

CHAPTER I

INTRODUCTION

1.1 Background

Foot-and-Mouth Disease (FMD), locally known as Penyakit Mulut dan Kuku (PMK), is a highly contagious animal disease that significantly impacts cattle productivity. This disease is caused by an RNA virus in the genus Aphthovirus and is characterized by fluid-filled blisters on the gums, nose, and hooves (cloven hooves), accompanied by excessive frothy salivation [1]. However, these clinical symptoms do not necessarily appear simultaneously in all affected areas. In the field, veterinary officers need only examine one of these areas to determine whether the cattle are infected with FMD.

In addition to reducing livestock productivity, FMD carries a high risk of mortality, particularly in calves (pedet). A 2024 study published in Scientific Reports reported that calves under two months of age infected with FMD face a high risk of sudden death due to acute myocarditis. In that study, sudden deaths were reported in four calves under 2 months old, with postmortem findings showing characteristic “tigroid heart” myocardial lesions caused by FMD infection [2]. Another study mentioned that the FMD virus can be transmitted vertically from the dam to the calf during pregnancy [3]. These findings indicate that delayed treatment in pregnant cows can increase the risk of calf mortality after birth.

Field observations and interviews with animal health officers in Tuban Regency also revealed a similar pattern. Calf mortality frequently occurs in dams that are still infected with FMD during calving. Several cases were recorded within 1 to 5 days after birth. This condition underscores the need for early detection in cattle, particularly in pregnant dams, to minimize the risk of calf death.

FMD cases have surged again in Tuban Regency, peaking at 312 in February 2025, with active cases still being reported through December 2025. The Tuban Regency Food Security, Agriculture, and Fisheries Service (DKP2P) has implemented several prevention measures, including the closure of all livestock markets from January 28 to February 17, 2025, stricter monitoring of livestock traffic, and an FMD vaccination campaign allocating 7,000 doses prioritized for beef cattle, dairy cattle, and buffalo to prevent wider spread [4][5][6]. However, field observations indicate

persistent challenges in disease control efforts, primarily due to a shortage of veterinarians and extensive areas of responsibility. Examinations are often conducted only at the end of the day or the following day after reports are received, due to restrictions on handling FMD cases. Veterinarians who have treated FMD cases cannot examine non-FMD livestock on the same day to prevent disease transmission. As a result, examination response times cannot be met within a single day.

This situation highlights the necessity of an image-based detection system to help farmers recognize early signs of FMD. Such a system would enable farmers to take initial isolation and treatment measures, based on veterinary advice, while awaiting direct examination by officers. With rapid detection, the risk of disease transmission can be minimized, and cattle survival can be improved.

Previous studies have investigated image-based detection of animal diseases using deep learning methods. Research by Rizki Dwiki Pamungkas et al. (2025) utilized DenseNet enhanced using Convolutional Block Attention Module (CBAM) for classify FMD, achieving 99% accuracy on secondary data. However, when tested on primary field data, the accuracy dropped significantly to 53% due to differences in image distribution and uncontrolled environmental conditions [7]. This demonstrates models that achieve high performance on structured datasets may not generalize optimally to real-world field conditions.

Another study by Rony et al. (2021) proved that InceptionV3 delivered the best performance in classifying FMD in cattle, outperforming VGG-16 and conventional CNN with 98% accuracy [8]. In the field of human health, InceptionV3 has also been shown to outperform DenseNet in detecting oral cancer. Research by Ormeño-Arriagada et al. (2025) demonstrated that in identifying mucosal lesions, ulcerations, and epithelial tissue changes in the oral cavity, InceptionV3 achieved an accuracy of 78.02%, surpassing all DenseNet variants, which ranged between 68–74% [9]. This advantage indicates that InceptionV3 has better capability in extracting complex lesion patterns in the oral area. The visual characteristics of oral cancer share similarities with FMD symptoms in cattle, both involving sores and blisters in the mouth area.

Based on findings from previous studies, the InceptionV3 architecture was utilized in this research due to its proven superior for FMD classification and has demonstrated better performance than DenseNet in oral cancer research, which involves similar visual lesion characteristics (sores and blisters in the mouth area).

Furthermore, the InceptionV3 architecture is designed with a multi-scale feature extraction concept, utilizing multiple parallel convolution paths of different sizes (1×1 , 1×7 , and 7×1) within a single module to capture features at various scales and resolutions. This approach has been proven to improve generalization stability on images with variations in lighting, shooting angles, and non-uniform field conditions [10]. Furthermore, InceptionV3 is integrated with a CBAM-based attention mechanism to improve the model's ability to focus on important image regions that indicate FMD infection, including lesions found on the gums, nose, and hooves. The CBAM mechanism operates through two attention processes, namely channel attention and spatial attention. This integration is expected to generate a more reliable and robust detection model when evaluated using real-world field data compared to earlier approaches.

To ensure optimal model performance, this study also applies Bayesian Optimization as a hyperparameter optimization technique. Nugroho et al. (2025) reported that Bayesian Optimization significantly enhanced the performance of the InceptionV3 model, increasing accuracy by 8.85% [11]. Moreover, Bayesian Optimization works efficiently in optimizing complex hyperparameter spaces by utilizing a surrogate model to estimate hyperparameter performance without having to evaluate all combinations directly [12].

In this research, an FMD detection system is developed using the InceptionV3 architecture integrated with CBAM and optimized through Bayesian Optimization to improve accuracy, adaptability, and model stability on field documentation data. The proposed model is intended to identify FMD lesions on cattle noses, gums, and hooves using field documentation data collected from the Animal Health Division of the Tuban Regency Food Security, Agriculture, and Fisheries Service.

1.2 Problem Statement

The research problems addressed in this study are formulated as follows:

1. How can the InceptionV3-CBAM method be applied to detect FMD in cattle using image-based detection?
2. What impact does Bayesian Optimization have on the performance of the InceptionV3-CBAM architecture compared with the model without hyperparameter optimization?

3. How can the FMD detection model be implemented into a mobile Android-based application so that farmers in the field can practically use it?

1.3 Objectives

This study aims to develop an image-based model for detecting FMD in cattle using the InceptionV3 architecture enhanced with a CBAM attention mechanism and to implement the developed model in an Android-based mobile application.

1.4 Benefits of the Research

This study is intended to benefit farmers and veterinarians, particularly in Tuban Regency, by developing an image-based assistive tool implemented in a mobile application that detects symptoms of FMD quickly and accurately.

1.5 Scope and Limitations

This research has several limitations to maintain a focused scope, namely:

1. The model only classifies into two classes: “FMD” and “Healthy”.
2. FMD detection is based solely on images of blisters or lesions appearing on the gums, nose, and hooves of cattle, without considering other clinical signs such as lameness or decreased appetite.
3. The image data source is obtained from the documentation of the Animal Health Division, Food Security, Agriculture, and Fisheries Service of Tuban Regency.