MRI DL Models for Assisted Diagnosis of Knee Pathologies and Injuries:

A Systematic Review

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Introduction

Several studies have demonstrated that deep learning (DL) models can be effectively trained on MRI data to assist clinicians in identifying knee injuries and pathologies. This systematic review was conducted to explore the current landscape of existing DL models developed for detecting knee injuries and pathologies through magnetic resonance imaging (MRI) and to assess their potential clinical applications.

Methods

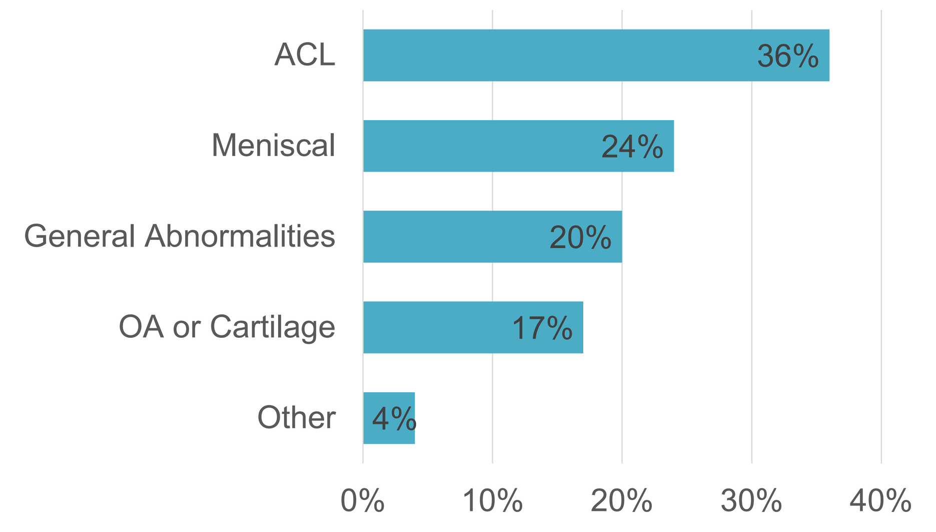
Five online databases were systematically searched from the 1st January 2013 until 12th May 2024 using the terms (magnetic resonance OR magnetic resonance imaging OR MRI) AND, (knee) AND (deep learning OR DL) AND (3D OR Three-dimensional). Selected inclusion criteria were used to screen publications by title abstract, and full text in Covidence. A data extraction template was utilised, and the synthesis of results was also facilitated by Covidence. Study quality was assessed by two independent reviewers to minimise the potential for bias. The final manuscript was structured according to The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist [1].

Results

General Study Information, Pathology, and Article Data Sources

- Fifty-four articles were included.
- 54% of the studies used local or private databases, while the rest employed open-access databases like MRNet (17%) and the OAI dataset (11%).

Pathology of Focus in Studies Analysed



CNN Architecture and Data Processing

- The DL models in this review primarily used the following CNNs: ResNet (21%), VGG (11%), DenseNet (8%), and DarkNet (6%).
- Whilst transfer learning was utilised in some studies, it did not significantly improve the performance of these models.

The **accuracy** of DL models in the **assisted detection** of knee pathology is **promising** for future **clinical implementation**, especially with the use of **pathology-specific** DL models.

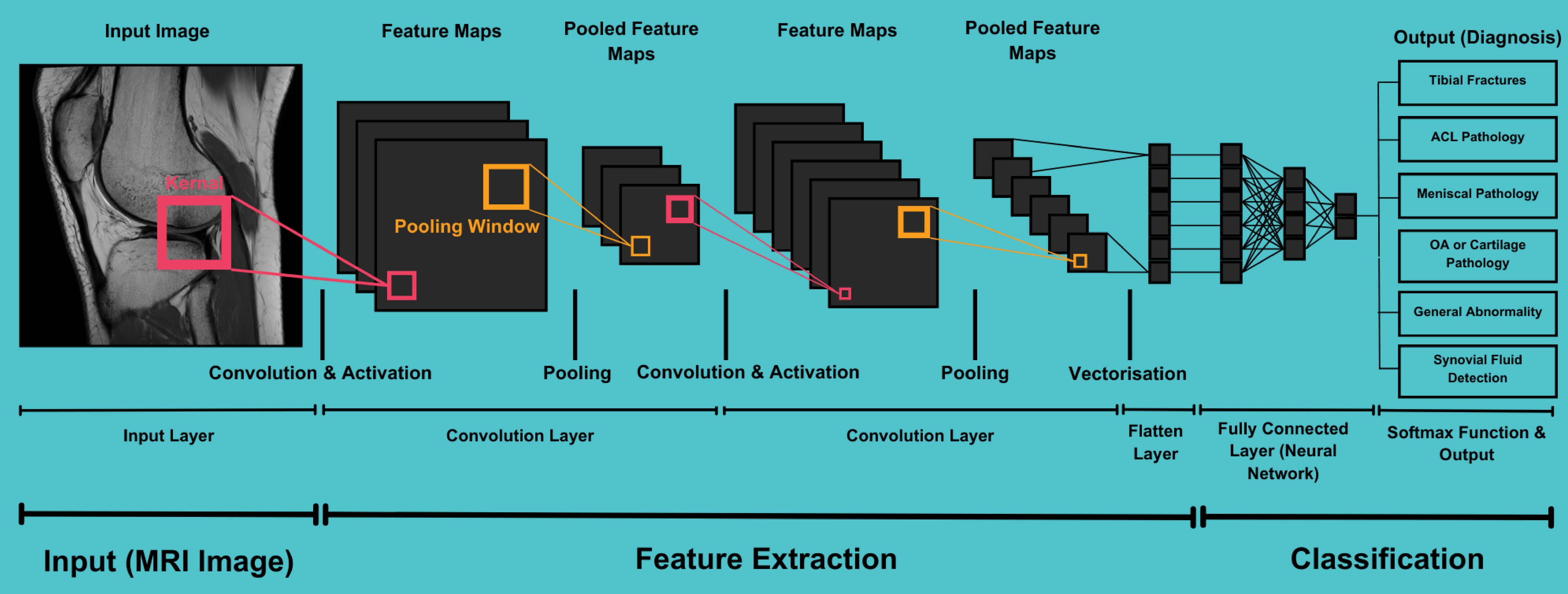
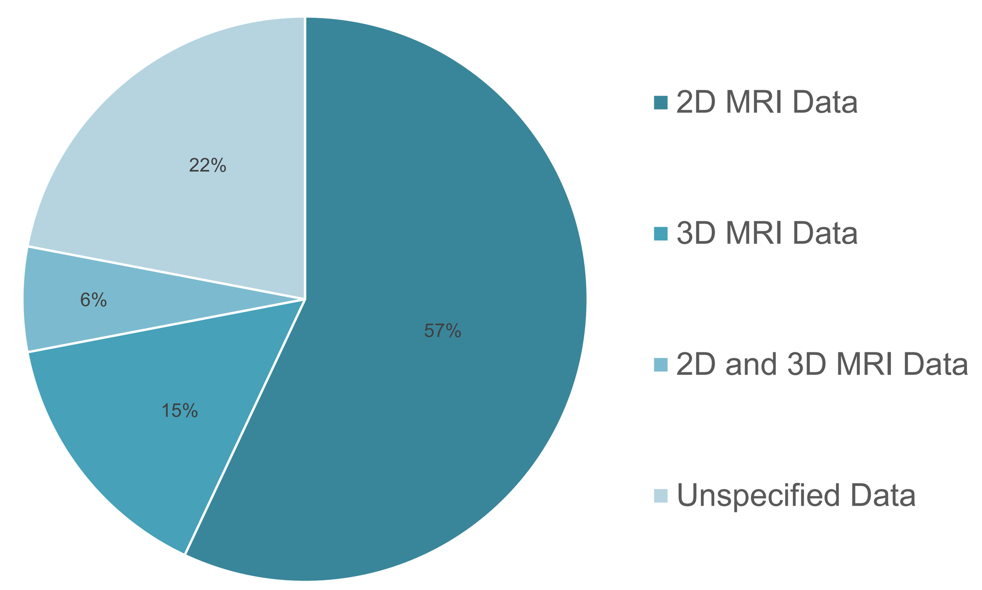


Figure 1: Example of a CNN architecture and its function showing a knee MRI image as input, extracting key features, and determining the output, or diagnosis.

MRI Data Used in Studies Analysed



Performance Outcomes and Ground Truth References

- DL models showed high-performance metrics compared to ground truth.
- DL models for the detection of a specific injury outperformed those by up to 4.5% for general abnormality detection.
- The utilisation of 2D MRI data yielded higher model performance averages.

Performance Factor	Sub-Set of Data	Average Specificity Value	Average AUC-ROC Value	Average Accuracy Value	Average Sensitivity Value
Pathology Focus	ACL Injuries	0.937	0.960	0.911	0.932
	Meniscal Injuries	0.869	0.893	0.863	0.809
	General Abnormalities	0.865	0.893	0.845	0.868
	Osteoarthritis or Cartilage Pathologies	0.887	0.924	0.883	0.874
	Synovial Fluid Detection	0.821	Not measured	0.868	0.893
	Tibial Fractures	0.932	Not measured	0.953	0.969

Conclusion

Despite the varied study designs used among the reviewed articles, DL models showed promising outcomes in assisted detection of selected knee pathologies by MRI. This review underscores the importance of validating these models with larger MRI datasets to close the existing gap between current DL model performance and clinical requirements.

Acknowledgements

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