Accounting for Variance in Brain Atrophy Measurements by Quantifying Image Quality Differences across Longitudinal Imaging Studies

A modeling and data science approach

R. J. Crowley BS[1,2], K. M. Leyden MRes[1], A. Keshavan PhD[1]

[1]Octave Bioscience, Menlo Park, CA, [2]University of Cambridge, Cambridge, England

Presented at the 7th annual Americas Committee for Treatment and Research in Multiple Sclerosis (ACTRIMS) Forum, February 24-26, 2022, West Palm Beach, FL

Introduction

- Brain **atrophy** is associated with Multiple Sclerosis (MS) **disability progression** but image quality confounds measurements
- Lack of trust in atrophy measurements **limits clinical use**
- 68 intrinsic **imaging features** were shown in the literature to reliably represent MRI image quality (Fig.1)
- **Objective:** Create a **single** metric to quantify image quality **differences** to aid atrophy measurements

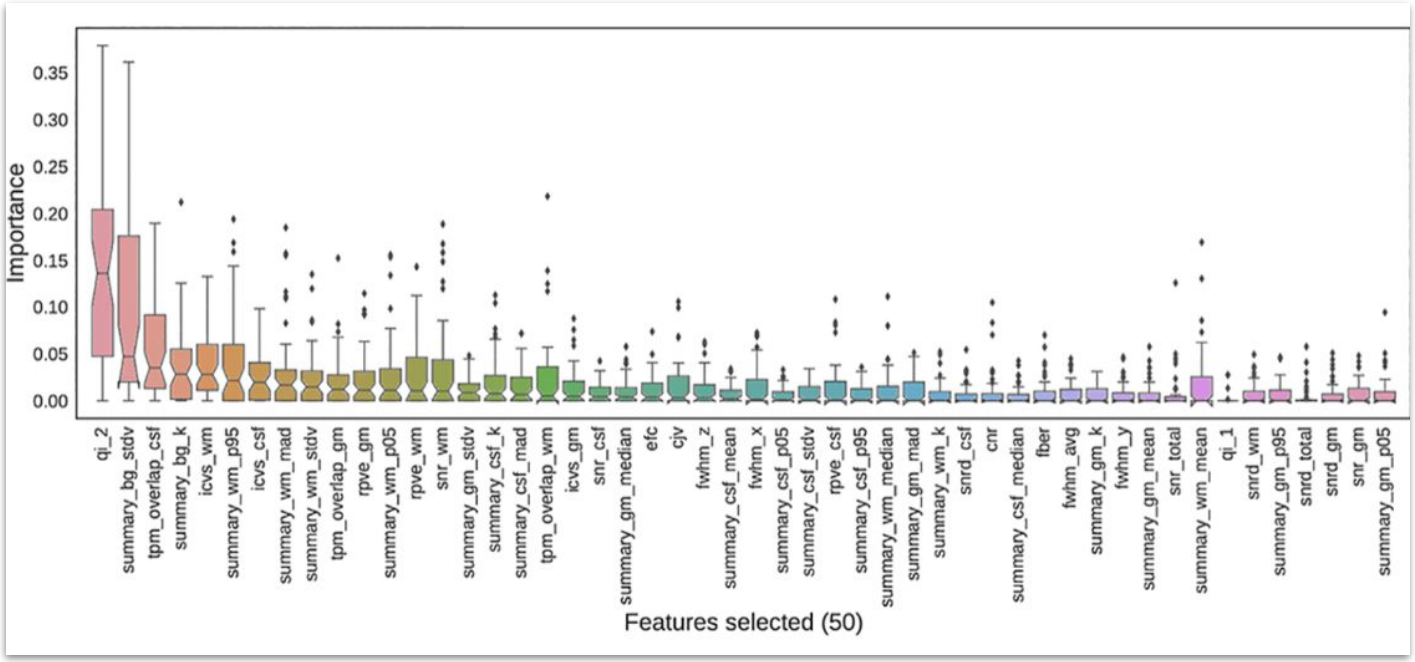


Figure 1: MRIQC Features (Esteban, 2017)

Methods

Patient Population	**480 MS patients**, each of whom had Time Point Pairs (TPPs) with both **T1** and **T2-FLAIR** sequences, were retrospectively identified
Euclidean Distance	Calculated the full **Euclidean Distance** between consecutive image TPPs for the **136 imaging features** (68 for T1 and 68 for T2-FLAIR)
Model Assessment	Assessed the **performance** of model in representing **image quality** and adjusting **LVVC measurements**

Results: Validation of QC Approach for MRI

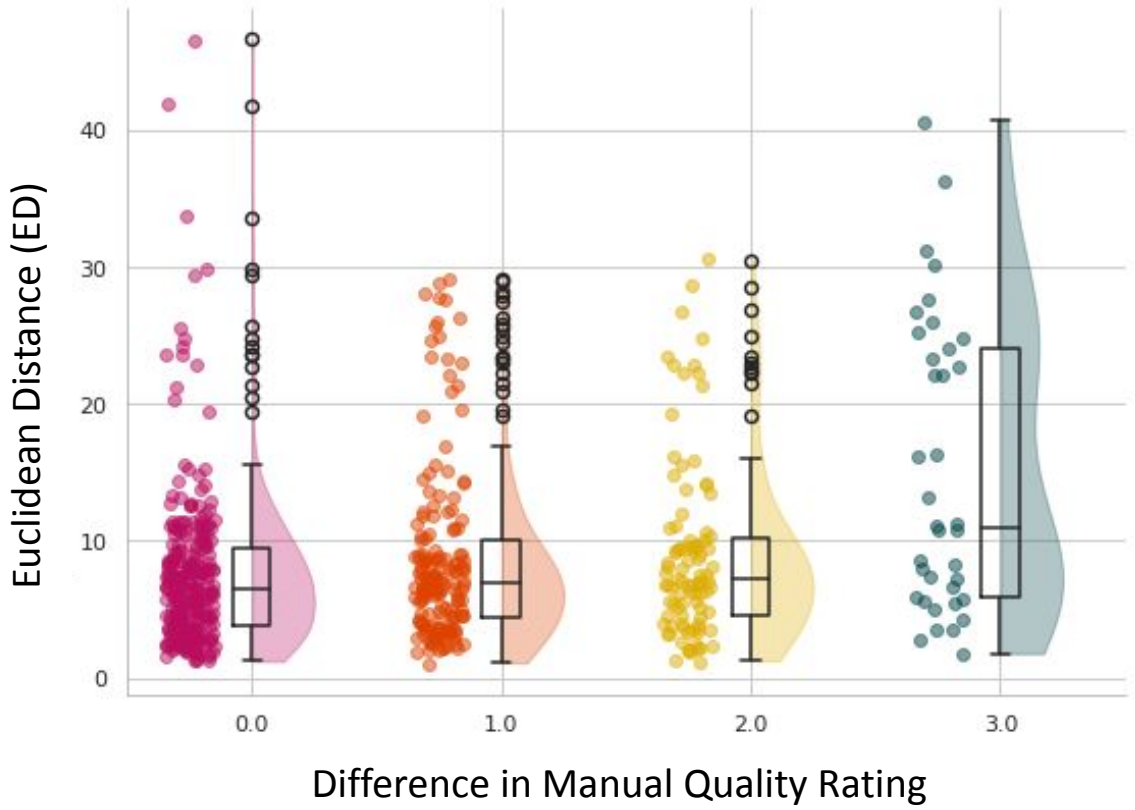


Figure 2: Pairwise Distances versus Differences in Manual Quality Ratings
(0 = similar in quality, 3 = different in quality)

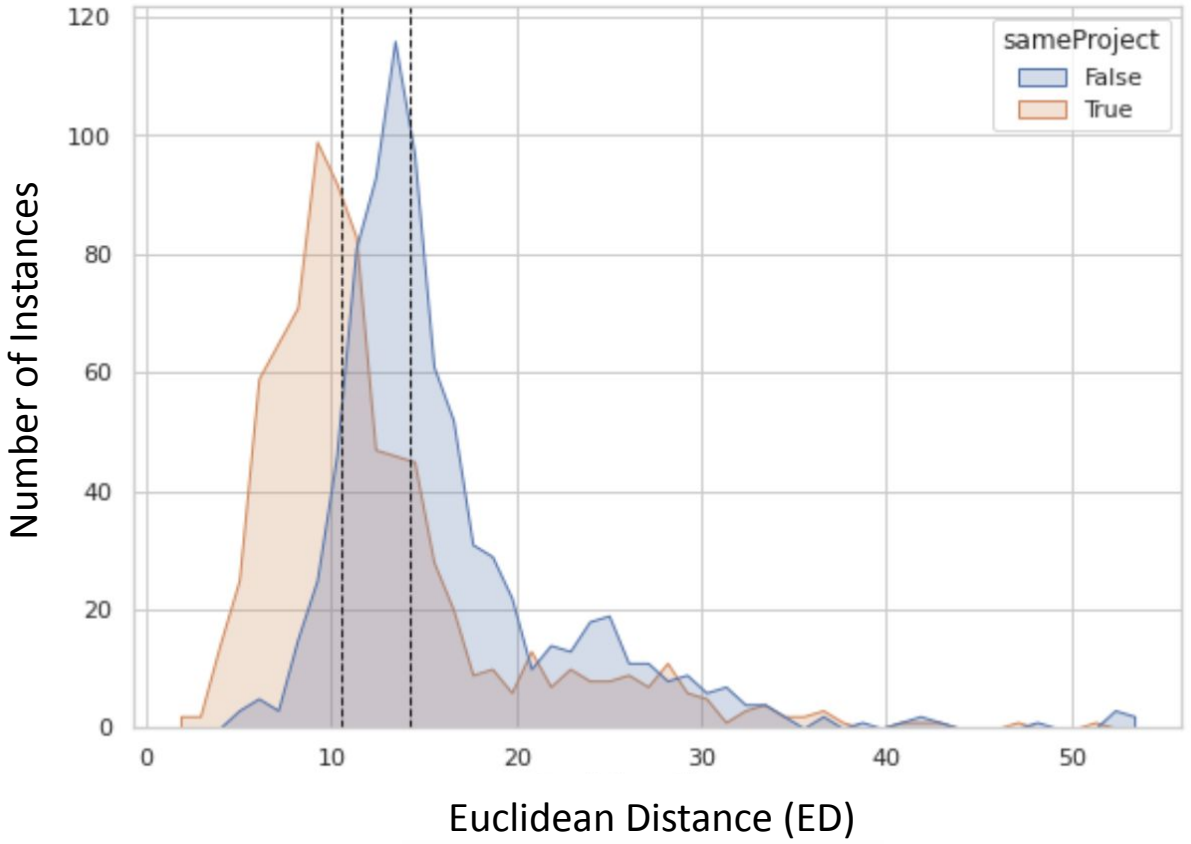


Figure 3: Randomized Pairwise Distances for Studies in Same versus Different Clinic
(High ED signifies larger difference in image quality)

Results: Validation of QC Approach for MRI

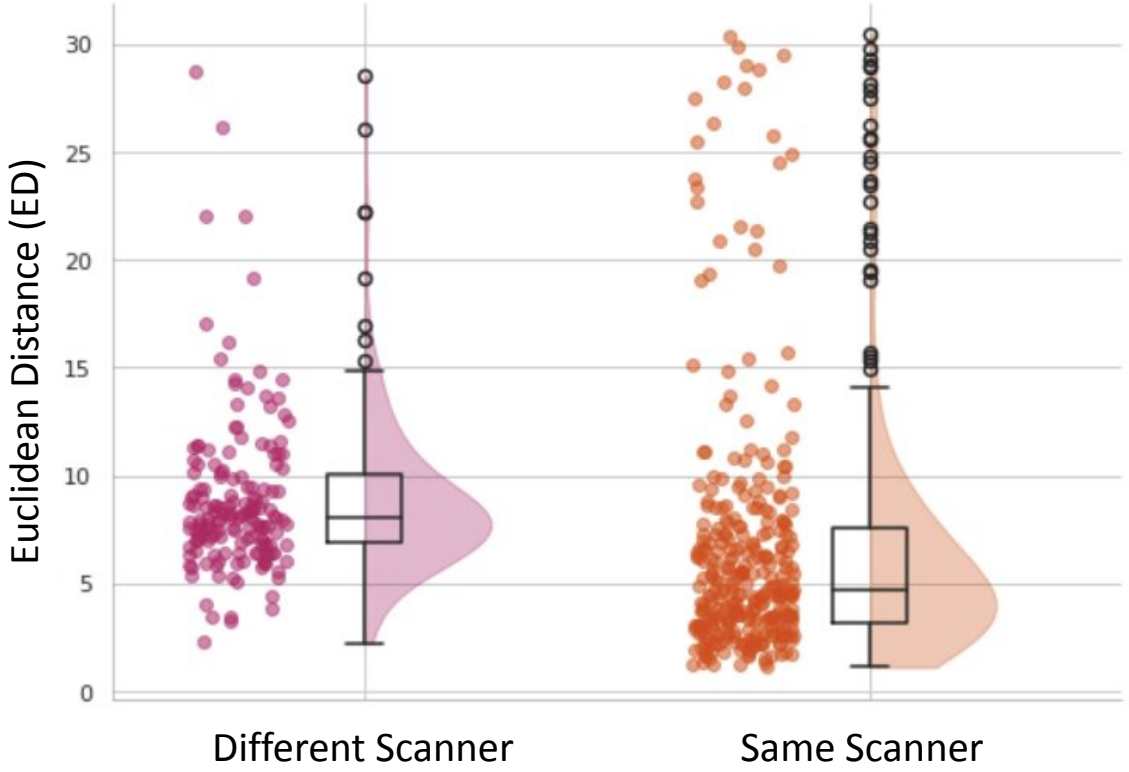


Figure 4: Euclidean Distances for Same versus Different Scanner **Model**

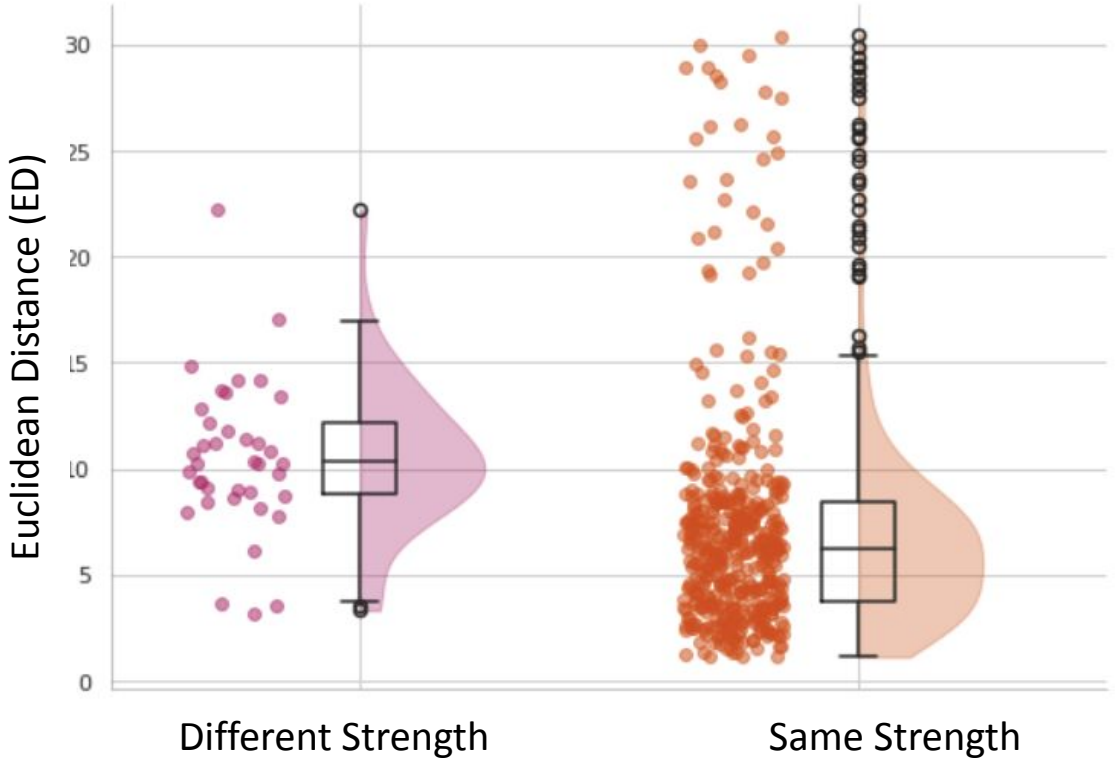


Figure 5: Euclidean Distances for Same versus Different Scanner **Strength**

Results: Regression Model

Model Formulation	Effectiveness of ED in adjusting LVVC measurements was assessed using a **linear regression** model of the form: **LVVC ~ 1 + Age + Sex + Euclidean Distance**
Model Results	The **adjusted R-Squared** for the regression model incorporating ED was **.067**, while the adjusted R-Squared for the model containing only age and sex was **.042.** Increases in Euclidean Distance were related to increases in LVVC

Visualization of MRI Quality Differences

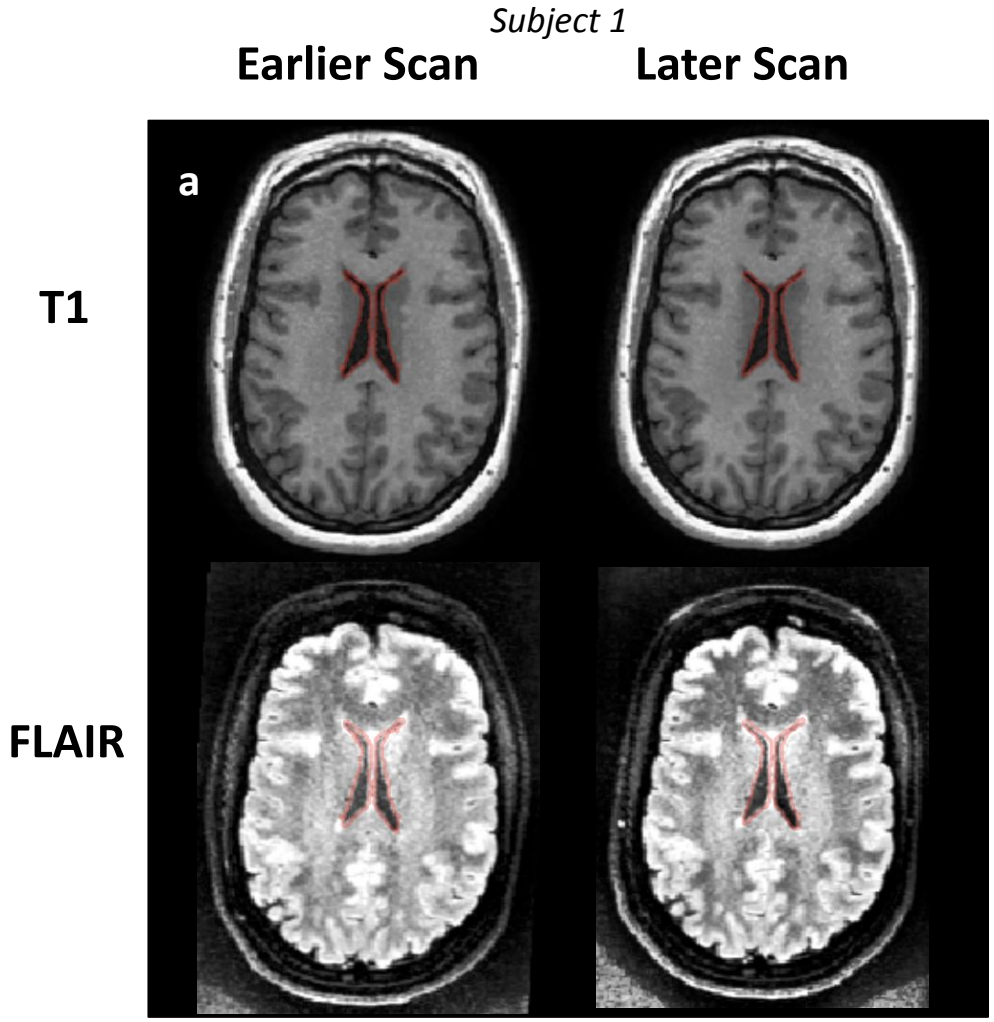


Figure 6a: Images “Close” in Image Quality

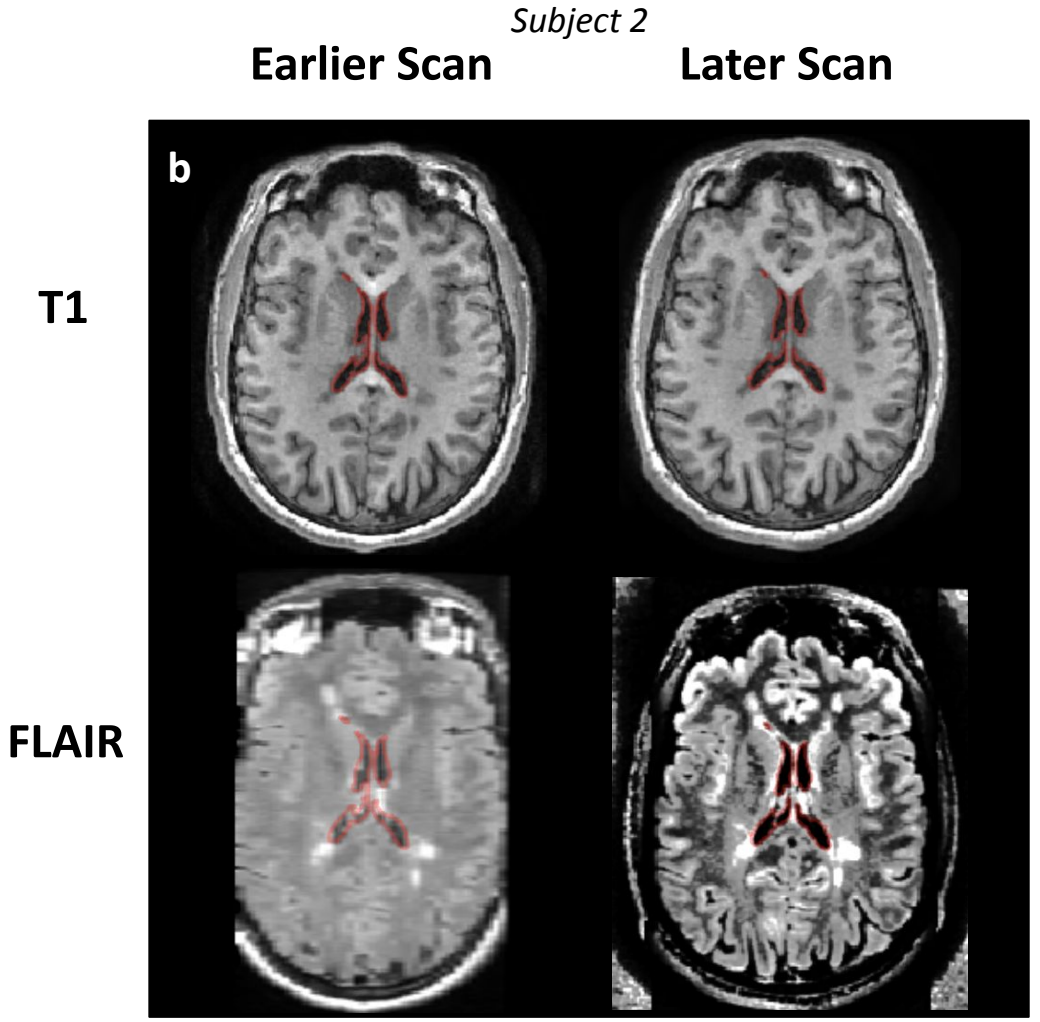


Figure 6b: Images “Far” in Image Quality

MRI Images of Clinically Relevant Atrophy

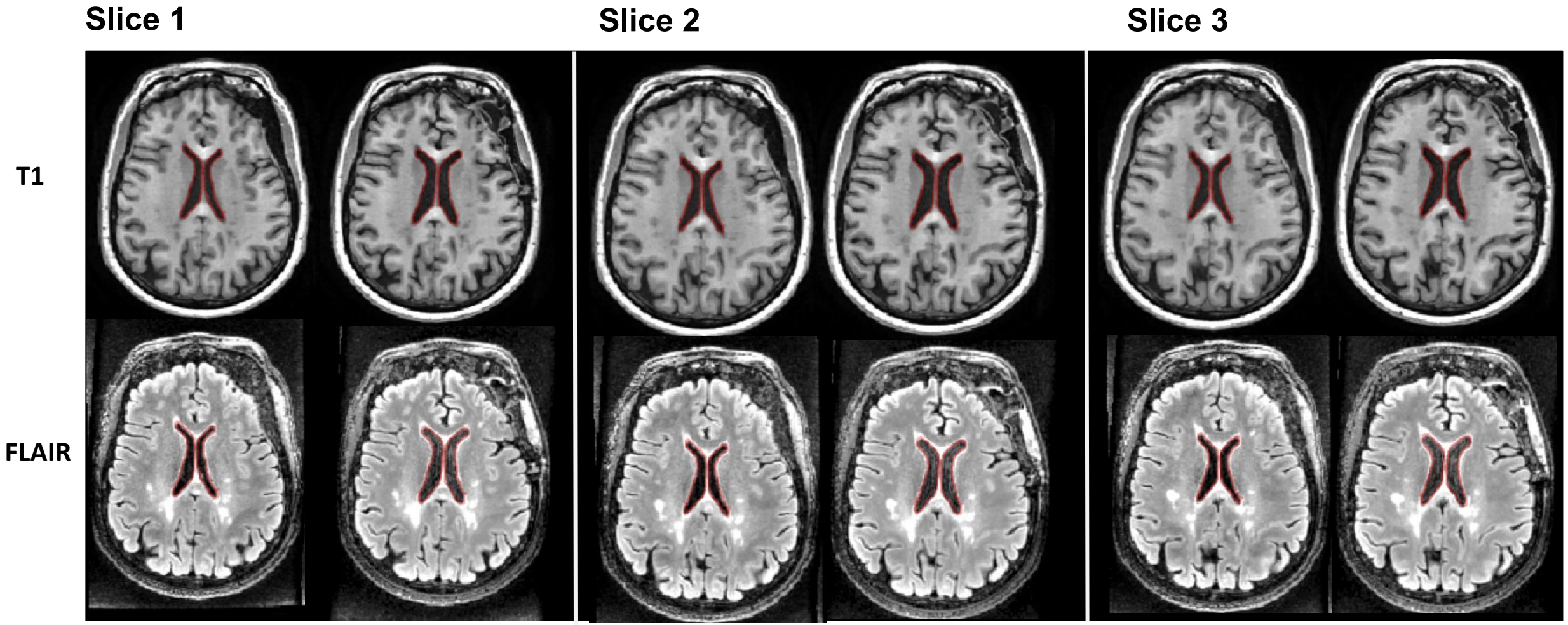
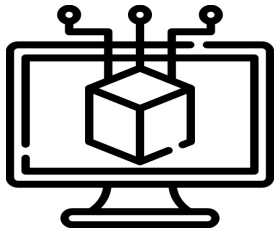


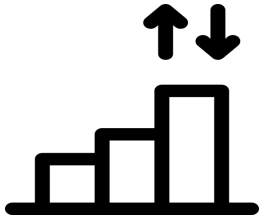
Figure 7: T1 and T2-FLAIR Images for Patient with Brain Atrophy

Concluding Thoughts

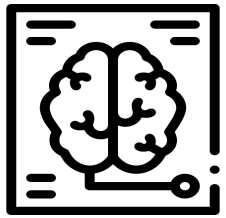
Key Takeaways for MRI QC



This **model** demonstrates initial **success** in quantifying image quality differences for MRI QC



Quantification of **differences** in image quality can account for **variation** in atrophy measurements



Further explorations of this **approach to MRI QC** of utilizing image quality differences are **merited**

Acknowledgements

- Special thanks to Taki Shinohara for his guidance in supporting this work

- If you have any questions, please feel free to contact Anisha Keshavan (akeshavan@octavebio.com)