

Big data in health care: Why? How?



Prof. Philippe Lambin
U.H. Maastricht

The 4 « P's » of Precision medicine

« P » for Personalized

« P » for Preventive

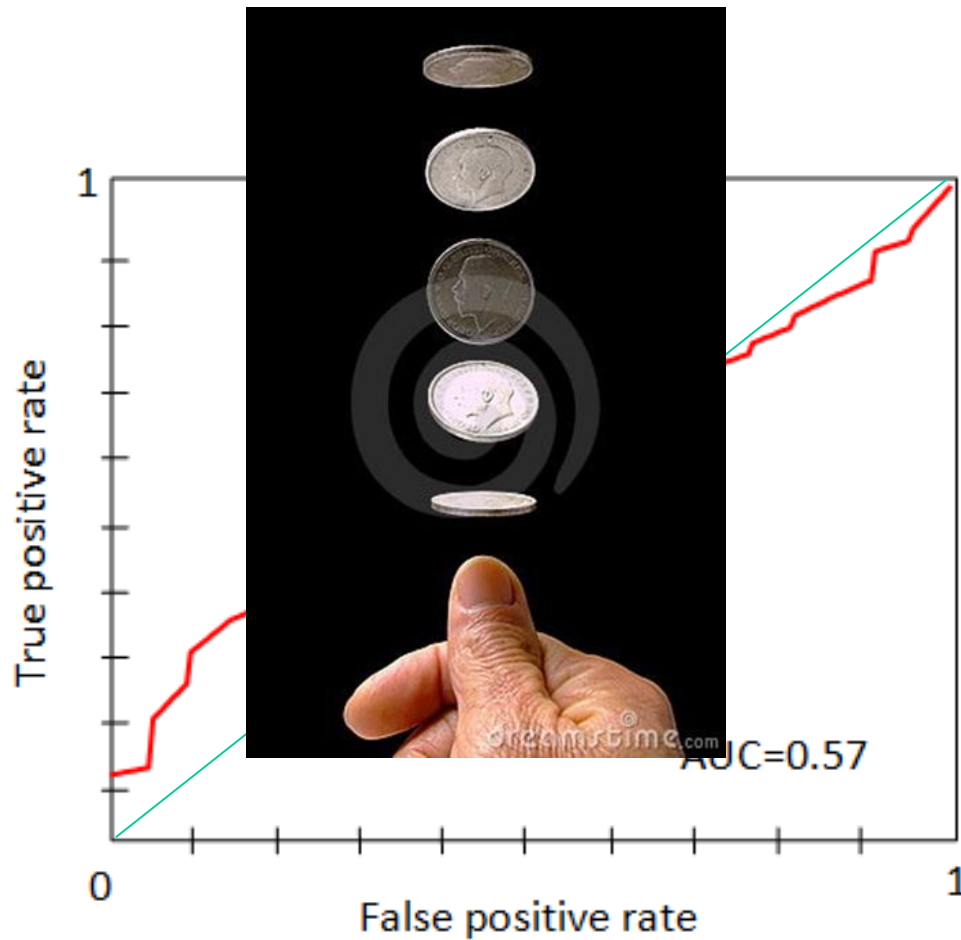
« P » for Predictive

« P » for Participative

And « P » for Particle therapy



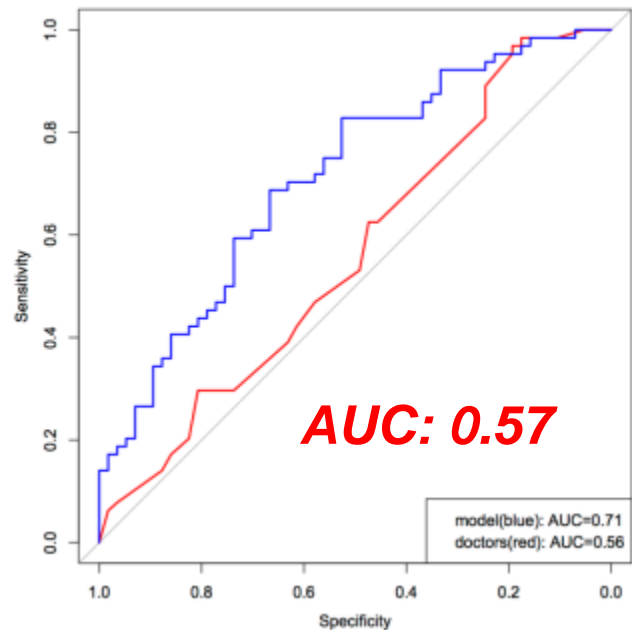
Prediction by RadOnc's? Two years survival of inoperable NSCLC? Curative or palliative?



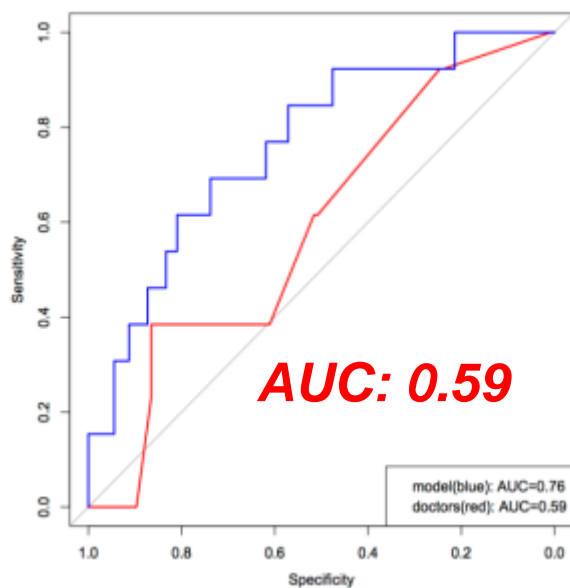
- Non Small Cell Lung Cancer
- 2 year survival
- 30 patients
- 8 MDs
- ***Retrospective***
- ***AUC: 0.57 (AUC 0.5 = random)***

Prospective trial (n=154): Models always significantly better than Rad Onc & TNM

Death at 2 years

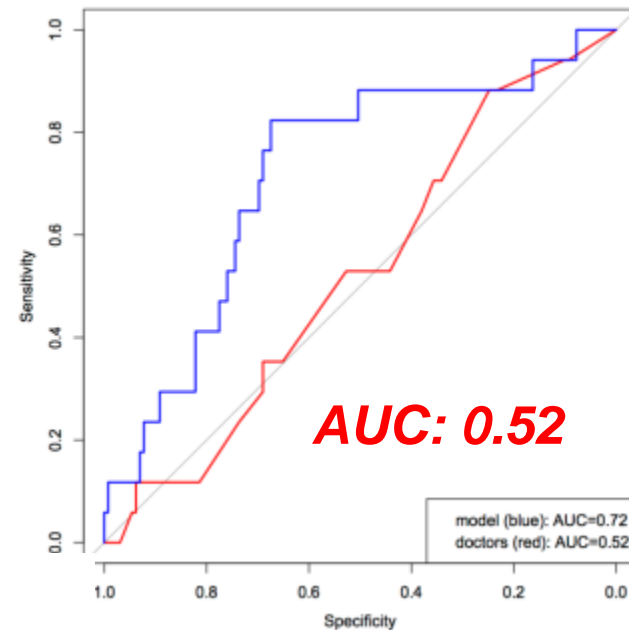


Dyspnea



— RO's
— models

Dysphagia





The Telegraph

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Cancer patients could rather than a doctor

Cancer patients may soon have their treatment decided by a doctor after scientists devised a way of predicting how sufferers will respond to different treatments.



The computers curing cancer: Software is better than doctors at judging which treatments will work

Zimbabwe Star

From Zambezi to Limpopo

Zimbabwe Star <http://www.zimbabwestar.com> Volume 2013/04

Zimbabwe News Breaking International News Breaking Business News South Africa News Zambia News Agriculture News
Musio News Breaking Health News Public Health News Zimbabwe News Travel News Weather News

computer models to help cancer patients predicting how patients doctors
ors that affect prognosis treatment option

Doctors Out-Maneuvered By Mathematical Models In Predicting Cancer Patients' Responses To Treatment

Latest Zimbabwe Star news

Despite Newly Free Deliveries in Kenya Some Mothers Opt for Traditional Birth
<http://www.science.org/doi/10.10420110651.htm>

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cases/2013/04/

The INDEPENDENT

The computer will cancer prediction than a doctor

Science

Chemotherapy that are better than a computer rather

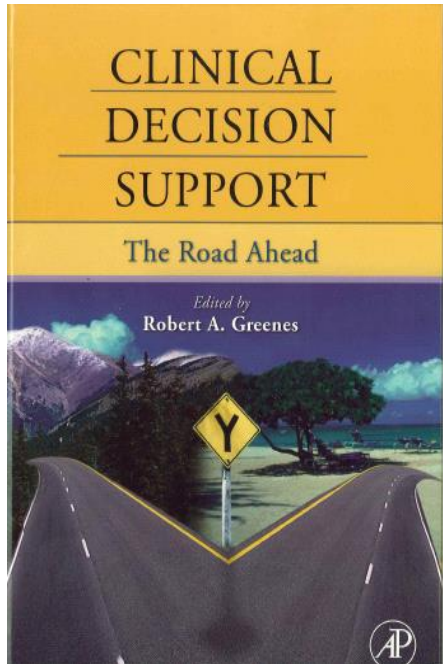
Your source for the latest research.

Mathematical Models Out-Perform Doctors in Predicting Cancer Patients' Responses to Treatment

Mathematical prediction models are better than doctors at predicting the outcomes and responses of patients to treatment, according to new research presented today (Saturday) at the 2nd Forum of the European Society for Medical Oncology (ESTRO).

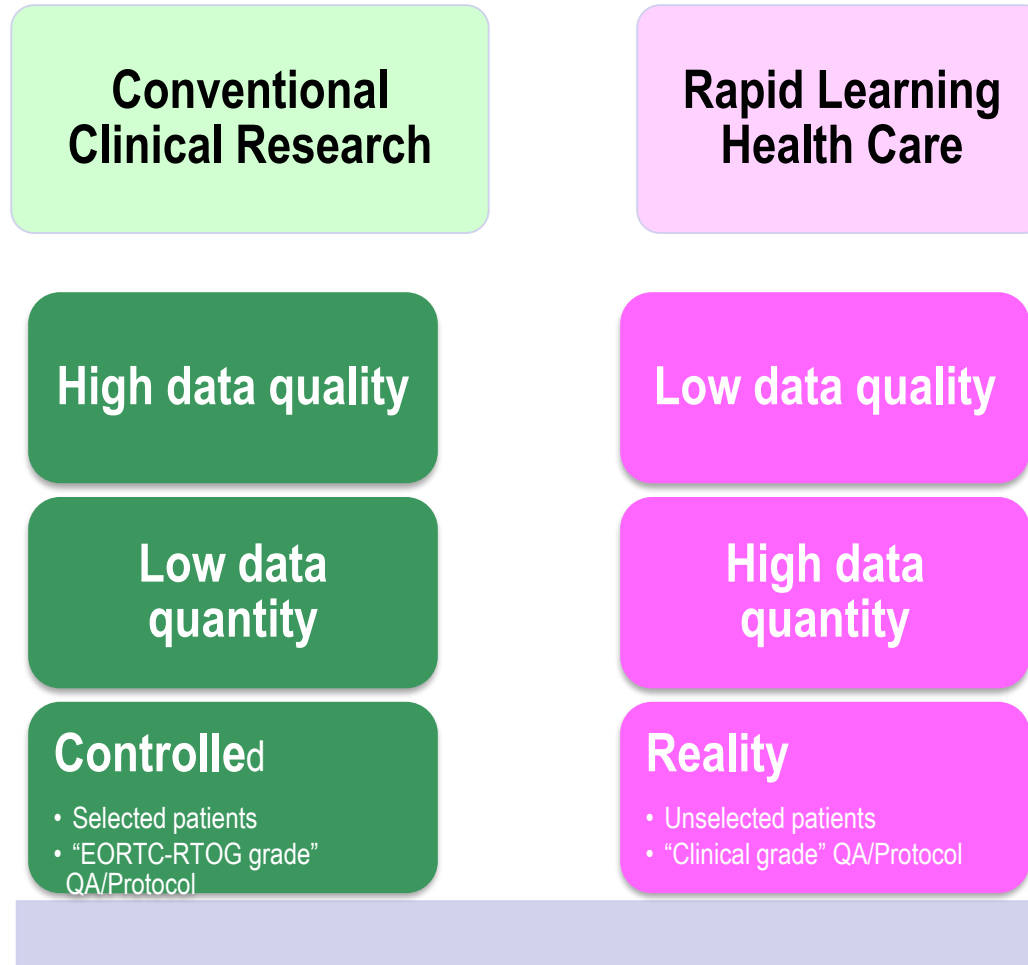
Mathematical formulas can outperform doctors
Steve Connor
22 April 2013

It is *unethical* to ask Medical Doctors to make, on their own, complex decisions, as it is to use only DVH.



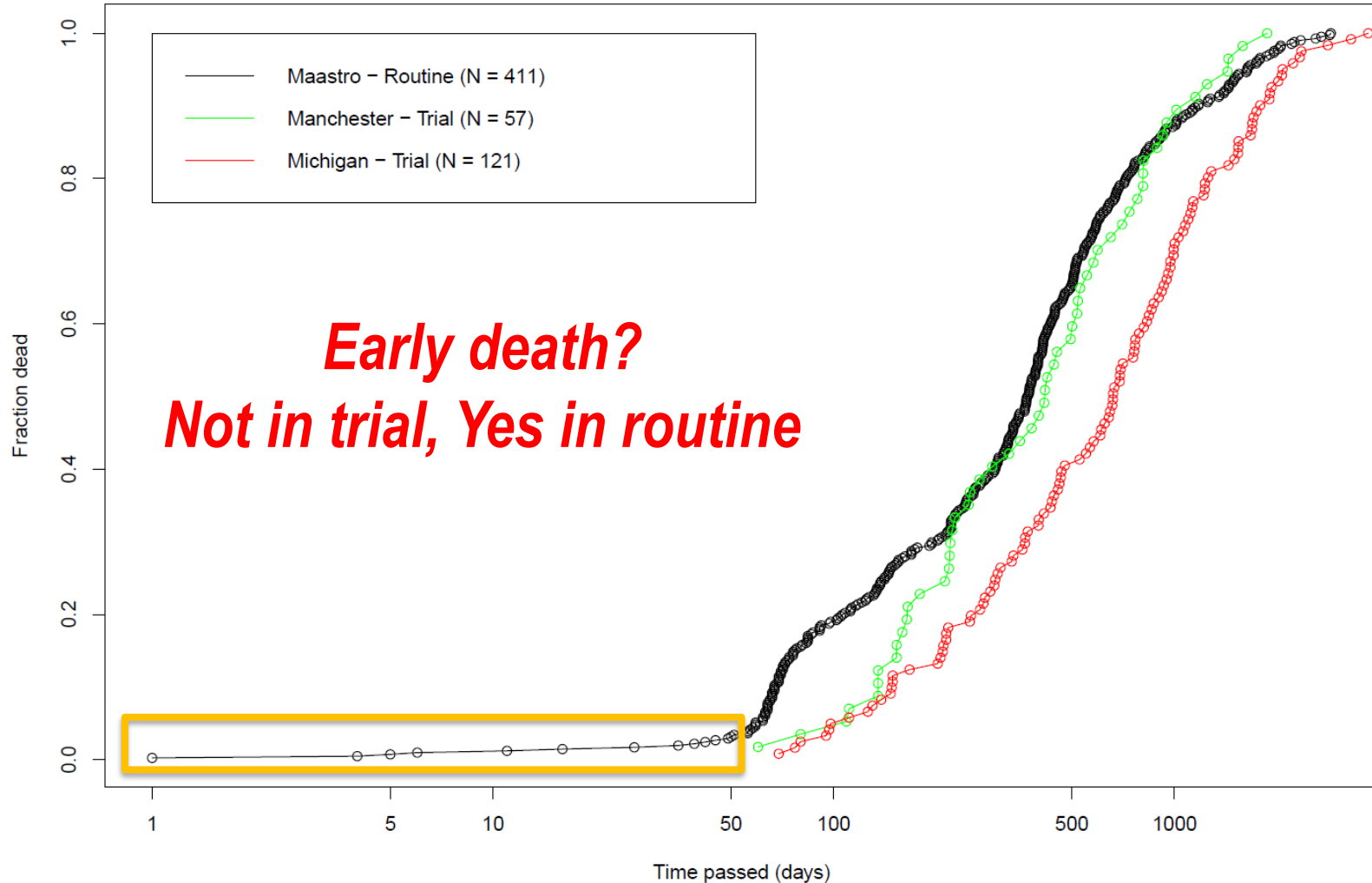
We need a validated “decision support system” (“a meta TPS”)

Two type of clinical research



Example: Early death

Overall survival in clinical trials vs routine



"Data! Data! Data!" he cried
impatiently.

"I can't make bricks without clay."

Sherlock Holmes - The Adventure of the Copper
Beeches by Sir Arthur Conan Doyle

Watch the animation

- Distributed learning: <https://youtu.be/nQpqMluHyOk>
- Eurocat: <https://youtu.be/ZDJFOxpwqEA>
- How to participate?
<http://www.eurocat.info/membership.html>

CAT network (<http://www.eurocat.info/join.html>)

CORAL: Community in Oncology for Rapid Learning

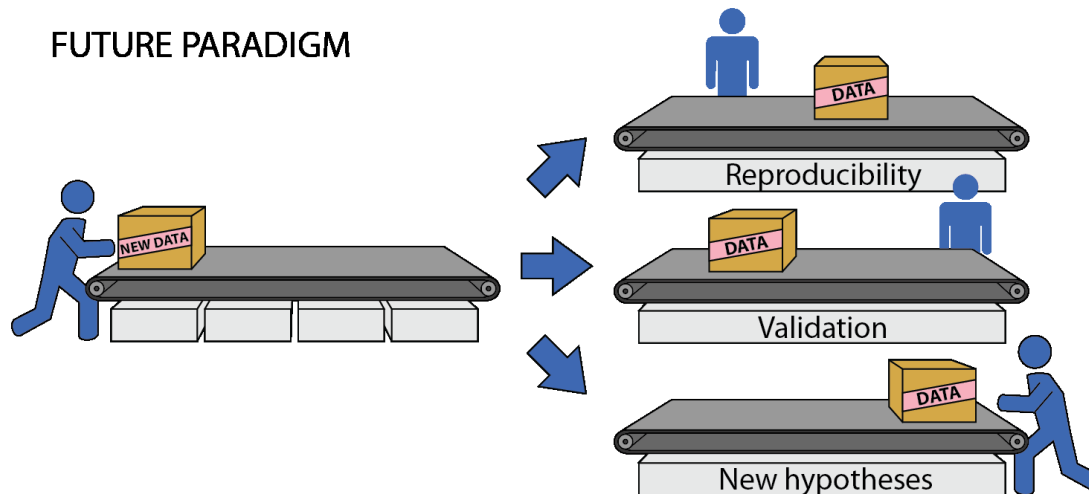
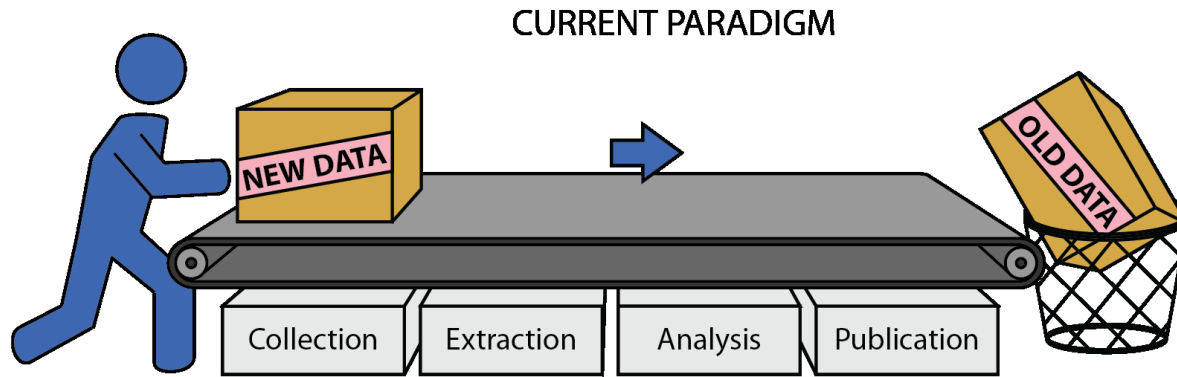


How to get

the data?

The open repository approach

Utopia: All our published data available opensource



Modified from
Deasy et al.



Sharing medical data for cancer research

About CancerData

The *CancerData* site is an effort of the Medical Informatics and Knowledge Engineering team (*MIKE* for short) of Maastric Clinic, Maastricht, The Netherlands. Our activities in the field of medical image analysis and data modelling are visible in a number of projects we are running. Please refer to the [Links](#) for more information.

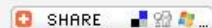
Open source driven

CancerData is build using Free and Open Source Software (FOSS) only. Refer to [this page](#) for more information on the used software.

In return, we offer tools for image analysis and more. Have a look at the [file manager](#) (ps: allow popups).

Contact us

Please use the [Contact form](#) for feedback or more information.



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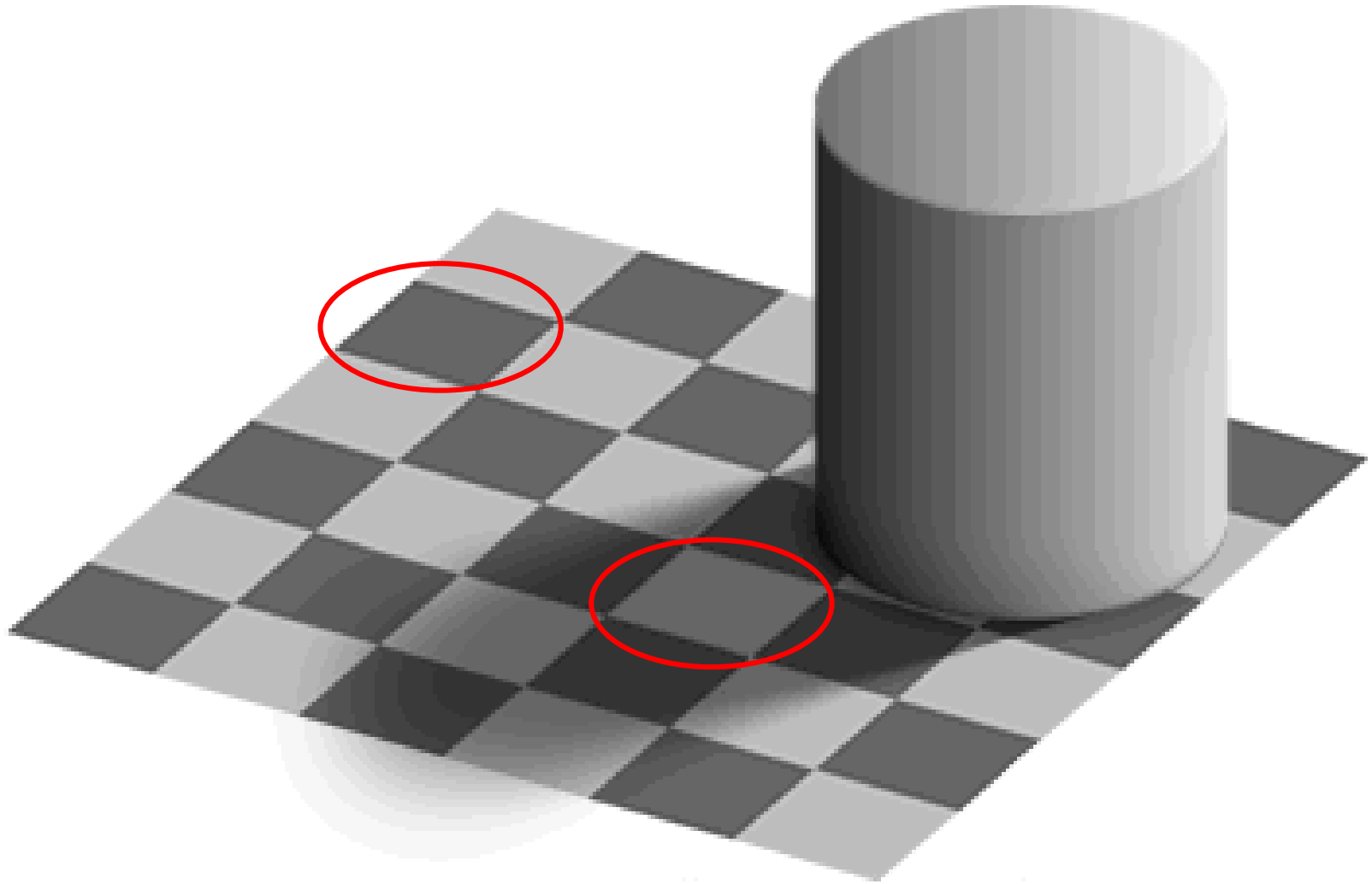
An examples
of new knowldege coming from
Rapid Learning Health Care
approaches

The Radiomics story

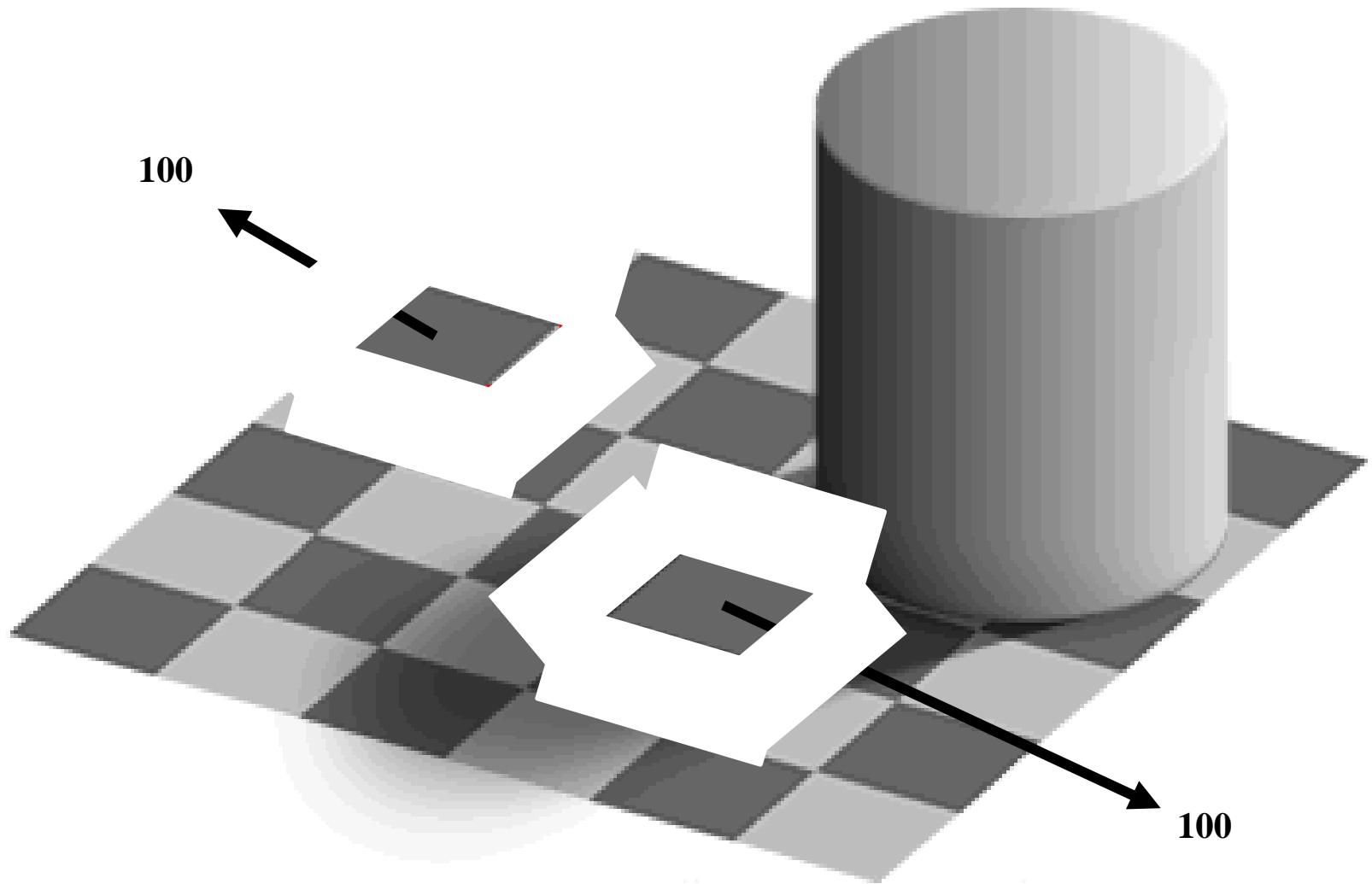


*Lambin *et al.* Eur J Cancer 2012; Aerts, Lambin *et al.* Nature Commun 2014

How good is our judgement?



How good is our judgement?



The human eyes have

serious limitations

Watch the animation

- Radiomics: <https://youtu.be/Tq980GEVP0Y>
- More info on www.radiomics.org

The Radiomics hypothesis

One can extract more *quantitative* information from standard imaging in contrast with RECIST, WHO...)



Radiology:

- Implicit knowledge
- Interpretability



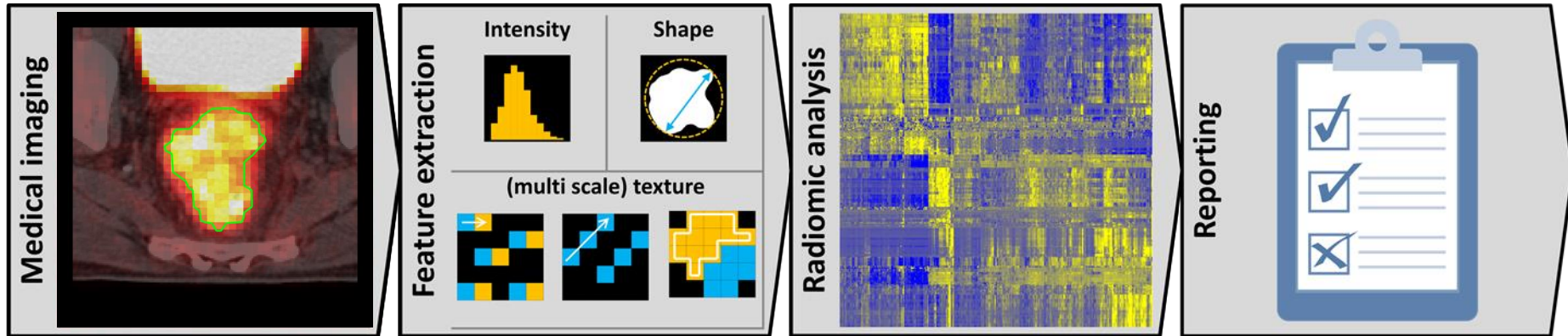
QUANTIFICATION



RADIOMICS

Extract *quantitative* features from images

The Radiomics workflow in a nutshell



A high-throughput approach to convert medical images to minable data

The analysis extracts diagnostic, theragnostic, prognostic and predictive Radiomics signatures

ARTICLE

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DOI: [10.1038/ncomms5006](https://doi.org/10.1038/ncomms5006)

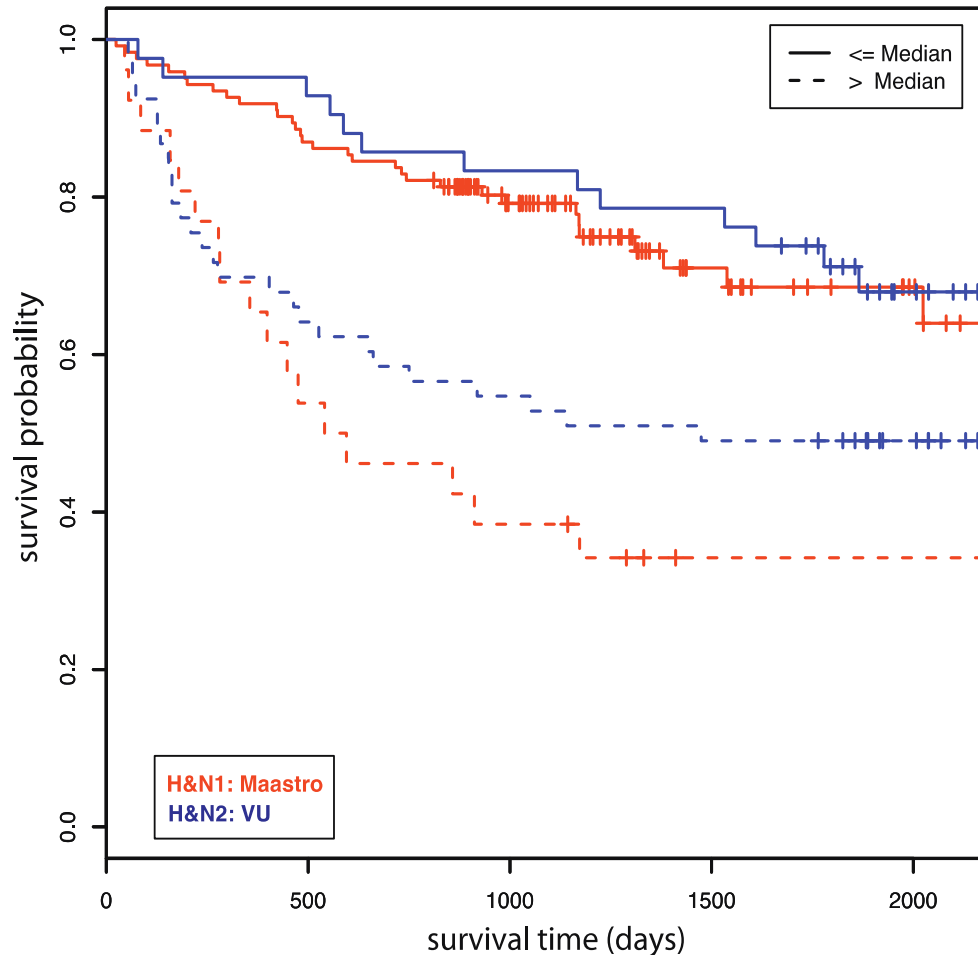
OPEN

Decoding tumour phenotype by noninvasive imaging using a quantitative radiomics approach

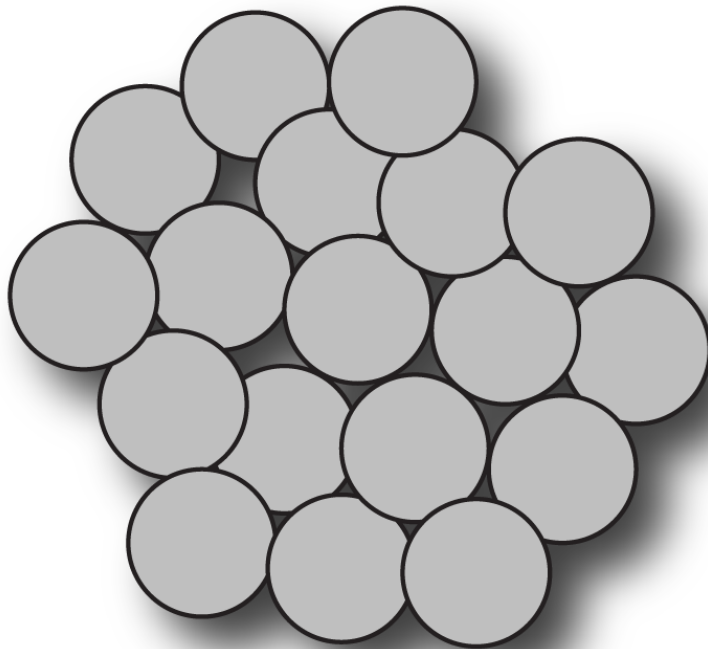
Hugo J.W.L. Aerts^{1,2,3,4,*}, Emmanuel Rios Velazquez^{1,2,*}, Ralph T.H. Leijenaar¹, Chintan Parmar^{1,2}, Patrick Grossmann², Sara Cavalho¹, Johan Bussink⁵, René Monshouwer⁵, Benjamin Haibe-Kains⁶, Derek Rietveld⁷, Frank Hoebers¹, Michelle M. Rietbergen⁸, C. René Leemans⁸, Andre Dekker¹, John Quackenbush⁴, Robert J. Gillies⁹ & Philippe Lambin¹

Predict survival in Lung and Head & neck cancer better than TNM

Kaplan–Meier Radiomics Signature



...in other words, visualize



Good

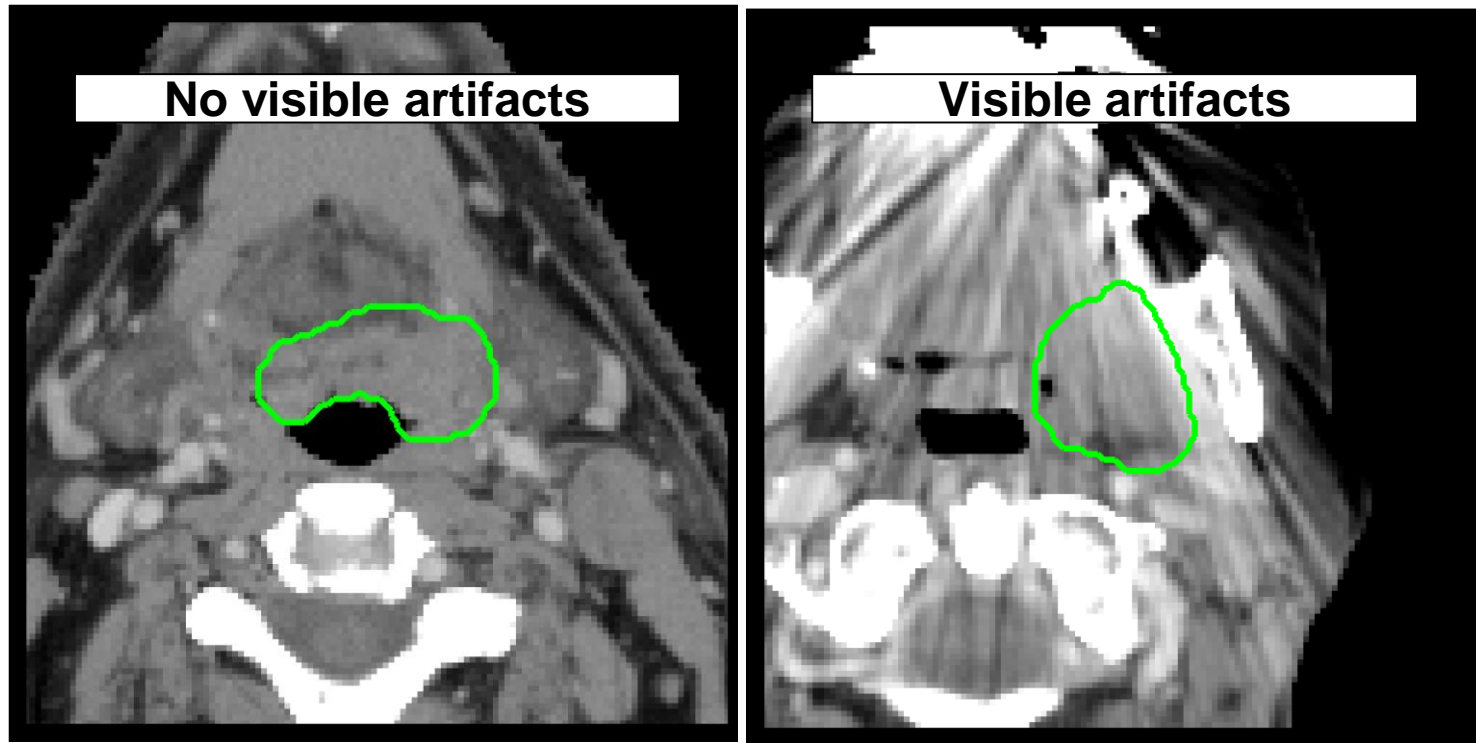


Bad
Higher proliferation

What about

North americans?

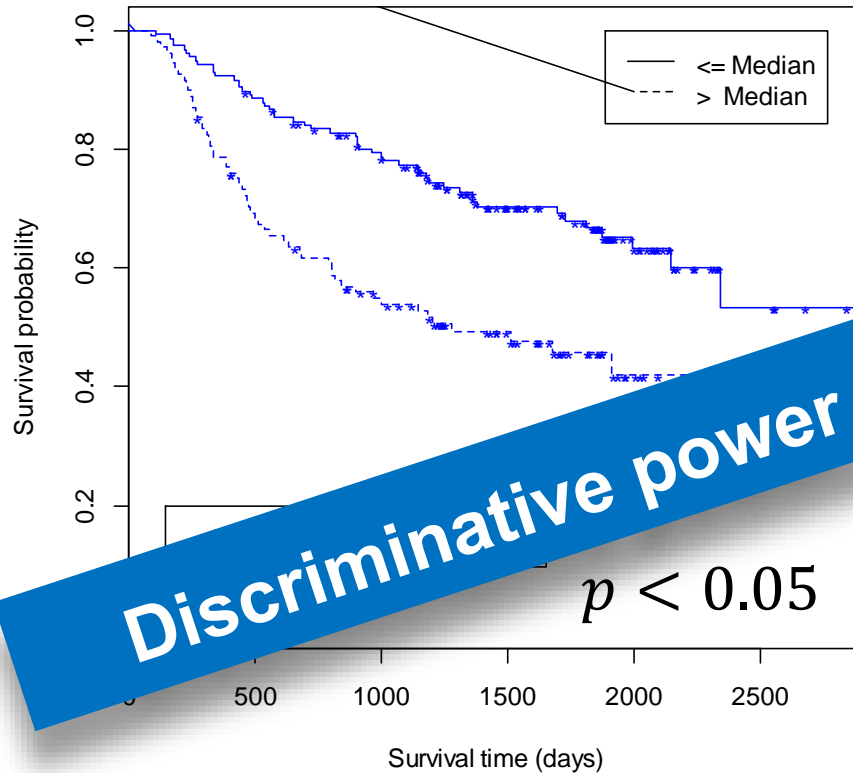
...and what about CT artifacts?



The signature was built on Lung cancer data → CT artifacts uncommon (e.g. pacemakers)

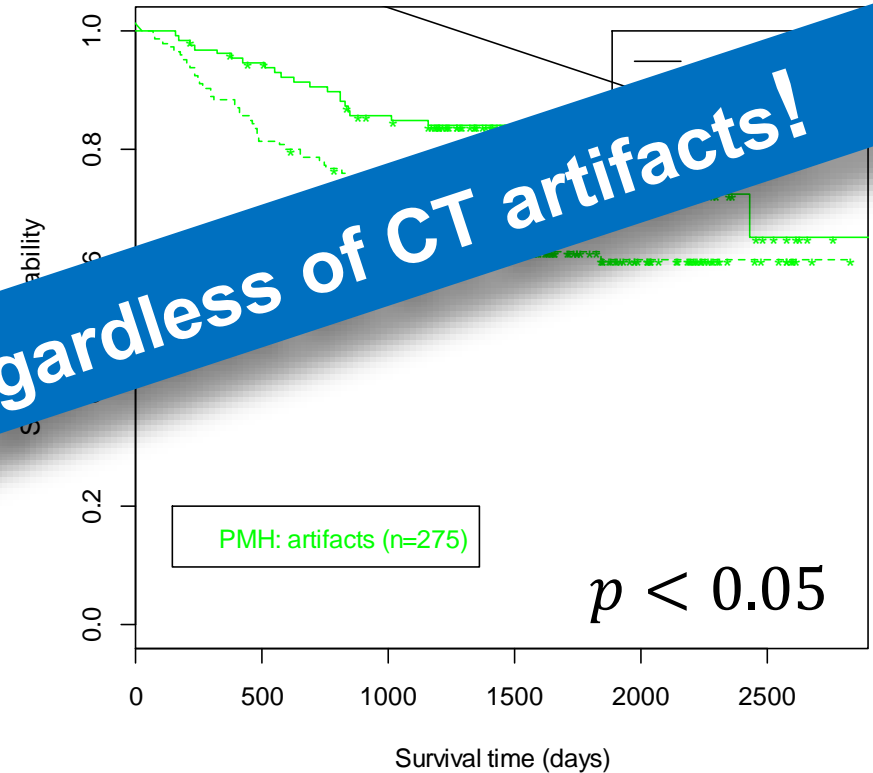
Is the signature robust? what about CT artifacts in H&N?

Kaplan-Meier Radiomic Signature



Without artifacts (N=267)
C-index: 0.634

Kaplan-Meier Radiomic Signature



With artifacts (N=275)
C-index: 0.647

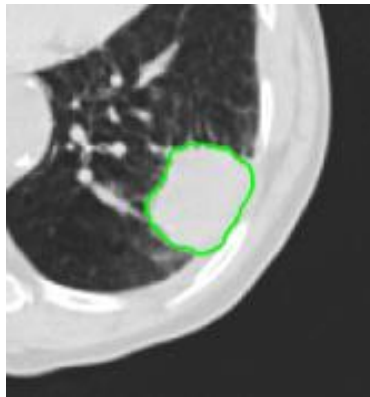
Discriminative power regardless of CT artifacts!

New

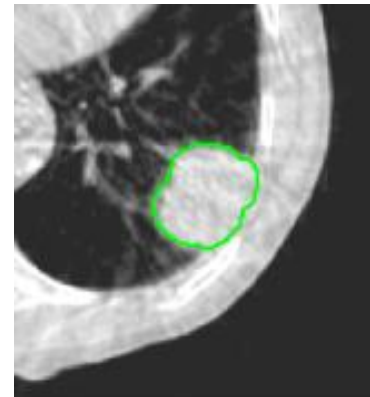
Would it work with

cone beam CT?

Conventional CT



vs. kV cone-beam CT



2016 :

“Deep learning”-based software has
beaten the champion of the “Go game”

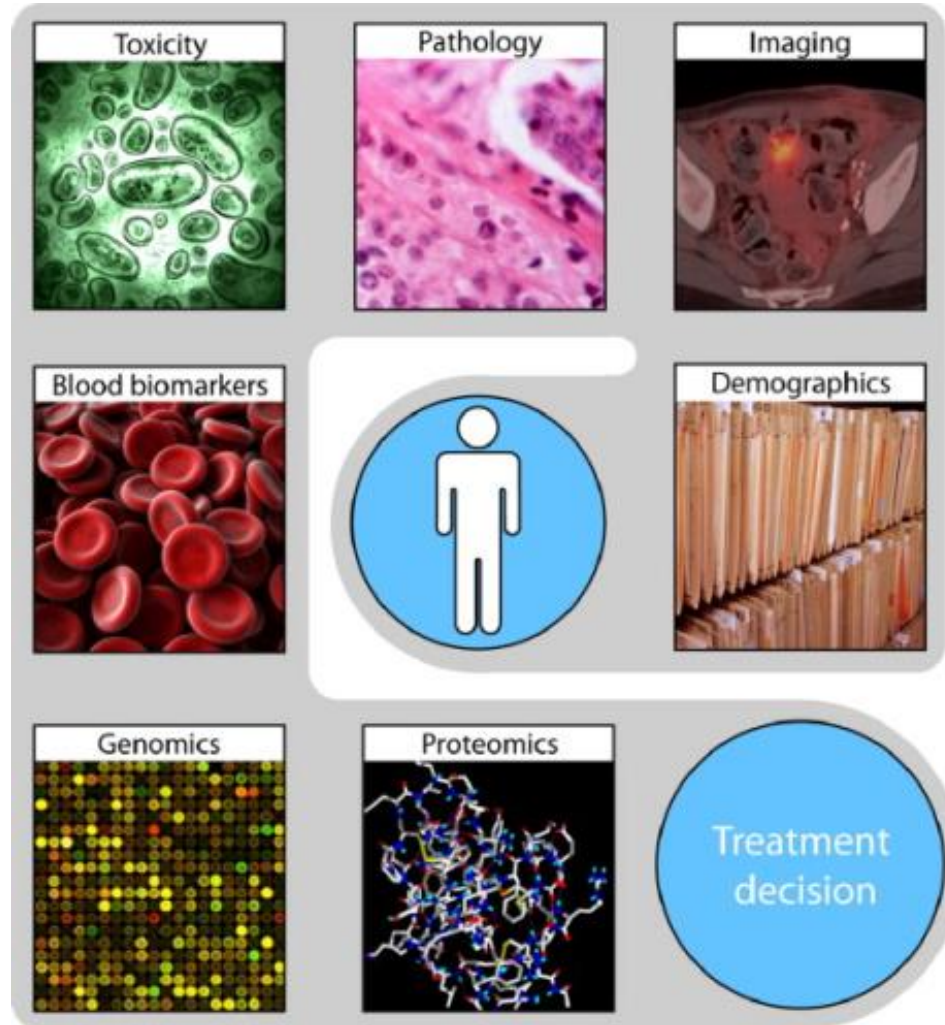
Example with the Atari game

Give me an

example?

The model-based indications for protons

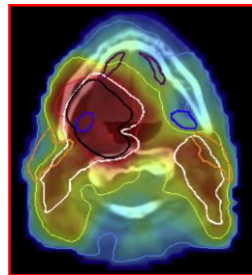
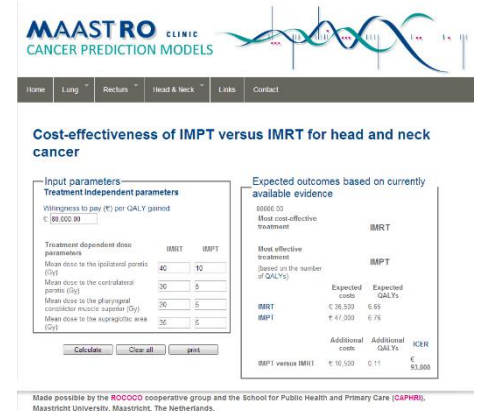
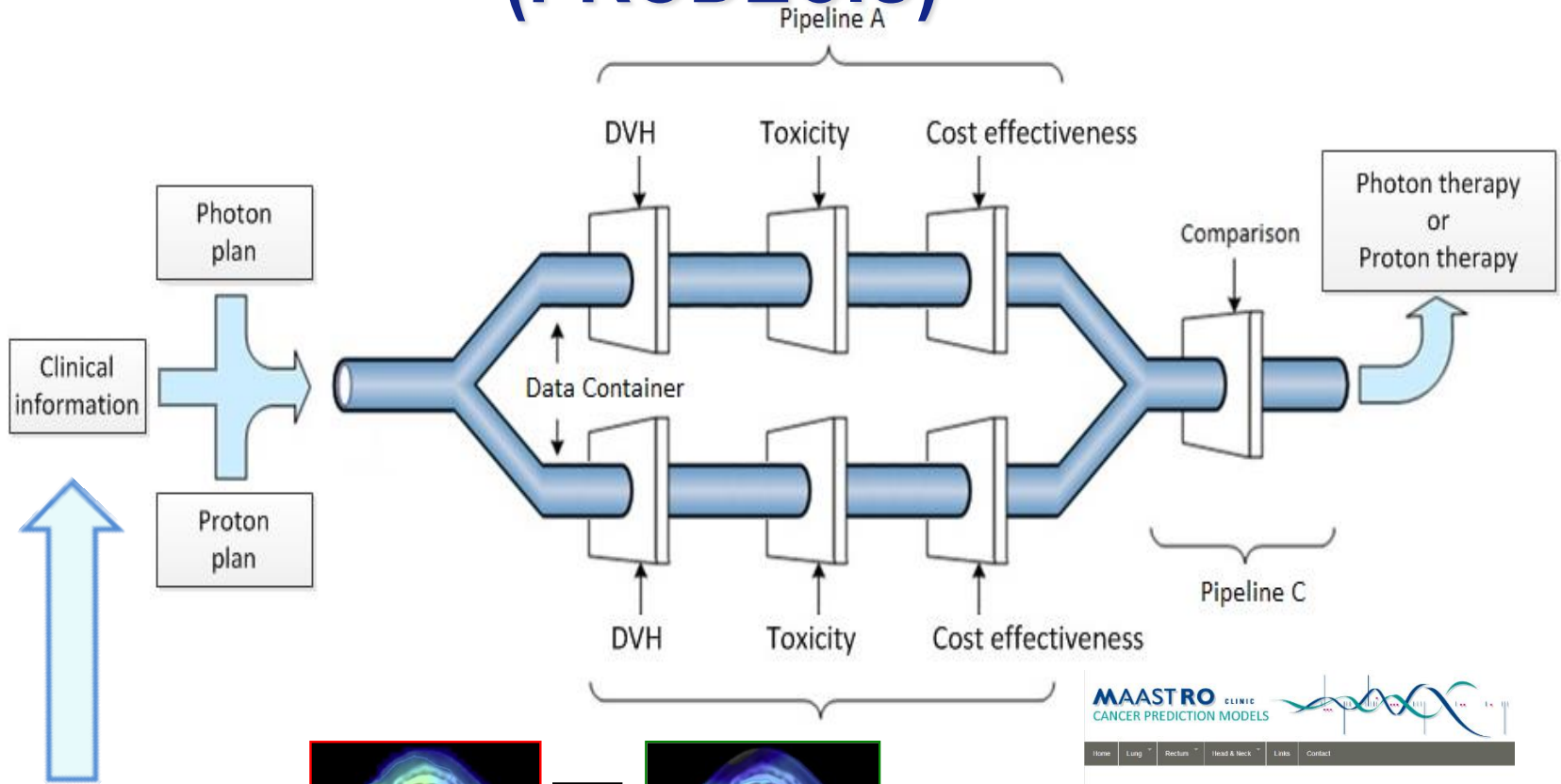
Build a machine for precision medicine: **“Multifactorial Decision Support System”**



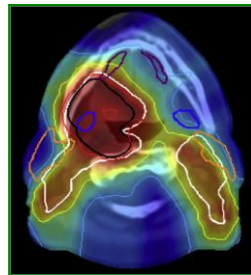
A meta-TPS

**Reuniting
Physics &
Biology**

Proton therapy Decision Support System (PRODECIS)



66.5 Gy
51.3 Gy
40.0 Gy
20.0 Gy
10.0 Gy

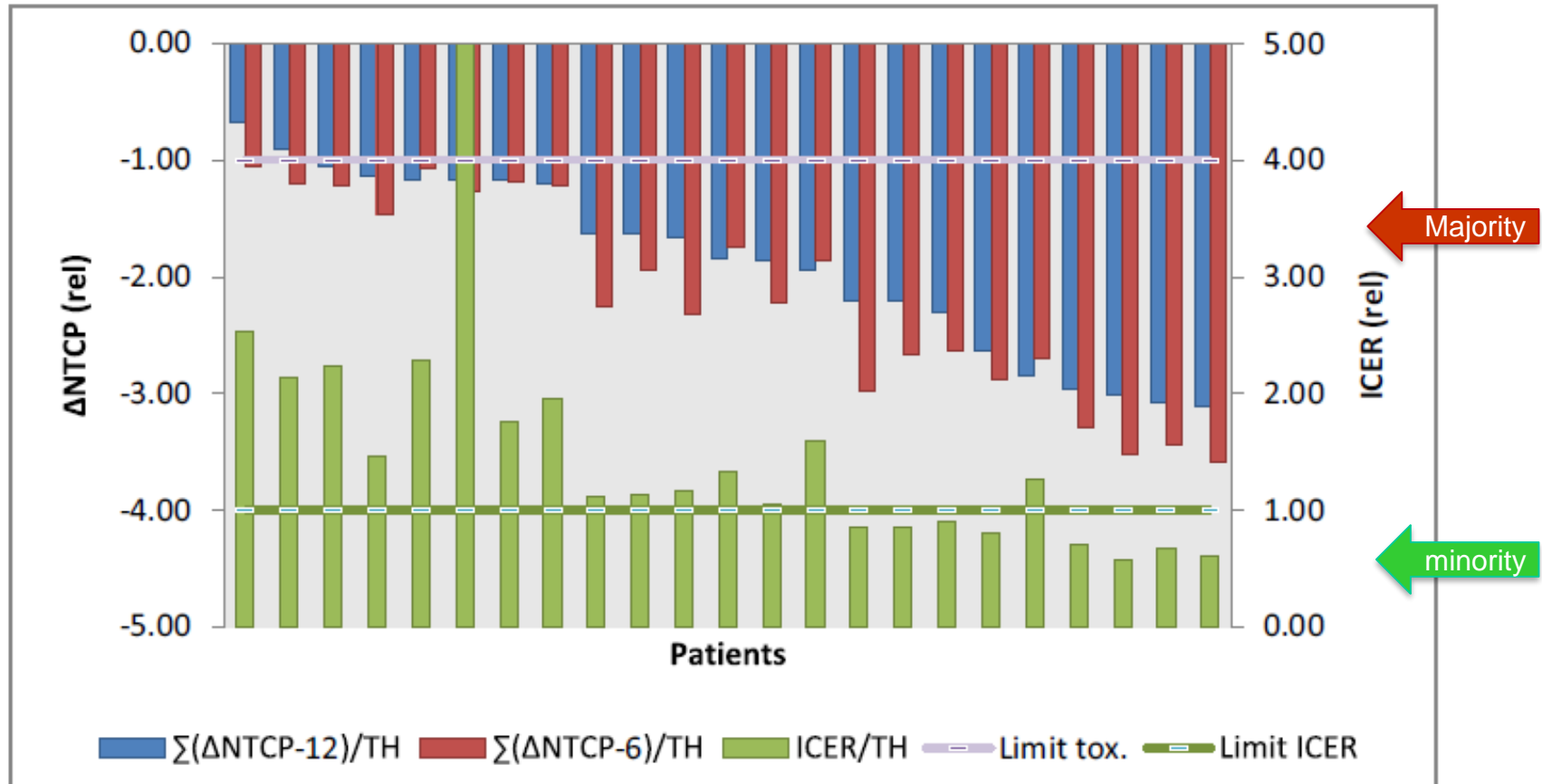


Sample handling

Isolation + processing

Result on interface

Proton therapy Decision Support System (PRODECIS)



Conclusions

- *We need a Big Data-based Decision Support System, **in particular for particle therapy.***
- *The “fashion” of Big Data induces a change of culture: to gather data.*
- *Radiomics is an approach which allows us to extract clinical and biological information from standard imaging (including cone-beam CT).*

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Main MAASTRO collaborators



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- Ralph Leijenaar
- Janita van Timmeren
- Wouter van Elmpt

