



ARA

Integrating BioGears Simulations and Electronic Health Records (EHR)

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March 18, 2020

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NATIONAL SECURITY



INFRASTRUCTURE

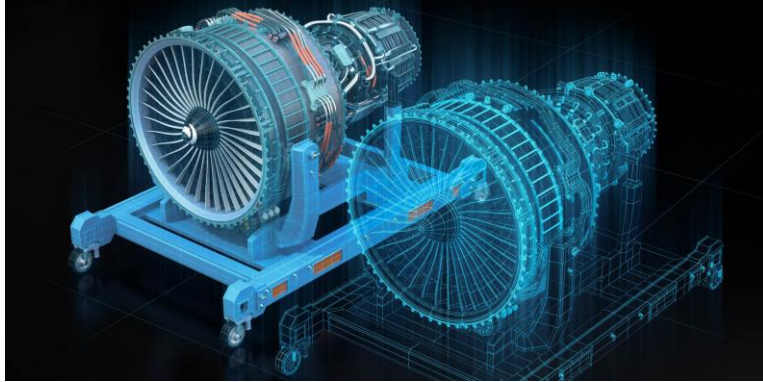


ENERGY & ENVIRONMENT

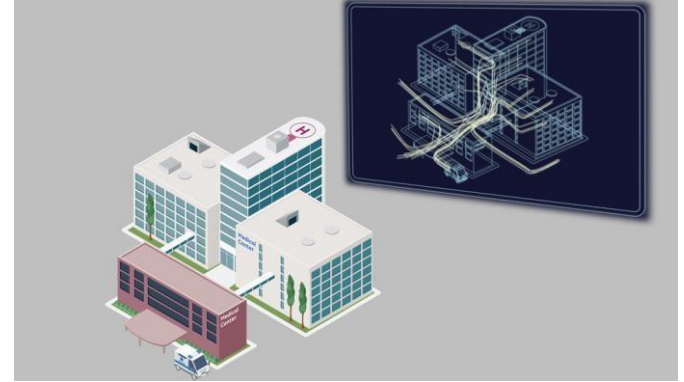


HEALTH SOLUTIONS

Digital Twin: Sensor-simulation trade-off



Functional



Social



Biology

“Biology easily has 500 years of exciting problems to work on” – Donald Knuth



Current State of Predictive Modeling

Machine Learning Modeling

- **4TDS**
- Image classification
- Observational data analysis

Mechanistic Modeling

- **BioGears**
- Physics/first-principles based
- Differential Equation solvers



The future of data-driven healthcare is a combined modeling strategy



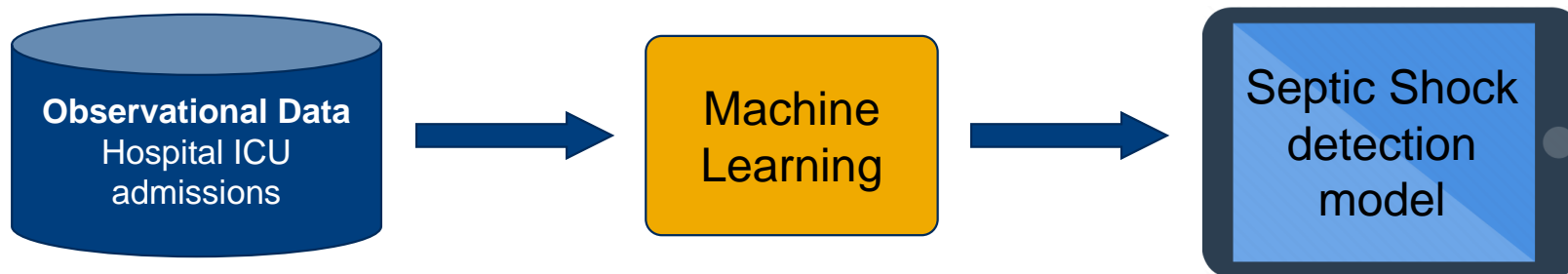


4TDS Goal & Strategy

Goal: Improve quality and efficiency of medic performance in combat casualty care using health IT and data analytics

Strategy

- Feature engineering to capture physiology changes





4TDS data: Electronic Health Records (EHR)

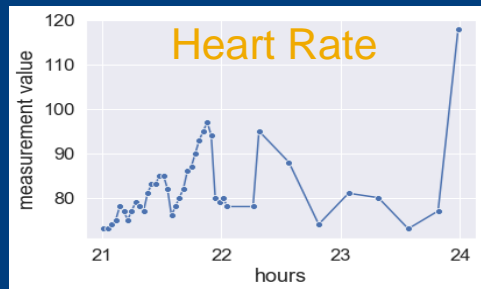
- Comprehensive medical history of a patient across multiple healthcare admissions
- Designed for billing purposes

Challenges

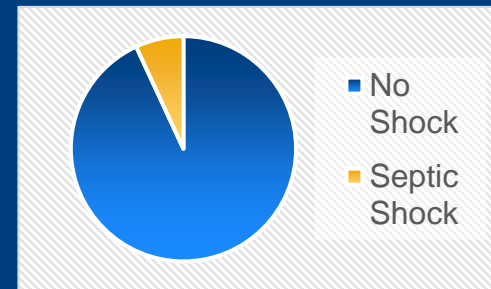
Not collected from
controlled experiments



Missing / noisy data



Imbalanced classes





Long Term Collaboration Goal

Improve 4TDS Machine Learning Model

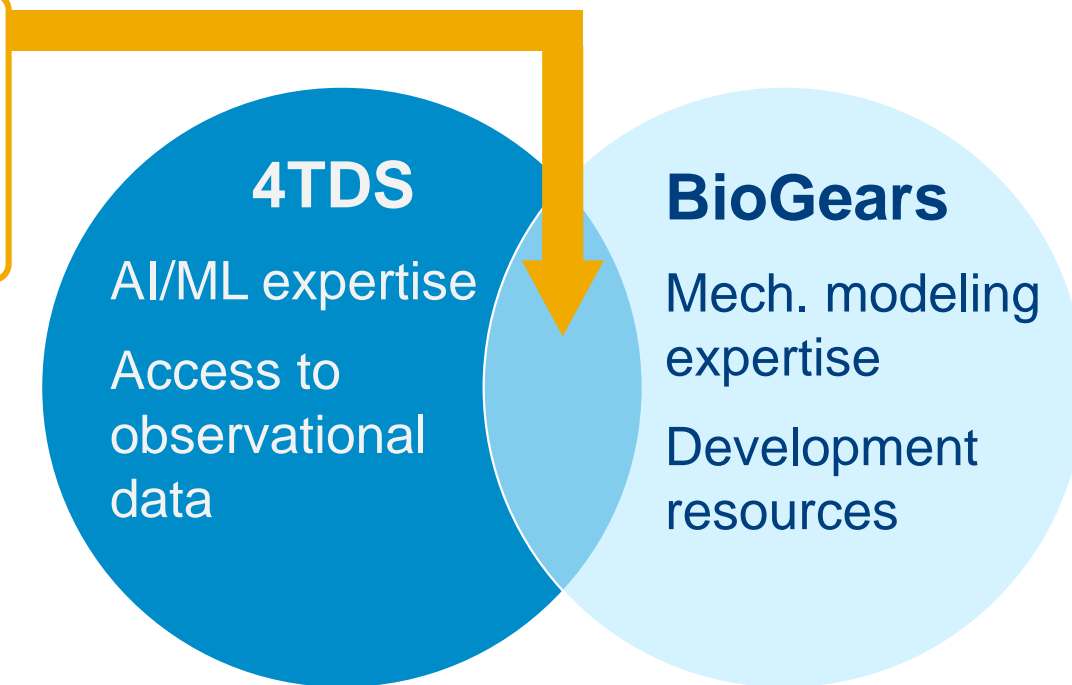
- Supplement positive septic shock class with data from BioGears





ARA is positioned to develop new tools

- Collect output data from BioGears scenarios
- Use to enhance 4TDS dataset





Initial Feasibility Studies

BioGears / EHR integration

- Can we generate BioGears simulations that match the trends and level of variation in real ICU patients?

BioGears / Machine Learning integration

- Can we generate BioGears simulations that span the solution space of the underlying physiology model?



Creating a dataset of BioGears simulations

Example / Howto – Patient Generation

Input

.csv file with rows denoting scenario parameters

- Length of scenario
- Severity of infection
- Min inhibitory concentration
- Time of first antibiotic dose
- Frequency of subsequent doses
- Patient state file

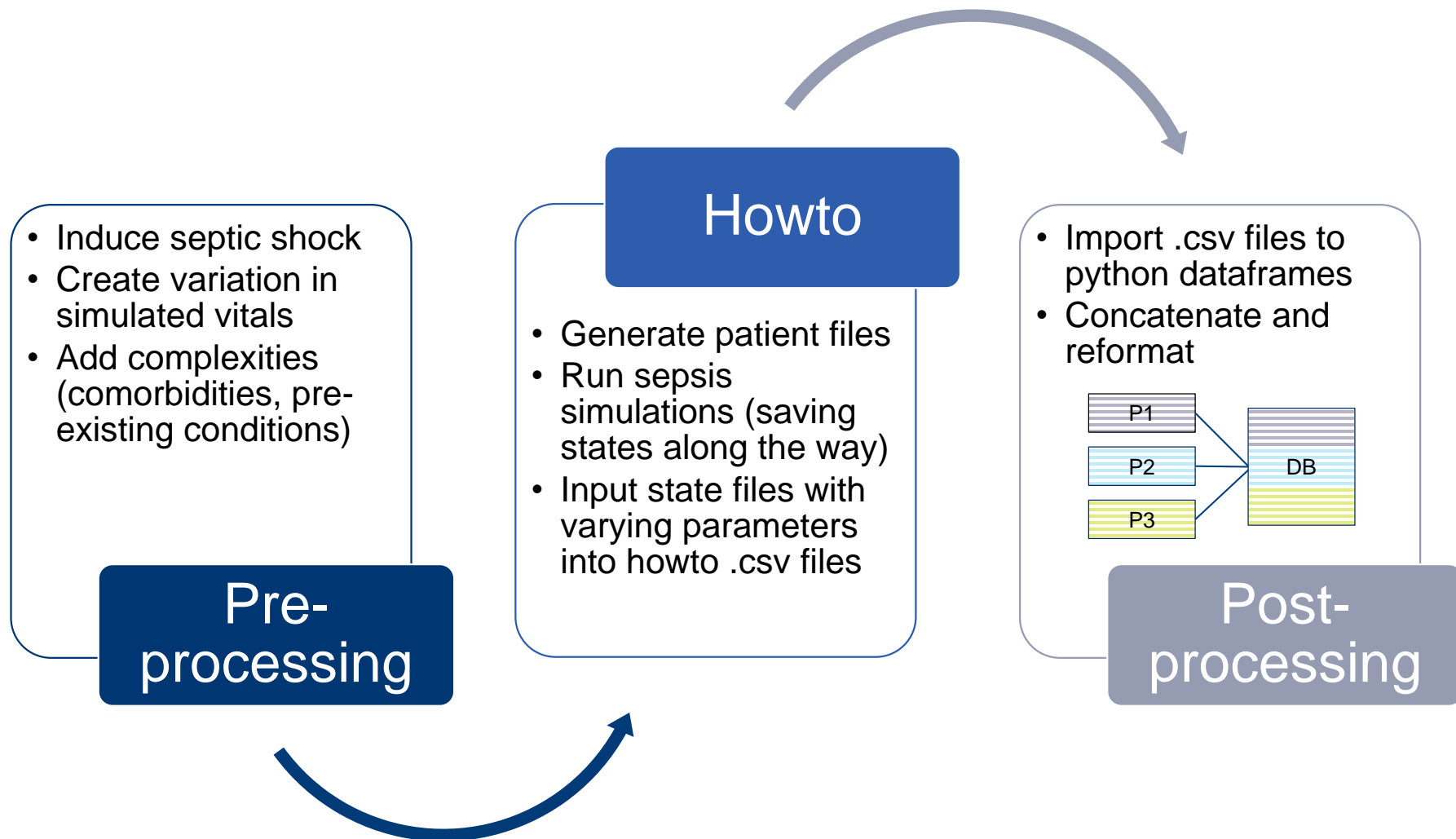


Output

.csv of data requests for each scenario passed from input



From start to dataset



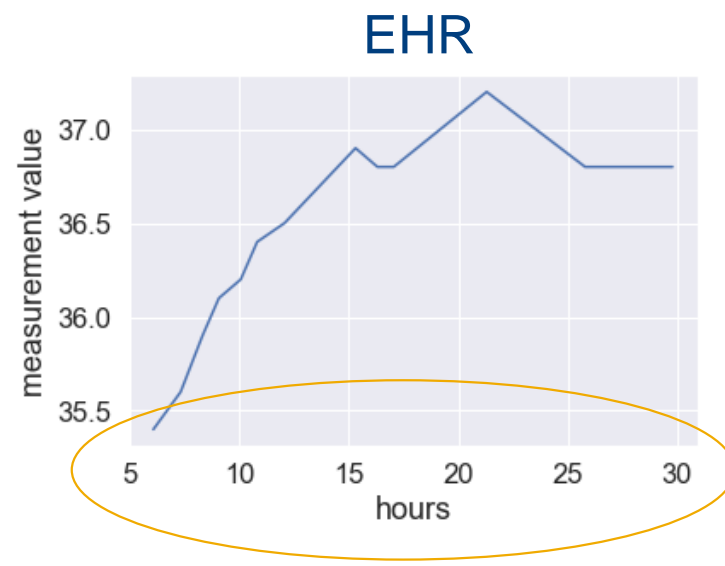
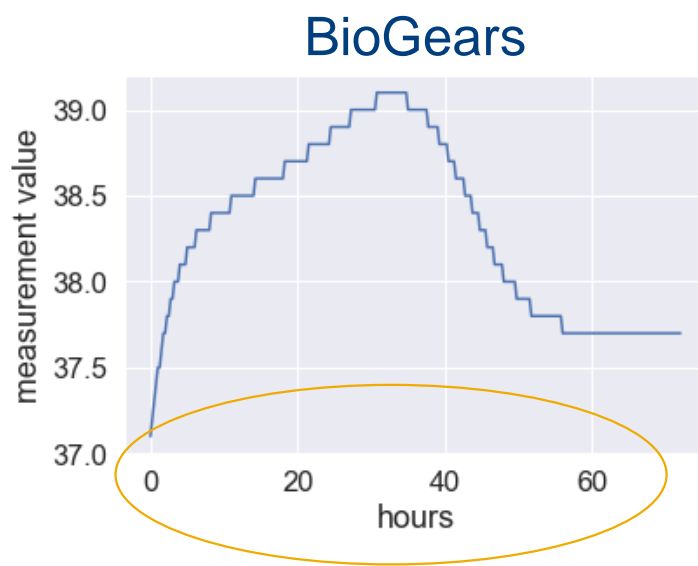


Feasibility Study Results

BioGears / EHR integration – capturing trends

- Introduce actions (pre-existing conditions, drugs, etc)
- Next steps: quantify similarity

Core temp
(C)





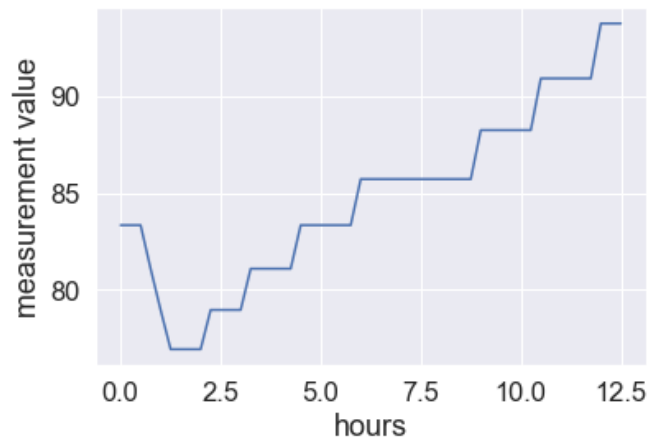
Feasibility Study Results

BioGears / EHR integration – creating “noise”

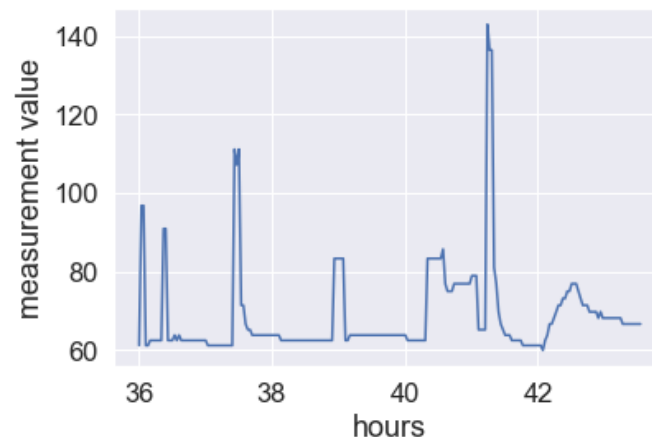
- Introduce actions (pain, stress, exercise)

Heart Rate

BioGears – no actions



BioGears – with actions



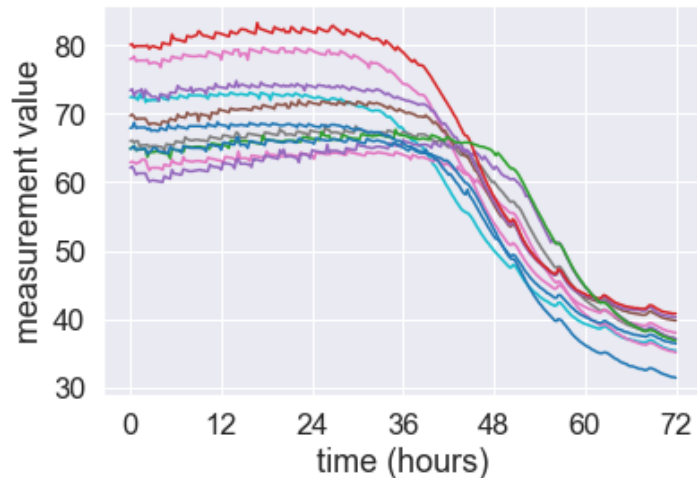


Feasibility Study Results

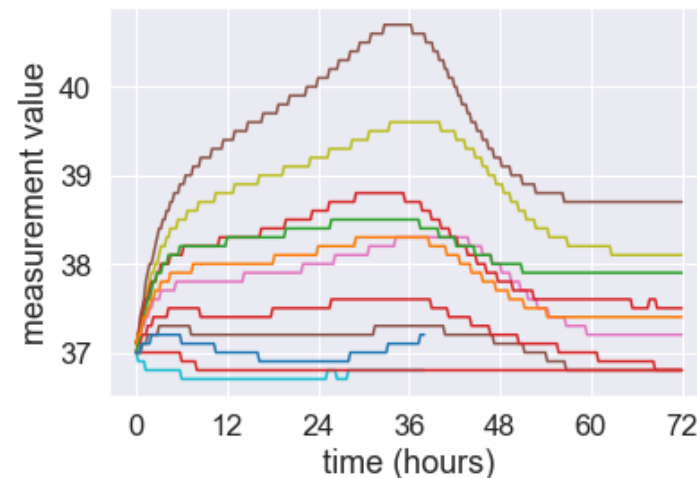
BioGears / Machine Learning integration

- Random initial patient generation
- No-action time lapse with infection and meals every 8 hours

Diastolic BP



Core temperature (C)





Wrap up



Future use cases

Supplement 4TDS dataset with BioGears data

- Increase number of septic shock patients in training

Generalizing to other scenarios

- Beyond sepsis

Physics-based Machine Learning research

- Capture the underlying mechanics of BioGears in a machine learning model



Takeaways

- 1 New BioGears feature in dev has enabled dataset creation
- 2 Dataset up on github today!
- 3 BioGears can help bridge the gap between Machine Learning and physics-based modeling
- 4 Smart resource management for multi-casualty care is on the horizon



Thank you!