Image Classification using Transfer Learning (Potholes Detection)

A Research Proposal Presentation

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Research Context / Background

Introduction to the Problem: Potholes in roads cause safety hazards and financial burdens.

Current Scenario: The South African government has spent R22 billion in the past 3 years on pothole repairs.

Role of AI in Image Classification: Automating pothole detection using deep learning models can improve road maintenance efficiency.

Research Problem

- **Identified Gap:** Manual pothole detection is inefficient and prone to human error.
- **Research Question:** How can transfer learning improve the accuracy of pothole detection in road images?
- **Justification:** Transfer learning can leverage pre-trained deep learning models to reduce computational cost and enhance model performance.

Research Aim and Objectives

Aim: To develop an image classification model using transfer learning for pothole detection.

Objectives:

- To preprocess and analyze the MIIA pothole dataset.
- To implement and compare different transfer learning models.
- To evaluate model performance based on accuracy and other metrics.
- To optimize hyperparameters for improved classification results.

Literature Review

Author	Title	Year	Methodology	Findings	Gap
Naushad et al.	Deep Transfer Learning for Land Use and Land Cover Classification	2021	Applied transfer learning using VGG16 and WRNs for land use classification	WRNs outperformed previous methods with 99.17% accuracy.	Limited focus on real-time classification and diverse geographical datasets.
Cheng et al.	Multi-Domain Collaborative Transfer Learning for Underwater Image Classification	2022	Used MDCTL with multi-scale attention for sonar image classification	Achieved 99.21% accuracy, improving over fine-tuned VGG19.	Requires further validation on diverse sonar environments.
Ayana et al.	Multistage Transfer Learning for Ultrasound Breast Cancer Image Classification	2022	Applied MSTL with pre-trained EfficientNetB2, InceptionV3, and ResNet50	ResNet50-Adagrad achieved 99% accuracy.	Needs further validation across different imaging modalities.
Paymode & Malode	Transfer Learning for Multi-Crop Leaf Disease Classification	2022	Used CNN-based VGG for disease classification in crops.	Achieved 98.40% accuracy for grapes and 95.71% for tomatoes.	Requires larger dataset validation and real-world testing.
Gulzar	Fruit Image Classification using MobileNetV2 with Deep Transfer Learning	2023	Used MobileNetV2 with transfer learning for fruit classification.	Achieved 99% accuracy, outperforming other deep learning models.	Requires deployment validation in real-time applications.

Research Methodology

Approach: Experimental, quantitative research.

Research Strategy:

- Train, validate, and test deep learning models using transfer learning.
- Compare multiple architectures (ResNet, VGG16, EfficientNet).
- Optimize model performance via hyperparameter tuning.

Data Collection & Processing:

- Dataset: MIIA Pothole Image Classification Challenge.
- Preprocessing: Image augmentation, normalization, resizing.

Research Philosophy and Approach

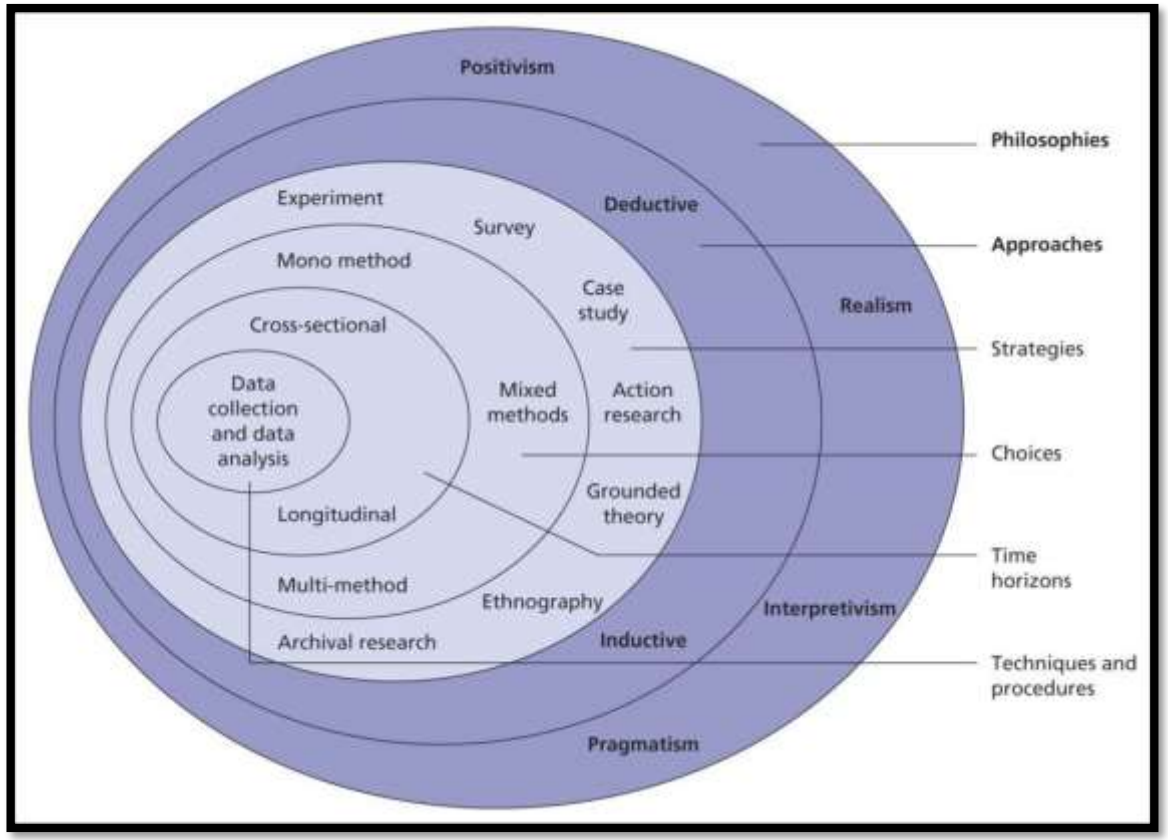
Philosophical Basis:

- **Positivism:** Data-driven, empirical analysis.

Research Approach:

- **Deductive:** Hypothesis-driven model evaluation.

Time Horizon: Cross-sectional



Model Development Process

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Step 1: Data Preprocessing

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Step 2: Implementing Transfer Learning (ResNet, VGG16, MobileNet)

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Step 3: Model Training and Fine-tuning

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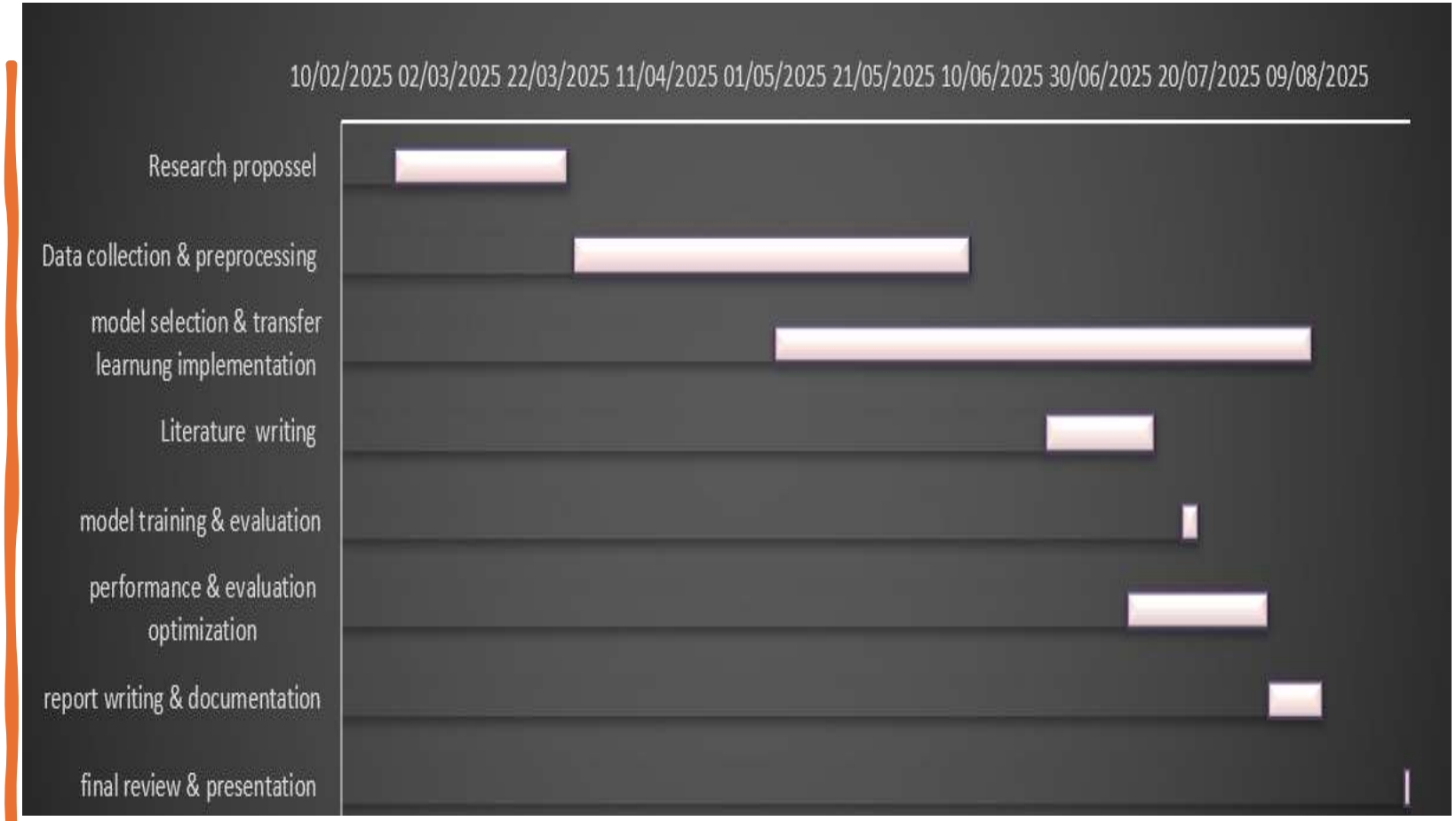
Step 4: Performance Evaluation (Accuracy, Precision, Recall, F1-score)

5

Step 5: Interpretation of Results

Project Planning and Resources



- **Tools & Technologies:**
  - Python, TensorFlow, Keras, OpenCV, Pandas, NumPy.
- **Hardware Requirements:**
  - GPU-accelerated computation (Google Colab)

Project Impact and Limitations

Impact:

- Improved road safety by enabling automated pothole detection.
- Reduced maintenance costs and faster response times.

Limitations:

- Dataset limitations (specific to South Africa, may not generalize well).
- Model dependency on high-quality images.
- Computational challenges for real-time deployment.

Ethical Considerations

Data Privacy: Use of publicly available images, no personal data collection.

Bias Mitigation: Ensuring model fairness across different road conditions.

Transparency: Open-source model implementation.

Conclusion

- Application of transfer learning for pothole image classification.
- Potential to enhance road maintenance strategies.
- Future work: Real-time deployment and larger dataset training.

References

[1] Naushad, R., Kaur, T., & Ghaderpour, E. "Deep Transfer Learning for Land Use and Land Cover Classification: A Comparative Study," Sensors, vol. 21, no. 8083, pp. 1-13, 2021. DOI: 10.3390/s21238083.

[2] Cheng, Z., Huo, G., & Li, H. "A Multi-Domain Collaborative Transfer Learning Method with Multi-Scale Repeated Attention Mechanism for Underwater Side-Scan Sonar Image Classification," Remote Sensing, vol. 14, no. 355, pp. 1-25, 2022. DOI: 10.3390/rs14020355.

[3] Ayana, G., Park, J., Jeong, J.-W., & Choe, S.-w. "A Novel Multistage Transfer Learning for Ultrasound Breast Cancer Image Classification," Diagnostics, vol. 12, no. 135, pp. 1-14, 2022. DOI: 10.3390/diagnostics12010135.

[4] Paymode, A. S., & Malode, V. B. "Transfer Learning for Multi-Crop Leaf Disease Image Classification using Convolutional Neural Network VGG," Artificial Intelligence in Agriculture, vol. 6, pp. 23-33, 2022. DOI: 10.1016/j.aiia.2021.12.002.

[5] Gulzar, Y. "Fruit Image Classification Model Based on MobileNetV2 with Deep Transfer Learning Technique," Sustainability, vol. 15, no. 1906, pp. 1-14, 2023. DOI: 10.3390/su15031906.