Bone Advisor: AI-guided Bone Regeneration Prediction and Recommendations

[1]P.Neela Sundari, [2]Patibandla.KrishnaSri, [3]Korada.Vennela, [4]Kavala.Bhavana, [5]Mandadapu.Srilakshmi, [6]Kollipara.Sri Harshitha

1Assistant Professor, Department of CSE, KKR & KSR Institute of Technology and Sciences, A.P, India.

[2,3,4,5,6] B. Tech Student, Department of CSE, KKR & KSR Institute of Technology and Sciences, A.P, India.

ABSTRACT:

The bone is a major component of the human body. Bone provides the ability to move the body. Bone fractures are common in the human body. Although external fixation is being widely used by orthopedic surgeons in treatment of bone fractures, the surgical procedure and recovery includes the possible complications which can significantly decrease the treatment's efficiency and effectiveness. In this project we propose the improvement of a fixation device design by introducing the machine learning and deep learning technology. The Bone Regeneration Prediction and Recommendation System project represents a paradigm shift in orthopedic care. Through the integration of predictive modeling and machine learning, the system forecasts bone regeneration outcomes with maximal accuracy. Beyond predictions, the system generates personalized recommendations, to the individuals based on the patient data given to the model.

Keywords: Machine Learning, Deep Learning, Recommendation system, prediction system, orthopedic

1.INTRODUCTION

Orthopedic disorders and bone-related injuries pose significant challenges to both patients and healthcare providers. The process of bone regeneration , recovery and restoration of skeletal function, varies widely among individuals and is influenced by diverse factors such as genetics, lifestyle, and treatment history etc.. Traditional approaches to bone healing often lack the precision required for optimal outcomes and additional resources. In response to these challenges, this project Bone Regeneration Prediction and Recommendation System is introduced . By using advanced technologies such as artificial intelligence and predictive analytics, this system finds the way to approach bone healing.Previously existing systems are expanded up to detecting the bone fracture only. We are going to update that to the finding of the healing time of the Bone Fracture.By using deep learning we trained the dataset by which machine is going to predict the range of the healing bone like Severe Bone Fracture,Moderate Bone Fracture,Mild Bone Fracture,Normal Healed Bone.By analyzing comprehensive patient data and utilizing machine learning algorithms, the system predicts the likelihood of successful bone regeneration based on each patient's unique profile.

Apart from predicting the bone regeneration or bone healing the model also provides the personalized recommendations to the patients regarding their diet plans to be in-taken for faster recovery as well as the exercises they need to be followed based upon the healing rate takes place and as per the patients convenience. All diet and

exercise recommendations provided by the system are evidence-based and grounded in scientific research. They take into account each patient's individual circumstances, including any pre-existing health conditions or limitations. It will recommend the exercise and diet recommendations on the basis of one's previous health issues.Exercise and Diet recommendations will be helpful for the patient faster recovery of the Bone Fracture. Exercise and Diet recommendations will depend on which bone situation is.The role of nutrition in bone health is quite important. Adopting a balanced diet, rich in nutrients, minerals, and vitamins, can contribute significantly to bone health.Ensures secure and private handling of patient data.Provides personalized treatment plans, user-friendly interface, utilizes predictive analytics, maintains transparent ethical practices, encourages interdisciplinary collaboration, and prioritizes patient empowerment.In a world where technological advancements redefine possibilities, ethical considerations and patient privacy become guiding principles. We do so with a commitment to safeguarding patient

privacy, ensuring data security, and upholding the highest ethical standards. By pushing the boundaries of traditional approaches, we aspire to set new standards in orthopedic care, ultimately improving patient outcomes and quality of life. In an era where technological advancements redefine healthcare possibilities, these supplementary features exemplify the project's dedication to setting new standards in orthopedic care, emphasizing patient outcomes, quality of life, and ethical considerations.This system has the potential to reduce healthcare costs by facilitating faster and more efficient recoveries. By predicting healing times and potential complications, the system can optimize treatment plans, potentially reducing unnecessary hospital stays and interventions. Additionally, personalized diet and exercise recommendations can empower patients to take an active role in their healing, potentially leading to fewer readmission rates. This comprehensive approach to bone fracture management can contribute to significant cost savings for both patients and healthcare systems.

Figure 1. Sample image of Bone Implants

Figure1 will be the format in which the user is going to upload. Users have to upload the image of x-ray in any of the formats. Users can capture the image of the x-ray and have to upload it to the system and then the image is moved to the next stage.

2. LITERATURE REVIEW

[1] In 2020, D. P. Yadav and Sandeep Rathor introduced the model of bone fracture detection ,They used the technology of Deep Learning but this promising bone fracture model faces hurdles due to its small dataset risks in overfitting risks the patient safety with inaccurate diagnosis.Their proposed method utilizes convolutional neural networks (CNNs) to automatically learn features from X-ray images of bones, which are then used to identify and categorize different types of fractures such as transverse, oblique, spiral and comminuted.

[2] In 2019, Manavendra dattatreya , Abhishek kumar , Bibhas ghoshal, introduced a model of Predicting Bone Modeling Parameters using the technology of Neural Networks.They aimed to develop a predictive computational framework to estimate bone modeling parameters in response to mechanical loading. The researchers developed a finite element (FE) model of a human femur subjected to varying magnitudes and directions of loadings. They applied a gradient-based optimization technique to calibrate the FE model and estimate bone remodeling parameters such as periosteal and endocortical surface stiffnesses.

[3] In 2018,According to Songyuan Tang, Anuj Chaudhry, Md Islam, Namhee Kim, Fernando introduced a model on long bone fracture and its effect using elastography but CT and elastography offers valuable insights but are not successful in all cases.They explores how long bone fractures impact ultrasound strain elastography imaging. To do this, they developed a computational model simulating longitudinal compression during ultrasound scanning of a long bone with a fracture.

[4] In 2020,According to Leonardo Tanzi , Enrico Vezzetti , Rodrigo Moreno, they developed a model for bone fracture classification using X rays , using the technology of deep learning they detected only the fractures with no additional features which already existed.By establishing a strong baseline, this work serves as a foundation for future improvements and refinement of automated X-ray bone fracture classification methods, ultimately aiming at enhancing diagnostic accuracy and timeliness.

[5] In 2023,According to Sina Bheyraghi,Javad Shabanapour , Mir Emad Lajevardi , the researchers created a custom dataset comprising microwave signals acquired from healthy and fractured human humeri. Utilizing time-domain features extracted from the raw signal measurements, they implemented a deep feedforward neural network for binary classification between intact and fractured bones. Experimental results demonstrated successful discrimination between healthy and fractured bones, highlighting the feasibility of incorporating microwave technology alongside machine learning algorithms for cost-effective, safe, and rapid bone assessment.

[6] In 2018 , Dragan Milan Mitkovic Milorad developed a model that discusses real-time monitoring of bone fracture healing using aware, sensing, smart, and active orthopedic devices within the Internet of Things (IoT) context. The authors propose a system combining wearable sensors integrated into immobilization casts or braces to collect relevant physiological information related to bone recovery.

[7] In 2020, Muhammad Waqas Nadeem , Hock Guan Goh , Abid Ali, developed the model to predict Bone Age Assessment, they used the technology of Deep Learning but the potential disadvantage of this approach is obtaining extensive datasets for bone age assessment from medical images is limited..

[8] In 2019 , Young min son , Namgi kim , Nojun introduced a model to predict Automated Bone Age Assessment

System , Used the technology of deep neural networks the main disadvantage here is BIAS in bones which leads to inaccurate predictions.Ultimately, this tailored deep learning strategy offers substantial benefits in terms of objective, precise, and swift evaluation of bone age, thereby expediting growth-related diagnoses and interventions.

[9] In 2023,According to Pei-Ching Kung , Chia-Wei Hsu , An-Cheng Yang describes a novel approach leveraging deep learning to anticipate bone healing surrounding dental implants under diverse boundary circumstances.They used the technology of deep neural networks but the disadvantage here is this approach is not successful in multiple test cases during the detection of multiple fractures

[10] In 2019 , Ari Wibisono, Mei Silviana Saputri, Petrus Mursanto, Alberto, introduced a deep learning and classic machine learning approach for Automatic Bone Age Assessment. This approach has slower execution time when compared with other ML models leads to many inaccurate predictions.The study employed two widely adopted bone age assessment methods—Greulich and Pyle and Tanner–Whitehouse 3 (TW3)—and evaluated nine classifiers.Among all tested algorithms, DCNN emerged as the most proficient option, delivering exceptional accuracies exceeding those reported previously.

[11] In 2022,According to Fırat Hardalac, Fatih Uysal , Ozan Peker introduced a model for Fracture Detection in Using Deep Learning-Based Object Detection Models.Two popular object detection architectures, You Only Look Once v3 (YOLOv3) and Single-Shot MultiBox Detector (SSD), were fine-tuned using a curated dataset comprising normal and fractured wrist X-ray images. The main disadvantage here is employing deep learning based object detection introduces computational complexity and resource intensives..

[12] In 2022,According to Irfan Khatik , Sachin Kadam predicted a Systematic Review of Bone Fracture Detection Models using Convolutional Neural Network Approach.They built a four-block Convolutional Neural Network (CNN) featuring batch normalization layers, max pooling operations, and dropout mechanisms to prevent overfitting.The main disadvantage of this approach is inconsistent evaluation method predictions leads to inaccurate outcomes..

[13] In 2022, According to Tabassum Nahid Sultana , Asma Parveen, provides an exhaustive examination of recent literature focusing on bone fracture recognition via Convolutional Neural Network (CNN)-powered models.The main disadvantage of this approach is the proposed model achieves high classification accuracy but limited insight to interoperability of CNN

[14] In 2023, According to Anusha Seles, Sneha, Vijitha, similar to other models, introduced a Bone Fracture Detection System.The authors secured a substantially high degree of accuracy, sensitivity, and precision for detecting anomalous structures suggestive of bone trauma.The main disadvantage of this approach is The model completely relies on a dataset; an extensive and accurately annotated dataset is not readily available in all situations.

3. REVIEW FINDINGS

1.Several reviews explore the bone fracture detection, classification, healing using deep learning and neural networks. Results indicate that these new approaches perform reasonably well, but there are drawbacks too. For example, deep learning models might struggle with overfitting, inaccurate diagnoses, dependence on extensive datasets, and poor incorporation of useful features.

2. Based on the above Survey and reviews , we got an idea that how bone fracture detection models existed and its disadvantages

3.We also learned the various detection algorithms and technologies they had used such as Deep learning , Neural Networks etc.

4.Many of the prediction systems used IOT devices for sensing the Regeneration which was not much successful.

4. PROPOSED WORK

Our method Aims to predict the Bone regeneration from the patients X-RAYS using the technology of image processing. The procedure is divided into 4 stages . The first stage is to collect the data . The second stage is to process the image and it is the input to the machine learning model . The Third stage is predicting the growth rate. The Fourth stage is Generating the recommendations regarding the Diet and Exercises..

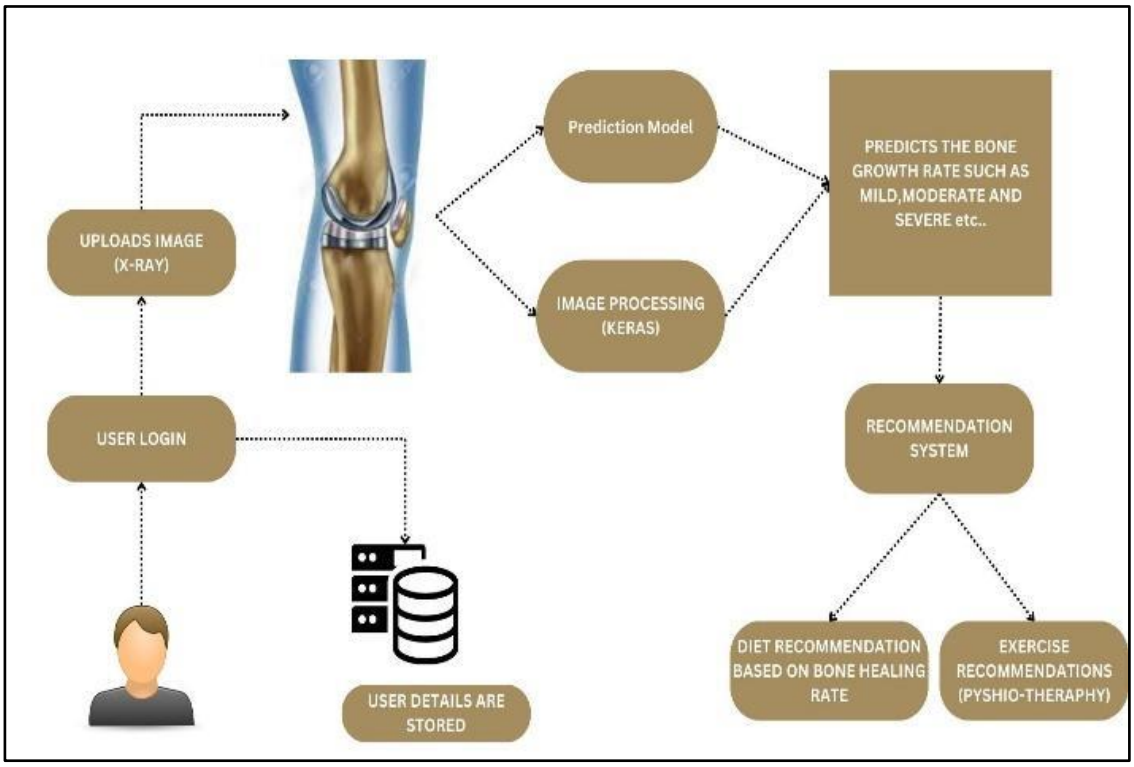

Figure2. System Architecture

Figure2 explains how the System workflow is executed. Firstly users have to create an account using signup option.so that user can login at any time. After login the user is going to upload an x-ray image and then after the image processing system predicts the type of the fracture and it recommends exercise and exercise plans based on the type of the fracture.

STAGE 1: As shown in the above fig. The initial step is collecting the data. We collected the dataset which contains the fractured bones , non-fractured bones and implanted bones and also some kind of common bones from Kaggle, a commonly well known platform for machine learning and deep learning datasets. The dataset consists of real time X-Ray images of the bones.For the accurate prediction and proper working of the system,it needs a large size of dataset.

STAGE 2: The second stage is processing the input X-RAY image . The processing is done using the machine learning library KERAS which is most commonly used for processing the images.In this preprocessing stage noise in the dataset is removed.The uploaded image is pre-processed with the help of TensorFlow and Keras. This processing the image acts as an detection system or prediction system in ML After the Preprocessing image is moved to the next stage.

STAGE 3 : The Third stage is predicting the growth rate of the bone. Using the machine learning algorithm. Based on Image uploaded by the user the model predicts the bone growth rate as mild, normal, moderate , severe etc.. by processing the image. The user can find his growth rate of the bone using this machine learning prediction system.Then the system moves to the next stage.

STAGE 4: The final stage is generating the recommendations regarding the diet plans and exercises. Based on the growth rate of the bone .

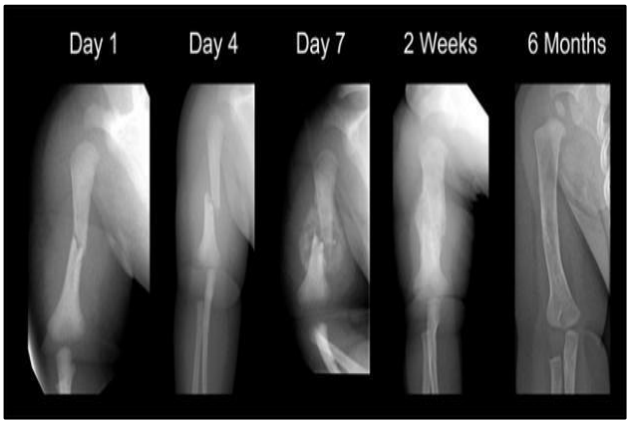

Figure3. Stages of Healing

Figure3 shows how the stages of bone healing are done. Bone healing will change day by day. Healing of the fracture depends on the depth of the fracture. Our system predicts the time of the healing depending on the type of the fracture.

5. RESULTS

Here in this session output of the System is shown.In this after uploading of the image and applying of the algorithm how the system displays the type of the fracture and recommendation of exercise and diet.

Figure4. Stage of Fracture

Figure4 explains how the system shows the type of the fracture based on the fractured bone image uploaded like Normal,Mild,Moderate,Severe Bone fractures.And the users can click on the Exercise Button,Diet Button based on user need.

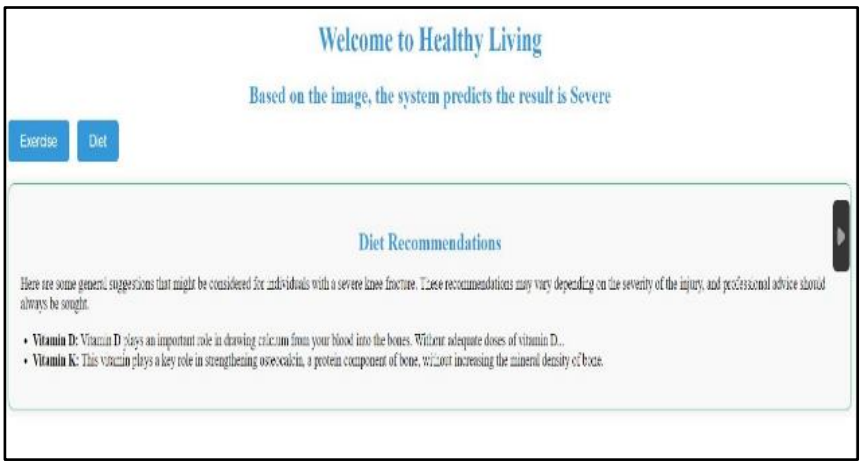

Figure5.Diet Recommendation

Figure5 explains the diet recommendations given by the system based on the image uploaded and the type of the fracture.These diet recommendations will be helpful for the faster recovery of the bone fracture.

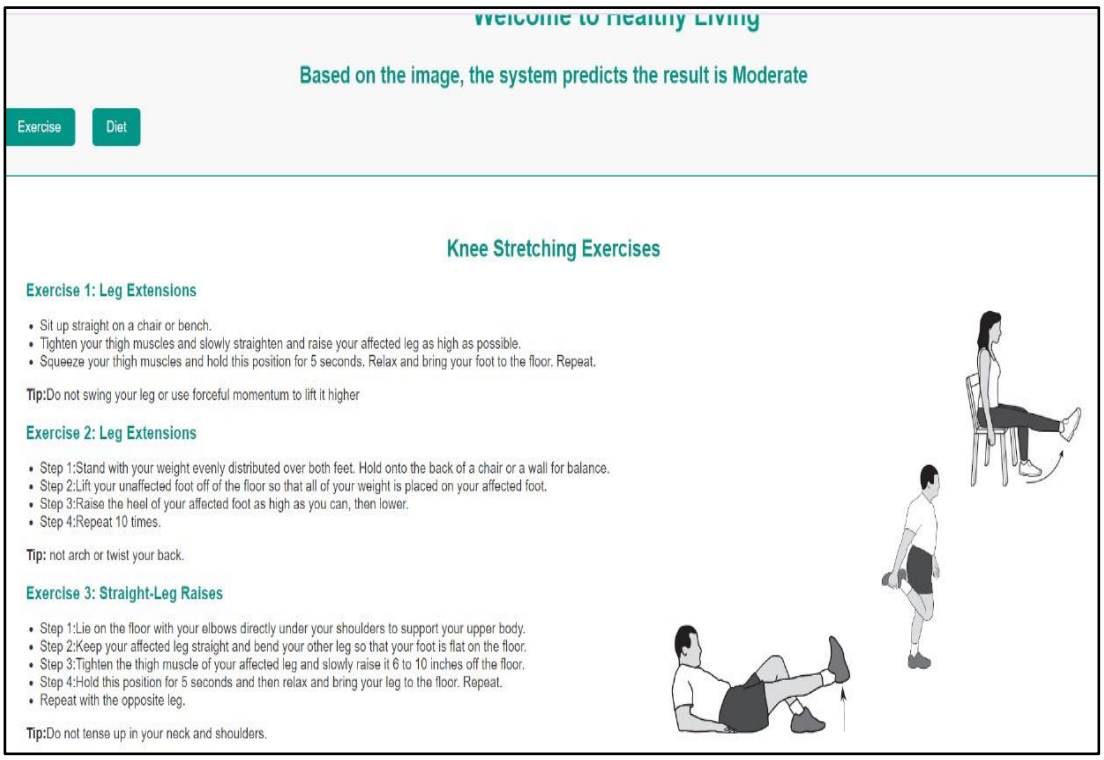

Figure6. Exercise Recommendation

Figure6 shows the exercise recommendations given by the system in step by step process with some tips users have to consider while exercising.By following these exercises periodically helps the patient in faster recovery.Here step by step description for the exercise recommendations are given in the simple language so that users can easily understand.

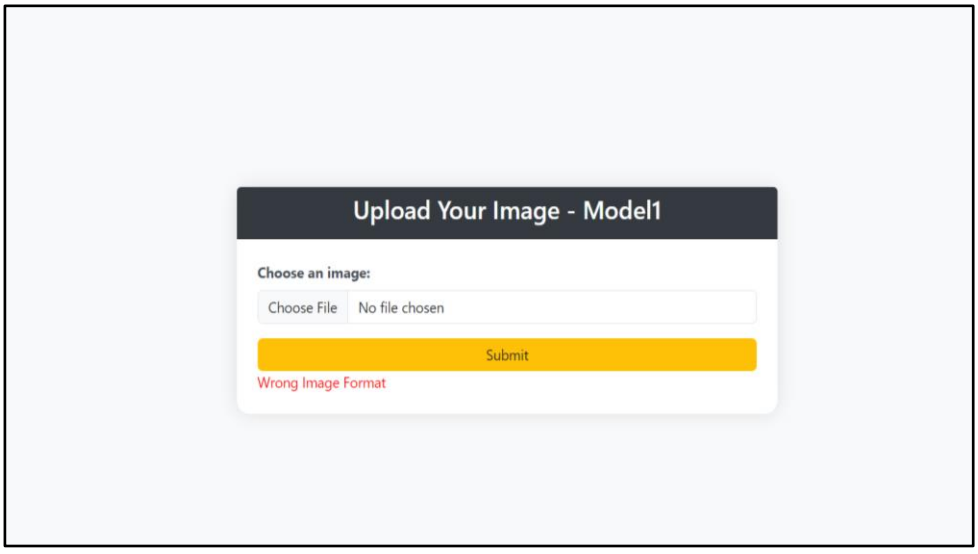

Figure7. Image Format Error

Figure7 explains how the system shows the error as wrong image format when an image uploaded is other than the bone.This system is used for knowing about the fracture type,healing time and for getting the recommendations.so user have to upload the image of the bone.whenever user upload the image other than the bone system shows this type of error.

6. CONCLUSION

In conclusion, the development of a bone regeneration prediction and recommendation system holds significant promise for revolutionizing the treatment landscape in orthopedic care. By harnessing the power of advanced Technology, personalized medicine, this project aims to address the growing demand for treatment strategies for bone injuries and diseases. Through the integration of diverse data sources, predictive modeling techniques, and user-friendly interfaces, the system has the potential to empower healthcare providers, researchers, and patients alike in making informed decisions about bone regeneration therapies.

Through its innovative features, interdisciplinary collaboration, and commitment to patient- centered care, the project aims to revolutionize how bone injuries and diseases are treated, ultimately improving outcomes and quality of life for patients worldwide.

7. FUTURE ENHANCEMENTS

Applying new and advanced imaging techniques, like 3D pictures, functional MRIs, or specialized microscope methods, gives us much more information and details about bones. With this added info, our system can make better predictions and give more targeted advice for each person's unique situation.

By collecting historical medical records, lifestyle habits, and genetic traits, the envisaged intelligent platform shall facilitate detailed analyses to generate personalized meal plans and exercises, taking into account any underlying comorbidities or constraints.

Adding real-time monitoring options like fitness trackers or implanted devices lets the system watch how well you're doing during your whole treatment. Collecting constant updates about bone healing, movement, discomfort, and other important things helps the system send useful feedback to doctors and patients so everyone involved can actively change treatment plans if needed.

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