

Declarative analysis
of **Spatial**
structures and
Medical Images

Vincenzo Ciancia

Formal Methods and Tools lab.

ISTI-CNR Pisa

vincenzo.ciancia@isti.cnr.it

A short story



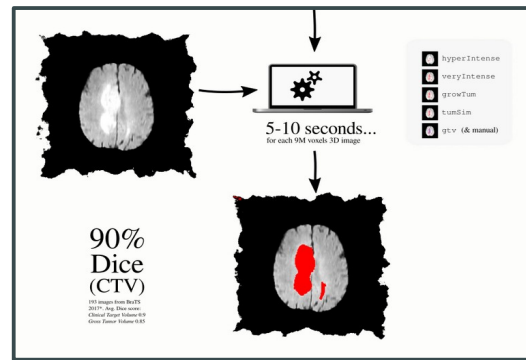
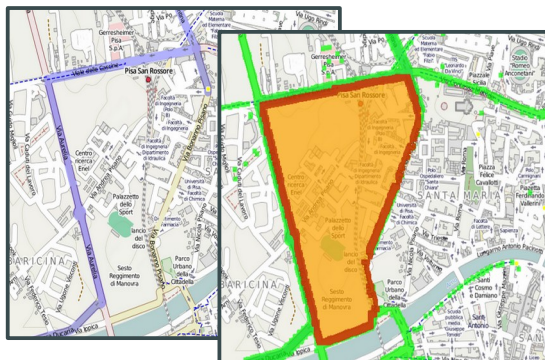
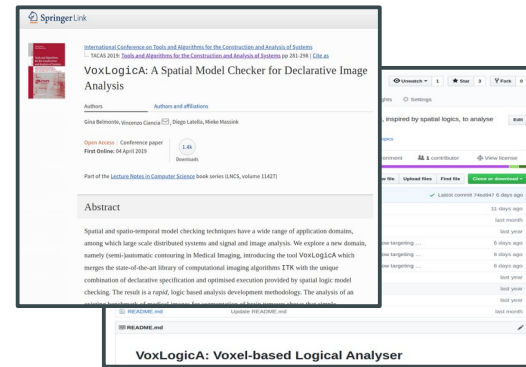
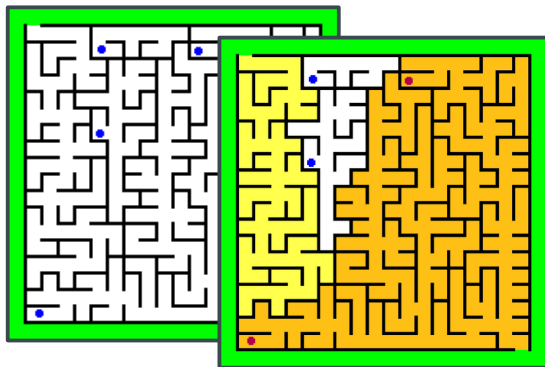
Session:	Computational Biology, Data Science, Machine Learning & Optimization
Nadia Pisanti Dept. of CS - University of Pisa [e-mail]	Computational Pan-Genomics with elastic degenerate strings
Paolo Miazzo Dept. CS - University of Pisa [e-mail]	Computational analysis of biological networks
Alina Sirbu Assistant Professor, SPARK Pisa, KDD - University of Pisa [homepage] [e-mail]	Research in Computational Health
Marco Pellegrini IIT - CNR [e-mail]	Bioinformatic Research at IIT: the Highlights
Vincenzo Ciancia Researcher, Formal Methods and Tools Lab, ISTI-CNR [group page] [homepage] [e-mail]	Declarative analysis of spatial structures and medical images

Model checking, tools

Requirements engineering

Applications (train control, smart cities)

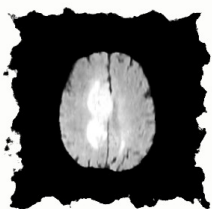
Spatio-temporal model checking



Tumour delineation for radiotherapy

Example: contouring glioblastoma in 10 lines

```
background removal { load flair = "flair.nii.gz"
                     let background = touch(intensity(flair) <. 0.1, border)
                     let brain = complement(background)
thresholding { let normFlair = percentiles(intensity(flair), brain)
              let hyperIntense = filter(5.0, normFlair >. 0.95)
              let veryIntense = filter(2.0, normFlair >. 0.86)
semantic noise removal { let growTum = grow(hyperIntense, veryIntense)
texture similarity { let tumSim = similarTo(growTum)
                   let tumStatCC = filter(2.0, tumSim >. 0.6)
                   let gtv = grow(growTum, tumStatCC)
```



5-10 seconds...
for each 9M voxels 3D image



90%
Dice
(CTV)

193 images from BraTS
2017. Avg. Dice score:
Clinical Target Volume: 0.85
Gross Tumor Volume: 0.85

Accuracy:

in par with humans
and best-in-class machine learning

Dataset:

circa 200 cases, ground truth available
MICCAI-BraTS 2017

Speed:

6 seconds for each 3d image – 9 million voxels
on a intel Core-I7 desktop computer

Why

Declarative Image Analysis

for clinical practice, research, preprocessing in data analysis

Formal methods in Medical Imaging

specify and check protocols; monitor results (humans, and A.I.)

Quality Assurance in Medical Physics

first contact made with Associazione Italiana di Fisica Medica

Who wants to join us

Theory

logics, category theory, automata, model-checking

Parallel computing

CPU, gpu, distributed

Artificial Intelligence

spatial logics in A.I., machine learning

Human-Computer Interaction

design principles and usable interfaces for logics in domain-specific environments

Talk to us
it's free*

*like the software we make!

References

VoxLogicA: a Spatial Model Checker for Declarative Image Analysis

https://link.springer.com/chapter/10.1007/978-3-030-17462-0_16

<http://www.voxlogica.org>

Model Checking Spatial Logics for Closure Spaces

<https://lmcs.episciences.org/2067>

Spatio-temporal model checking of vehicular movement in public transport systems

<https://link.springer.com/article/10.1007%2Fs10009-018-0483-8>

Handbook of spatial logics

<https://www.springer.com/la/book/9781402055867>