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On a Data Fusion Model of the Navigation and Communication Systems of a Ship

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ABSTRACT: Ship mates should be aware of images, numerical values, texts and audio-based information of radar, AIS, NAVTEX, VHF, and etc. for safe navigation. However, it is very complicated and difficult for them to acquire such information and use it as data for decision-making for safe navigation while keeping watch for navigation. So, a system to understand, unite and provide multimedia marine information for mates in voice is necessary. This study tries to suggest data fusion model of the navigation and communication system.

1 INSTRUCTIONS

A ship's navigation instrument produces and provides a variety of information necessary for safe navigation.

A number of researches' efforts to provide more advanced information for safe navigation.

Related studies include a study on collision avoidance assistant system using fuzzy case-based reasoning[1] and a study on a conceptual model for collision avoidance for ontology-based fuzzy CBR support system[2], and a study on a system that automatically sets up routes and supports the description of the set route for mates on small ships, who are lacking of expertise[3]

In addition, there are a study that built an embedded system that can control ships steering system of ships with speech wheel order[4], speech-recognition-based intelligent ships steering control system suggested by Gyei-Kark Park and Ki-Yeol Seo[5], and a study on ontology based fuzzy ships steering control system[6].

However, studies so far have been carried on systems for navigators without expertise on small ships without automatic control, and related systems or studies which can provide comprehensive information efficiently for experts are lacking.

This study tries to suggest data fusion models necessary for the construction of the system to understand, unite, and provide the multimedia marine information for mates. A ship's navigation instrument produces and provides a variety of information necessary for safe navigation.

2 OVERVIEW OF A DATA FUSION MODEL FOR NAVIGATION INFORMATION

Such a process as Figure 1 is necessary for establishing a data fusion model to recognize a situation using the multimedia navigation safety information provided by diverse navigation equipment, induce the information needed for decision-making, and provide it linguistically.

First of all, this paper composes a data field by navigation equipment by analyzing the raw data produced and provided by navigation equipment such as GPS, ARPA, AIS, NAVTEX, VHF, etc. and then establishes a knowledge representation model to express the data in each data field and the relationship between objects as subjects between attributes linguistically using a semantic network.

Next, this paper establishes a data fusion model using a knowledge representation model, and provides the information obtained newly by providing the information of a data fusion model in a language

or by fusing or inducing the information provided by a data fusion model in a language.

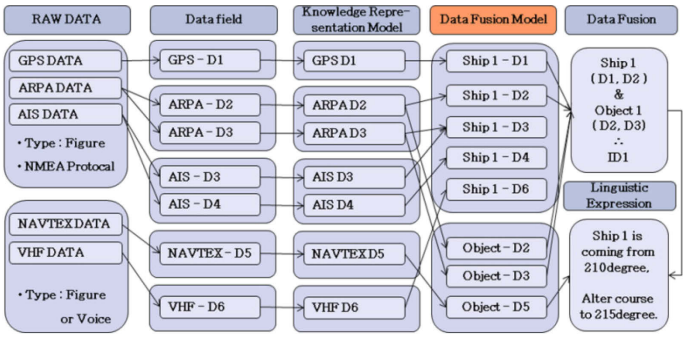

Figure 1. Diagram of providing the inferred information

3 KNOWLEDGE REPRESENTATION AND DATA FUSION MODEL

3.1 *Data field of navigational equipments*

To use the information provided by navigation equipments, the information provided by the equipment was analyzed and data field for the equipment were prepared.

GPS, ARPA and AIS information should provide which is specified in SOLAS resolutions.

NAVTEX provides information received in the unit of a character of English alphabet in a text form, natural language processing is completed so it was assumed that an appropriate data field was obtained.

Most navigation warning, weather warning and other urgent safety-related notices NAVTEX provides were discovery of a new navigation obstruction, change of aids to navigation, construction or training section, or threatening weather occurrence, etc., and such information consists of the name, the term of validity and location or area.

VHF is communication equipment using frequency. Since it communicates using human language directly, information and types obtained using this equipment are unlimited. However, the most important thing is that it has a merit that through which the intention of the other ship can be known.

Using these, data fields were prepared.

To use information that can be provided by navigational equipments, it was assumed that speech recognition and natural language processing had been completed.

3.2 *Knowledge Representation Models*

The Knowledge Representation Model by navigation instruments was built by expressing the knowledge relationship between the data related to the subject and the subject using semantic network, and the information which each equipment provides was expressed in simple sentences, and the knowledge representation by the subjects was constructed using the knowledge representation by navigation instrument.

3.2.1 *Knowledge Representation Model of GPS*

All information provided by GPS is included.

Figure 2 is Knowledge Representation Model of GPS and it expressed information which is provided by this model in a simple sentence.

"Ownship's Position's GPS position Is latitude 34° 12.5´N, longitude 126° 22.4´E."

"Ownship's Speed Is 18.3 kts."

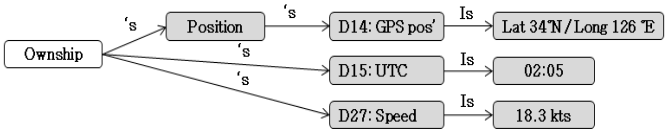

Figure 2. Knowledge Representation Model of GPS

3.2.2 *Knowledge Representation Model of ARPA*

All the information provided by ARPA is included and D1: Bearing & D2: Range as location information added vertices as position before connecting with subject for amalgamation with information which is provided by other navigation instrument.

Figure 3 is Knowledge Representation Model of ARPA, and it expressed information which is provided by this model in a simple sentence.

"Ship 1's Position is Bearing 312 degree."

"Object 1's CPA Is 0.0 miles."

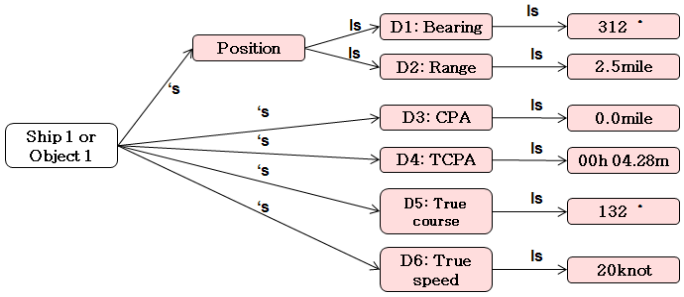

Figure 3. Knowledge Representation Model of ARPA

3.2.3 *Knowledge Representation Model of AIS*

All information which is provided by AIS can be expressed but only D14: GPS position as location information was connected to ship as subject through the vertices as position.

Figure 4 is Knowledge Representation Model of AIS, and it expressed information which is provided by this model in a simple sentence.

"Ship 1's Heading Is 000 degree."

"Ship 1's Name is SAEYUDAL."

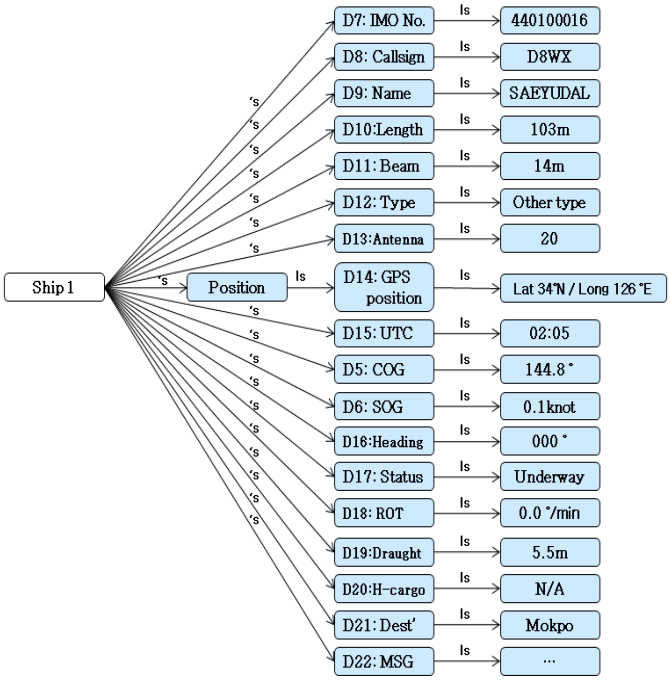

Figure 1. Knowledge Representation Model of AIS

3.2.4 *Knowledge Representation Model of NAVTEX*

It was designed using data field of NAVTEX.

Figure 5 is Knowledge Representation Model of NAVTEX, and it expressed information which is provided by this model in a simple sentence.

"Object 1's Name is Dangerous wreck."

"Object 1's Position is latitude 34° 12.5′ N and longitude 126° 22.5′ E."

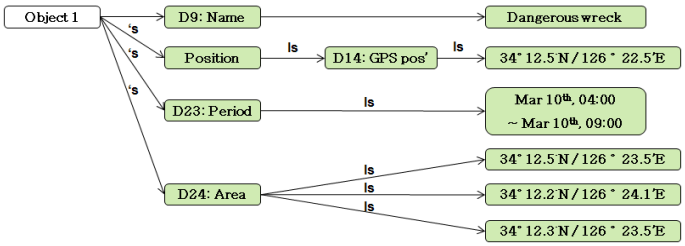

Figure 5. Knowledge Representation Model of NAVTEX

3.2.5 *Knowledge Representation Model of VHF*

It was designed using data field of VHF.

Figure 6 is Knowledge Representation Model of VHF, and it expressed information which is provided by this model in a simple sentence.

"Ship 1's Intention Is overtake."

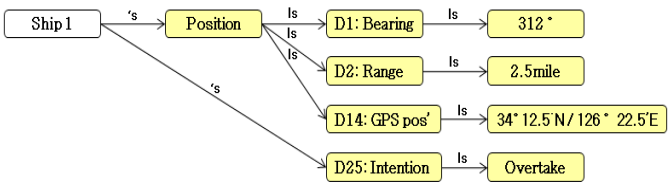

Figure 6. Knowledge Representation Model of VHF

3.3 *Data fusion algorithm*

A data fusion process is necessary for fusing a knowledge representation model into a data fusion model.

In order to judge that the data provided by two knowledge representation models are the information of the same objects, the data with the same meaning among the data provided by two knowledge representation models should be comparable, and it can be judged that the data provided by two knowledge representation models are the information with the same objects when their similarity is within a certain range after comparison.

Figure 7 shows a proposed data fusion algorism.

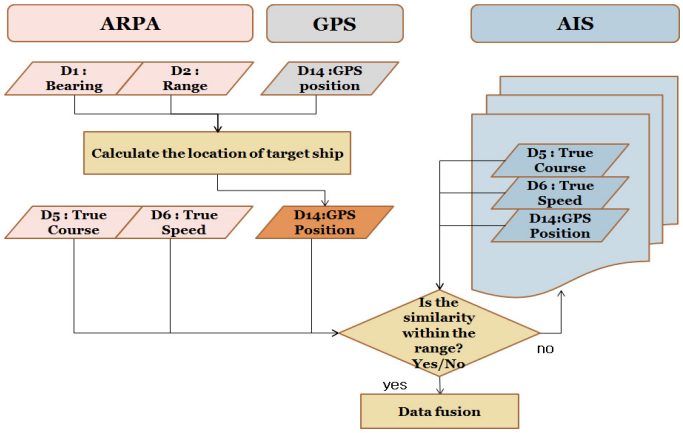

Figure 7. Data fusion algorithm

3.4 *Data fusion model*

3.4.1 *Data fusion model in the case of a ship as target*

In the case of ship as subject, information can be obtained using ARPA, AIS and VHF in general. Therefore, it was represented by combining knowledge representation models of ARPA, AIS and VHF.

Figure 8 is data fusion model in the case of a ship as target.

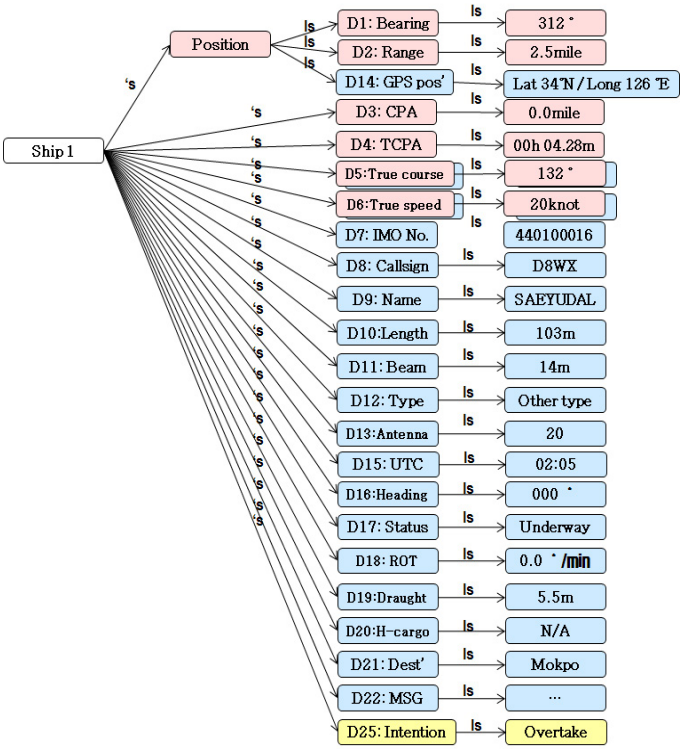

Figure 8. Data fusion model in the case of a ship as target

3.4.2 *Data fusion model in the case of a object as target*

In the case of subject as except ship, the information can be obtained by ARPA or NAVTEX etc, so it was represented by combining knowledge representation models of ARPA and NAVTEX.

Figure 9 is Data fusion model in the case of a object as target.

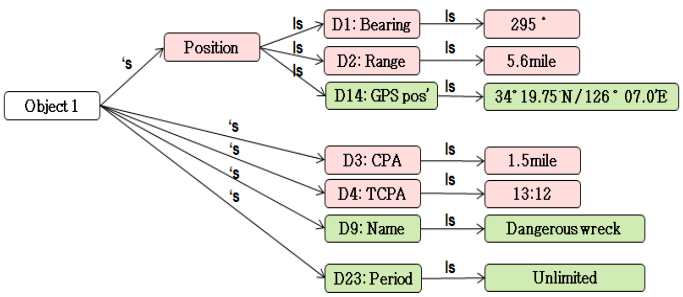

Figure 9. Data fusion model in the case of the subject as except ship

4 APPLICATION OF DATA FUSION MODEL

4.1 *Description of navigation situation using data fusion model by subject*

It explained the navigation situation and the information of other ships and marine obstacle which mate can obtain in the given navigation situation was expressed using Data Fusion Model by subject in the sentence.

The navigation situation of Figure 10 is a dangerous one in which two ships are encountering while they pass through a narrow channel.

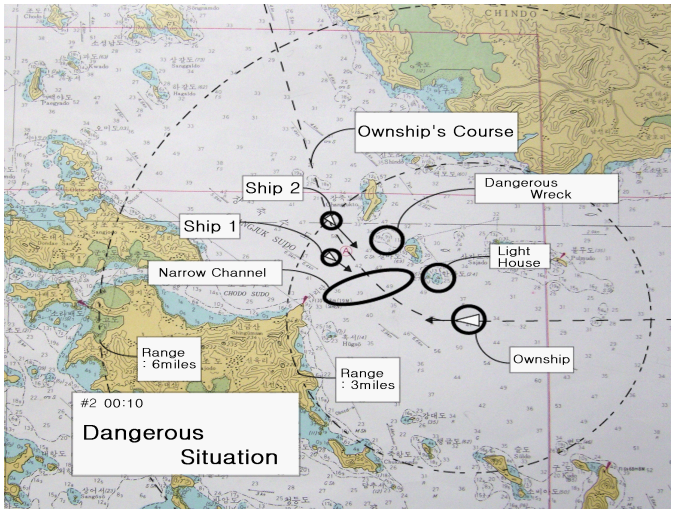

Figure 10. Navigational Situation "Dangerous Stage"

4.2 *Navigation situation expression of information that can be obtained from Data Fusion Model*

Figure 11 shows a data fusion model for the information acquirable in a dangerous situation of scenario.

The data fusion model in Figure 11 can provide all the information provided by navigation equipment in a navigation of scenario in a simple sentence.

This expresses the meaning of information on Ship1, Ship2 and Object1 provided by a given data fusion model in a simple sentence.

"Ship 1's Position Is D1:Bearing Is 304°."

"Ship 1's Position Is D2:Range Is 2.12 miles."

"Ship 1's Position Is D14:GPS position Is Latitude 34° 19.4' N and longitude 126° 05.85' E.

"Ship 1's D3:CPA Is 0.15 miles."

"Ship 1's D4:TCPA Is 5.2 minute."

"Ship 2's D5:True course Is 126°."

"Ship 2's D6:Ture speed Is 10.0 kts."

"Ship 2's D7:IMO No. Is 440100001."

"Ship 2's D18:Rate of turn Is 0.0°/min."

"Object 1's Position Is D1:Bearing Is 332°."

"Object 1's Position Is D2:Range Is 1.7 miles."

"Object 1's Position Is D14:GPS position Is Latitude 34° 19.75' N and longitude 126° 07.0' E.

"Object 1's D9:Name Is Dangerous wreck."

"Object 1's D23:Period Is Unlimited."

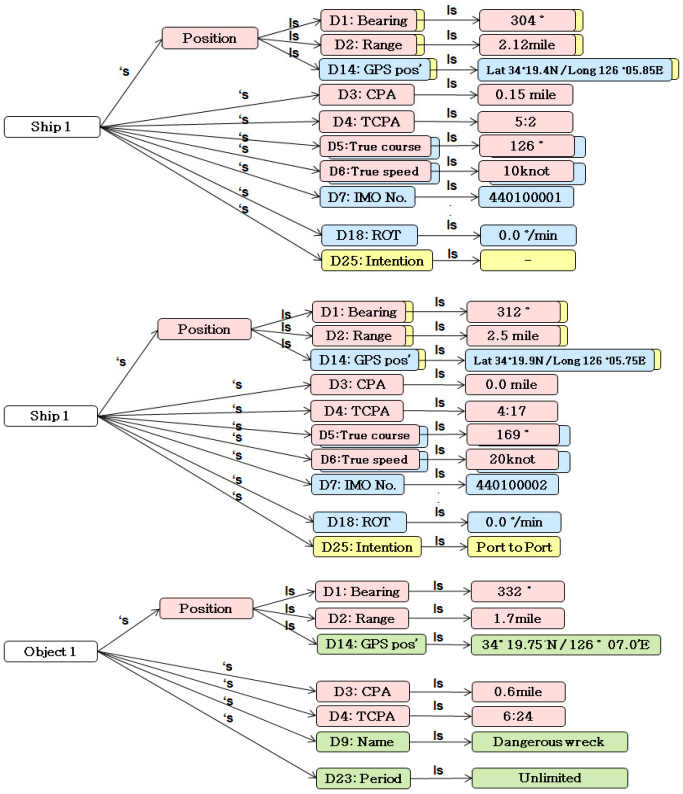

Figure 11. Navigation situation expression using the Data Fusion Model for each object

4.3 *Navigation situation expression using the Data fusion model*

Figures 12, 13 and 14 express the information obtainable through induction by a mate in a navigation situation of scenario using a data fusion model in Figure 11.

Figure 12 expresses the information of a new meaning inducing sentence using the meaning of multiple objects "the CPA of Ship1, Ship2 and Object1 is all within 1mile and less than 7 minutes, so it is very dangerous" using a data fusion model.

The meaning except for the meaning created newly after induction can be expressed linguistically.

- Ship1`s D3, D4, Ship2`s D3, D4, Object1`s D3, D4.

"Ship1's CPA Is 0.15mile, TCPA Is 5:2, Ship2`s CPA Is 0.0mile, TCPA Is 4:17, Object1`s CPA Is 0.6mile, TCPA Is 6:24."

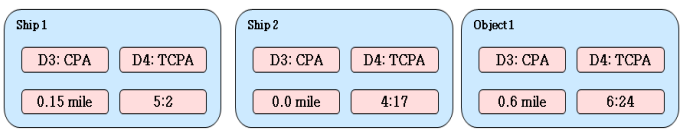

Figure 12. Navigation situation expression – 1

Figure 13 expresses the information of a sentence induced by combining the meaning of an object acquired from multiple navigation equipment "Object1 has Bearing 332°, Range 1.7mile, CPA 0.6mile, and TCPA 6:24, and its name is Dangerous wreck"using a data fusion model.

All the meanings of a sentence can be expressed.

-Object1`s D1, D2, D3, D4, D9.

"Object1 `s Bearing Is 332°, Range Is 1.7mile, CPA Is 0.6mile, TCPAIs 6:24, Name Is Dangerous wreck."

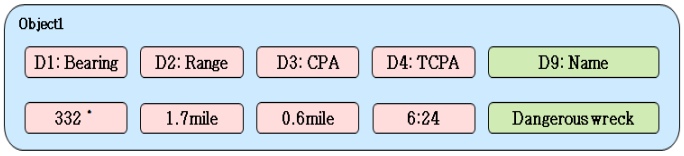

Figure 13. Navigation situation expression - 2

Figure 14 expresses the information of a sentence inducing a situation and presenting a solution by combining the meanings of an object acquired from multiple navigation equipment "Ship 1 has CPA 0.15mile and TCPA 5min 2sec, but it doesn't veer and respond to communication, so do DSC(Digital Selective Calling) for IMO No. 440100002"using a data fusion model.

The induced meaning cannot be expressed, but the information can be expressed.

- Ship1`s D3, D4, D18, D25, D7.

"Ship1`s CPA Is 0.15mile, TCPA Is 5min 2sec, Rate of turn Is 0.0°/min, Intention is nothing, DSC Is 440100002."

Ship1`s CPA Is 0.15mile, TCPA Is 5min 2sec, But, Rate of turn Is 0.0°/min, Intention is nothing ∴ DSC 440100002.

Ship1`s D3, D4 But D18, D25, DSC D7.

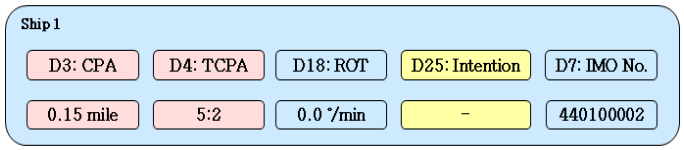

Figure 14. Navigation situation expression - 3

5 CONCLUSIONS

This study proposed a data fusion model using semantic network to analyze the information provided by each navigation equipment and express the meaning of information provided by navigation equipment by selecting navigation equipment such as GPS, ARPA, AIS, NAVTEX, VHF receiver, etc. providing essential information for grasping a navigation situation, and explained the information acquirable and the inducible by a mate in a navigation situation of scenario using a data fusion model.

The test of the proposed model in some real navigation situations will be done to verify its validity in future.

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