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Smart Library Service Based on Quick Response Code on Smartphone

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Abstract: This study aims to develop a QR Code-based Smart Library software as a valid library service so that it can be used optimally in supporting library collection search and management activities. This Smart Library development research uses the Research and Development (R&D) method with the Unified Modeling Language (UML) development approach. The stages of this research include problem identification, data collection, system design, program creation, and testing stages. At the creation stage, the QR Code was developed using Quick Response Code Maker which was then integrated into the digital library system. The main software in the development of this Smart Library was built using Android Studio. Supporting facilities owned by Smart Library include the ability to display book collection metadata, display a list of collections based on the shelf number searched, and provide access to e-books from the library collection. This system also allows users to scan QR Codes directly via smartphones to get detailed information about available books. The results of the system test show that all application activities and performance run well and are in accordance with their functional needs. This QR Code-based Smart Library application program can produce output as expected and has fulfilled the basic functions of a smart library-based library service. Therefore, this QR Code-based Smart Library software development system is declared valid and suitable for use as an efficient library service solution.

Keywords: QR Code; Smart library; Valid activity

Introduction

The development of digital technology has driven major transformations in various aspects of life (Harasim, 2017; Risling, 2017) , including in the field of education and information services (Latif et al., 2024; Subianto et al., 2025). One of the technologies that has experienced rapid growth is smartphones. A'yun & Wilujeng (2024), which are not only used as a communication tool (Adiyanto et al., 2024), but also as the main means of accessing information effectively and flexibly (A'yun & Wilujeng, 2024). Various studies have shown that the use of smartphones in the learning process provides significant benefits for students and educational institutions (Auvisena & Fathurrahman, 2024; Latif et al., 2024; Muvidah et al., 2025; Pratama et al., 2024).

The use of smartphones in library services, especially at the university level, is still not optimal. . Many libraries still rely on manual systems or digitization that are limited to catalogs (Pandia et al., 2022). Aithal (2016) without providing easy remote access that suits the needs of the digital generation. The emergence of Quick Response (QR) Code technology offers significant potential. Az-zahra et al. (2025); Widanti & Fathurrahman (2024) to provide a solution to the gap between physical and digital access in modern library services.

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QR Code is a visual technology that can store data in two dimensions and can be read quickly via a smartphone camera (Bajpai, 2015; Chaigneau et al., 2011; Durak et al., 2016; Widanti & Fathurrahman, 2024). This technology was originally developed by Denso-Wave in Japan for tracking automotive industrial products. Law & So (2010) has been widely used in various fields (Sondhi & Kumar, 2022) , such as education (Alharbi & Al Sawy, 2022; Utami et al., 2024), and marketing (Mileva & Stoyanova, 2017) . The advantage of QR Code lies in its ability to store more information than barcodes. (Chaigneau et al., 2011)as well as ease of distribution (Alharbi & Al Sawy, 2022) , ease of access (Walsh, 2011) and has many other benefits and functions (Farashbandi & Najafi, 2014)

The use of QR Codes in digital libraries has begun to be implemented in several institutions as an effort towards smart libraries (Momin & Gaonkar, 2013; Priantina et al., 2023; Rahaman, 2016). Baker (2010), a library service concept that integrates information technology to improve efficiency. Momin & Gaonkar (2013), convenience, and accessibility for users (Aithal, 2016; Cao et al., 2018). By adding QR Codes to physical and electronic collections, users can easily access metadata. (Alharbi & Al Sawy, 2022; Bajpai, 2015; Durak et al., 2016; Momin & Gaonkar, 2013), a list of collections on the intended bookshelf, and e-books from the specified digital content collection, or lending services with just one scan from a smartphone (Parabhoi et al., 2017). QR code This technology also speeds up the information search process. (Cata et al., 2013; Pambudi et al., 2020; Saputra et al., 2024), reduces service queues, and supports a more efficient data-based administration system. The development of QR Codes in smartphone-based libraries has become an application platform that functions to reorganize library services to be better (Das & Kumbar, 2020), so that it is increasingly able to increase user satisfaction (Rahaman, 2016). There is still a gap in the development of systems that allow remote QR Code-based library access, especially those integrated with websites and smartphones simultaneously. Previous studies have generally focused on the use of QR Codes for local labeling and access (Pons et al., 2011), but not many have developed a comprehensive platform that allows users—especially students—to browse collections, check availability, and even borrow remotely.

This research aims to design and test a smart library platform based on QR Code. Rahaman (2016) which is integrated with the website (Sulaiman et al., 2021). Innovation in designing this smart library, students can search and borrow books independently without having to come directly to the library. This system is designed as an adaptive solution to students' digital behavior and supports the development of more modern, efficient, and technology-based library services (Cao et al., 2018; Saputra et al., 2024; Yu et al., 2019) . The novelty of this research lies in the integration between QR Code technology and a website system designed to provide mobile-based self-service for library users in the digital era.

Method

The research on the design of a Smart Library based on Quick Response (QR) Code on a Smartphone through 5 stages of the UML (*Unified Modeling Language*) method was carried out, namely, the problem identification stage, data collection stage, design stage, and manufacturing stage and testing stage (Booch et al., 1996). The flow of the methodology in this study can be seen in Figure 1: Unified Modeling Language is a development procedure that was initiated by Grady Booch and James Rumbaugh in 1994 by combining the Booch and OMT methods and OOSE (Object Oriented Software) developed by Ivar Jacobson (Booch et al., 1996).

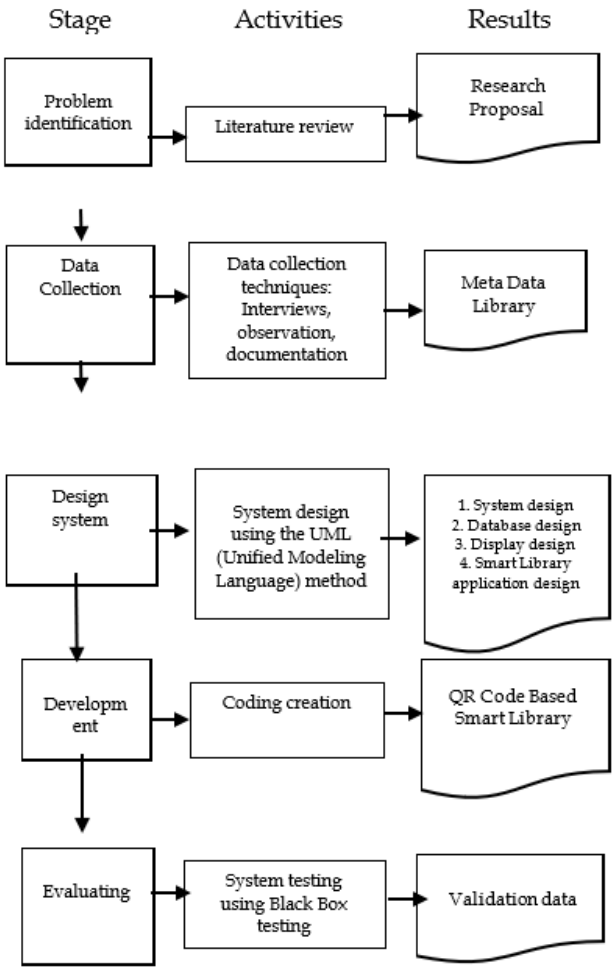

Figure 1 . Research Methodology Flow

UML (Unified Modeling Language) is a graphical language for specifying , documenting, and building a software system. UML can be used to describe object-oriented systems more clearly and in detail, resulting in diagrams or images including classes and their attributes and operations, relationships between classes including inheritance, association, and composition. The objectives of the Unified Modeling Language (UML) development procedure include:

An expressive, ready-to-use visual modeling language is available for developing meaningful exchange of object models, Supports language-independent specifications and specific development processes, Provides a formal basis for understanding modeling languages, Encourages the growth of object-oriented tools, and Supports higher-level development concepts such as components, collaboration, frameworks, and patterns.

UML has several notations that can be used as a communication tool for actors in the design analysis process of the product being developed. The notations in UML include the following (Gunawan et al., 2021) :

Actor

It is anything that interacts with a computer application system. Actors can be people, *hardware*, or hardware, or they can also be other objects in the same system. The interaction carried out by actors in a system is to order the system or provide information to the system to do something.

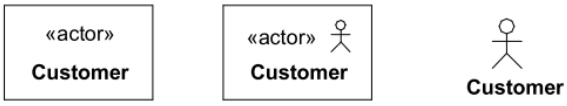

Figure 2. Actor Symbol in UM .

Class

Class is a form of object-oriented system because class shows a collection of objects that have the same attributes and operations. Class is used to implement *interface.* Class is used to a abstract the elements of the system being developed. Class can be presented as hardware or software, both concepts and real objects. The class notation in the diagram is a rectangle containing three parts. The top box in the class is the name of the class, the bottom box for the operating system and the middle rectangle for attributes. Attributes in the class are used to store information. Attribute names use nouns that can clearly explain the information that can be done by the object, and use verbs.

Interface

It is a collection of operations without implementation of a class. The implementation of operations from *the interface* is described by the operating system in the class. Therefore, the existence of an interface is always accompanied by a class that implements its operations. *Interfaces* are one way to create encapsulation in objects.

Use Cases

Describes the sequence of activities carried out by actors and systems to achieve a certain goal. Although it describes activities in the system, *use cases* only explain what actors do in the system, and not how actors and systems carry out these activities.

Development Procedure

Stages of developing *a QR Code*- based *Smart Library application*:

Needs Analysis (Problem Identification)

The steps taken related to the problems studied are literature studies. To find out the product to be developed, it is necessary to review research and information related to the planned product. At the problem identification stage, difficulties were found in finding reading references in the field of physics at the college level. From the problem identification, the research objectives and data needed can be planned.

Data collection

Interview

Interviews were conducted with the aim of collecting by conducting questions and answers and consultations directly or indirectly with the Central Library and ICT information center of UIN Walisongo Semarang. FGD (Focus Group Discussion) was conducted during the pre-research to find out what can be explored and developed from the planned product.

Observation

Observation is defined as observation, systematic recording of phenomena encountered in the field (Danowski & Choi, 1999). At this stage, the researcher visited the Central Library and ICT Center of UIN Walisongo Semarang to collect data through direct observers. The data obtained from the observation results : The situation and environmental conditions of the Central Library and ICT Center of UIN Walisongo Semarang, The condition of facilities and infrastructure related to the management of the collection arrangement of the Central Library and ICT Center of UIN Walisongo Semarang and Collection categories on the bookshelf according to the DDC (*Dewey Decimal Classification*) guidelines.

Documentation

The method of collecting data by means of documentation is to utilize records (documents) whose sources of information are in the form of written or recorded materials. The author collects relevant written materials and studies records regarding the respondents' personal data. Documents are written records of various activities or events in the past. The documentation method in this study is to obtain data on the meta data of the shelf collection that is used as the subject of the study. This technique is used to obtain data relating to the arrangement of collections in categories according to DDC rules.

Design

This means creating a product design and developing the initial form of the product produced. The design steps are as follows:

System Design

This stage is a stage for designing or modeling the processes that will occur in the system, data storage processes, data viewing processes from databases, and others. The designer at this stage uses *the Unified Modeling Language* (UML) by describing *use case diagrams, class diagrams, sequence diagrams* and *Activity diagrams*. UML consists of grouping system diagrams according to certain aspects or points of view, explained as follows :

Use Case Diagram

This diagram shows a set of functional cases and actors (special class types) and their relationships: *Class Diagram*. This diagram shows classes, interfaces and collaborations and their relationships; *Sequence Diagram*

This diagram shows the interactions that occur between objects. This diagram is a dynamic view of the system. This diagram highlights the time sequence of messages that occur.

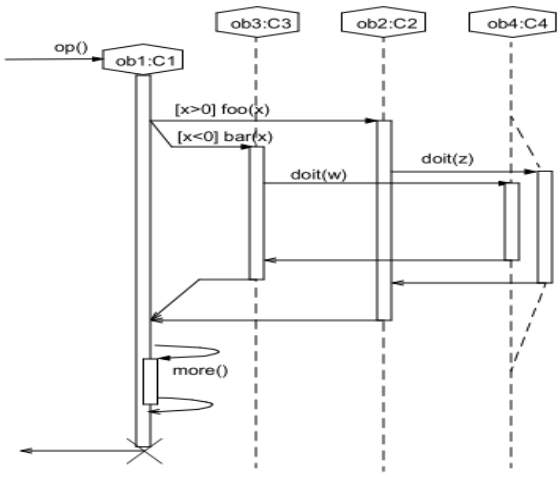

Figure 3. Structure *Sequence Diagram*

Activity Diagram

This diagram is intended to show the flow of activities in the system. This diagram is a dynamic view of the system. This diagram is important for modeling system functions and the pressure of control flow between objects.

Database Design

Database design is a stage in designing or modeling a database by designing a table structure with relationships between tables needed to develop a *QR Code*- based *Smart Library application.*

Display Design

Display design is the *user interface design stage* of the *QR Code*- based *Smart Library application. The application interface* menu design is explained to make it easier to design the program. *The user interface design* must be clearly visible and easy to navigate.

QR Code Design

Design is adjusted to the size and type of QR Code used: Making, the creation stage includes programming and coding to *complete* the design stage that is created, then applied in the coding process to create a *Smart Library application* based on *QR Code* with the PHP and MySQL programming languages; Testing, this test is carried out by conducting expert validation with the *black box test method* against expert validators. Expert validators are asked to use this system, whether the use of this application can work well and according to its function.

Results and Discussion

Analysis to help identify the requirements needed to build an application includes technology analysis in the form of needs analysis results from observation and analysis of software and hardware requirements.

Analysis of Observation Results Needs

Based on the results of observations conducted, all librarians are very good at operating the facilities and infrastructure related to the management of the collection arrangement of the Central Library and ICT Center of UIN Walisongo Semarang. The description of the book grouping category listed on the shelves is not specific so it takes a long time to find the desired book. Classification of shelf arrangement according to the *Dewey Decimal Classification* (DDC) guidelines. Based on the meta data statistics obtained from the UIN Walisongo library, it can be developed into a book search system with more detailed information so that it makes it easier for library visitors to find books.

Software and Hardware Requirements Analysis

The needs analysis at this stage is carried out to determine the hardware *needed* and the software *used* to run this *QR Code*- based *Smart Library application*. The hardware used to run the QR Code-based Smart Library application consists of one laptop unit with an Intel Core processor, 2GB of RAM, a 250GB hard disk, and an NVidia GeForce graphics card, as well as one Android device running Android 10. And the software used in developing the QR Code-based Smart Library application includes Windows 10 64-bit as the operating system, 5.6.25, Visual Studio Code 1.59.1, and web browsers such as Mozilla Firefox and Google Chrome . .

System Design

At this stage the design process that occurs in the system is modeled using UML. The following are some process diagrams of the *QR Code* -based Smart Library application which include use case diagrams, class diagrams, sequence diagrams and activity diagrams.

Use Case Diagram

Use case is a way to describe the interaction between users and systems using graphical and textual models in a structured manner. *Use cases* identify the actors involved in the interaction and state the type of interaction. Then additional information that describes the interaction with the system. Additional information can be a textual description or a graphical template. *Use case diagrams* involve systems, actors, *use cases, and* the relationships between actors and *use cases* (Kania et al., 2023).

The actors in this developed system are Application Admin, Librarian Admin, and Library Visitors. Application Admin is a person from the library who has full authority to interact with the system. Librarian Admin is a person from the library who has authority over half of the system. Library visitors include lecturers and students who interact with the library supported by the system.

Figure 3 illustrates *the sequence diagram* of loan data management. Stages when the system user enters loan data management, the system user can view loan data, and enter loan data. If the loan data fails to be done by the system user, a failure warning will appear and re-enter the loan data.

Data Management Return Sequence Diagram
Activity Diagram

Activity Diagram shows the activities involved in a process or in data processing. This diagram illustrates the functionality of a use case or between use cases through the depiction of the flow of activities that provide value to the actors. UML activity diagrams play a role in completing use cases by graphically depicting the flow of interactions in a particular scenario (Suryn, 2014). The beginning of a process in an activity diagram is marked with a full circle, ending with a full circle in a circle. Rectangles with rounded corners in the activity diagram represent certain subprocess activities that must be performed. Activity diagrams for the Smart Library application include login activity diagrams, user data management activity diagrams, book search data management activity diagrams, loan data management activity diagrams, and return data management activity diagrams.

Login Activity Diagram

Activity diagram describes all users who perform the login process. The users in question include the application admin, librarian admin, and library visitors. The activity begins when the actors, namely the application admin, librarian admin, and library visitors open the login page. Users log in by entering a username and password. The system will search for the username and password in the database along with the authentication of the username and password. When the search is complete, the user can successfully access the homepage if the username and password match during authentication.

User Data Management Activity Diagram

Activity diagram describes the system user activities to manage user data. Users here include application admins and librarian admins. The activity begins with the admin selecting the user data menu. The system will search for options in the database. After the search is complete, the admin will select a menu button such as add, edit, and delete.

The first activity after the admin presses the 'ADD' or 'EDIT' button is to fill in the form provided and perform the save activity. An alternative flow of save activity appears when incomplete data entry occurs. When the admin performs the save process, the system will identify each attribute, if there is an attribute that has not been filled in, namely name, ID/code, class, year of graduation, gender, address, telephone, the system will display an error message. The admin will understand the errors and anticipate errors in entering data that has not been filled in. The admin selects the 'DELETE' button, the system will delete the database and return to all user data.

Book Search Data Management Activity Diagram

The activity diagram of book search data management illustrates the activity of system users to search for books. The users in question are library visitors. The first activity carried out is scanning *the QR Code* on the bookshelf, the system will open a *database*

connection connected to *the QR Code.* After the book data on the shelf appears, the user can select the book data.

Loan Data Management Activity Diagram

The activity diagram of managing borrowing data illustrates the activities of system users to manage book borrowing data. Users here include admins, namely application admins and librarian admins. The system will search for options in *the database*. After searching for member data, the admin selects book data. The activity after the admin selects book data is saving borrowing data, the system will save member data and selected book data.

Return Data Management Activity Diagram

The activity diagram of borrowing data management describes the activities of system users to manage book borrowing data. Users here include admins, namely application admins and librarian admins. The system will search for options in *the database.* After the search for member data that returns books is complete, the admin chooses to save the book return data, the system will save member data and returned book data.

Database Design

Smart *Library application database* uses tables based on the results of *the class diagram* formed. This stage aims to design the system data structure and present it in the database. *The database* used is called a library, with the following data structure research design and methods should be clearly defined.

Conclusion

The results of the development and research conducted by researchers on the QR Code-Based *Smart Library Application on Smartphones* have the following conclusions t his research produced a product, namely the QR Code-Based *Smart Library application on Smartphones* using PHP and MySQL programming. The development method according to Booch goes through 5 stages, namely problem identification, data collection, design, development, and evaluating. The product testing stage uses a *black box* test to find functional errors in the program and the results of *black box* testing on the system show valid activity and performance in accordance with its functional needs. The *QR Code* - Based *Smart Library application program* on *Smartphones can produce the* desired output and has fulfilled the basic functions of the program

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Author Contributions
The authors contributed their work in the research and preparation of the manuscript as follows: E.D.A., A.R.M., and A.M.R., contributed to analysis, investigation, data sources, writing-original draft preparation. E.D.A., M.A.K., contributed to conceptualization and methodology, validation, writing—review and editing. E.D.A., A.M.R. contributed to , software, system testing, writing-review and editing methodology and supervision.

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Conflict of Interest
All authors declare that they have no conflict of interest

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