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Rapid Application Development of Indonesian Culture Game with Breadth First Search Algorithm

Abstract: - Indonesia is a country with a lot of diverse and unique cultures in each region, including traditional houses and traditional musical instruments. However, along with the entry of foreign cultures, interest in the nation's culture is decreasing, especially among young people. Therefore, there is a need to introduce Indonesian culture to its young generation interestingly and engagingly. This study aims to create a mobile puzzle game application that introduces Indonesian traditional houses and musical instruments. The puzzle game is built using the Rapid Application Development (RAD) method. RAD is a system development model that emphasizes a short development process and has a fast iteration. The game also has an auto-completion feature to assist in completing the puzzle automatically by utilizing the Breadth First Search (BFS) algorithm. The application has been successfully built on the Android platform and has been evaluated using the User Acceptance Testing (UAT) tool. The results of the UAT evaluation show that all game functions worked as expected and could receive perceived usefulness of 85.0625%, perceived ease of use of 92%, perceived ease of learning of 91.125%, and perceived satisfaction of 79.9%.

Keywords: Breadth First Search (BFS), Indonesian Culture, Puzzle Game, Rapid Application Development (RAD), User Acceptance Testing (UAT).

I. INTRODUCTION

Indonesia is one of the largest archipelagic countries in the world with a total of 17,504 islands, of which 16,771 islands have been validated and verified [1], [2]. With a large number of islands stretching from Sabang to Merauke, Indonesia has bequeathed many diverse and unique cultures for each region. One of those cultures is the traditional house and traditional musical instruments.

Traditional houses are built with little or no changes from generation to generation. Traditional houses have different styles of buildings because they were built by taking into account the usefulness, social function, and cultural meaning behind the style of the building. Traditional musical instruments are typical musical instruments of an area that have been developed and passed down from generation to generation. Traditional musical instruments are generally used to accompany folk songs, to accompany regional dances, as a means of entertainment, and for traditional ceremonies of an area.

Many children today lack or even do not know the culture of their nation. One of the contributing factors is the entry of foreign cultures that look more attractive and cool so interest in the nation's culture is getting less and less [3]. In addition, the lack of encouragement from parents to introduce the nation's culture is also one of the factors why the nation's culture becomes less known, less desirable, and less cared for by children. If this continues, there will be opportunities for other countries to claim national culture such as traditional houses and traditional musical instruments as their own. Therefore, it is a very important task for the younger generation to preserve the nation's culture. These traditional houses and traditional musical instruments need to be introduced to children from an early age, namely the age of 5 to 12 years because at this age, children have a great curiosity and are potential learners. In addition, children in this age range can think, learn, and remember better than the previous age and their reading interest tends to continue to increase [4].

To help add insight and preserve Indonesian culture, such as traditional houses and traditional musical instruments, a puzzle game application with the theme of Indonesian culture was built. Games are an attractive option for learning because learning while playing has tremendous benefits for children's development, including increasing children's motivation and developing children's cognitive and critical thinking skills [5]–[8]. It is considered as

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one of most popular entertainment forms nowadays [9] and even could be designed to help targeted users in learning a subject as in [10]. With the construction of this application, it is hoped that the application can be accepted by children and help introduce Indonesian cultures to children, especially related to traditional houses and traditional musical instruments.

The type of puzzle game that will be built is 8-puzzle. Puzzle game was chosen because children can hone their skills in terms of remembering through the correct position of puzzle pieces, the ability to think and use logic through finding the right steps and solutions to complete puzzles, eye and hand coordination through what they see and their hands do in putting together puzzles, as well as emotional abilities in setting goals, such as the goal of completing puzzles faster and without assistance [11], [12]. In addition, the type of 8-puzzle which has a slightly higher difficulty level than other types of board or jigsaw puzzles also has benefits that not only improve thinking and problem-solving skills but can also train children's patience and stimulate children to run a simulation in their minds to solve the puzzle, so that it can help them find a way to solve the game [13], [14]. Because the target of this research is children, there is a concern that they will have difficulty in completing the given puzzle, so an automatic completion feature will be built to solve this 8-puzzle game using the Breadth First Search (BFS) algorithm.

II. METHODS

A. Breadth First Search

Breadth First Search (BFS) is a path search algorithm that is carried out by a widening process. This algorithm starts the search from the initial node, continues by visiting every node at level n, then continues by visiting every node at level $n + 1$, and will continue until it reaches the desired goal (goal state) [15]. An illustration of the BFS algorithm can be seen in Fig. 1.

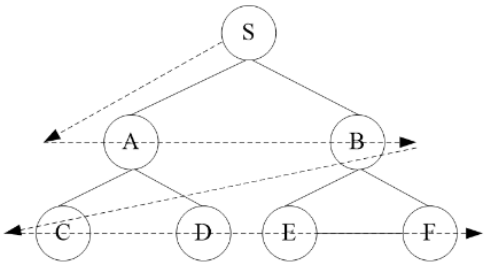

Fig. 1. Breadth-first search illustration as adapted from Lina and Rumetna [16]

The BFS algorithm can be applied in various ways. Some examples of the application of the BFS algorithm are 1) Web search engine [17], 2) Geographical Information System [18], 3) Shortest path and the minimum spanning tree of an unweighted graph solution [19], 4) Wireless sensor networks routing [20], and 5) Traditional 'congklak' game solution [21].

The BFS algorithm has the following advantages [22]: 1) If there are one or more solutions, the BFS algorithm will always find those solutions, 2) There are no unused paths and nodes because every path and node must be visited, and 3) If there is more than one solution, the BFS algorithm can provide the optimal solution, i.e. the solution with the fewest steps. Despite the advantages, BFS also has the following drawbacks [22]: 1) Uses more storage as it needs to store every visited and connected node and path, and 2) If the solution is very far from the starting node, it takes more time to reach the solution or goal.

B. Rapid Application Development

To develop this application, the author uses the Rapid Application Development (RAD) method. RAD is a system development model that is incremental. By using RAD, the development of a system can be done in a relatively short time because this model emphasizes a short development cycle.

RAD consists of three phases involving the analyzer and the user in the assessment, design, and implementation stages. These phases are requirements planning, RAD design workshop, and implementation [23]. After the application is implemented and tested, one more stage will be carried out, namely testing and evaluation to determine the success rate of the application based on feedback from users.

The advantages of using RAD are as follows [24]: 1) Useful for projects where user requirements are uncertain and imprecise, 2) Encourages active user and management participation (as opposed to passive reactions to non-working system models). This increases the end user's enthusiasm for the project, 3) Projects have higher visibility and support due to extensive user involvement throughout the process, 4) Users and management see solutions that are software-based and work faster than model-driven development, 5) Error and omissions tend to be detected earlier in prototype than in system models.
The disadvantages of using RAD are as follows [24]: 1) Some argue that RAD encourages a "code, implement, and improve" mentality that increases the lifetime costs required to operate, support, and maintain the system, 2) RAD prototypes can easily solve the error because the problem analysis is shortened or ignored, 3) RAD-based prototype items may discourage analysts from considering other, more valuable technical alternatives, 4) Sometimes it's better to throw out a prototype, but stakeholders are reluctant to do so because they see it as a loss of time and effort in the current product, 5) The emphasis on speed can have an impact on quality due to poorly suggested shortcuts through the methodology.

C. User Acceptance Testing

User Acceptance Testing (UAT) is a type of testing performed by end users or clients to verify or accept a software system before moving a software application to a production environment. The main purpose of this UAT method is to validate the business flow, so this method does not focus on assessing the display (user interface), writing errors, or system errors. In UAT, the end user will interact directly with the system and check whether the function is working properly and according to the function and needs [25].
UAT is performed in a separate test environment with a production-like data setup. This method is a type of black box testing, which is a test in which two or more end users will be involved in observing the results of the execution of test data and checking the functionality of the software without testing the internal structure. What this means is that the end user only knows what an application is supposed to do, without needing to know how it should be done. Thus, the test results will show whether the user can use the application system as it should [26].

D. Game Application Workflow

The overall game application flow can be described as follows. Firstly, when the application is opened, the application will display the main menu scene. On this page, there is a title of the game as well as the start, credits, and exit buttons. If the user presses the credit button, the application will open a credit scene. If the user presses the exit button, the user will exit the application and the application will be closed. When the user presses the start button, the application will open a category-select scene.
On the scene to select a category, there is a back button and two categories in the application. If the back button is pressed, it will return to the main menu scene. If the traditional house category is selected, the application will open a scene containing a list of available traditional houses. If a musical instrument category is selected, the application opens a scene with a list of available musical instruments. Both on the traditional house list scene and the musical instruments list scene, users can select the traditional house or musical instrument they want to play by pressing the provided image.
After the user selects, the application will open the puzzle game scene. When the game scene opens, the puzzle will automatically be in a random position. In this scene, the user can press the puzzle pieces to move them. If the puzzle piece can be moved, that is, if the pressed puzzle piece is next to an empty space, then the puzzle piece will move to that empty space and the empty space will move to where the previous puzzle piece was. In addition, on this page, there are also pause, hint or auto-complete, and view details buttons. If the pause button is pressed, it will open a pause menu that contains two buttons, namely the button to continue the game and return to the category selection scene. Pressing the view details button will open a scene containing an explanation of the selected puzzle image.
If the hint button or auto-complete button is pressed, the application will call the Breadth First Search (BFS) function to find the solution to the puzzle game. When the BFS function is called, it will first create a logger to record every neighbor that has been visited. Then proceed with creating an empty queue. After the queue is created, the initial state or current state will be entered into the queue for processing and marked as visited. Then it will be checked whether the queue is currently empty or not. If not, it will remove the first element from the queue to be included in a variable and search for its neighbors. Then it is repeated for each neighbor. If the neighbor being processed has already been visited, it will continue to the next neighbor. If not, it will be noted that the neighbor

has now been visited and queued for processing. Before checking the neighbors or other elements in the queue, it will be checked first whether the neighbor obtained is a goal state or not. If so, it will return the path traversed and the process ends. If not, it will check the next neighbor. The iteration process will continue until a solution is found.

The difference between using the hint button and the auto-complete button is that if the user uses the hint button after the completion solution is obtained, it will only move one puzzle piece, whereas if the user uses the auto-complete button, it will move the puzzle until the puzzle is completed. Whenever there is a change in the position of the puzzle, the application will check whether the current state of the puzzle is the goal state or not. If it is the goal state, the application will open a detailed scene containing an explanation of the image in the puzzle. The user can then return to the scene to select a category by pressing the button provided. If the user wants to end the game, they can return to the main menu by pressing the back button provided on each scene or pressing the back button on Android devices. Then, on the main menu, the user can press the exit button or press the Android back button again to exit the game application.

III. RESULTS

In this section, the puzzle game application that has been built will be explained. There are several scenes in this application, such as the main menu scene, credit scene, category selection scene, traditional houses selection scene, musical instruments selection scene, game scene, and explanation scene of selected traditional house or musical instrument.

The main menu scene of the Indonesian culture-themed puzzle game application can be seen in Fig. 2. The main menu scene is the scene that the user will first see after the user opens the application. The background image of this scene uses a picture of the islands in Indonesia to represent that this game will have an Indonesian theme, according to the name or title listed at the top center of this scene. There are three buttons with their respective functions, namely the start button, credit button, and exit button. If the user presses the start button, the application will open the next scene, which is the scene for selecting the category. If the user presses the credit button, the application will open a credit scene containing the sources of various assets in the application. If the user presses the exit button, the application will be closed.

Fig. 2. Main menu scene

The scene for viewing credits is shown in Fig. 3. This credit scene will open when the user presses the credit button on the main menu scene. This credit scene contains sources for all assets, such as images and tools used in the application. In addition, there is a UMN logo, the campus that shelters and helps researchers in conducting research and developing this puzzle game application. Both the UMN logo and the credit list are in a scroll view, so users can scroll in that area or use the available scroll bar to view the complete credit list. At the bottom right of the scene, there is a button that has a function to return to the main menu scene.

Fig. 3. Credit scene

The scene for selecting the puzzle category users want to play can be seen in Fig. 4. In this scene, there are two categories that users can choose from, namely traditional houses and musical instruments. These two categories are represented by three available images in each category and can later be selected by the user. The left one is for traditional houses. If the user selects this, the application will redirect to a scene to select the available traditional houses. The right side is a musical instrument. If the user selects this, the application will redirect to a scene to select an available musical instrument. In the upper left corner, there is a back button to return to the previous scene, i.e., the main menu scene.

Fig. 4. Select 'category' scene

The scene for selecting traditional houses can be seen in Fig. 5. The page for choosing a traditional house is divided into two scenes, where in each scene five pictures of a traditional house can be chosen to be used as puzzles and played. At the top left, there is a button to return to the previous scene, which is the scene to select a category. At the top center, there is the name or title of the current page. At the bottom right, there is an arrow that has a function to navigate from scene one to scene two of the traditional houses select scene and vice versa.

Fig. 5. Select 'traditional houses' scene

The scene for selecting musical instruments can be seen in Fig. 6. The page for choosing a musical instrument is divided into two scenes, where on each scene there are five pictures of musical instruments that can be chosen to be used as puzzles and played. At the top left, there is a button to return to the previous scene, which is the scene to select a category. At the top center, there is the name or title of the current page. At the bottom right, there is an arrow that has a function to navigate from scene one to scene two of the musical instrument select scene and vice versa.

Fig. 6. Select 'traditional musical instruments' scene

The Indonesian culture-themed puzzle game scene can be seen in Fig. 7. In the game scene, there is a puzzle that is already in a random condition on the left and an example of a complete picture on the right. At the top center,

there is a button that when pressed will open the pause menu and at the top right, there is a button with a light bulb symbol which is the hint button. When the button is pressed, it will move a puzzle piece automatically based on the solution obtained from the Breadth First Search (BFS) algorithm. At the bottom of the sample image, there are two buttons, namely a button with an exclamation mark to view details and an auto-complete button. When the button to view details is pressed, it will open a scene containing an explanation of the selected puzzle. If the auto-complete button is pressed, it will move each puzzle piece automatically until the puzzle is completed based on the solution obtained from the Breadth First Search algorithm.

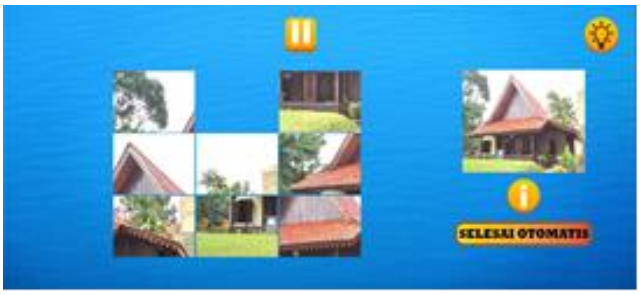

Fig. 7. Puzzle game scene

The detailed explanation scene of the selected puzzle can be seen in Fig. 8. The detail scene can be accessed in two ways, by pressing the button to view the detailed description of the puzzle image and by completing the puzzle. On the detail scene, there is an image previously selected by the user and an explanation at the bottom of the image. The description of the image is in a scroll view, so the user can scroll on the text or use the scroll bar provided to the right of the text to continue reading the description of the selected image.

Fig. 8. Detail information scene

IV. Discussion and Evaluation

Application functionality testing is carried out by using the black box testing method, a functional application testing without looking at the internal structure or source code of the application. Testing is done by receiving input from the user to find out whether the output given by the application is correct. Thus, the results obtained will indicate whether the application can be used by the user and is working as it should. Based on the results of the tests carried out, it is known that each function in the application can accept input from the user and provide the appropriate output in each case from user input.

Application evaluation is then carried out by providing a questionnaire to be filled out by end users to determine the level of acceptance of the application. A total of 40 respondents were involved and willing to try the application by giving their oral consent then fill out the questionnaire. Questions are made based on the User Acceptance Testing (UAT) method, adopted from the Technology Acceptance Model (TAM) [27], [28]. The questions on the questionnaire consist of four parts, namely the application benefits section (perceive usefulness), the application ease of use section (perceive ease of use), the ease of learning application section (perceive ease of learning), and the application satisfaction section (perceive satisfaction). Types of answers to the questionnaire are based on a five-level Likert scale [29], namely a scale value of 1 for “Strongly Disagree”, a scale value of 2 for “Disagree”, a scale value of 3 for “Neutral”, a scale value of 4 for “Agree”, and a scale value of 5 for “Strongly Agree”. The results of the questionnaire showed the level of user acceptance was 85.0625% for perceived usefulness, 92% for

perceived ease of use, 91.125% for perceived ease of learning, and 79.9% for perceived satisfaction, which means that the application is useful and quite well received by children.

The design and development of an Indonesian culture-themed puzzle game using the Rapid Application Development (RAD) method can work well. The use of the RAD method in building applications is useful because RAD with the advantage of quick iteration can allow developers to make changes when there are parts of the design that do not comply with requirements and the application can be completed in a relatively short time. The RAD method is also quite flexible to changes so that during application development, changes to applications can be made quickly.

The development of the automatic puzzle-solving feature within the game application using the Breadth First Search (BFS) algorithm can be carried out properly. The use of the BFS algorithm for puzzle solving feature is useful because this feature can help users in solving puzzle games. This is indicated by the results of various user feedback on the question of whether users can complete the game without the help feature, which gives a result of 27.5% of users feeling strongly agree, 27.5% users feeling agree, and 45% of users feeling neutral. Meanwhile, with this help feature, all users strongly agree that the game can be completed easily. The BFS algorithm will always be able to get a solution from a puzzle game, so even though the puzzle situation has changed greatly from its initial state, this algorithm will still find and provide a solution when the user needs it.

V. CONCLUSION

An Indonesian culture-themed puzzle game for Android has been successfully designed and built with the Rapid Application Development (RAD) method. The automatic puzzle-solving feature using the Breadth First Search (BFS) algorithm has been successfully developed and applied to the game application. Based on the questionnaire compiled to determine the level of user acceptance of the game that has been built, the user acceptance rate is 85.0625% for perceived usefulness, 92% for perceived ease of use, 91.125% for perceived ease of learning, and 79.9% for perceived satisfaction, which means that the application is useful and quite well received.

From the experimental and evaluation results, it was concluded that the applied RAD method with its quick prototyping paradigm could be useful in developing a simple game application within a tight time constraint. The BFS could be applied as an automatic puzzle-solving feature in the game application which enhances the overall user experience and the game quality.

Based on the research that has been done, suggestions that can be given for further application development are to change the appearance of the application user interface to be more attractive to children by making it more interactive, applying animations when transitioning between scenes, using more interesting font types, and applying other game dynamics to make it not rigid.

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