantages of mixed-effects models

The *shrinkage* phenomenon

- Strenio et al., Biometrics 39, 1983.

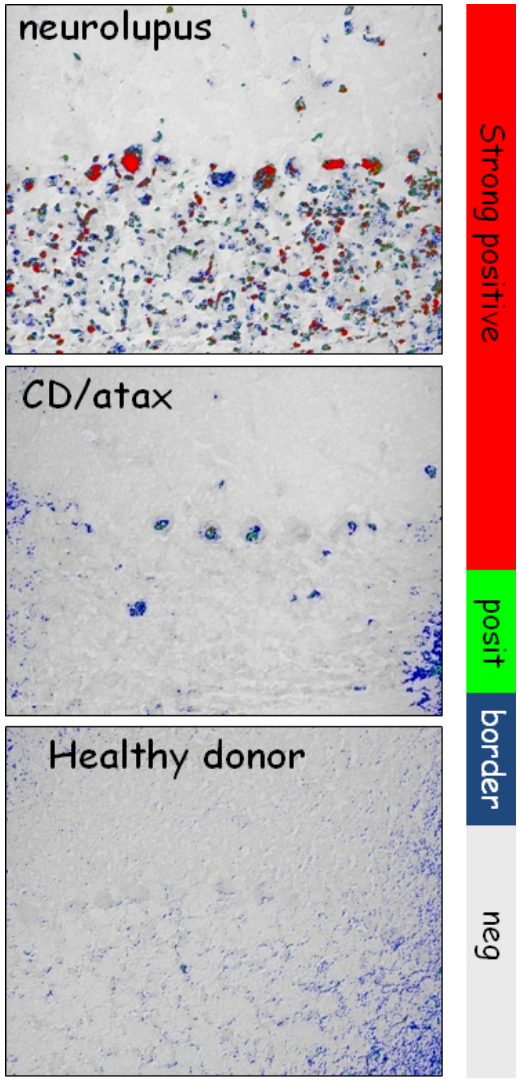


A previous result with mixed-effects modelling

Trieste Autoimmune Brain Atlas

- S. Zulian, M. Borelli, E. Tongiorgi. *Ongoing*

$$densito_{ij} = \beta_i + b_j + \epsilon_{ij}$$



Cancer detection by mixed-effects modelling 1/2

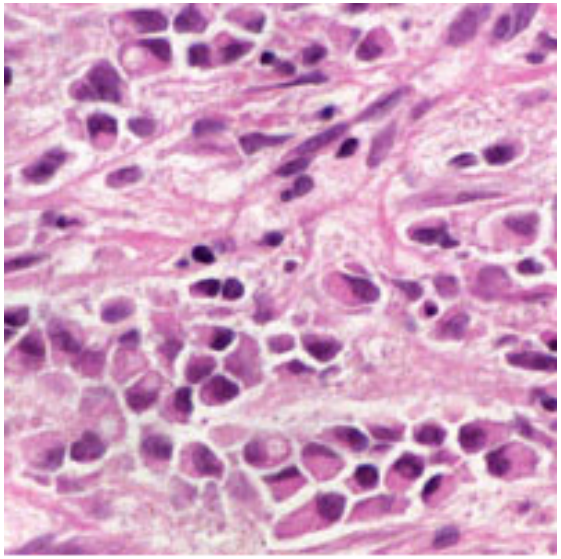
Open source softwares

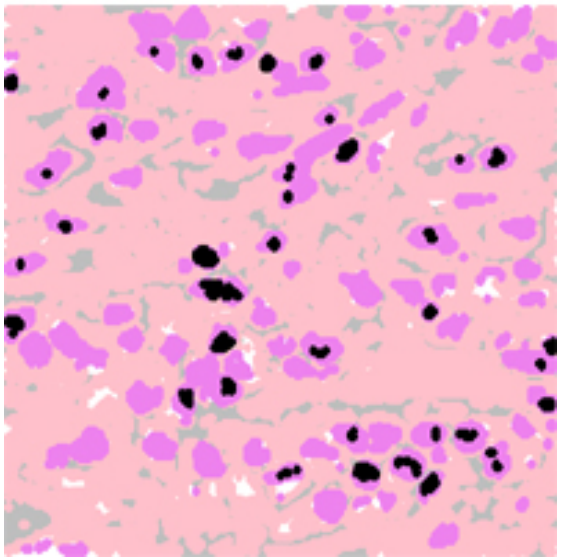
- imagemagick
- R
  - library(pixmap)
  - library(lme4)
- bioconductor
  - graph

Cancer detection by mixed-effects modelling 2/2

Results

- detection of nuclei
  - Manhattan distance
- counts of nuclei
  - Depth first search algorithm

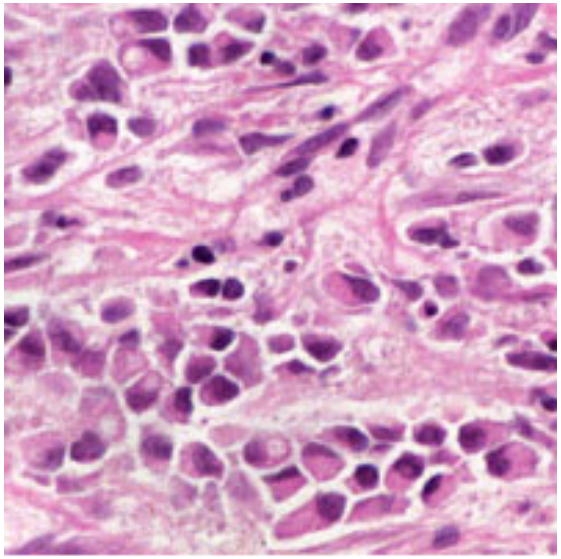


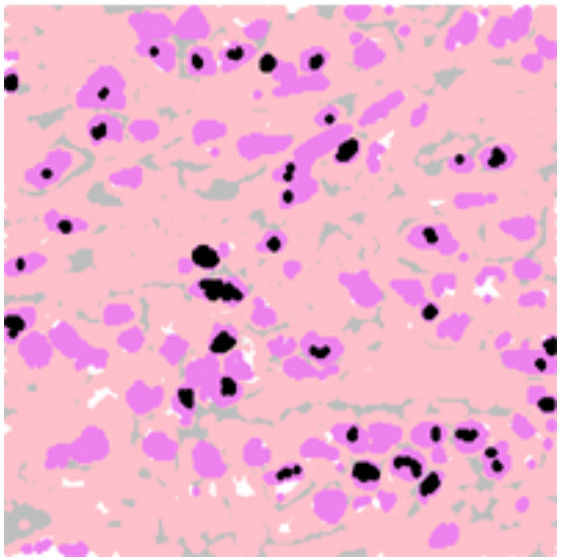


Cancer classification by mixed-effects modelling

Future steps

- supervised classification
  - to train a *learning machine*





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