Characterization of Road Network Using Balanced Path Model in Mega Cities

Bee Geum   Hwan-Gue Cho

Dept. of Computer Science and Engineering
Pusan National University
Busan, South Korea
{rmaql0106, hgcho}@pusan.ac.kr

Abstract—The quality assessment of road networks for the stability and efficiency of autonomous vehicle operation in the Fourth Industrial Revolution is a crucial topic. Research has been conducted using the shortest path and quickest path to evaluate road network quality. However, in actual urban roads, various environmental factors can influence vehicle driving. For instance, natural disasters or road construction can lead to the inaccessibility of specific routes. Therefore, we need to explore a new route that complements the shortest path and quickest path. In this study, we introduce a new concept called the balanced path, which mutually complements the time and distance of the shortest path and quickest path. Based on this, we aim to evaluate the quality of road networks in 10 major Korean cities and 10 representative foreign cities. Additionally, we intend to investigate the impact of expressways on the quality of the road network. Expressways may be longer in length but can reduce travel time.

Index Terms—shortest path, quickest path, drone path, balanced path, expressway

I. MOTIVATION

The criteria by which drivers choose roads in actual urban environments are intricate and diverse. Among the various factors drivers consider when selecting a route are traffic congestion, road quality, safety, and fuel efficiency. Often, these factors are not sufficiently reflected in the shortest path or quickest path. We will explore which cities are more comfortable to drive in based on these criteria. As autonomous driving becomes more mainstream, self-driving cars will also need to choose routes in the same way drivers do.
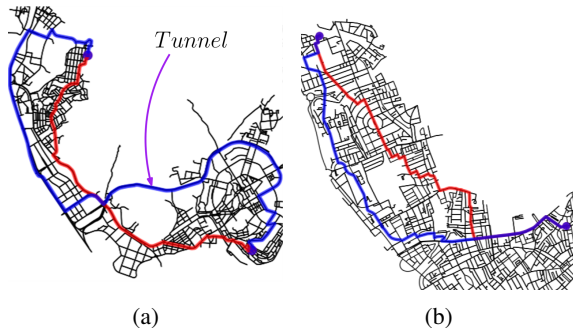

Fig. 1. Quickest Path(Blue), Shortest Path(Red) for Two Cities
(a) Haeundae, Korea, (b) Chelsea, London

In Korea, platforms like Naver Maps and, in the USA, Google Maps only offer the shortest path and quickest path. In Figure 1, the blue route represents the quickest path, and the red route represents the shortest path. The quickest path in the left city (a) in Figure 1 ensures the shortest time since it passes through a tunnel with fewer intersections. However, neither service provides any information about the Balanced Path, which guarantees a balance between the shortest path and quickest path. Knowing about the presence or absence of such a Balanced Path is crucial. This is because, due to various reasons like natural disasters or road construction, there may be situations where neither the shortest path nor quickest path can be utilized. In such cases, an alternative route needs to be explored. Therefore, we propose a new concept of the Balanced Path, which complements the spatially shortest distance with the quickest possible time. With this, we aim to discuss the method of finding the Balanced Path that the aforementioned two companies do not offer and the prevalence of the Balanced Path in 10 Korean cities and 10 foreign cities. We intend to use this as a metric to compare the quality of road networks.

II. RELATED WORK

Until now, many studies have been conducted on algorithms to find the shortest path in a given graph. However, in actual cities, drivers choose routes based on various conditions rather than just the shortest path due to diverse situational factors[1]. Merely finding the quickest route mathematically has its limitations. Instead of congested shortest routes, drivers might opt for less busy detours, broader roads that are easier to navigate, routes that provide more accessible charging or refueling for electric vehicles, or paths that ensure the fewest turns[2]. This indicates that drivers choose routes based on psychological comfort and preferences rather than just the mathematically shortest path[3]. Such routes, which also consider the cognitive processes of drivers, are referred to as the "Simplest Path"[4].

Furthermore, there have been studies on calculating routes with minimal turns and simplicity[5, 6], as well as research focused on the structure of road networks[7]. However, there hasn't been any research assessing the quality of urban road networks.

In this study, the goal is not to find a route for a specific purpose quickly, but rather to evaluate the quality of each road