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Are 24 bits too high of a resolution for wearable sEMG devices? What open datasets say

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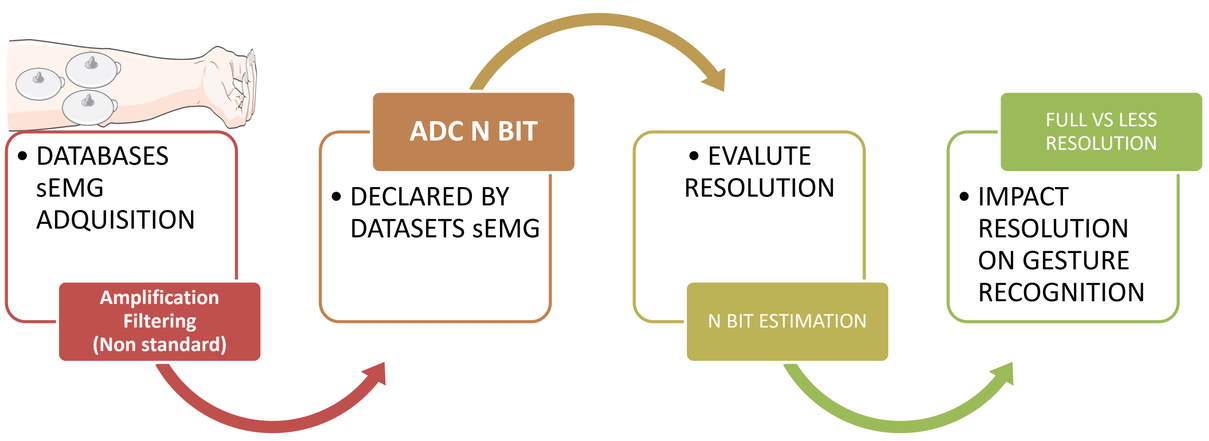
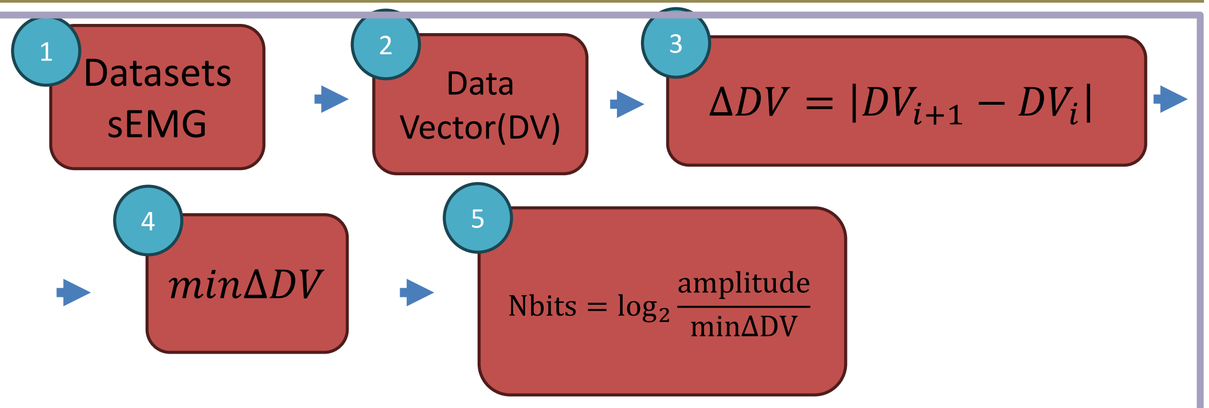
ABSTRACT

The surface electromyography (sEMG) signal is used in the medical field for treating various diseases related to muscular conditions, as well as in other applications such as video games, gesture detection for smart devices, motion pattern recognition, and monitoring muscle activity in athletes[1]. The proper acquisition, processing, and handling of this signal are important for data reliability. There are specialized devices that digitize the sEMG signal, but since there is no established standard resolution, the resolution varies from one device to another. Currently, semiconductor companies are marketing remarkable 24-bit data acquisition chips. This article delves into the real resolution used to develop sEMG-based applications by first investigating the open access sEMG database accuracy and comparing it with the claimed resolution. A methodology is proposed for resolution evaluation. Additionally, hand gesture evaluation was conducted using classification algorithms attempting to ascertain the suitability of using 24-bit versus a lower resolution performance. Preliminary results of hand gesture evaluation demonstrated a better classification when using 24-bit resolution but only for an average accuracy improvement of 1.35% using the 24-bit data resolution. Some of the conditions under which this high resolution may be relevant are identified.



METHOD

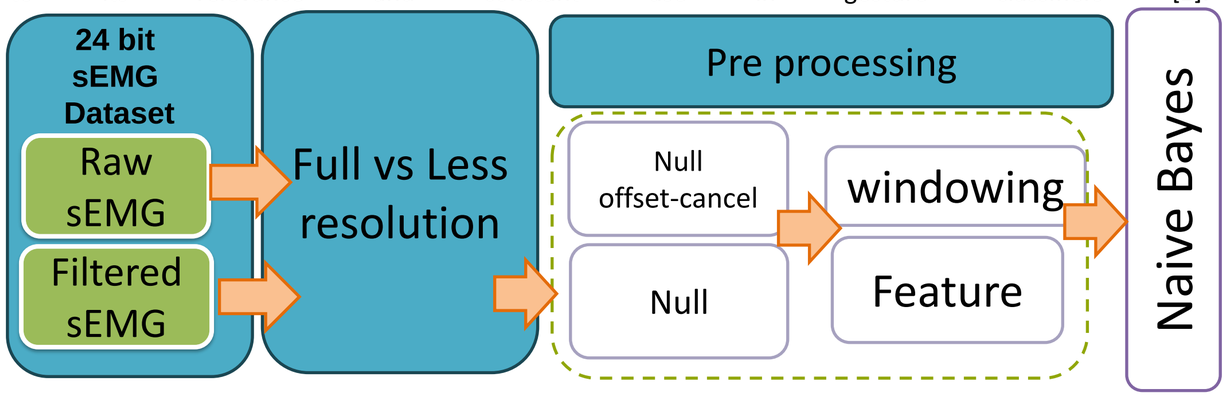
sEMG Datasets N bit resolution estimation



To evaluate the resolution, a data vector (DV) is taken from the database, then the difference ΔDV between the future sample minus the present sample is calculated by going through the entire vector. The resulting minimum value is the floating-point resolution and the formula in point 5 is then applied.

Impact resolution on gesture recognition

To compare the impact of resolution on gesture recognition, a methodology was implemented to reduce the number of bits from the original 24 to 16. Since the 24 bits database units was on mV, the floating-point resolution was calculated, obtaining 0.3uV or 7 digits, therefore for 16 bits the result was 0.1mV or only 4 floating point digits. Taking this into consideration, two groups of data were obtained, which were named full resolution for the database with full 24-bit resolution, and less resolution for the database in which the resolution was reduced to 16 bits. To verify the impact of resolution on gesture recognition, different pre-processing applied to full, and less resolution were evaluated. For this analysis, the 4 channels, 9 gestures of patient 1 were used. The following figure summarize the steps performed on the original database signal files. A windowing of 150 samples was performed. Then a feature (see Fig.1) was applied to each preprocessing. In addition to the above, The classifier algorithm used was Naive Bayes due to its relevance and constant use in gesture classifiers [2].



FEATURES

$$\frac{1}{k}\sum_{n=1}^{k}|X_n|$$

Mean absolute value(MAV)

$$\sqrt{\frac{1}{k}\sum_{n=1}^{k}|X_n^2|}$$

Root mean square(RMS)

$$\sum_{n=1}^{k-1} f[(|X_{n+1} - X_n|)]$$

Wavelength(WL)

Fig1. features equations[3]

RESULTS & DISCUSSION

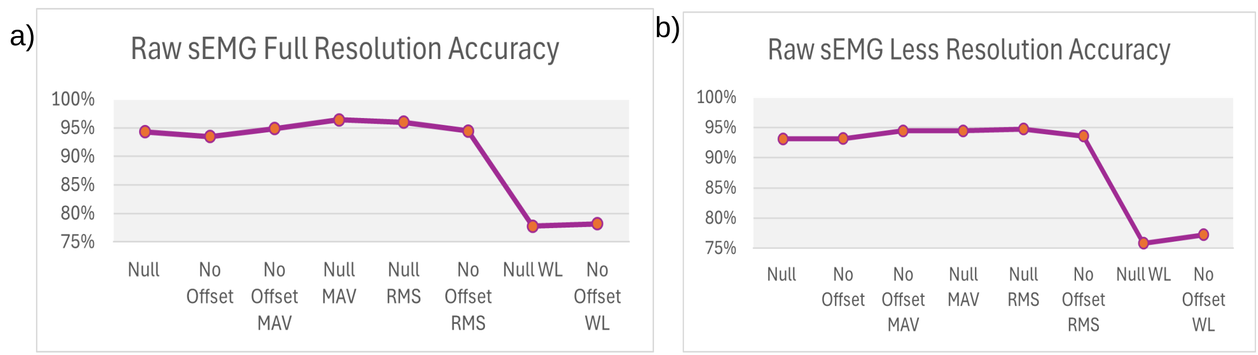
sEMG Datasets N bit resolution estimation

No	Autor	DR bit	ER bit	Device
1	Mehmet Akif, Ozdemir	24	23	BIOPAC MP36
2	Ashirbad Pradha	16	16	EMGUSB2
3	N. Krilova	8	7	MYO Thalmic
4	Asad Mansoor Khan	8	7	MYO Thalmic
5	R.N. Khushaba	12	11	Delsys Bagnoli-8
6	Weidong Geng	16	14	Developed prototype ADS1298
7	Gomez-Correa, M.,	12	11	WyoFlex armband
8	Christos Sapsanis	14	7	NI USB-09

Table 1. Table of SEMG databases for resolution estimations.

Table 1 shows that the result of the evaluated bit resolution (ER bit) is very close to the declared bit resolution (DR bit), except in database 8. Where ER bit is half of the DR bit. The methodology implemented to analyse the databases results in the number of bits declared by the site being lower in the data provided. The estimated resolutions are 1 bit lower than declared, which is understandable since the goal is to avoid a saturated signal.

Impact resolution on gesture recognition



Graphic 1. a) Shows accuracy of Full resolution Raw sEMG signal. b) Shows accuracy of Full resolution Raw sEMG signals c) Shows accuracy of Full resolution Filtered sEMG signals. d) Shows accuracy of Less resolution Filtered sEMG signals

Full resolution improvement
1.11%
1.84%
Average improvement 1.35%

The gesture recognition accuracy for full and less resolution raw sEMG signals results in values above 90% with the exception of the WL feature. The gesture recognition accuracy for full and less resolution filtered sEMG signals, results in values above 60% with the exception when null preprocessing was applied, where the accuracy is just above 30%. The impact of full resolution is 1.11% for the raw signal and 1.84% for the filtered signal. And the overall average improvement was 1.35%. The Maximum peak classification accuracy is 96.36% accuracy for MAV. Notice a drop in accuracy for WL in raw sEMG signal and a drop in filtered sEMG signals, when no feature is applied.

CONCLUSION

1. **Analysis of the resolution of sEMG databases can be applied to understand the signal quality of these and to validate the reliability of the data when using classification algorithms.**
2. **Using a 24-bit resolution, although it improves classification, does not represent a significant improvement with respect to a 16-bit resolution.**
3. **The applied features where an improvement in classification was obtained, were MAV and RMS for the Raw sEMG signal and WL for the filtered sEMG signal.**

FUTURE WORK

- **Inquire of the wireless transmission confirmed for eight high-resolution sEMG channels.**
- **Model gesture classifier for the 40 patients in database.**

REFERENCES

[1] Hogrel JY. Clinical applications of surface electromyography in neuromuscular disorders. Neurophysiol Clin. 2005 Jul;35(2-3):59-71. doi: 10.1016/j.neucli.2005.03.001. PMID: 16087069.

[2] Y. Narayan, "Comparative analysis of SVM and Naive Bayes classifier for the SEMG signal classification(2021)," *Materials Today: Proceedings*, 37(2), pp. 3241-3245. doi: 10.1016/j.matpr.2020.09.093.

[3] Amezquita García A., Murrieta Rico F., Ezrre Gonzalez S.,Gomez Caraveo A & Bravo Zanoguera M.(2024). Memorias del congreso Internacional sobre la Enseñanza y Aplicación de las Matematicas, Altamira Ibarra, Hernandez Castillo, Lopez Pachecho(Eds.). Analisis de parametros matematicos en EMG: influencia en la diferenciacion de movimientos en miembro superior. (pp. 318 – 329). Mexico