A Study On MRI-Based Early Alzheimer's Detection and 3D Analysis

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BACKGROUND

- Over 7.2 million Americans aged 65+ are living with Alzheimer's in 2025. Early detection is vital due to its subtle onset and progressive nature.
- MRI is non-invasive and captures structural changes like hippocampal shrinkage, cortical thinning and white matter damage.
- FLAIR MRI suppresses cerebrospinal fluid signals, making white matter lesions more visible key for identifying early-stage abnormalities.
- MPRAGE MRI provides high-resolution anatomical detail, enabling precise brain volume measurements over time.
- Our method uses 2D slice extraction, skull stripping, and intensity-based segmentation to create 3D visualizations of lesion patterns.
- Combining FLAIR lesion analysis with MPRAGE volume tracking offers a powerful tool for early diagnosis and longitudinal monitoring.

PROBLEM

- Why do early signs of Alzheimer's often get missed, even in detailed brain scans?
- Are we overlooking small white matter changes just because they don't stand out clearly?
- Can we use MRI FLAIR images to bring out those subtle lesions that usually go unnoticed?
- What if there's a way to see what doctors can't easily spot in routine evaluations?

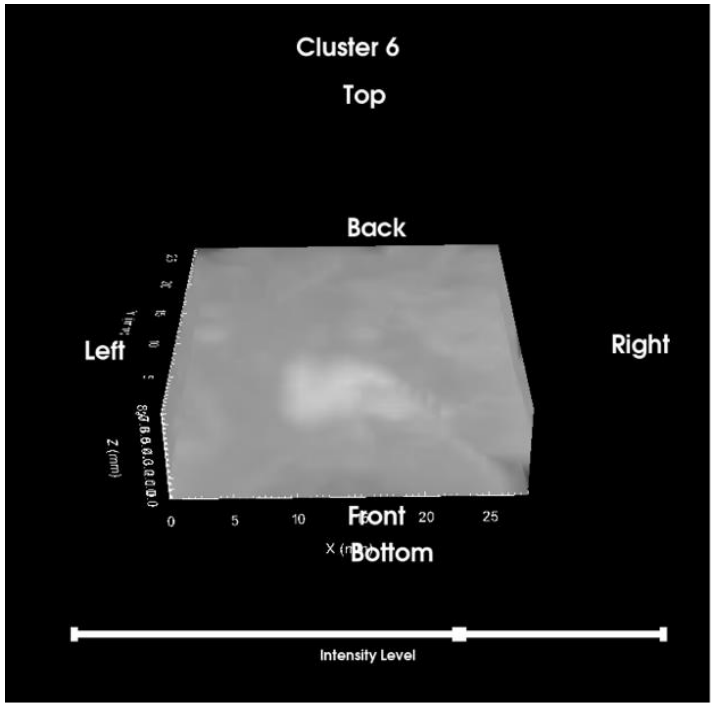
SOLUTION

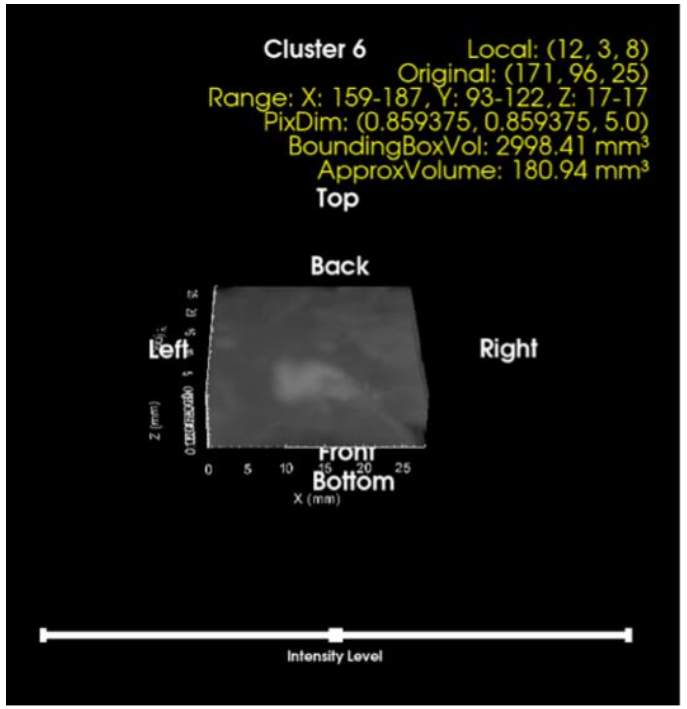
3D White matter lesions scanning

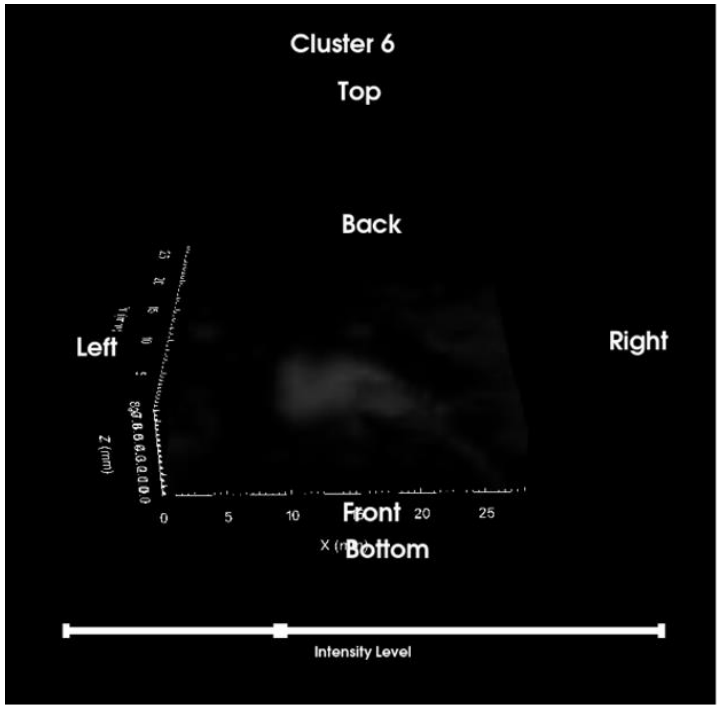
- We started with FLAIR MRI scans because they're really good at showing small changes in white matter that often go unnoticed.
- Instead of looking at the whole 3D scan at once, we broke it down into 2D slices, especially slices 16 to 25, where key regions like the corpus callosum is clearly visible.
- We removed the skull and cleaned up the images so we could focus only on the brain.
- Then, we picked out the pixel intensity values from each slice basically, checking how bright certain spots were, which can hint at lesions.
- After that, we took those slice details and built a 3D model, so we could actually see where the changes are happening, not just guess from flat images.

DEMO

3D Visualization







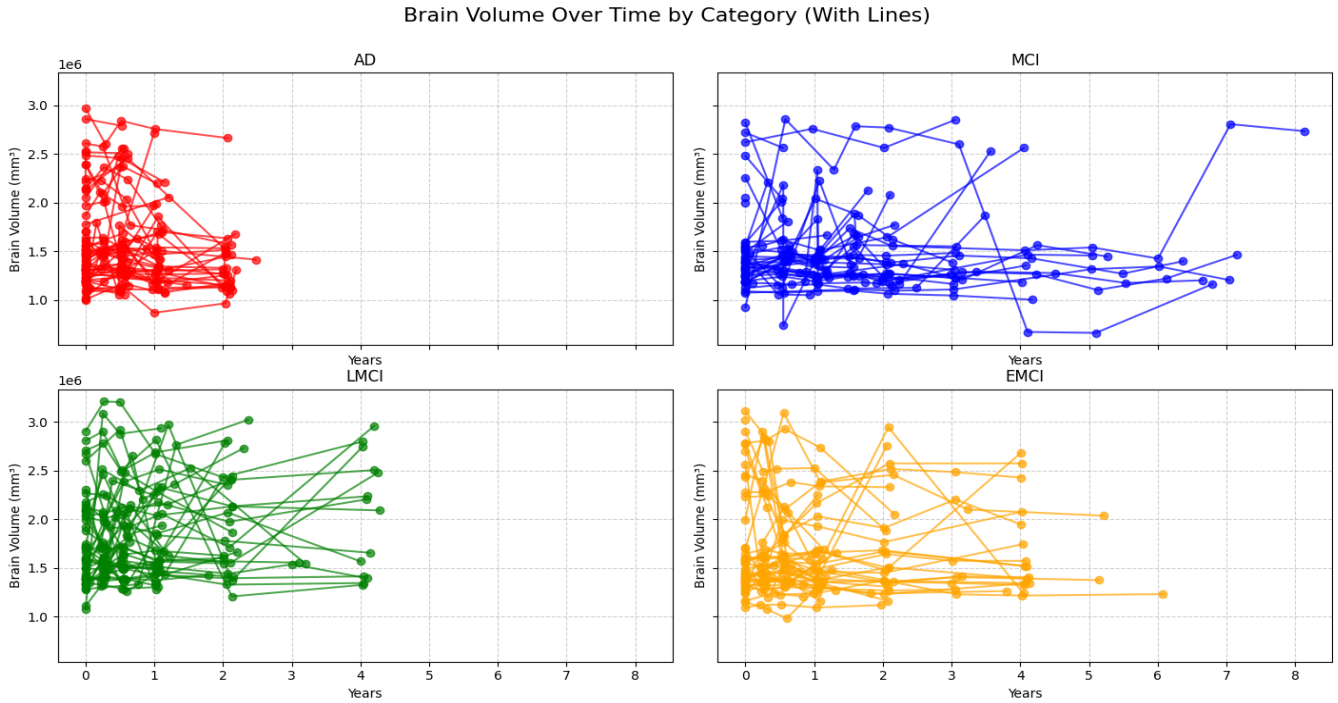
SOLUTION

Brain matter volume predictions

- Along with the lesion detection, we also wanted to check if we could track brain shrinkage another sign of Alzheimer's.
- For that, we used a different type of MRI scan called MPRAGE, which gives time,, high-detail brain images.
- We grouped the scans by subject and sorted them by time to see how the brain changed from one scan to the next.
- Then we used a simple K-Means method to separate the brain from the rest of the image and calculate how big the brain area was.
- We plotted how the brain volume changed over time, but the results weren't consistent.

DEMO

Brain Volume predictions



VALIDATION AND ASSESSMENTS

- When we built the 3D models from FLAIR scans, we compared them with known brain regions especially around the corpus callosum and the results lined up well.
- We noticed that the bright spots showed up within a specific intensity range and appeared consistently across slices not just randomly here and there.
- The way those patterns continued smoothly from one slice to the next made it clear they weren't just random noise but actually forms like tumors.
- We added an intensity scale to the model, so the brighter and darker regions were easier to understand visually.
- On the brain volume side, we tracked changes using MPRAGE scans over time. But the results didn't always follow a steady trend some volumes jumped unexpectedly.
- That showed me there's still room to improve the process, especially with how we segment and align the scans for better accuracy next time.

CONCLUSION AND FUTURE WORK

- Using FLAIR MRI, we were able to bring out subtle white matter changes that usually go unnoticed in early Alzheimer's cases.
- Breaking the scans into 2D slices and turning them into 3D models helped make the lesion areas, especially near the corpus callosum which is more clearly visible.
- The brain volume tracking with MPRAGE scans showed some promise, but the results were inconsistent at times, highlighting areas that need better tuning.
- To improve brain volume results, segmentation and alignment need refinement due to errors from measurement issues, image processing faults and noise in segmentation.
- Automate slice selection instead of manually picking them, possibly using AI/ML.
- Combine lesion detection and volume tracking into a single, more robust pipeline.

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