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

Connection between different organ systems

- Endocrine system ↔ Circulation system
- Nerve system ↔ muscle & skeleton system ↔ Circulation system
- ......

Haemorrhage in the brain → neurologic emergency
Connection between different organ systems

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

Image courtesy of Dr. J. Wu
Connection between different organ systems

In a neurosurgery:

- Blood circulation
- Lung function
- Nerve system
- ....

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

Image source:
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

Ontology-based Software architecture

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

High level design of the system

Ontology

- Anatomical structure
  - Reference ontology
    - The Foundational Model of Anatomy (FMA)

- Physiological structure
  - Ontology of Physics for Biology (OPB) Project
    - ......

- Computational structure
  - Variables
  - equations
Ontology based software structure

Ontology

Ontology Standards

Ontology database

Biosimulation

FMA, OPB, ...

Protege, ...

Software structure

Biosimulation

Link layer

- Circulatory_mediator
- Nervous_mediator

Anatomy layer
- Blood vessel
- Nerve fiber

Physiology layer
- Blood vessel
- Nerve fiber

Comp layer
- Variables
- Equations
• 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 → 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?