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A Study on Public Library Book Location Guidance System based on AI Vision Sensor

Soyoung Kim[1], Heesun Kim[2]

[1]*Instructor, Institute of Liberal Arts Education Center, Andong National University, Korea*
1083young@hanmail.net

[2]*Professor, Department of Software Convergence, Andong National University, Korea*
hskim@anu.ac.kr

Abstract

The role of the library is as a public institution that provides academic information to a variety of people, including students, the general public, and researchers. These days, as the importance of lifelong education is emphasized, libraries are evolving beyond simply storing and lending materials to complex cultural spaces that share knowledge and information through various educational programs and cultural events. One of the problems library user's faces is locating books to borrow. This problem occurs because of errors in the location of borrowed books due to delays in updating library databases related to borrowed books, incorrect labeling, and books temporarily located in different locations. The biggest problem is that it takes a long time for users to search for the books they want to borrow. In this paper, we propose a system that visually displays the location of books in real time using an AI vision sensor and LED. The AI vision sensor-based book location guidance system generates a QR code containing the call number of the borrowed book. When the AI vision sensor recognizes this QR code, the exact location of the book is visually displayed through LED to guide users to find it easily. We believe that the AI vision sensor-based book location guidance system dramatically improves book search and management efficiency, and this technology is expected to have great potential for use not only in libraries and bookstores but also in a variety of other fields.

Keywords: *AI Vision Sensors, Arduino, Library Book Location Notification*

1. INTRODUCTION

Libraries are key places for education and academic growth. It is also a space where many people explore and research knowledge and information. Over the centuries, the role of libraries has changed along with changing society and technological trends. The increase in the number of books is causing serious library management issues. In particular, a lot of time and money is spent on problems related to the lending and

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Corresponding Author: hskim@anu.ac.kr
Tel: +82-54-820-5478, Fax: +82-54-820-6257
Professor, Department of software Convergence, Andong National University, Korea

returning processes, as well as the organization and storage of books [1]. However, the essential purpose of the library, that is, the storage and transmission of knowledge, has not changed. Therefore, efficiently managing books in libraries and providing them to users has been considered a very important task. Korea's representative book classification system is the KDC. It is published by the Classification Committee of the Korean Library Association based on Western classification methods, including the Dewey Universal Decimal Classification (DDC), and the main table arrangement, addition of early tables, and main table items have been adjusted to suit the Korean information [2]. This system consists of the following classification numbers: 000 general science, 100 philosophy, 200 religion, 300 social science, 400 natural science, 500 technical science, 600 art, 700 language, 800 literature, and 900 histories. Based on this, call symbols in libraries include the method of classifying and arranging books in the following order: separate symbol, classification symbol, author symbol, volume symbol, and copy symbol. This system was relatively efficient when the library was small, but it causes several problems in modern large libraries.

The first problem is that as the size of the library grows, the time it takes for users to find the books they want increases. In fact, even if you know the location of a particular book, traveling to that location and finding the book can take a considerable amount of time. In particular, in the case of lower elementary school students, there are many cases where they give up because they cannot find the location of the book. Second, if a book's location changes or is on loan, the user must invest additional time to find the desired book. Lastly, users who are visiting the library for the first time or who are not familiar with the classification system may have great difficulty finding the books they want. To solve these problems, this paper presents a book location notification system that utilizes digital technology, artificial intelligence, and AI vision sensors, which have recently been in the spotlight. The book location notification system using an AI vision sensor was designed based on Python, C language, and Arduino. This system reads the QR code of the book name generated through an AI vision sensor equipped with machine learning functions and informs the user of the location of the book they wish to borrow. Technological developments in the 4th industry can provide efficient services to library users so that they can find the location of books more intuitively. Through these technological advances, libraries can further expand their functions and roles and improve user experience. The structure of this paper is as follows. In Chapter 2, we look at the technologies and sensors that form the basis of the system presented in this paper, and in Chapter 3, we describe the configuration of a book location notification system using an AI vision sensor. Chapter 4 examines the experiments and results of this study, and Chapter 5 examines the conclusions and suggests future supplements and improvements.

2. RELATED STUDIES

2.1 AI Vision Sensor

AI vision sensor is a sensor that combines artificial intelligence, camera, and computer vision technology. This sensor is used to recognize, process, and analyze the shape, size, color, and characteristics of objects using computer vision technology to image data input through a camera. Understand the content of captured images and recognize specific patterns or objects. Pattern matching in AI vision sensors is one of the most crucial image analysis techniques and is the most commonly used method in machine vision applications [3]. In this way, AI vision sensors, particularly cameras that recognize the position of objects, are gaining attention. This is due to advancements in computer hardware, which have significantly improved the efficiency of processing large volumes of information, such as camera image processing [4].

AI vision sensors can recognize specific objects or patterns based on training data. Data is analyzed in real time and immediate responses are possible. Data recognized through the AI vision sensor is continuously learned and improved through machine learning algorithms. It provides accurate results even under various environmental conditions, such as lighting and complex backgrounds. Data processed through AI vision sensors are used in various application fields. Representative examples include self-driving cars, robots, manufacturing, security, and healthcare. Self-driving cars use AI vision sensors to recognize the surrounding environment and control driving. Robots use AI vision sensors to identify and manipulate objects, and in manufacturing, AI vision sensors are used for quality inspection, inspection, and assembly. In security, AI vision sensors are used to detect intruders, face recognition, etc.

In healthcare, AI vision sensors are used for medical image analysis and medical diagnosis. Related research using AI vision sensors is as follows. "AI-Based Vision Recognition Through Emotional Glasses" transmit information obtained through non-verbal emotions through vibration, which is sensory information, for the visually impaired who cannot receive visual information. In order to increase accuracy in recognizing emotions, we utilize a complex image database for Korean emotion recognition provided by AI Hub and create deep learning-based real-time objects for five emotions such as joy, anger, sadness, and surprise. YOLOv5, a recognition algorithm, was applied to AI-based vision recognition and used for emotional communication of visually impaired people [5]. In "A Study on AI Techniques to Improve Fiber Recognition Rate Based on Vision Sensor" we compared and analyzed the AI CNN algorithm to recognize the pattern and density of the fabric and measured the quality of the fabric by applying the density measurement algorithm and AI CNN algorithm [6]. AI vision sensors are developing further along with the development of artificial intelligence technology, and it is expected that AI vision sensors will be used in more diverse fields in the future.

2.2 Library Literature Classification Code System

Figure 1 shows the KDC book classification codes divided into detailed categories. The KDC book classification system is a code system used to classify libraries and organize books and other materials within them. KDC was developed to reflect Korea's culture, history, and social characteristics and is mainly used in Korean libraries. The KDC system consists of 10 major classifications (0 to 9).

700 Language				
700 Language	710 Korean	720 Chinese	730 Japanese and other Asian languages	740 English
701 Linguistics	711 Phonetics, phonology, writing	721 Phonetics, phonology, writing	731 Phonetics, phonology, writing	741 Phonetics, phonology, writing
702 Writing Systems	712 Grammar	722 Grammar	732 Grammar	742 Grammar
703 Dictionaries	713 Vocabulary, lexicology	723 Vocabulary, lexicology	733 Vocabulary, lexicology	743 Vocabulary, lexicology
704 Collections of Lectures, Essays	714 Literature	724 Literature	734 Literature	744 Literature
705 Periodicals	715 Conversation, idioms, proverbs	725 Conversation, idioms, proverbs	735 Conversation, idioms, proverbs	745 Conversation, idioms, proverbs
706 Societies, Organizations, Institutions, Conferences	716 Regional dialects	726 Regional dialects	736 Regional dialects	746 Regional dialects
707 Methods of Teaching, Research Methods, Education, Educational Materials	717 History and geography	727 History and geography	737 History and geography	747 History and geography
708 Collected Works, Series	718 Dictionary and glossary	728 Dictionary and glossary	738 Dictionary and glossary	748 Dictionary and glossary
709 History of Language, Language Policy, Language Administration	719 Other subjects (e.g., K-Pop, drama)	729 Other subjects (e.g., HSK, drama)	739 Other subjects (e.g., JLPT, drama)	749 Other subjects (e.g., TOEFL, drama)

Figure 1. Part of the KDC

As shown in Figure 2, the classification code for public libraries in our area is displayed. The code "747.5 Mun53 ㅇ" appears within the KDC Code System. The "747.5" code is categorized under languages in the 700s, with "740" specifically referring to English. Thus, "747.5" indicates the subject of the material, while

"Mun53 ○" provides the author information. Figure 2 is a part of the KDC book classification code.

[Location Information]
Title: The Miracle of 100 Days of Basic English Conversation:
After 100 Days, I Will Speak English Too!
Publisher: Nexus
Call Number: 747.5 Mun53 o
Registration Number: EM0000173893
Author: Written by Sung-Hyun Moon
Library: General Library
Shelf Name:

Figure 2. Local public library classification code

In the current library system, it is common to loan and return books by attaching call numbers to them. In the paper "Development of an RFID based Library Management and Search System" the RFID system is used to determine the location of books in real time, and the LED on the shelf where the book is located is turned on using Bluetooth communication. The R-LIM system was presented as a location recognition-based book search system that searches for book locations. In this case, there is a problem that the number of RFID antennas increases [7].

2.3 Arduino's Field of Application

Arduino consists of a microcontroller MCU, a USB connector, 14 digital pins including 6 pins capable of PWM output, 6 analog pins, and a power connection and reset button. As an open-source platform, all materials, including circuit diagrams and compatible sensors, have been made public on the Arduino official website, and integrated IDE software is also provided free of charge. Coding education refers to the process of coding various hardware and its movements, downloading them to a digital device, and outputting the results through a serial monitor or various sensors. In other words, it means that computers and the real world communicate through data [8]. Arduino is a coding tool that can be purchased inexpensively as an embedded system-based board and is believed to be easily accessible for educational purposes [9]. Arduino uses various compatible sensors to create various smart IoT products that are used in real life. It is a teaching aid widely used in physical computing coding education, where the program is coded and uploaded to a made product, and the principles and concepts of coding are learned through the operation results [10]. The book location notification system using the AI vision sensor designed and implemented in this paper learns data through the Husky lens with the AI vision sensor function and uses Arduino and Neopixel for intuitive expression. We selected a few books to borrow in advance and installed Neopixels at the locations of the books to be borrowed. In advance, the book location notification system using the AI vision sensor is explained to 4th grade elementary school students and 3 adults. First, the time it takes to find a borrowed book based on the call number, which is the existing method, and second, AI vision. We tested two methods for finding a borrowed book based on the location notification of the borrowed book recognized by the book location notification system using a sensor, and compared and analyzed the time difference between the two cases.

3. DESIGN AND IMPLEMENTATION

3.1 System Configuration Diagram

The location notification system for books to be borrowed using an AI vision sensor presented in this paper was designed using Python, C language, an AI vision sensor capable of machine learning, and Arduino. Currently, the biggest problem that arises in the process of finding the location of a book when borrowing it from a public library is the time it takes to find it. To solve this problem, we implemented a book guidance system that shows the location of books based on AI vision sensors, Arduino, and Neopixel sensors. As shown in Figure 3, the overall configuration of the loaned book location notification system using an AI vision sensor is displayed. Neopixels are attached to each library shelf based on the sections divided by area. For experimentation and testing, we searched for several books and printed out dictionary QR codes.

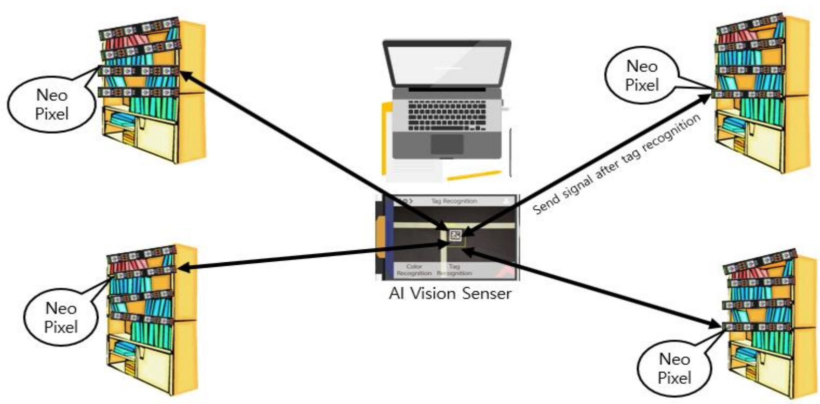

Figure 3. Configuration diagram of location notification system

As shown in Table 1 below, the configuration of the sensors required to design a book location notification system using an AI vision sensor is detailed. This system consists of the AI vision sensor Husky Lens, Arduino, and Neopixels for intuitive notification of the location of borrowed books. It also includes an Arduino board and a breadboard to connect multiple Neopixels.

Table 1. Configuration of sensors of book location notification system

Type	Usage
AI Vision Sensor (Huskylens)	Artificial Intelligence Camera
Arduino UNO	Main board driving the sensor
Neopixel	location notification

The connection process between the above board and sensor is as follows. Husky Lens jumper cable red wire (5V pin) and black wire (GND pin) connect to Arduino to 5V pin and GND pin, respectively. To transmit data between Husky Lens and Arduino, connect the blue line (SCL) to the A5 pin of the Arduino and the green line (SDA) to the A4 pin of the Arduino to transmit data. In this paper, the four Neopixels above were connected to the experiment to output the location of the borrowed book using LED. To connect multiple Neopixels, expand Arduino Vin and GND to a breadboard. Connect the 5V pin and GND of the Neopixel with a breadboard and connect each of the four Neopixels to pins D7 to D10 of the Arduino's digital area.

As shown in Figure 4, this is the design diagram of the public library book location guidance system. We designed a book location notification system using an AI vision sensor, Python, and Arduino. If the Husky Lens recognizes tag ID 1, Neopixels 1 and 4 light up to show the bookshelf and book location. For ID 2, Neopixels 2 and 4 light up, and for ID 3, Neopixels 3 and 4 light up, indicating the bookshelf and book locations.

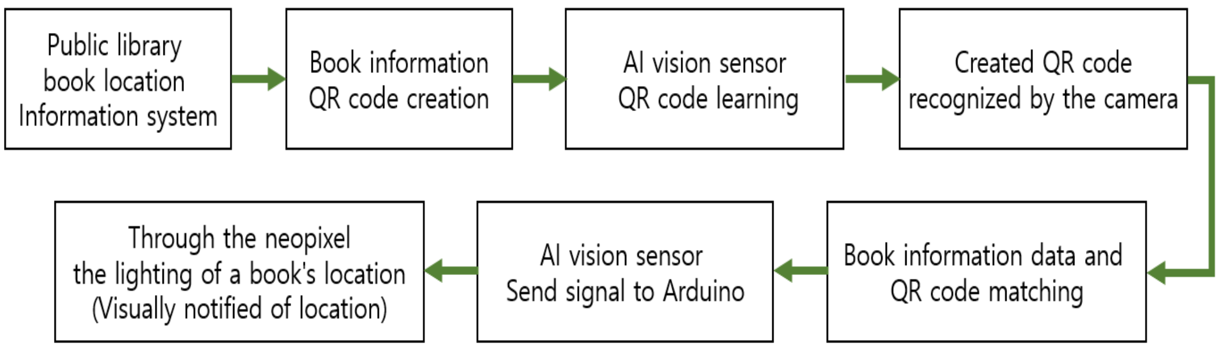

Figure 4. Book location guidance system flowchart

3.2 Search process of book notification system

In order to search for the current book in advance for the experiment, several books were searched through a centrally located device and the call numbers were printed out. To utilize the location notification system using an AI vision sensor, a QR code was created by entering several books from the library into Python code. Learn the generated QR code using the tag recognition function of Husky Lens. For the pre-learned QR code, the AI vision sensor sends a signal according to the learned tag number, and the Neopixel that receives the signal lights up, indicating the location of the book so that you can immediately find it. As shown in Figure 5 below, the actual installation of the loaned book location notification system using Husky Lens, as implemented in this paper, is displayed in a public library.

Figure 5. Location notification system installation

4. EXPERIMENT AND ANALYSIS

In this paper, one 4th grade elementary school student and three adults are targeted to test the book notification system using the proposed AI vision sensor. A book location information system was pre-installed, and the system was explained in advance to one elementary school student and four adults who entered the library. An experiment was conducted by selecting books in similar positions among five bookshelves on the same floor, taking the distance into account. The experimental method is as follows. The first experimental method was to search for a total of two books per person using the call number, which is the existing method. The second experiment was a book location guidance system using an AI vision sensor and was tested by using a QR code to recognize the QR code on the Husky lens and go to the Neopixel where the notification was received. Two books were searched. A total of 4 book borrowers searched a total of 8 books, 2 books each using the traditional method and 2 books each using the notification system and recorded the time results. Fourth-grade elementary school students and book borrowers could be seen wandering around in front of the five bookshelves of the borrowed books holding a conventional call number, and even after finding the bookshelf with the corresponding call number, they seemed to be confused. As shown in Figure 6 below, the fourth-grade students and adults who participated in the experiment are struggling for a long time to find the bookshelf by looking at the call number, which was the first experiment method.

Figure 6. First experimental method

As shown in Figure 7 below, the fourth-grade students and adults who participated in the experiment are searching for a book using Neopixel to recognize a QR code on a Husky Lens camera, which is the second experiment method.

Figure7. Second experimental method

Table 2 shows the results of an experiment conducted on five bookshelves at a designated location in a public library. The first experimental method measures the time taken to find borrowed books based on call numbers, while the second experimental method measures the time taken to find borrowed books using the notification system. The measurement times are expressed in seconds only. Looking at the experimental results, you can see that the existing method took an average of about 1 minute and 49 seconds to search for a borrowed book based on the call number. When using the second method, the book location guidance system, you can see that the result took an average of about 13 seconds. As a result of the experiment, it was confirmed that the location guidance system for borrowed books using an AI vision sensor was faster than the time to find borrowed books using existing call numbers. Looking at the two methods in the first and second cases, even if the book was searched using the same method, the time difference between the first search and the second search could be confirmed.

Table 2. Experiment result table

Test Subject	First Test 1	First Test 2	Second Test 1	Second Test 2
Student 1	03:52	02:38	00:13	00:12
Adult 1	01:40	00:53	00:19	00:13
Adult 2	01:24	01:15	00:14	00:12
Adult 3	01:26	01:30	00:17	00:11
Average	02:05	01:34	00:15	00:12

5. CONCLUSION

This paper designed and implemented a location guidance system for borrowed books using an AI vision sensor to solve the difficulty of finding the location of books to be borrowed when borrowing books from a public library. This system intuitively provides student and adult borrowers with the location of books.

We expect that this system will shorten the time required to search for the location of books to be borrowed, thereby improving borrowers' satisfaction with using the library. In the future, we plan to research ways to indicate the location of books by color-coding each section within a bookshelf and develop solutions to problems that may occur when multiple users search for books using AI vision sensors. In conclusion, we believe that this system will significantly enhance the efficiency and user experience in libraries.

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