PHD

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

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Appendixes

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).

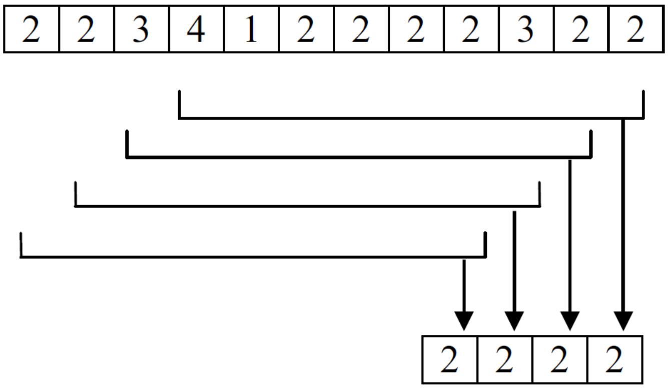

Figure A.1 Majority Vote post processing

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

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 501.3ms which 5 times larger than the estimated based on the old estimation proposed by (Englehart and Hudgins 2003) (see E**q. A.2**). This delay exceeds the acceptable level of controller delay which is between 100 and 128 ms (Farrell and Weir 2007).

$$\boldsymbol{D = \left(\frac{n+1}{2}\right) T_a + \tau} \qquad \text{A-1}$$

where D is the optimal controller delay, n is the number of majority votes, T_a is the analysis window length and τ is the processing time

$$n \times \mathrm{T}_{\mathrm{new}} \leq 300\ ms. \qquad \text{A-2}$$

where n is number of majority votes, T_{new} is the window overlap and τ 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*50=200 ms. However, the original equations proposed by Englehart were called into question by Farrell (2011) (see E**q. 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+ τ 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).

$$\boldsymbol{D = \frac{1}{2} T_a + \frac{n}{2} T_{new} + \tau} \; \text{0-3}$$

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

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

$$J(x)=H(x_{Guass})-H(x) \quad \text{C-1}$$

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

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