

Medical Informatics

Lecture 14: Imaging and text data in Medicine

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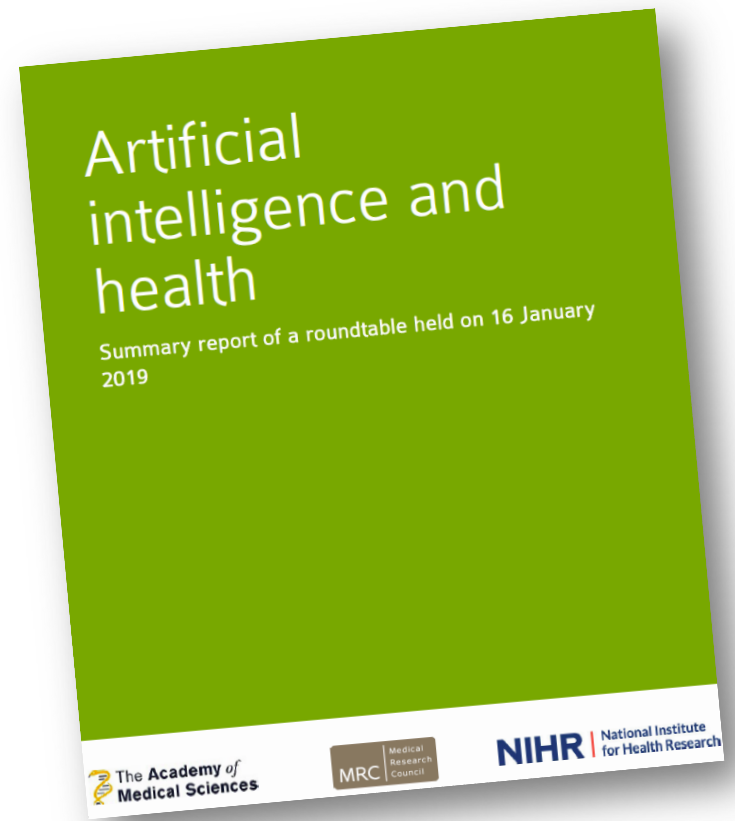
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Beyond tabular data

*“AI can add substantial value to learning systems that have cryptic hard to define features, such as those found in **images**, free **text** or **video** footage.”*



Medical Imaging

Medical imaging

- Medical imaging allows us to create visual representations of the interior of the body for clinical analysis and medical intervention.
 - To reveal internal structures hidden by the skin and bones
 - To diagnose and treat disease
- Medical imaging in the data science era:
 - unprecedented growth in the volume of medical imaging data
 - challenges, due to the complexity and the poor quality of imaging data

Medical imaging

- How do we acquire medical images?
- What is the format of medical images?
- How do we store and access medical images?
- How do we analyse medical images?

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Medical imaging modalities

- X-ray imaging
- Computed Tomography (CT)
- Magnetic Resonance Imaging (MRI)
- Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT)

Medical imaging modalities

- X-ray imaging
 - the oldest medical imaging technique
 - Dense parts of the body show up as clear white areas on the image, while softer parts show up as darker areas.



*[Image by Louis Philippe Lessard
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Medical imaging modalities

- X-ray imaging
- Computed Tomography (CT)
 - Also called Computed Axial Tomography (CAT)
 - A type of slice imaging: imaging by sections or slices through the body
 - It can produce detailed images of many structures in a thin section of the body.

Medical imaging modalities

- X-ray imaging
- Computed Tomography (CT)
- Magnetic Resonance Imaging (MRI)
 - Can be used to examine almost any part of the body
 - MRI vs. CT:
 - MRI has excellent soft tissue contrast. CT is preferred for lung and bone imaging.
 - CT is faster and it is more widely used than MRI.
 - CT scanning is associated with increased risk of cancer. MRI scanning does not have such health hazards.

Medical imaging modalities

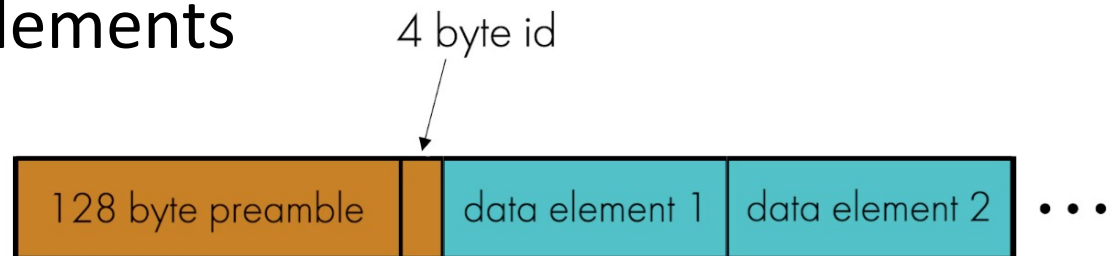
- X-ray imaging
- Computed Tomography (CT)
- Magnetic Resonance Imaging (MRI)
- Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT)
 - nuclear imaging: assessment of physiology rather than anatomy
 - Modern scanners may integrate PET or SPECT with other modalities.

Medical imaging

- How do we acquire medical images?
- **What is the format of medical images?**
- How do we store and access medical images?
- How do we analyse medical images?

DICOM format

- DICOM (Digital Imaging and Communications in Medicine) is an international standard for storing, exchanging and transmitting medical images.
- DICOM file content:
 - image pixel data
 - header of fixed length, followed by a sequence of tagged data elements



*[Image from
DataSciMed MOOC]*

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 - header of fixed length, followed by a sequence of tagged data elements
 - The header contains information about the file, the imaging equipment used, the study and the patient that it belongs to.

Medical imaging

- How do we acquire medical images?
- What is the format of medical images?
- How do we store and access medical images?
- How do we analyse medical images?

PACS

- Medical images are created, stored, accessed and processed in the restricted environment of a hospital.
- They are typically kept in a **Picture Archiving and Communication System** (PACS).
- A PACS archives medical images (and the associated meta-information) within radiology and distributes them to departments that ordered the images.

Medical imaging

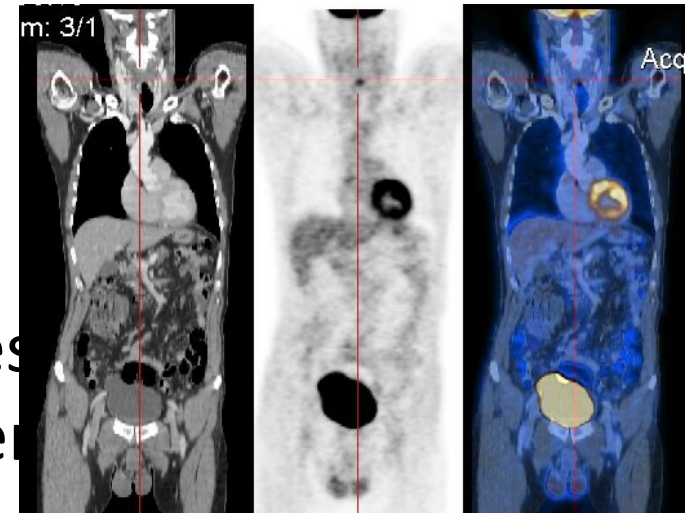
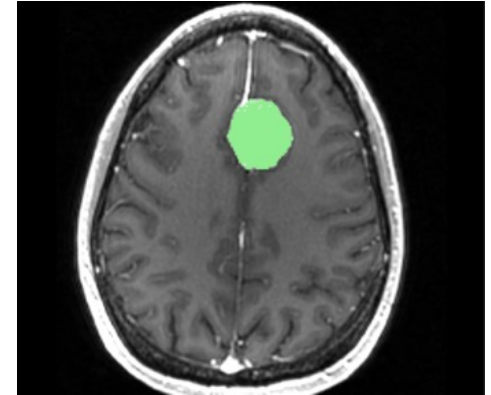
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Medical imaging pre-processing

- We typically **enhance** the image before analysing it
 - to enhance contrast by reducing any artefacts or noise in the image or by emphasising differences between objects (e.g. enhancing edges)
- **Feature detection**: may involve edge tracking, corner detection and template matching, e.g. blob detection

Medical imaging analysis

- **Segmentation**: to partition an image into different meaningful segments, such as particular organs, different tissue classes or pathologies
- **Registration**: to compare or combine different images by determining a one-to-one mapping between the coordinates in one image and those in another



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Segmentation techniques

- Thresholding:
 - the simplest segmentation method
 - it works particularly well when there is a good level of contrast between different structures
- Region growing
 - domain knowledge: the user specifies a seed point in an object of interest that needs to be separated
- Region merging
- Watershed transform
- Live wire

Natural Language Processing

pathology reports,
clinical notes, referral
letters, radiology
reports, etc.

Processing text in an *automated* fashion and extracting *meaning* from it is very challenging.

Natural Language Processing

- **Natural Language Processing** is a set of computational methods to analyse, understand, and derive meaning from human language.
- Typical tasks:
 - sentence boundary detection
 - tokenisation
 - part-of-speech tagging
 - named entity recognition

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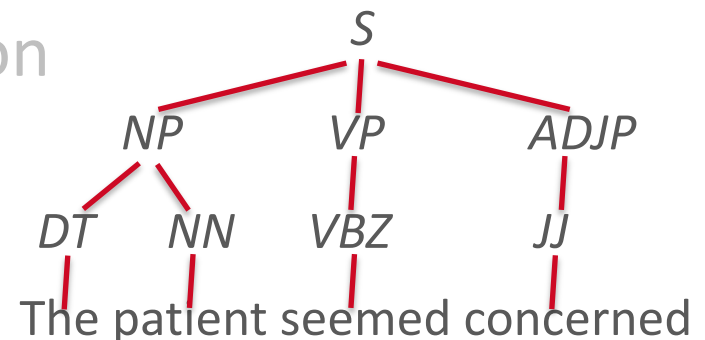
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Tokens: ['The', 'patient', 'seemed', 'concerned', ':']

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|
PERSON

Natural Language Processing

- **Natural Language Processing** is a set of computational methods to analyse, understand, and derive meaning from human language.
- Other high-level tasks:
 - word sense disambiguation
 - negation and uncertainty identification
 - relationship extraction
 - temporal inferences

Computational methods in NLP

Two main approaches:

- rule-based: using linguistic rules and patterns
- machine learning:
 - neural networks and deep learning
 - support vector machines

Ontologies in NLP

Suppose that we want to analyse free text in electronic health records to answer two questions:

- Does the patient have disease X?
 - Use ontologies to make use of definitions and synonyms of diseases
- Which patients are on mood stabilisers?
 - Use ontologies to make use of terminological information, e.g. subClass

Recommended reading at <https://towardsdatascience.com/derive-insights-from-health-data-using-knowledge-graph-technologies-b6cf2b742cd6>

Conclusions

- Imaging and natural language data are unstructured data. Their analysis is challenging.
- Some success stories in medical image analysis using artificial intelligence.
- Growing interest in the automated analysis of free text in electronic health records.
- Watch this space!