Time's Up for the Myo?

The Smartwatch as an Alternative for Audio Gestural Analyses

Wearable gestural sensors have proved integral components of many past NIMEs [7, 8, 12, 15]. Previous implementations have typically made use of specialist, IMU and EMG based gestural technologies. Few have proved, singularly, as popular as the Myo armband.

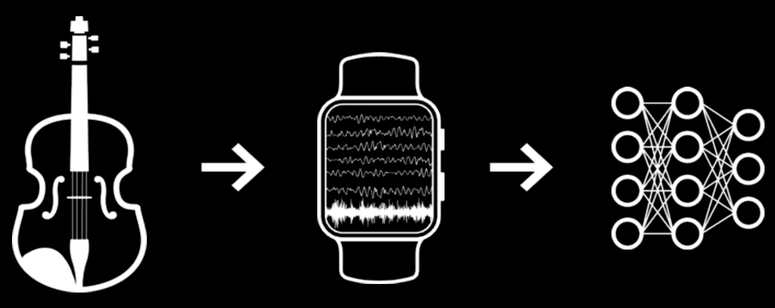
An informal review of the NIME archives found that the Myo has featured in 21 NIME publications, since an initial declaration of the Myo's promise as "a new standard controller in the NIME community" by **Nyomen et al.** in 2015 [10].

Following discontinuation of the Myo, we investigate the promise of the smartwatch as an audio-gestural tool.

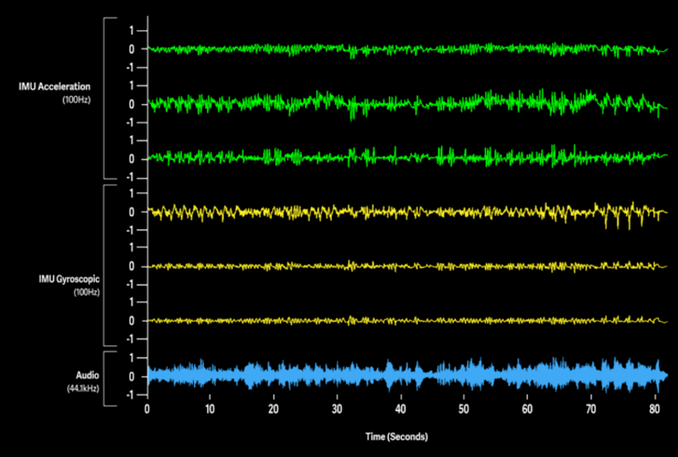
A purpose-built recording application was developed for the Apple Watch, based upon Logger7 by GitHub user Shakshi3104

The application - VioLogger - logs IMU (SR: 100Hz) and Audio (SR: 44.1kHz) data concurrently.

A sample recording is depicted adjacent.



Apple Watch IMU-Audio sample recording of Bach's Cello 78 Suite No.1 in G Major, Prélude



Comparison Methodology

Prior studies have assessed the utility of forearm-IMU technologies for the purposes of violin performance classification:

Sarasúa et al. [13] reported high classification accuracies when using the Myo to identify a range of bow articulation conditions within performed material, through the use of an HMM based classifier.

The authors found that the inclusion of EMG data increased early gestural recognition rates, but decreased over- all gestural recognition rates when compared to classification upon lone IMU data.

Dalmazzo et al. [5] compared the utility the Myo with an optoelectric system. The authors reported marginally higher classification accuracies through use of the Myo alongside a J48 Decision tree algorithm

Noting a disparity in cost between the two implemented technologies, the authors concluded: "this result shows that it is possible to develop music-gesture learning applications based on low-cost technology which can be used in home environments for self-learning practitioners" [5].

Auepanwiriyakul et al. [1] assessed the utility of the Apple Watch for the purposes of hospital inpatient monitoring, comparing these to a "gold standard" optoelectronic Opti-Track system, in addition to a number of specialist IMU sensors.

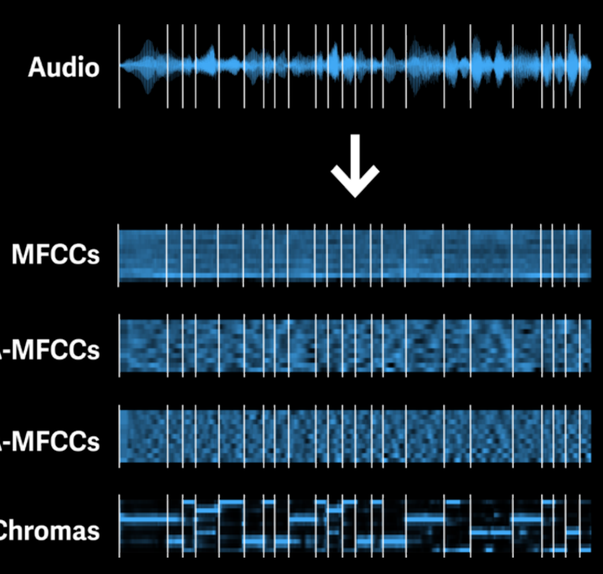
The authors concluded that "with relatively few drawbacks, consumer-grade smartwatches can be objectively used within a clinical- and research-grade setting"

Such approaches informed our assessment of VioLogger as an alternative to the Myo.

Six violinists were recorded performing two-octave G and D major scales, chosen with the intention to capture a comprehensive range of both the violin's typical performance register, and movement along the four strings. Participants were required to play each note twice, such that both an up-bow and a down-bow were captured on each note. Each bow-stroke one beat in duration, at a tempo of 110BPM. Each scale was performed in two bow-articulation techniques; Spiccato and Legato. Three takes of each exercise were recorded.

Participants were recorded using both a Myo and VioLogger simultaneously, in addition to a freestanding microphone.

Concurrent signals were first trimmed, and then segmented into series of individual bow-strokes through use of the madmom audio onset-detector.



Features were derived from the audio data. For each segment of audio data, sequential arrays of **MFCCs, Delta-MFCCs, Delta-Delta-MFCCs,** and **Chroma** coefficients were calculated, depicting both timbral and pitch characteristics of each note, while preserving temporality.

Three bow-stroke classification tasks were completed through use of an MLP neural network:

Participant Identification:
segmented bow-strokes were classified by performer.

Bow Articulation:
segmented bowstrokes were classified as being either Spiccato or Legato.

Scale Belonging:
segmented bow-strokes were classified as having occurred in either of the recorded scales.

The inclusion of audio-derived MIR features increased classification accuracies markedly, however; data- type combinations wherein MIR features were included averaged 97.71%.

Of the two recording mechanisms, differences between the observed classification accuracies proved negligible. During participant identification, slightly higher classification accuracies were achieved through the use of the watch's combined audio and IMU datatypes.

Classification accuracies were highest in the "Bow Articulation" task, wherein segmented bowstrokes were classified as being either Spiccato or Legato, with a mean accuracy of 97.89%

The lowest accuracies were achieved in the "Scale Belonging" task. In this instance, lone gestural data-types performed poorly, exhibiting accuracies approximating that of random classification.

	Classification Task Test-Accuracies		
Training Data Types	**Participant Identification**	**Bow Articulation**	**Scale Belonging**
Watch IMU	94.79%	97.30%	49.65%
Watch Audio	82.63%	100.0%	96.96%
Watch IMU + Audio	95.54%	100.0%	98.48%
Myo IMU	88.81%	88.61%	50.68%
Myo EMG	90.07%	95.18%	50.98%
DPA Audio	89.45%	100.0%	98.48%
Myo IMU + Myo EMG	91.19%	100.0%	50.99%
Myo IMU + DPA Audio	91.49%	100.0%	95.28%
Myo IMU + Myo EMG + DPA Audio	91.60%	100.0%	99.39%

The detailed results demonstrate the prospective utility of the smartwatch as an alternative to the IMU capabilities of the Myo Armband, although considering the Apple Watch's lack of EMG sensing functionality, it is arguable that a true parallel cannot be drawn. Further considering the native functionalities of each device, the lack of an integrated microphone within the Myo armband necessitates the use of additional hardware for the purposes of audio-gestural analyses.

While the affordability of the Apple Watch may prove debatable, since discontinuation, the Myo may be considered a specialist device; significant technical knowledge was required to facilitate recording, through the circumvention of now-outdated drivers. As the smartwatch may be considered to be comparatively ubiquitous, its utility could help to democratise both the conduction of audio-gestural research and the products thereof.

Remote distribution of VioLogger may allow participants to engage with future works globally, facilitating the development of a larger dataset for the purposes of more comprehensive analyses. While its offline recording mechanism may limit VioLogger's current utility, largely, to analytical ends, the introduction of a real-time data-transfer functionality may prove to facilitate its use as a tool for augmented performance or practice feedback tool.

Wilson, W. Granieri, N., and Ali-MacLachlan, I. 2023