JOURNAL OF TRAFFIC AND TRANSPORTATION ENGINEERING (ENGLISH EDITION) 2017; X (X): 1–12

Available online at www.sciencedirect.com

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journal homepage: www.elsevier.com/locate/jtte

Original Research Paper

A virtual globe-based visualization and interactive framework for a small craft navigation assistance system in the near sea

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HIGHLIGHTS

- This research introduced the construction of a virtual globe-based navigation assistance system.
- The integrated system work processes and architecture of the virtual globe-based navigation assistance system are elaborate.
- The authors have developed data processing programs that are glued together with the C# language.
- Experiments for estimating the application have been made around the near coastal area, and the performance and deficiencies are discussed.

ARTICLE INFO

Article history:
Received 5 November 2015
Received in revised form
30 March 2016
Accepted 31 March 2016
Available online xxx

Keywords:
Small craft
Navigation assistance
GIS
Virtual globe-based
Keyhole markup language

ABSTRACT

With the growing popularization of small crafts, the accidents that happen among such crafts are also drawing increasing attention, according to the marine accident data released by the Japan Coast Guard. In order to prevent possible navigation accidents, the authors considered that besides sharing information from land by the coast office broadly, managers on land can also watch out and give appropriate advice for operators in crafts one-to-one. This paper discusses the technical issues of developing virtual globe-based (Google Maps/Earth geographic information system (GIS)) 3D visualization stand-alone software for small craft navigation assistance in the aim to facilitate the safety and sufficiency of small crafts in the near sea. The system was developed using web services and object-oriented programming disciplines to support the integration of a virtual global framework, GPS, and real-time imaging data. The authors have also developed data processing programs that are glued together with C# language, JavaScript language, National Marine Electronics Association (NMEA) instance data, and keyhole markup language (KML) data. Experiments for evaluating the framework have been made around the near coastal area. The performances and deficiencies are discussed in this paper. In order to evaluate the validity of the performance and the functionality of the system, authors conducted a questionnaire

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Peer review under responsibility of Periodical Offices of Chang'an University.
http://dx.doi.org/10.1016/j.jtte.2016.03.011

survey among third year students of the Voyage Course at Kobe University. The evaluation of the system suggests valuable potential for the small craft navigation assistance system.

1. Introduction

In recent years, piloting pleasure boats in leisure time has become a widespread activity all over the world. However, with the popularization of these small craft, accidents involving small craft are becoming a marine traffic safety problem. In order to prevent personal injury and loss of life, Japan Coast Guard started strengthening its information service in 2013 by sending emergency alarm emails, such as meteorological warnings (Japan Coast Guard, 2012). However, providing navigation information by email is obviously inadequate during bad weather, in poor traffic conditions, or for navigating at night. In order to prevent possible navigation negligence, the authors considered that besides sharing information from land with craft at sea, managers on land can also watch out for the craft when the operator is inattentive and give appropriate advice for panicked operators who lack experience in unfamiliar sailing environments. For this purpose, monitors on land first need to sufficiently understand the situation of the small craft in real time and then supply appropriate information or advice to the sailor. To fully understand the real-time situation of small ships, nautical information such as electric chart display and information system (ECDIS) and radar data are important for a monitor on land. However, these data are hard to collect for small craft, since most small craft are not equipped with these nautical instruments. For this reason, in this study the authors only employ GPS and web camera as data resources to share with the monitor on land remotely.

With the emergence of technology such as GIS and virtual globe-based 3D visualization (Bailey and Chen, 2011), by building an intercommunication system and displaying the navigation information in a virtual globe environment, this system provides a new way to exchange information and understand the situation at sea. This system is not designed to replace existing nautical equipment such as ECDIS, but to be used in combination with other devices to obtain efficient and comprehensive information. The device is similar to a car navigator, which supplies drivers with information along the road, not only the car's position, but also the road markings, etc. Furthermore, car navigators improve driver safety by making it easier for drivers to understand the conditions of the road. The system in this study is more like a car navigator than a professional ECIDS device.

This paper discusses the technical issues of developing a virtual globe-based 3D visualization stand-alone application for small craft navigating assistance. With C# language, JavaScript language, NMEA instance data, and the KML data format, the authors have developed data processing programs for integrating distributed resources and interactive functions such as text telecommunicating, email, and intercoms. The auxiliary spatial analysis and video monitoring tools in this system can assist end users to perform interactive activities such as 3D distance measurement and web camera monitoring (Wu et al., 2010).

Supplementary video related to this article can be found at http://dx.doi.org/10.1016/j.jtte.2016.03.011.

The remainder of this paper is organized as follows. Section 2 introduces the present status of and related work involving marine accidents in Japan. Section 3 introduces the construction of a virtual globe-based navigation assistance system. The integrated system work processes and the architecture of the virtual globe-based navigation assistance system are also elaborated (Wang et al., 2009). In Section 4, the authors report on a performance experiment based on the method discussed in this paper and share the results and errors. Last, but not least, the conclusion and future of this system are introduced.

2. Background and related work

2.1. Background

According to data released by the Japan Coast Guard in 2012, 78% of marine accidents involved small boats, such as fishing boats and pleasure boats; 43% of these accidents were caused by human factors, such as inattention (26%), inappropriate maneuvering (8%), drowsy operation (2%), and so on. Furthermore, marine accident data from the past 5 years shows the same accident ratio pattern (Table 1). In Table 1, marine accident data from the Japan Coast Guard shows that 75% of all accidents involved small craft/boats, such as pleasure boats, fishing boats, and sport fishing boats. This accident proportion is unchanged from the pattern of 2012.

2.2. Studies of navigation support systems for small craft

Urakami et al. (2008) investigated the effectiveness of wireless communications using a common communication method

Table 1 – Marine accident ratio.

Ship type	Number	Proportion (%)
Pleasure boat	4909	41
Fishing boat	3782	31
Cargo ship	1617	13
Tanker	410	3
Sport fishing boat	390	3
Passenger ship	221	2
Other	828	7

Please cite this article in press as: Liu, X., Shiotani, S., A virtual globe-based visualization and interactive framework for a small craft navigation assistance system in the near sea, Journal of Traffic and Transportation Engineering (English Edition) (2017), http://dx.doi.org/10.1016/j.jtte.2016.03.011