SensiML - Boxing PoC

In boxing, if you don't know to punch properly, strength and power won't do you any good. Before you can become the next Muhammad Ali, you need to master the basics. The power behind each punch comes from practice and repetition. It is important to learn the technique for each punch before you can execute them safely and effectively in the ring.

In this project, we are helping boxers to improve their punching techniques. The SensiML boxing model detects specific boxing punches (gestures) with a wearable device and advise boxers in real-time of proper punching technique by using a low-power sensing wearable incorporated into a typical punching glove as shown. Thus, boxers can compare their punches with the ideal punching technique.

Boxing Punches

Here are the four fundamental boxing punches that coaches believe every boxer needs to know.

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	Jab: A quick, straight punch thrown with the lead hand from the guard position. The jab extends from the side of the torso and typically does not pass in front of it.
	Hook: A semi-circular punch thrown with the lead hand to the side of the opponent's head. From the guard position, the elbow is drawn back with a horizontal fist (knuckles pointing forward) and the elbow bent.
	Uppercut: A vertical, rising punch thrown with the rear hand. From the guard position, the torso shifts slightly to the right, the rear hand drops below the level of the opponent's chest and the knees are bent slightly.
	Overhand: The overhand right has a looping circular arc as it is thrown over-the-shoulder with the palm facing away from the boxer.

Orientation of the sensors

We've collected example data sets with Chilkat EOS™ S3AI Hardware Development Kit. Click here to download the boxing demo project.

Sensor orientation is important. The goal is to maximize usable signals while locating it on a stable surface. Also, it is important to train the model and test it with the same orientation. In this project, we placed the Chilkat device on the right-hand boxing glove to collect punching data. It is built into the outside of the boxing glove at the midway vertically on the glove and close to the wrist. The picture on the right shows the orientation of the sensor.

Signal Characteristics of the Punches

Each boxing punch has its own signal signature as shown in the figure given below. SensiML transfers these signals to feature space and finds the features that maximize the differences between the boxing punches. These selected features are used to build the model.

Overhand
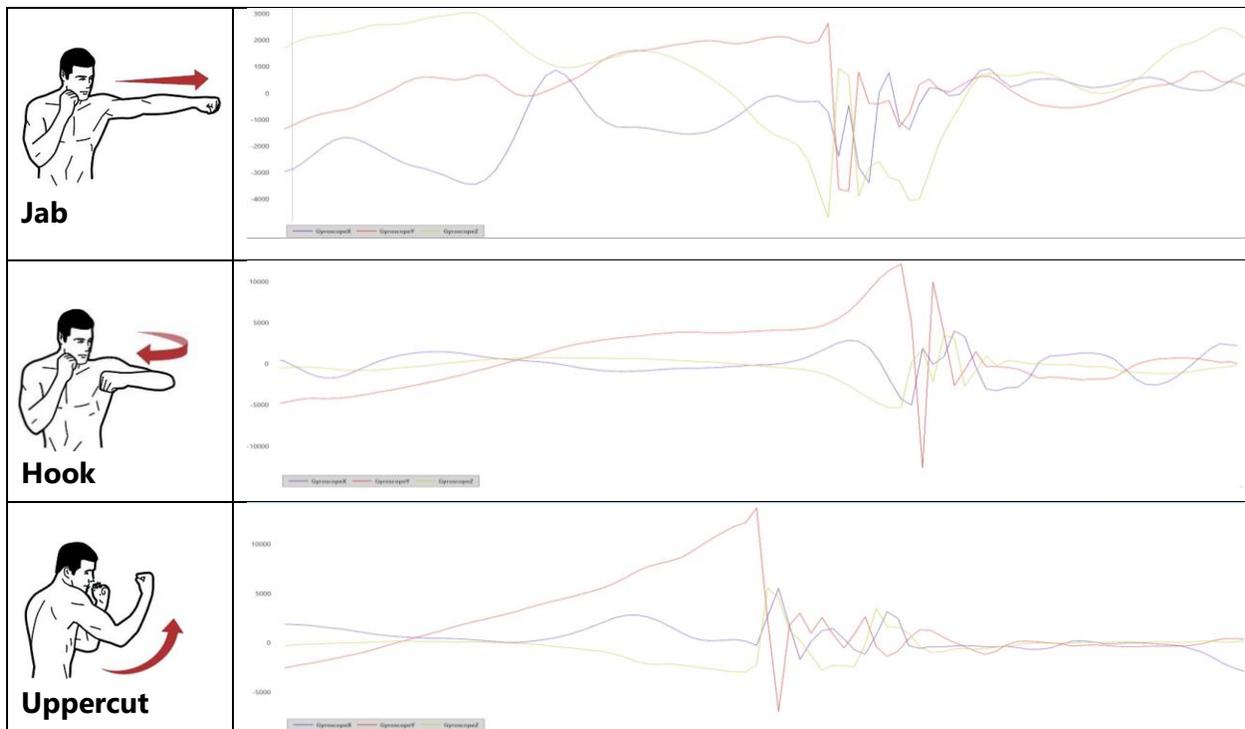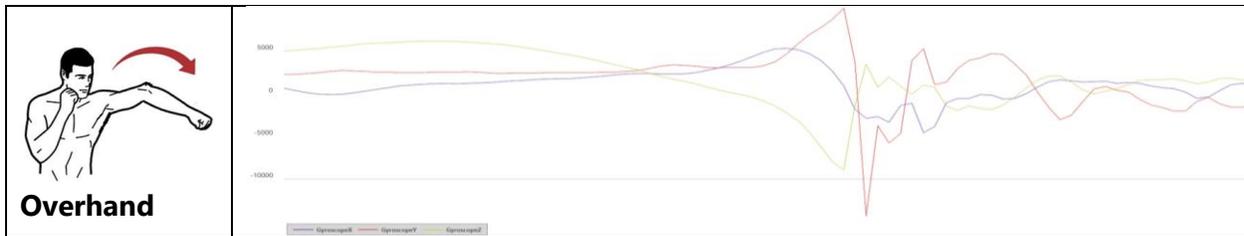
Smart Edge AI Test Plan

Creating a plan before you start your project is a very useful practice. This will help you avoid collecting unnecessary data. In your test plan, always address the items given below.

- Document model insight goals upfront
    - List out discrete classes or regression outputs sought
    - Means for determining ground truth (if not obvious)
    - Desired follow-on insights (collect now or wait for later)
- Enumerate all sources of variance, desired or otherwise
    - Plan to capture all potentially desired variance sources as metadata
    - Consider how to control, reduce, or eliminate undesired variance (ex. bias from different data collector technicians and methods)
- Consider sensor selection, configuration, placement carefully
    - Goal is to maximize usable signal. (Get close to source, signal gain just shy of clipping, shield EMI/RF on analog)
    - Sample rates: If in doubt, go higher. (Much easier to downsample than add back missing data)

Excerpt of Test Plan for the SensiML Boxing Demo is given below

Smart Edge AI Test Plan: *Boxing Punch Detection Wearable*				
Revision: *1.0*	**Last Revised:** *12/15/2019*		**By:** *SensiML AE Team*	
Application Summary: *Motion classification for recognition of boxing punches from glove-mounted 3-axis accelerometer and 3-axis gyro sensor device.*				
SensiML Test Plan Template 1.0, ©2020 SensiML Corporation				
Desired Inference Classifications				
Categorical Variable *(SensiML Event Group)*	Class 1 *(SensiML Event 1)*	Class 2 *(SensiML Event 2)*	Class 3 *(SensiML Event 3)*	Class 4 *(SensiML Event 4)*
Must Include				
Boxing Punch	*Jab*	*Hook*	*Uppercut*	*Overhand*
Should Include				
Boxing Impact	*Knockout Punch*	*Solid Connect*	*Glancing Blow*	*Miss*
May Include				
Boxing Stance	*Upright*	*Semi-crouch*	*Full Crouch*	

Future Classes				
Boxing Defense	Bob	Block	Clinch	Cover-Up

Intended Variance				
Metadata Variable	Metadata Value 1	Metadata Value 2	Metadata Value 3	Metadata Value n
Annotated Metadata				
Subject ID	Unique User ID#			
Device ID	Unique Device ID#			
Gender	Male	Female		
Experience	Expert	Intermediate	Novice	
Dominant Hand	Left-Handed	Right-Handed	Ambidextrous	
Calculated Metadata				
Subject Height	Height (inches)			
Subject Weight	Weight (lbs)			

Unintended Variance				
Metadata Variable	Metadata Value 1	Metadata Value 2	Metadata Value 3	Metadata Value n
Annotated Metadata				
Test Technician	Technician ID#			
Collection Date	m/d/y h:m			
Calculated Metadata				

Sensor Inputs				
Sensor	Sample Rate	Full Scale Range	Type (Digital, ADC)	Notes
6DoF IMU (Accel/Gyro)	100 Hz	+/-2G, +/- 2000 dps	Digital	QuickLogic Chilkat EVB (on-board sensors)