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UNIVERSITY OF TECHNOLOGY




UNIVERSITY OF GOTHENBURG

# Enhancing a Deep Learning Camera-Based Approach for Heart Rate Detection in Vehicles Using Non-Functional Requirements

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# Introduction

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- Heart rate monitoring to detect sudden illness using remote photoplethysmography and deep learning
  - Challenge of using Requirements Engineering (RE) in Machine Learning (ML)
  - The goal is to enhance a deep learning model based on quality attributes



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# Research Questions

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- **RQ1:** What are the challenges associated with consistently monitoring heart rate in diverse driving conditions?
  - **RQ2:** How can explainability contribute to understanding and enhancement of a deep learning approach?
  - **RQ3:** How do robustness and reliability quality attributes play a role in systematically evaluating and enhancing a deep learning approach?
  - **RQ4:** What recommendations can be produced for software engineers based on the process of enhancing a deep learning model?

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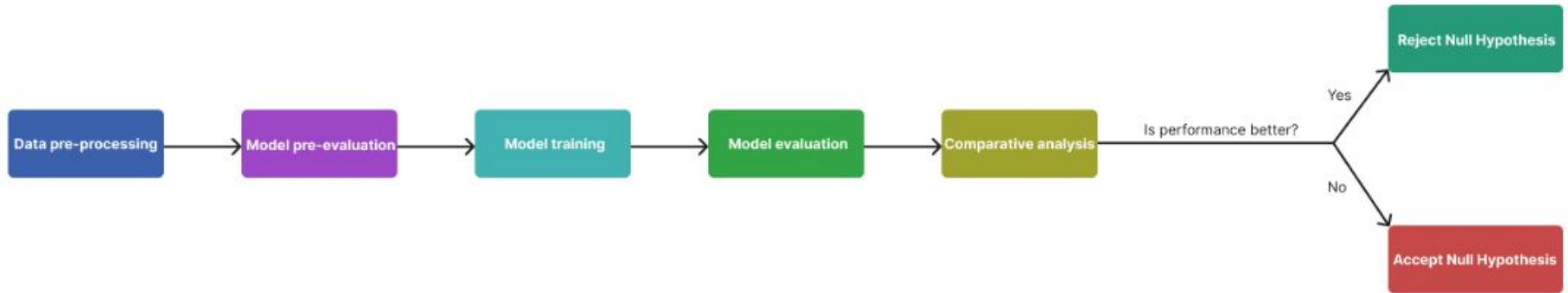
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# Research methodology

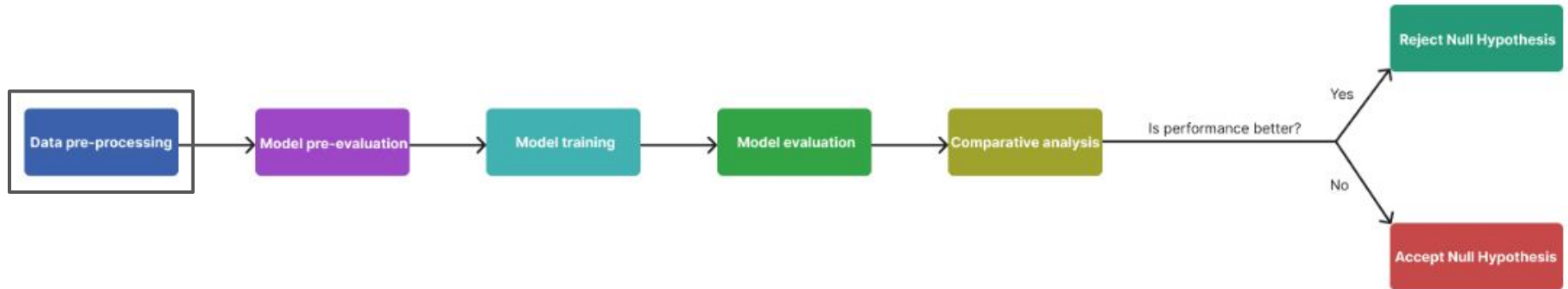


- Using field experiment to compare and evaluate deep learning models
- Iterative steps of enhancement and Null Hypothesis
- Literature review



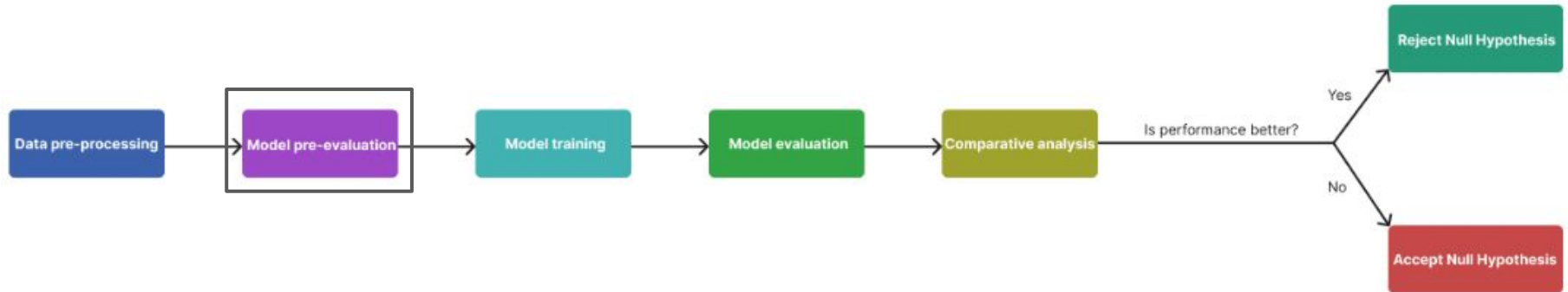
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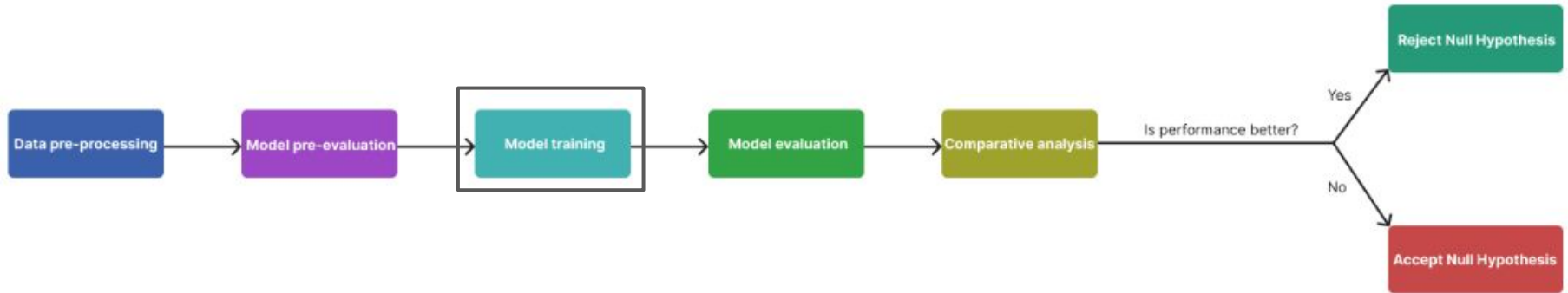
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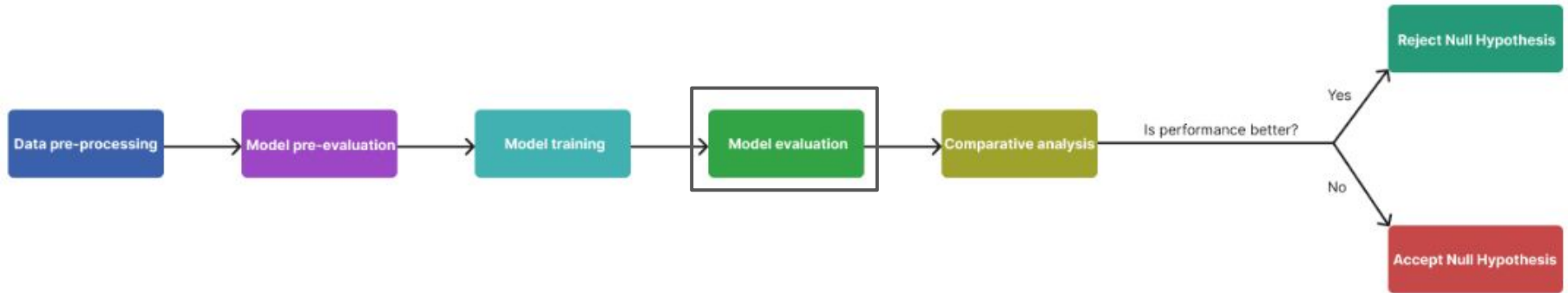
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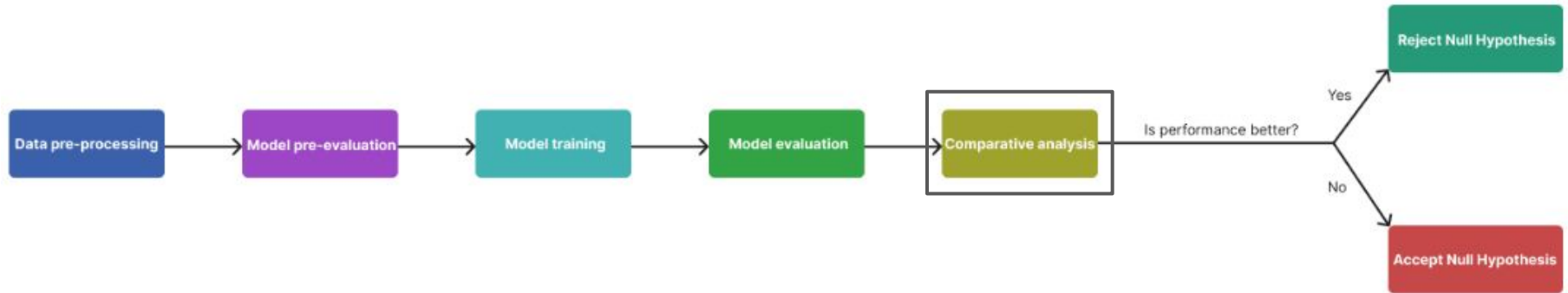
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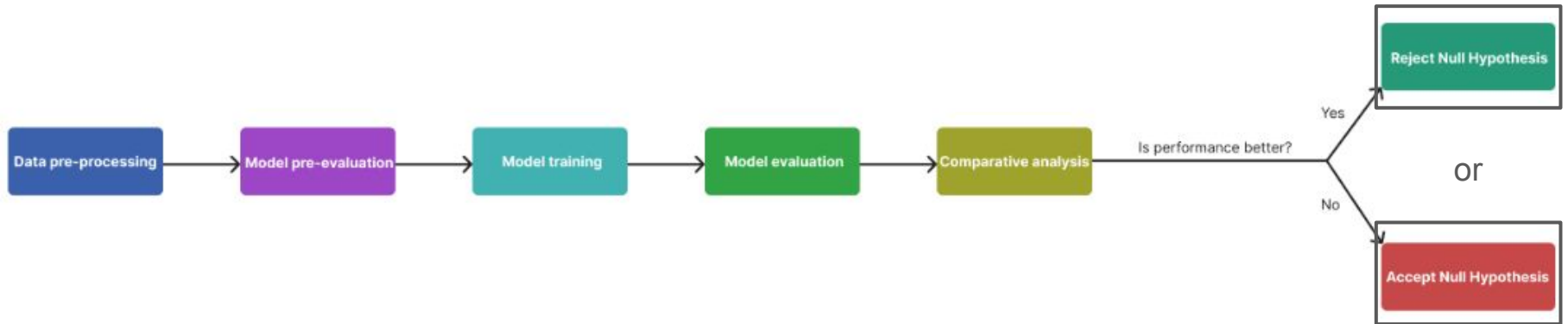
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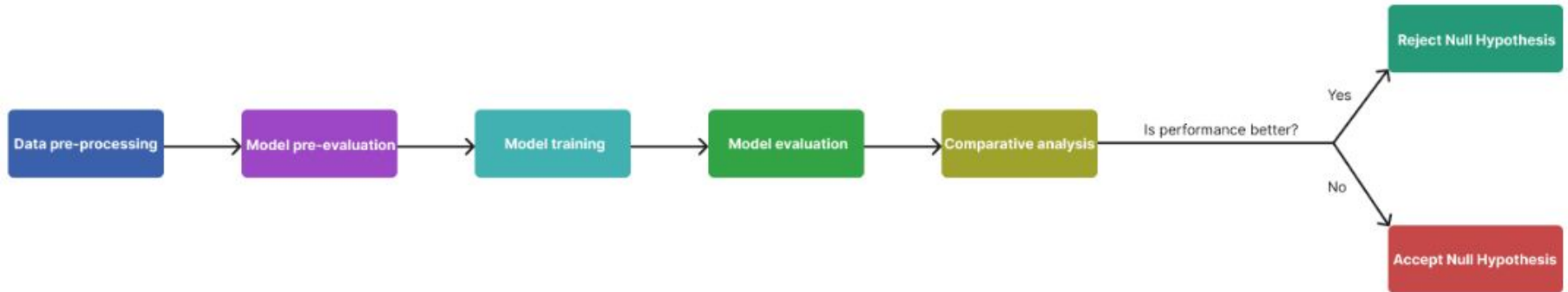
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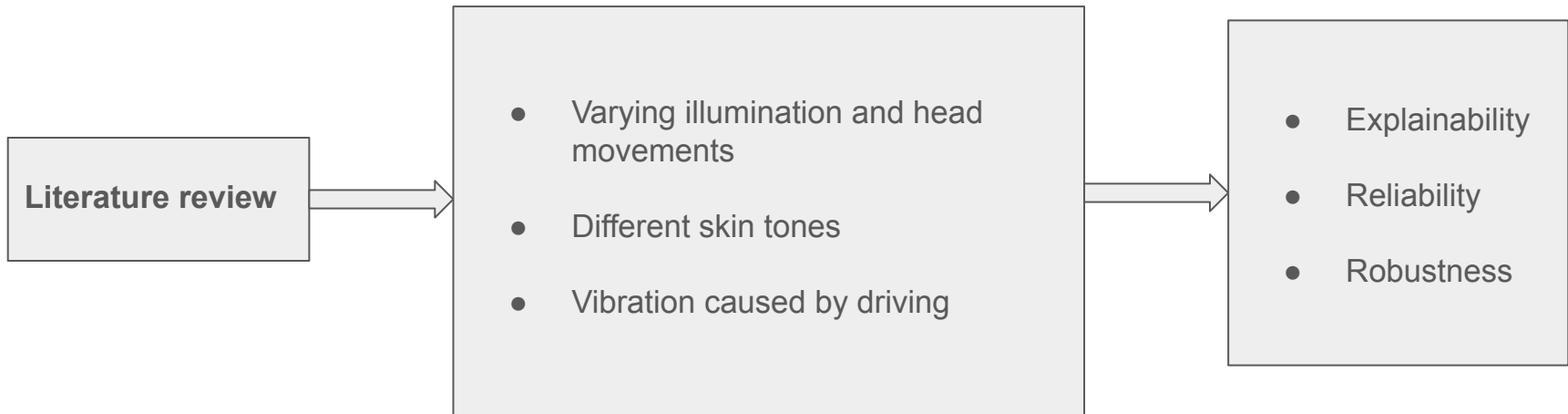
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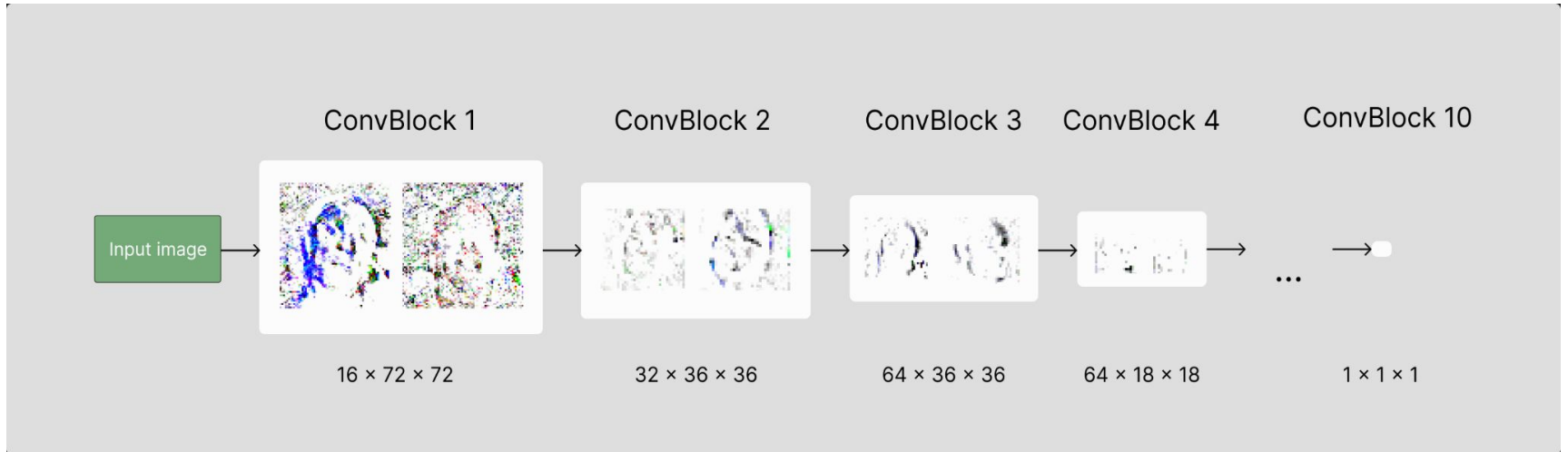
# Results & Discussion

**RQ1:** What are the challenges associated with consistently monitoring heart rate in diverse driving conditions?



# Results & Discussion

**RQ2:** How can explainability contribute to understanding and enhancement of a deep learning approach?



# Results & Discussion

**RQ3:** How do robustness and reliability quality attributes play a role in systematically evaluating and enhancing a deep learning approach?

Models	MAE	RMSE	MAPE	SNR
PhysNet(Pre-enhanced)	4.2827	9.0170	5.6655	2.0243
<b>PhysNet(Enhanced)</b>	<b>4.2966 ↓</b>	<b>9.2360 ↓</b>	<b>5.7370 ↓</b>	<b>2.4500 ↑</b>
PhysFormer	6.4194	11.0054	8.3306	-0.3872
DeepPhys	7.4537	12.6894	9.9498	-4.3735
TS-CAN	6.7798	11.7558	9.1654	-4.1959

*Average results across all five folds for all the models*

Fold	Models	MAE	RMSE	MAPE	SNR
1	PhysNet(Pre-enhanced)	4.7251	8.7611	6.8127	-0.0911
	<b>PhysNet(Enhanced)</b>	<b>4.0094</b>	<b>8.5693</b>	<b>6.1740</b>	<b>2.1791</b>
2	PhysNet(Pre-enhanced)	3.6425	8.4647	5.6647	2.2839
	<b>PhysNet(Enhanced)</b>	<b>3.7695</b>	<b>8.5475</b>	<b>5.9132</b>	<b>2.7771</b>
3	PhysNet(Pre-enhanced)	2.7244	5.8102	3.9590	3.1817
	<b>PhysNet(Enhanced)</b>	<b>3.0690</b>	<b>6.3595</b>	<b>4.5107</b>	<b>2.9616</b>
4	PhysNet(Pre-enhanced)	5.7843	13.1602	6.1664	1.5952
	<b>PhysNet(Enhanced)</b>	<b>6.7007</b>	<b>14.7606</b>	<b>7.1017</b>	<b>1.4591</b>
5	PhysNet(Pre-enhanced)	4.5375	8.8888	5.7248	3.1519
	<b>PhysNet(Enhanced)</b>	<b>3.9351</b>	<b>7.9442</b>	<b>4.9859</b>	<b>2.8733</b>

*Performance of enhanced and pre-enhanced on five folds*

# Results & Discussion

Robustness FOLD6

Models	MAE	RMSE	MAPE	SNR
<b>PhysNet(Enhanced)</b>	<b>0.5530 ↑</b>	<b>2.2765 ↑</b>	<b>0.7830 ↑</b>	<b>9.8815 ↑</b>
PhysNet(Pre-enhanced)	0.5715	2.3915	0.8070	9.6955

# Results & Discussion

**RQ4:** What recommendations can be produced for software engineers based on the process of enhancing a deep learning model?



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Identify the relevant non-functional requirements

Analyze the tradeoffs

Choose relevant explainability tools

# Conclusion and Future Work

- Importance of using non-functional requirements for model evaluation
- Understanding the effectiveness of using non-functional requirements on ML models

