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A Study of Development of Vessel Medicine Management System Based on Image Processing

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Abstract : *This paper presents the Vessel Medicine Management System (VMMS), designed to enhance the management of medications on ships through the application of advanced image processing technologies. The system incorporates Optical Character Recognition (OCR) for the extraction of text from medication packaging, barcode recognition for standardized drug coding, and an intuitive search interface to facilitate efficient inventory management. By automating these processes, the VMMS alleviates the workload of navigational officers and ensures precise tracking of medication usage in accordance with international medical guidelines. A comprehensive database provides essential information regarding dosage, efficacy, and side effects, thereby promoting safety in medical care at sea. Additionally, the system enhances communication with onshore medical professionals, resulting in improved emergency response times and crew welfare. This integration not only addresses the complexities associated with onboard medication management but also supports prospective advancements in maritime remote medical systems. Overall, the VMMS signifies a substantial advancement in the enhancement of healthcare delivery within isolated maritime environments.*

Key words : *medicine, medication, OCR, medical manager, vessel medicine management system*

1. Introduction

To operate a vessel, crew members are required. Given that crew members work in isolated and specialized environments, they cannot easily access medical facilities if they are sick. In the event of a medical emergency, crew members must rely on onboard medications or seek telemedical advice for emergency treatment. Therefore, it is crucial for vessels to maintain a stock of medications and manage them effectively for immediate use in emergencies.

The International Medical Guides for Ships (IMGS), jointly published by the World Health Organization (WHO), the International Labour Organization (ILO), and the International Maritime Organization (IMO), recommend that ocean-going vessels stock 54 types of medications(Schlaich et al., 2009). Additionally, the Ministry of Oceans and Fisheries in Korea has designated mandatory medications for different types of vessels(MOF, 2024a). Typically, shipping companies supply vessels with legally required and recommended medications according to company policy, which includes both non-prescription medications and prescription medications.

According to Article 85 of the Seafarers Act, medical managers are required to be onboard(MOF, 2024b), and Rule 52 of the Seafarers Act Enforcement Rules stipulates that these medical managers are responsible for the prescription and management of ship's medications(MOF, 2024c). Most medical managers are appointed from among the ship's navigation officers, often those with less extensive sailing experience, such as third officers, who may lack specialized knowledge and experience compared to senior officers. This raises concerns about the effectiveness of medication use in emergency situations, considering that crew members are not medical professionals. Distinguishing and using medications correctly is highly specialized, especially when dealing with medications with similar names or effects. For example, antibiotics are broadly classified into five groups based on their mechanism of action, with each group further divided into 3 to 5 classes based on their chemical properties, each containing numerous substances with varying properties. Similarly, the dosage of a commonly known medication like aspirin can affect its intended use.

Typically, in accordance with the International Safety

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Management Code (ISM Code), shipping companies are required to maintain records of medication procurement, distribution, inventory, and expiration dates manually(IMO, 2014). Fig. 1 illustrates a portion of the medication management log used on a vessel of a P shipping company.

품 명 :
(Names of Medicines)

1. 주사제 (Injection)

용 도(Purpose) : 용 법(Usage) :
비치기준량(A standard amount) : 단 위(Unit) :
처방전 발급일(Date of issue of prescription) :
처방전 발급 병원/의사명(Hospital of issue of prescription) :
유효기간(Expiration date) :

수 급(Demand & Supply)			사 용(Use)			현재량 Holding Quantity	확인 서명 Signature of Confirmation
일 자 Date	항 구 Port	수 량 Quantity	일 자 Date	적 요 (Brief)	수량 Quantity		

Fig. 1 Medication management log of P shipping company

When shipping medications to vessels, companies often face local customs restrictions, which necessitate purchasing medications locally and distributing them onboard. This process can result in the introduction of unfamiliar medications to crew members or discrepancies in labeling languages, which may lead to issues. For instance, when medications are supplied from Korea, there may occasionally be a lack of English instructions, making it difficult for non-Korean-speaking crew members to understand how to use these medications. In such cases, vessel may need to request company for instruction in English.

The problems associated with the misuse of shipboard medications and the current state of onboard medication management have been addressed in previous studies(Jun et al., 2017). For manually maintained medication management logs, there exists a program developed to establish a medication management coding system for electronic oversight. This program incorporates a communication protocol designed for ship communication networks, thereby enhancing the efficiency of the medical information system between vessels and onshore facilities(Jun and Lee, 2003).

The existing program has developed its own medication coding system; however, this study aims to broaden its applicability by categorizing medications according to domestic standard codes and the WHO codes used globally. Furthermore, while previous methods required manual input of medication information, this study employs advanced image recognition technology. Instead of entering detailed medication information directly, we utilize Optical Character Recognition (OCR) to automatically recognize medication names and search for them in a proprietary database. This approach facilitates easy and rapid inventory management, providing convenience to users.

For domestic medications, the utilization of standardized barcodes allows for immediate access to inventory information simply by scanning the barcode. Additionally, to prevent misuse of medications, we intend to include information regarding administration methods, efficacy, and potential side effects.

2. Design of a image recognition-based system module

In this study, Vessel Medicine Management System (VMMS) is designed based on image recognition technology, aiming to facilitate efficient and rapid medicine management. The automation of medicine management is expected to enhance the efficiency of navigational officers, reduce their workload, and enable systematic computerized management.

The proposed system is designed and implemented with modules for text recognition from images of medication containers and packaging, barcode recognition, and a user search interface. Text recognition utilizes Optical Character Recognition (OCR) technology. By making shipboard medications database, the system allows for efficient management, including inventory control, differentiation of specialized pharmaceuticals, and verification of medication usage.

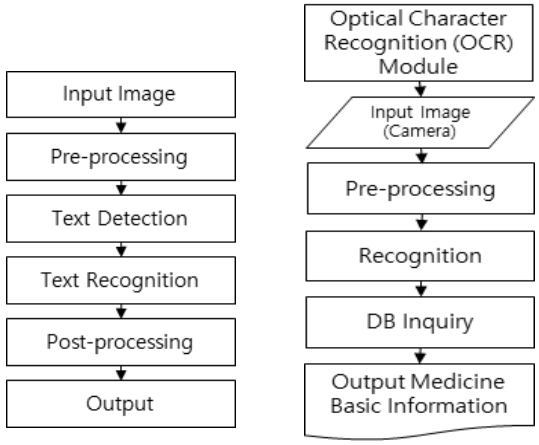
2.1 System Module Configuration

The System Module Configuration is structured around three primary components: the Optical Character Recognition (OCR) Module, the Barcode Recognition Module, and the User Search Module. The OCR Module is responsible for converting text images into machine-readable characters, enhancing the accessibility of written information. The Barcode Recognition Module interprets the Korea Drug Code, facilitating efficient management of pharmaceuticals. Lastly, the User Search

Module allows users to quickly search for medication names, improving the retrieval process of pharmaceutical information.

1) Optical Character Recognition (OCR) Module

Optical Character Recognition (OCR) technology, a subfield of pattern recognition, involves the conversion of text images, which can be handwritten or machine-printed, into machine-readable characters. As illustrated in Fig. 2(a), the OCR process encompasses four major stages: preprocessing, text detection, text recognition, and post-processing.



(a) OCR in general (b) OCR module

Fig. 2 Flowchart of OCR

Preprocessing stage addresses potential issues such as noise in images captured by cameras, aiming to improve the performance of text recognition. Techniques are employed to enhance image clarity and prepare it for further processing. During Text Detection stage, regions containing text are identified within the entire image. The goal is to isolate areas where text is present to facilitate more accurate recognition. In Text Recognition stage, the isolated text regions are analyzed to recognize the actual characters. The text recognition process is pivotal, with prominent OCR technologies including Tesseract-OCR and TensorFlow being commonly used(Smith, 2007; Abadi et al., 2016). Following text recognition, Post-Processing stage involves correcting any contextually unnatural elements or errors in the recognized text. This step ensures that the final output is coherent and accurate. Fig. 2(b) illustrates the flowchart of the Optical Character Recognition (OCR) module in Vessel Medicine Management System (VMMS) for maritime vessels.

Tesseract-OCR, developed by HP from 1984 to 1994 and released as open-source in 2005, is a versatile OCR engine capable of recognizing almost all languages(Smith, 2007). However, Tesseract-OCR's performance can degrade if the input images are not preprocessed adequately, as it excels in processing black-and-white images. While it demonstrates high accuracy in English recognition, its performance with Korean text is less accurate due to a smaller dataset for Korean compared to English.

Tensorflow, developed by Google, supports machine learning with distributed processing and visualization tools, allowing for effective model training and visualization(Abadi et al., 2016). However, TensorFlow does not support Korean language recognition. For maritime applications, it is crucial that the OCR system supports Korean and is lightweight considering internet connectivity constraints.

PaddleOCR is another option that addresses these requirements. It is a lightweight OCR system featuring database text detection, character shape adjustment, and CRNN-based text recognition, and it supports Korean. Consequently, Vessel Medicine Management System (VMMS) utilizes PaddleOCR technology. As shown in Fig. 3, when using the PaddleOCR-based optical recognition module to identify medications, the characters highlighted in red are recognized. The accuracy of recognition varies depending on the font size and type.

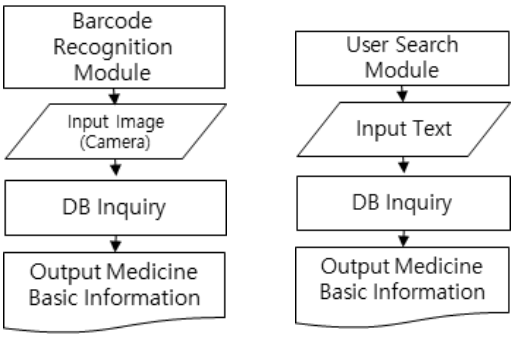
Fig. 3 Result of OCR module

2) Barcode Recognition Module

In Korea, pharmaceuticals are assigned a standardized code known as the Korea Drug Code (KD Code), which became mandatory for code labeling in 2009. Additionally, the mandate for barcode labeling of small pharmaceutical

products, specifically those of 15ml(g) or less, was implemented in 2010(MOHW, 2021). The KD Code is a 13-digit number uniquely assigned to each medication, comprising a national identification code, manufacturing and importing company codes, item codes, and a verification number.

For efficient electronic management of Korean pharmaceuticals through barcode recognition, the open-source Python library Pyzbar was utilized to design the barcode recognition module. Fig. 4(a) depicts the flowchart of the barcode recognition module within the comprehensive pharmaceutical management system for maritime vessels.



(a) Barcode module (b) User search module

Fig. 4 Flowchart of modules

3) User Search Module

In addition to the optical character recognition (OCR) module and the barcode recognition module, the user search module allows users to manage pharmaceuticals by searching for medication names directly. Fig. 4(b) illustrates the flowchart of the user search module within Vessel Medicine Management System (VMMS). This module enables users to perform searches based on medication names, facilitating efficient management and retrieval of pharmaceutical information.

2.2 Database Configuration

The database for the Vessel Medicine Management System (VMMS) is constructed using MySQL(DuBois, 2013). It is organized into four primary categories: crew information specific to the vessel, medicine inventory information, medicine distribution/consumption reports, and medication usage instructions. Fig. 5 illustrates tables of database. Medication usage instructions utilize public data from the medicine Public Data Portal. The data includes information such as medication name, manufacturer, drug specifications, total product quantity, dosage form, packaging type, product standard code, active ingredients, efficacy, usage instructions, precautions, and adverse reactions.

Access to the database is restricted to users with administrative privileges, who must log in with an ID that grants permission to modify or delete data.

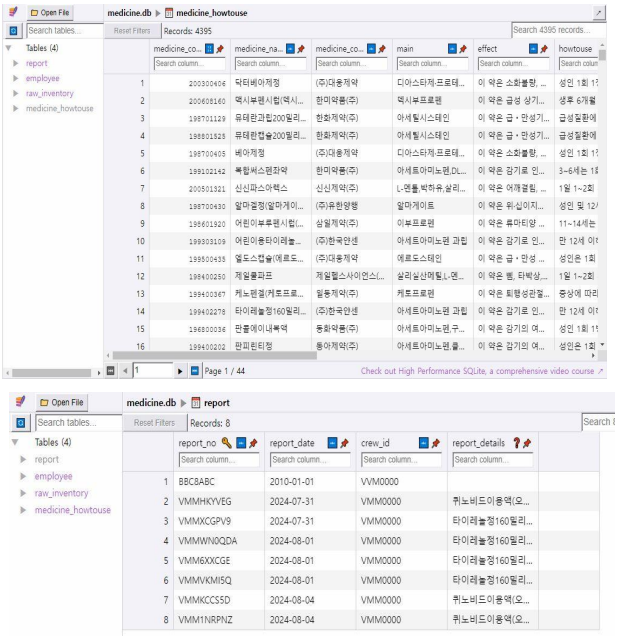


Fig. 5 Tables of database

3. Comprehensive Vessel Medicine Management System Design

3.1 System Operation and Management Framework

The system is divided into two modes: User Mode and Administrator Mode. Users can access the system with a general seafarer ID, while administrators require a specific ID with elevated privileges to directly modify or delete database records. Fig. 6 shows login screen of Vessel Medicine Management System (VMMS).

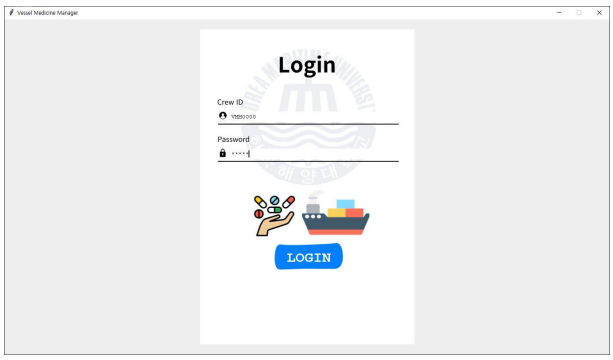


Fig. 6 Login screen

3.2 User Mode

User Mode consists of three primary components: Supply Mode, Consume Mode, and How to Use Mode. Each mode utilizes the Optical Character Recognition (OCR) module, the Barcode Recognition module, and the User Search module to facilitate medicine management. Users can also manually input additional information, such as expiration dates, quantities, and patient information. Fig. 7 shows a flow of user mode. The system automatically generates medicine management reports, which contributes to reduced workload and increased operational efficiency. Fig.8 shows a supply and consume mode screen when generates reports of Vessel Medicine Management System (VMMS).

In How to Use Mode, users can access detailed explanations of medication usage which is information that cannot be inferred solely from drug components by utilizing public data that has been integrated into the database. This feature allows for prompt and accurate responses in the event of a medical incident. Fig. 9 shows how to use mode screen of Vessel Medicine Management System (VMMS).

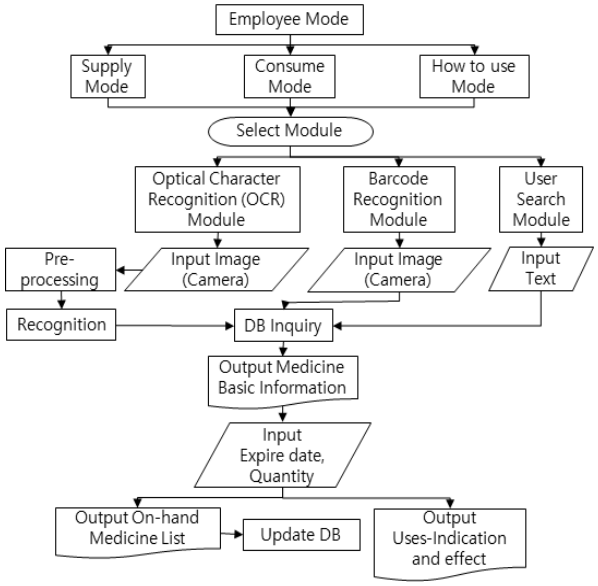


Fig. 7 Flowchart of user mode

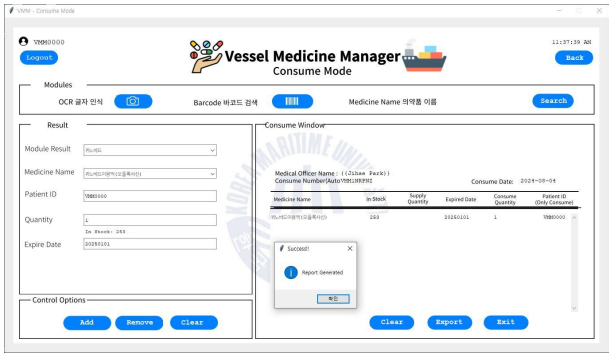


Fig. 8 Screen when generates reports of consume mode

Fig. 9 How to use mode screen

3.3 Administrator Mode

Administrator Mode comprises four primary components: Inventory Management, Employee Management, Report Management, and Development Information.

In Inventory Management, the quantities of medications distributed and consumed are automatically updated based on reports generated in the Supply Mode and Consume Mode. Administrators with the appropriate ID can directly register, modify, or delete records. Even medications not initially present in the database can be registered, allowing for effective electronic management of local pharmaceuticals procured on board. To register a new medication, details such as the medication name, manufacturer, medication barcode, WHO ID, and stock quantity must be specified. Fig. 10 shows a flow of admin mode. Fig. 11 shows inventory management screen of Vessel Medicine Management System (VMMS).

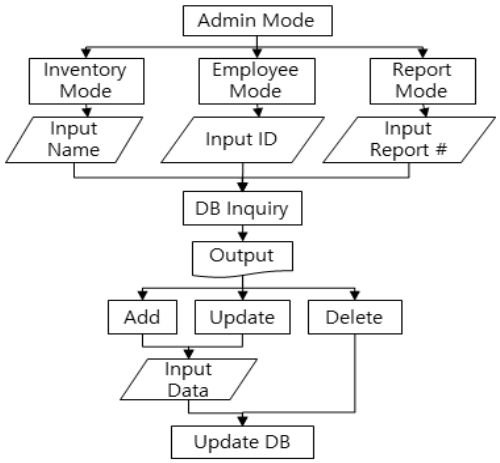


Fig. 10 Flowchart of administrator mode

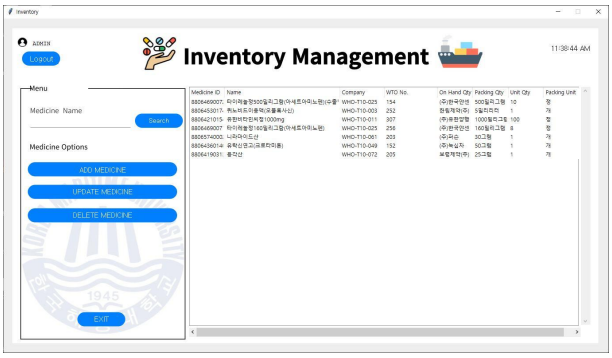


Fig. 11 Inventory management screen

Similar to Inventory Management, Employee Management allows for the registration, modification, and deletion of seafarer records. Each seafarer must have an ID, name, phone number, address, rank, and password specified. Deletion of records is restricted for administrators with ID permissions.

In Report Management, administrators can delete records from the Supply Mode and Consume Mode reports. This function enables the maintenance of accurate and current records within the system. Fig. 12 shows report management screen of Vessel Medicine Management System (VMMS).

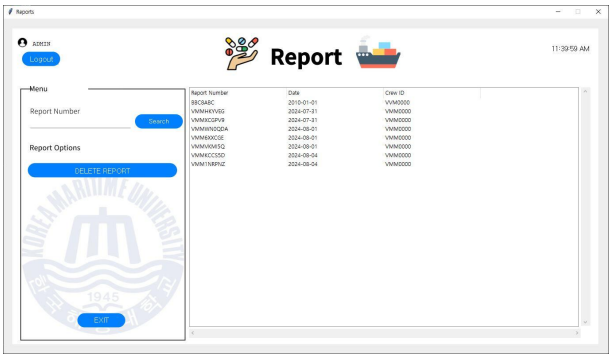


Fig. 12 Report management screen

4. Conclusion

This study presents the design and implementation of a Vessel Medicine Management System (VMMS) based on image recognition technology, focusing on enhancing the efficiency and accuracy of medicine management aboard ships. The system integrates Optical Character Recognition (OCR), barcode recognition, and user search functions to offer a comprehensive solution for medicine management and verification on vessels.

By managing medications based on image recognition, the system significantly enhances the efficiency of navigation officers' tasks while reducing the burden of manual work. Additionally, the system systematically organizes information through a medicine database, facilitating efficient data retrieval and management, while also enhancing system security by restricting data modification and deletion access to authorized personnel only. As a future task, further research is needed to validate the performance of the current system.

The computerized management system is ready to integrate with future maritime remote emergency medical systems. This integration would enable onshore medical professionals to monitor vessel medicine inventories in real-time, thereby preventing prescription delays and securing the golden hour in emergency situations, which ensures timely patient care. Furthermore, managing the pharmaceutical history of crew members contributes to their welfare.

In conclusion, the Vessel Medicine Management System (VMMS) effectively addresses the challenges of medicine management in isolated maritime environments. By leveraging image recognition technology and providing a user-friendly interface, the system improves overall crew welfare. There is potential for further refinement of these functionalities and expansion into other areas of vessel management, such as ship supplies, provisions, and safety equipment.

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