Artificial intelligence – image interpretation platforms

RAD Magazine, 45, 527, 21-22

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In 1995, I worked as a junior doctor on the wards in medicine. I often performed an ECG on patients with acute chest pain. Interestingly, even back then the ECG graph was accompanied by a machine-generated clinical interpretation or ECG report, eg left bundle branch block, myocardial infarction etc. These interpretations helped the inexperienced junior doctors, non-specialist doctors and nurses.

As I progressed in my experience as a junior doctor doing medicine, my reliance on the computer-generated reports reduced. I started to see its limitations and inaccuracies. It was well-recognised by the medical community that the computer-generated ECG report could not be fully relied on. I do not think a cardiologist could use the computer-generated ECG report in their medico-legial defence, for final decision making and prescribing drugs. The human interpretation of the ECG has remained the gold standard. Human interpretation takes into account the clinical history and patient symptoms/signs before decisions on patient management are made. The interesting article ‘Can we trust our ECG machines?’ published in the British Journal of Cardiology highlights this. Even 25 years later human ECG readers are considered the final decision-makers. However, computer-generated ECG reports continue to be valued by non-specialist general practitioners and emergency doctors for identifying when an urgent specialist review is required.

Computer vision AI and radiology

Computers have increased in sophistication and image recognition algorithms are now commonplace in real-world (eg facial recognition in passport control) and social media applications. Radiology image interpretation has gained huge momentum over the last year. There has been a lot of hype in the press about radiologists being replaced by machines. In the same way as cardiologists are still in a job and continue to read ECG graphs, radiologists and other human reporters will remain the final arbiter and interpreter of machine-generated reports, and continue to hold the medico-legal responsibility for interpretation. The human interpretation will take into account the patient’s symptoms and signs, previous images, blood tests, histopathology reports etc (in the same way as a cardiologist does). Radiologists (and other reporters) will continue to issue actionable reports, which provide a tentative or differential diagnosis and advice on the next step of management and continue to be medico-legally responsible for the final report issued.

Computer-generated reports will enormously assist patient management. Non-specialist emergency doctors make decisions on whether the patient has a fracture or a pneumothorax. They are reading images in poor lighting conditions, and are not trained in final interpretation of radiology images. They are extremely busy and in the NHS very short-staffed too. AI decision-support tools would greatly help them. However, there needs to be a declaration accompanying every computer-generated report about its limitations, ie sensitivity and specificity, so that doctors on the frontline do not consider it to be gospel truth. A final report should be performed by a human specialist who is trained in radiology image interpretation and will take into account the limitations of the computer-generated report. Reports issued by the human specialist should be actionable as per national guidelines for radiology reporting. It will give advice on the next step of management, which is often dictated by local circumstances and availability of services.

Radiology image analysis AI platforms

At ECR 2019, AI image analysis platforms were emerging as a common theme among PACS vendors. Most PACS vendors are incorporating an AI platform into their PACS portfolio. These platforms contain various types of AI algorithms for image analysis and decision support. Many of these algorithms are being developed by small niche vendors and research groups.

In future, all the images sent from the modalities to PACS will be pre-analysed by AI image analysis platforms. These platforms will identify the modality and body parts within the study (using the DICOM header metadata) and apply the appropriate AI algorithm to the study. For digital radiography AI algorithms will detect fracture in the appendicular skeleton, and on chest x-ray detect a pneumothorax, rib fracture, consolidation, tube placement, pleural effusion and lung nodule. On CT head studies, AI algorithms will detect skull fracture, brain haemorrhage, brain infarct, brain tumour and pneumocephalus. On MRI of the brain AI algorithms will include detection of MS, stroke, brain bleed and tumour. On body CT AI algorithms will detect liver lesions, lung nodules and vertebral body fracture. On mammography AI algorithms will assess for suspicious lesions or calcification. If an abnormality is detected by the algorithm, it will ‘query’ and ‘retrieve’ a prior similar study for analysis and comparison.

Benefits to the reporting workflow

The output from the AI platform will enhance the reporting workflow in two ways:

1. provide computer pre-analysis of the radiology images to help inform and augment the human-generated radiology report;
2. help reprioritisation of reporting worklists when an abnormality is detected.

AI platform outputs and standards

The AI platform will generate two types of data: segmented area of the region of interest (ROI) as a graphical output and text information about the detected abnormality. When customers are procuring or implementing AI platforms they must ensure that the platform is able to communicate with PACS via DICOM for display of the graphical output and associated text, and RIS via HL7 standard for worklist prioritisation.

Standard outputs from AI image analysis platforms must include the following:

a. graphical representation of the ROI (of the detected abnormalities) or mark-ups/pointers – should always be output using DICOM standards, so that they can be viewed in the PACS views. However, there are various options:
   i. DICOM SR (structured report) and DICOM segmentation – preferred by standards bodies due to robust
interoperability for both graphics and text;
ii. DICOM presentation states – commonly used in clinical PACS and has the toggle on-off option for the graphics;
iii. DICOM overlay – toggle on-off option for graphics;
iv. secondary capture (burned in pixels) – limited by no toggle on-off feature.

b. abnormality classification as text data sent as DICOM SR: eg fracture, haemorrhage, consolidation, infarct, pleural effusion etc.

c. abnormal flag notification – when an abnormality is detected, a notification needs to be sent as an abnormal flag via an HL7 ORM message in OBX 8.

d. abnormality classification in HL7 – fracture, haemorrhage, consolidation, infarct, pleural effusion etc should be sent in HL7 ORM message in OBX 5.

e. declaration/disclaimer – the AI platform should always send out a report that includes:
   i. list of the abnormalities that were evaluated by the algorithm/s in the platform and applied to the study (eg for CT head – brain haemorrhage, skull fracture, brain infarct etc);
   ii. sensitivity and specificity of the applied algorithms for each of the abnormalities evaluated.

This declaration should be communicated as a PDF-wrapped DICOM structured report format that is added as an additional series on PACS.

AI platform relationship with PACS

It is vital that studies from modalities always go to the AI platform first, before arriving in PACS for display. This workflow will prevent inadvertent reporting of images by radiologists, before the analysis by the relevant AI algorithm has taken place. It is also important that the AI algorithm is capable of performing a DICOM query retrieve from the local PACS, so that when an abnormality such as a lung nodule is detected, the AI algorithm should be able to do a query retrieve for prior similar studies from PACS, and perform a comparison for rate of growth analysis. The same analogy would apply for liver lesions, MS plaques etc.

In addition, the PACS vendor must be capable of storing and displaying the graphical outputs segmented ROI and also the text classification.

PACS capabilities

When implementing an AI platform, customers must ensure that their PACS is capable of:
1. displaying DICOM graphical information and DICOM SR (segmented ROI areas and text overlay) from AI, which can be toggled on and off by the PACS viewer icon. It must support DICOM SR display, DICOM presentation state etc;
2. displaying the declaration information from the AI platform about the algorithms used on the study, with the sensitivity and specificity for each abnormality detection.

Reporting worklist prioritisation

Reporting prioritisation by individual reporters currently takes into account many RIS data items that are sorted and filtered by radiologists. These include referral location type (A&E, inpatient, outpatient or GP), modality type (CT, MRI, DR etc), speciality of the referrer (eg ENT, paediatrics, gastroenterology etc), referrer’s urgency (eg urgent, 2WW or routine), intended reporter (work allocation by operators) and date and time of examination completion. Radiologists prioritise their work based on the session. During an emergency duty session, the radiologist will filter out all the CT and MRI for A&E and inpatient referrals.

AI decision support tools have a potential to enhance the worklist prioritisation by allowing inclusion of additional data fields such as abnormalities detected by the AI algorithm. By notifying the RIS and PACS when an abnormality is seen and the type of abnormality, these additional data items can be used for enhanced sorting and filtering of reporting worklists.

Many customers (especially in the NHS) use RIS worklists for reporting. The notification and type of abnormality classification needs to be transmitted in standard HL7 v2 messages to help with worklist prioritisation on RIS. AI platforms should send out an HL7 ORM OBX 8 for abnormal flag notification when an abnormality is detected, and OBX 5 for type of abnormality detected.

Image acquisition optimisation for AI

The sensitivity and specificity of the AI algorithm (eg fracture detection, lung nodule detection etc) is much higher if the acquisition parameters can be optimised for the AI detection algorithm. Hence, for improving the sensitivity and specificity of detection, the acquisition parameters should be optimised in consultation with the AI vendor, at the time of AI implementation.

Radiology AI and the NHS

There is huge potential for positively improving patient management decisions with artificial intelligence in the NHS. Improving detection of abnormalities such as fracture and pneumothorax and supporting the frontline emergency doctors would be invaluable. This will certainly have cost savings for a public-funded NHS as it will introduce safety in clinical practice. Currently a single human reader evaluates radiology examinations. Introducing a computer AI as an additional reader for all examinations will improve the sensitivity and specificity of the human reader. Computer algorithms will look for specific abnormalities, while the human reader will look at medical interpretation of the images and advise on management. There will be real collaboration between man and machine.

Individual radiologists are going to find it difficult to justify AI investment in their department. It really needs a national direction encouraging AI adoption for image pre-analysis by the AI platforms.

References


Further reading