

1. Introduction

Government Regulation No. 15 of 2005 defines toll roads as public roads within the national road network where users must pay fees [1]. Toll rates are determined by vehicle classifications, which are categorized into five classes based on KEPMEN PU/PR No. 370/KPTS/M/2007. Class I includes cars, jeeps, minibusses, and two-axle small trucks. Class II to Class V cover trucks, categorized by the number of axles: two axles (Class II), three axles (Class III), four axles (Class IV), and five or more axles (Class V) [2][3]. Toll roads use the Automatic Vehicle Classification (AVC) system to determine vehicle classifications and applicable toll rates, which rely on various sensors [4]. However, sensor-based systems face challenges such as high costs and technical errors that can disrupt vehicle flow.