# Quantifying Hippocampus Volume for Alzheimer's Progression

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### 0.0.1 Background

Alzheimer's disease (AD) is a progressive neurodegenerative disorder that results in impaired neuronal (brain cell) function and eventually, cell death. AD is the most common cause of dementia. Clinically, it is characterized by memory loss, inability to learn new material, loss of language function, and other manifestations.

For patients exhibiting early symptoms, quantifying disease progression over time can help direct therapy and disease management.

A radiological study via MRI exam is currently one of the most advanced methods to quantify the disease. In particular, the measurement of hippocampal volume has proven useful to diagnose and track progression in several brain disorders, most notably in AD. Studies have shown a reduced volume of the hippocampus in patients with AD.

The hippocampus is a critical structure of the human brain (and the brain of other vertebrates) that plays important roles in the consolidation of information from short-term memory to long-term memory. In other words, the hippocampus is thought to be responsible for memory and learning (that's why we are all here, after all!)

Figure 1: 3D Images

Humans have two hippocampi, one in each hemisphere of the brain. They are located in the medial temporal lobe of the brain. Fun fact - the word "hippocampus" is roughly translated from Greek as "horselike" because

of the similarity to a seahorse observed by one of the first anatomists to illustrate the structure, but you can also see the comparison in the following image.

Figure 2: Seahorse and Hippocampus preparation of a human hippocampus alongside a sea horse.

According to Nobis et al., 2019, the volume of hippocampus varies in a population, depending on various parameters, within certain boundaries, and it is possible to identify a "normal" range taking into account age, sex and brain hemisphere.

You can see this in the image below where the right hippocampal volume of women across ages 52 - 71 is shown.

There is one problem with measuring the volume of the hippocampus using MRI scans, though - namely, the process tends to be quite tedious since every slice of the 3D volume needs to be analyzed, and the shape of the structure needs to be traced. The fact that the hippocampus has a non-uniform shape only makes it more challenging. Do you think you could spot the hippocampi in this axial slice below?

As you might have guessed by now, we are going to build a piece of AI software that could help clinicians perform this task faster and more consistently.

You have seen throughout the course that a large part of AI development effort is taken up by curating the dataset and proving clinical efficacy. In this project, we will focus on the technical aspects of building a segmentation model and integrating it into the clinician's workflow, leaving the dataset curation and model validation questions largely outside the scope of this project.

### 0.0.2 What You Will Build

In this project you will build an end-to-end AI system which features a machine learning algorithm that integrates into a clinical-grade viewer and automatically measures hippocampal volumes of new patients, as their studies are committed to the clinical imaging archive.

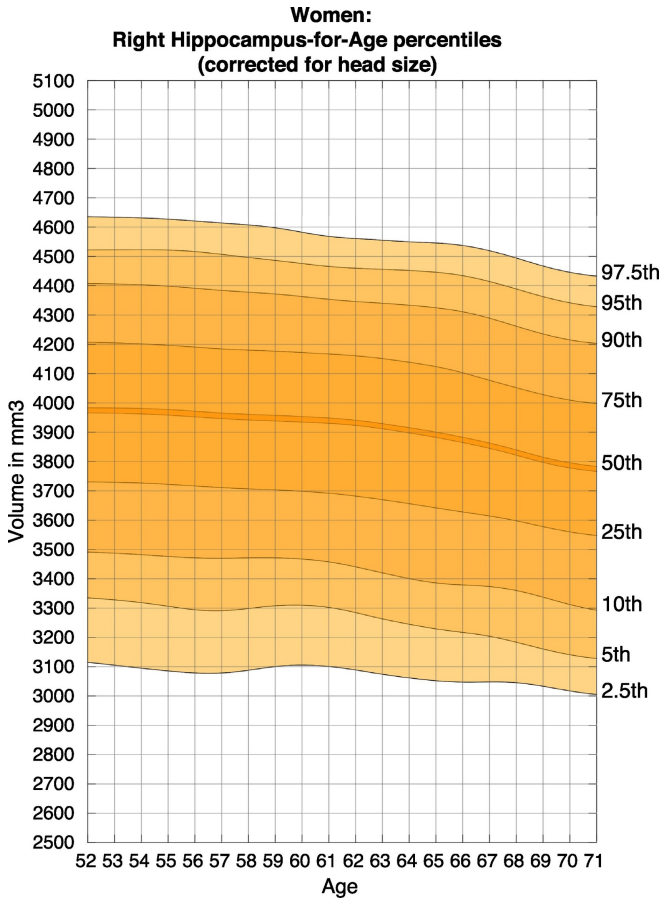


Figure 3: Nomogram -Female, Right Hippocampus Volume, Corrected for Head Size

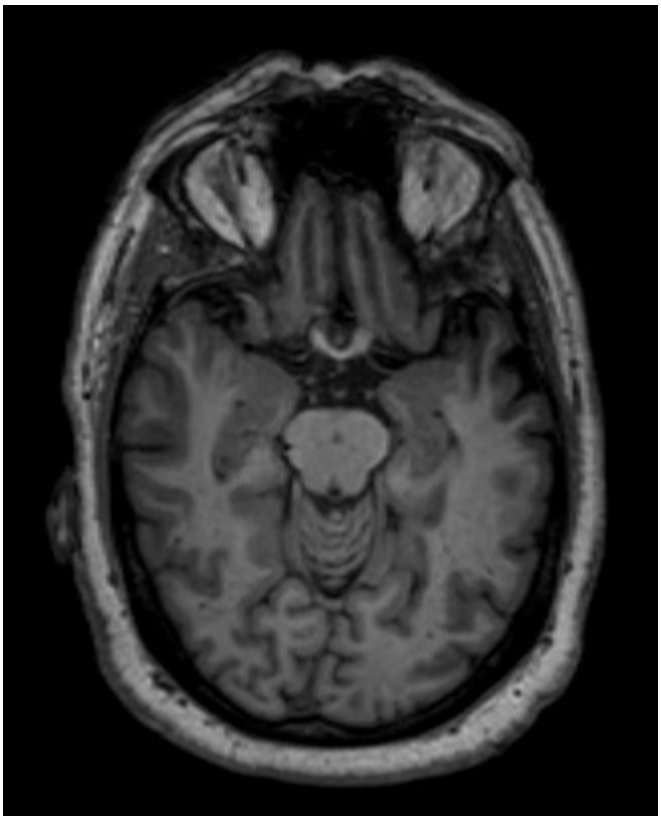

Figure 4: Axual Slice pf MRI image of the brain

Fortunately you won't have to deal with full heads of patients. Our (fictional) radiology department runs a HippoCrop tool which cuts out a rectangular portion of a brain scan from every image series, making your job a bit easier, and our committed radiologists have collected and annotated a dataset of relevant volumes, and even converted them to NIFTI format!

You will use the dataset that contains the segmentations of the right hippocampus and you will use the U-Net architecture to build the segmentation model.

After that, you will proceed to integrate the model into a working clinical PACS such that it runs on every incoming study and produces a report with volume measurements.

#### 0.0.3 Section 1: Curating a Dataset of Brain MRIs