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Knee Osteoporosis Diagnosis at an Early Stage Using a Fine-Tuned VGG19 Model on X-rays

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Abstract.

Knee Osteoporosis (KO) is a widespread degenerative disorder that erosion of strength of bone and fosters the possibility of fractures resulting in pain and impaired movement movements. Effective treatment is possible only in early stages of detection but there are cases when the traditional means of diagnosis, physical examination, and bone mineral density testing, do not detect abnormalities of the first stage. This research paper includes a trained VGG19 deep learning model that is tailored to distinguish between healthy and osteoporotic knee X-ray images. Transfer learning was deployed to use binary classification on the already trained VGG19 architecture which is popular with image classification. This model was trained and tested using a dataset of 1,258 training images, 315 validation images and 472 testing images. It showed excellent performance with a precision of 97.5 and high recall as well as F1- scores of 0.97 in each class. The confusion matrix showed few cases of misclassifications and false negatives were 12 and there were no false positives which shows that the model had good generalization. In general, this study demonstrates that deep learning, especially VGG19, is a suitable method to automatize KO and enhance the diagnostic accuracy. It is also possible to use more advanced regularization and hyperparameter optimization to further minimize overfitting and enhance the robustness of the models in clinical settings, as will be the focus of future work

Keywords. Artificial Intelligence, Deep Learning, Knee Osteoporosis, Model Training, VGG19 Model.

1. INTRODUCTION

Knee Osteoporosis (KO) is a degenerative disease which weakens the historical stability of bones and cartilage surrounding the knee joint and results to pain, dysfunction, and increase chances of fracture. The paper presents a research on the application of VGG19 on a binary classification task where images of knee X-rays with osteoporosis and without it are compared. The model can offer a possible diagnostic aid due to the ability to learn intricate patterns in radiological information that allow physicians to make the right decision at the right time. Earlier studies have made a correlation between osteoarthritis and osteoporosis of the knee joint [1–3] and transient knee osteoporosis and the results of post-arthroplasty have provided the difficulties in diagnosis [4-5].

2. INPUT DATASET

The dataset used in this study was sourced from an open-access Kaggle repository designed for knee osteoporosis detection research. It contains two labeled categories of knee X-ray images—Healthy and Osteoporosis—divided into three subsets for training, validation, and testing. The training set includes 1,258 images, enabling the model to learn distinguishing features; the validation set comprises 315 images for tuning hyperparameters and assessing generalization; and the testing set includes 472 images to evaluate performance on unseen data. This publicly available dataset ensures transparency, reproducibility, and encourages further research advancement in automated knee osteoporosis detection, as illustrated in Fig. 1.

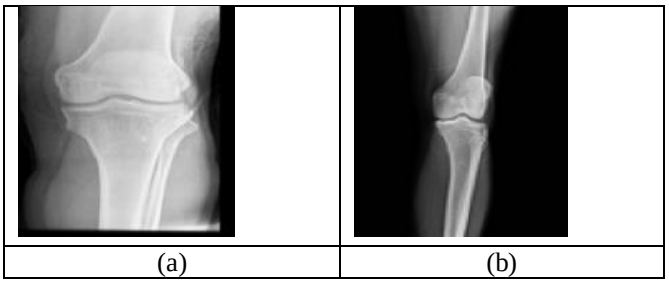


Fig.1. Dataset image for (a) Healthy, (b) Osteoporosis.

3. PROPOSED METHODOLOGY

The paper is based on the two-step research process that includes data preparation, data collection, model creation, and analysis. The first phase involves a labelled sample of knee X-ray images, classified based on being osteoporotic and non-osteoporotic, acquired in medical archives and hospital partnerships and checked by professional radiologists. The dataset is diverse both in terms of demographic categories and various levels of severity of knee osteoporosis. The second phase involves an image size reduction to the VGG19 image size and data augmentation is adopted through rotation and flipping which improves the diversity of the images.

4. RESULTS

The model on the test set had a very high precision of 97.5 in prediction of knee osteoporosis. The report had a high accuracy, recall and F1-score (0.97) in the classification of Healthy

and Osteoporosis classes in the classification report. Table of confusion revealed that the number of misclassifications was insignificant with 12 false negatives and zero false positives.

A. Analysis of Classification Report.

The knee osteoporosis detection model shows a very good performance with both classes, Healthy and Osteoporosis. Both classes show balanced performance and dependable performance as the F1-score is 0.97. The model has a high classification rate, as well as an overall accuracy of 97.5. Also, it has been shown that the macro and weighted averages were precise (0.98) and had a recall of 0.97, which confirms the consistency and stability of the results in both categories, as shown in Fig. 3.

	precision	recall	f1-score	support
Healthy	0.95	1.00	0.97	231
Osteoporosis	1.00	0.95	0.97	241
accuracy			0.97	472
macro avg	0.98	0.98	0.97	472
weighted avg	0.98	0.97	0.97	472

Accuracy of the Model: 97.5%

Fig.3. Classification Report Analysis.

A. Confusion Matrix Analysis

The knee osteoporosis detection model confusion matrix has excellent classification results. The model correctly discriminated the 231 and 229 cases of Healthy and Osteoporosis respectively and had high discrimination. This small mistake notwithstanding, the model showed a recall of 100% on the Healthy category and a high level of precision in general. The findings imply that there is minimal misclassification and high reliability that support the practicality of the model in the consistent and accurate clinical diagnosis as demonstrated in Fig. 4.

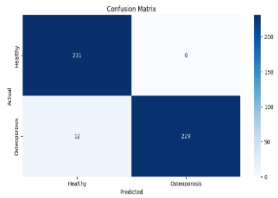
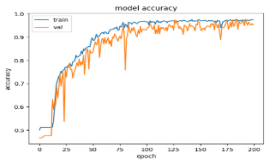


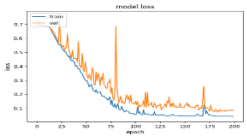
Fig.4. Confusion Matrix Analysis

B. Training and Validation Accuracy and Loss Analysis

The accuracy and loss curves in training and validation in 200 epochs of the model give a holistic perspective of the way the model learns. Still, in general, the findings confirm the high strength and reliability of the model to properly determine the presence of the knee osteoporosis as it is demonstrated in Fig. 4(a) and (b).



(a)



(b)

Fig.4.(a) Training and Validation Accuracy Analysis, (b) Training and validation Loss Analysis

5. CONCLUSION

The current paper is an X-ray image-based method to predict knee osteoporosis on the basis of a highly-tuned VGG19 deep learning model. The model shows an outstanding skill in the possibility to identify a healthy and osteoporotic knee condition, based on a strong score of 97.5 on the test sample. Its strength is also confirmed by the classification report as both of the classes have high precision, recall, and F1-scores of 0.97 indicating a balanced performance of the classes. The confusion matrix demonstrates the reliability of the model with the results of the existence of only 12 false negatives and no false positives.

REFERENCES

[1] Karvonen, R.L., Miller, P.R., Nelson, D.A., Granda, J.L. and Fernandez-Madrid, F., 1998. Periarticular osteoporosis in osteoarthritis of the knee. The Journal of rheumatology, 25(11), pp.2187-2194.

[2] Ramesh Kumar, Ratneshwar Kumar Ratnesh, Jay Singh, Ashok Kumar and Ramesh Chandra, IoT-Driven Experimental Framework for Advancing Electrical Impedance Tomography, ECS Journal of Solid State Science and Technology, Volume 13, Number 2, 13 027002, 7 February 2024

[3] Yoshimura, N., Muraki, S., Oka, H., Mabuchi, A., En-Yo, Y., Yoshida, M., Saika, A., Yoshida, H., Suzuki, T., Yamamoto, S. and Ishibashi, H., 2009. Prevalence of knee osteoarthritis, lumbar spondylosis, and osteoporosis in Japanese men and women: the research on osteoarthritis/osteoporosis against disability study. Journal of bone and mineral metabolism, 27, pp.620-628.

[4] Parker, R.K., Ross, G.J. and Urso, J.A., 1997. Transient osteoporosis of the knee. Skeletal radiology, 26, pp.306-309.

[5] R. Kumar, Vevekanandam, and R. Dey, “IoT-enabled bioimpedance and thermal imaging system for non-destructive fruit maturity assessment,” International Journal of Vegetable Science, pp. 1–23, 2025, doi: 10.1080/19315260.2025.2574898.