Model simulations suggest that speech motor control is more sensitive to estimated than true sensory noise levels

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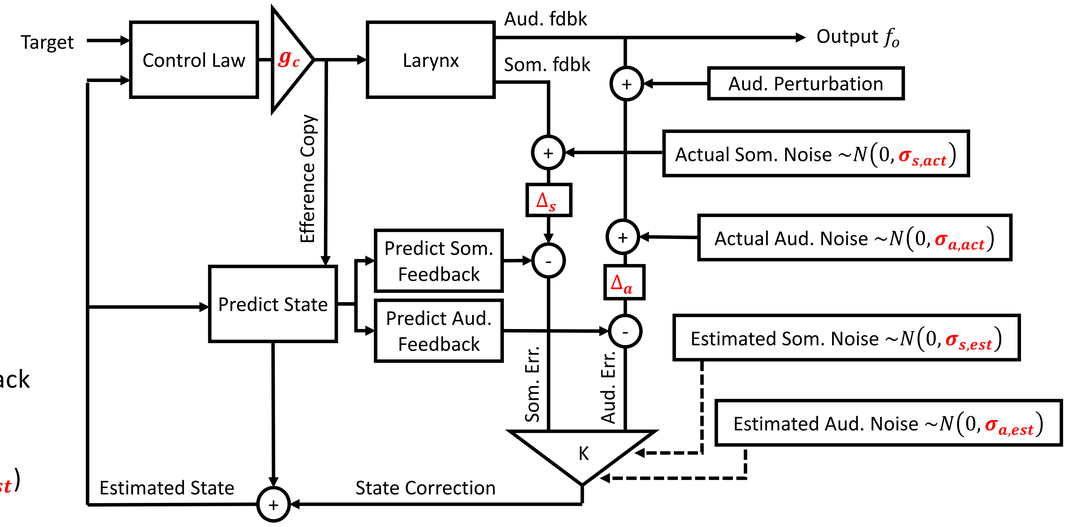
Introduction

- State feedback control of f_o is being used to model the pitch perturbation response behavior of various clinical populations and control groups
- In this model, the incorporation of sensory feedback into the internal estimate of laryngeal state is weighted by Kalman gain
- Kalman gain is calculated using an internal estimate of the amount of noise in each feedback signal
- The original state feedback control model [1,2] assumed that the system had perfect knowledge of sensory feedback noise
- In this investigation, we separate actual noise in the sensory signal from the estimated noise used to calculate Kalman gain

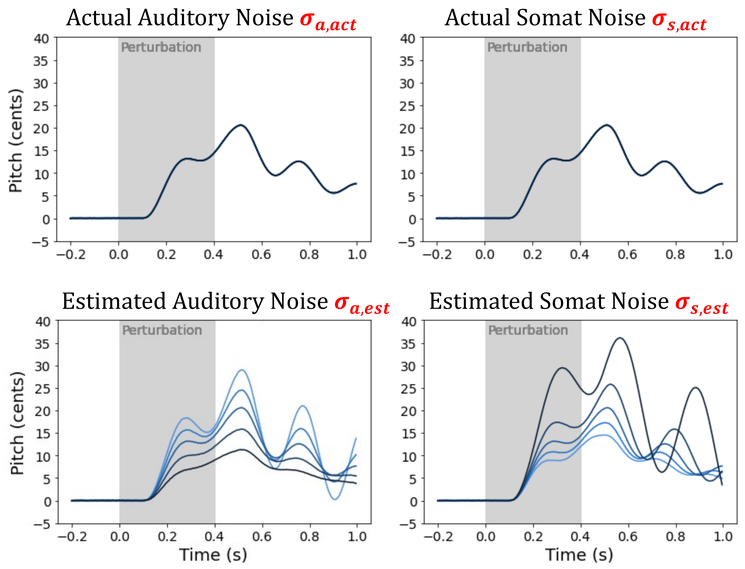
Simulator

The state feedback control model architecture is shown here. The original parameter set is composed of auditory feedback delay (Δ_a), somatosensory feedback delay (Δ_s), auditory feedback noise variance ($\boldsymbol{\sigma_a}$), somatosensory feedback noise variance ($\boldsymbol{\sigma_s}$), and controller gain ($\boldsymbol{g_c}$).

Here we have separated auditory feedback noise variance ($\boldsymbol{\sigma_a}$) and somatosensory feedback noise variance ($\boldsymbol{\sigma_s}$) into actual ($\boldsymbol{\sigma_{a,act}}$,$\boldsymbol{\sigma_{s,act}}$) and estimated ($\boldsymbol{\sigma_{a,est}}$ $\boldsymbol{\sigma_{s,est}}$) values.



Parameter Sweeps



Changes in actual sensory feedback noise cause minimal changes in model output

Changes in the internal estimate of sensory feedback noise cause changes in model output

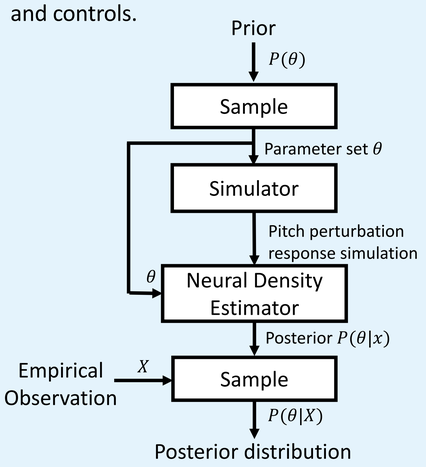
Noise Levels :

σ_a = 1e-6, 1.2e-6, 1.5e-6, 2e-6, 3e-6

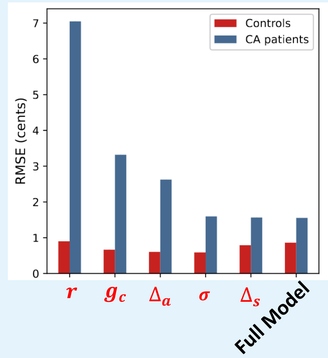
σ_s = 5e-7, 6e-7, 7.3e-7, 1e-6, 2e-6

Application

A previous modeling study [2] fit the SFC model to behavioral pitch perturbation data from individuals with cerebellar ataxia (CA) and controls.



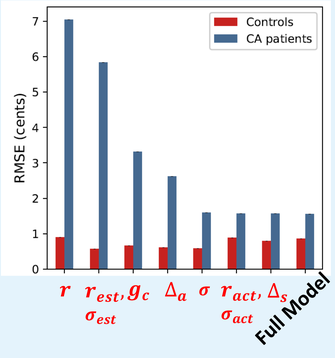
An ablation study indicated that the relative noise between sensory modalities is very important in fitting the differences between groups. Is this high impact a result of differences in actual or estimated noise?



Overall Feedback Noise $\sigma = \sigma_a$

Feedback Noise Ratio $r = \sigma_a/\sigma_s$

Results indicate that the high impact of relative noise is due to the impact of estimated noise. Ablating estimated noise has similar impact on model fit as ablating feedback noise ratio, while ablating actual noise has minimal effect on model fit.



In r and σ, $r_{est} = r_{act}$ and $\sigma_{est} = \sigma_{act}$

References

[1] Houde, J.F., et al. (2014, May 5-8). 10th ISSP, Cologne, Germany.
[2] Gaines, J.L. et al. (Submitted).

Acknowledgements

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