Virtual Globe Visualization of Real-time AIS Data with KML

Liu, Xinzhu

Shiotani, Shigeaki

(Citation)
Journal of maritime researches,6:73-82

(Issue Date)
2016-06

(Resource Type)
departmental bulletin paper

(Version)
Version of Record

(JaLCDOI)
https://doi.org/10.24546/81009503

(URL)
https://hdl.handle.net/20.500.14094/81009503

Journal of Maritime Researches Vol. 6, March 2016: 73-82.

Virtual Globe visualization of real-time AIS data with KML

Xinzhu LIU*,
Shigeaki SHIOTANI**

ABSTRACT

With highly developed virtual globe technology, navigational supporting applications should fully in use of this technology by incorporating the nautical traffic information within a 360° view to improve maritime safety. Virtual globe of a 3D view in navigation would be an important development, allowing navigators to precisely understand the real-time nautical situation in a more natural way. Marine AIS (Automatic Identification System) transmitters are fitted to vessels, navigation markers, and certain types of shore stations for navigation, anti-collision systems by supplying real-time vessel and trajectory information. AIS has been proven to be the most effective and sufficient data for representing surrounding nautical information for navigation.

In this paper, authors discuss a new method of modeling real-time AIS data of ships and other navigational objects using KML (Keyhole Markup Language) in a virtual globe system. Data processing programs are developed with C# in order to glued together Real-Time NMEA (National Marine Electronics Association) instance data and KML data. Simulation of navigating situation with AIS data was supplied to visualize the application of KML in nautical world.

Keyword

AIS, Virtual Globe, KML, C#

* Ph.D Candidate Student, Xinzhu Liu Graduate School of Maritime Sciences ,5-1-1 Fukae-Mibnami, Higashinada, Kobe 658-0022 JAPAN Email: xinzhuliu@stu.kobe-u.ac.jp Tel: (81)90-6674-9960

** Professor, Graduate School of Maritime Sciences, Kobe University. 5-1-1 Fukaeminamimachi, Higashinada, Kobe, Hyogo, 658-0022, Japan. Email : shiotani@maritime.kobe-u.ac.jp

1. INTRODUCTION

To support maritime navigation and communications, from the traditional 2D Graphic Information System (GIS —Electronic Charting and Navigational Supporting System) to new real 3D specialized temporal application, sea authorities have discussed various specifications and technologies (Goralski & Gold, 2007). However, these methods have not sufficiently addressed the visualization of situations similitude to any other obstacles (e.g., other vessels' nautical situations, bridges, and lighthouses). Taking appropriate action to avoid collision may be difficult, especially when features that could be seen from a bridge are obscured by bad lighting and weather, as most important information concerning navigational aid is only supplied on 2D charts (e.g., Electronic Chart Display & Information System (ECDIS)) or in paper pilot books. Therefore, integrating all of the above elements and real-time nautical traffic information within a 360° view would be helpful to upgrade the level of maritime safety. Ship supporting assistance should exploit virtual globe technology in the modern navigational world.

Marine AIS transmitters are equipped to vessels, certain types of shore stations for navigation, anti-collision systems, and other users (Raymond 2014). Since AIS data contains real-time vessel and trajectory information, in recent years, it has become an advanced GPS device that is utilized in the professional domain. By combining AIS data with other nautical equipment, such as ECDIS, captains are more aware of the situation around them when they use the status of neighboring vessels to avoid collisions. In recent research, AIS data has been employed to characterize marine traffic patterns and ship collision risks based on past routing data (Aarsæther et al, 2009). Also, elements of risk analysis for collision have also been evaluated based on the real-time data (Silveira, 2013).

The idea behind displaying AIS data inside a virtual globe was based on recent studies that have introduced virtual globe tools that can be used to integrate heterogeneous geospatial data (Bailey et al, 2011; Bailey et al, 2012). Regarding the potentiality of Google Earth for supplying input data by saving KML objects manually, Chien and Tan introduced KML outputs from the AnuGA hydrodynamic model made by an employer within the program (Chien et al, 2011). These output from the model are employed to visualize the dynamic data spatially and temporally, which offers the disaster management the awareness of the current situation (Tomaszewski, 2011). Mochales et al. (2014) introduced a model of paleomagnetic data in virtual globes. The model provides coincidental visualization of local magnetic cones showing characterized data from diverse positions and scales

In the present article, the authors discuss a method of modeling real-time AIS data of ships and other navigational objects using KML in a virtual globe system. Part 2 introduces the AIS data and the traditional AIS model in navigation. Part 3 introduces a model of real-time AIS data in Virtual Globe and the drawbacks of using this method. Part 4 introduces a real-time decoder module and model with KML in a virtual globe environment.

2.TRADITIONAL REPRESENTATIONS OF AIS DATA

In modern navigation, data received from AIS regarding a vessel's position and direction is displayed inside a 2D ECDIS in the vessel bridge, as shown in Fig.1. All of the ships surrounding the home-ship are displayed as moving triangle icons that point in the direction of movement. In some cases, ships carrying dangerous cargo are colored red. As the vessels travel and broadcast data, the positions of marks are updated accordingly to show the current position of vessels obtained through the AIS transponder. However, besides the position data, AIS data contains other important and valuable information about vessels and their trajectories. Vessel information consists of MMSI (Mobile Marine Service Identifier), vessel name, directions, and category of ships, e.g., tanker ship or cargo ship. Trajectory information includes real-time location, receiving time, velocity, degree of course, navigational status and so on (Tsou, 2010). As shown in Figure 1, except for the route and direction of the triangles, all other information is displayed in a text format on the right side of the ECDIS system. Although the text information is readable for users, it also takes more time to understand or judge the actual surrounding situation.

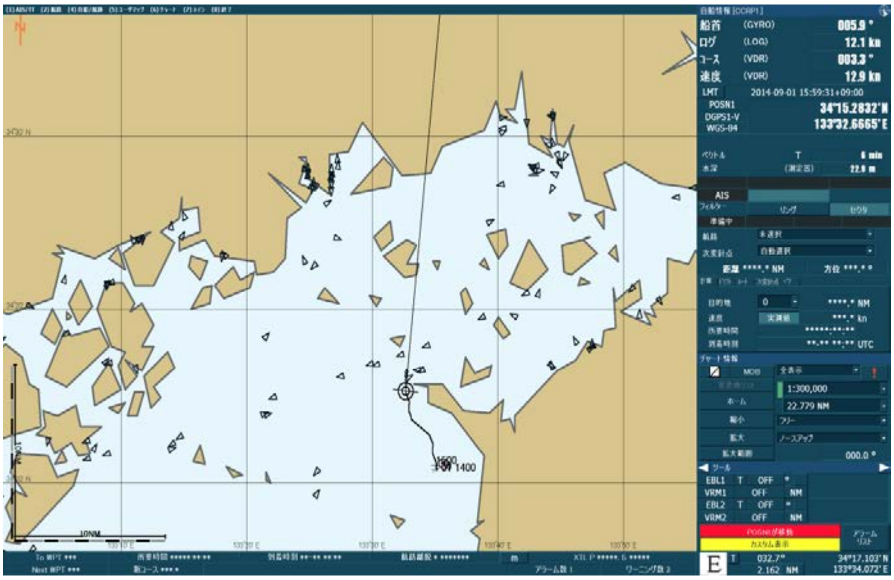

Fig.1 Traditional Representation of AIS Data in ECDIS

3. REPRESENTATION OF AIS DATA IN VIRTUAL GLOBE

Generally, sailing ships can receive compressed AIS information of surrounding vessels in 20NM. According to AIS protocol, ships are categorized into 100 types. In this study, vessels, nautical lighthouses, and obstacles such as bridges and tide preventive breakwaters are represented on COLLADA models. Vessel and lighthouse models were created in SketchUp (a software for creating 3D models), some models are downloaded and edited from 3D Warehouse (*3D Warehouse, 2014*). These ship models were gathered into a 3D database which was saved on a local device. Some of the representative models are shown in Fig.2.

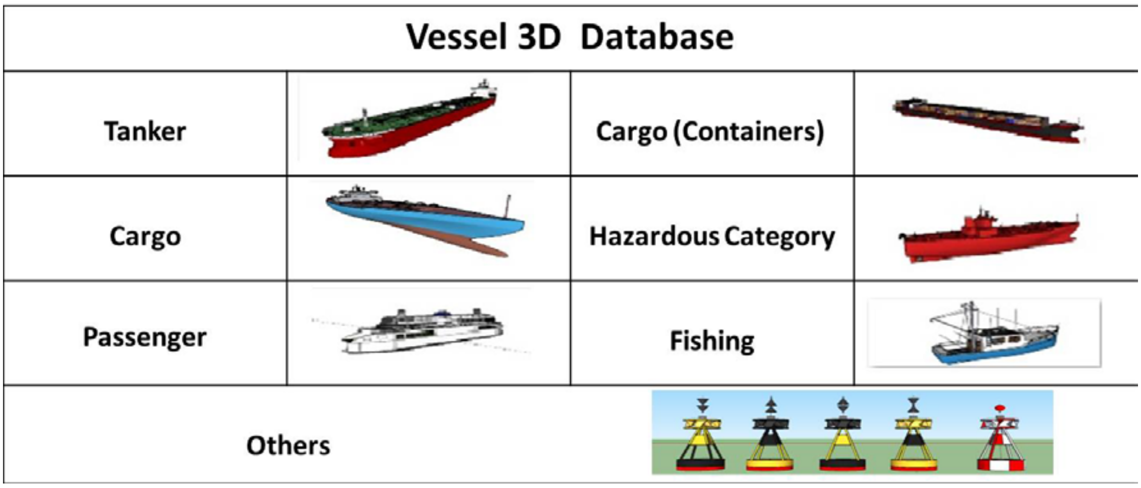

Fig. 2 Vessel Model Database

As introduced in part 2, the traditional representation method of AIS involves plotting the ship's positional data on ECDIS or other 2D charts using triangular icons. Except for the directional and positional icons, other detailed information is presented in text and listed at the side of the charts. Distinct from the 2D representations in ECDIS，Fig.3 shows ship figures constructed by KML data in a virtual globe. The ship model shows that the ship is a training ship; the model size is also set based on the actual size of the ship. The yellow line and the direction icon we call HDG show the direction the ship's bridge is facing. The light blue line and the direction icon labeled COG are the actual route of trajectory and the sailing direction, respectively. As can be seen from Fig.3, the angle difference between the true heading and the course over ground is represented visually. Normally during marine navigation, each ship's true heading is different from its course over ground, depending on the forward speed of the vessel in its medium, the drift speed in its medium, and the wind speed and wind direction or current speed and current direction. Under these circumstances, an angle between the HDG and COG will be generated. Sometimes, this angle can be misinterpreted by other ships' sailors, leading to collisions. Therefore, besides a clearer visual representation, the greatest advantage of this 3D visualization as compared to previous 2D standard map symbols is that the direction component of each ship can be visualized. By using COLLADA models in KML to represent the AIS data, especially when bad lighting and weather obscure the view from the bridge, the intuitive visualization in virtual globe can help the sailor or anyone monitoring the traffic situation to be able to visualize the real view from any angle on any ship. It should be clear to correspond this view with the real world while adding ship 3D models useful for navigation.

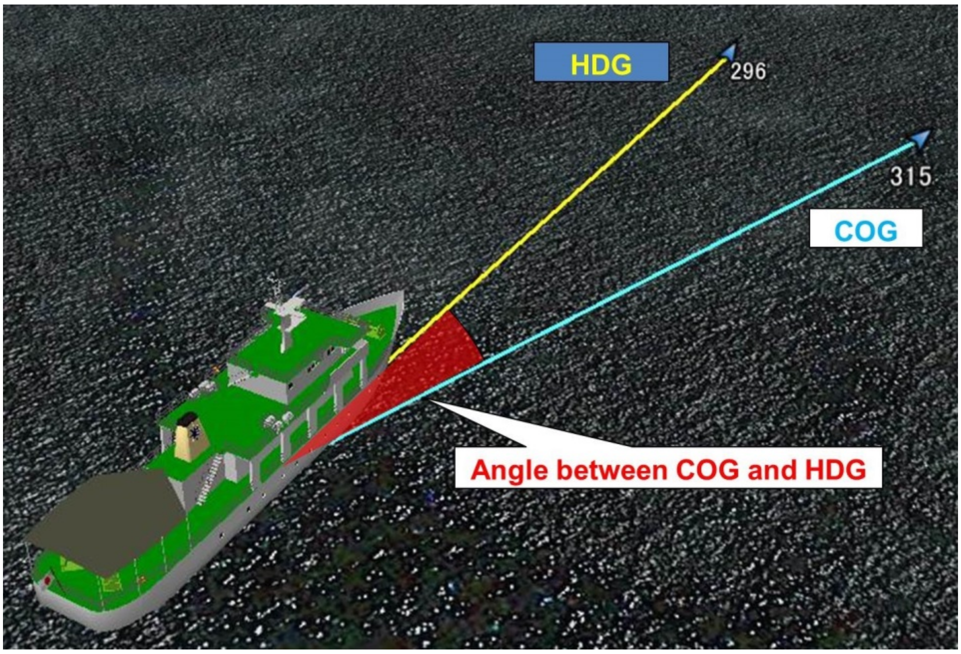

Fig.3 Training Ship Figure Constructed by KML Data in Virtual Globe

As an example study, the authors have created an evacuation simulation based on the AIS data after the Great Tohoku Earthquake (2011) of the Tokyo Bay Area in use of timestamp features and animations of KML. According to Liu et al [13], half an hour after the earthquake, most of the ships in Tokyo Bay started to take precautions for a tsunami, such as anchoring inside of Tokyo Bay or evacuating away from land. For the ships that chose to anchor inside the bay area, because the speed of ships during anchor status is less than 3 knot, the movements of these ships are largely affected by the current of the tsunami [13]. As shown in the animation of Appendix 1, a ship was passing through the anchoring area at a very low speed of around 4 knots. Including the ship herself, the angles between the COG and HDG of the ships are changing irregularly. Since the ships' true headings are totally different from where the ships are moving to, this could cause serious misunderstanding for ships that navigated in or near the area. However, with the direction being clearly pointed out with the 3D, anyone with or without navigating experience can understand the true navigating situation of each ship. This method would make an inexpensive and superior substitute to the chart plotters, especially in the absence of the ship-maneuvering simulators that are only available in sailor training schools.

Taking advantage of user-defined data sets in the KML file, the authors also input all of the AIS data and the specific website from the AIS map of each ship inside the model's property. As shown in Fig.4, sailors can check all of the relevant information from the property with just a click. This can help any sailor—even with insufficient experience—to obtain enough information regarding the nautical environment in any visibility or weather condition.

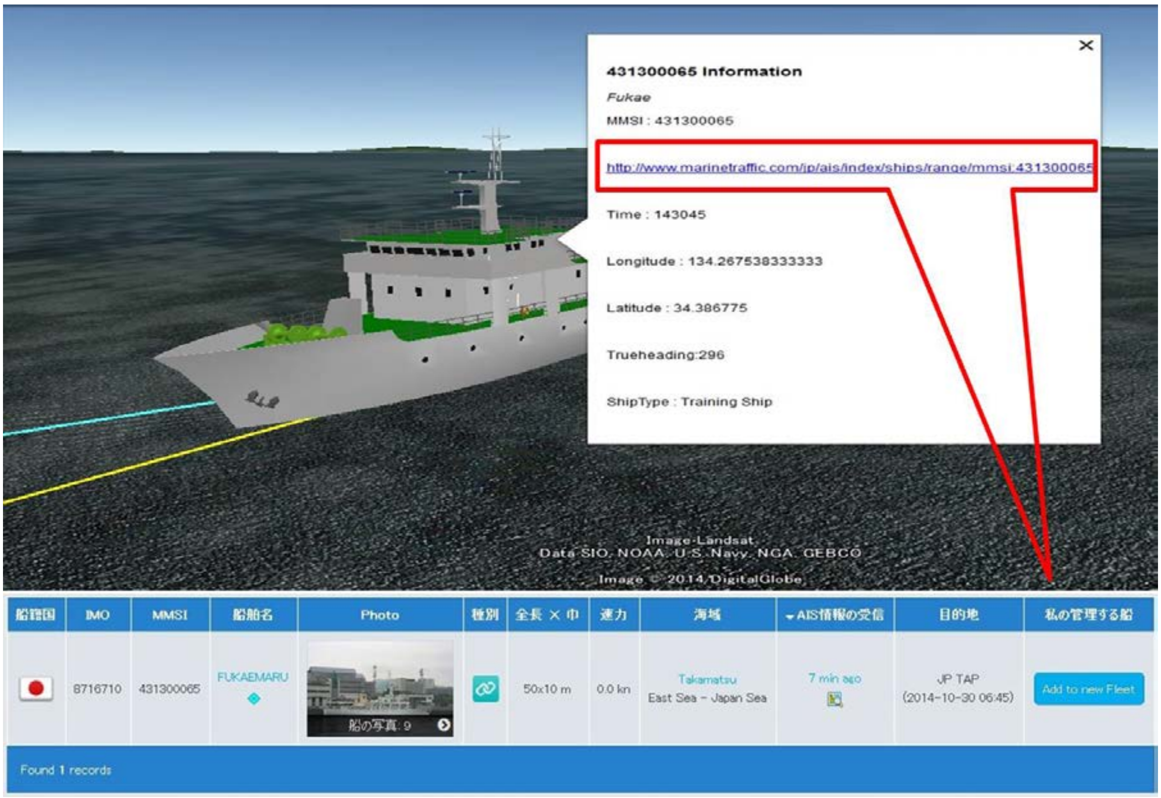

Fig.4 Relevant Ship Information in the Model's Sub-Property using KML

In addition to the convenience of measuring the distance of ships, by maintaining spatial connection and providing the required geographic information features, virtual globe also precisely expresses the relationships of nearby vessels; this is used for collision sensing and avoidance. Fig.5 shows the relative positions of a training ship and a tanker. In addition to checking the object from the bridge view (bottom left in Fig.5), it is free to check other ships' models at any range and any angle without misinterpretation. To understand the relative positions from a birds-eye view, the top image in Figure 6 is the view from a 651-m height, at -123°. Also, the distance between any obstacles can be measured. By taking advantage of the ruler function in Google Earth, we can tell from the bottom left figure that the distance between these two ships is 458 m, and the tanker ship is 87° from the training ship.

Virtual globe not only allows one to display the dynamic AIS models as a layer with KML but also supports the visualization of multiple geographic data, such as bathymetry data and nautical traffic data overlaid together. The coastal landscape and building models are supplied selectively. Programs are employed to generate the KML shoreline line data, the low water line, and the depth contour and are calculated and generated based on the ECDIS IMO standard. By displaying these layers separately or together, useful information can be appropriately supplied without being overly concentrated. Fig.6 is the AIS data overlaying the traffic area (the Akashi Route) based on information from the Japan Coast Guard.

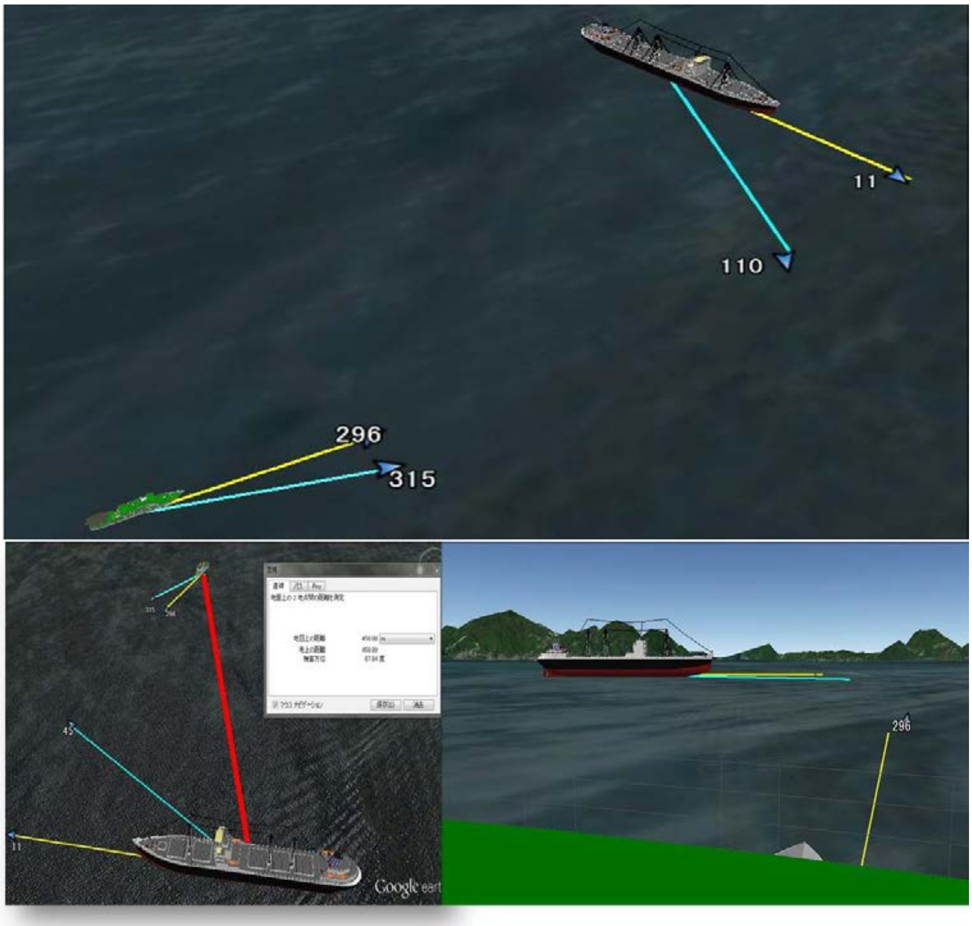

Fig.5 Views in Different Directions and Ranges

4. CREATING KML FORMATE FILE FROM AIS DATA

In order to supply the real-time ship data, authors have built an interface between the virtual globe and the AIS signal transmitter. First, an external specialized database for decoding and receiving AIS messages was created and implemented with object-oriented c# programming language. The database supports real-time monitoring and recording of the real-time AIS information and also can be used for its later reproduction for simulation and testing purposes. When a new line of an AIS message is received, it is decoded into readable nautical data such as dynamic data (traffic information, including position, velocity, direction, etc.) and static data (identify information such as ship name, ship size, destination, etc.). Second, these data are updated or input into the dynamic and static AIS message database. Third, the timing and spacing range base on the dynamic data of the target ship are calculated. The timing condition is calculated by the current timing data minus 30 minutes. The spacing condition is the square range with the current coordinate point as the center point and a radius of 20NM. Then, the database is searched based on the spacing and

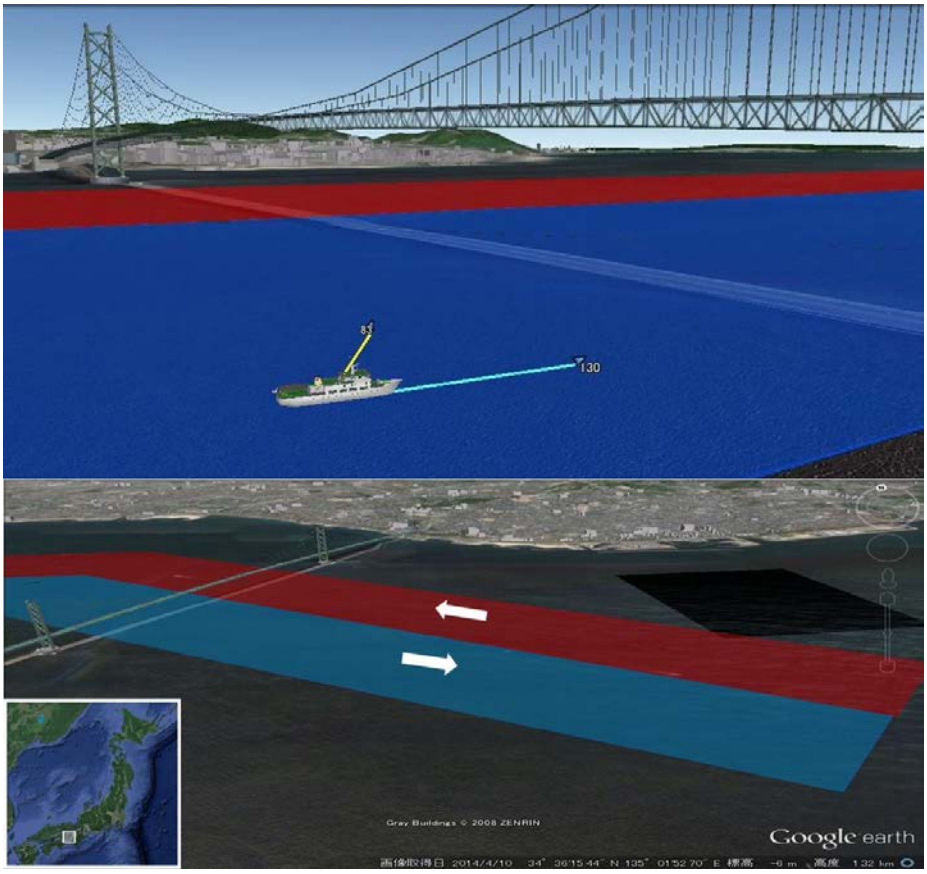

Fig.6 Models Based on AIS Data Overlaying with a Traffic Area (the Akashi Route)

temporal condition. Next, the information lists of the surrounding ships is recorded, including the MMSI number as the model name, time as property, longitude, latitude, velocity, true heading, and ship type in order to control the ship models with CODDA based on the decoded AVIDO data. Finally, a KML file is updated or created for a birds-eye view or ship's bridge view according to the ship's list. Based on this information, real-time moving/changing 3D models can be constructed inside the virtual globe environment. Fig.7. illustrates this process in a flow chart. The authors have supplied the c# file as an example for generating AIS data in KML. The AIS data should be prepared as string lists in order of MMSI number, time, longitude, latitude, HDG, COG, ship model (.dae file), and ship length. And the (.cs) files should be operated in a c# environment to test and generate KML files.

5. CONCLUSION

Using virtual globes is a fast and easy method to visualize, save, and share dynamic ship information. C# is used to generate KML format data for representation in virtual globes. The advantages of visualizing AIS data in the method proposed here include the ability to visualize both COG and HDG together simultaneously with the

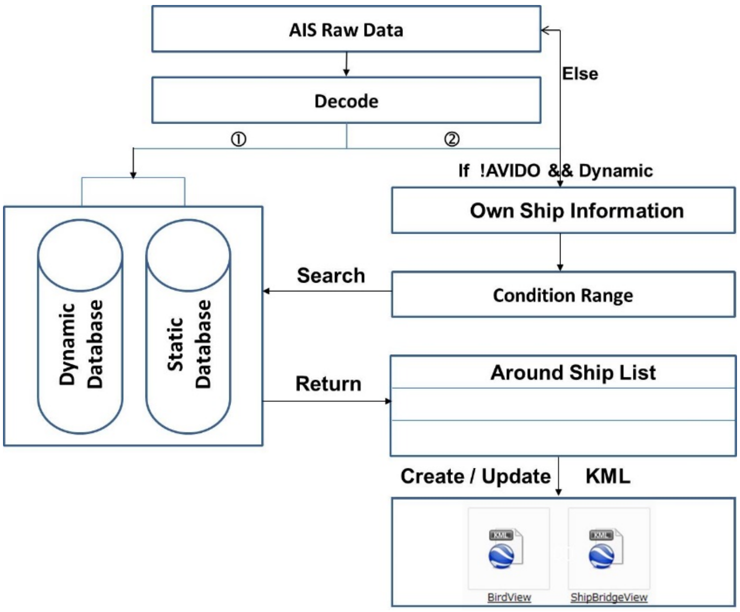

Fig.7 Flow Chart for Generating KML Files from AIS data

ship model and accurate geolocation representation, which allows navigators to evaluate the situation in a more instinctive way. The authors also input all of the AIS data and the specific website from an AIS map of each ship inside the model property. Virtual globes also supply the capacity of performing simulations of lighting and weather conditions. By maintaining spatial correlations and providing the required geographic features, virtual globes also precisely express the relationship of neighboring vessels on the sea's surface, which is used for collision sensing. This method proves that the idea behind displaying AIS data inside a virtual globe would be a significant improvement in navigation.

ACKNOLEDGEMENT

Finally, the author gratefully acknowledges the support and contributions of members of the Shiotani laboratory at Kobe University for this study.

REFERENCES

Goralski, R. I., & Gold, C. M. (2007). The development of a dynamic GIS for maritime navigation safety. In *ISPRS Workshop on Updating Geo-spatial Databases with Imagery and The 5th ISPRS Workshop on DMGISs* (pp. 47-50).

Raymond, E. S., “AIVDM/AIVDO protocol decoding.” http://catb.org/gpsd/AIVDM.html; last accessed 2014/11/26

Gunnar Aarsæther, K., & Moan, T. (2009). Estimating navigation patterns from AIS. *Journal of Navigation*, *62*(04), 587-607.

Silveira, P. A. M., Teixeira, A. P., & Soares, C. G. (2013). Use of AIS Data to

Characterise Marine Traffic Patterns and Ship Collision Risk off the Coast of Portugal. *Journal of Navigation*, *66*(06), 879-898.

Bailey, J. E., & Chen, A. (2011). The role of Virtual Globes in geoscience. *Computers & Geosciences*, *37*(1), 1-2.

Bailey, J. E., Whitmeyer, S. J., & De Paor, D. G. (2012). Introduction: The application of Google Geo Tools to geoscience education and research. *Geological Society of America Special Papers*, *492*, vii-xix.

Chien, N. Q., & Keat Tan, S. (2011). Google Earth as a tool in 2-D hydrodynamic modeling. *Computers & Geosciences*, *37*(1), 38-46.

Tomaszewski, B. (2011). Situation awareness and virtual globes: Applications for disaster management. *Computers & Geosciences*, *37*(1), 86-92.

Mochales, T., & Blenkinsop, T. G. (2014). Representation of paleomagnetic data in virtual globes (a case study from the Pyrenees). *Computers & Geosciences*.

Tsou, M. C. (2010). Discovering knowledge from AIS database for application in VTS. *Journal of Navigation*, *63*(03), 449-469.

3D Warehouse, https://3dwarehouse.sketchup.com/?hl=ja,last accessed 2014/12/10

Yu, L., & Gong, P. (2012). Google Earth as a virtual globe tool for Earth science applications at the global scale: progress and perspectives. *International Journal of Remote Sensing*, *33*(12), 3966-3986.

Liu, X., Shiotani, S., & Sasa, K. (2014). Simulation of Vessel Evacuation after the Great Japan Earthquake in Virtual Globe Environment. *International Symposium INFORMATION ON SHIPS ISIS 2014*, (2014), 80-90.1