CHAPTER I
INTRODUCTION

1.1. Background

One of the functions of bones, muscles, and joints is to support the movement of the human body, thus every human being can carry out his daily activities. A joint is a special structure that connects and moves two bones [1]. Osteoarthritis (*OA*) is a progressive degenerative disease that attacks the cartilage of the joints. Some of the impacts of osteoarthritis are stiff joints, deformity, pain, and discomfort when moving [2]. The knee joint is one of the most common joints attacked by Osteoarthritis followed by the hip and hand joints [3]. Osteoarthritis of the knee and hip joints can lead to an increased risk of cardiovascular and premature death [4].

Between 1990 and 2019, the worldwide prevalence of osteoarthritis expanded from 247.51 million to 527.81 million individuals, marking an upward trajectory of 113.25% [4]. Statistics from 2019 highlight that knee osteoarthritis comprised the majority of these diagnoses at 60.5%, outnumbering cases located in the hands, hip joints, and other musculoskeletal regions [4]. According to data from 2019, the prevalence of joint diseases including Osteoarthritis, hyperuricemia, and rheumatoid arthritis in Indonesia reached 713,783 people with a prevalence of 119,664 people in the 45 to 54 years age range and 79,919 people in the 55 to 64 years age range [5]. The prevalence of Osteoarthritis cases will continue to increase as the elderly population increases [6].

Based on data from 2024, by 2030 it is predicted that one in six people in the world will be 60 years old or older [7]. At this time, it is predicted that the population aged 60 years or older will increase from one billion in 2020 to 1.4 billion [7]. Based on data [8] published by the Central Statistics Agency, Indonesia has entered the ageing population structure since 2021 where the percentage of the elderly population in Indonesia has increased by at least four percent from the range of 2010 to 2022 to 11.75 percent. From this data, it shows that the increase in the elderly population in Indonesia is increasingly significant [8].

In recent years, medical imaging and diagnostic techniques have come a long way and play an important role in clinical analysis and disease diagnosis [9]. Medical

imaging is a two-dimensional image that shows the inside of the human body. Medical imaging serves to detect and analyze patient's diseases. Some of the methods used to obtain medical images are *X-Ray, Magnetic Resonance Imaging (MRI), Computed Tomography (CT-Scan), Endoscopy, Nuclear Medicine, and Ultrasonography (Ultrasound)* [9]. One of the common problems in medical imaging is the quality of scan results that decrease due to noise factors [10]. In addition to noise, medical images especially X-Rays generally have low contrast [11]. With these problems, it is difficult for doctors and medical personnel to analyze and diagnose diseases in patients, so it is important to use the right image quality improvement methods [10].

To structurally evaluate and monitor the long-term progression of knee osteoarthritis, conventional X-ray imaging remains a fundamental tool in research and clinical practice [12]. Clinicians generally estimate the severity of these radiographic images by employing semi-quantitative scales like the Kellgren-Lawrence (KL) system [12]. Because relying solely on experienced radiologists for this task demands significant time and yields only moderate agreement rates, automated intervention becomes highly necessary [12]. Integrating deep learning approaches can address these limitations, offering a faster and more efficient alternative for detecting and assessing osteoarthritis severity [12].

Several previous studies have shown that *the Deep Learning* approach results in higher diagnostic performance results for detecting and assessing the severity of *knee osteoarthritis* compared to the non-CNN-based image classification approach as well as the diagnosis results of the *CNN* modelequivalent to the results of an experienced musculoskeletal radiological diagnosis and even on par with the radiologist's level of agreement in assigning *Kellgren-Lawrence* (*KL)* grades [12]. In a study [13] using *DenseNet* to detect and assess the severity of *Osteoarthritis* in Knee *X-Ray* with a total dataset of 33,652 images, *DenseNet* obtained a sensitivity of 84%, 70%, 69%, and 86% to detect *Osteoarthritis* in KL knee *X-Ray* at grades 0, 1, 2, 3, and 4. In a study [14] using *ResNet* to detect and assess the severity of *Osteoarthritis* with a dataset of 3850, *ResNet* obtained results of 0.91, 0.80, 0.69, 0.86, and 0.96 for KL with levels 0, 1, 2, 3, and 4.

In previous research on the diagnosis of *osteoporosis* disease on *knee X-Ray* based on *deep learning* by [15]. This study compared several transfer learning and custom cnn methods for the detection and classification of *Osteoporosis* disease on

knee X-Ray, VGG-19 obtained the best results in both scenarios, namely binary and multiclass with an accuracy of 97.5% and 92.0%.

In a previous study on improving the quality of dental panoramic images using *Multiscale Mathematical Morphology* by [16]. This study compares several image quality improvement methods applied to dental panoramic images where MSTHGR obtained high average results on *the CIR, Entropy,* and *SF* metrics with values of 0.773, 7.462, and 20.019 as well as competitive average results on *the REC*, *PSNR*, and *AMBE* metrics. High results on *CIR*, *Entropy*, and *SF* metrics indicate that this method is optimal in improving the quality of detail and edges in dental panoramic images. This study also suggests the use of MSTHGR in the pre-process automatic detection model in diseases affecting bones or teeth.

To classify and detect the progression of knee joint osteoarthritis, this study proposes a combined framework utilizing MSTHGR for X-ray quality enhancement and VGG-19 for deep learning-based classification. Both algorithms were selected because prior studies demonstrated their optimal capabilities and robustness compared to alternative image processing and neural network models.

1.2. Problem Formulation

Given the aforementioned background, the problem formulation of this study is structured as follows:

1. How is the combined implementation of MSTHGR as a method of improving image quality and VGG-19 as a classification model in detecting and classifying the severity of Osteoarthritis in X-Ray images of the knee joint?
2. Is the combination of MSTHGR as a method of improving image quality and VGG-19 as a classification model accurate enough in detecting and classifying the severity of Osteoarthritis on X-Ray images of the knee joint?

1.3.Research Objectives

Based on the exposure of the problem formulation, here are some of the main objectives of this study:

1. To know the combined implementation of MSTHGR as a method of improving image quality and VGG-19 as a classification model in detecting and classifying the severity of Osteoarthritis in X-Ray images of the knee joint.

2. Evaluate the accuracy of the combined MSTHGR as a method of improving image quality and VGG-19 as a classification model in detecting and classifying the severity of Osteoarthritis on X-Ray images of the knee joint.

1.4. Research Benefits

The benefits that can be obtained through the implementation of this research are as follows:

1. Adding research references in X-Ray image processing in the context of detection and classification of Osteoarthritis severity.
2. Provide an initial referral for medical personnel for the detection and diagnosis of the severity of Osteoarthritis in the knee joint.

1.5. Problem Limitations

The limitations of the problem set in this study are as follows:

1. The study only used X-Ray images of the knee joint as the main object of the classification that is publicly available through the Kaggle website: Knee Osteoarthritis Dataset with Severity Grading with 5 severity levels (grades 0-4) based on the Kellgren-Lawrence scale.
2. The test metrics used include accuracy, precision, recall, F1-score, macro, micro average, and confusion matrix.