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## Software Quality Measurement for Functional Suitability, Performance Efficiency, and Reliability Characteristics Using Analytical Hierarchy Process

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**Abstract**— The quality model used in this paper is ISO 25010. Functional Suitability, Performance Efficiency, and Reliability are the characteristics to be used. The case study used is the ITS Academic Information System, and the method used for the basis of calculation is the AHP (Analytical Hierarchy Process) method. The initial stage is to make a list of questionnaire questions, which are then filled out by three stakeholders: experts, students, and developers. With the AHP method, experts will analyze the questionnaire results to determine the required weight. This weight is used to calculate the quality of the software. There are two types of software measurements: student questionnaires and developer questionnaires. These two questionnaires become data input. Automatic measurements are carried out on Time Behavior aspects, namely Response Time Testing. In the automatic measurement stage, the URL to be tested by the tester is used as data input. From this automatic measurement, we experimented with the response time of the destination URL to respond to requests and conversion results on a scale of one hundred. The final value of these two types of measurements will be used in several equations to get the final value of the quality of the software. The study results are in the form of automatic measuring instruments of software quality. The measurement results can be used as feedback in making improvements so that the quality value increases when measured. Regarding Functional Suitability, the ITS Academic Information System has provided features according to user needs. In the aspect of Performance Efficiency, the ITS Academic Information System can provide performance and performance according to user needs. Meanwhile, regarding reliability, the ITS Academic Information System can carry out a function under certain conditions and times.

**Keywords**— ISO 25010; functional suitability; performance efficiency; reliability; AHP; response time testing.

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### I. INTRODUCTION

Software needs to be measured for quality. One standard that can be used is ISO 25010. ISO 25010 is the latest ISO standard for assessing software quality. ISO is a standard model of assessment and evaluation of software products [1]. ISO-25010 is a software quality model that has been widely used. Quality of operation has a quality attribute that focuses on the output of interaction when the software is used. ISO-25010 is a quality model which is used to assess the quality of software products. There are eight characteristics of quality attributes: functional suitability, reliability, performance efficiency, usability, security, compatibility, maintainability, and portability. Each characteristic has sub-attributes due to its wide scope [2].

ISO 25010:2011 contains eight characteristics and 38 sub-characteristics. Improvements from previous ISOs, such as

usability, further emphasize the issue of Accessibility, and there are additional quality attributes, efficiency, freedom from risk, and context scope, as well as defining lower levels [3]. An essential aspect of the software is functionality; the estimated value of the software agreed upon by the end-user and the development team must be expressed in a certain amount, one of which is in terms of functional size measurement (FSM) [4]. Fungsionalitas adalah fungsi sistem utama atau layanan yang disediakan oleh komponen perangkat lunak [5]. In the ISO/IEC 25030 standard, functional requirements define software quality requirements that determine how well software performs. So, the quality requirements indicate how much the software can provide and maintain the specified service [6].

Quality Criteria Aspects of Function have sub-criteria of Conformity, Accuracy, and Security. Usability has sub-criteria Learnability, User Error Protection, and User

Interface Aesthetics. Reliability has sub-criteria of Maturity, Availability, and Recoverability. Portability has sub-criteria Adaptability, Instability, and Replaceability. Finally, security has sub-criteria of Confidentiality and Non-repudiation [7]. Functional suitability refers to the software's completeness, Correctness, and suitability to achieve specific purposes. In this context, evaluation calculates the completeness of the software to provide the necessary functions with the correct and appropriate output for use by the user [8].

The finished software can be measured for quality based on the ISO 25010 model. It involves functional suitability, usability, performance efficiency, portability, and security analysis. This model can be used for web-based software [9]—the software quality, functional suitability, usability, performance efficiency, portability, and security aspects. In the functional suitability aspect, all functions in the system ran well [10]. Functional suitability represents the extent to which the software product provides the entire user. These characteristics include functional Correctness, completeness, and appropriateness [11].

## II. MATERIAL AND METHODS

### A. MyITS Single Sign-on

MyITS Single Sign-on is a web-based university information system at the Sepuluh Nopember Institute of Technology. This system is used as an information service and manages academic data to facilitate ITS management and decision-making in the university environment.

### B. ISO 25010

ISO 25010 is an international standard published by the International Organization for Standardization to evaluate software quality, which is another part of the Software Product Quality Requirements and the development of the previous software quality model, ISO 9126. In ISO 25010, a metric-based approach is used to assess the quality of the software. This standard is divided into eight quality characteristics, each of which has several sub-characteristics [8]. The total number of characteristics that exist in ISO 25010 reaches eight characteristics with thirty-one sub-characteristics. This study presents three software quality characteristics: functional suitability, performance efficiency, and reliability [3]. As for automatic testing, the sub-characteristic that is presented is time behavior.

1) *Functional suitability* is the ability of software to provide functionality that meets stated and implied needs when used under certain conditions [11]. Functional suitability consists of 3 sub-characteristics, namely:

- *Functional completeness* is the ability of software to provide functions that cover all tasks and specific user goals.
- *Functional Correctness* is the software's ability to provide precise and correct results according to user requirements.
- *Functional Appropriateness* is the ability of software to provide functions that can facilitate the completion of certain tasks and goals.

2) *Performance Efficiency* is the ability of software to provide appropriate performance relative to the number of

resources used under certain conditions. Performance Efficiency consists of 2 sub-characteristics, namely [12]:

- *Time Behavior* is the ability of the software to provide response and processing time [13].
- *Resource Utilization* is the ability of software to use its resources when performing specified functions [14].
- *Capacity* is the ability of the software to meet the needs under the maximum limit or system parameters [15].

3) *Reliability* is the ability of software to perform specified functions under specified conditions for a specified period. Maintain a certain level of software performance. Reliability consists of 4 sub-characteristics, namely [16]:

- *Maturity* is the ability of software to meet requirements reliably under normal circumstances [17].
- *Availability* is software's ability to be operated and accessed when needed [18].
- *Fault Tolerance* is the software's ability to run and maintain its performance if there is an error in hardware or software [19].
- *Recoverability* is software's ability to rebuild the performance level when a system failure occurs, including data and network connections [20].

### C. Analytical Hierarchy Process (AHP)

Analytical Hierarchy Process adalah metode pengambilan keputusan yang dikembangkan oleh Thomas L. Saaty. Model pendukung keputusan ini menangkap masalah dengan faktor dan kriteria yang kompleks. According to Saaty (1993), hierarchy represents a complex problem in a multilevel structure. The initial step is the goal, followed by factors, criteria, sub-criteria, and so on, until the last alternative level (Saaty, 1993). In this study, the AHP method was used as the basis for weighting characteristics and sub-characteristics in ISO 25010 on the grounds.

- AHP has a hierarchical structure, so it is very suitable to be used in ISO 25010, which has many sub-criteria.
- AHP pays attention to validity at the limit of acceptance of inconsistencies as criteria and alternatives chosen by decision-makers.

The weighting steps using the AHP method in this study are as follows:

- Create a pairwise comparison matrix between quality characteristics or sub-characteristics.

$$A(i, j) = n \Rightarrow A(j, i) = \frac{1}{n}, i \neq j \quad (1)$$

$$A(i, j) = A(j, i) = 1, i = j \quad (2)$$

- Provide an assessment of the quality characteristics or sub-characteristics compared in the matrix. The intensity of interest used for the assessment process can be seen in Table 1.

TABLE I  
INTENSITY OF INTEREST

Intensity of Interest	Definition
1	Both elements are equally important
3	One element is slightly more important than the other
5	One element is more important than the other elements

Intensity of Interest	Definition
7	One element is very important from the other elements
9	One element is very important from the other elements
2, 4, 6, 8	The value between the values above

- Calculating matrix normalization.

$$\sum_i a_{ij} = 1 \quad (3)$$

- Calculating *eigenvector*/weight.

$$W_i = \frac{1}{n} \sum_j a_{ij} \quad (4)$$

- Determine the relative weight for each of the existing quality sub-characteristics.

#### D. Calculation of Total Software Quality

To calculate the total value of software quality, the absolute weight is first calculated by multiplying the characteristic weight by the relative weight of the sub-characteristics. Then, the value of the quality subfactor is calculated by multiplying the average questionnaire data per sub-characteristic by twenty-five. This is because the questionnaire is filled in on a scale of zero to four. Thus, to convert the data to a scale of one to one hundred, the data in the questionnaire was multiplied by twenty-five. After that, the absolute value is calculated by multiplying the absolute weight by the value of the quality sub-characteristics. The total software quality is obtained by adding up the absolute values of all sub-characteristics. In this calculation, the applicable equation is as follows:

$$AW = QCW \times SRWW_i \quad (5)$$

$$VQS = \text{Average per sub} \times 25$$

$$NA = AW \times VQS$$

$$\text{Total Quality} = AV1 + AV2 + AV3 + \dots + AVn$$

Where:

AW = Absolute Weight

QCW = Quality Characteristic Weight

SRW = Sub-characteristic Relative Weight

VQS = Value of Quality Sub-characteristics

AV= Absolute Value

#### E. Response Time Testing

Response time testing measures the time that passes between a user's request and a response from the server, application, website, or device. In this software measurement tool, an automatic testing feature automatically allows users to find out the value of a sub-characteristic. The sub-characteristic that was used as an automatic testing feature is Time Behavior. Time behavior can be measured by conducting response time testing, which tests the response time, which refers to the time required for the system to respond to requests. Response time begins when the user sends a request and ends when the application responds to the request. Response Time Testing has three assessment criteria which are shown in Table 2.

TABLE II  
RESPONSE TIME CRITERIA

Response Time	Description
0.1 second	This is the most preferred response time. If the response time is 0.1, the user always feels that the application or system responds instantly and does not experience any disturbance.
1.0 second	This is defined as the maximum acceptable response time. Users are unlikely to experience any disturbance, although they may experience some delays. Response times of more than 1 second may interfere with the user experience.
10 second	This is the maximum after the response time exceeds the acceptable limit.

#### F. AHP Algorithm Design

The characteristic weight calculation algorithm used in this tool serves to determine the characteristic weight to be used based on the results of the expert questionnaire using the AHP method. The following is the pseudocode of the AHP algorithm.

```

input
    k1, k2, k3, k4, k5, k6, k7, k8
output
    characteristic weight
read (k1, k2, k3, k4, k5, k6, k7, k8)
for k=1 to 8
    for ka=1 to 8
        matrix [ka] [k]
        normalization [ka] [k] = matrix [ka] [k] /
        amount [ka]
    for k=1 to 8
        normalization amount = normalization [k] [k]
        characteristic weight = normalization
        amount/count [k]

```

#### G. Architecture Design

The architecture used on this research web platform uses the Laravel framework with the Model-View-Controller or MVC design pattern, shown in Figure 1.

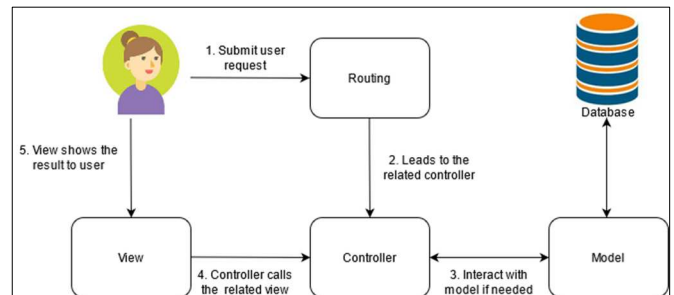


Fig. 1 Architecture Design

In the MVC architecture, the client requests data, and then routing will receive and direct the request to the controller associated with the request given. The controller will interact with the required model, and the model will perform queries against the database. The model returns the required data to the controller. Then, the controller calls the corresponding view to display the results requested by the user via the browser.

## H. Use Case Diagram

A software tool was created to support automatic calculation, and the requirement functional is shown in the Use Case Diagram (Fig 2).

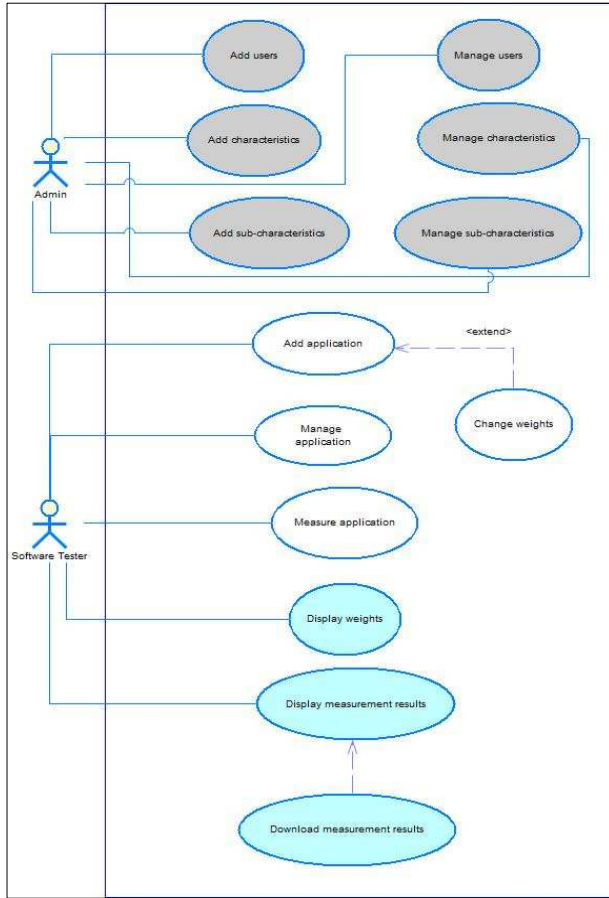


Fig. 2 Use Case Diagram

## I. Data Design

In making an application in an information system, analysis is needed in the form of database design. In doing this research, the database used is MySQL because it is widely used in general and easy to use. The database design is displayed in the form of CDM (Conceptual Data Model) and PDM (Physical Data Model) (Fig 3 and Fig 4.)

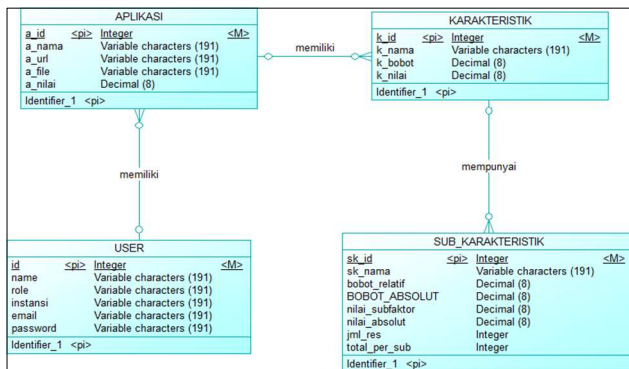


Fig. 3 CDM

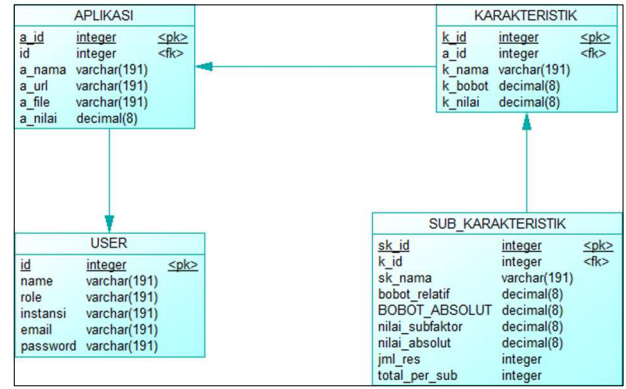


Fig. 4 PDM

## III. RESULT AND DISCUSSION

### A. Automatic Testing Algorithm Design

This tool's response time testing algorithm serves to get the time needed for the web to respond to requests and convert it to a scale of one to one hundred to get the value of the Time Behavior quality subfactor. In this study, the equation used to convert the results of response time testing is as follows:

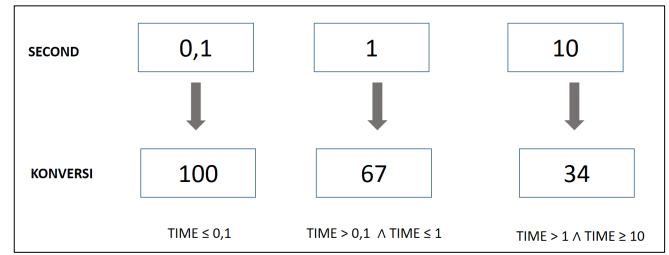


Fig. 4 Response Time Conversion

The above equation is obtained assuming that the three Response Time Testing assessment criteria must be converted to a scale of one hundred so that they are under other sub-characteristic values and can be added to calculate the total value of software quality. In obtaining this equation, the hundredth scale is divided into three according to the number of existing criteria, and the median values are one hundred, sixty-seven, and thirty-four. After that, the following rules will apply:

- If the response time is less than equal to 0.1 seconds, then the conversion value is 100.
- If the response time is more than 0.1 seconds and less than 1 second, the conversion value is 67.
- If the response time is more than 1 second and more than equal to 10 seconds, then the conversion value is 34.

The following is the pseudocode for the Response Time Testing algorithm:

```

input
  URL
output
  characteristic value
read (URL)
for request=0 to 7000
  do curl_multi_exec
output
  total time
do
  
```

```

results = total time / 7000

if results <= 0
    subfactor value = 100

else if result > 0.1 && result <= 1
    subfactor value = 100

else if result > 1 && result <= 10
    subfactor value = 33

else
    subfactor value = 33

absolute weight = characteristic weight
* relative weight
absolute value = absolute weight *
subfactor value
total = sum absolute value
characteristic value = total /
(characteristic weight * 100) * 100

```

### B. Creation of Measurement Aids

This research implements software quality measurement tools using the PHP programming language, Laravel framework, and MySQL database. Admin adds the weight of characteristics and sub-characteristics of Functional Suitability, Performance Efficiency, and Reliability. Then, the software tester will create an application measurement project. The software tester can choose to do custom weights or use the weights entered by the admin. If we choose to do custom, the software tester replaces the benchmark weight that has been provided. Then, the data from the questionnaire is entered, and the toolkit will display the measurement results of the application.

### C. Automatic Testing Implementation

Automatic testing is implemented using curl multi, which is used to make requests to URLs. In this study, a response time function is used to make requests to the destination URL, which is inputted by the software tester, and get the response time required by the destination URL in response to requests or requests. The implementation steps for Response Time Testing are as follows:

- Get the targeted automatic testing sub-characteristics and the URL inputted by the software tester.
- Determine the number of requests to the destination URL.
- Run curl and get the total response time.
- Get the response time for each request and perform the conversion according to the equation that has been made.
- Calculate absolute weight, absolute value, characteristic value, and application value based on the Response Time Testing results that have been carried out.

### D. Trial and Evaluation

This section will discuss the testing process in the use cases used. Testing is carried out using the black box testing method to test each functionality that has been designed. In the process of testing the software measurement tools, the results were as expected.

In this study, case study testing was carried out using questionnaire data regarding the ITS Academic Information System. This measurement aims to assess the quality of the ITS Academic Information System based on the quality model that has been created. The following are the steps to carry out the measurement process on the ITS Academic Information System:

- Distributing questionnaires containing statements regarding the ITS Academic Information System based on ISO 25010 sub-characteristics filled out by students and DPTSI developers.
- Measure the software's quality using a tool created by entering the details of the ITS Academic Information System data in the form of application names, URLs, test files in php format, and custom weights if needed. After that, the software tester and the DPTSI developer entered the results of the student questionnaire.
- The results of measuring the quality of the ITS Academic Information System were displayed in the form of a report.
- The ITS Academic Information System quality measurement report can be downloaded in PDF format.

### E. Analysis of Test Results

The measurement results of the ITS Academic Information System on the characteristics of Functional Suitability, Performance Efficiency, and Reliability can be seen in Table 3.

TABLE III  
MEASUREMENT RESULTS OF SIAKAD ITS

ID	Characteristic	Description	Characteristic value	Notes
1.	Functional Suitability	The ability of the software to provide features that meet needs under certain conditions	81.03	fulfilled
2.	Performance Efficiency	The ability of the software to perform relative to the number of resources used under certain conditions	93.71	fulfilled
3.	Compatibility	The ability of software to exchange information with other products, systems, or components and perform the required functions within the hardware environment	81.25	fulfilled

The test results on the characteristics of Functional Suitability get a total absolute value of 26.74. The weight of the Functional Suitability characteristic is 0.33. If converted,

the maximum value of the Functional Suitability characteristic is 33. It can be concluded that the value of the ITS Academic Information System case study test for the Functional Suitability characteristic is 81.03.

The test results on the characteristics of Performance Efficiency get a total absolute value of 6.56. The weight of the Performance Efficiency characteristic is 0.07. If converted, the maximum value of the Performance Efficiency characteristic is 7. It can be concluded that the value of the ITS Academic Information System case study test and myITS Single Sign-on Performance Efficiency characteristic is 93.71.

The test results on the reliability characteristics get a total absolute value of 6.48. The reliability characteristic weight is 0.09. If converted, the maximum value of the Reliability characteristic is 9. So, it can be concluded that the value of the ITS Academic Information System case study test of Reliability characteristics is 72.00.

The minimum quality rating standard for web applications is 70 [6]. So, it can be concluded that the ITS Academic Information System has met the quality standards on the characteristics of Functional Suitability, Performance Efficiency, and Reliability.

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#### REFERENCES

- [1] A. Hussain and E. Mkpojiogu, "Armstrong & Nelles 4.pdf," *J. Teknol. (Sciences Eng.,* vol. 5, pp. 9–13, 2015, [Online]. Available: [https://www.researchgate.net/publication/283767184\\_An\\_application\\_of\\_the\\_ISOIEC\\_25010\\_standard\\_in\\_the\\_quality-in-use\\_assessment\\_of\\_an\\_online\\_health\\_awareness\\_system](https://www.researchgate.net/publication/283767184_An_application_of_the_ISOIEC_25010_standard_in_the_quality-in-use_assessment_of_an_online_health_awareness_system)
- [2] L. A. Tilahun and B. Sekeroglu, "An intelligent and personalized course advising model for higher educational institutes," *SN Applied Sciences*, vol. 2, no. 10, Sep. 2020, doi: 10.1007/s42452-020-03440-4.
- [3] L. Buglione, "248-1827-1-Pb," vol. 4, no. 3, pp. 72–79, 2015.
- [4] I. Castillo, F. Losavio, A. Matteo, and J. Boegh, "REquirements, Aspects and Software Quality: the REASQ model," *The Journal of Object Technology*, vol. 9, no. 4, p. 69, 2010, doi:10.5381/jot.2010.9.4.a4.
- [5] Y. Jiang et al., "Study on the Evolution and Optimization of the Spatial Structure of the Oasis in the Arid Area: A Case Study of the Aksu River Basin in China," *International Journal of Environmental Research and Public Health*, vol. 20, no. 6, p. 4920, Mar. 2023, doi:10.3390/ijerph20064920.
- [6] M. S. Rahman, S. M. Shuhidan, and M. N. Masrek, "The Influence between GIS Quality and user Satisfaction towards Individual Work Performance: A Proposed Conceptual Framework," *International Journal of Emerging Technology and Advanced Engineering*, vol. 11, no. 12, pp. 164–170, Dec. 2021, doi: 10.46338/ijetae1221\_17.
- [7] S. J. R. Manglapuz and L. L. Lacatan, "Academic Management Android Application For Student Performance Analytics: A Comprehensive Evaluation Using Iso 25010:2011," *International Journal of Innovative Technology and Exploring Engineering*, vol. 8, no. 12, pp. 5085–5089, Oct. 2019, doi: 10.35940/ijtee.I2735.1081219.
- [8] L. Souza-Pereira, S. Ouhbi, and N. Pombo, "A process model for quality in use evaluation of clinical decision support systems," *Journal of Biomedical Informatics*, vol. 123, p. 103917, Nov. 2021, doi:10.1016/j.jbi.2021.103917.
- [9] F. Abdillah, S. PH, and Sukardi, "Test Analysis Of The Development Conversion And Recognition Prior Learning Models On Vocational Teachers' Education," *International Journal of Engineering and Advanced Technology*, vol. 8, no. 5c, pp. 1456–1460, Sep. 2019, doi:10.35940/ijeat.e1213.0585c19.
- [10] J. M. S. França, A. A. da Costa Junior, and M. S. Soares, "Architecture-Driven Development of an Electronic Health Record Considering the SOAQM Quality Model," *SN Computer Science*, vol. 1, no. 3, Apr. 2020, doi: 10.1007/s42979-020-00150-x.
- [11] M. Haeoues, R. Mokni, and A. Sellami, "Machine learning for mHealth apps quality evaluation," *Software Quality Journal*, vol. 31, no. 4, pp. 1179–1209, May 2023, doi: 10.1007/s11219-023-09630-8.
- [12] N. Kadoić, D. Šimić, J. Mesarić, and N. Begičević Redep, "Measuring Quality of Public Hospitals in Croatia Using a Multi-Criteria Approach," *International Journal of Environmental Research and Public Health*, vol. 18, no. 19, p. 9984, Sep. 2021, doi:10.3390/ijerph18199984.
- [13] M. J. Blas, H. Leone, and S. Gonnet, "Modeling and simulation framework for quality estimation of web applications through architecture evaluation," *SN Applied Sciences*, vol. 2, no. 3, Feb. 2020, doi: 10.1007/s42452-020-2171-z.
- [14] G. Chen, J. Zhang, W. Tan, S. Zhang, and B. Yan, "Customer knowledge management competence evaluation of agritourism enterprises by using the balanced scorecard and fuzzy-AHP: Evidence from Chengdu-Chongqing economic circle," *PLOS ONE*, vol. 18, no. 2, p. e0280482, Feb. 2023, doi: 10.1371/journal.pone.0280482.
- [15] T. Q. Nguyen, L. T. T. Ngo, N. T. Huynh, T. L. Quoc, and L. V. Hoang, "Assessing port service quality: An application of the extension fuzzy AHP and importance-performance analysis," *PLOS ONE*, vol. 17, no. 2, p. e0264590, Feb. 2022, doi: 10.1371/journal.pone.0264590.
- [16] S. A. AlQahtani, "Cooperative-Aware Radio Resource Allocation Scheme for 5G Network Slicing in Cloud Radio Access Networks," *Sensors*, vol. 23, no. 11, p. 5111, May 2023, doi: 10.3390/s23115111.
- [17] J.-L. Li et al., "The Efficacy and Safety of Acupuncture for Treating Osteoporotic Vertebral Compression Fracture- (OVCF-) Induced Pain: A Systematic Review and Meta-Analysis of Randomized Clinical Trials," *Evidence-Based Complementary and Alternative Medicine*, vol. 2021, pp. 1–12, Sep. 2021, doi: 10.1155/2021/8574621.
- [18] B. Lee et al., "Implementation and quality assessment of a clinical orthopaedic registry in a public hospital department," *BMC Health Services Research*, vol. 20, no. 1, May 2020, doi: 10.1186/s12913-020-05203-8.
- [19] T. Wang, N. Li, and H. Li, "Design and development of human resource management computer system for enterprise employees," *Plos One*, vol. 16, no. 12, p. e0261594, Dec. 2021, doi:10.1371/journal.pone.0261594.
- [20] R. Qiang and J. Yang, "Influential Spreader Identification in Complex Networks Based on Network Connectivity and Efficiency," *Wireless Communications and Mobile Computing*, vol. 2022, pp. 1–8, Apr. 2022, doi: 10.1155/2022/7896380.