Using Machine Learning to Predict Arterial Compliance

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SHINE Summer High School Intensive in Next-Generation Engineering

Introduction

Professor Pahlevan's research team, which includes Soha Niroumandi and Coskun Bilgi, focuses on studying the dynamics of the cardiovascular system using computational and experimental tools. As an example, they recently designed a physiologically accurate in-vitro setup that models the left side of the heart including left ventricle (connected to a programmable pump for modeling cardiac contraction and relaxation), left atrium, aorta and all its branches. Using such a setup, they can collect accurate data from different anatomical sites and model various cardiovascular diseases (CVDs). The setup can also be used for building an inclusive database for future studies.

Objective & Impact of Professor's Research

The research being done at the USC Medical Flow Physics Lab will go towards studying the physiology of cardiovascular system through experimental and numerical approaches:

- Developing experimental tools and devices for collecting data e.g., the mechanical setup that models circulatory system
- Developing a database with information that can indicate CVD risk factors and their relation to the physiological measurements of patients.
- Creating more effective ways for diagnosis and prognosis of CVDs using machine learning.

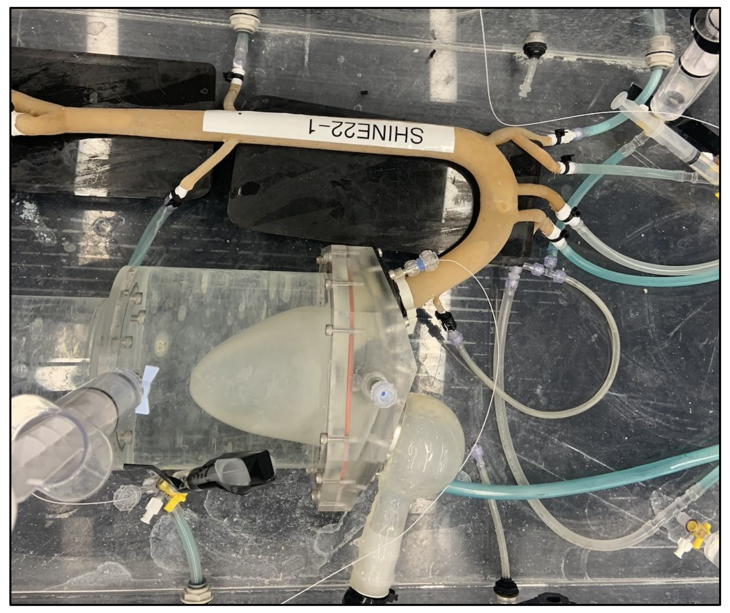

Figure 1: Artificial aorta, left ventricle (LV) and left atrium (LA) in the mechanical setup. PC: Christopher Lopez

Skills Learned

Throughout the program, I was introduced to numerous new concepts and skills that I had little to no knowledge of before. I was able to learn:

- Coding in Python language.
- What machine learning is and how it applies in real-world problems
- How to develop a simple neural network

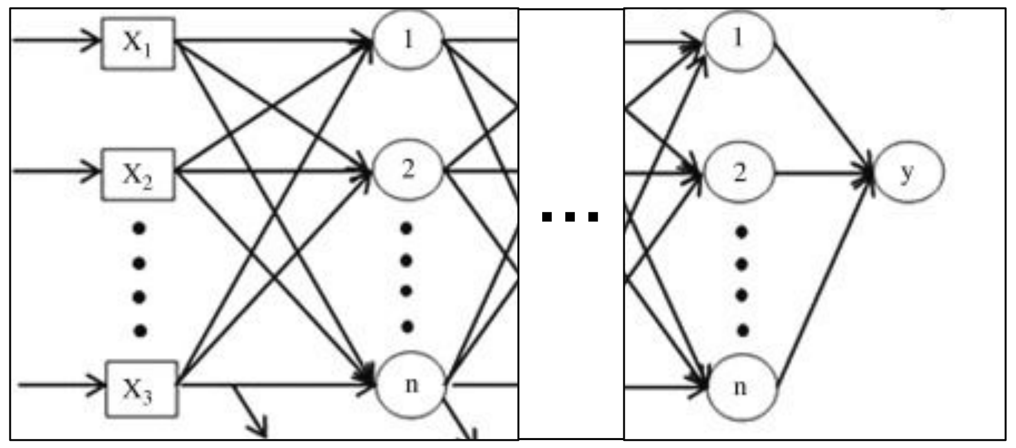

Figure 2: Neural network. "Intelligent Data Analysis for Biomedical Applications." by N.J. Sairamya, L. Susmitha, S. Thomas George, and M.S.P. Subathra, 2019, Copyright 2019 by Elsevier Inc.

- How to fabricate artificial organs including human-scale aorta, left atrium (LA), and left ventricle (LV) using both latex and silicone material.

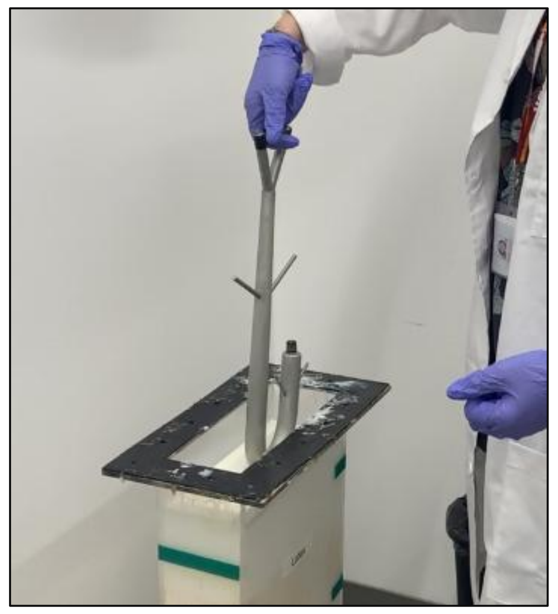

Figure 3: Fabricating an artificial aorta by dipping it in latex. PC: Christopher Lopez

- How to collect data using a tonometry-based device like Vivio.

Figure 4: Vivio Niema device. "Proof-of-concept for a non-invasive, portable, and wireless device for cardiovascular monitoring in pediatric patients." by Jennifer Miller, Jennifer Shepherd, Derek Rinderknecht, Andrew Cheng, and Niema Pahlevan, 2020.

Methods & Results

For my final project, I was tasked with using the data from Framingham Heart Study database (including a cohort of 6698 female and male participants with a wide age range of 19 to 90) to train a machine learning model for predicting total arterial compliance, which is an indicator of CVD.

To achieve this, I coded a neural network (shown in Figure 2) using TensorFlow framework. Below are my model details:

- Input features: 13
- Output: 1
- Learning rate: 1e-4
- Width: 15
- Depth: 10

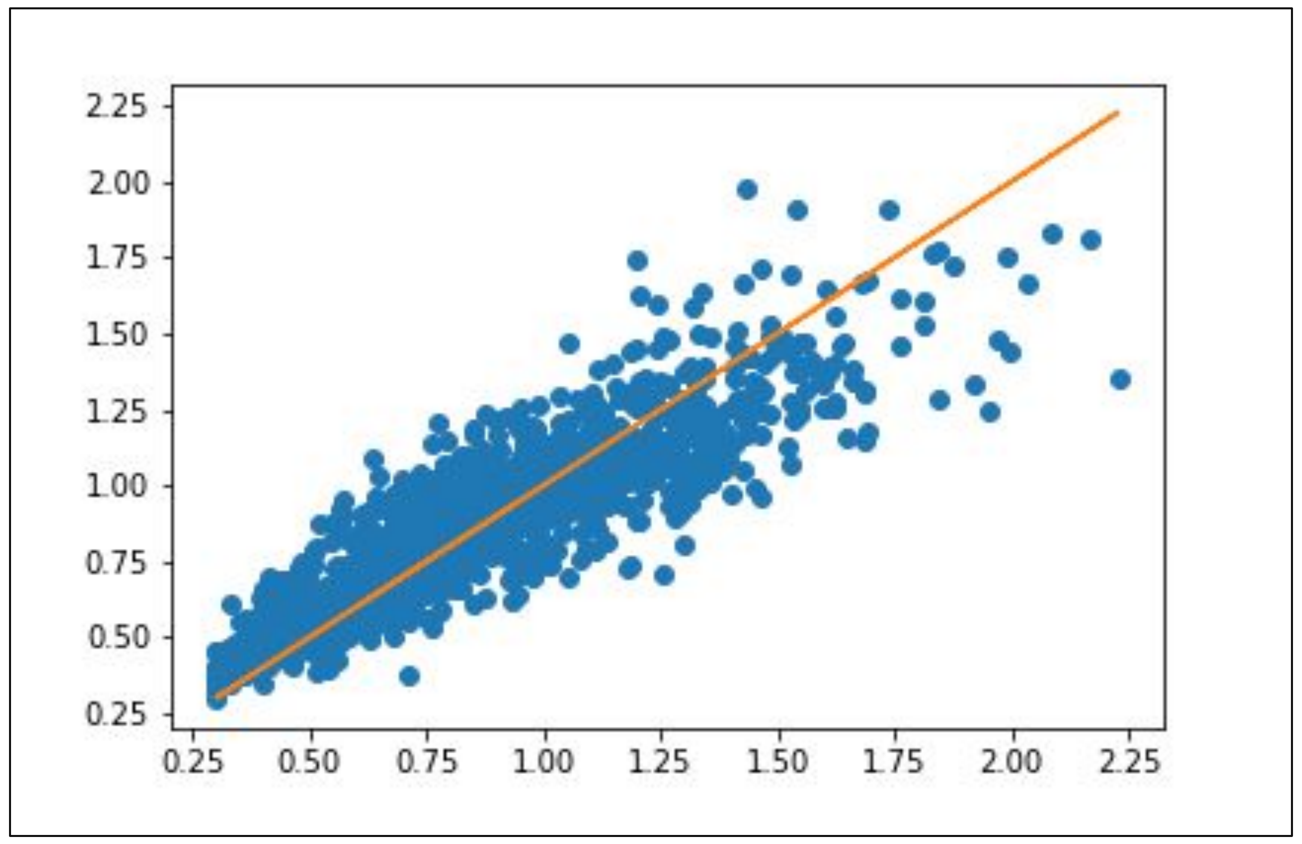

Figure 5: Plot of total arterial compliance based on data from FHS-Cohort. PC: Christopher Lopez

Once I ran my code and received a prediction, I was able to acquire a correlation coefficient of 0.87, which is extremely great as it demonstrates a strong correlation between the target and the predicted values. This meant that my neural network could predict compliance well and, as total arterial compliance is a biomarker for CVD, it can successfully aid with studying the possibility of CVDs, including heart failure.

Advice for Future SHINE Students

My advice to any future SHINE student would be to value the time they have in the program. 7 weeks looks like a lot on paper but it passes by so quickly that one is left wondering what even happened. Use the time you have to immerse yourself in your lab and have initiative. Do what you can and help in any way possible. Also, the people at SHINE are amazing so don't be afraid to branch out and meet new people.

Acknowledgements

I would like to thank Soha, Coskun, and Professor Pahlevan for their support, patience, kindness, and amazing guidance throughout SHINE. I wouldn't have been able to do anything without my mentors. I would also like to thank Dr. Mills, my center mentor Marcus Gutierrez, Monica Lopez, my lab mates, and the whole SHINE team for making this such a wonderful and educational experience that I will never forget. Special thanks to Steven Dorfman who made it possible for me to participate in this program and take part in such amazing research. Finally, thank you to my parents for being my biggest supporters. Thank you to everyone.