Correcting Racial Bias in Measurement of Blood Oxygen Saturation

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Hugging Face Link
Tableau Dashboard Link

Motivation

Respiratory epidemics occur; people need a way to monitor blood oxygenation at home, especially during hospital surges.

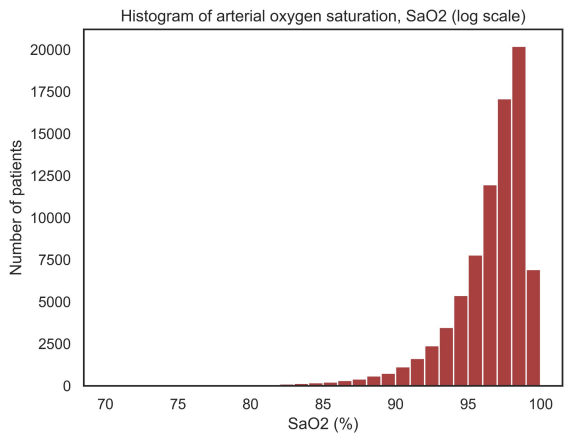
Occurrences of hidden hypoxemia have been found to disproportionately affect patients of color, since skin pigmentation interrupts oximeter operation.

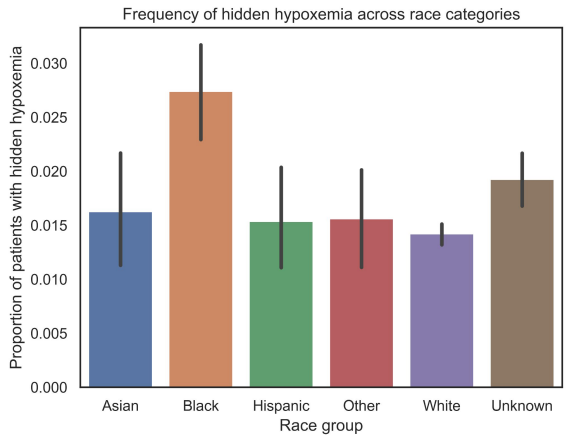
Goal: Develop models that accurately predict arterial blood oxygen saturation and hidden hypoxemia.

Source: MichiganDaily.com

Exploratory Data Analysis

- Data source: Publicly available dataset of de-identified medical records from ≈50,000 unique patients at Beth Israel Deaconess Medical Center in Boston, MA, between 2008 - 2019.

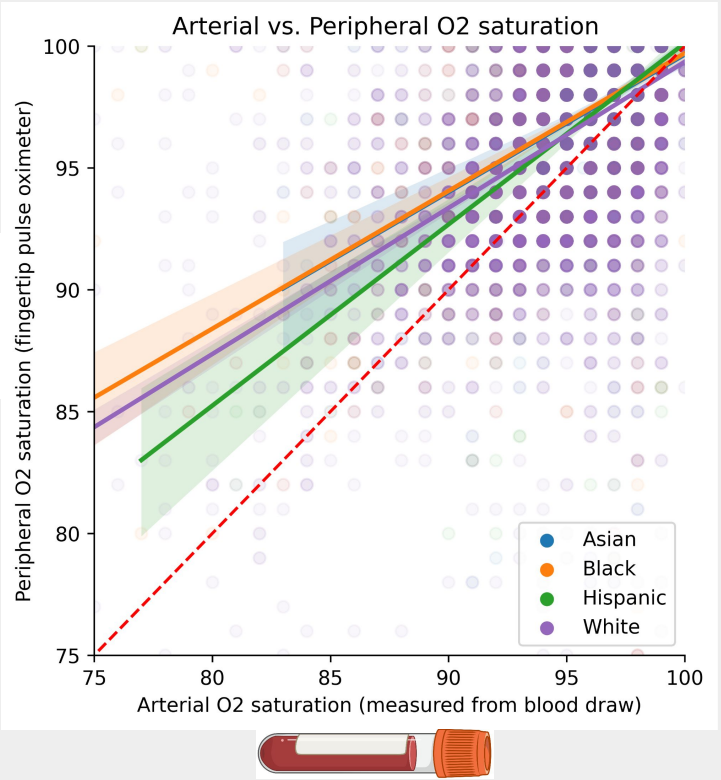




1. Most patients have healthy blood oxygen levels; **blood oxygen saturation skewed toward 100**
2. **Prevalence of hidden hypoxemia differs among race groups**
3. **Only 1.6% of patients have Hidden Hypoxemia** (over 98% do **not** have hidden hypoxemia)

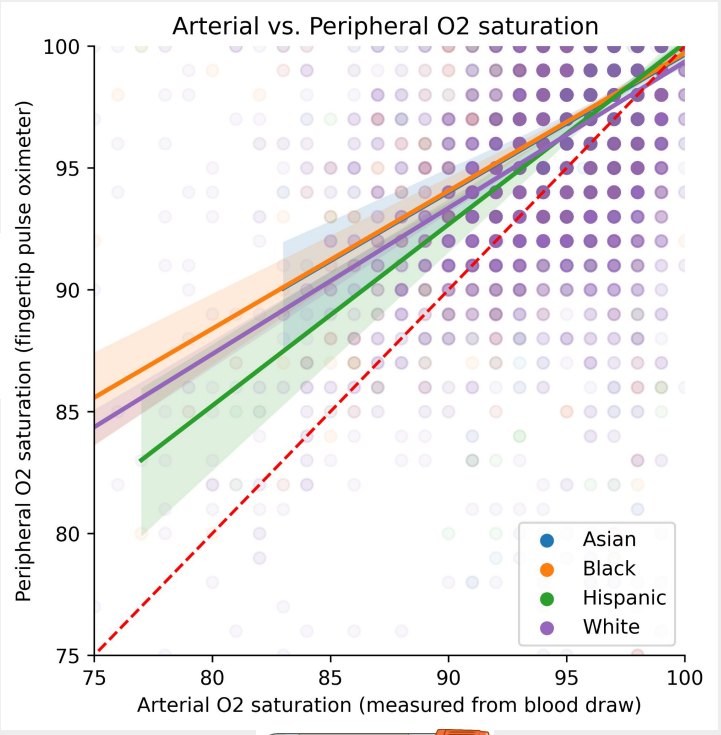
- **GOAL:**
  Fitting Regression to predict SaO2 and fitting classification to predict hidden hypoxemia.

Finding a better predictor for oxygen saturation

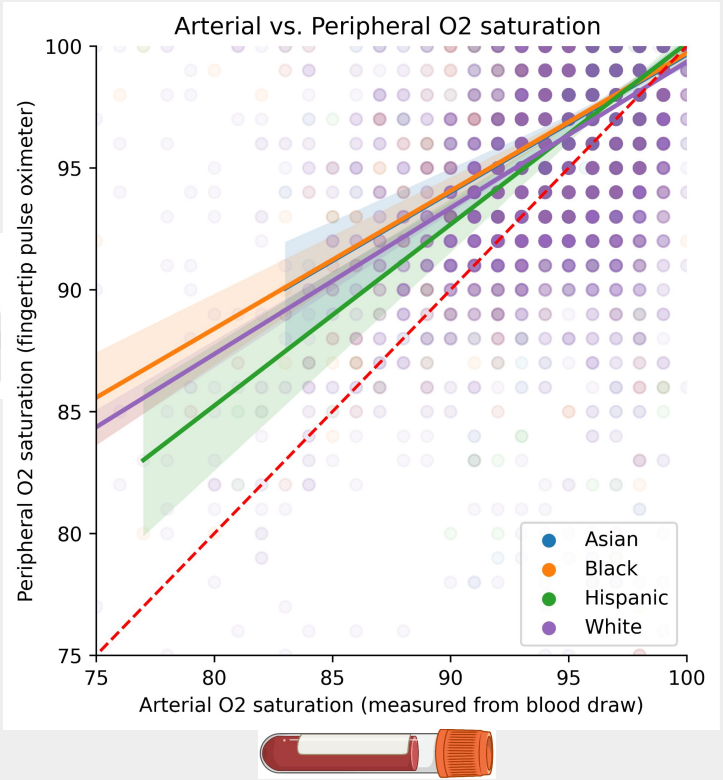


- Peripheral (fingertip) O2 saturation (y-axis) overestimates oxygen saturation compared to blood-drawn arterial value (x-axis)
- Overestimate is worst for patients self-identifying as Black (orange line)
- High values overrepresented in dataset (= most patients had healthy oxygen levels)
  - Use ensembled undersampling to account for this

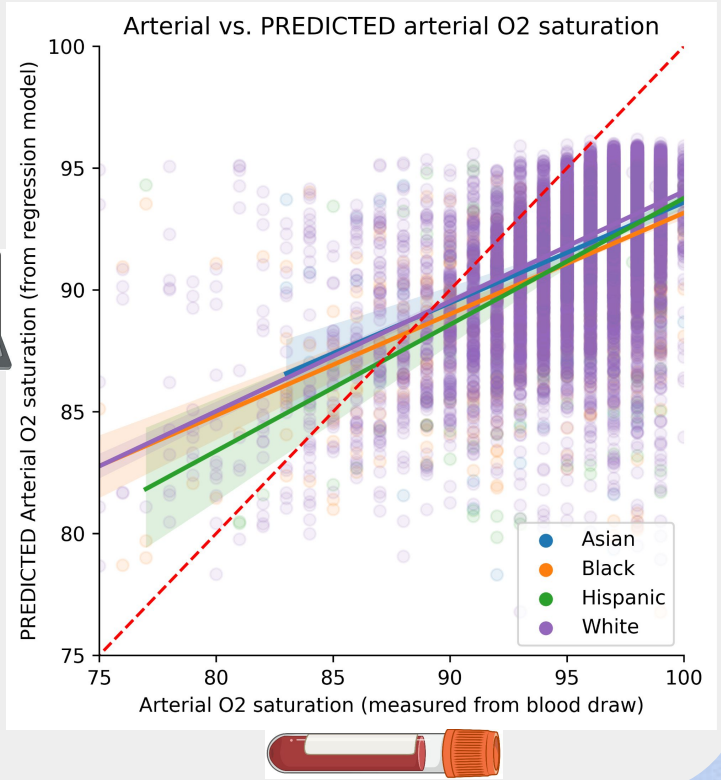
Pulse oximeter



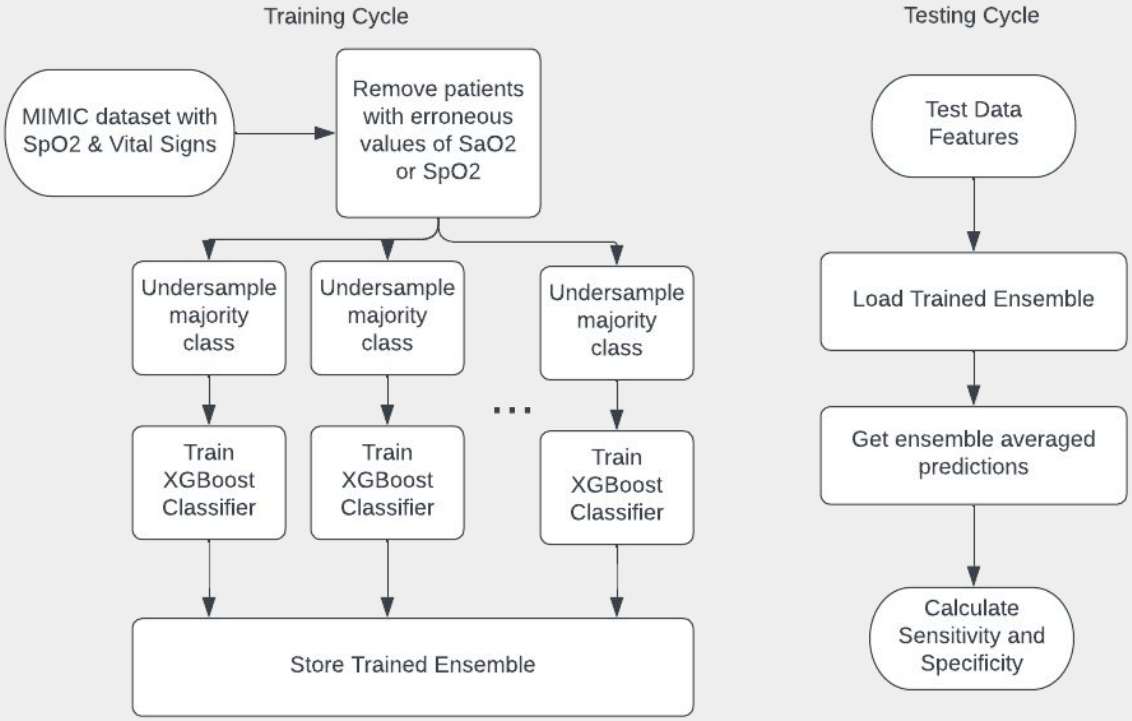
Pulse oximeter



Model result



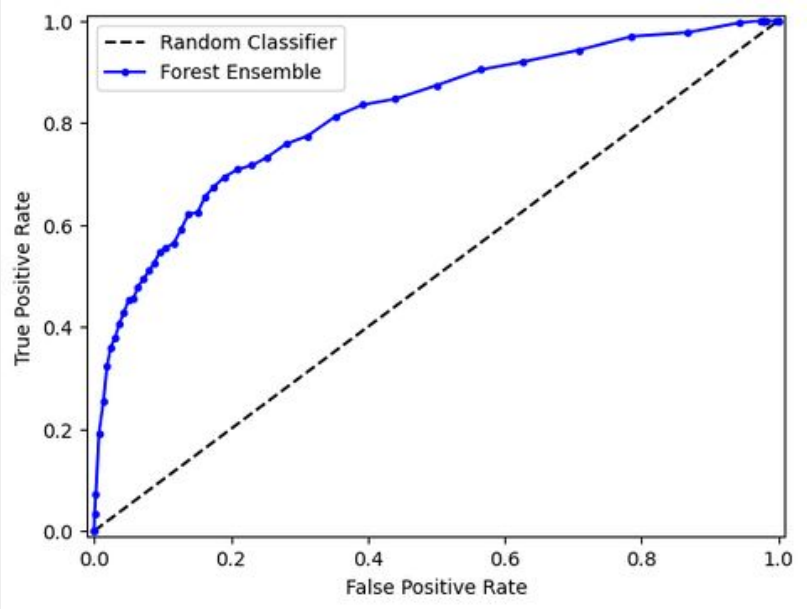
Hidden Hypoxemia Classification



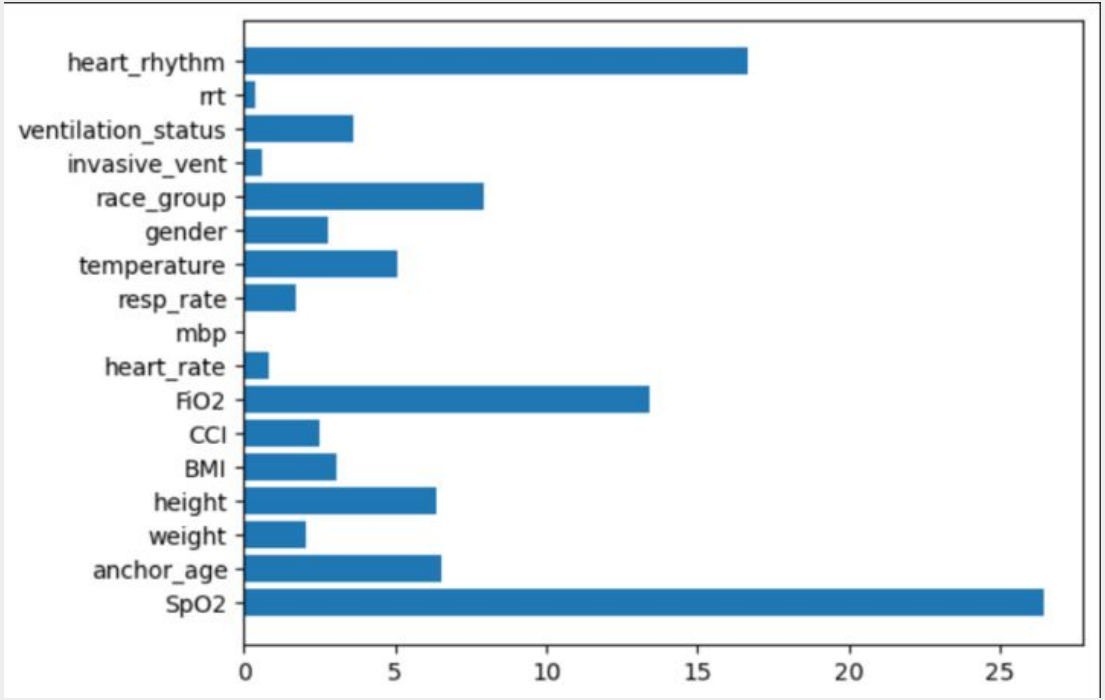
Accuracy measures

- Simply calculating accuracy is not good enough; we look at **sensitivity** (true positive rate), **specificity** (true negative rate) and their sum (J-statistic).

- Our model is able to identify **7 out of 10 people** correctly as having hidden hypoxemia while not sacrificing specificity (true negative rate).

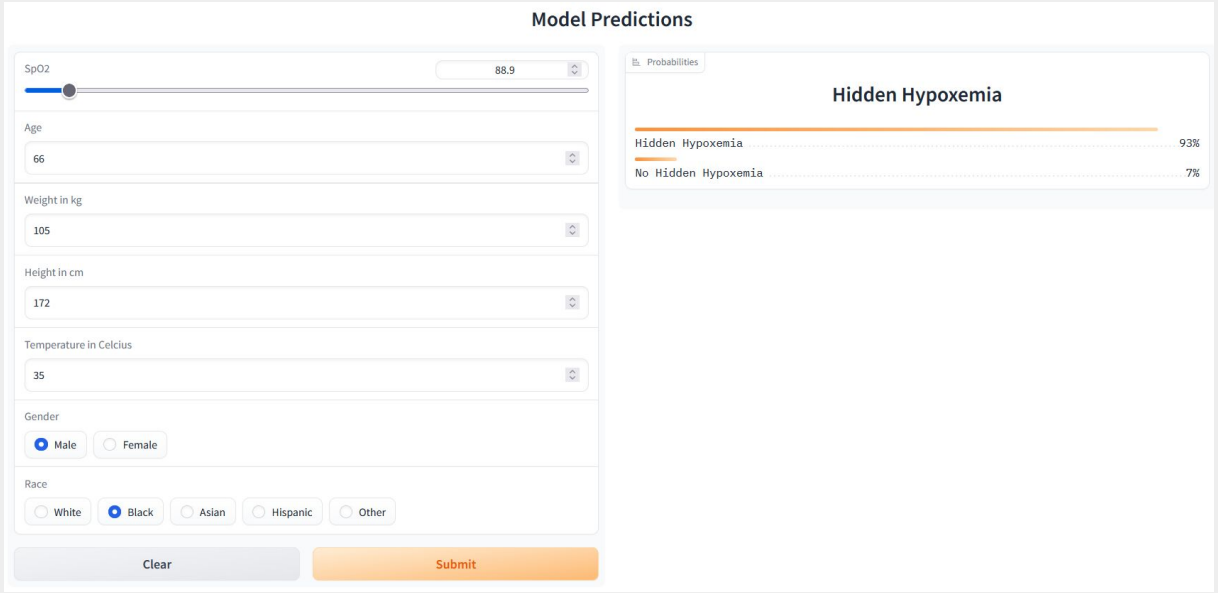


Ensemble Averaged Feature Importances



Conclusions and Next Steps

- Confirming our premise, we found race to be an important variable for our model.
- Ideally our model would use skin pigmentation rather than race.



Hugging Face Link

Acknowledgements

Thank you to Roman Holowinsky, Matt Osborne, Alec Clott, Olivia Haimerl, and the Erdös Institute for their support throughout the Spring 2023 boot camp.

Thank you to Kenny Chou for his mentorship throughout the project.

And finally, thank you to the PhysioNet team for the dataset, and the MIT Critical Datathon 2023 for presenting this data challenge.

Dataset references:

Matos, J., Struja, T., Restrepo, D. S., Nakayama, L. F., Gallifant, J., Weishaupt, L., Mullangi, N., Loureiro, M., Shapiro, S., Carrel, A., & Celi, L. A. (2023). MIT Critical Datathon 2023: a MIMIC-IV Derived Dataset for Pulse Oximetry Correction Models (version 1.0.0). *PhysioNet*. https://doi.org/10.13026/jfpc-pz79.

Goldberger, A., Amaral, L., Glass, L., Hausdorff, J., Ivanov, P. C., Mark, R., ... & Stanley, H. E. (2000). PhysioBank, PhysioToolkit, and PhysioNet: Components of a new research resource for complex physiologic signals. Circulation [Online]. 101 (23), pp. e215–e220.

Predict arterial oxygen saturation (SaO_2)