Research Paper on Data Analysis in Categorizing Head CT Scans

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Abstract

Qure.ai's deep learning algorithms detect, localize and quantify a growing list of brain pathologies including intra-cerebral bleeds and their subtypes, infarcts, mass effect, midline shift, and cranial fractures.

Qure'sqER triages head computed tomography to ensure that those most likely to contain serious pathology are pushed to the top of the reporting pile. These types of software have the potential to improve the prioritization of tasks to allow radiologists to work more safely and effectively. Taking a synergistic approach offers the opportunity to improve patient care by optimizing human workflow and workload.

qER serves as a radiology assistant to augment the fast and accurate detection of abnormalities and thus helps radiologists evolving in a highly constrained environment to optimize hospital workflow and patient classification. Qure.ai's deep learning algorithms detect, localize and quantify a growing list of brain pathologies including intra-cerebral bleeds and their subtypes, infarcts, mass effect, midline shift, and cranial fractures.

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Key Words:Head CT Scan, Epidural hemorrhages, subdural hemorrhages, subarachnoid hemorrhage, Intraparenchymal hemorrhage, Intraventricular hemorrhage

Introduction

AI helps to incorporate self-improvement skills and provides automatic updating of medical data to various health devices. Its ability to reduce diagnostic and therapeutic errors, create real-time risk alerts and predict health outcomes over time. Specifically, AI is a useful computer algorithm to find conclusions without direct human input.

AI technology is different from traditional technologies in health care because of its facility to know information, process it and provides a well-defined output to the end-user. AI does this through machine learning algorithms and deep learning. These algorithms can recognize patterns in behavior and make their own logic. so on reduce the margin of error, AI algorithms need to be tested repeatedly. AI algorithms behave differently from humans in two ways: (1) algorithms are literal: if you set a goal, the algorithm can't adjust itself and only understand what it's been told explicitly, (2) and a couple of deep learning algorithms are black boxes; algorithms can predict with extreme precision, but not the cause or the why.

1. Literature Review:

1.1 Qure.ai

Qure.ai was founded in 2016. The firm's mission is to use artificial intelligence to make healthcare more accessible and affordable. The core team combines deep learning expertise with clinical, scientific and regulatory knowledge. The advisory panel consists of radiologists, other doctors and public health experts. The teams work with these specialists to define clinically relevant problems and design real-world solutions.

1.1.1 Research Highlights:

Visualizing what deep neural networks learn - Interpretable AI

When working with AI, doctors find it useful to see a region-of-interest, or an indication of which parts of the image the algorithm relies on most strongly while reaching a conclusion. This enables them to 'see through the algorithm's eyes'. This enables them to 'see through the algorithm's eyes'. Such area markers or heat maps provide visual cues to clinical users which could make it clearer whether to accept or reject a chest x-ray finding detected by AI.

For Qure.ai — Algorithm interpretability is an active area of deep learning research. Current visualization methods can be classified into 2 categories: perturbation-based visualizations and backpropagation-based visualizations. Using chest X-rays as an example we've experimented with these methods and put together a blog series on how they work with medical images.

Validation Study and Open dataset

Head CT is the standard initial imaging study for patients with head trauma or stroke symptoms. We performed a study to validate the accuracy (versus 3 radiologists) of a set of deep learning algorithms that were trained to detect head CT abnormalities requiring urgent attention. Five kinds of intracranial hemorrhages (ICH) can be detected with these trained algorithms namely subdural (SDH), extradural (EDH), intraparenchymal (IPH), intraventricular (IVH) and subarachnoid (SAH), and skull fractures. As indicators of severity of the brain injury they also detect both mass effect and midline shift.

As part of the study, we've made a large head CT scan dataset, including 3 radiologist reads, available for public download in partnership with CARING, so that others can use it to develop and benchmark new methods.

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Natural Language Processing for Radiology Reports

Large amounts of well-labelled training data is required for building accurate deep learning models. To achieve high accuracy for radiological scans, they used the most scalable way by accompanying clinical reports as ground truth to supply classification algorithms with the data.

As the reports are typically written in free-form text rather than a structured format. Developing smart natural language processing (NLP) algorithms to step into the expertise contained in radiology reports is important because it allows us to create ground truth labels at scale (hundreds of thousands to millions of scans).

To parse the unorganized content and structure it, rule-based NLP systems use a list of manually created rules. On the other hand, machine Learning (ML) based NLP systems automatically generate the rules when trained on a large annotated dataset. We developed a custom dictionary-based NLP method to read radiology reports, and compared it with machine-learning approaches.

1.1.2 Products:

Automated Chest X-ray Interpretation – qXR v2.0

qXR detects abnormal chest X-ray findings. It can be used to separate normal from abnormal X-rays, for a radiology audit too, or as pre-read assistance l. qXR includes a proprietary algorithm that screens X-rays for signs of tuberculosis.

Automated chest X-ray reads are the longer term of TB screening

When interpreted consistently, chest X-rays are the foremost sensitive and cost-efficient thanks to screen for tuberculosis and other lung diseases. As there are not enough qualified physicians to interpret every chest X-ray on time - leading to delays in TB diagnoses.

To automate the chest X-ray interpretation process, qXR uses deep learning technology. qXR significantly reduces time to diagnosis, when used as a point-of-care screening tool, followed by immediate bacteriological/NAAT confirmation .

Head CT scan Triage and Quantification aid

qER includes a triage aid to prioritize and notify critical head CT scans, a TBI progress monitoring tool, and a reporting assistance mode that pre-populates radiologist templates. qER is CE certified.

The current standard for initial imaging of patients with head trauma or stroke symptoms is non-contrast head CT scan. Aims to validate and develop a set of deep learning algorithms for automated detection. This results in finding the insights from these scans as follows:

intracranial hemorrhage and its types (ie, intraparenchymal, intraventricular, subdural, extradural and subarachnoid); calvarial fractures; midline shift; and mass effect. This shows that, the deep learning algorithms can identify head CT scan abnormalities with a requirement of urgent attention. Also opens up the possibility to use deep learning algorithms to automate the triage process.

2. MATERIAL AND METHODS

2.1 Materials.

- UBUNTU (version 16.02)
- MIPAV (version 9.0.2)
- PYTHON (version 3.5)
- JUPYTER
    - Jupiter core : 4.5.0
    - Jupiter-notebook : 6.0.1
- ANACONDA (version 1.7.2)
- Google Sheets

2.2Software and tools used.

1. Python
2. Jupiter notebook
3. MIPAV (Medical Image Processing and Visualization)
4. Microsoft office

2.3 Methods.

Overview: Reports are acquired as data from hospitals/diagnostic centers. The reports are analyzed, validated and verified, then are categorized and classified based on the type of abnormality. The tool MIPAV is also used to achieve this. The classified reports are used as data to feed in the Deep Learning Algorithm. This algorithm will then help detect/identify the abnormality.

Data Filtering:

The raw data is read, all the noisy and duplicate data is removed.
Remaining data which is the proper data which is then taken for validation.

Validation:

Reports are given with their unique identification numbers (UID) which are fed into the excel sheets with multiple columns viz., 'Type of Hemorrhage, 'Extent of Hemorrhage', etc. depending on the current project.

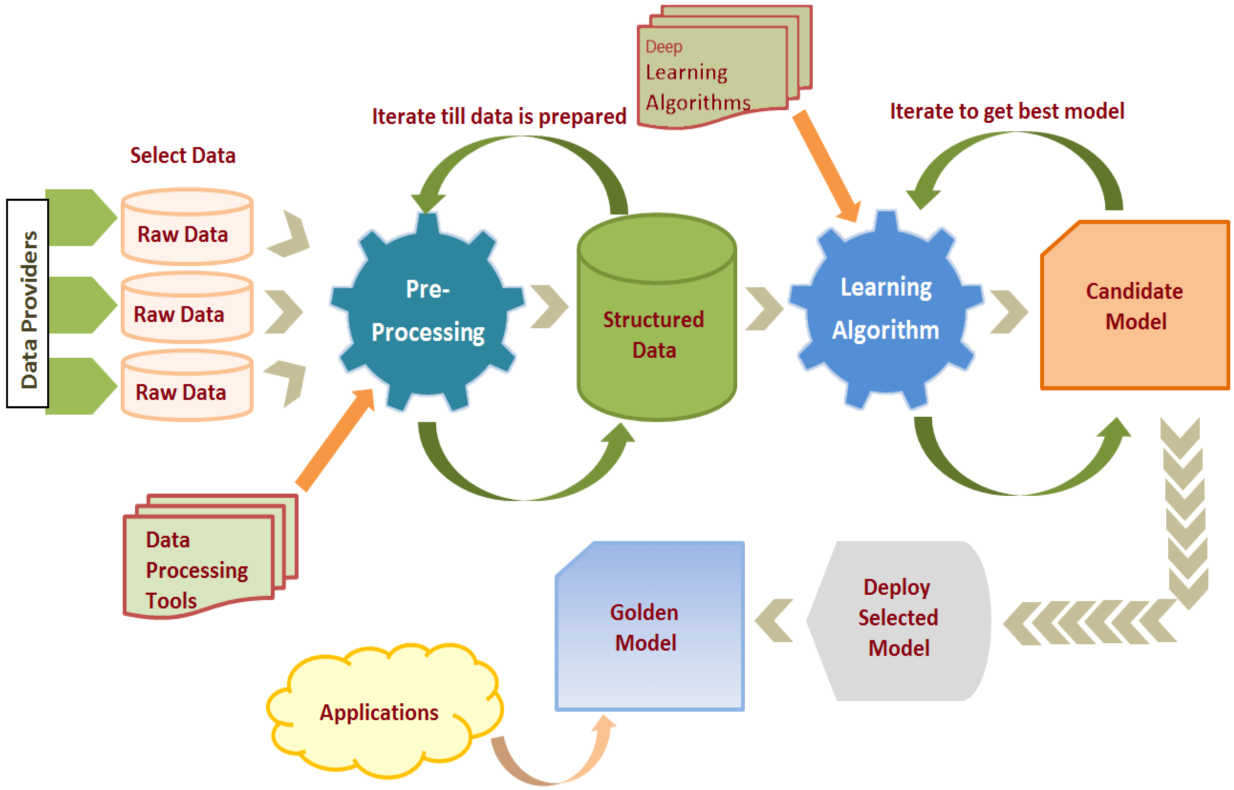
The case, each at once is analyzed on the basis of reading the report and comparing the cogency between it and its respective scans.
Post this, the columns are filled in with the requisite details based on the evidence.
Using Python, this validated data is analyzed and then moved to the respective directories.

Processing:

The processed data is named using unique identification numbers (UID) and fed into sheets, which is used for maintaining the records.
From the respective directories the data is pulled and processed using MIPAV, Python, and Internal software tools.
Which is further used to train the deep learning model.

Analysis:

The data in this stage is analyzed to check if the model is generating proper output.
If the generated output is improper then again it is analyzed to rectify the mistakes made by the model so the data is re-processed.



3. DISCUSSION AND SUMMARY

Qure.ai Head CT scan interpretation software, qER is a deep-learning-based software device that screens head CT scans for signs of intracranial hemorrhage, cranial fractures, mass effect, midline shift, infarcts or cerebral atrophy in order to prioritize them for clinical review. The standalone software device consists of an on premise module and a cloud module. qER accepts non-contrast adult head CT scan DICOM files as input and provides a priority flag indicating critical scans and overlay highlighting the location of abnormal finding in the scan.

The core deep learning analysis module underlying qER consists of a set of independent algorithms, each providing a probability score. A pre-specified threshold is then applied to the score to generate a 'present' or 'absent' status for each abnormality. The presence of any of the 4 abnormalities 'intracranial hemorrhage', 'mass effect', 'midline shift' or 'cranial fracture' triggers a Priority status flag that is displayed on the radiology worklist as 'qER_abnormal finding' and may be used as a reference by the end-user when deciding which study to read next. For studies where the software detects the presence of one of these abnormalities, an overlay indicating the position of abnormal finding is displayed. Information about the type and location of the finding is provided to the user through a text report. Additionally, the software has the capability to send the preview of critical scans to the medical specialist using messenger application.

The software can identify the following abnormalities:

Intracranial Hemorrhage:

For each type of hemorrhage, the software detects, quantifies and localizes the suspected bleed;

- Epidural hemorrhages
- Subdural hemorrhages
- Subarachnoid hemorrhage
- Intraparenchymal hemorrhage
- Intraventricular hemorrhage

An incoming Head CT scan is reviewed and prioritized based on the presence of abnormalities and integrated within the Radiologist's worklist. Each scan can be further analyzed with interpretations from qER to review the extent of the suspected bleed and location of the abnormalities.

qER has the capability to:

a) Identify abnormalities in a Head CT and priorities scans in the Radiology worklist in an Emergency care setting;

b) Provide further information on type of abnormality and location for review through an overlay and text information;

c) Generate preview of critical scans using messenger application

This product is defined as a "Medical Device" as per the definition in European Communities Council Directive 93/42/EEC Concerning Medical Devices.

Table 1: The table below details the product code and specification for each model:

Product Name	**Product description**
qER	qER is a radiological computer aided triage and notification software indicated for use in the analysis of non-enhanced head CT images, the device identifies abnormalities on head CT scans and prioritizes scans on the radiology worklist in an emergency care setting.

4.Conclusion:

qER is a radiology computer aided triage and notification software indicated for use in the analysis of non-contrast head CT scans. The device is intended to assist trained medical specialists by indicating the presence of the following findings on head CT scan images: Intracranial hemorrhage, mass effect, midline shift, cranial fracture, infarcts and cerebral atrophy. qER uses an artificial intelligence algorithm to analyze images in parallel to the ongoing standard of care image interpretation and highlight head CT scans containing critical findings. As an added feature, the device can outline the above pathologies on the head CT scan. The user is presented with preview images highlighting the abnormal findings that are meant for informational purposes only and not intended for diagnostic use.

The device does not change the original medical image and is not intended to be used as a diagnostic device. The outcome of the device are intended to be used in conjunction with other patient information and based on professional judgment, to assist with triage and prioritization of medical images for review. Notified clinicians are responsible for viewing the original head CT scans as per the standard of care.

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