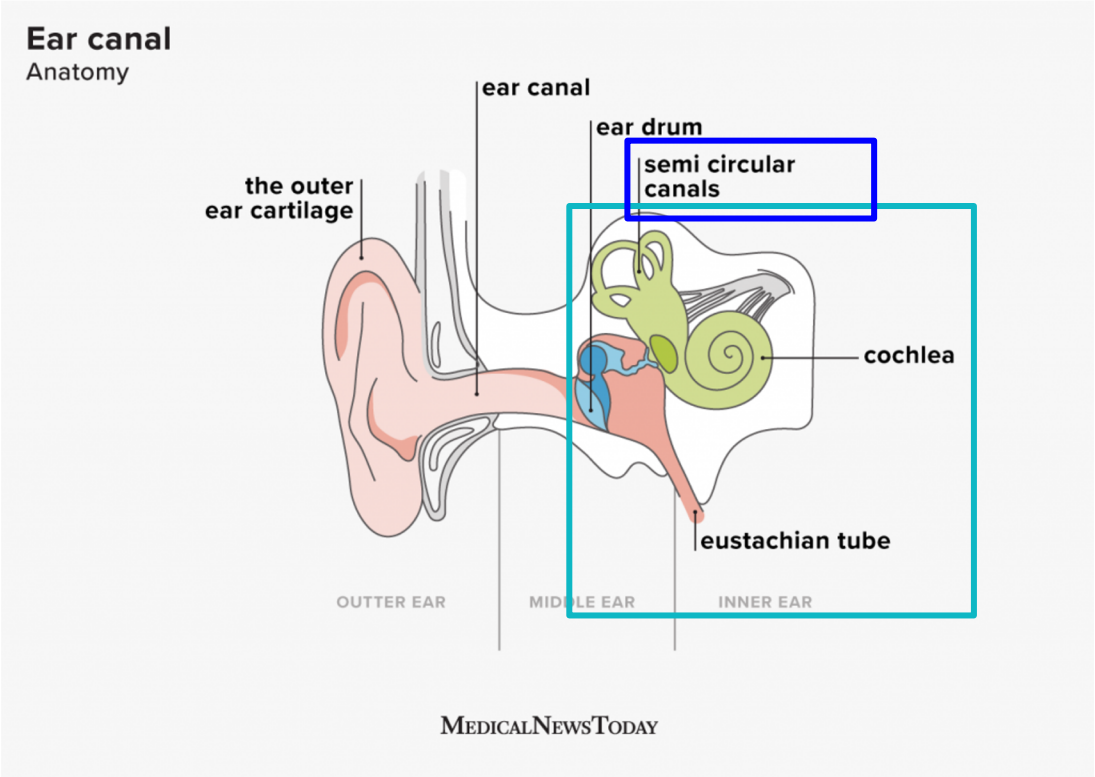
Modeling the Vestibular System of the Human Body in Simulink

Fangyi Lu, Mary Nguyen, Yen Nguyen, Karthik Raj, and Zoe Tcheng

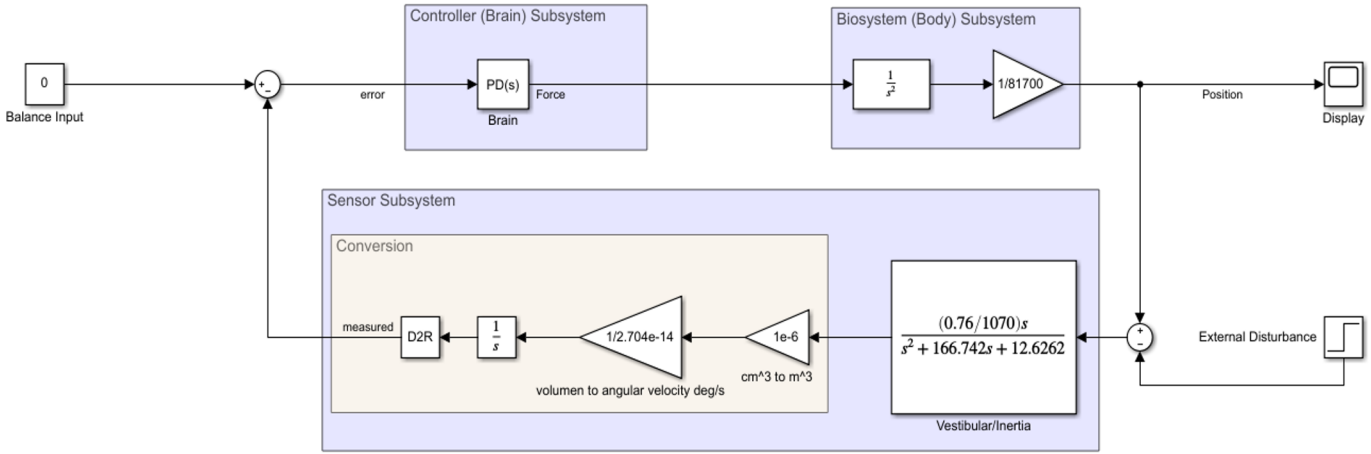
Background


Ear canal
Anatomy
ear canal
ear drum
semi circular canals
the outer ear cartilage
cochlea
eustachian tube
OUTTER EAR
INNER EAR
MedicalNewsToday

Assumptions

1. There is no stiffening or dampening in the body, so we only consider mass.
2. Consider the semicircular canals as the most essential input of the vestibular system.
3. Using superposition, all three of the semicircular canals in one ear are such that we only have one input and one output.
4. The mass of the body in this scenario is roughly that of an average American (81.7 kg).

Simulink Model



Simulink Model (cont.)

$$T_{ssc}(s) = \frac{Q(s)}{\omega(s)} = \frac{ds/m}{\left(s + \frac{1}{\tau_1}\right)\left(s + \frac{1}{\tau_2}\right)}$$

Unit math:

$$\frac{cm^3}{rad/s}\left(\frac{m^3}{cm^3}\right)\left(\frac{deg/s}{m^3}\right) = \frac{deg/s}{rad/s}$$

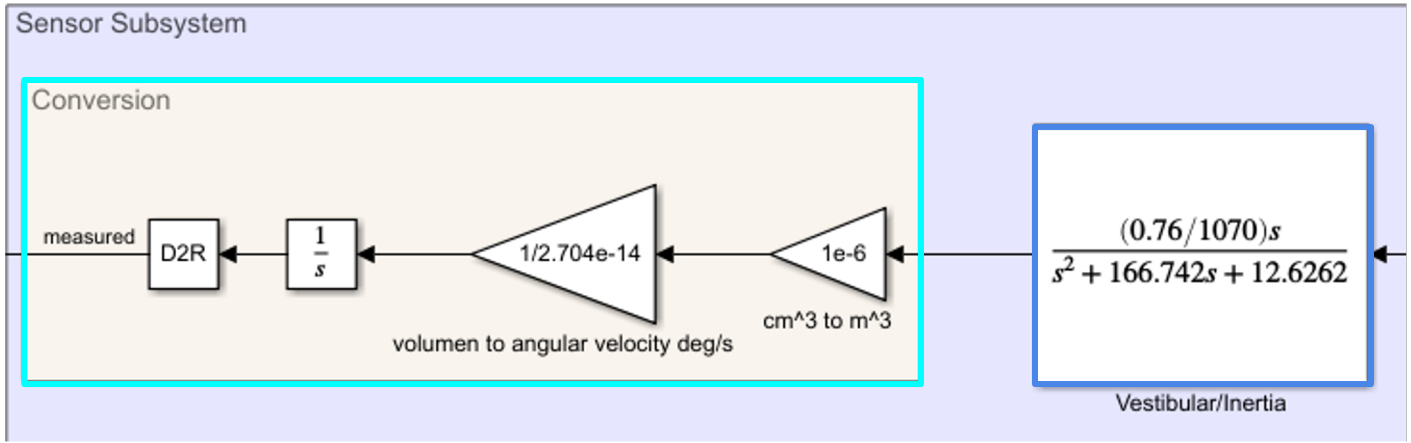
T_{ssc} $V_{dis} \rightarrow x$ $V_{dis} \rightarrow \omega_{ang}$

$$\frac{deg/s}{rad/s} \rightarrow \frac{1}{S} \rightarrow \frac{deg}{rad}\left(\frac{rad}{deg}\right) = 1$$

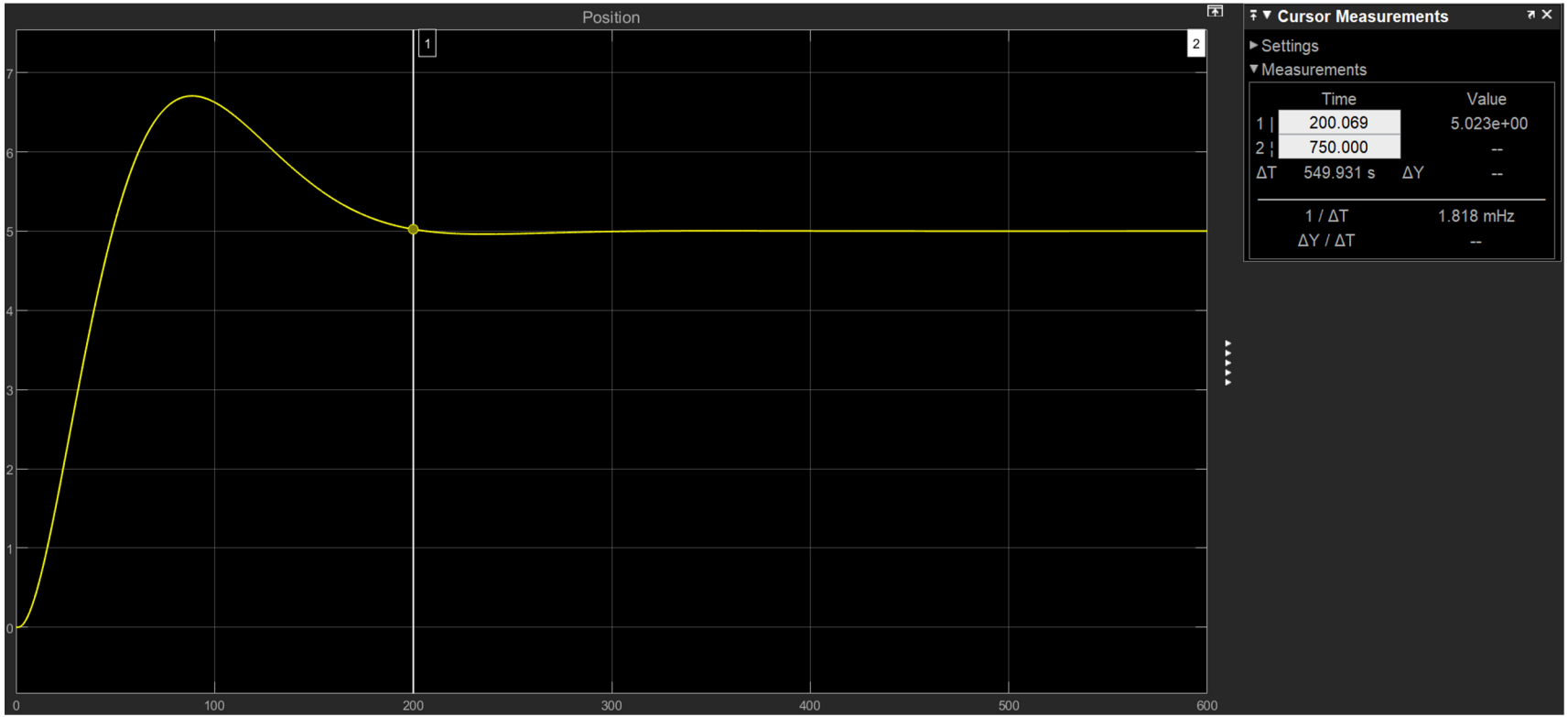
position!

$\frac{d\omega}{dt}$

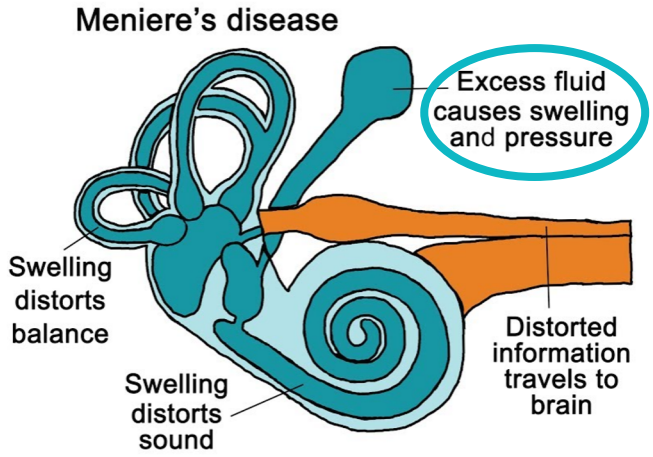
(from past HW simulink diagrams)

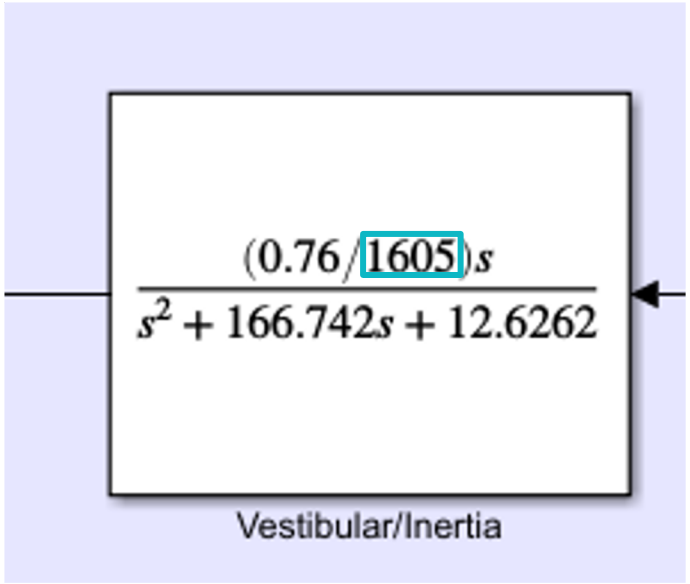


Results (Healthy System)



Impacted System (Meniere's Disease)





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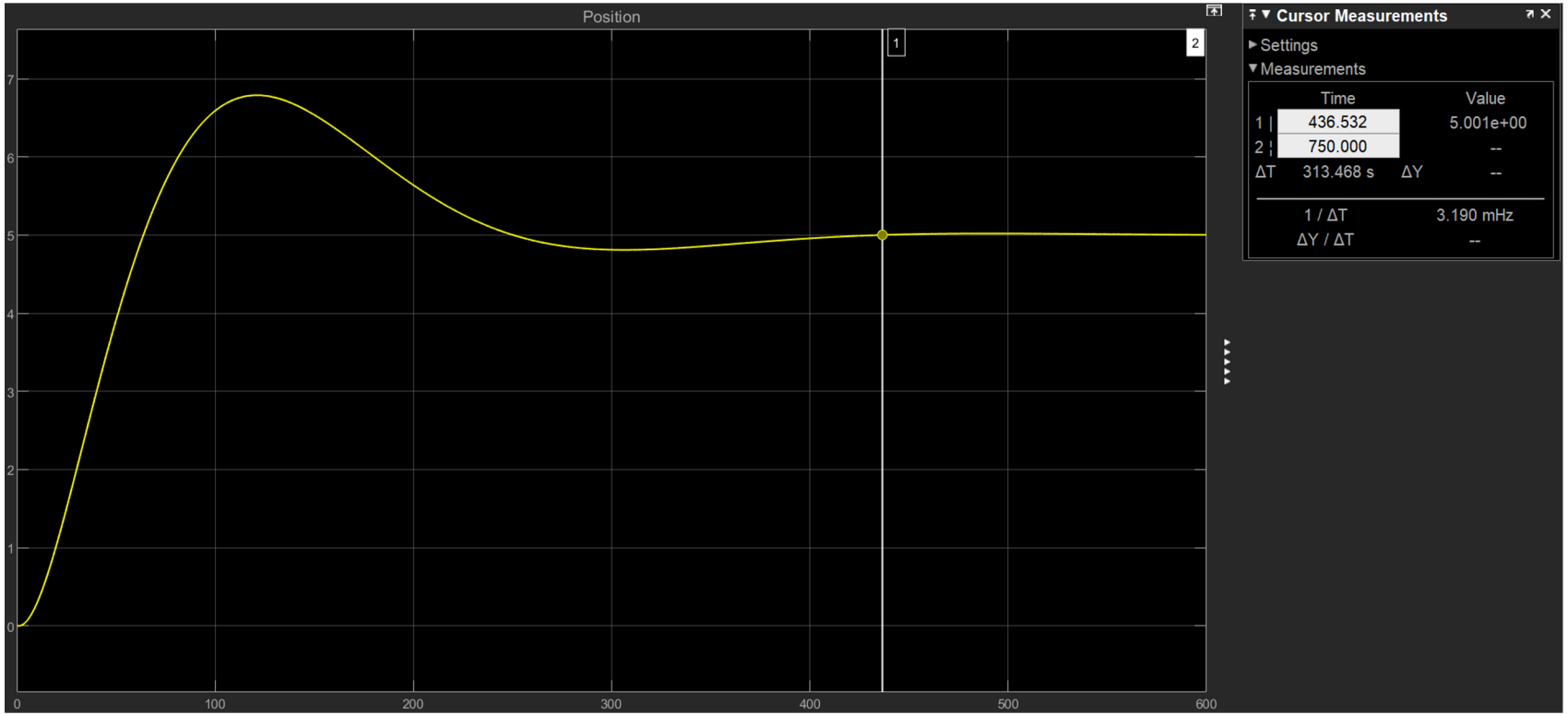

References

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- Modeling of the Human Vestibular System and Integration in a Simulator for the Study of Orientation and Balance Control https://ruc.udc.es/dspace/bitstream/handle/2183/25034/2018_Canelo_Angel_Modeling_human-vestibular-system.pdf

Questions?