Study of Fuzzy Theory and Geographic Information Systems and Their Application to Safeguarding Navigation of Fishing Vessels

Abstract

In recent years, casualties of fishing vessels have often appeared in maritime ship collision incidents, with the major causes being human error and unpredictable conditions. This study aims to create a set of collision-avoidance measures for fishing vessels by way of time and space management. It will propose a new safe collision-avoidance guarding ring for navigational safety between fishing vessels and merchant ships, enabling fishing vessels to establish the dynamic state of approaching operated ships. This study utilizes maximum relative speed and relative bearing between fishing vessels and merchant ships as the reference value of space, and the escape time of fishing vessels as the reference value of time. These three items are used as the linguistic input variables of fuzzy control theory. Following a calculation, a safeguarding ring radius is obtained, which is then shown on the platform of marine geographic information systems (GIS) in accordance with the actual proportion. Following simulation analyses, a safe collision-avoidance guarding mode for the operated fishing vessel is created. In addition, in order to further determine the danger relationship for the collision of two ships, the area difference calculated through GIS is used as the evaluation basis for a danger index for two ships. It is expected to promote the collision-avoidance guarding capability of the operated fishing vessel effectively, improve the safety of fishermen operating at sea, and reduce marine casualties for merchant ships and fishing vessels.

Keywords: Fuzzy theory, marine geographic information systems, safeguarding ring, danger index

1. Introduction

Taiwan is surrounded by sea, the natural environment is remarkable and the long coastline is made up of numerous coral reefs. On account of the abundant marine fisheries resources, there is a large number of harbors and fishing vessels. Fishing has become the most important economic activity and provides a livelihood for many people in Taiwan. In order to promote the navigational safety and information transmission ability of maritime transportation, the International Maritime Organization (IMO), International Association of Lighthouse Authorities (IALA), International Telecommunications Union (ITU) and International Electronic Committee (IEC) participated in setting up the equipment for the Automatic Identification System (AIS). It was stipulated that CLASS A AIS should be installed for ships over 300 tons, and CLASS A AIS should be installed for ships less than 300 tons. The Taiwanese government has not enforced the installation of CLASS B AIS on

all fishing vessels because the small-scale fishing vessels do not have AIS transceiver function. When such fishing vessels and merchant ships collide, merchant ships with AIS are unable to provide the necessary collision-avoidance information to the crew of fishing vessels effectively.

Marine casualties of fishing vessels are a regular occurrence. According to Article 2 of the “Disasters Prevention and Protection Act”, “marine casualty” disasters are mainly dealt with by government authorities. The “Enforcement Rules of Disasters Prevention and Protection Act”, promulgated by the Ministry of Interior and the “Operation Plan for Prevention and Protection of Marine Casualty”, promulgated by the Ministry of Transportation and Communications, define marine casualty as the breakdown, foundering, stranding, collision, fire, explosion, or leaking of a ship or other extraordinary accidents associated with a ship, its crew or its passengers.

Ships include but are not limited to, cargo ships, passenger ships, fishing vessels, and government ships. According to statistical data from the Ministry of Transportation and Communications [1], the major causes for marine casualty of fishing vessels in Taiwan are “mechanical breakdown”, “fire” and “collision”, which accounted for 81.2, 23.5 and 16.7 ships in the past six years, respectively. Among them, a serious accident of a “collision between a cargo ship and fishing vessel” occurred off Keelung Islet, Taiwan on January 5, 2008 between the fishing vessel “Pacific Ocean 168”, which was sailing around the Islet, and the cargo ship “Country Rich Carrier”, which lay behind the Islet. Although the radars of both ships were scanning the sea surface continuously, only Keelung Islet could be seen on the screen. Unable to see each other until it was too late, the occurrence of a marine casualty was unavoidable. Operating fishing vessels frequently drift at sea. If the on-watch crew of merchant ships neglect to keep a good lookout, collisions can occur due to human error.

Collisions may not be the only accidents caused by merchant ships. They can also cause fishing vessels to shed their nets or capsize. Fishing vessels and merchant ships differ in many ways. When merchant ships approach fishing vessels, the resulting wake can affect the operation of fishing vessels and can result in net shedding or capsizing. If fishing vessels are unable to send out guarding messages in time, marine casualties will result. At present, the safe collision-avoidance guarding mode for operating fishing vessels has not been created domestically and there are very few domestic or international scholars researching this topic. This study shows that it is necessary to create a safe collision-avoidance guarding mode for fishing vessels. First, AIS receivers are employed to set safe collision-avoidance guarding modes for operating fishing vessels. After it is stipulated by the law, CLASS B AIS can be installed in order to improve the navigational safety of ships. The safe collision-avoidance guarding mode for operating fishing vessels proposed by this study can be widely applied and the marine casualty of fishing vessels will be greatly reduced for future statistical investigations.

模糊理论与海洋地理信息系统应用于　　渔船航行安全警示之研究

摘要

近年来，在船舶碰撞事件上，渔船海难时有所闻，探其原因多归咎于人为疏失与无法察觉。因此，本研究拟建立一套作业中渔船安全避碰警示模式，藉由时间与空间管理的角度切入，针对作业中渔船与商船之间的航行安全提出新的安全避碰警示圈，使作业渔船能警觉接近中船舶的动态，避免发生碰撞。本研究主要利用渔船与商船间最大相对速度及相对方位为空间参考值，结合渔船各类渔具渔法的相异脱逃时间为时间参考值，以此三项为模糊控制理论的输入语意变量，经计算后，得出安全警示圈的半径，再依实际比例显示于海洋地理信息系统平台上，经由多次模拟分析后，完成构建作业中渔船安全避碰警示模式。另外，为了进一步分析两船间的碰撞危度关系，透过 GIS 快速计算面积差的能力，作为两船间危度指标的评量依据。期望有效地提升作业中渔船安全避碰警示的能力，提高渔民在海上作业时的安全，以期降低商船与渔船海难事故发生。

关键词：模糊理论、海洋地理信息系统、安全警示圈、危度指标

一、前言

台湾四面环海，天然环境优越，海岸线十分发达，四周珊瑚礁石密布，蕴藏着丰富的海洋渔业资源，港湾渔船为数甚多，使渔业资源成为台湾地区重要的经济活动及民生产业。为提升海洋运输的航行安全，国际海事组织(IMO)、国际灯塔协会 (IALA)、国际电信联盟(ITU)及国际电子委员会(IEC)等，共同参与船舶自动识别系统(AIS)的设备制定，以提高船舶航行安全及信息传送能力，且规定 300 吨位以上船舶需装设 CLASS A；300 吨位以下装设 CLASS B。碍于我国政府尚未强制推动渔船皆需装设 CLASS B，小型渔船并无 AIS 收发机的功能，且当渔船与商船发生碰撞时，装设 AIS 的商船无法有效提供船舶避碰信息给航行人员，造成渔船海难碰撞事件之发生。

一直以来，渔船海难事故不断发生，根据我国「灾害防救法」第二条条文指出「海难」为我国政府机关主要防救的各类灾害之一，至于我国政府主管机关对「海难」的定义，依据内政部所发布的现行「灾害防救法施行细则」，以及交通部依据「灾害防救法」所制订的「海难灾害防救业务计划」，皆将海难定义为：船舶发生故障、沉没、搁浅、碰撞、失火、爆炸，泄漏或其它有关船舶、船员或客船的非常事故。

由于上述海难所涉及的船舶包括货船、客船、渔船、公务船舶等各式船舶。由交通部统计数据显示[**Error! Reference source not found.**]，我国渔船海难事故中，「机器故障」、「失火」及「碰撞」列为三大类型，近六年平均肇事渔船数分别为 81.2、23.5 及 16.7 艘。其中，2008 年 01 月 05 日发生在台湾基隆屿海域的「货轮撞渔船」海难重大事故，主要原因系渔船「太平洋 168 号」航行至基隆屿附近，而货轮「国富号」位于基隆屿后面，两船雷达虽不断扫描，但受到障碍物影响，屏幕上仅看到基隆屿，无法扫描到彼此回迹，等到发现对方，为时已晚，海难事故已无可避免。渔民在海上漂泊作业，由于本身专注于捕鱼作业或商船航行当值人员的人为疏失及耽于航行作业，而造成船舶碰撞海难事故的发生，甚至商船碰撞渔船前后仍有浑然不知的情况，造成无法适时补救的重大遗憾。

渔船海难不仅有商船所造成的碰撞事故，商船对作业中渔船也会造成倾覆及脱网的海难事件。由于渔船有别于一般商船，当商船接近渔船时，往往因航迹流及俥叶流效应造成海面上产生波浪而影响航行中渔船作业，使运转受限制作业中渔船造成倾覆及脱网，且渔船本身无法适时发出警示，致使渔船倾覆的海难事故层出不穷。由于目前国内未建立作业中渔船安全避碰警示模式，国内、外探讨此议题的学者也非常少，因此，本

研究认为渔船航行安全警示的建立是有必要的。本研究先以 AIS 接收机构建作业中渔船安全避碰警示模式，待法律制定后，将可装设至渔船 CLASS B，提升船舶间航行安全，藉由本研究所提出作业中渔船安全避碰警示模式，以广泛运用在作业中渔船，而使未来在海难事故调查的统计上，渔船的海难事件能够大幅降低。