Chapter 11
Car Navigation System Using Genetic Algorithm Processor

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ABSTRACT

Recently, car navigation systems that support safe and comfortable driving have been used widely. This chapter proposes a new car navigation system which enables the provision of the following three services: (1) the route search service including unspecified stopover points, (2) the route search service for traveling through sightseeing spots and considering sightseeing time, and (3) the quick response using dedicated hardware. Moreover, the proposed car navigation system is implemented on a field programmable gate array, and its validity is verified by several evaluative experiments using actual map information.

INTRODUCTION

The automobile industry has become a communication tool facilitating the movement of people as well as providing a means of transport. In particular, car navigational systems that support safe and comfortable driving are becoming more and more sophisticated. When a car navigation system was first put into practical use, its function was only to display maps using a CD-ROM. Later, however, technological progress made it possible to build various functions and services, such as voice guidance service and traffic congestion information displays, into car navigation systems. Generally, the main role of car navigation systems is a route search from a specified starting point to a final destination.

General car navigation systems use the Dijkstra algorithm (DA) (Fujita, et al., 2003) for route search. Although the DA can obtain the shortest route between two points represented on a graph, it cannot obtain the shortest route within an allowable processing time when a problem’s scale becomes large. Moreover, the DA cannot search for a route that includes multiple unspecified transit points, or search for a route considering time spent at a transit point.
However, users of car navigation systems, drivers, desire that a route search can be performed in consideration of several unspecified stopover points (transit points) before reaching their final destination. In real life, for instance, a driver deposits mail at a post office and supplies oil to his car on a gas station before arriving at his final destination. In this case, the post and gas station are not necessarily specified, and a short travel route from the starting point to the final destination, including several stopover points, is desirable.

On the other hand, convenient travel involves an efficient route through sightseeing spots within a limited time. Namely, if a route search can consider transit points (sightseeing spots) and sojourn times (sightseeing times), the car navigation system will be convenient for drivers.

This chapter proposes a new car navigation system that enables a route search that includes multiple unspecified transit points and considers time spent at transit spots. The proposed car navigation system uses a genetic algorithm (GA) (Goldberg, 1989 and Holland, 1992) as its basic algorithm, which is based on technologically modeling biological evolutionary process; and it has a powerful searching ability for combinatorial optimization problems. However, because a GA is a multi-points search algorithm, it has an inherent processing time problem. This chapter introduces dedicated hardware for a GA to realize high-speed processing. Moreover, the proposed car navigation system is implemented on the field programmable gate array (FPGA), and its validity is verified by several evaluation experiments using actual map information.

The organization of this chapter is as follows: Section 2 briefly surveys the researches in terms of route search algorithms using GA and dedicated GA hardware. Section 3 explains the base route planning algorithm in the car navigation system. Section 4 discusses dedicated hardware of the proposed car navigation system. Section 5 reports the experiments, and Section 6 summarizes and concludes the chapter.

RELATED STUDIES

Kanoh, et al. (2000) and Chakraborty, et al. (2005) have studied a route search using a GA. Kanoh et al. (2000) introduced virus operators into a route search, and created a route search algorithm that includes unspecified stopover points. They proved its validity by evaluative experiments. Chakraborty, et al. (2005) proposed a multi-objective route search algorithm containing a shortest route search and minimum turning. However, these studies of a route search using a GA were always based on software processing.

On the other hand, examples of dedicated hardware for a GA have been reported by Imai, et al. (2002) and Scott, et al. (1995). Imai et al. (2002) created the architecture of a parallel GA and, by estimating the number of processing steps, they expected high-speed processing to be realized in the dedicated hardware. The dedicated hardware’s processing speed could be several dozen times faster than that of software. Scott et al. (1995) developed a hardware-based GA and demonstrated its superiority to software in speed and solution quality.

However, these studies of dedicated hardware aimed to solve small and simple problems, and no studies have been reported on practical problems such as a car navigation system. Thus, car navigation systems using dedicated hardware for a GA, which enable two types of route searches, have not been studied.

ROUTE SEARCH ALGORITHM

This chapter proposes a route search algorithm using a GA as the basic algorithm, and aimed to realize the following two route searches: (1) a route search including unspecified stopover points, and (2) a route search for traveling through sightseeing spots.
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