



Snap, Crackle, Pop: Joint Sounds in JIA

Investigating Acoustic Emissions from the Joints as a Biomarker for JIA

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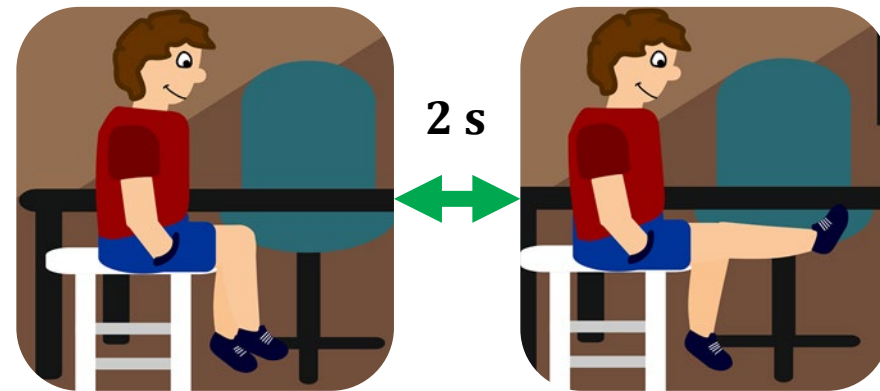
JAMS Enrollment – Emory and CHoA

- Children 6-18 years old
- 3 Groups:
 - Active JIA
 - JIA Post-Treatment (minimum 6 weeks)
 - Healthy Controls

Group:	# Enrolled:	Age (years):	Male	Female
JIA	25	12.23 ± 3.1	5	20
JIA Follow-up	12	12.91 ± 2.7	1	11
Healthy Controls	18	12.50 ± 3.2	3	15

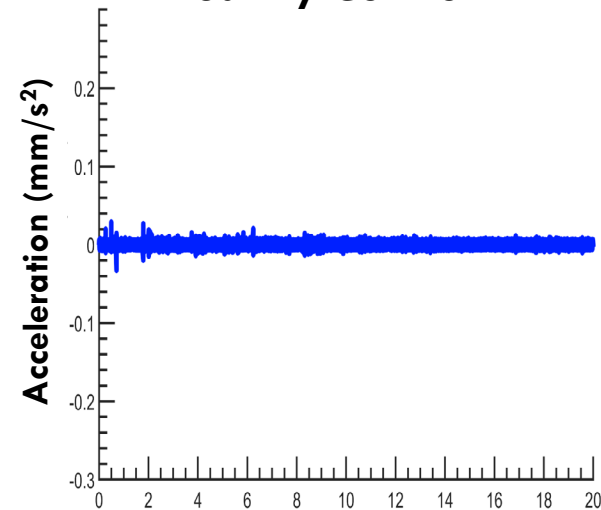
Method

- We attach two contact microphones and an IMU onto each knee.
- The patient flexes/extends their leg 10 times.
- Recorded sounds are analyzed for patterns that could:
 - Differentiate JIA from HCs
 - Monitor progression of JIA

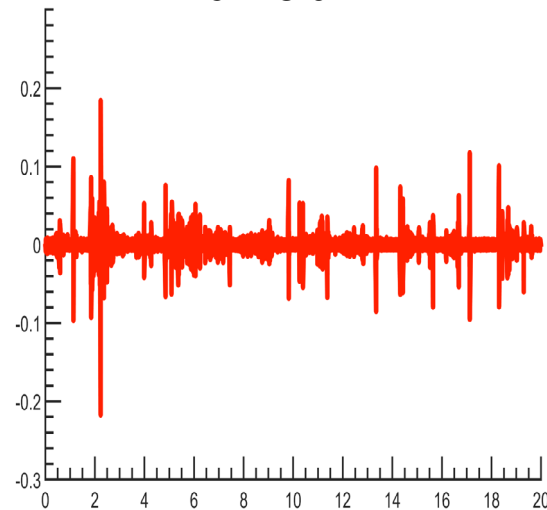


Example Sound Recordings

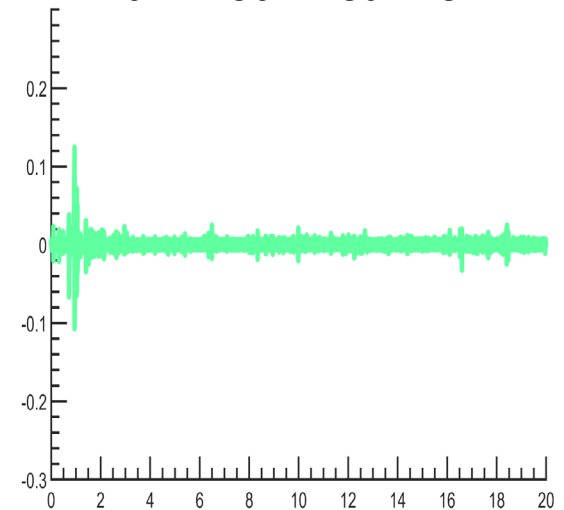
Healthy Control



Active JIA



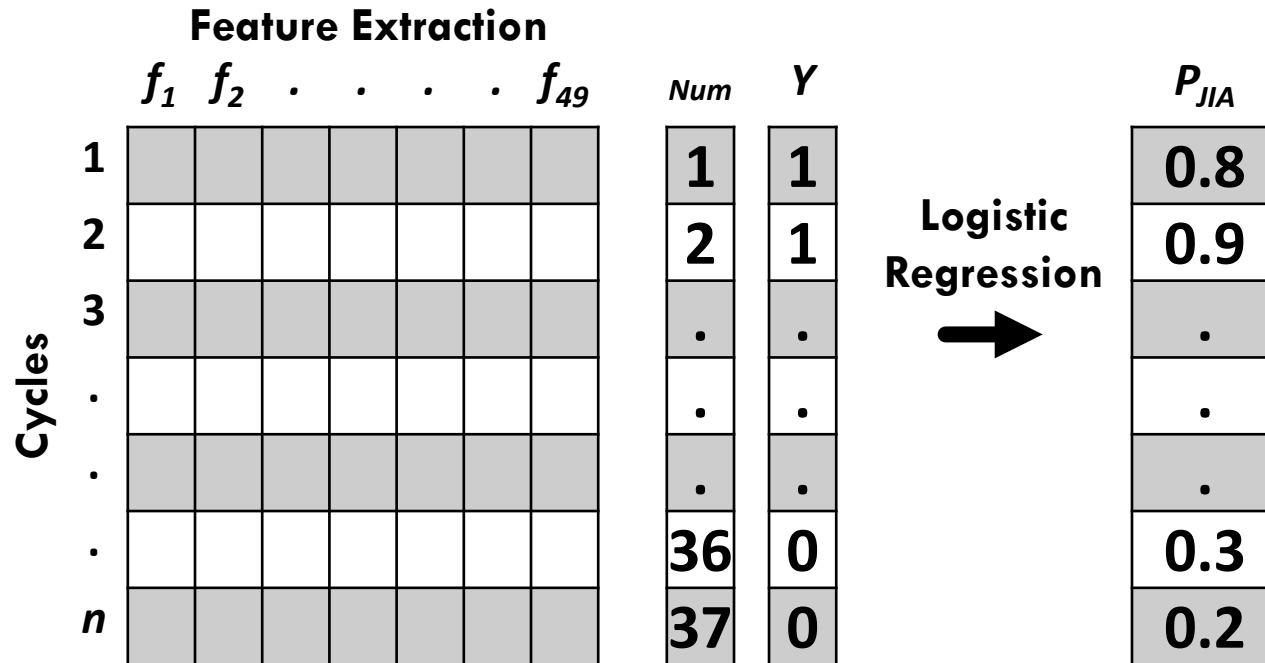
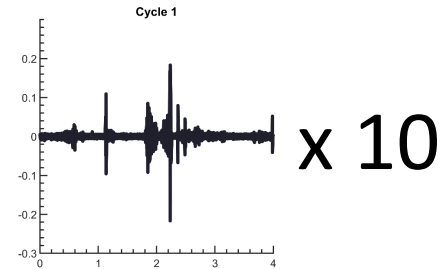
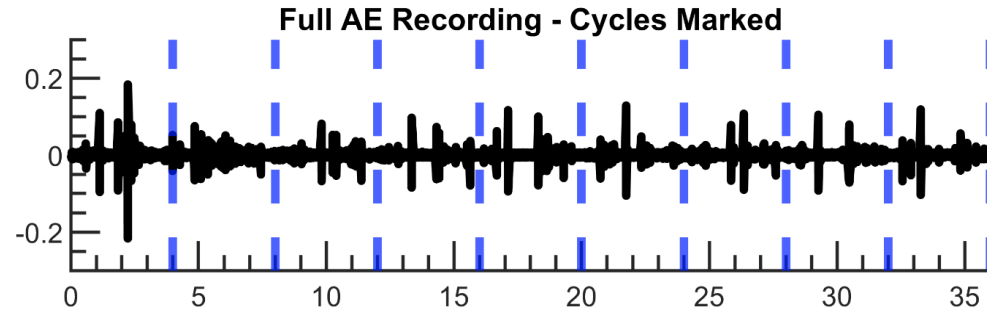
JIA Post-Treatment



Time (s)

Representative time domain AE signals of four FE repetitions. Healthy controls (HC) have virtually no sounds, JIA patient have repetitive click with a more heterogenous signal, and the follow-up returns toward healthy.

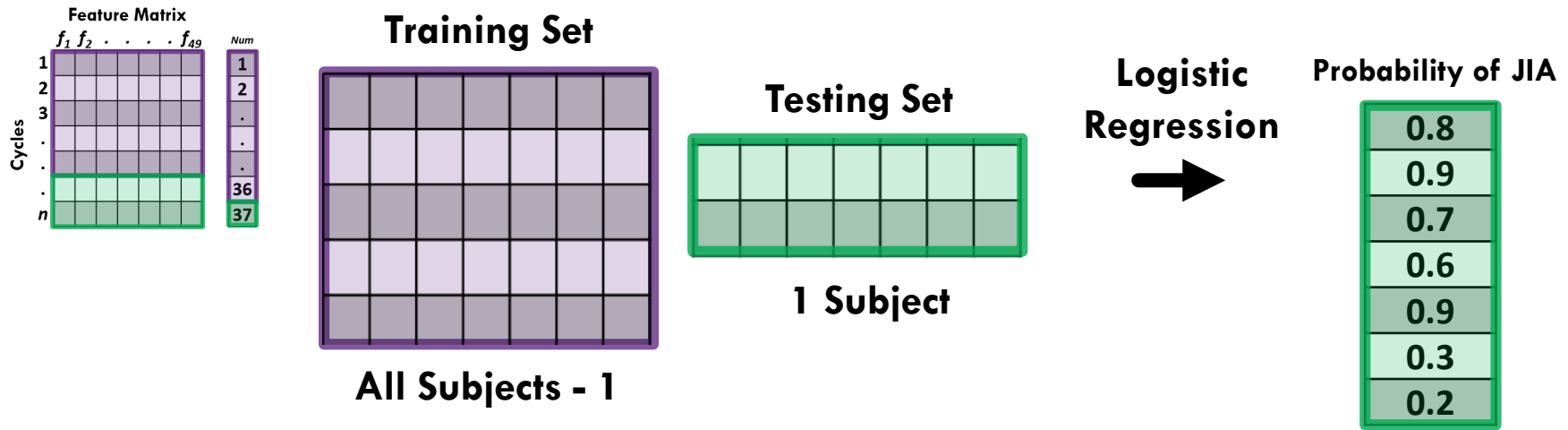
Signal Analysis



Feature Matrix = feature per cycle, Num = subject numbers, Y = ground truth JIA status

P_{JIA} = Probability Estimate of JIA

LOSO-CV Accuracy Calculation



Repeat for each subject . . .

$$Accuracy = \frac{\text{Cycles Labeled Correctly}}{\text{Total Cycles}}$$

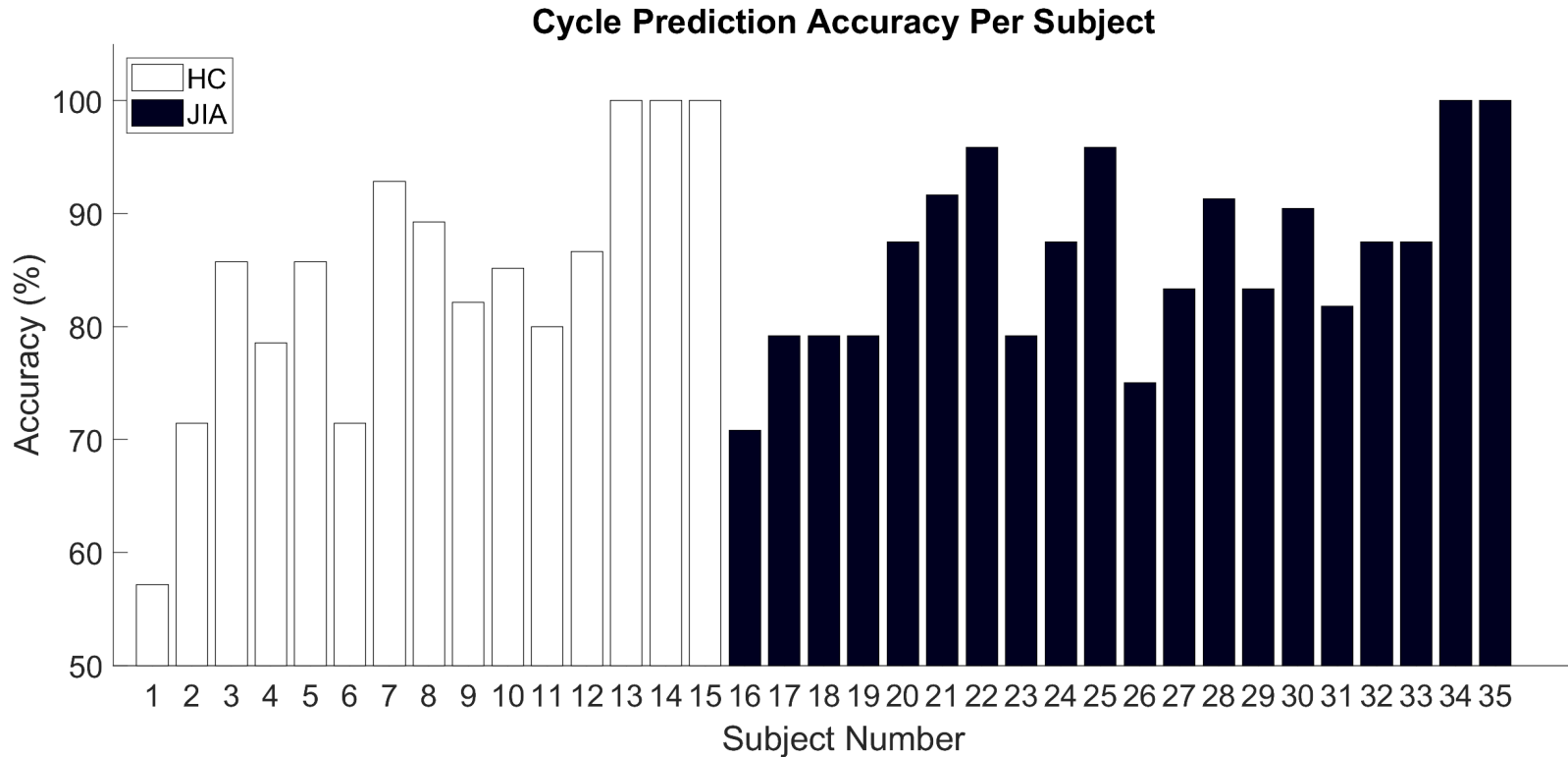
$$Knee Health Score = \frac{\sum \text{Probabilities}}{\# \text{ of Cycles}}$$

JIA if Knee Health Score > 0.5

or

Healthy if Knee Health Score ≤ 0.5

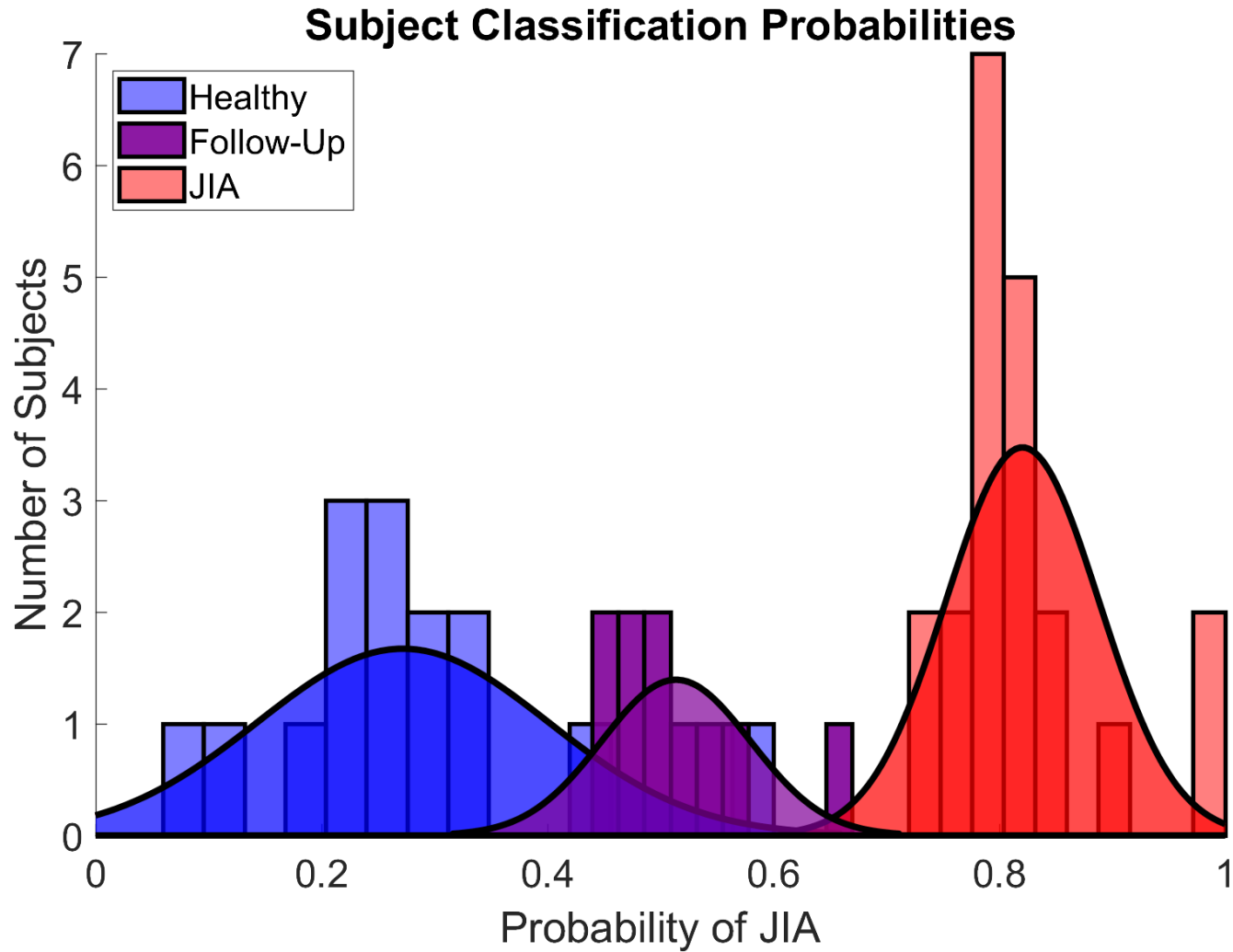
Cycle Prediction Accuracy Per Subject



Most subjects had >70% cycle labeling accuracy.

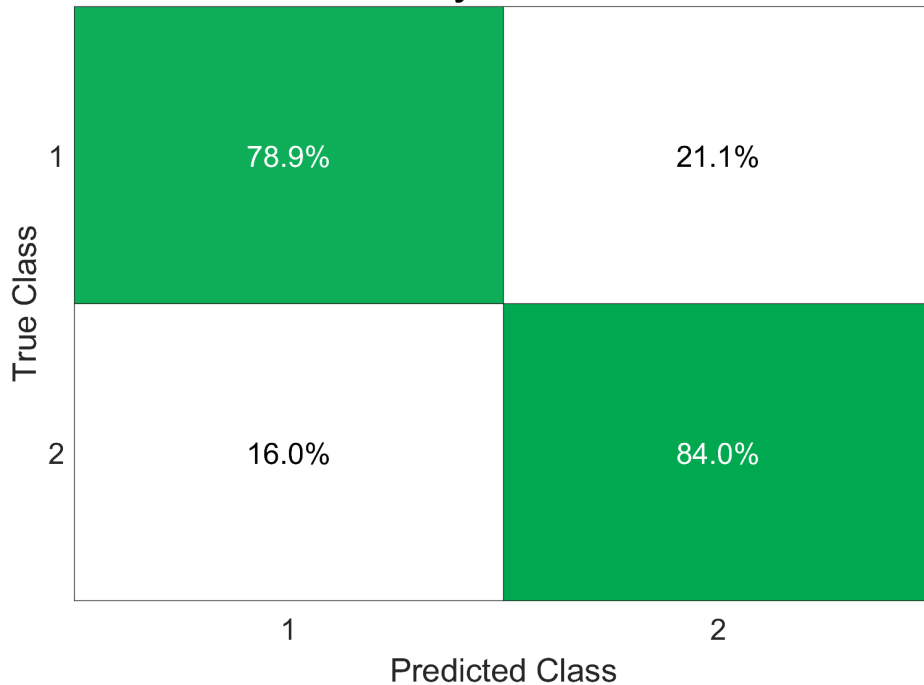
Overall Accuracy = 81.7%

Subject Knee Scores Distribution

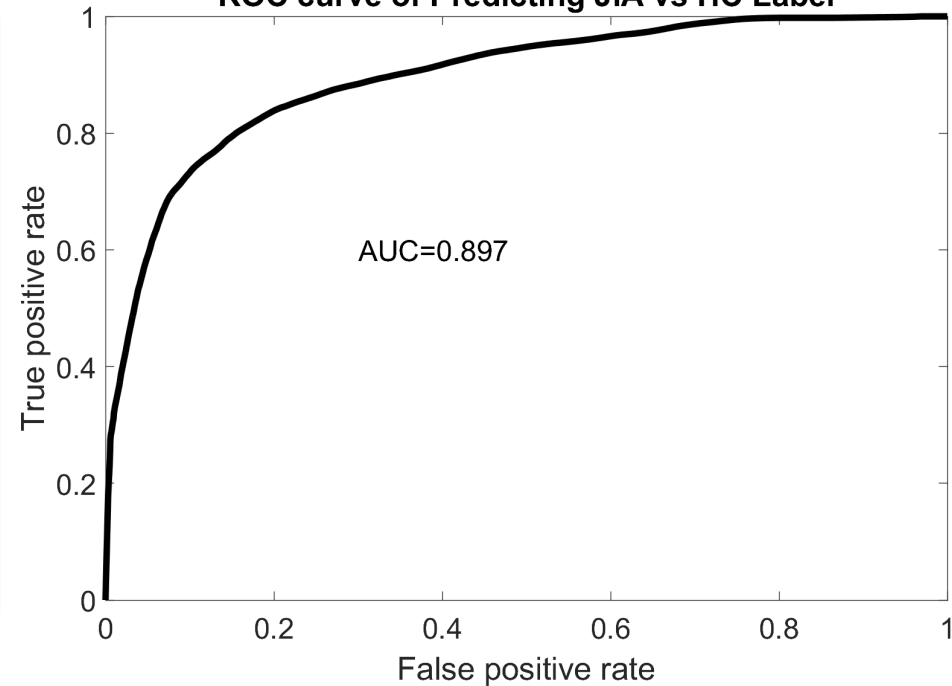


Model Classification Performance

HC vs JIA Cycle Classification



ROC curve of Predicting JIA vs HC Label

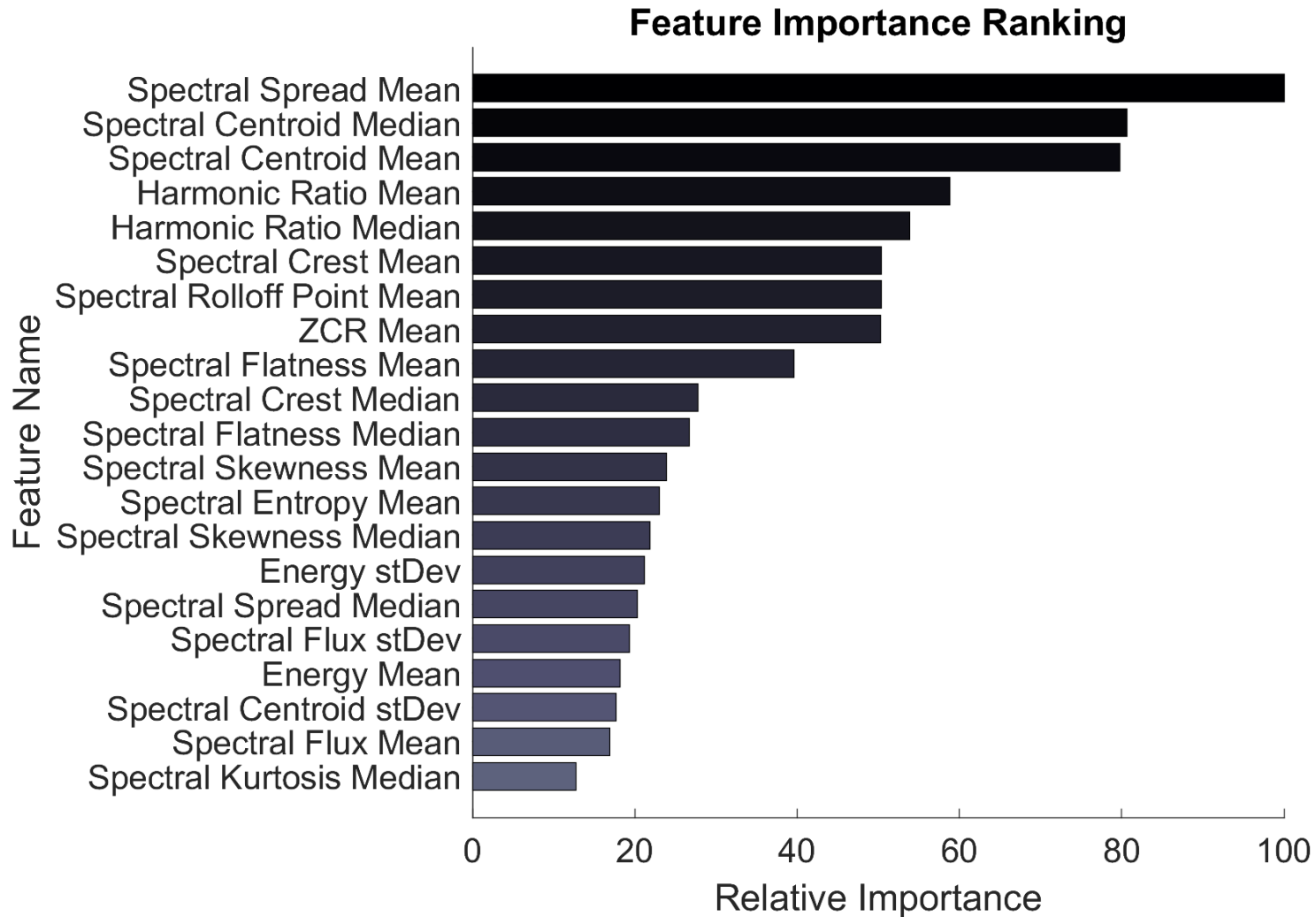


Specificity = 78.9%

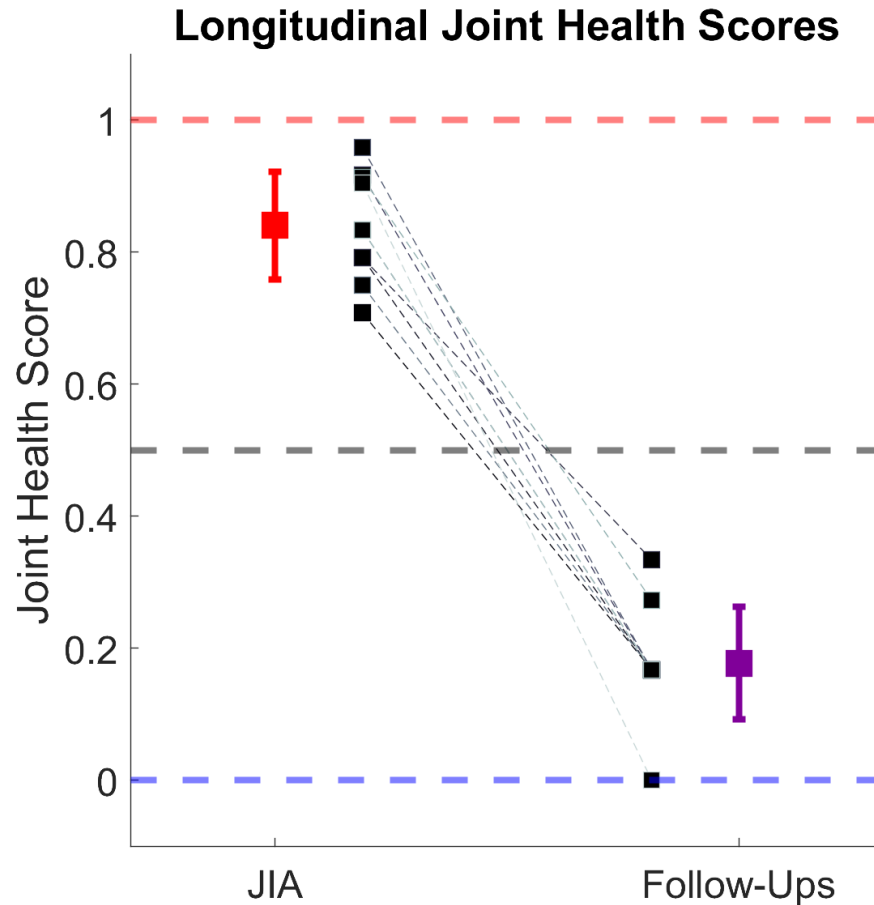
Sensitivity = 84.0%

ROC - Area Under Curve = 89.7%

Feature Importance



Tracking the Follow-ups



**All but one of the follow-ups showed improvement in their joint health score.
The outlier also did not show clinical improvement at 2nd visit.**

Conclusions

- **Joint sounds show promise for screening, diagnosing, and tracking JIA.**
- **We should continue recruitment efforts to ensure this model generalizes.**
- **The feature selection and number of cycles recorded both impact the accuracy of joint sound analysis.**



**Thanks,
Questions?**

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