Developing a Program to Pre-process AIS Data and applying to Vung Tau Waterway in Vietnam
- Based on the IWRAP Mk2 program -

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AIS 데이터 전처리 프로그램의 개발 및 Vung Tau 해역에의 적용
- IWRAP Mk2 프로그램을 기초로 -

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Abstract : *The IWRAP program (Inland Waterway Risk Assessment Program) is a useful program for risk assessment of a waterway. However, in the basic version, the function which is used to import AIS data is not included. So users have to prepare the data and input to the program manually. And not all waterways have enough statistical data about passing vessels especially in developing countries as Vietnam. This paper studies the development of a program to pre-process AIS data for using the IWRAP Mk2 program basic version. In addition, it provides users basic information about marine traffic in a waterway such as routes layout, number of passages at a gate classified by type, size and time. The developed program, named TOAIS (Total AIS), was successfully used to pre-process AIS data collected in the Vung Tau waterway-Vietnam. As a result, the IWRAP Mk2 program basic version using data pre-processed from TOAIS could effectively assess the risk of collision in this waterway.*

Key Words : *IWRAP program, Risk assessment, Pre-processing AIS data, Marine traffic, TOAIS program, Vung Tau waterway*

요   약 : IWRAP 프로그램은 수로에서의 위험성을 평가하는데 유용한 프로그램이다. 그러나 이 프로그램의 기본 버전의 경우 AIS 데이터를 수집하는 기능이 포함되지 않아서, 더구나 베트남과 같은 개발도상국에서는 해상교통량 통계 데이터가 없는 실정이다. 사용자들은 수동으로 준비하여 입력하여야 한다. 이 연구는 IWRAP Mk2 프로그램 기본 버전을 사용하는데 있어 AIS 데이터를 전처리(pre-process) 할 수 있는 프로그램을 개발하고자 하였으며, 선박 형태, 선박 크기, 통과 시간 등으로 분류한 통항로에서의 선박 통항 척수 및 항로 배치와 같이 해역 내 해상교통에 관한 정보들을 사용자에게 제공하도록 고안되었다. 이렇게 개발된 통합 AIS 프로그램(Total AIS, TOAIS)은 베트남 Vung Tau 해역의 AIS 수집 데이터를 전처리할 수 있는지에 대하여 검증하였다. 그 결과, 통합 AIS 프로그램에서 전처리한 데이터를 이용한 IWRAP 프로그램은 베트남 해역의 위험성을 효율적으로 평가할 수 있었다.

핵심용어 : IWRAP 프로그램, 위험 평가, AIS 전처리 데이터, 해상교통, 통합 AIS 프로그램, Vung Tau 해역

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1. Introduction

The IALA Waterway Risk Assessment program (IWRAP program) was developed by IALA together with the Canadian Coast Guard, Technical University of Denmark and the Maritime Simulation Centre Warnemünde in 1990s and the IWRAP Mk2 program was released in 2009 (IALA, 2009).

According to IALA recommendation No. O-134, the IWRAP program is a useful program for risk assessment of a waterway (IALA, 2009). In the commercial version, this program is able to obtain required input data (volume of traffic and lateral distribution of traffic on each route leg) from AIS data automatically. But in the basic version, this function was removed (IWRAP, 2012). So users have to calculate these data and input to the program manually. In this paper the IWRAP Mk2 program basic version is briefly called the IWRAP program and its required input data are called "IWRAP program's input data".

Kim et al.(2011) has calculated by hand the "IWRAP program's input data" in Ulsan waterway based on a previous study on the Japanese inland sea and statistic data from port authorities. Then, he input to the IWRAP program to assess risk of this area by IWRAP model and compare the result with the ES model (Environment Stress model).

Nowadays, not all waterways have enough statistical data about passing vessels especially in developing countries such as Vietnam. So it is impossible to prepare enough data for the IWRAP program by the way as Kim did for the Ulsan waterway.

Before 2010, IALA and DAMSA (Danish Maritime Safety Administration) developed a set of external tools for IWRAP program, that were able to calculate the "IWRAP program's input data" from AIS data (IWRAP, 2012). However, they are no longer developing.

GateHouse(2012) is introducing an IWRAP Mk2 AIS Import program, but its license fee is too high so it is not suitable for developing countries.

Because of the above reasons, this paper studies the development of a program, that has the same functions as the external tools, which are mentioned above. This program is named Total AIS (TOAIS). It is developed by Microsoft Visual Basic 6.0 and Microsoft Access 2003.

The developed program was successfully used to pre-process AIS data of the Vung Tau waterway-Vietnam for the IWRAP program to assess the risk of collision in the intersection area of this waterway.

2. Design of program functions

To be able to calculate the "IWRAP program's input data" from AIS data, the program must have two main functions as shown in Fig. 1.

The first function is collecting and storing AIS data transmitted from ships. The second is processing these data to obtain the final result, that is "IWRAP program's input data".
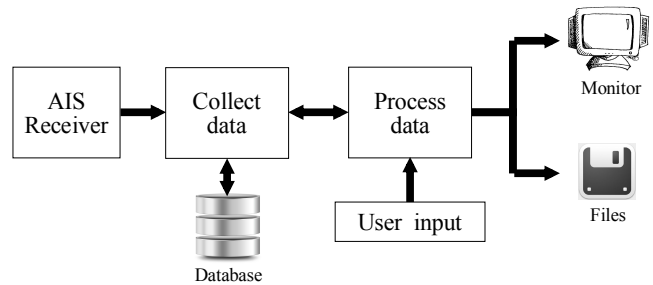

Fig. 1. Functions diagram.

2.1 Collecting and storing AIS data function

AIS signals, that are transmitted from ships will be received by an AIS receiver and transferred to a computer simultaneously. By this function the program will receive raw data from the AIS receiver then decode and store them to a database.

Receiving and decoding data from AIS receiver are complex processes, so this paper chose another solution as shown in Fig. 2 below.
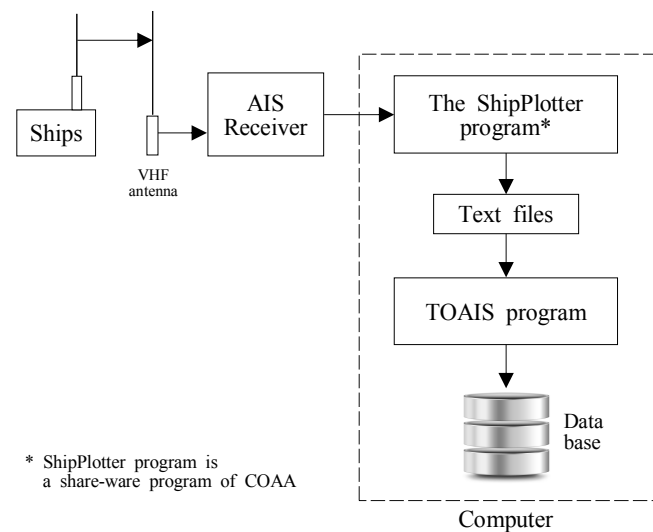
Fig. 2. Process for collecting and storing AIS data.

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In the diagram the ShipPlotter program (COAA, 2012), will receive AIS raw data from AIS receiver, decode and store to text files. Then the TOAIS program will read and transfer data in these text files to the database.

The text files are classified into two types:

(1) The first is "shipinfo.log" type. This type has only one file, which stores static AIS information such as MMSI, name, call sign, dimensions, flag, etc. of all ships.

(2) The second is "shipplotterYYMMDD.log" type. It has many files. Each dynamic and voyage AIS information such as position, speed, heading, course, draft, etc. collected in a day are stored in one file. These files are named shipplotterYYMMDD.log where YYMMDD is an abbreviation of the date when the file is created.

2.2 Processing AIS data function

This function will process AIS data stored in the database to obtain the "IWRAP program's input data". The process of this function is shown in Fig. 3.
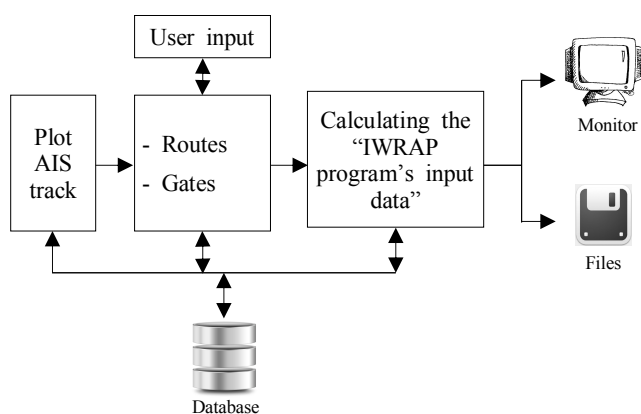

Fig. 3. Data process function.

(1) The function of the "Plot AIS track" block is reading and filtering AIS data from the database based on user-defined period of time and excluded ship list. Then the filtered data will be plotted on the screen as ship tracks. The excluded ship list is a list of ships, which will not be plotted. They will also not form part of the calculation because they have many movements but a negligible effect on traffic in the area such as pilot boats, anchored ships, etc.

(2) The "Routes & Gates" block will help users to input routes and gates definitions based on the ship tracks.

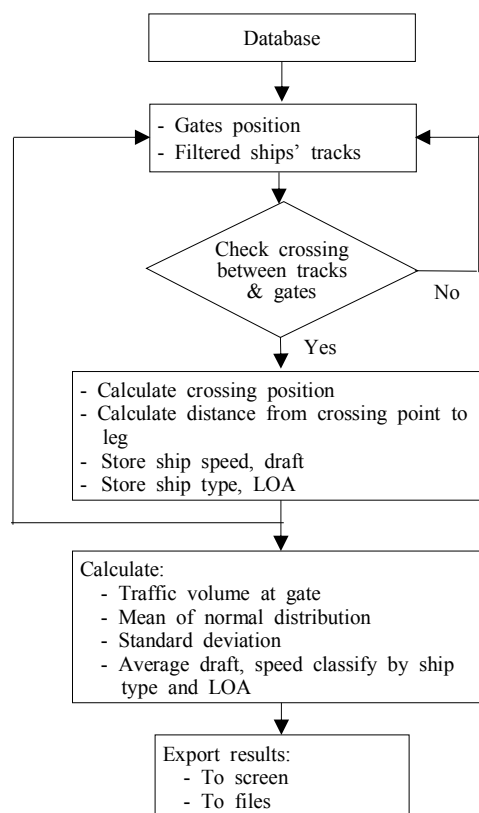(3) The detail of "Calculating the IWRAP program's input data" block is shown in Fig. 4

Fig. 4. Flow for data process.

2.3 Other functions

In addition, some other functions were designed to support user for different purposes and make the program easier to use such as:

- Plot tracks of vessels one by one to help users find ships, that should be in the excluded ship list;
- Exclude the noise data caused by radio noise when receiving AIS signal from ships;
- Zoom in and out the plot area of ship tracks;
- Provide users basic traffic information of a waterway such as frequency of passing vessels classified by type, size and time. These data are displayed on the screen and able to export to Microsoft Excel file. Fig. 5 and Fig 6 show some examples of this function.
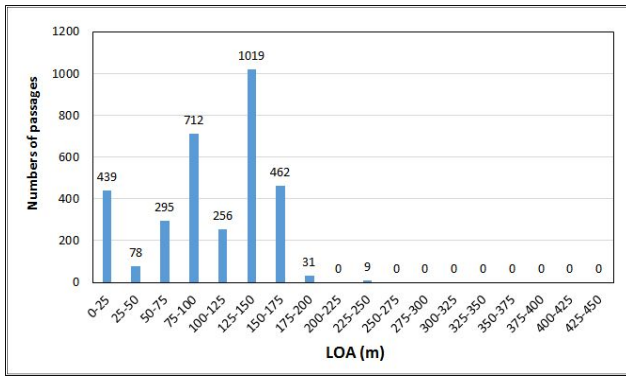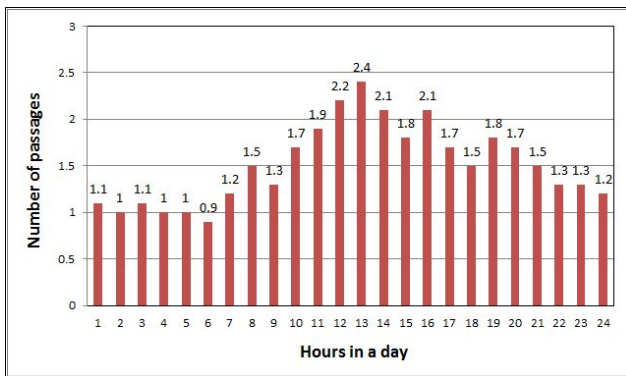
Fig. 5. Frequency of vessels by size.

Fig. 6. Frequency of vessels by time.

3. Design of program database

The database has to meet the two main requirements: ① able to store all AIS information; ② make it easier to retrieve and useful for other research. In addition, it should be portable for moving and do not require a strict security. Because of the above, a Microsoft Access database is the best solution to store the AIS data.

The AIS data consists of three types of data: (Navigation Center, 2012)

(1) Static data: MMSI, name, IMO number, call sign, ship dimensions, type, etc.
(2) Dynamic data: position, speed, course, heading, etc.
(3) Voyage data: destination, ETA, draft, crews, etc.

Static data are stored in table named VESSELS, dynamic and voyage data are stored in table TRACKS. The two tables are related by the MMSI field.

Tables 1 and 2 below show the detail description of vessels and tracks data tables.

Table 1. Data for vessels

Fields	Data type	Data size	Remarks
"VESSEL": store vessel static information			
MMSI	Text	9	Primary key
SHIPNAME	Text	20	
IMO	Text	9	
CALLSIGN	Text	7	
SHIPTYPE	Number	Byte	
LOA	Number	Integer	
B	Number	Integer	Ship breadth

Table 2. Data for tracks

Fields	Data type	Data size	Remarks
"TRACKS": store dynamic & voyage information			
MMSI	Text	9	Primary key
RCVDTIME	Date/Time		Primary key
LATITUDE	Number	Single	
LONGITUDE	Number	Single	
SPEED	Number	Single	
COURSE	Number	Single	
HEADING	Number	Single	
DRAFT	Number	Single	

In addition, the database must have some other tables to store user input data such as routes, gates, excluded ship list, co-ordinate of coast line points, output results, program parameters, etc.

Table 3 below shows data for route and gate.

Table 3. Data for route and gate

Fields	Data type	Data size	Remarks
"ROUTES": store navigation routes in area			
ROUTEID	Number	Byte	Primary key
WPTNO	Number	Byte	Primary key
X	Number	Single	
Y	Number	Single	
"GATES": store gates' position			
GATEID	Number	Byte	Primary key
xA	Number	Single	Position of A end & B end of gate
yA	Number	Single	
xB	Number	Single	
yB	Number	Single	

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4. Applying the program for the Vung Tau waterway

The Vung Tau waterway in Vietnam is an intersection of three fairways, that connect the triangular economic zone in Southern Vietnam with the open sea. According to information of Vung Tau Port Control, in the last five years about 80% of marine accidents in this area were caused by collisions between ships or between ships and obstacles. Because of this, the risk of collision in the intersection area of Vung Tau waterway has to be evaluated and find solution to improve marine traffic safety.

But the statistic information of traffic in this area is not enough to prepare input data for running the IWRAP program. However, most passing ships have AIS installed (almost ocean vessels and some big fishing boats). So using the TOAIS program to pre-process AIS data and then running the IWRAP program is a reasonable method to assess risk in this area.

An AIS data collection system was installed in Vung Tau as shown in Fig. 7. The system was monitored from remote through the TeamViewer program. Every day, the text files containing AIS data of previous 24 hours, which is exported by the ShipPlotter program, will be sent to a remote user automatically.
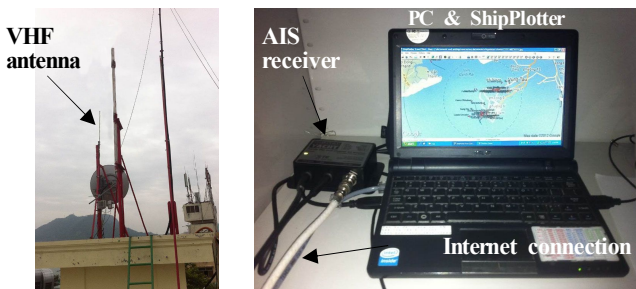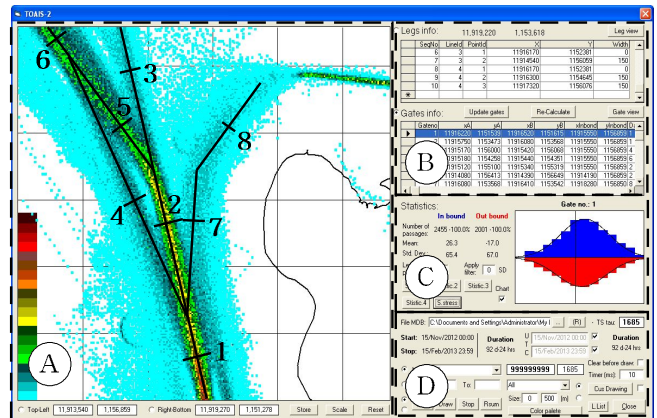

Fig. 7. AIS data collection system.

The collected AIS data are imported to the TOAIS program and then displayed on the screen. Routes and gates in this area were defined by user on the map of traffic density as Fig. 8 below.

A: Plotting area
B: Area to define routes and gates
C: Area for display traffic volume and lateral distribution
D: Area for other functions (open file, user's options, etc.)

Fig. 8. Main screen of the TOAIS program.

Base on the defined routes and gates, the program will calculate traffic volume and normal distribution of traffic at each gate. The TOAIS program was run with the AIS data collected in 3, 7 and 90 days for comparison.

Fig. 9, 10 and 11 below, show the distribution curves and histograms of traffic volume at a sample gate (gate No. 1), which were calculated based on different AIS data packages.
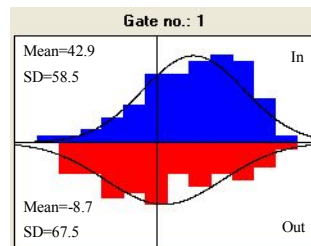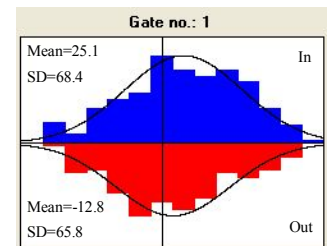

Fig. 9. 3 days AIS data.
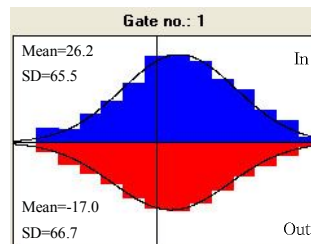

Fig. 10. 7 days AIS data.
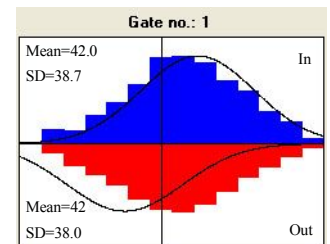

Fig. 11. 90 days AIS data.

Fig. 12. Using formula (1).

In Fig. 12, the histograms show traffic volume in 90 days and the curves show normal distribution of traffic, which was calculated manually according to the previous study on the Japanese inland sea. In accordance with this study, center of distribution is fixed a tenth of fairway width from the right side of the center of fairway. Standard deviation is calculated as formula (1) (Park et al., 2002),

$$\sigma = -9.49 + 0.106\omega + 3.33Q \qquad (1)$$

where:

σ : standard deviation (m)

ω : width of fairway (m)

Q : traffic volume (vessels/hour)

Fig. 13 shows some sample text files which contained data of traffic volume and average speed classified by ship type and LOA. These files were exported by the TOAIS program and used to input to the IWRAP program.

Fig. 13. Frequency and speed data files.

The IWRAP program requires the input data that are collected in a year (365 days). To get the approximate data for 365 days, the traffic volume calculated based on 3, 7 and 90 days AIS data must be multiplied with 365/3; 365/7 and 365/90 respectively.

Fig. 14 to Fig. 17 below, show the risk of collision in the intersection area of the Vung Tau waterway, which were calculated by the IWRAP program based on the input data were pre-processed by the TOAIS program and manually calculation by formula (1).
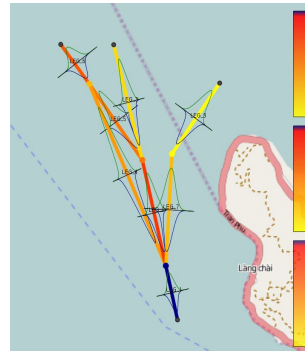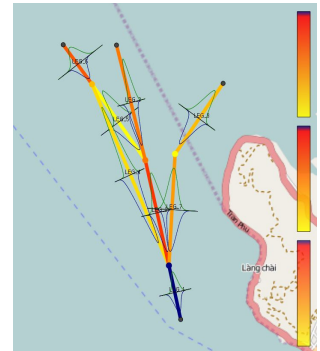

Fig. 14. 3 day AIS data.
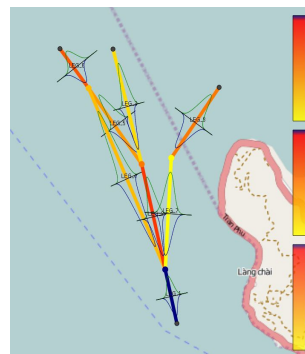

Fig. 15. 7 days AIS data.
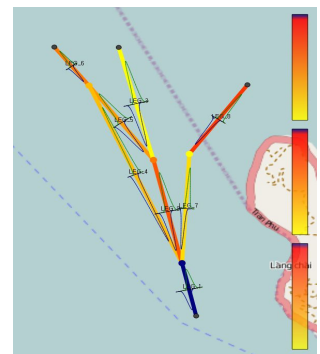

Fig. 16. 90 day AIS data.

Fig. 17. By formula (1).

Fig. 14 to Fig. 17 show that there is no significant difference between these results. The highest risk of collision areas are along the leg No. 1 followed by leg No. 2 and 6.

However, Fig. 9 to Fig. 12 show that:

- The distribution of traffic calculated manually by the formula (1) is not suitable for the Vung Tau waterway.

- And when using the TOAIS program, the distribution which is calculated based on longer AIS data is more exact.

In addition, the 365 days traffic volume data will also be more exact when using AIS data collected for longer time.

Because of the above reasons, the IWRAP result based on 90 days AIS data, which were pre-processed by the TOAIS program is the most exact compared with others.

5. Conclusion

This paper presents a method for developing of a program to pre-process AIS data for the IWRAP program basic version to assess the risk in a waterway.

The developed program, TOAIS program, was used to pre-process AIS data collected during 90 days in Vung Tau

waterway-Vietnam for the IWRAP program basic version to assess the risk of collision in the intersection area of this waterway. The result show that the most dangerous area is along the leg No. 1. And it also shows that risk assessment result of the IWRAP program will be more exact when using the AIS data collected in a longer time.

In addition, it also provides users basic traffic information of a waterway. And the AIS data are stored in a Microsoft Access database file, that can easily be used for further research.

In future, the program will be developed according to the following points:

(1) Other distribution functions such as Lognormal, Uniform, etc. should be added;

(2) Improving speed of the program;

(3) Improving program user interface;

(4) Testing the program with more AIS data packages.

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