Point/Counterpoint Live Debate: Artificial Intelligence Will Soon Change the Landscape of Medical Physics Research and Practice

Introduction to Artificial Intelligence

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Applications of AI in Medical Physics

- Tumor detection, segmentation, and classification
- Image landmark detection and registration
- Automatic treatment planning, dose prediction
- Outcome prediction (survival, toxicity, recurrence)
- Clinical workflow (QA, Tx strategy, etc.)
- Radiomics & radiogenomics
  - Tumor classification, segmentation
  - Outcome prediction

~25 Sessions in 2018 AAPM

Recent Radiomics Studies

Br J Radiol 2017; 90: 20160642.

Big Data in Medical Physics

Information type	Data examples
Baseline clinical data	Demographics (including co-morbidity and family history), TNM-stage, date of diagnosis, histopathology
Diagnostic imaging data	Diagnostic CT, MR and PET imaging
Radiotherapy treatment planning data	Delineation/structure sets, planning-CT, dose matrix, beam set-up, prescribed dose and fractions
Radiotherapy treatment delivery data	Cone beam CTs, orthogonal EPID imaging, delivered fractions
Non-radiotherapy treatment data	Surgery, chemotherapy
Outcome data	Survival, local control, distant failure, toxicity (including patient reported outcomes), quality of life
Follow-up imaging data	Follow-up CT, MR and PET imaging
Biological data	Sample storage, shipping, tracing and lab results
Additional study conduct data	Study design, protocol, eligibility criteria

Data types and approximate sizes for a single patient.

Data type	Format	Approx. size
Clinical features	Text	10 MB
Blood tests	Numbers	1 MB
Administrative	ICD-10 codes	1 MB
Imaging data	DICOM	450 MB
Radiation oncology data (planning and on-board imaging)	DICOM, RT-DICOM	500 MB
Raw genomic data	BAM: Position, base, quality	6 GB
Total		**7.9 GB**

10 GB
per patient

Radiother Oncol. 2014 Dec; 113(3): 303–309. J.-E. Bibault et al. / Cancer Letters 382 (2016) 110–117

Challenges

- Improved ML methods, especially for unsupervised learning and reinforcement learning.
- Model verification, validation, and trust
  -> robust machine learning
- Potential pitfalls of model:
  - garbage in, garage out
  - bias data, biased results

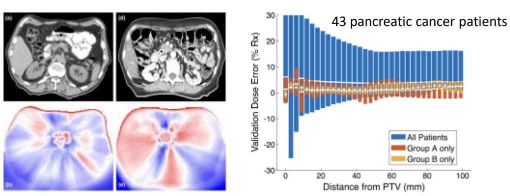
Thomas Dietterich, PhD, Oregon State University

Benefits and limitations of different machine learning (ML) methods

Algorithm	Advantages	Limitations
Decision Tree	• Easy to understand • Fast	• Classes must be mutually exclusive • Results depend on the order of attribute selection • Risk of overly complex decision trees
Naive Bayesian	• Easy to understand • Fast • No effect of order on training	• Variables must be statistically independent • Numeric attributes must follow a normal distribution • Classes must be mutually exclusive • Less accurate
k-nearest Neighbors	• Fast and simple • Tolerant of noise and missing values in data • Can be used for non-linear classification • Can be used for both regression and classification	• Variables with similar attributes will be sorted in the same class • All attributes are equally relevant • Requires considerable computer power as number of variables increases
Support Vector Machine	• Robust model • Limits the risk of error • Can be used to model non-linear relations	• Slow training • Risk of overfitting • Output model is difficult to understand
Artificial Neural Network and Deep Learning	• Tolerant of noise and missing values in data • Can be used for classification or regression • Can be easily updated with new data	• Output model is difficult to understand (« black-box ») • Risk of overfitting • Requires a lot of computer power • Requires experimentation to find the optimal network structure

J.-E. Bibault et al. / Cancer Letters 382 (2016) 110–117

Inter-observer Variation: neural network dose models for knowledge-based planning in pancreatic SBRT



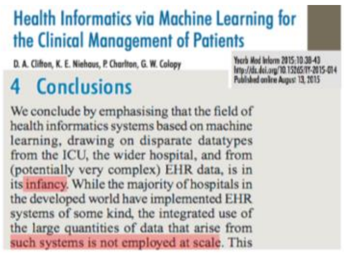
- Remarkable improvements by **training separate models for each physician**

Med Phys, 2017, November, DOI: 10.1002/mp.12621

Figure 2 Farming is a useful metaphor for envisioning the issues in creating outcomes databases in health care.

Advances in Radiation Oncology (2016) 1, 260-271

Where we are?



Health Informatics via Machine Learning for the Clinical Management of Patients

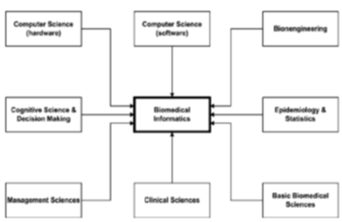
D. A. Clifton, K. E. Niehaus, P. Charlton, G. W. Colopy

Yearb Med Inform 2015:10:38-43
http://dx.doi.org/10.15265/IY-2015-014
Published online August 13, 2015

4 Conclusions

We conclude by emphasising that the field of health informatics systems based on machine learning, drawing on disparate datatypes from the ICU, the wider hospital, and from (potentially very complex) EHR data, is in its infancy. While the majority of hospitals in the developed world have implemented EHR systems of some kind, the integrated use of the large quantities of data that arise from such systems is not employed at scale. This

Role of Physicist in AI Medicine



Kagadis et al.: Medical physicists and health care applications of informatics, Med. Phys. 35 (1), January 2008

I used to be a medical physicist, but I did not learn AI……

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For the Proposition

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