1. Introduction

The use of technology to improve quality and maintain health is needed during the coronavirus disease 2019 (COVID-19) pandemic [1], [2]. COVID-19 can be transmitted from someone who has been infected to others through splashing water from the mouth or nose when coughing, sneezing, and talking. The World Health Organization (WHO) stated that COVID-19 has infected 222 countries [3]. One of the currently crucial technological needs is to support the reduction of the spread of the COVID-19 disease outbreak. One way to prevent the spread of the virus is to practice physical distancing.

Physical distancing activities are the procedures to maintain a distance between individuals, especially in public spaces [4]–[6]. The defined safe distance is 1 meter [7], [8]. Physical distancing procedures are seen to be capable of reducing the number of spreading [5], [9]. However, people often ignore the rules for doing physical distancing and the supervisor cannot monitor. The absence of an early warning causes the crowd to not disperse immediately. Besides, the locations to be monitored by the government and the police are dynamic.

Researchers from around the world collaborate to offer solutions to the problem of early warning to the crowd. Solutions with artificial intelligence based on machine learning can offer solutions to early warning problems in the crowd [1], [2], [10]–[15]. Technology that can solve this problem is generally camera-based machine learning [10], [16], [17] that can detect people in cameras and provide distance between individuals [10], [18]. However, machine learning requires machines or computers that have considerable resources. The computers with considerable resources make them less mobile.

Constrained computers are capable of providing high mobility. They can be in the size of an ID card enabling them to be highly mobile. However, conventional machine learning is not optimal on such constrained computers. Another machine learning model that is capable of being implemented in constrained computers is needed. The method must be able to use optimal resources without sacrificing accuracy. Thus, a device that provides an ability to run machine learning on constrained computers is needed. Tensorflow Lite is a set of tools allowing machine learning to run on constrained computers. It is specially designed to perform inference on constrained computers. An early warning system for physical distancing, therefore, can be implemented on constrained computers.

This study proposes an early warning system with a machine learning-based camera using the Tensorflow Lite framework. This early warning system uses constrained computers with high mobility. It can be placed in public areas, which are indicated to cause crowds. This study aimed to evaluate the machine learning model in the proposed Tensorflow Lite framework against the proposed test scenario. The scenario test was to test the accuracy of the distance between individuals and the accuracy of detection. Then, the model was evaluated based on the distance accuracy and detection accuracy in each of the mentioned scenarios.

The research presentation on the machine learning-based early warning system model is discussed in the following order. Chapter 2 describes a number of previous studies related to machine learning-based physical distancing. Chapter 3 contains the methods and designs of machine learning models in the Tensorflow Lite framework and test data used in physical distancing detection. Chapter 4 and Chapter 5 respectively contain the results and discussion of this research and conclusions from all research activities.