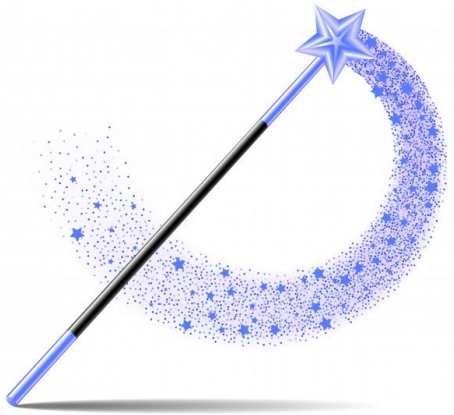


Optimizing Feature Sets for Gesture Recognition

Minimizing Model Size for the Arduino Nano 33 BLE Sense

Brad Voracek

9th grade software development

Phoenix Coding Academy

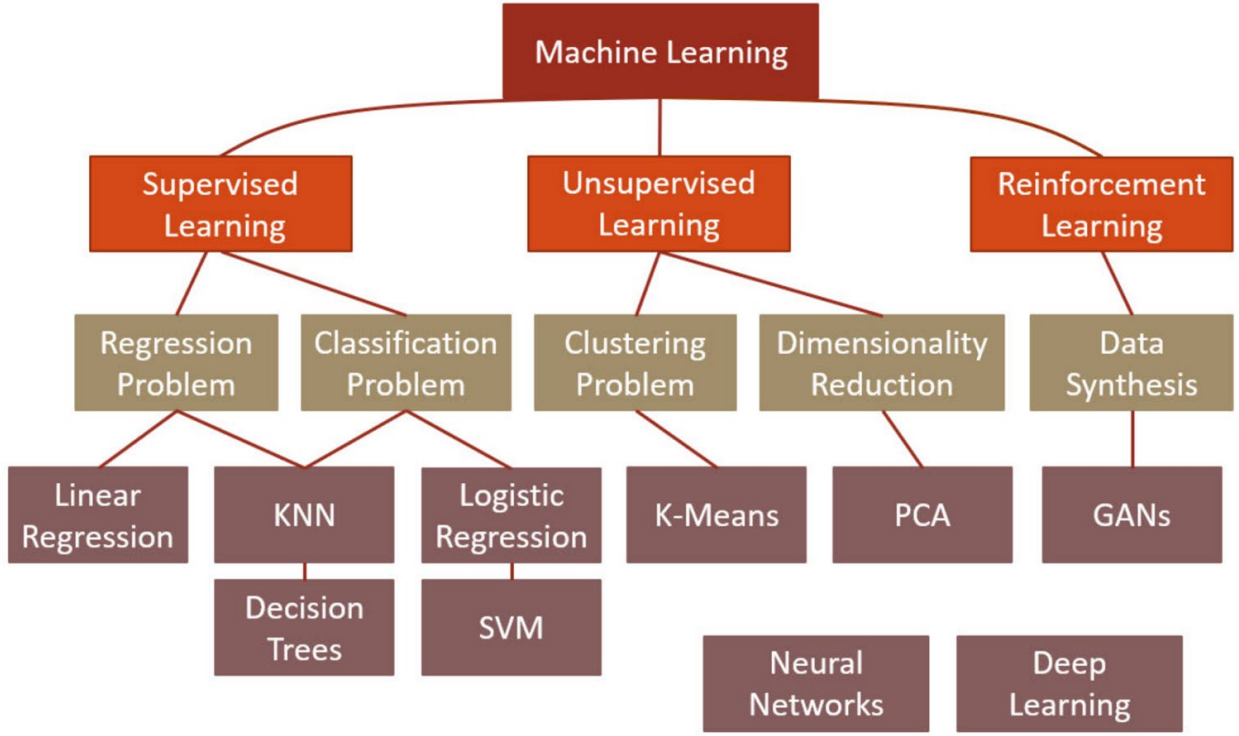
Mentors: Michael Stanley, Andreas Spanias

NSF Award 1953745

https://sensip.engineering.asu.edu/ret/

Introduction

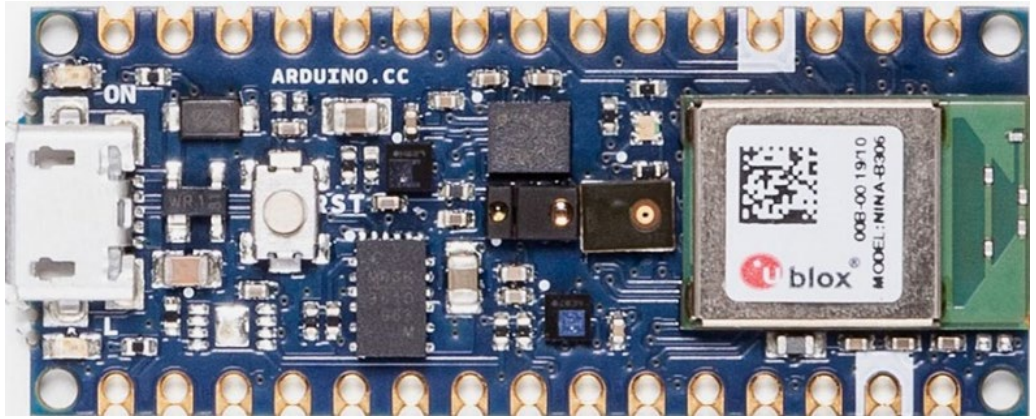
- The RET project exposed us to various machine learning techniques
- They helped us understand these techniques to apply them to a small research project
- We learned basics so that we could implement a lesson about an aspect of them in our classrooms
- The RET experience is a great way to help teachers expose students to cutting edge research and technology



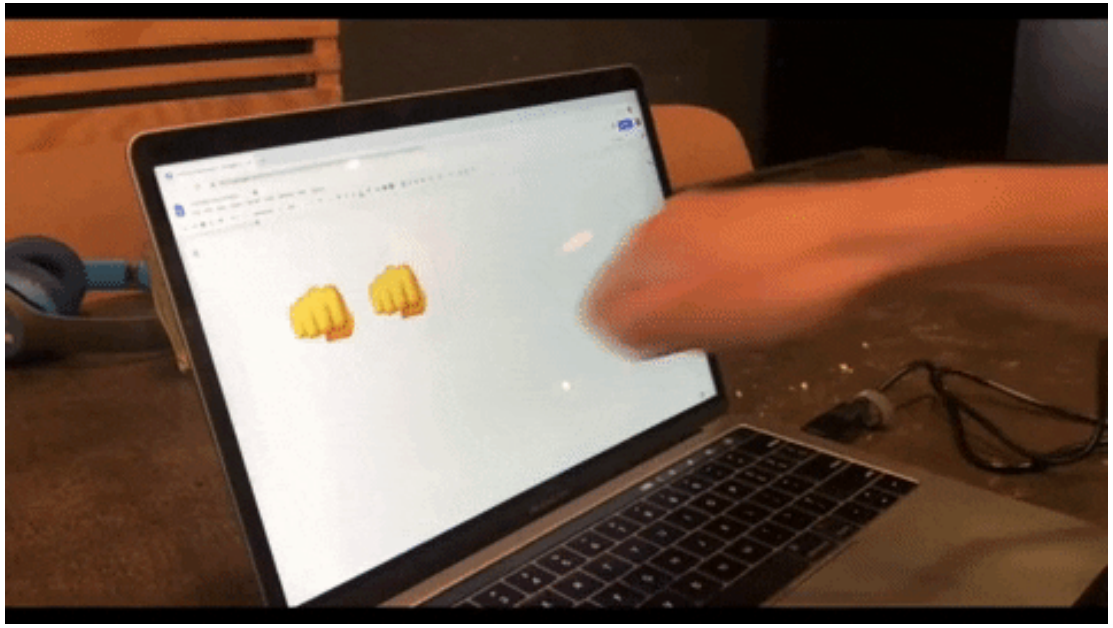
ML Overview by Kristen!

Research Project

- I chose to use the Arduino Nano 33 BLE sense for its capabilities at running TinyML and collecting data
- Gesture recognition “magic wand” is a beginner example, and I wanted to focus my research around it
- Decided to do a feature study to try and minimize the model size while maintaining accuracy
- This led me to learn different techniques for determining the most predictive features, and gave an authentic research experience



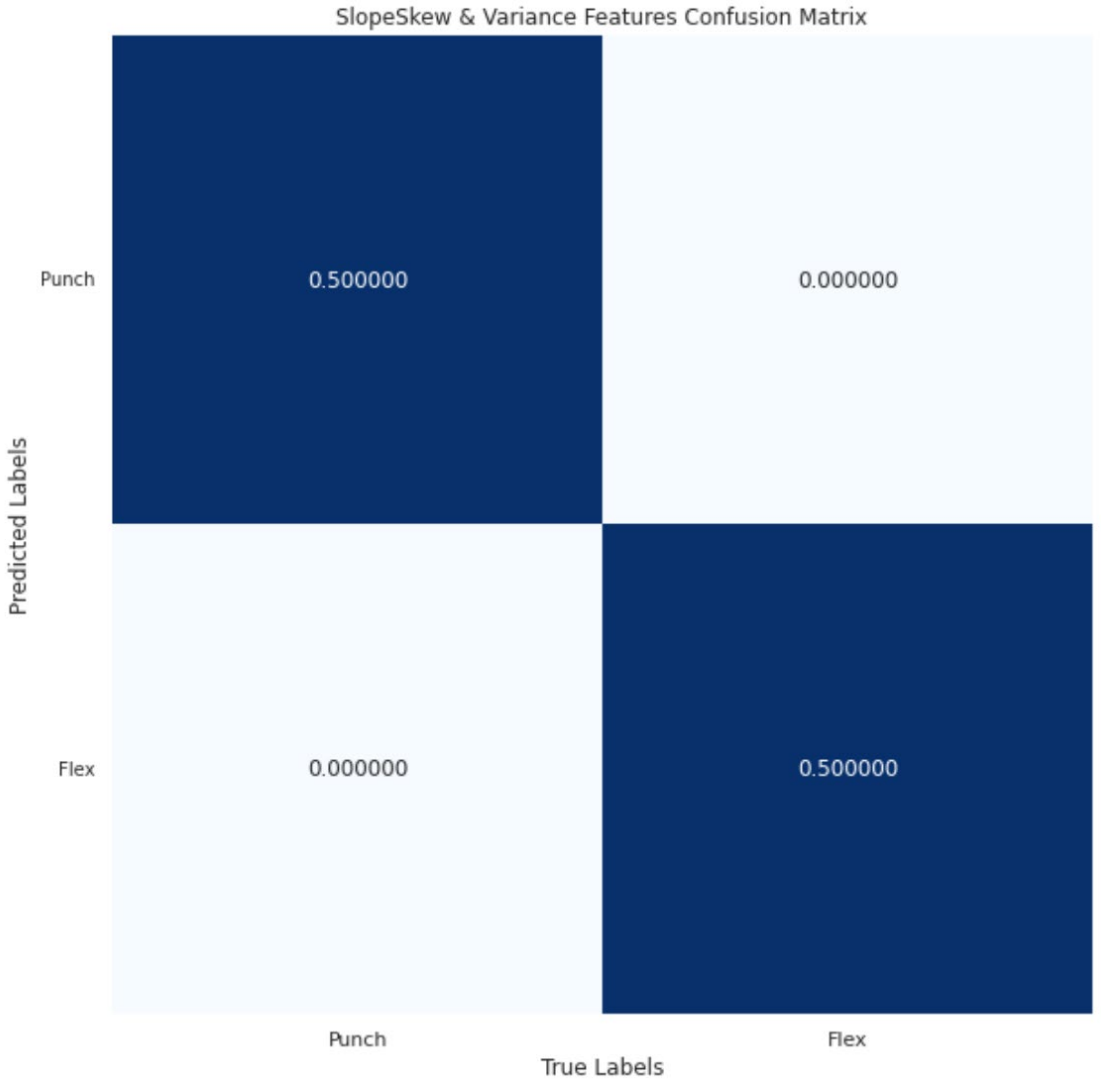
Arduino Nano 33 BLE Sense Board



Recognizing the ‘punch’ gesture

Research Project

- I first collected my own samples to use for this project, 50 ‘punch’ and 50 ‘flex’ data points
- I chose to use the xyz accelerometer data, and the xyz gyroscope data to make predictions
- The gesture recognition example uses the keras sequential algorithm from TensorFlow
- I generated different statistical features about my data to try and minimize model size



Confusion matrix from one model

Research Project

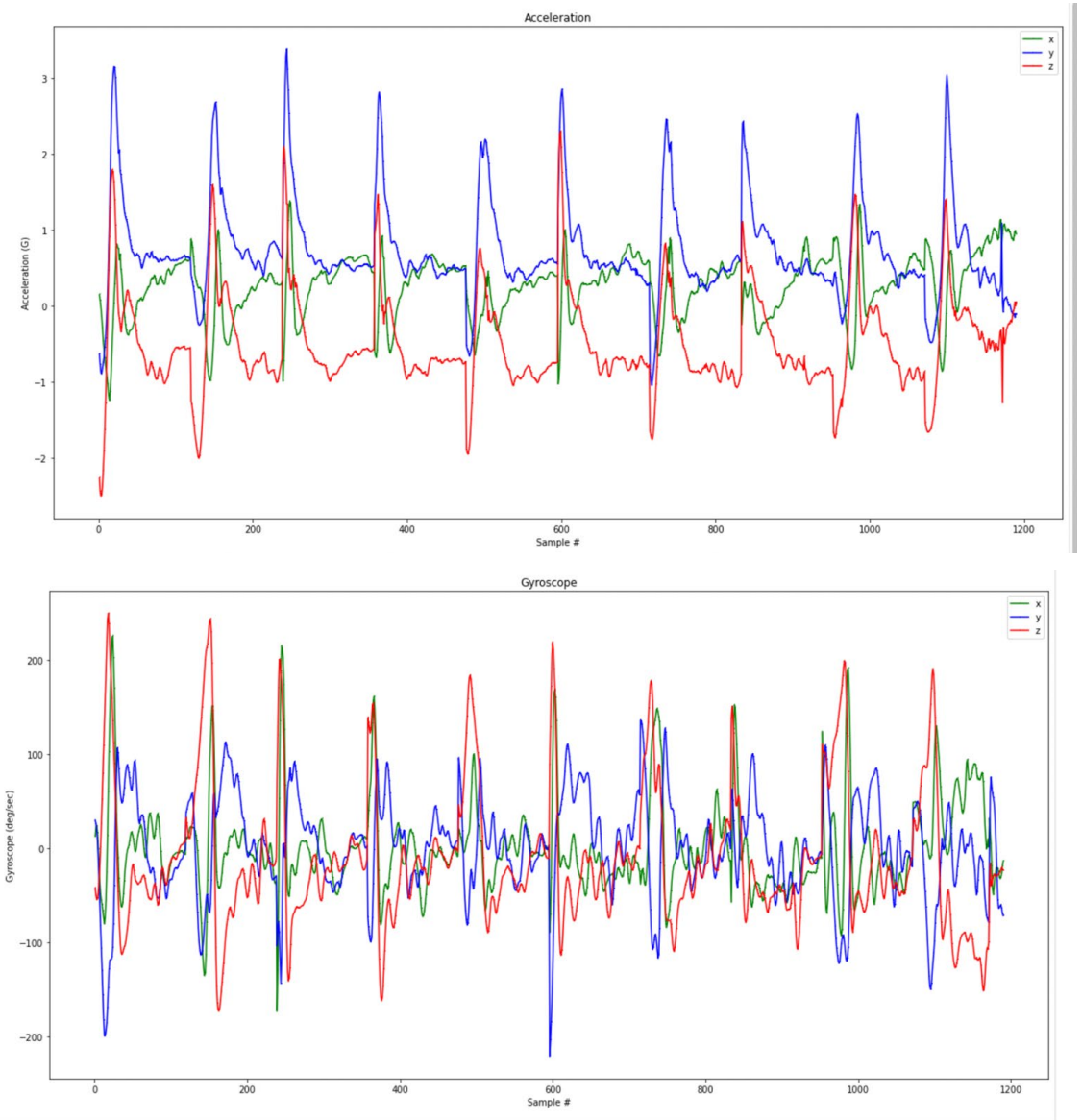
- The baseline to beat was using all 119 raw data points to make predictions, which gives a perfectly accurate model at 911kB of model size.
- Sampling 1/10 of the raw data still gave perfect accuracy with only 112kB of data
- Purely statistical features didn't add much, but I decided the slope made sense to research further, and found that the skew of slope was very predictive
- My best model was still perfect accuracy at 45kB of data using this and variance

Model Name	Model Size	Accuracy	Misclasifications
Features & Raw Data	8,249,802	1	0
Raw Data Only	911,468	1	0
Delta raw data	911,468	1	0
Delta Features	149,268	0.9	2
1/10 Raw Data	112,268	1	0
Features Only	90,068	0.95	1
42 Selected Features	82,668	0.95	1
1/20 Raw Data	75,268	0.95	1
1/20 Slope Data	75,268	1	0
Hybrid	60,468	1	0
22/42 Selected	58,002	0.9	2
Max & Var & SlopeSkev	53,068	1	0
Max & Var	45,668	0.85	3
Var & SlopeSkew	45,668	1	0
Slope Min/Max	45,446	0.9	2
Top 10 Slope Features	43,202	0.8	4
Top 3 Overall Features	34,568	0.95	1
Top 3 Skew Features	34,568	0.85	3
gYSlopeSkew	32,102	0.9	2

Summary Results

Lesson Plan

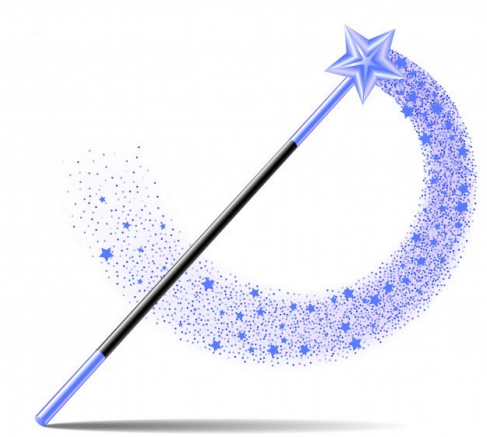
- I teach 9th grade so the concept of machine learning being based on pattern recognition in data is where I focused my lesson.
- Students will collect sample data of their own gestures, and then this data will be randomized and distributed to teams of students
- Teams will work together to identify patterns in data, and classify which gesture each sample represents
- Students “acting as the algorithm” learn a key concept of machine learning



Data generated from 10 punches

Conclusion

- Thanks to Kristen Jaskie, Michael Stanley, Jean Larsen, Andreas Spanias, and others I had a great summer research experience
- I believe that this experience helped demystify machine learning for myself and will help me teach it to my students
- Some feedback for the program would be to clearly define research projects before students come in, as 1 month is very little time to do authentic research
- Thank you!



https://sensip.engineering.asu.edu/ret/