A Contact Selectivity Index for Multi-Contact Nerve Cuff Electrodes Guided by Feature Selection Algorithms

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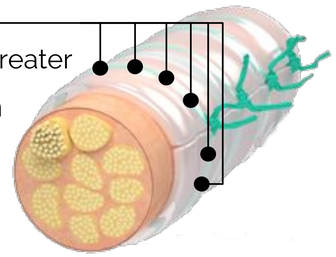
Introduction

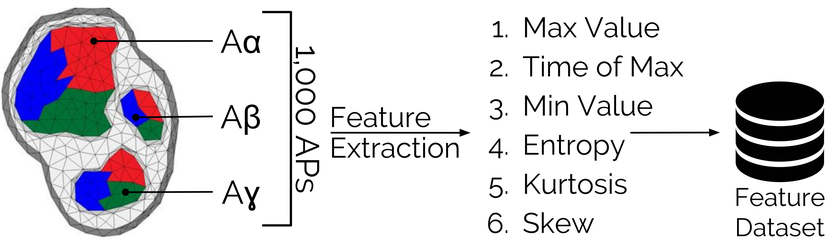
Decoding the bioelectric signals of the peripheral nervous system would enable us to extract motor commands and sensory feedback signals for a variety of **neuroprosthetic devices**. To achieve highly selective recordings, a **Contact Information Metric (CIM)** has been developed to quantify the information value of each contact location in a nerve cuff electrode [1]. This metric is unique because it remains unbiased by the number of contacts in **multi-contact nerve cuff (MCC)** configurations.



Objective: Design an **enhanced CIM** with greater discriminative ability as well as a **validation system** to compare between both metrics.

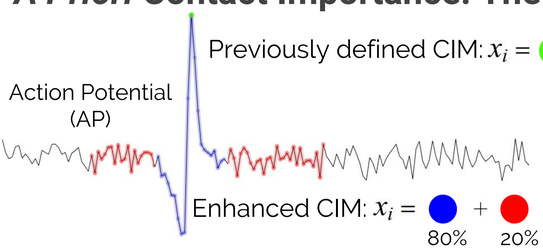
Methods

Model, Dataset & Feature Extraction



Finite Element Model of Rat Sciatic Nerve

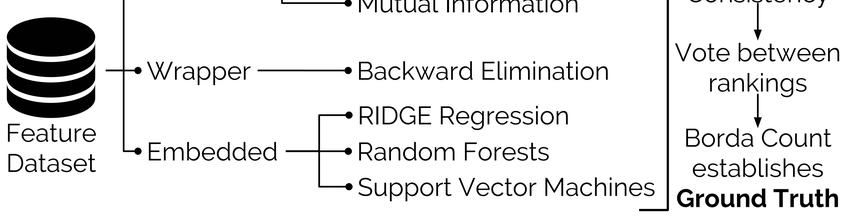
A Priori Contact Importance: The Enhanced CIM



$$H_k = -\sum_i^n P_{x_i} \log_2 P_{x_i}$$

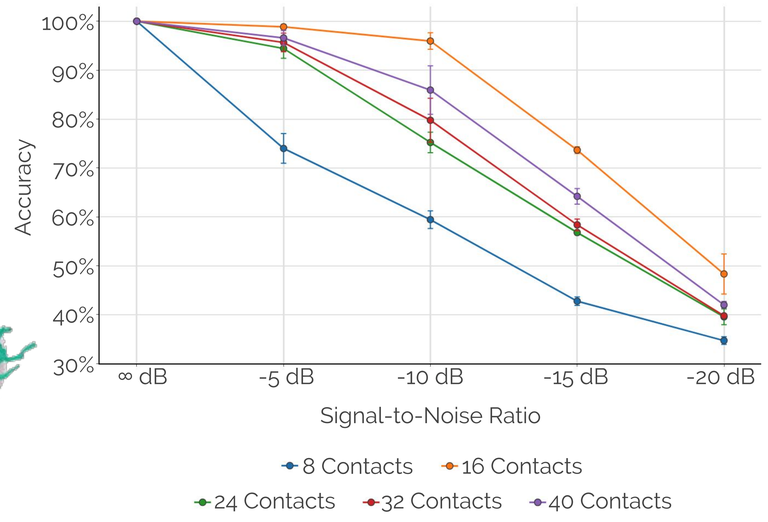
Based on distribution over all trials

A Posteriori Contact Importance: Feature Selection



Results

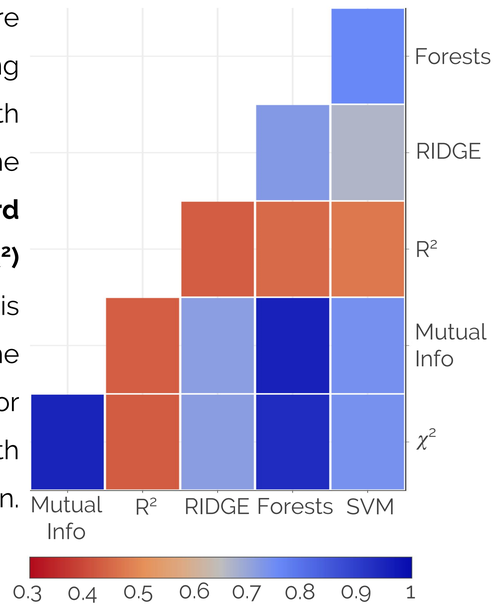
Classifier Performance



As expected, accuracy **decreases** with increasing noise levels and **remains relatively stable** with MCCs (excluding the 8-contact system). Accuracy is **averaged** among the **three embedded methods**.

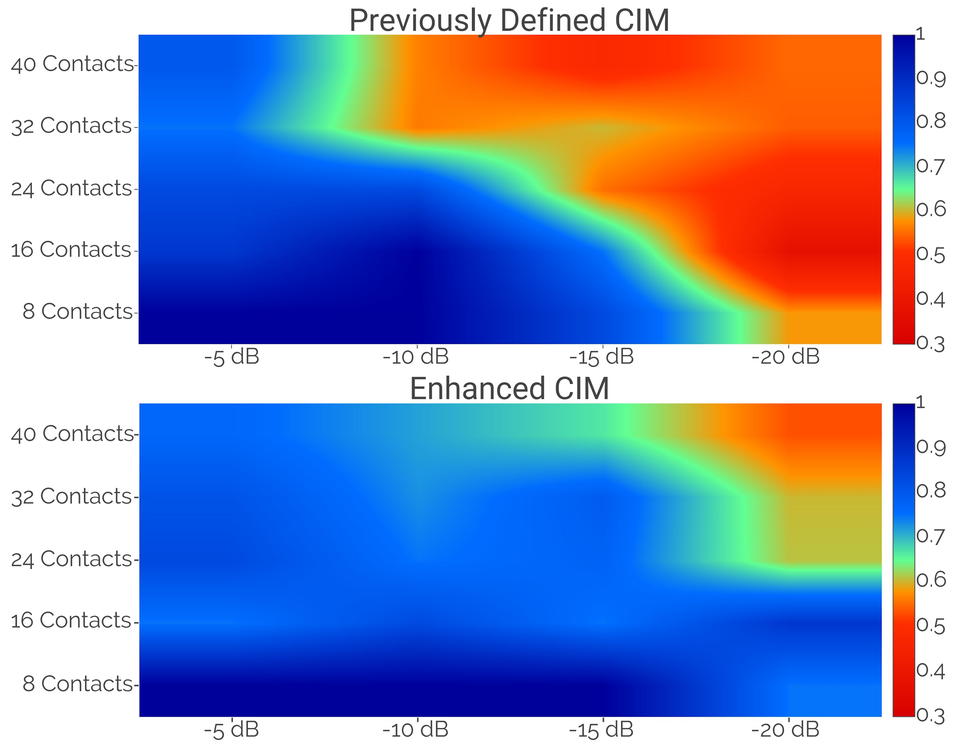
Feature Selection Consistency

Rankings are **consistent** among feature selectors with the **exception** of the **backward elimination (R^2)** method. As such, it is **not considered** in the **voting process** for ground truth determination.



CIM Assessment

The **top 50%** of contacts selected by each metric is compared to the ground truth (1 = perfect similarity, 0.5 = rankings produced by chance).



The **enhanced CIM** demonstrates **closer similarity** to the ground truth rankings, especially with **larger MCC configurations** and **noise levels**.

Discussion

In this study, we define a new CIM that demonstrates **improved discrimination** in characterizing contact importance by incorporating the **overall shape of an AP**. We additionally present a **novel paradigm** of **validating metric performance** and **obtaining true selectivity** rankings through a **holistic feature selection approach**. This work will provide a valuable tool for optimizing our ability to extract information from neural activity and enabling finer control of assistive technologies.

References

1. Koh RG, Zariffa J. Effects of the choice of reference on the selectivity of a multi-contact nerve cuff electrode. In Engineering in Medicine and Biology Society (EMBC), 2016.

Acknowledgments

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