AN INVESTIGATION OF ELECTROMYOGRAPHIC (EMG) CONTROL 
OF DEXTROUS HAND PROSTHESES FOR TRANSRADIAL 
AMPUTEES

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Appendix-A

The optimal controller delay requirements for the case of Majority Voting (MV)

In some occasions, the classification accuracy for a pattern recognition system is calculated with the application of majority voting. Majority vote is a type of post processing that will improve recognition accuracy by a small percentage (Englehart, Hudgins et al. 2003). Majority-vote employs $n$ previous and after classification results with the present one. Then, the classification results then are judged on the basis of the common class which appeared in each window (see Figure. A.1). The process will reject the false misclassification and ensure a smooth operation (Chan and Green 2007).

As for controller delay requirements, the original equations proposed by (Englehart and Hudgins 2003) for calculating the controller delay were called into question by Farrell (2011) (see Eq. A.1 for detached segmentation scheme). Farrell’s results were supported by Smith, Hargrove et al. (2011) and Simon and Hargrove (2011) who have shown that majority voting adds a delay that has an adverse effect on performance (see details in

Figure A.1 Majority Vote post processing
Section 4.1). According to Farrell (2011), the new optimal controller delay (see Eq. A.1) for an example window of 100 ms window size, 1.3 ms processing time and 9 votes is 501.3 ms which 5 times larger than the estimated based on the old estimation proposed by (Englehart and Hudgins 2003) (see Eq. A.2). This delay exceeds the acceptable level of controller delay which is between 100 and 128 ms (Farrell and Weir 2007).

\[ D = \left( \frac{n+1}{2} \right) T_a + \tau \quad \text{A-1} \]

where \( D \) is the optimal controller delay, \( n \) is the number of majority votes, \( T_a \) is the analysis window length and \( \tau \) is the processing time.

\[ n \times T_{\text{new}} \leq 300 \text{ ms.} \quad \text{A-2} \]

where \( n \) is number of majority votes, \( T_{\text{new}} \) is the window overlap and \( \tau \) is the processing time.

According to Eq. A.2 (Chan and Englehart 2003; Englehart and Hudgins 2003; Chan and Englehart 2005), the optimal controller delay is \( 4 \times 50 = 200 \) ms. However, the original equations proposed by Englehart were called into question by Farrell (2011) (see Eq. A.3 for detached segmentation scheme). According to Farrell (2011), the new optimal controller delay (see Eq. A.3) for an example of 150 ms window size, 50 ms window overlap and 10 votes is \( 325 + \tau \) ms which larger than the acceptable level of controller delay which suggest that this processing chain may not be suitable for the real-time implementation (Farrell and Weir 2007).

\[ D = \frac{1}{2} T_a + \frac{n}{2} T_{\text{new}} + \tau \quad \text{0-3} \]

where \( D \) is the optimal controller delay, \( n \) is the number of majority votes, \( T_a \) is the analysis window length, \( T_{\text{new}} \) is the window overlap and \( \tau \) is the processing time.

Appendix- 2
Appendix- B

Negentropy:

Negentropy is a measure based on the information theoretic quantity of (differential) entropy. The value of Negentropy is zero for a Gaussian variable and is always non-negative for other distributions (Nazarpour, Sharafat et al. 2005). The Negentropy is given by

\[ J(x) = H(x_{Gauss}) - H(x) \]

where \( J \) is the Negentropy, \( H \) is the entropy and \( x_{Gauss} \) is a Gaussian random variable with the same covariance matrix as \( x \).
References for the appendixes


