Machine Learning for Sjögren Syndrome Classification

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Problem Statement

Client

- Dr. Sara McCoy
- Looking for a machine learning algorithm to diagnose Sjögren's Syndrome from salivary gland ultrasound scans

Problem

- Current methods are invasive and/or subjective
- Ultrasound scans can be time consuming to score

Background - Sjögren's Syndrome

- Chronic disorder where immune system attacks moisture glands in the body
  - Primarily in the mouth and eyes
- The primary symptoms are dry eyes and mouth
  - Other symptoms may include:
    - Joint and muscle pain
    - Fatigue
    - Swelling of glands…
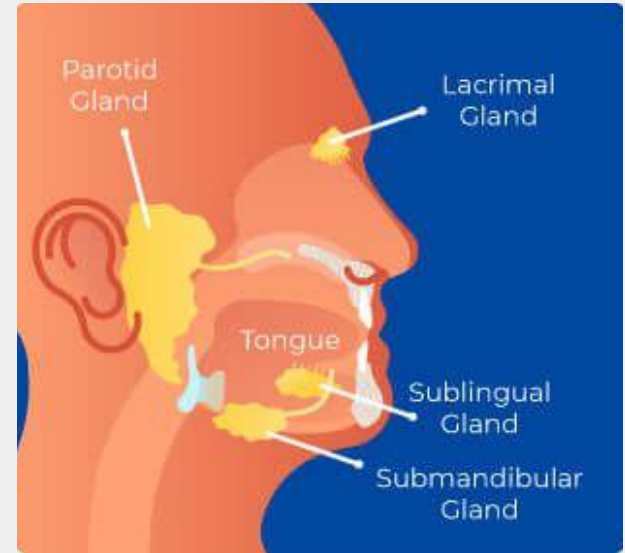- Believed to be caused by genetic and environmental factors [1]

Figure 1: Parotid/Submandibular Glands [2]

Background - Competing Designs

OMERACT Ultrasound Scoring System

- Currently used to score heterogeneity in salivary gland ultrasound scans
- Not entirely objective and lacks nuance

Other diagnostic Methods

- blood and urine tests
- Schirmer tear test
- Sialography
- Salivary scintigraphy
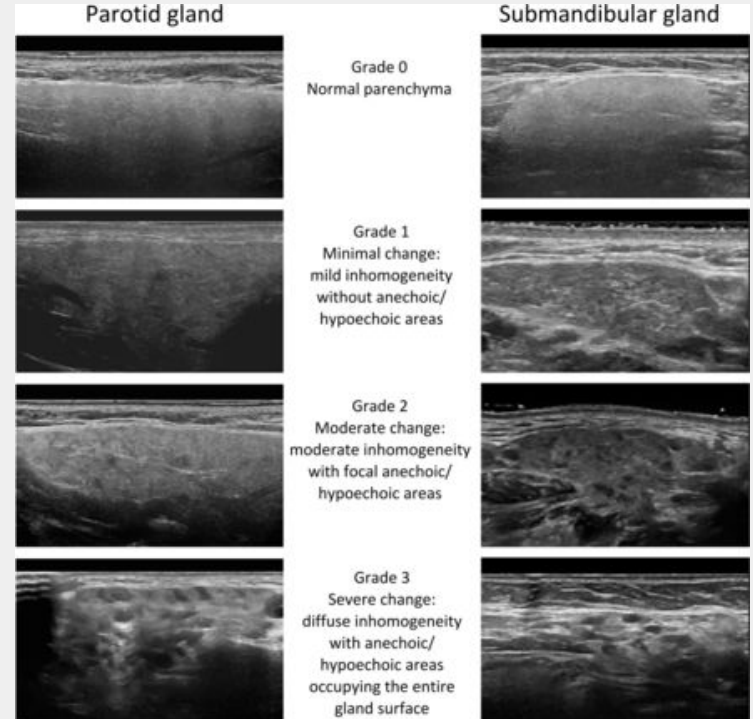- Lip Biopsy

Figure 2: Lip Biopsy [3]

Figure 3: OMERACT Scoring System [4]

PDS–Client Requirement

- Ultrasound→Diagnosis
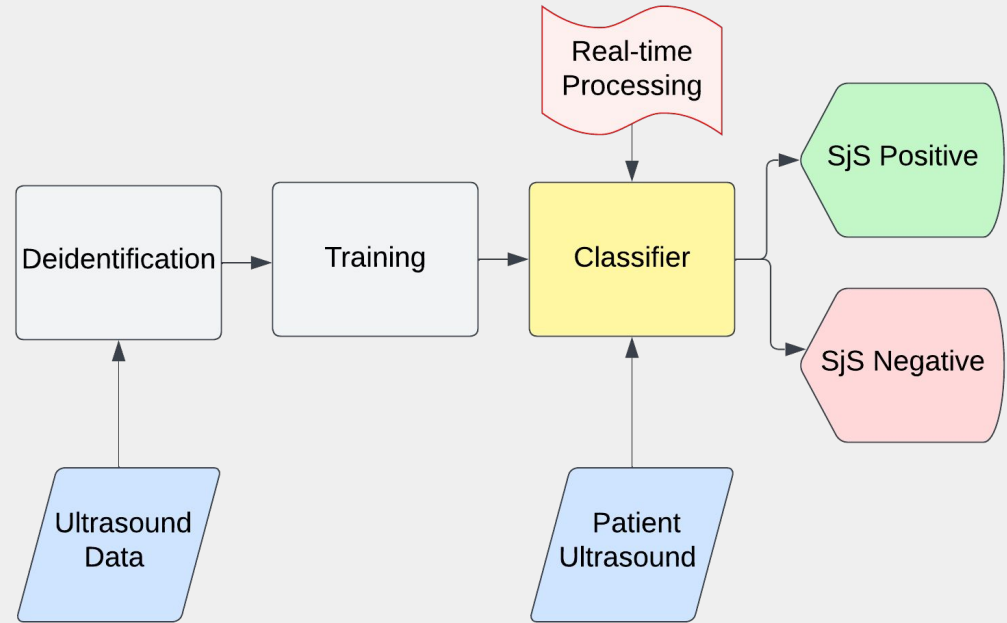- Real-time Processing
- De-identification
- Generalizability

Figure 4: Client Requirement

PDS–Model Validation

- Baseline/final model
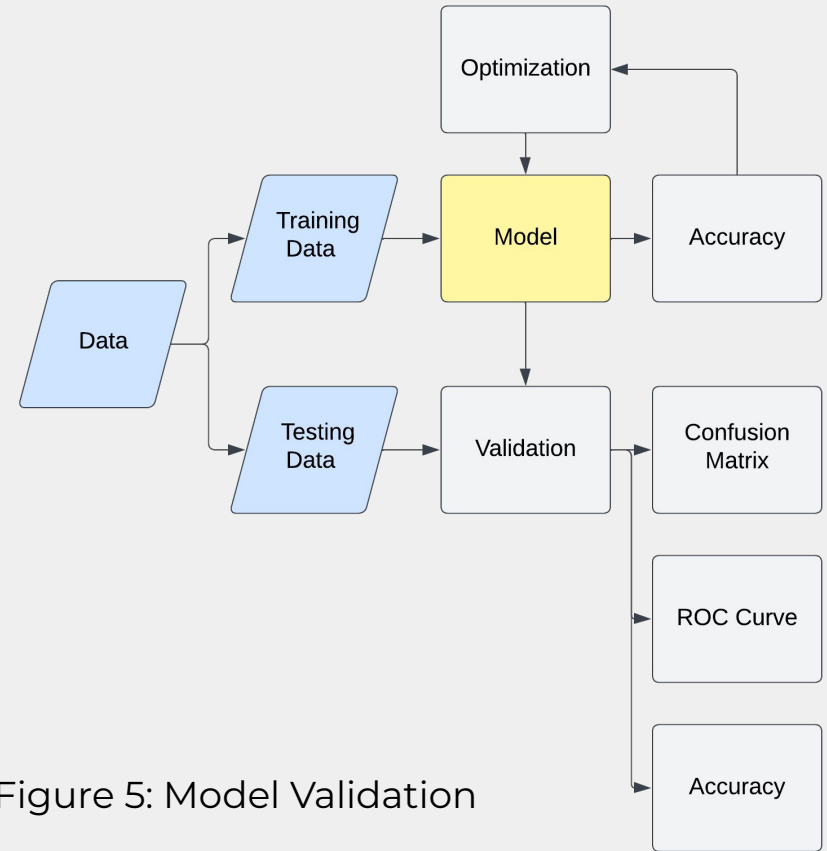- 7:3 training-validation split

Figure 5: Model Validation

PDS–Model Validation

- Baseline/final model
- 7:3 training-validation split

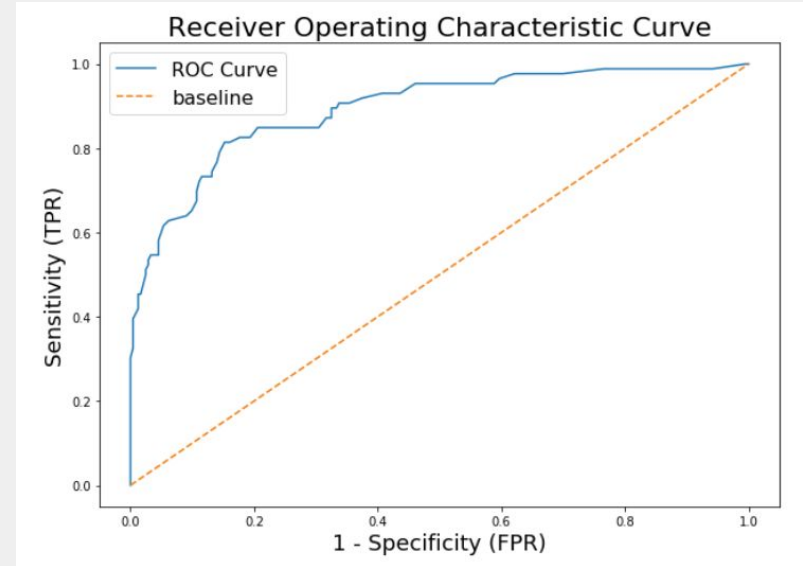| Confusion Matrix		
	Actually Positive	Actually Negative
Predicted Positive	True Positive	False Positive
Predicted Negative	False Negative	True Negative

Table 1: Sample Confusion Matrix

Figure 6: Sample ROC Curve [5]

PDS–Standards

- Human Data collection
  - 21 CFR 56.102
- De-identification, Data Usage, Patient Safety
  - 45 CFR 164.514

Design Matrix Criteria

- Accuracy/safety
- Processing speed
- Build complexity
- Compactness
- Scalability

Baseline Algorithm Design Matrix

	Baseline Model				
	Support Vector Machine	Import Vector Machine	Random Forest	K - Nearest Neighbor	Weights
Accuracy/Safety	14	16	16	18	20
Processing Speed	10.5	13.5	9	10.5	15
Building Complexity	8	7	5	9	10
Compactness	7	8	6	8	10
Scalability	7.5	12	9	12	15
Sum	67.14%	80.71%	64.29%	82.14%	70

Table 2: Baseline Algorithm Design Matrix

Final Model Design Matrix

	Final Model					
	ResNet-50	VGG-19	DNN	CNN	U-net	Weights
Accuracy/Safety	18	18	18	16	16	20
Processing Speed	7.5	10.5	9	10.5	10.5	15
Building Complexity	7	7	4	6	6	10
Compactness	6	7	6	7	7	10
Scalability	10.5	9	12	10.5	10.5	15
Sum	70.00%	73.57%	70.00%	71.43%	71.43%	70

Table 3: Final Algorithm Design Matrix

Future Work

- Splitting our work into three groups

- Will get access to data once client confirms our eligibility.

- Begin training and testing once data comes through

  - Splitting data into a 7:3 ratio (70% training, 30% testing)

  - If no access to images at the time, we will use "dummy data"

  - Data remains consistent across both models

- Create a frontend interface for ease of use for the client.

Reference

1. "Sjögren's syndrome," National Institute of Arthritis and Musculoskeletal and Skin Diseases, https://www.niams.nih.gov/health-topics/sjogrens-syndrome/basics/symptoms-causes (accessed Oct. 5, 2023).
2. M. Nohr, "Sjogren's syndrome: Symptoms, causes, and natural support strategies," DrJockers.com, https://drjockers.com/sjogrens-syndrome/ (accessed Oct. 5, 2023).
3. "Iowa head and Neck Protocols," Lip Biopsy for Sjogren's Syndrome (Minor Salivary Gland Biopsy) Using Chalazion Clamp | Iowa Head and Neck Protocols, https://medicine.uiowa.edu/iowaprotocols/lip-biopsy-sjogrens-syndrome-minor-salivary-gland-biopsy-using-chalazion-clamp (accessed Oct. 5, 2023).
4. V. Fana, U. M. Dohn, S. Krabbe, and L. Terslev, "Application of the omeract grey-scale ultrasound scoring system for salivary glands in a single-centre cohort of patients with suspected Sjögren's syndrome," RMD Open, vol. 7, no. 2, 2021. doi:10.1136/rmdopen-2020-001516
5. A. P. Chazhoor, "ROC curve in Machine Learning," Medium, https://towardsdatascience.com/roc-curve-in-machine-learning-fea29b14d133 (accessed Oct. 4, 2023).