Connecting circulation and nerve systems: some ideas

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Outline

- Why
 - concepts
- Current physiological models
 - Circulation system
 - Nerve system
- Connection?
 - Information flow
 - ontology based software structure

Conclusion



Section I: Why



System integration: vertical & horizontal directions



Erson and Cavusoglu (2008) A Software Framework for Multiscale and Multilevel Physiological Model Integration and Simulation, *Conf Proc IEEE Eng Med Biol Soc*. 2008:5449-53.

Connection between different organ systems

- Endocrine system $\leftarrow \rightarrow$ Circulation system
- Nerve system ←→ muscle & skeleton system ←→ Circulation system
-



Haemorrhage in the brain \rightarrow neurologic emergency

Connection between different organ systems



Image source: Ho et al (2010)



Image courtesty of Dr. J. Wu

A giant cerebral aneurysm \rightarrow the ophthalmic artery \rightarrow compress optic nerve

 \rightarrow Vision system

Connection between different organ systems

In a neurosurgery:



What in a neurosurgeon's mind is more like a horizontally integrated information of various organ systems



Section II: Current physiological models

Circulation system





Image source: CMISS example

Nerve system



Motor unit recruitment

Image source:

Kim et al (2007) Anatomically based lower limb nerve model for electrical Stimulation, *Biomedical Engineering Online*, 6:48 doi:10.1186/1475-925X-6-48



Similarity and difference

• Tree model construction

- Anatomical structure
 - Blood vessel
 - Nerve fiber



- Physiology ← computational models
 - Navier-Stokes equation
 - Bidomain equation



Section III: Connection?

Information flow



Erson and Cavusoglu (2008) A Software Framework for Multiscale and Multilevel Physiological Model Integration and Simulation, *Conf Proc IEEE Eng Med Biol Soc.* 2008:5449-53.

Ontology-based Software architecture



 these components are ontology-based structures and are extracted from database

High level design of the system¹

¹Erson and Cavusoglu (2008) A Software Framework for Multiscale and Multilevel Physiological Model Integration and Simulation, *Conf Proc IEEE Eng Med Biol Soc*. 2008:5449-53.

Ontology

• Anatomical structure

Reference ontology

- The Foundational Model of Anatomy (FMA)
- Physiological structure
 - Ontology of Physics for Biology (OPB) Project

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- Computational structure
 - Variables
 - equations

Ontology based software structure



Conclusion

- Contents here are ideas, sketch only
- No implementation yet
- Light weight, lumped parameter models to start off for physiological models
- Coupling occurs with lumped parameter models
- Lumped parameters models drive large, heavy weight models \rightarrow patient-specific models

• Maybe in the future an integrated, multi-organ bio-simulation can 'think' like a surgeon

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Thanks for your attention.

Questions?