NUCLEAR MEDICINE EUROPE
the industry association

ARTIFICIAL INTELLIGENCE IN NUCLEAR MEDICINE

Opportunities and Challenges

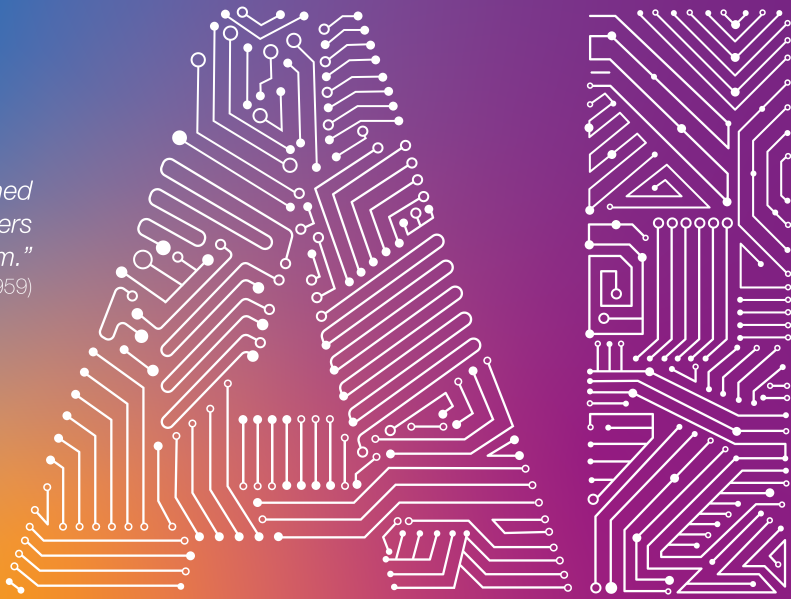
Nuclear Medicine (NM) and Artificial Intelligence (AI) together empower medical doctors for more effective patient management and better outcome. Nuclear medicine provides non-invasive, quantitative information on physiology and signalling that is essential to interpret for understanding diseases and assigning appropriate therapies.

This information is amended by morphological information in the context of hybrid anatomo-metabolic imaging that has become prevalent today through SPECT/CT, PET/CT and PET/MR imaging. Moreover, additional clinical and non-clinical information is included in medical decision making, thus calling for a highly integrative data analysis.

This analysis is supported more and more by AI algorithms to help the medical professionals see through the multiplexed attributes of their patients, attributes of patients or study subjects. We, as Nuclear Medicine Europe, support the adoption of AI in the context of routine NM applications and future derivatives in tracer development, drug candidate selection, NM imaging and therapy decision making.

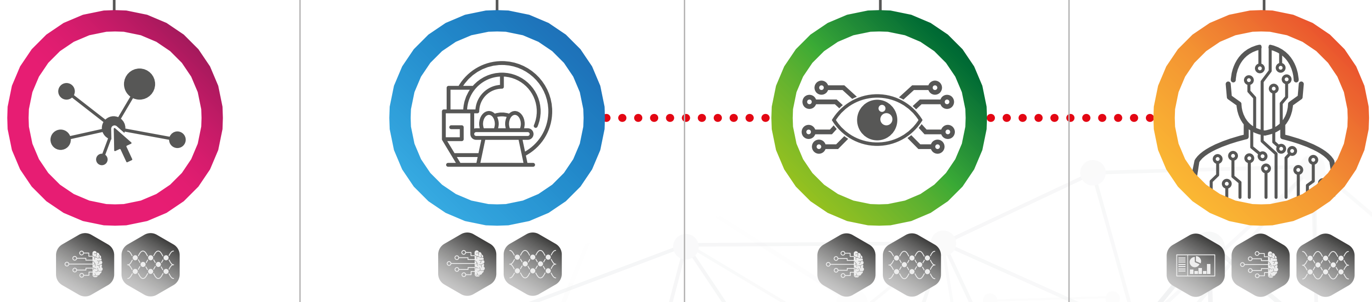
Notably, AI comes with a number of promises and caveats alike.

"A computer can be programmed so that it will learn to play a better game of checkers than can be played by the person who wrote the program."
Arthur Samuel (1959)



Over the past decade, **AI has become widely available** and contributed significantly to the field of medical imaging, mainly in Radiology (for reasons of exponential growth of image data), and less so in NM. However, this is changing thanks to the expansion of the NM imaging market, growing reimbursement for NM imaging and expanded proof-of-concept for NM-guided patient management.

Target Selection | **Data acquisition & reconstruction** | **Image-processing** | **Data-mining**

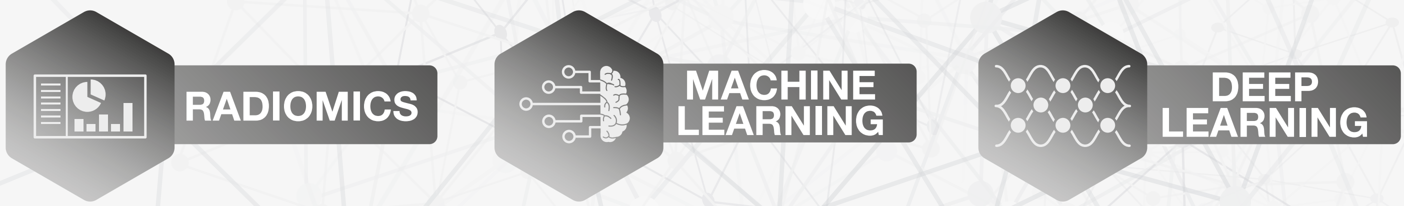


Target Selection
- Promises in fast-tracking novel radiotracers
- Prediction of relevant targets
- Potential economies

Data acquisition & reconstruction
- Improved signal detection
- High quality reconstruction from sparse data
- Fast reconstructions
- Data-corrections
- De-noising

Image-processing
- Segmentation
- Metal-artefact removal
- Motion-correction
- Image-synthesis

Data-mining
- Image classification
- Image-based prognosis
- Clinical decision support system

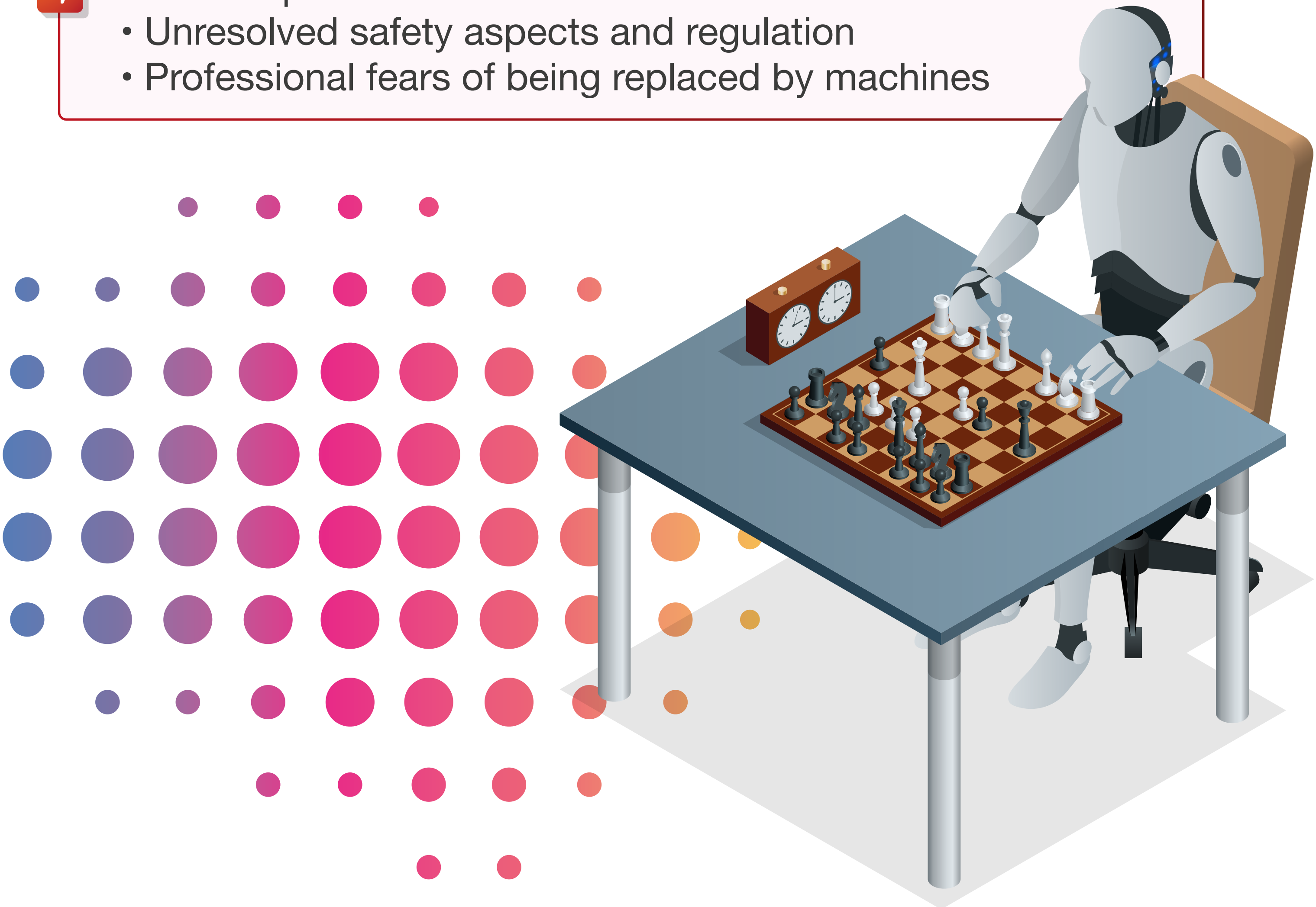


AI describes the use of high-performance computing to extract hidden layers of information from large amounts of a variety of data (“big data” concept).

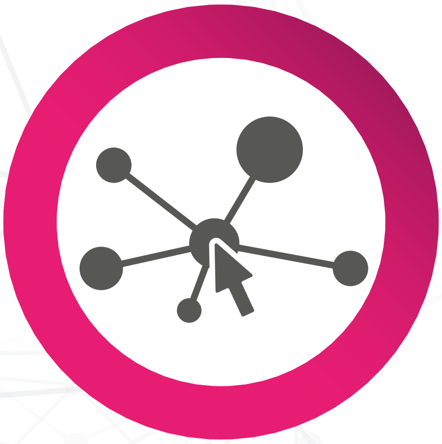
AI in healthcare includes several facets: **radiomics** extracts features that are descriptive of images (e.g., noise) and that can be fed into a **machine learning** algorithm; **shallow learning** is a way of learning from data that are described by pre-defined features and, thus, presents a **reasoning** facet of AI, similar to that of human beings; finally, **deep learning** automatically learns the bespoke features with their weights, i.e. level of importance.

- Generating new knowledge from a large and complex data
- Reduced reader variability
- Automation and cost saving
- Free medical staff to do higher-level work

- Input data bias leading to inaccurate models
- Data protection hampers data pooling
- Limited patient trust
- Unresolved safety aspects and regulation
- Professional fears of being replaced by machines



Opportunities | Role of AI in NM



Target Selection

This, although perhaps the least investigated, field for NM **holds substantial promises in fast-tracking novel radiotracers.** Creating digital disease and physiological models (digital twin concept), prediction of relevant targets and ruling out the least probable tracer candidates can be a few of the potential economies that can be achieved with AI in the new tracer development process.

Data acquisition & reconstruction

First AI algorithms have been proposed to help choose the right imaging protocol for the specific patient; this includes patient positioning, CT dose modulation and image reconstruction of noisy (aka lower-dose) data. Making better use of sparsely sampled data (from faster acquisitions) through AI, **helps improve image quality and throughput.** AI was shown to hold great promise for scatter and attenuation correction for both, SPECT and PET.

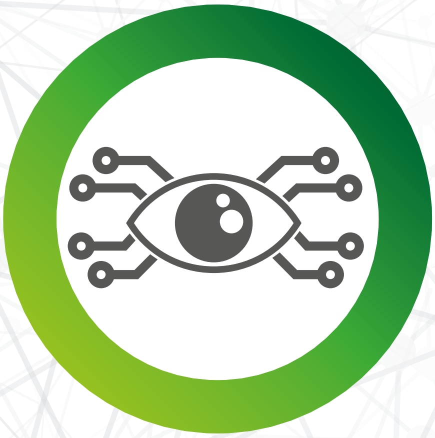


Image-processing

Lesion detection and quantification requires careful screening of the corrected NM images. AI has been demonstrated to **help segment malignant lesions on NM alone or by using hybrid image information.** Deep learning in particular is being explored for routine metal artifact correction or motion compensation, as well as inter-modality image transformation, for example, for MR-guided radiation treatment planning using PET/MR data.

Data-mining

Deep learning is a powerful discovery tool for data mining approaches and hypothesis generation, even more so, when using multi-parametric image and non-image information.
As a first step, radiomics feature can be extracted and correlated with non-invasive phenotypes of diseases.
Further, these features allow to **build prediction models** for the existence of a disease, target expression and even therapy response; all pending the availability of appropriate reference data.

Risks and Caveats | Role of AI in NM

AI HOLDS A GREAT POTENTIAL TO SUPPORT A QUANTUM LEAP OF MEDICAL DIAGNOSIS AND PATIENT MANAGEMENT

Numerous pre-clinical studies attest to the benefit of making use of computer-based processing of NM imaging.

Despite these promises, **a number of caveats need to be recognized**, these pertain mainly to the lack of ample evidence of reproducibility of developed AI tools; showing them to work at one site without disseminated accuracy proofs at other sites will not help their adoption in routine NM management.

Secondly, **the quality of the training data must be high** to ensure a high performance of the AI functionalities. Here, NM can play a role model for its tireless and long-lasting efforts to standardize and harmonize imaging procedures and – more recently – for the application of AI to NM images.

A conceptual merger of AI with NM

SEVERAL APPROACHES
CAN HELP EXPLORE AND ADOPT AI FOR NM-CENTRIC PATIENT MANAGEMENT

Making use of existing **open-source routines** to expedite the development of proof points

Encourage **multi-centric studies** for more robust AI evaluation, thereby making provisions to tap into GDPR-compliant data pools

Foster local and globally accessible **High-Performance Computing environments**

Ensure **continuous training and education** of all stakeholders involved, including patients.

This pictorial view is an innitiative of the Nuclear Medicine Europe Innovation Working Group

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