

Project 18:

Automatic Mechanical Ventilation Control (AMVC)

- Stated topic and goal
 - Controlling Pressure Controlled Ventilator with an RL agent
 - The agent will be able to use Inputs(Inspiratory Pressure, Respiratory Rate, PEEP and IERatio) to achieve an intended output.
- Team members, mentor
 - Mentor: Dr Antwan D. Clark
 - Team Members: Haoyu Shi, Jiahe Xu
- Short statement of relevance/importance
 - Requires Less Input from Clinicians(Professional Personnel)
 - More Accurate Decisions without the need of manual calculations
 - Real Time Monitoring and Adjustments
 - Consistent and Predictable Performance
- Short technical summary of approach
 - Build a mathematical model of a Pressure Controlled Ventilator(PCV) to simulate responses and status of lung
 - Derive the MDP model of PCV controller from the collected simulation Data

- Apply reinforcement learning to get an advanced controller
- To evaluate the performance, survival analysis and similar statistical methods are planned to be used with the MIMIC-III dataset in constructing the reward function.
- List of “deliverables” (min, expected, max)
 - Min: (4/4/2022)
 - Build a reliable mathematical lung model and a Pressure Control Ventilator model
 - Train a RL agent that automatically makes decisions to adjust the parameters
 - Expected:(4/18/2022)
 - Initial proof of concepts of MDP in ventilator controller
 - Documented code and performance metrics
 - Max:(4/28/2022)
 - Improving Based on Feedbacks from Clinicians or Evaluation Metrics
 - Conference Paper
- Key dates & assigned responsibilities
 - All work is expected to be done in collaboration
 - Completion of Simulation Model(2.21.2022)
 - Choosing from Papers(2.14.2022)
 - Completion(2.21.2022)
 - Producing Markov Decision Model(3/18/2022)
 - Data Collection(2/25/2022)
 - Flow Related(3/4/2022)
 - Volume Related(3/7/2022)

- Pressure Related(3/11/2022)
 - Driving-pressure/Other Possible Output Parameters Related(3/14/2022)
 - Build RL environment(3/21/2022)
 - Build MDP model in AI-GYM environment(3/21/2022)
 - Build Interface Linking Python and Simulink Inputs(3/21/2022)
 - Train the RL agent(4/4/2022)
 - Explore Possible Networks(3/25/2022)
 - Train Networks(4/4/2022)
 - Evaluate Results(4/18/2022)
 - Explore Various Metrics(4/11/2022)
 - Compare Results Among Different Networks(4/18/2022)
 - Using Feedbacks to Improve Model(4/28/2022)
 - Note: This is the Maximum Deliverable, will be carried out if time permitting
 - Collect Feedback(4/21/2022)
 - Explore Ways of Improving(4/28/2022)
 - Completing Report and Documentations(5/5/2022)
- List of dependencies & plan for resolving

Name	Method	Alternative	Impact	Status	Responsible Personnel
MIMIC III Dataset	Apply for access	Simulation	Affect Training Results	Waiting for Approval	Haoyu Shi

Computer for Training Datasets	Google Cloud	NA	Unable to finish training	Not Started	Haoyu Shi, Jiahe Xu
Interface between simulink and python	Self Constructed	Rebuild lung model in python	Need a week or two to migrate the code.	Completed	Jiahe Xu

- Management Plan
 - Our Data and Code will be stored in a private repository on Github
 - Meetings twice a week with Dr Antwan D. Clark(Mondays and Fridays at 1pm)
 - Communications between Team members and Mentors through Hopkins email
- Reading list
 - Messina, Z. (2021, August 2). Pressure controlled ventilation. StatPearls [Internet]. Retrieved February 22, 2022, from <https://www.ncbi.nlm.nih.gov/books/NBK555897/>
 - Mohammad Jaber, Lara Hamawy and Mohamad Hajj-Hassan et al. MATLAB/Simulink Mathematical Model for Lung and Ventilator. DOI: 10.1109/ICM50269.2020.9331820
 - H. Y. Al-Hetari, Y. Alginahi, M. N. Kabir, N. Q. Al-Naggar, M. A. Al-Rumaima and M. M. Hasan, "Modeling Lung Functionality in Volume-Controlled Ventilation for Critical Care Patients," 2020 IEEE 2nd International Conference on Artificial Intelligence in

Engineering and Technology (IICAET), 2020, pp. 1-4, doi:
10.1109/IICAET49801.2020.9257851.

- Al Naggari, N.Q. (2015). Modelling and Simulation of Pressure Controlled Mechanical Ventilation System. Journal of Biomedical Science and Engineering, 08, 707-716.
- Yan Shi, Shuai Ren, Maolin Cai, Weiqing Xu, Qiyong Deng, "Pressure Dynamic Characteristics of Pressure Controlled Ventilation System of a Lung Simulator", Computational and Mathematical Methods in Medicine, vol. 2014, Article ID 761712, 10 pages, 2014.
<https://doi.org/10.1155/2014/761712>
- Talebi, S. (2021, January 8). The wavelet transform. Medium. Retrieved February 28, 2022, from
<https://towardsdatascience.com/the-wavelet-transform-e9cfa85d7b34>