Digital Twin Adaptation to In Silico Patients

- **Description**: Develop clinically useful digital twin model and techniques to fit model state/parameters to in silico patient simulation.
- **What Students Will Do**:
  - Extend existing in silico model to pediatrics
  - Develop digital twin model
  - Develop techniques to fit digital twin to in silico model
  - Evaluate trade-offs in effectiveness vs efficiency
- **Deliverables**: Proposal on digital twin design and parameter fitting. Git repository of digital twin and parameter fitting algorithms. Manuscript for publication.
- **Size group**: negotiable
- **Skills**: C++, Python, ML, GBD understanding, Optimization, Control theory, Software Engineering
- **Mentors**: Jules Bergmann, MD, MS, MHS ([jbergma8@jh.edu](mailto:jbergma8@jh.edu)), Jim Fackler, MD ([jim@jhmi.edu](mailto:jim@jhmi.edu))

\[ \frac{dx}{dt} = Ax + Bu \]
\[ y = Cx + Du \]

or ... What is the State?

(Ursino, Magosso AJP 2000:279:H149)
**Primary Focus**

**Simulate patient**
- Using BioGears
- Re-targeted for
  - Pediatrics
  - Receiving MV
  - Common scenarios
- Clinician validated
  - Match real physiology

**Fit State/Parameters**

**Applications**

**In Silico Patient Model**
- Using BioGears
- Re-targeted for
  - Pediatrics
  - Receiving MV
  - Common scenarios
- Clinician validated
  - Match real physiology

**Digital Twin Model**
- Based on ...
  - (Simplified?) BioGears, or
  - Targeted model
- States / Parameters
  - Cardiac function,
  - Vascular compliances
- How?
  - Inversion, optimization
  - GBD, ML, genetic alg

**Potential Applications**
- Causal Inference
- Physiology Based Machine Learning
  - On state (x)
  - Rather than outputs (y)
- Reinforcement Learning
  - Prospective,
  - Not off-policy

**Next Steps**

**The Ideal Candidates:**
- Interest / Expertise in
  - ... C++, python
  - ... machine learning
  - ... modeling (ODE systems)
  - ... optimization
  - ... control theory
- Ready to
  - work hard,
  - learn a lot (and teach us too!),
  - create something awesome, and
  - have fun!

**Investigators:**

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Please contact us with any questions!