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Median Nerve Stimulation to Detect Awake and Anesthetized States with Riemannian Classifiers

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Among all the operations with general anesthesia worldwide, some patients have had the terrible experience of Accidental Awareness during General Anesthesia (AAGA), an unexpected awakening during surgery [1], potentially leading to pain, recall of surgical events and post-traumatic stress disorders [2]. The inability to predict AAGA using only clinical signs, leads to the use of brain activity monitors [3]. Given AAGA patients' first reflex to move, impeded by neuromuscular-blocking agents, we propose using a new Brain Computer Interface (BCI) with Median Nerve Stimulation (MNS) to detect their movement intentions (MI). Combining MI and MNS significantly impacts MNS-generated patterns, leading to better MI detection accuracy. MNS also provides a trigger, resulting in better classification (+18%) compared to asynchronous BCI [4].

To continue in this direction, we analyzed the MNS patterns of 13 patients receiving propofol, an intravenous anesthetic, during surgery at CHU Brugmann, Belgium [5]. Two conditions were examined: EEG activities of preoperative MNS while the patient is awake (MNS-awake), and intraoperative MNS during various stages of anesthesia (MNS-anesthesia). Then, a Riemannian Minimum Distance to the Mean classifier achieved 97% test balanced accuracy in distinguishing awake and anesthetized states. We also observed the classifier's response evolution with anesthesia depth, in terms of distance between the MNS-awake class centroid and covariance matrices of other trials throughout the surgery (Fig. 1). This distance appears to track the patients' awareness level: it is greater during the maintenance phase, at deeper anesthetic concentrations, than during the induction or emergence phases. This holds potential for creating a one-class classifier using this distance, only relying on MNS-awake data, as MNS-anesthesia data are usually unavailable for calibration during regular surgeries.

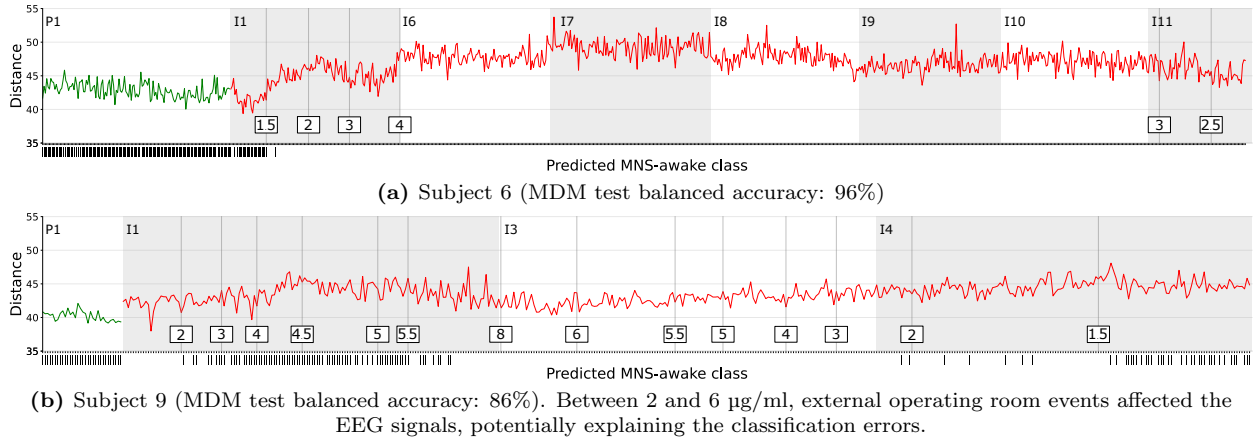


Figure 1: Distances of each test sample to the MNS-awake class centroid. Real labels are presented by colors: green for the preoperative session (MNS-awake) and red for the intraoperative session (MNS-anesthesia). Below, a bar indicates when the classifier predicted MNS-awake. When propofol reaches the target concentration, a gray line with a label indicate the corresponding propofol concentration (in µg/ml). Each run is differentiated by alternating background colors (white, gray), and labeled as preoperative (P) or intraoperative (I) runs.

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