MODERN RADIOLOGY eBook

AI in Radiology

AI 在放射学中的应用

EUROPEAN SOCIETY OF RADIOLOGY

/ Preface

Modern Radiology is a free educational resource for radiology published online by the European Society of Radiology (ESR). The title of this second, rebranded version reflects the novel didactic concept of the *ESR eBook* with its unique blend of text, images, and schematics in the form of succinct pages, supplemented by clinical imaging cases, Q&A sections and hyperlinks allowing to switch quickly between the different sections of organ-based and more technical chapters, summaries and references.

Its chapters are based on the contributions of over 100 recognised European experts, referring to both general technical and organ-based clinical imaging topics. The new graphical look showing Asklepios with fashionable glasses, symbolises the combination of classical medical teaching with contemporary style education.

Although the initial version of the *ESR eBook* was created to provide basic knowledge for medical students and teachers of undergraduate courses, it has gradually expanded its scope to include more advanced knowledge for readers who wish to 'dig deeper'. As a result, *Modern Radiology* covers also topics of the postgraduate levels of the *European Training Curriculum for Radiology*, thus addressing postgraduate educational needs of residents. In addition, it reflects feedback from medical professionals worldwide who wish to update their knowledge in specific areas of medical imaging and who have already appreciated the depth and clarity of the *ESR eBook* across the basic and more advanced educational levels.

I would like to express my heartfelt thanks to all authors who contributed their time and expertise to this voluntary, non-profit endeavour as well as Carlo Catalano, Andrea Laghi and András Palkó, who had the initial idea to create an *ESR eBook*, and - finally - to the ESR Office for their technical and administrative support.

Modern Radiology embodies a collaborative spirit and unwavering commitment to this fascinating medical discipline which is indispensable for modern patient care. I hope that this ***educational*** tool may encourage curiosity and critical thinking, contributing to the appreciation of the art and science of radiology across Europe and beyond.

Minerva Becker, Editor
Professor of Radiology, University of Geneva, Switzerland

/ **AI** in Radiology

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章节大纲：

/ 前言

*《现代放射学》*是由欧洲放射学协会 (European Society of Radiology,ESR) 在线发布的免费放射学教育资源。第二版（更名版）标题反映了 *ESR 电子书*新颖的教学概念，它以简洁页面的形式巧妙地融合文本、图像和示意图，并辅以临床影像学案例、问答部分和内容超链接，使读者能够在各基于器官的部分、更具技术性的章节、摘要以及参考文献之间快速切换浏览。

其章节以 100 多名公认欧洲专家的优秀稿件为根基，涉及各类一般技术和基于器官的临床影像学主题。同时采用了全新的图形外观，展示了佩戴时尚眼镜的 Asklepios，象征着传统医学教学与现代风格教育的结合。

虽然初版 *ESR 电子书*旨在为医学生和本科生教师提供医学基础知识，但现已逐渐扩充其知识领域，为希望“深入挖掘”的读者提供了更多高阶技术知识。因此，*《现代放射学》*还涵盖了*欧洲放射学培训课程*研究生水平的各类主题，旨在解决住院医师的研究生教育需求。此外，书中还囊括了全球医疗专业人士的反馈，他们希望更新自己在医学影像特定领域的知识，并对 *ESR 电子书*在基础和高等教育水平上的深度和清晰度表示高度赞赏。

我要衷心感谢所有为这项非营利活动自愿贡献时间和专业知识的作者，以及最初提出创作 *ESR 电子书*的 Carlo Catalano、Andrea Laghi 和 András Palkó，最后还要感谢 ESR 办公室所提供的技术和行政支持。

*《现代放射学》*充分体现了医者的协作精神和对这门热门医学学科坚定不移的承诺，这是现代患者护理必须具备的优秀精神品质。我希望这款***教育***工具能够激励各位始终保持好奇心和批判性思维，从而促进整个欧洲乃至欧洲以外地区对放射学艺术和科学的认识。

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瑞士日内瓦大学放射学教授

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This is a translation of the Chapter of the **Modern Radiology eBook.**

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NOTE FROM THE COORDINATORS:
Thank you to Chinese radiology experts for bridging languages and open the world-class English resource by ESR to every Mandarin-speaking student, fueling global radiology talent with a single click

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章节大纲：

翻译致谢

本章节为《现代放射学电子书》的部分译文。

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中华医学会放射学分会

译者寄语：
感谢中国放射学专家们的倾力奉献！你们跨越了语言的鸿沟，将欧洲放射学会 (ESR) 的世界级学术宝库呈献给广大中文学子。如今，前沿智慧一键即达，为全球放射学人才的蓬勃发展注入了强劲动力。

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/ Signage

<▪> **CORE KNOWLEDGE**

<!> **ATTENTION**

<↑> **HYPERLINKS**

>▪< **FURTHER KNOWLEDGE**

>|< **COMPARE**

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<?> **QUESTIONS**

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>▪< **进阶知识**

>|< **比较**

<∞> **参考文献**

<?> **问题**

MODERN RADIOLOGY eBook

Based on the ESR Curriculum for Radiological Education

AI in Radiology

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AI in Radiology

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AI 在放射学中的应用

基于 ESR 课程的放射学教育

章节大纲：

AI 在放射学中的应用

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- Definitions

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- Reinforcement Learning

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章节大纲：

/ 简介

/ Why Should We Learn About AI?

/ Artificial intelligence (AI) is a rapidly growing field, influencing every aspect of our lives, including the way we practice medicine. Healthcare workers should **keep up with the pace of digital development** to advance the field.

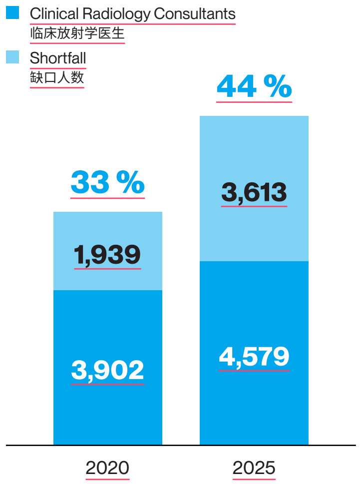
/ While the volume and complexity of imaging is skyrocketing, there is a rise in workforce shortages and strain on radiologists. As a result, quality decreases and reporting backlogs are growing. **AI may increase both the speed and quality** of reporting, while boosting physicians job satisfaction.

/ The use of AI in healthcare poses **potential risks**, such as large number of errors or additional unnecessary costs. Therefore, we should learn more about AI in order to deploy AI tools safely and effectively in medicine.

/ In the following section we will learn more about the applications of AI in radiology, **but first let's look at the brief history of and fundamental information about AI.**

Forecast Shortfall of Clinlcial Radiolgy Consultants in UK 2020-2025

英国临床放射学医生 2020-2025 年度预测缺口



<∞> REFERENCE

Adapted from Clinical radiology UK workforce census 2020 report

https://www.rcr.ac.uk/publication/clinical-radiology-uk-workforce-census-2020-report

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/ 我们为什么要了解 AI?

章节大纲：

/ 人工智能 (AI) 是一个快速发展的领域，影响着我们生活的方方面面，包括医疗实践方式。医疗工作者应该**跟上数字化发展的步伐**，以推动该领域的发展。

/ 随着医学影像数据量和复杂性的激增，放射科医师面临人力短缺和工作压力加剧的挑战。这导致诊断质量下降，报告积压问题日益严重。**人工智能可以提高报告的速度和质量**，同时提高医生的工作满意度。

/ 不过，AI 在医疗领域的应用也存在**潜在风险**，例如可能出现大量误诊或产生不必要的额外成本。因此，我们必须深入了解 AI，才能安全有效地将 AI 工具应用于医疗领域。

/ 在接下来的章节中，我们将重点探讨 AI 在放射学中的应用，**但首先，让我们简要了解 AI 的发展历史和基础知识。**

<∞> 参考文献

Adapted from Clinical radiology UK workforce census 2020 report

https://www.rcr.ac.uk/publication/clinical-radiology-uk-workforce-census-2020-report

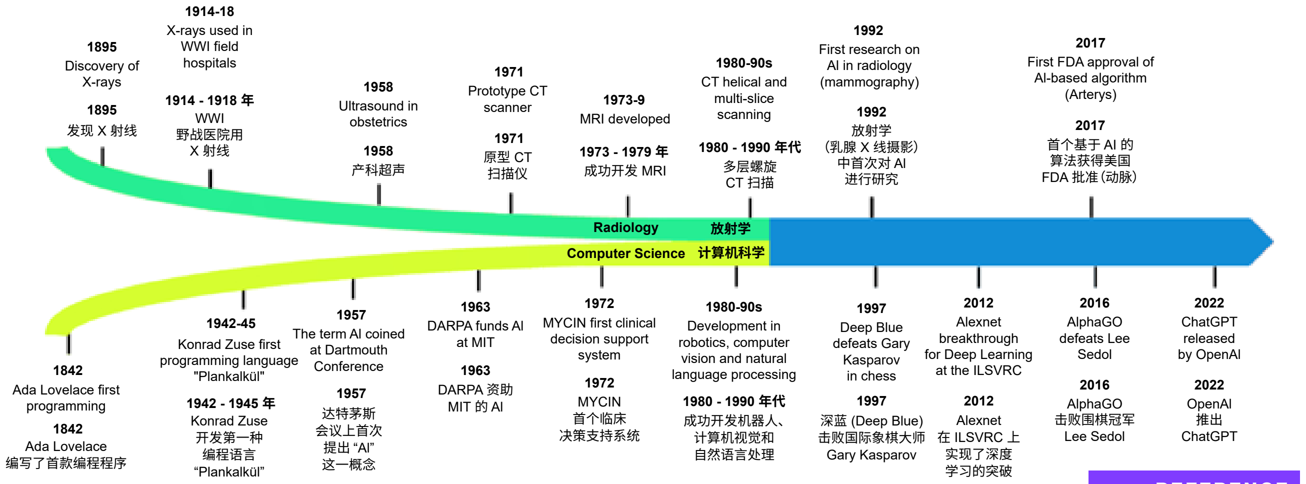
/ Brief History of AI in Radiology

/ Ada Lovelace conceptualised the first programming in 1842, marking the birth of computer science.

/ In 1895, William Conrad Roentgen discovered the first X-ray, leading to the emergence of radiology as a specialty.

/ Krizhevsky et al., won the ImageNet challenge in 2012 with AlexNet, a convolutional neural network, and the field of Deep Learning has skyrocketed.

/ First AI-based algorithm is cleared by FDA in 2017 and officially entered to clinical setting.



<∞> REFERENCE

Adapted from Clin Transl Sci (2020) 13, 216–218; doi:10.1111/cts.12704

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/ AI 在放射学领域的发展简史

/ 1842 年，Ada Lovelace 提出了首个编程概念，标志着计算机科学的诞生。

/ 1895 年，William Conrad Roentgen 首次发现 X 射线，放射科由此应运而生。

/ 2012 年，Krizhevsky 等人凭借卷积神经网络 AlexNet 赢得 ImageNet 竞赛，深度学习领域自此蓬勃发展。

/ 2017 年，首个基于 AI 的算法获得美国 FDA 批准，正式进入临床应用。

<∞> 参考文献

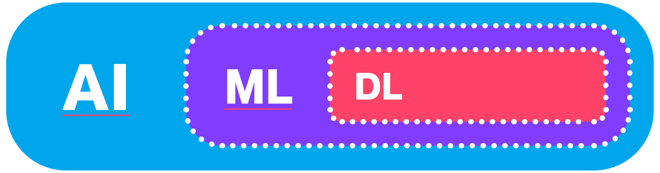
Adapted from Clin Transl Sci (2020) 13, 216–218; doi:10.1111/cts.12704

/ Definitions

>|< COMPARE

/ **Artificial Intelligence (AI):** a field within computer science focused on creating solutions capable of **performing tasks that are typically associated with human intelligence**. It is a broad term that encompasses a wide range of technologies, and even a basic rule-based model can be considered a form of AI.

/ **Machine Learning (ML):** a subset of AI that revolves around the creation of algorithms capable of learning from data and making predictions. However, these algorithms still rely on **human supervision**. ML is not a new concept within the AI field. In computer vision, traditional ML algorithms often entail image processing and explicit feature extraction.



/ **Deep Learning (DL):** a subset of ML that utilises **neural networks** to learn patterns in data. It is considered a relatively new field within AI and has experienced a surge in popularity in recent years. Training a DL model usually requires large amounts of data and computational resources due to the complexity of neural network architectures. Nowadays, that's feasible thanks to graphic cards specialised in matrix operations.

<!> ATTENTION

AI is an umbrella term and can be applied to many domains in many forms.

In this chapter we focus mainly on **deep learning in image recognition.**

/ AI in Radiology

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章节大纲：

/ 定义

>|< 比较

/ 人工智能 (AI)：计算机科学的一个分支领域，致力于开发能够执行通常需要人类智能才能完成任务的解决方案。这是一个广义术语，涵盖多种技术，即使是基于规则的简单模型也可视为 AI 的一种形式。

/ 机器学习 (ML)：AI 的子集，围绕开发能够从数据中学习并进行预测的算法。但这些算法仍需要人类监督。在 AI 领域中，机器学习并非全新概念。在计算机视觉领域，传统的 ML 算法通常涉及图像处理和显式特征提取。

/ 深度学习 (DL)：ML 的子集，利用神经网络来学习数据模式。它被认为是 AI 中一个相对较新的领域，近年来发展迅猛。由于神经网络架构的复杂性，训练 DL 模型通常需要大量的数据和计算资源。如今，得益于擅长矩阵运算的显卡技术，这已成为可能。

<!> 注意

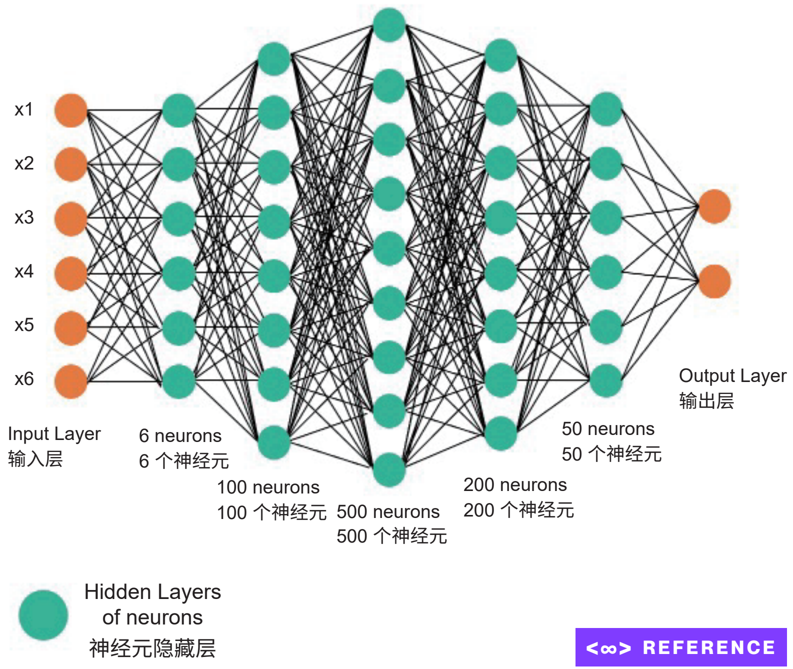
AI 是一个总称，其应用形式多样且覆盖众多领域。

本章我们将主要聚焦于图像识别中的深度学习。

>|< COMPARE

/ **Artificial Neural Network (ANN):** a type of machine learning algorithm that mimics the structure and function of the human brain. They contain multiple neurons organised in hierarchical layers. The layers closest to the input layer are responsible for processing and transforming the input data to extract relevant features, whereas the output layer is responsible for the final output.

/ **Deep neural network (DNN):** a specific type of neural network composed of multiple intermediate layers (i.e., hidden layers). They can be used to train powerful models based on large amounts of data.



<∞> REFERENCE

Adapted from M. Bahi and M. Batouche, "Deep Learning for Ligand-Based Virtual Screening in Drug Discovery," doi: 10.1109/PAIS.2018.8598488

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>|< 比较

章节大纲：

/ 人工神经网络 (ANN)：一种模拟人脑结构和功能的机器学习算法。其由多层级排列的神经元组成。最接近输入层的层级负责处理和转换输入数据以提取相关特征，而输出层则负责生成最终结果。

/ 深度神经网络 (DNN)：由多个中间层（即隐藏层）组成的特定类型的神经网络。基于海量数据训练，该网络能够构建高性能的模型。

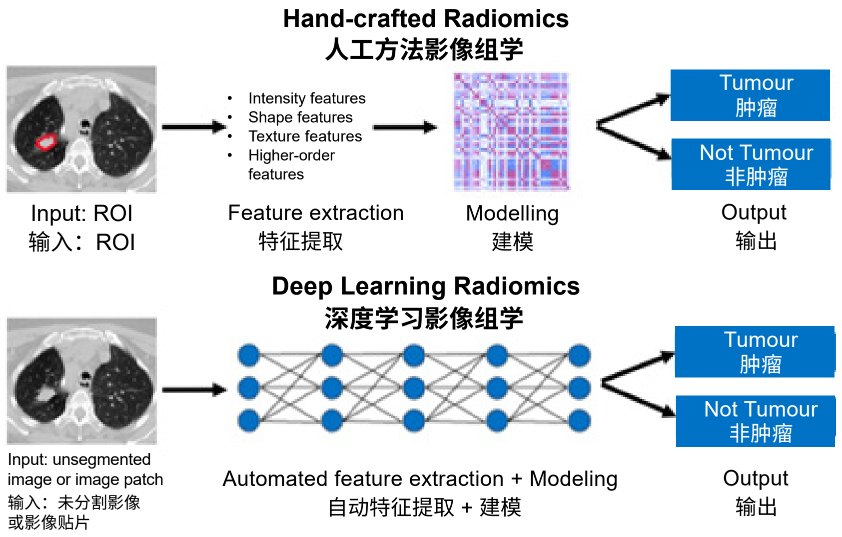
<∞> 参考文献

Adapted from M. Bahi and M. Batouche, "Deep Learning for Ligand-Based Virtual Screening in Drug Discovery," doi: 10.1109/PAIS.2018.8598488

Radiomics: refers to **extracting quantifiable and minable features** from medical images. It is a rapidly growing research field and mostly applied in the field of oncological imaging.

Currently, radiomics is still **largely a research area**, but efforts are being made to translate these research findings into the clinic.

Depending on whether one uses **hand-crafted or deep learning approaches**, the radiomics workflow may include clinical and imaging data curation, image pre-processing, image segmentation, feature extraction, model development, and model validation.



Courtesy of Tugba Akinci D'Antonoli

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章节大纲：

影像组学：指从医学影像中提取**可量化、可挖掘的特征**。这是一个快速发展的研究方向，目前主要应用于肿瘤影像学领域。

尽管现阶段影像组学**仍以科研探索为主**，但人们正致力于推动其向临床转化。

根据所使用的是**人工方法还是深度学习方法**，影像组学工作流程可能包括临床与影像数据管理、图像预处理、图像分割、特征提取、模型开发和模型验证。

来源：Tugba Akinci D'Antonoli

Fundamentals of AI

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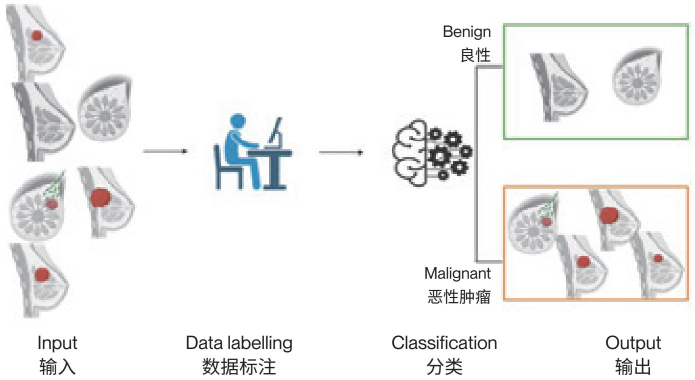
章节大纲：

AI 基础

/ Supervised Learning

Supervised learning is a ML paradigm that uses **human-labelled** training data. Then, the model predicts (this is called 'classification') outcomes on a new, unlabelled data set. It is the most **commonly used technique**.

Labels can be for example a **region of interest (ROI)** that points to a malignant breast tumour (see image below), a **bounding box** that indicates a focal lesion, or **text-based label** such as "fracture".



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>•< FURTHER KNOWLEDGE

Common supervised methods:

/ **Regression** → estimates relationships between variables.

/ **Decision tree algorithms, DTA** (e.g., random forest) → DTA are used for classification & regression tasks; they have a hierarchical tree structure with a root node, branches, internal nodes and leaf nodes.

/ **Support Vector Machine (SVM)** → are used for classification & regression tasks; they are especially useful to classify data into 2 groups.

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章节大纲：

/ 监督学习

监督学习是一种使用**人类标注**训练数据的 ML 范式。随后，模型会对新的未标注数据集进行结果预测（这一过程称为“分类”）。这是目前**最常用的技术**。

标注可以是例如指向乳腺恶性肿瘤的**感兴趣区域 (ROI)**（见下图）、指示局灶性病变的**边界框**或**基于文本的标签**（如“骨折”）。

>•< 进阶知识

常见的监督方法：

/ **回归分析**→估算变量之间的关系。

/ **决策树算法，DTA**（如随机森林）→DTA 用于分类和回归任务；具有分层树状结构，包含根节点、分支、内部节点和叶节点。

/ **支持向量机 (SVM)** → 用于分类和回归任务；尤其适用于将数据分为两组。

图片由 BioRender.com 绘制

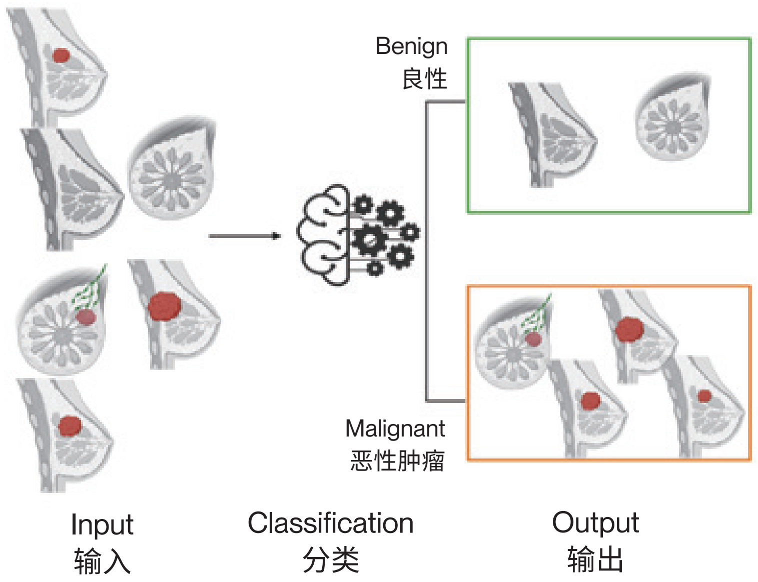
/ Unsupervised Learning

/ **Unsupervised Learning** bypasses manual data labelling through clustering techniques such as k-means.

/ The model is fed with typically a large amount of **unlabelled data**, and then finds patterns based on the data structure.

/ Unsupervised learning is typically used for **large sets of unstructured data**, e.g., in discovering new biomarkers.

/ In medical imaging, a common example is Generative Adversarial Network (GAN), used to make synthetic (=fake) images.



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章节大纲：

/ 无监督学习

/ **无监督学习**通过 k-means 等聚类技术绕过手动数据标注。

/ 通常向模型输入大量**未标注数据**，然后根据数据结构发现其中的模式。

/ 无监督学习通常用于**大规模非结构化数据集**，例如发现新的生物标志物。

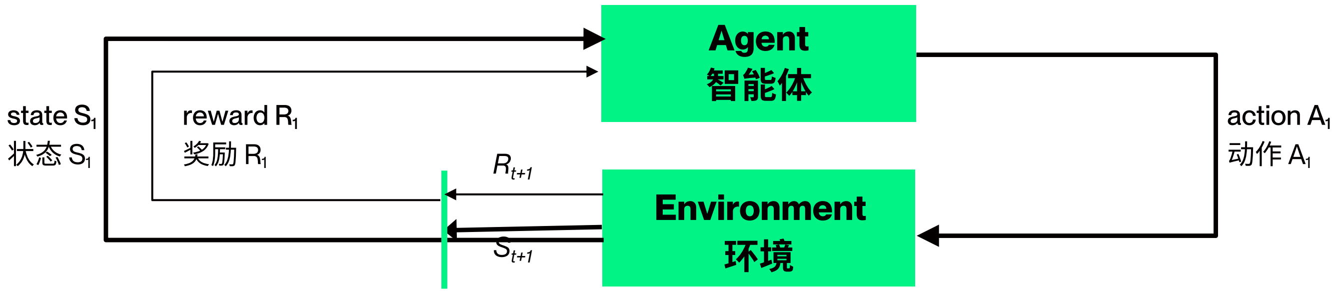
/ 在医学影像中，常见例子是生成对抗网络 (Generative Adversarial Network, GAN)，用于生成合成（即虚拟）图像。

图片由 BioRender.com 绘制

/ Reinforcement Learning

Reinforcement learning is a learning approach based on **rewards and punishments**. An agent interacts with the environment by sensing its state and learning to perform actions to maximise long-term rewards.

By this approach, the agent must maintain a balance between reward and punishment with trial and errors to favour the actions that will yield the greatest benefit.



<∞> REFERENCE

Adapted from the image by Shweta Bhatt.

https://towardsdatascience.com/reinforcement-learning-101-e24b50e1d292

/ AI in Radiology

CHAPTER OUTLINE:

/ AI 在放射学中的应用

章节大纲：

/ 强化学习

强化学习是一种基于奖惩的学习方法。智能体通过感知环境状态与环境交互，并学习执行动作以最大化长期奖励。

通过这种方法，智能体必须在试错过程中维持奖惩平衡，从而优选能产生最大效益的行为。

<∞> 参考文献

Adapted from the image by Shweta Bhatt.

https://towardsdatascience.com/reinforcement-learning-101-e24b50e1d292

Advanced Topics about AI

AI in Radiology

AI 在放射学中的应用

CHAPTER OUTLINE:

章节大纲：

AI 进阶专题

/ Deep Learning Applications in Medical Imaging

Medical imaging has been one of the main areas of interest when it comes to developing deep learning models for medical applications. Many examples can be found on algorithms developed for different imaging modalities (MR, CT, X-ray, ultrasound). On the next few pages, you will find the types of tasks where deep learning has been used, along with some examples of models:

Classification: train a model that is able to categorise images.

Examples:

/ Binary classification: Normal vs abnormal chest X-ray without specification of a pathology.

/ Positive for a specific disease vs negative (e.g., classification of brain MRs in positive or negative for Alzheimer's Disease).

/ Anatomical planes (multi-class) classification: axial vs coronal vs sagittal.

/ AI in Radiology

/ AI 在放射学中的应用

/ 深度学习在医学影像学中的应用

医学影像一直是深度学习医疗应用开发的主要关注领域之一。目前已有大量针对不同的影像学检查方法（MR、CT、X 射线、超声）开发的算法实例。接下来的几页将介绍深度学习已应用的任务类型及部分模型示例：

分类：训练能够对图像进行分类的模型。

示例：

/ 二分类：正常胸片与异常胸片（无具体病理标注）。

/ 特定疾病阳性与阴性（如阿尔茨海默病的脑 MR 分类）。

/ 解剖平面（多分类）分类：轴位、冠状位与矢状位。

Detection: the goal of these algorithms is to identify anatomical or pathological 'objects' within an image.

Often the detected object can be highlighted with the use of **bounding boxes (see image).**

Examples include:

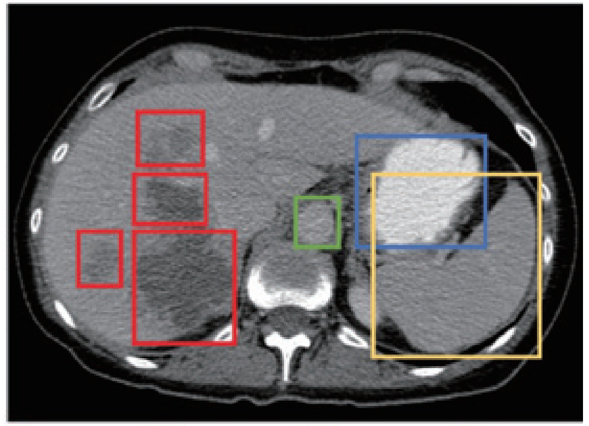
/ Landmark detection for spinal surgery planning on X-rays

/ Lung nodule detection on CT scans

/ Kidney stone detection on CT scans

/ Liver lesion detection on CT scans

Object detection
目标检测



Metastases 转移 | Aorta 主动脉 | Stomach 胃 | Spleen 脾

<∞> REFERENCE

Cheng PM. Published Online: September 01, 2021

https://doi.org/10.1148/rg.2021200210

/ **AI** in Radiology

CHAPTER OUTLINE:

/ **AI** 在放射学中的应用

章节大纲：

检测：这些算法的目标是识别图像中的解剖或病理“目标”。

通常通过边界框（见图示）标注检测目标。

例如：

/ X 射线下用于脊柱手术规划的标记点检测

/ CT 扫描中的肺结节检测

/ CT 扫描中的肾结石检测

/ CT 扫描中的肝脏病灶检测

<∞> 参考文献

Cheng PM. Published Online: September 01, 2021

https://doi.org/10.1148/rg.2021200210

Segmentation: task of dividing the pixels of an image into multiple regions or segments, where each segment corresponds to a particular object or class (e.g., an organ or pathology).

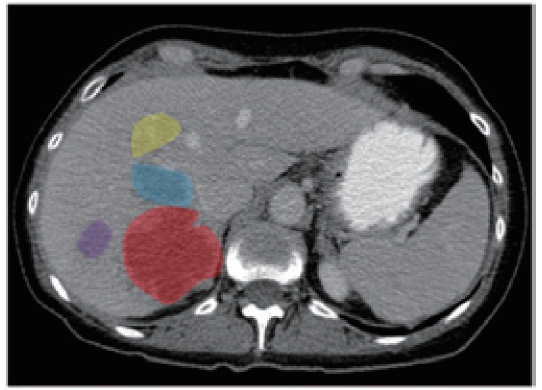
In general, this is the first step facilitating classification or quantification (e.g., measurement) as a next step.

This type of application is one of the popular uses of DL in medical imaging.

Examples:

/ Prostate segmentation on MR
/ Liver segmentation on CT
/ Brain tumour segmentation on MR
/ Cardiac segmentation on CTA
/ Pulmonary tumour segmentation on CT
/ Stroke segmentation on CT/MR

Segmentation of liver metastases on a CT scan.



Metastasis 1 转移 1 | Metastasis 2 转移 2 | Metastasis 3 转移 3 | Metastasis 4 转移 4

<∞> REFERENCE

Cheng PM. Published Online: September 01, 2021
https://doi.org/10.1148/rg.2021200210

/ AI in Radiology

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章节大纲：

分割：将图像像素划分为多个区域或片段，每个片段对应特定目标或类别（如器官或病理）。

该任务通常是后续分类或量化分析（如测量）的基础步骤。

这类应用是深度学习在医学影像中的热门用途之一。

示例：

/ MR 影像中的前列腺分割
/ CT 影像中的肝脏分割
/ MR 影像中的脑肿瘤分割
/ CTA 影像中的心脏分割
/ CT 影像中的肺部肿瘤分割
/ CT/MR 影像中的卒中病灶分割

CT 扫描显示肝脏转移灶分割。

<∞> 参考文献

Cheng PM.Published Online: September 01, 2021
https://doi.org/10.1148/rg.2021200210

Image enhancement: deep learning models can be trained to perform tasks that improve image quality (or maintain image quality with lower dose) on medical images.

Applications include

/ **Denoising:** DL algorithms can learn to distinguish noise from the underlying signal. Noise can then be removed, while preserving the most important imaging features.

/ **Super-resolution:** DL models can learn to increase the spatial resolution (i.e., create high-resolution images from low-resolution images).

/ **Artifact removal:** removal of artifacts that impact image quality (such as motion artifacts, beam hardening).

/ **Virtual contrast enhanced scans:** DL models can be trained to simulate contrast-enhanced images based on a non-contrast study.

图像增强：深度学习模型可通过训练执行提升医学影像质量的任务（或在降低剂量情况下保持图像质量）。

应用包括

/ **去噪：**DL 算法可学习将噪声与基础信号区分开。然后去除噪声，同时保留最重要的影像特征。

/ **超分辨率成像：**DL 模型可提升空间分辨率（即从低分辨率图像生成高分辨率图像）。

/ **伪影消除：**消除影响图像质量的伪影（如运动伪影、射束硬化伪影）。

/ **虚拟增强扫描：**基于非增强检查，可以训练 DL 模型来模拟对比增强图像。

Non-interpretive use cases

Use cases or applications that do not have diagnostic or prognostic primary outcomes, but facilitate the digital radiological workflow, from patient scheduling to communication of results (see next page for examples). These applications are relatively novel and mostly still **under development**, but they hold great potential.

Some common examples:

/ **Scheduling support:** can help with workflow optimisation, by automating the process of scheduling studies and making sure that the workload is adequate for the department.

/ **Automation of radiology protocols:** based upon the available clinical information, AI can help identify the optimal image acquisition protocol, e.g., if an abdominal CT should be acquired with or without IV contrast.

/ **Worklist prioritisation:** some machine learning models are built to identify urgent studies that require prompt interpretation by a radiologist. This way, we can ensure that high priority studies are reviewed first.

/ **Hanging protocols:** some AI tools can help determining the layout by which radiology images are displayed according to the specific clinical scenario / study protocol.

非解读性应用场景

这类应用的主要目标并非诊断或预后，而是优化从患者预约到结果传达的数字化放射工作流程（具体示例见下页）。这类应用相对新颖且多处于**开发阶段**，但潜力巨大。

一些常见示例：

/ **预约调度支持：**通过自动化检查预约流程并确保科室工作量合理，帮助优化工作流程。

/ **放射学方案的自动化：**根据现有临床信息，AI 可辅助确定最佳影像采集方案（如腹部 CT 是否需要静脉造影）。

/ **工作列表优先级：**部分机器学习模型可识别需放射科医生立即解读的紧急检查。这样，我们可以确保优先审核高优先级病例。

/ **挂片方案：**一些 AI 工具可以根据特定的临床场景/研究方案，辅助确定放射影像的显示布局。

Vendors and clinicians have had a "tunnel vision" towards inter-pretive use cases, while there is an array of use cases beyond decision-making support (i.e., beyond making the diagnosis).

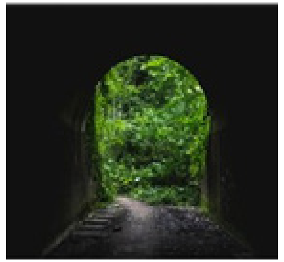
Imaging value chain | Non-interpretive use cases

Merel Huisman ESSR 2023

Upstream Workflow

- / Demand forecasting vs. staffing
- / Scheduling optimisation
- / Patient preparation (chatbot / GenAI)
- / Modality selection
- / Protocol selection
- / Contrast agent & dose reduction
- / Automatic quality control and rescan
- / Post-processing
- / Triaging (worklist)
- / Clinical information (LLM's)
- / Hands-free personalised navigation
- / Automated personalised hanging protocols

Decision-making



Downstream Reporting | Communication

- / Automatic guideline recommendations
- / Prepopulating reports
- / Auto-structuring
- / Automated impression
- / Laterality/age/gender correction
- / Multi-media enhanced reports
- / Patient friendly reports & translation
- / Critical findings & follow-up
- / Management
- / Billing
- / Resident Education
- / Business Intelligence (Dashboards)

/ **AI** in Radiology

CHAPTER OUTLINE:

/ **AI** 在放射学中的应用

章节大纲：

长期以来，供应商与临床医生过度关注解读性应用，却忽视了决策支持之外（即诊断之外）的广泛应用场景。

影像价值链 | 非解读性应用场景

Merel Huisman ESSR 2023

上游工作流程

- / 需求预测与人员配置
- / 调度优化
- / 患者准备 (chatbot/GenAI)
- / 检查方法选择
- / 方案选择
- / 造影剂和剂量降低
- / 自动质量控制和重新扫描
- / 后处理
- / 分诊（工作清单）
- / 临床信息处理（大语言模型）
- / 无干预个性化浏览
- / 自动化个性化挂片方案

决策

下游报告 | 结果传达

- / 自动指南推荐
- / 报告预填充
- / 结构自动生成
- / 自动生成诊断印象
- / 侧别/年龄/性别校正
- / 多媒体增强报告
- / 患者友好的报告和翻译
- / 危急结果与随访
- / 管理
- / 账单管理
- / 住院医师培训
- / 运营智能（智能驾驶舱）

/ Algorithm Development, Deployment, and Evaluation

>|< COMPARE

Use Case Definition

- / Define the goal of the algorithm (i.e., the clinical **condition to be targeted** by the application)
- / Define the inclusion and exclusion criteria associated with the clinical condition
- / Identify the **data elements** required for model development

Dataset Preparation

- / Collect **data** that **is representative** of the clinical condition
- / Label / annotate the collected data (this is the **ground truth** that will be used to train and test the model)
- / **Split** the dataset into training, validation and testing sets

Model Training

- / Evaluate what type of data **preprocessing** will be required
- / Choose the right model architecture approach for the task defined in the previous steps
- / Use the **training and validation** sets to evaluate performance of models trained with different approaches

Internal Validation

- / **Select** the model with the best performance on the validation set
- / Evaluate the **model performance** on the independent (i.e., holdout) **test set**
- / This performance will be an **approximation of the generalisability** of the model (i.e., how well the model would perform in another dataset)

External Validation

- / Evaluate **model performance** on external data - (e.g., data from other healthcare institutions)
- / Evaluates **model generalisability and reproducibility** (i.e., usefulness in varying settings / populations)
- / Helps to identify model **bias** (e.g., poor subgroup performance)

Clinical Deployment

- / Models are implemented in **the clinical workflow**, usually after **a pilot**
- / **Seamless integration** is not trivial but critical
- / Regulatory clearance is required (e.g., **CE-mark**)
- / **Usability factors** beyond model performance should be considered (e.g., how and when, speed, human-machine interaction)

Post-market Surveillance

- / Model output should be **continuously monitored** to detect performance drops in case of changing clinical parameters (called **data set shift**)
- / **Adverse events** related to model use should be reported
- / **User feedback** should be collected
- / **Model updates** can be implemented to address any issues that may be identified

/ AI in Radiology

CHAPTER OUTLINE:

/ AI 在放射学中的应用

章节大纲：

/ 算法开发、部署和评估

>|< 比较

应用场景定义

- / 定义算法目标（即应用所**针对的临床病症**）
- / 定义与临床病症相关的纳入和排除标准
- / 确定模型开发所需的**数据元素**

数据集准备

- / 收集能**代表目标**临床病症的**数据**
- / 对收集的数据进行标注/注释（作为训练和测试模型的**基准事实**）
- / 将数据集**划分**为训练、验证和测试集

模型训练

- / 评估所需的数据**预处理**方法
- / 为上述步骤中定义的任务选择合适的模型架构
- / 使用**训练和验证**集来评估使用不同方法训练的模型的性能

内部验证

- / **选择**在验证集内性能最佳的模型
- / 在独立测试集**（即保留集）**上**评估模型性能**
- / 该性能**可近似反映模型的泛化能力**（即模型在其他数据集上的表现）

外部验证

- / 使用外部数据（例如，来自其他医疗机构的数据）**评估模型性能**
- / 评估模**型的泛化性和可重复性**（即在不同环境/人群中的适用性）
- / 帮助识别模型**偏倚**（如特定亚组表现不佳）

临床部署

- / 模型通常在**试点**后投入**临床工作流程**
- / **无缝集成**并非易事，但却至关重要
- / 需获得监管批准（如 **CE 认证**）
- / 应考虑模型性能以外的**可用性因素**（如使用方式、时机、速度、人机交互）

上市后监测

- / 应**持续监测模型**输出，检测临床参数变化（称为**数据集偏移**）导致的性能下降
- / 应报告与模型使用相关的**不良事件**
- / 应收集**用户反馈**
- / 通过**模型更新**解决发现的问题

Algorithmic performance is constantly evaluated throughout model training, and then final performance is assessed on the test set, and later on external data during external validation.

Performance should always be evaluated **using multiple performance metrics** to get a comprehensive understanding of its strengths and weaknesses. The choice depends on the type of problem, disease prevalence and clinical context.

Common performance metrics in ML:

- **Dice similarity coefficient:** a pixel-based overlap measure between predicted and true areas in segmentation tasks, ranging from 0 (no overlap) to 1 (perfect overlap)
- **Mean squared error (MSE) / Mean absolute error (MAE):** assesses the quality of a regression model
- **Precision (=positive predictive value)*:** proportion of true positives out of all positive predictions, depends on prevalence
- **Recall (=sensitivity)*:** proportion of true positives out of all actual positive samples, independent on prevalence
- **Accuracy*:** proportion of correct predictions out of all predictions (%correct), intuitive but can overestimate performance
- **F1-score*:** metric for confidently predicting and not missing disease in a low prevalence setting, preferred over accuracy in rare diseases
- **Area under the ROC curve (AUC-ROC):** a graphical summary statistic for model discrimination plotted as the true positive rate against the false positive rate at multiple classification thresholds

*Derived from confusion matrix (see next page)

AI in Radiology

CHAPTER OUTLINE:

AI 在放射学中的应用

章节大纲：

在模型训练过程中需持续评估算法性能，然后在测试集中评估最终性能，并在外部验证阶段通过外部数据进一步检验。

性能评估应始终**使用多种指标**，以全面了解模型的优缺点。具体选择取决于问题类型、疾病患病率和临床场景。

ML 中的常见性能指标：

- **Dice 相似系数：**分割任务中基于像素的预测区域与真实区域重叠度度量，范围从 0（无重叠）到 1（完全重叠）
- **均方误差 (MSE)/平均绝对误差 (MAE)：**评估回归模型的质量
- **精确度（=阳性预测值）*：**真阳性占所有阳性预测的比例，取决于患病率
- **检出率（=灵敏度）*：**真阳性样本占所有实际阳性样本的比例，与患病率无关
- **准确度*：**正确预测占所有预测的比例（正确率百分比），虽直观但可能高估性能
- **F1 评分*：**用于在低患病率环境中准确预测疾病且不漏测的指标，相比准确度更适用于罕见病评估
- **ROC 曲线下面积 (AUC-ROC)：**模型判别能力的图形汇总统计，绘制为多个分类阈值下的真阳性率与假阳性率的关系曲线

*基于混淆矩阵（见下页）

The **confusion matrix** is critical to the model performance evaluation in classification tasks (e.g., benign vs. malignant lesion). It provides a comprehensive summary of the model's predictions compared to the ground truth labels (actual class).

		Prediction: POSITIVE	Prediction: NEGATIVE
Actual (Ground truth)	POSITIVE	TRUE POSITIVE (TP) Hit	FALSE NEGATIVE (FN) Type II error (miss)
	NEGATIVE	FALSE POSITIVE (FP) Type I error (false alarm)	TRUE NEGATIVE (TN) **Correct rejection**

Based on the confusion matrix, multiple performance metrics can be derived, including:

/ Sensitivity: TP / (TP + FN). Measures the model's ability to correctly identify positive cases (abnormalities) from all the actual positive cases

/ Specificity: TN / (TN + FP). Measures the model's ability to correctly identify negative cases (normal cases) from all the actual negative cases

/ AI in Radiology

CHAPTER OUTLINE:

/ AI 在放射学中的应用

章节大纲：

混淆矩阵在分类任务（如良性与恶性病变分类）的模型性能评估中至关重要。它通过对比模型预测结果与真值标签（实际类别），提供了全面的性能评估总结。

		预测结果：阳性	预测结果：阴性
实际值（真实标签）	阳性	真阳性 (TP) 命中	假阴性 (FN) II 类错误（漏诊）
	阴性	假阳性 (FP) I 类错误（误报）	真阴性 (TN) 正确排除

基于混淆矩阵可推导出多项性能指标，包括：

/ 灵敏度：TP / (TP + FN)。衡量模型从所有实际阳性病例中正确识别出阳性病例（异常）的能力

/ 特异性：TN / (TN + FP)。衡量模型从所有实际阴性病例中正确识别出阴性病例（正常）的能力

AI in clinical trials:

/ AI tools that are used in the setting of centralised image reading for clinical trials also require proper technical and clinical validation. Ground truth consistency and adequate population representation (including disease phenotypes, scanners and acquisition protocols variability) are equally essential in this scenario for training and testing of the algorithms.

/ AI can support/facilitate some trial-related tasks and/or image analysis, such as: patient selection according to inclusion criteria, image quality assessment from uploaded scans and evaluation of quantitative imaging biomarkers, bringing also notorious decrease of image annotation/reading time and reduction of inter-reader variability.

<∞> REFERENCE

Check out for more information:

https://www.eusomii.org/w60-validation-of-automated-image-analysis-tools-in-the-absence-of-a-ground-truth-by-marco-during/

临床试验中的 AI 应用：

/ 用于临床试验集中阅片的 AI 工具，同样需要经过严格的技术与临床验证。在此场景下，算法训练与测试必须确保真实标签一致性和充分的群体代表性（包括疾病表型、扫描设备及采集方案的变异性）

/ AI 可支持/辅助部分试验相关任务及/或图像分析，例如：基于纳入标准的患者筛选、上传扫描图像的质量评估以及量化影像生物标志物的评估，其应用可显著缩短影像标注/阅片时间，并降低阅片者间差异。

<∞> 参考文献

了解更多信息：

https://www.eusomii.org/w60-validation-of-automated-image-analysis-tools-in-the-absence-of-a-ground-truth-by-marco-during/

/ Data Sharing

Development and improvement of AI is largely based on the algorithm's learning experience. As algorithms learn from data, a more comprehensive data access is crucial for improved accuracy and implementation and, ultimately, for a better service provided to healthcare.

GDPR - General Data Protection Regulation

In May 25th 2018 GDPR came into effect. It applies to all EU member states and concerns processing of **personal data**, including (although not specifically designed for) data concerning health.

GDPR is a **binding law** and supersedes pre-existing laws.

PERSONAL DATA:

any information relating to an identified or identifiable natural person

PROCESSING:

any operation or set of operations which is performed on personal data

DATA CONCERNING HEALTH:

any information relating to an identified or identifiable natural person

<!> ATTENTION

Identified or identifiable natural person is a key concept in the matter of data protection.

<∞> REFERENCE

Take a look:
https://gdpr-info.eu/

CHAPTER OUTLINE:

章节大纲：

/ 数据共享

AI 的发展和改进主要基于算法的学习经验。由于算法从数据中学习，更全面的数据获取对于提高准确性、优化实施以及最终提供更好的医疗服务至关重要。

GDPR - 通用数据保护条例

GDPR 于 2018 年 5 月 25 日生效。其适用于所有欧盟成员国，涉及个人数据处理，包括健康相关数据（尽管并非专为此设计）。

GDPR 是有约束力的法律，取代现行相关法规。

个人数据：

与已识别或可识别的自然人有关的任何信息

处理：

对个人数据执行的任何操作或系列操作

健康相关数据：

与已识别或可识别的自然人有关的任何信息

<!> 注意

已识别或可识别的自然人是数据保护领域的关键概念。

<∞> 参考文献

可查阅：
https://gdpr-info.eu/

A particular setting where GDPR is of utmost importance is in Medical Devices (MD) development and commercialisation, specifically those implementing AI software, where access to appropriate datasets determines its performance and conformance to the **intended use**.

The EU Medical Device Regulation (MDR) replaced the EU Medical Device Directive (MDD) as of May 26, 2021. It imposes stringent regulatory requirements that need to be met before medical devices can be used in clinical practice. **The EU Medical Device Regulations (MDR) requires compliance with the GDPR.**

MDR applies to instrument, apparatus, appliance, software, implant, reagent, material, or other article for any of the following:

/ diagnosis, prevention, monitoring, treatment, or alleviation of a disease
/ investigation, replacement, or modification of an anatomical, physiological, or pathological process
/ providing data via in-vitro examination of samples derived from a human body

The **intended use** comprises:

(1) the actual medical purpose
(2) the authorised use, understood as defining the intended users and use environment, target patient population, or body parts

<!> ATTENTION

AI-based software tools are seen as a medical device and are regulated as such.

/ **AI** in Radiology

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/ **AI** 在放射学中的应用

章节大纲：

在医疗器械 (MD) 开发和商业化领域，特别是涉及 AI 软件的器械，GDPR 至关重要，因为获取适当数据集决定了其性能及是否符合**预期用途**。

欧盟医疗器械法规 (MDR) 已于 2021 年 5 月 26 日取代原欧盟医疗器械指令 (MDD)。该法规对医疗器械在临床应用前必须满足的监管要求作出了严格规定。**欧盟医疗器械法规 (MDR) 要求符合 GDPR 的规定。**

MDR 适用于以下用途的仪器、设备、器具、软件、植入物、试剂、材料或其他物品：

/ 疾病诊断、预防、监测、治疗或缓解
/ 解剖学、生理学或病理过程的研究、替代或修改
/ 通过对人体样本的体外检查提供数据

预期用途包括：

(1) 实际医疗目的
(2) 授权用途，即界定预期使用者、使用环境、目标患者群体或身体部位

<!> 注意

基于 AI 的软件工具被视为医疗器械，并受相应监管。

Techniques to mitigate data protection risks according to GDPR

/ **Pseudonymisation** - means the processing of personal data in such a manner that the personal data can no longer be attributed to a specific data subject without the use of additional information, provided that such additional information is kept separately. Pseudonymised data qualifies as personal data under GDPR.

/ **Anonymisation** - anonymous data is data from which no connection to a specific identifiable person can be drawn and falls outside applicability of the GDPR.

In the specific case of the health sector, where it is crucial to keep traceability, pseudonymisation is an example of an appropriate data protection safeguard.

<∞> REFERENCES

Check out for more information::

https://www.eusomii.org/protection-of-patient-data-in-eu-vs-us-by-erik-ranschaert-md-phd-2/
https://www.linkedin.com/pulse/anonymisation-now-house-cards-magali-feys

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依据 GDPR 降低数据保护风险的技术

/ **假名化** - 指以无法在不使用额外信息的情况下将个人数据归属于特定数据主体的方式处理个人数据，且此类额外信息需单独保存。根据 GDPR，假名化数据属于个人数据。

/ **匿名化** - 匿名数据是指无法与特定可识别个人建立关联的数据，不属于 GDPR 的适用范围。

在医疗领域这一需保留可追溯性的特殊场景中，假名化是一种适当的数据保护措施。

<∞> 参考文献

了解更多信息：

https://www.eusomii.org/protection-of-patient-data-in-eu-vs-us-by-erik-ranschaert-md-phd-2/
https://www.linkedin.com/pulse/anonymisation-now-house-cards-magali-feys

Health data may be processed:

- When the patient gives **explicit and unambiguous consent** to the use of their data
- When it is in the patient's **vital interest**
- For **healthcare purposes**
- For **public interest** in the area of public health
- For **archiving purposes** in the public interest, **scientific or historical research purposes or statistical purposes**
- In the field of **employment, social security and social protection law**

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European Society of Radiology (ESR). The new EU General Data Protection Regulation: what the radiologist should know. Insights Imaging. 2017 Jun;8(3):295-299. doi: 10.1007/s13244-017-0552-7. Epub 2017 Apr 24. PMID: 28439718; PMCID: PMC5438318.

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健康数据的处理可在以下情况下进行：

- 当患者明确且无歧义地同意使用其数据时
- 当符合患者的切身利益时
- 出于医疗保健目的
- 出于公共卫生领域的公共利益
- 出于公共利益、科学或历史研究目的或统计目的进行存档
- 在就业、社会保障和社会保障法领域

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European Society of Radiology (ESR). The new EU General Data Protection Regulation: what the radiologist should know.
Insights Imaging. 2017 Jun;8(3):295-299. doi: 10.1007/s13244-017-0552-7. Epub 2017 Apr 24. PMID: 28439718; PMCID: PMC5438318.

/ Possible Benefits, Risks, Available Evidence

AI applications in the clinical setting, specifically in the radiology workflow, comprise not only image recognition and support on decision-making (radiologist-centered) but also upstream and downstream procedures. For a smooth workflow, AI algorithms should be fully integrated in the PACS workstations.

Some possible **benefits** include automation of time-consuming tasks, namely in:

- Optimisation of worklist (e.g., facilitating the analysis of emergency examinations) and scheduling
- Modality and protocol selection
- Image acquisition time and radiation dose reduction
- Image processing
- Lesion detection, measurement and grading
- Reporting and communication to clinicians and patients
- Billing

<∞> REFERENCE

Artificial Intelligence in Medical Imaging: Opportunities, Applications and Risks | SpringerLink

CHAPTER OUTLINE:

章节大纲：

/ 可能的获益、风险与现有证据

AI 在临床环境中的应用，特别是在放射学工作流程中的应用，不仅包括图像识别和决策支持（以放射科医生为中心），还涉及上下游流程。为实现顺畅的工作流程，应将 AI 算法完全集成到 PACS 工作站中。

部分潜在优势包括对耗时任务的自动化处理，主要体现在：

- 优化工作列表（如加速急诊检查分析）和时间安排
- 检查方法和方案选择
- 图像采集时间及辐射剂量降低
- 图像处理
- 病灶检测、测量和分级
- 面向临床医生及患者的报告生成与传达
- 账单管理

<∞> 参考文献

Artificial Intelligence in Medical Imaging: Opportunities, Applications and Risks | SpringerLink

Other available current applications include scan-related automated processes such as:

- / Patient positioning at the isocenter (CT and MRI)
- / Identification of the region of interest (MRI)
- / Equipment maintenance (CT)

To be highlighted is that simultaneous time and costs saving, paired with reduced radiological workload and increased productivity and efficiency will primarily benefit the patient, but also the radiologist, referral physicians and the healthcare system in general.

Ultimately, AI solutions might also support an extension of healthcare services coverage where there is a shortage of practitioners.

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其他当前可用的应用包括与扫描相关的自动化流程，例如：

- / 患者扫描中心定位（CT 和 MRI）
- / 确定感兴趣区域 (MRI)
- / 设备维护 (CT)

需要强调的是，在节省时间和成本的同时，减少放射检查工作量并提高生产力和效率，将主要使患者受益，同时也使放射科医生、转诊医生和整个医疗系统获益。

最终，AI 解决方案还可能支持在从业人员短缺的情况下扩大医疗服务的覆盖范围。

<∞> 参考文献

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Some inherent risks need to be accounted for in AI applications, such as:

- **Unintended bias** potentially causing health disparities (e.g., gender, race, socioeconomic status)
- **Performance drop** in the clinical setting, or in certain subgroups
- **Inconsistent performance** of the algorithm over time
- **Overcomplicating** healthcare and **adding costs** without efficiency nor quality gains
- Lack of reimbursement (country-specific).
- **Post-market surveillance failure** (mandatory according to MDR)
- **Liability issues** (a malpractice aspect in the United States) on the final patient outcome - who is liable? the AI developer? The company which commercialises the algorithm? Or the radiologist?
- **Cyberattacks and data leakage.**
- **Automation bias** (i.e., humans following the AI blindly even if it is giving wrong advice)
- **Technical push > clinical pull** (i.e., developing tools because it is possible, not because it is needed)

It is essential to be aware of the **actual clinical problems** and the **appropriateness** of the AI-based solutions in a particular clinical setting; see AI as a means not as an end goal.

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章节大纲：

核心知识

AI 应用中存在一些内在风险需加以考量，例如：

- **非故意偏见**可能导致健康差异（如性别、种族、社会经济地位）
- **在临床环境或特定亚群中性能下降**
- **随时间推移，算法性能不一致**
- **医疗过度复杂化并增加成本**，却未能提升效率或质量
- 缺乏报销政策支持（因国家而异）。
- **上市后监测失败**（根据 MDR 为强制要求）
- **最终患者治疗结果的责任问题**（在美国属于医疗事故范畴）——谁应负责？AI 开发者？商业化该算法的公司？还是放射科医生？
- **网络攻击和数据泄露。**
- **自动化偏差**（即人类盲目遵循 AI，即使其给出错误的建议）
- **技术推动 > 临床需求**（即因为技术可行而开发工具，而非实际需要）

必须认识到**实际临床问题**和 AI 解决方案在特定临床环境中的**适用性**；应将 AI 视为一种手段，而不是最终目标。

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Future Aspects

AI in Radiology

AI 在放射学中的应用

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章节大纲：

未来展望

/ Future Aspects

/ Currently AI algorithms in radiology are narrowly focused, targeting a specific imaging feature or task (called a **point solution**).

/ In future, this might change with artificial general intelligence (AGI) and eventually AI could execute many tasks at a human level capability with limited human supervision.

/ In that case the day-to-day tasks of a radiologist might change drastically; we would have more time for patient contact, complex cases, and multi-disciplinary team meetings.

>|< COMPARE

NARROW AI (POINT SOLUTION)	GENERAL AI
Application specific/task limited	Perform general (human) intelligence tasks
Fixed domain models provided by programmers	Self-learns and reasons with its operating environment
Learns from thousands of labelled examples	Learns from few examples and/or from unstructured data
Reflective tasks with no understanding	Full range of human cognitive abilities
Knowledge does not transfer to other domain tasks	Leverages knowledge transfer to new domains and tasks
Today's AI in radiology	Future's AI in radiology?

/ AI in Radiology

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/ 未来展望

章节大纲：

/ 目前，放射学领域的 AI 算法的针对范围狭窄，仅针对特定影像特征或任务（称为**点解决方案**）。

/ 未来，随着通用人工智能 (AGI) 的发展，AI 可能在有限人工监督下达到人类水平的多任务执行能力。

/ 届时，放射科医生的日常工作将发生根本性转变；我们将有更多时间用于患者沟通、复杂病例分析及多学科团队会诊。

>|< 比较

狭义 AI（局部解决方案）	通用 AI
应用特定/任务受限	执行通用（人类）智能任务
程序员提供的固定域模型	能自我学习并与操作环境交互推理
需要数千个标注样本学习	从少量示例和/或非结构化数据中学习
无理解能力的反射性任务	具备人类全部认知能力
知识无法迁移至其他领域任务	能将知识迁移至新领域和任务
当前 AI 在放射学中的应用	未来 AI 在放射学中的应用

Large Language Models (LLM)

- LLMs are deep neural networks trained to generate human-level text.
- The GPT (generative pretrained transformer) family of LLMs are currently on the rise and are already being used in many areas of medicine and radiology.
- To date, several articles have been published using GPT-3.5 and GPT-4 showing that LLMs can support decision-making in mammography, write medical articles, or pass radiology board exams.
- There may be more to come in the near future, and LLMs may facilitate our path to AGI.

User prompt (text) 〉 **LLM (e.g., GPT-4)** 〉 **Generated text**

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章节大纲：

大语言模型 (LLM)

- LLM 是通过训练能生成人类水平文本的深度神经网络。
- 目前 GPT（生成式预训练变换器）系列 LLM 正在兴起，并已应用于医学和放射学的多个领域。
- 迄今为止，基于 GPT-3.5 和 GPT-4 的研究已发表，显示 LLM 可支持乳腺 X 线摄影决策、撰写医学文章，甚至通过放射学委员会考试。
- 近期或将出现更多突破，LLM 可能会促进我们实现 AGI。

用户提示（文本） 〉 **LLM（如 GPT-4）** 〉 **生成文本**

/ Take-Home Messages

/ AI is a multidisciplinary effort where computer scientists, medical physicists, and clinical experts collaborate in all steps of the process to achieve clinically applicable solutions.

/ Machine Learning uses algorithms capable of learning from data and making predictions, whereas Deep Learning is a subset of ML and utilises Deep Neural Networks to learn patterns in data.

/ There is a wide range of areas where Deep Learning can be applied in radiology, including imaging and non-imaging use cases.

/ Compliance with GDPR is fundamental: Data collection should be minimised and used fairly, with clear and legitimate purpose. Data should not be stored longer than necessary and must be protected with appropriate cybersecurity measures.

/ Benefits of AI implementation include reduction of image interpretation and processing time, optimisation of worklists and reduction of radiation dose.

/ Risks and limitations of AI include performance drop, liability issues, cyberattacks and data leakage.

/ Radiologists should become familiar with these and take advantage of this enormous potential for better patient care.

/ **AI** in Radiology

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/ 核心要点

/ AI 是一项多学科协作的工作，计算机科学家、医学物理学家和临床专家在整个流程的各个环节中协同合作，以实现具有临床适用性的解决方案。

/ 机器学习使用能够从数据中学习并进行预测的算法，而深度学习是机器学习的一个子集，它利用深度神经网络来学习数据中的模式。

/ 深度学习在放射学中的应用领域广泛，涵盖影像与非影像应用场景。

/ 遵守 GDPR 至关重要：数据收集应最小化并公平使用，且具有明确合法的目的。数据存储不应超过必要的时限，并且必须通过适当的网络安全措施加以保护。

/ 实施 AI 的好处包括减少图像解读和处理时间、优化工作列表和降低辐射剂量。

/ AI 的风险和局限性包括性能下降、责任问题、网络攻击和数据泄露。

/ 放射科医生应该熟悉这些，并充分利用这一巨大潜力来提供更好的患者护理。

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Test Your Knowledge

AI in Radiology

AI 在放射学中的应用

CHAPTER OUTLINE:

章节大纲：

知识测试

/ Test Your Knowledge

<?> QUESTION

1 What is TRUE about Deep Neural Networks?

- ☐ Their success is due to better hardware (graphic cards) specialised in matrix operations
- ☐ Need artificial biological, highly interconnected neurons to operate
- ☐ Are the only form of machine learning
- ☐ Need the manual extraction and coding of knowledge

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1 关于深度神经网络，哪项陈述是正确的?

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- ☐ 需要模拟生物中高度链接的神经元才能运作
- ☐ 是机器学习的唯一形式
- ☐ 需要手动提取和编码知识

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2 The different Machine Learning methods are:

- ☐ Pre-coded and post-coded learning
- ☐ Bottom-up and top-down learning
- ☐ Supervised learning, unsupervised learning and reinforcement learning
- ☐ Single-shot learning and multi-shot learning

CHAPTER OUTLINE:

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2 机器学习的不同方法包括：

- ☐ 预编码与后编码学习
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<?> QUESTION

3 What is TRUE about Data Sharing?

- ☐ Anonymisation allows safe data sharing and backtracking to the patient's original data
- ☐ Pseudonymous data is considered personal data under the GDPR
- ☐ For healthcare purposes patient data can be processed without consent
- ☐ Software does not always fall under the MDR

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章节大纲：

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3 关于数据共享，哪项陈述是正确的?

- ☐ 匿名化可安全共享数据并回溯患者原始数据
- ☐ 根据 GDPR，假名化数据属于个人数据
- ☐ 出于医疗目的，可以在未经同意的情况下处理患者数据
- ☐ 软件并不总是属于 MDR 的管辖范围

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<?> QUESTION

4 Regarding Algorithm Evaluation, which of followings is a suitable metric to evaluate a segmentation task?

☐ Mean squared error
☐ Precision
☐ F1-score
☐ Dice similarity coefficient

/ 知识测试

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4 关于算法评估，以下哪项是评估分割任务的合适指标?

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☐ 精确度
☐ F1 评分
☐ Dice 相似系数

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<?> QUESTION

5 Regarding Deep Learning Applications in Medical Imaging, splitting an image into multiple regions, where each region corresponds to a particular object or class, is an example of:

- ☐ Classification
- ☐ Image Enhancement
- ☐ Detection
- ☐ Segmentation

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章节大纲：

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5 关于医学影像中的深度学习应用，将图像划分为多个区域（每个区域对应特定对象或类别）属于：

- ☐ 分类
- ☐ 图像增强
- ☐ 检测
- ☐ 分割

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