

Brain Stroke Analysis from Non-Contrast Brain CT and Path-planning for Robot-assisted Thrombectomy

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Background

- A stroke is a medical emergency. Prompt treatment is crucial to reduce brain damage and other complications.
- There are *two prominent causes of stroke*: a blocked artery (**ischemic stroke**), or leaking or bursting of a blood vessel (**hemorrhagic stroke**).

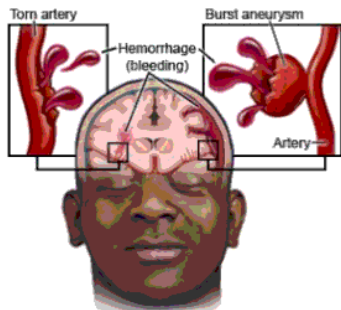
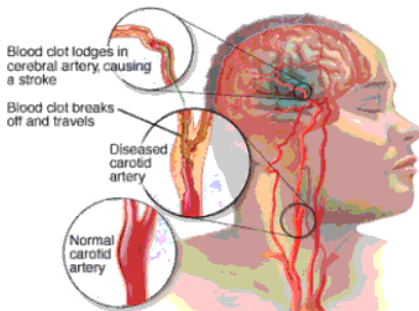


Figure: Depiction of brain strokes.

Problem Statement

Module A: Detect and localize stroke regions on NCCT volumes

- Context-aware segmentation of stroke regions.
- 2D and 3D feature fusion for multi-dimensional processing.
- Rendition of stroke and brain as 3D visualization.
- Potentially, make quantitative measurements to aid *module B*, if relevant metadata is available.

Module B: Perform path-planning for robot-assisted surgical intervention

- Assistive intervention using a 6-DOF robotic arm.
- Path-planning using Reinforcement Learning (RL).
- Specific focus on smooth operation in a precision setting.

The diagram illustrates the overall architecture of the proposed system, divided into three main modules: NCCT Analysis Module, Robotic Arm, and Path Planning Module.

NCCT Analysis Module: This module processes input CT volumes. It starts with "Input CT Volume" (1), which undergoes "Skull Stripping", "T1 Convolution", "Smoothing", and "Non-Local Denoising" to produce a "Preprocessed CT Volume". This volume is then processed by a "U-Net" architecture (2) to generate a "Segmented CT Volume". The U-Net consists of "Pre-1D", "Pre-2D", and "Pre-3D" feature maps, followed by "U-Net Segmentation Probability Map" and "U-Net Segmentation Probability Map 2". The output is a "Probability Map" (3) and a "Segmented CT Volume".

Robotic Arm: The "Robotic Arm" module receives the "Segmented CT Volume" and a "Planned Path" from the Path Planning Module. It performs "3D Rendering" and "Manual Intervention" to assist with "Surgical Planning".

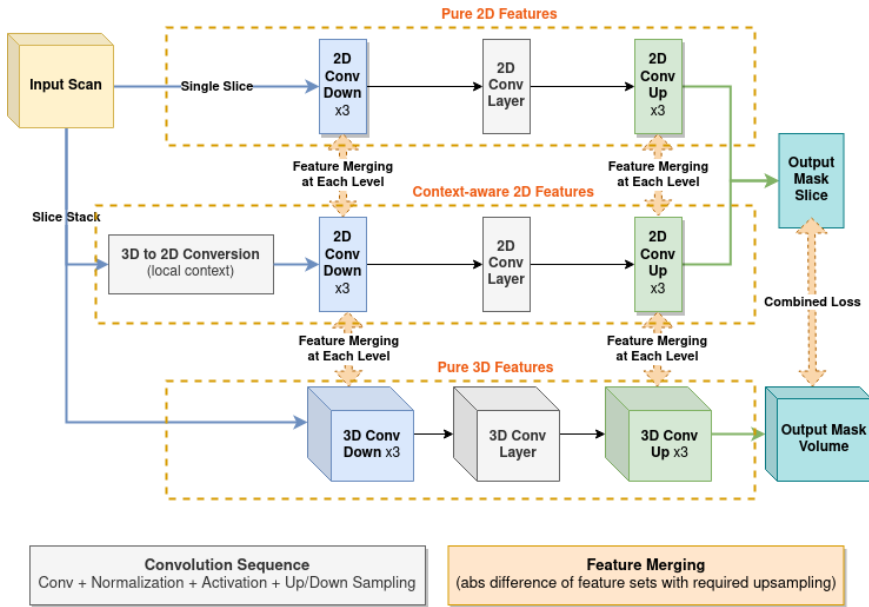
Path Planning Module: This module uses a Reinforcement Learning (RL) approach to find an "Optimum Path based on Maximum Rewards". It starts with a "Target Search Domain" and a "Quadrotor Survey". The process involves "Rescale to World Coordinates", "Computer Vision", "Global Position of the Objects", "Label Detections", and "Reward of Movement". The "Reward of Detection" is used for "Reward Calculation", which updates the "Q-Matrix" and the "State-Action Pair". The "Optimum Path" is then determined based on "Maximum Rewards". The module also includes a "Return Segmented Image" and a "New State".

Web-App: The "Web-App" module receives the "3D Rendering" and "Planned Path" from the Robotic Arm module and provides "Assist with Surgical Planning".

Legend: The diagram includes a legend for "Convolutional Neurons" (blue box) and "Neuron Mapping" (orange box), which represents the "loss of difference of values into with nearest neighborhood".

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Proposed Segmentation Network



Stroke Infarct Segmentation Approaches

Table: Comparison of segmentation approaches on open-access datasets.

Approach	Backbone	Dataset	DSC	Mean IoU	AuROC
FPN	EffNet-B0	Peer-Reviewed Open-Access	41.18%	28.20%	-
UNet	EffNet-B0		46.73%	30.42%	-
PSPNet			40.21%	27.51%	-
DeepLabV3+			33.82%	17.43%	-
Best UNet *		Intracranial Hemorrhage Dataset [1]	44%	27.5%	-
ChanVese [2]*			70%	-	-
M-Net			70.41%	59.95%	86.13%
Proposed			76.11%	64.52%	89.15%

*reported results from literature

Demo (cont.)

NCCT Analysis Module

- Qualitative analysis of results [Link].
- Prediction workflow [Link].
- Web-app for 3D segmentation demo [Link].

Path-planning Module

- Comparison of Deep-RL and Q-Learning [Link].
- Result representation of Q-Learning [Link].
- Web-app to assist robotic surgery for neurosurgeons [Link].