Medical Informatics and Explainable AI

CERN openlab Summer Student Lectures

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Outline

- What do we mean with Medical Informatics?

- Areas of application

- Outstanding issues and open questions:
  - Explainable AI, Trustability
  - Data Set generation and curation

- Our projects
  - Explainability as necessary piece for Machine Ethics (Taghi) → 2nd half of this presentation
  - BioDynaMo (Lukas)

Medical Informatics

- Intersection between CS, IT, AI and Health care

- Many branches:
  - Creation of patient Data Bases
  - Engineering works on medical devices
  - Robotic precision surgeries
  - Data Analytics and model building
  - Biological Simulations

- This talk:
  - More Data Analytics and Machine Learning focus

Areas of Application

Examples of Medical Imagery Analysis

- Classification of Brain Tumor

- Segmentation in Ultrasound Images

- Skull Stripping in MR Images (Image on Right)

- Detection of Prostate Cancer from biopsy

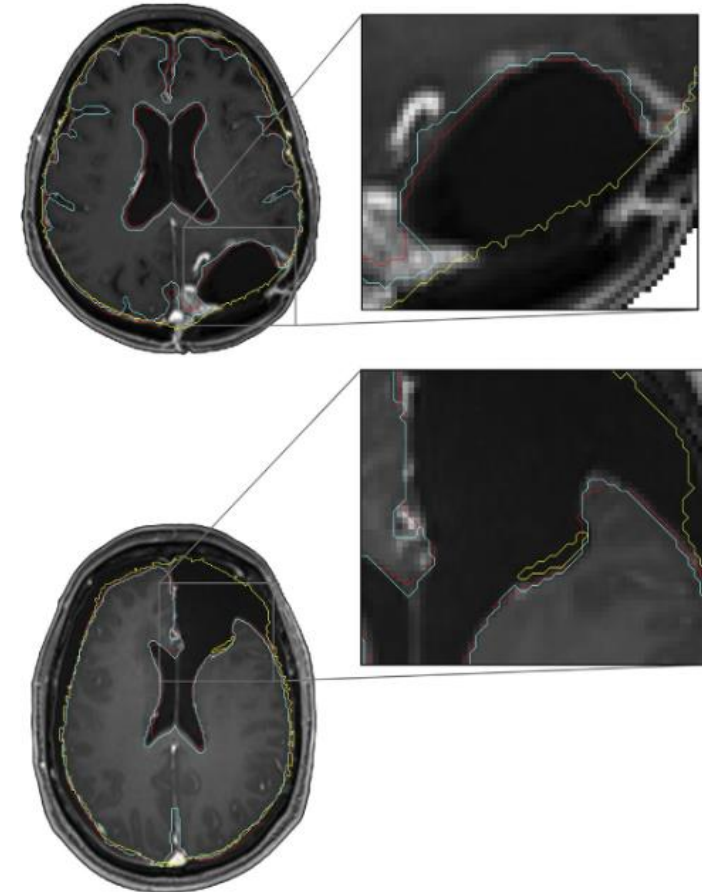- Identification of Breast Cancer in lymph nodes

Fig. 4. Example segmentations for the tumor data set. Brain masks generated by the neural architecture compare favorably to the masks generated by all other methods w.r.t the Dice score and specificity measure (cf. Table 3). Masks generated by the CNN are outlined in red, the ones generated by the method with the second best Dice score (3dSkullStrip) in yellow and the expert constructed GT in cyan.

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Areas of Application

Knowledge Discovery and Data Mining Examples

- Prediction of clinical outcomes
  - Survival Analysis
  - Diagnosis

- Identification of biomarkers
  - Neural Networks for biomarker identification for Alzheimer's
  - Population-studies

- Structural Variations in Genomes:
  - DeepVariant

Areas of Application

Knowledge Discovery and Data Mining Examples

- Personalized Medicine cases:
  - Analysis on Genome level for personalized drug development and usage
  - Respiratory Diseases: Role of Proteomics

- Graph approaches:
  - Causality
  - Bayesian/Markov Networks
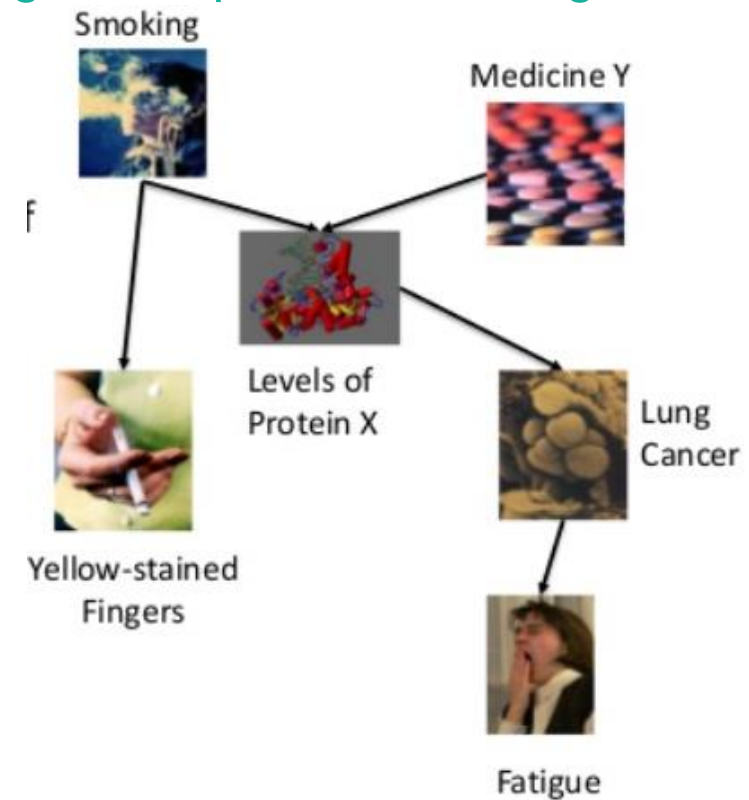
Pitfalls and open questions

- Two aspects:
    - Technical limitations
    - Algorithmic limitations

- Technical limitations:
    - Data set curation and generation
    - Partially resolved with Transfer Learning

- Algorithmic Limitations
    - Explainable AI, Machine Ethics → Rest of this talk

Ethics and Sustainability

Limitations, challenges, problems

- Limited negotiation powers in decision-making
    - With Deep Learning and other recent ML-based systems

- Not all the outputs understood or explained

- Ethical challenges:
    - Biased systems
    - Unavailability of explanations or explicit correlations
    - There will be talk on this in August → More announcements later

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Reasonable Inference

Explainable AI

- Ongoing preference towards non-"black box" models

- A paradox with recent advances:
  - Better models are available, however preferred to simpler models

- Explainability of the black box models
  - Open topic
  - Next necessary step in sustainability of Deep Learning models
  - Error correction

Explainable AI

Tendencies towards non Deep Learning approaches

Airplane | Automobile | Bird
Cat | Deer | Frog
Horse | Ship | Truck

Target classes

Original image (dog)

A White-Box Machine Learning Approach for Revealing Antibiotic Mechanisms of Action

Algorithms and Justice: Scrapping the 'Black Box'

By **Cynthia Rudin** | January 26, 2018

Explainable AI

Required characteristics

- Negotiate the inference

- Provide useful new insight from complex modelling techniques

- Meaningful human control over the systems

- Similar with scientific findings/hypothesis:
  - If a scientist produces a new theory or finding, they need to prove it and explain it
  - Same should be upheld for ML systems

Explainable AI

Twins UK Study together with King's College London

- A step towards interpretability and meaningful human control

- Detection of facial features in twins
  - Initially heritability analysis
  - Next clinical traits and disease symptoms

- Adaptive pipeline for deconvolution
  - Based off the work from M. Zeiler (2014)

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Explainable AI

Promising results

Conclusion

- Importance of Causal Reasoning
  - Cornerstone for Explainable AI

- Make sure to understand the needs of a project
  - Association-learning vs Explainability

- Other approaches:
  - Mechanical Approaches for well-designed simulation studies
  - More from Lukas right now!

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