Rapid ICH

Suspected intracranial hemorrhage identification: A technical overview of Rapid ICH and the role of machine learning

RapidAI has developed a computerized system based on machine learning that automatically screens CT scans for the presence of suspected intracranial hemorrhage (ICH) immediately after the scan acquisition. This technical paper highlights the importance of this development and the role of state-of-the-art AI systems—from methods and data to accuracy and performance.

ICH affects a large number of patients every year. It is caused by ruptured vessels in the brain or on the surface of the brain, and originates from diverse pathology, including trauma, hypertension, hemorrhagic conversion of ischemic infarction, and cerebral aneurysms, among other causes. The second most common subtype of stroke, ICH accounts for roughly 10 to 20% of all strokes. ICH is an emergency condition that can lead to severe disability or death. The fatality rate of ICH is high—40% in one month and 54% in one year.

Given these statistics, evaluation for acute intracranial hemorrhage plays a vital role in the clinical assessment of patients who present with neurological symptoms. It is critical for deciding on the need and approach for emergent surgical intervention. It is also essential for allowing the safe administration of thrombolytic therapy in acute ischemic stroke. Since 'time is brain', increased speed and reduced error in a clinical setting now allow for the usage of life-saving innovations. Hence, ruling out hemorrhage is the first step in stroke triage. CT scans are used worldwide to diagnose neurologic emergencies, but expertise is required to interpret these scans. In fact, even highly trained experts may miss subtle life-threatening findings. The challenge is to identify—with near-perfect sensitivity and specificity—often small, subtle abnormalities on a multi-slice, cross-sectional (3D) imaging modality that is characterized by poor soft-tissue contrast, low signal-to-noise, and a high incidence of imaging artifacts. The most commonly encountered types of ICH include subarachnoid, epidural, subdural, intraparenchymal (see Figure 1) and intraventricular hemorrhages.

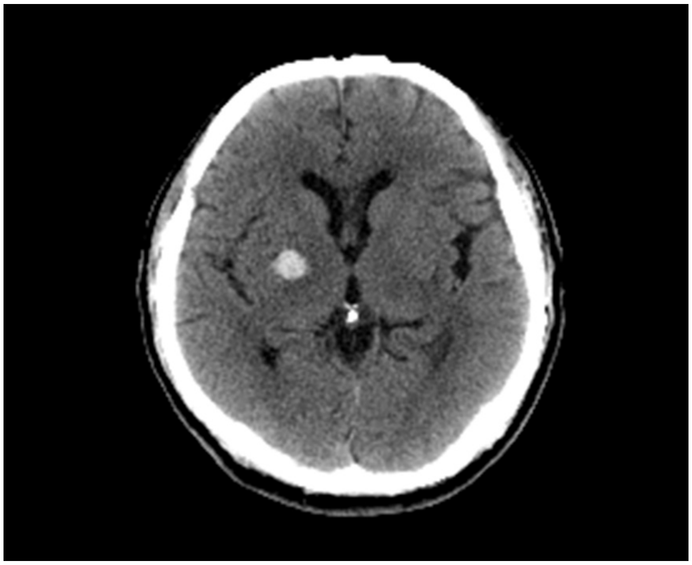

Figure 1: Intraparenchymal hemorrhage

To assist in the detection, screening, and identification of ICH in daily clinical routine, and to help reduce the rate of missed hemorrhages and speed up the ICH detection, RapidAI has developed a computerized platform based on machine learning. This platform automatically identifies the presence of a suspected ICH in a NCCT scan and sends results to stroke team members within minutes of receipt of the scan.

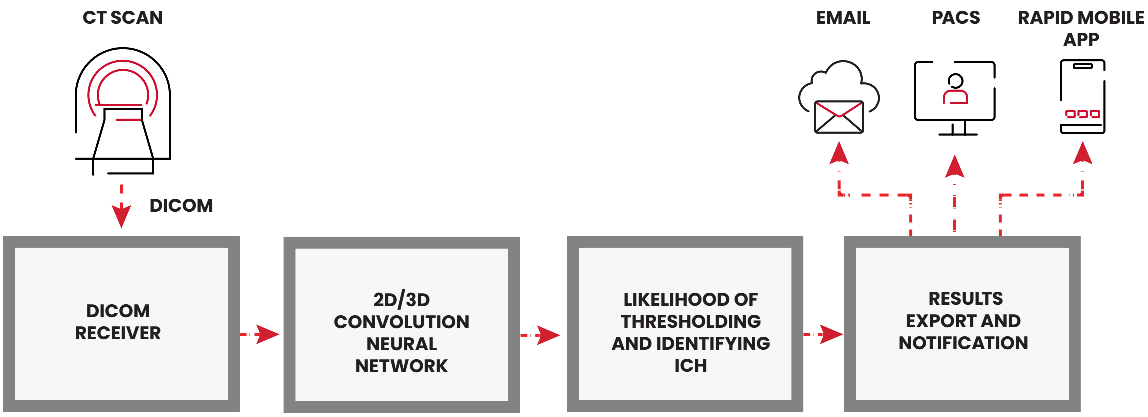

Figure 2: Rapid ICH process for identification of suspected ICH

Methods and data—convolutional neural networks

Identification of ICH requires visual recognition of complex patterns. It is a task well suited for state-of-the-art artificial intelligence systems. Modern convolutional neural networks (a class of deep neural networks), utilizing advances in machine learning, can be trained to recognize pathology patterns and to ignore imaging artifacts and pathology mimics. For identification of the ICH in the input images, RapidAI implemented a solution based on the U-Net neural network architecture. Input CT images are propagated through a series of convolution blocks with decreasing and subsequently increasing tensor dimensions. The last convolution layer of the network produces, in each volume element (voxel) of the evaluated input data, the likelihood of the voxel being ICH or not. This likelihood is then thresholded to obtain the final decision about hemorrhage being present in a given location (see Figure 2). A combination of Python, Keras, and TensorFlow tools was used to implement and "train" the network.

The training of the machine-learning model was performed using a cloud platform with a large dataset representing a wide variety of pathologic features, image properties, and characteristics. The data sets used for training and evaluation were collected from a large number of sites internationally. This allowed us to sample a wide range of state-of-the-art imaging protocols, scanner models, and acquisition artifacts typically present in head CT. The latest version of the product was substantially strengthened by the addition of many cases that contained significant artifact, particularly motion. The ground truth was defined by expert neuroradiologists with at least 10 years of experience.

Rapid ICH accuracy

After the development of Rapid ICH, clinical validation was executed on an independent dataset to assess the accuracy of the trained machine-learning model. The cases represented all types of ICH—excluding hemorrhagic transformations (HTs)—with hemorrhage volume ranging between 0.4 to 100.0ml, with the majority of the cases between 1.0 to 20.0ml. The cases were first adjudicated by 3 expert readers to establish the ground truth. The dataset was then analyzed by the Rapid ICH module and yielded a sensitivity of 98.1% and a specificity of 99.7% for detection of ICH (excluding HTs).

Performance results—under 1 minute

The Rapid ICH module is deployed on Rapid servers (physical or virtualized) within the existing Rapid platform. On a typical configuration (4 CPU cores, 8 GB RAM) the processing of a typical CT head scan processes in less than a minute. After processing, the information about ICH presence is immediately communicated to the physicians and Rapid ICH automatically sends notifications to PACS, email and the Rapid mobile app. (See Figure 3).

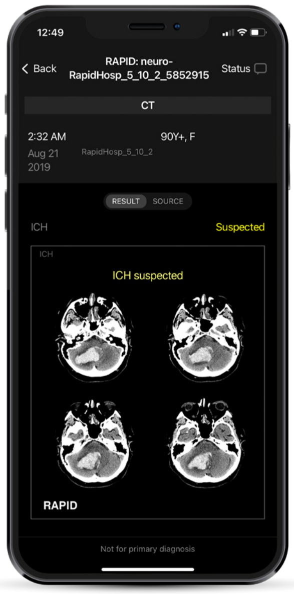

Figure 3: Rapid ICH presented in rapid mobile app

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