Volume 12 · July 2020 · ISSN 2449-4399
International Peer Reviewed Journal
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of Scholarly Publishers, Editors and Reviewers, Inc.
Registered in the Philippines' Securities
and Exchange Commission (CN201433407)

Virgu: Optimized Campus Virtual Tour Guide Based on A* Algorithm

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ABSTRACT

VirGu is a virtual tour guide application that enables the user to find and obtain the routes in much more detail than static maps of the campus and determine the optimized shortest path to traverse to avoid confusion during its visit. A* search algorithm is used to find the shortest path from the source to destination in an even three-dimensional environment simulation and heuristic approach to guide tours in an optimized way. VirGu gives

precise location details at the user's own time and pace in mobile form. Thus, it reduces the effort to walk all over the campus. This developed virtual tour guide was designed based on the Android cross-platform engine and distributed as a mobile application. Testing and evaluation were conducted by students, faculty, staff, and visitors with a rating of 4.56 or Excellent.

KEYWORDS

Computer, A* Search Algorithm, Virtual Tour Guide, Shortest Path, Optimization, Philippines

INTRODUCTION

Path-finding algorithm addresses the problem of finding the shortest path from the source position into a destination and avoiding obstacles (Barnouti, Al-Dabbagh, & Naser, 2016). One of the greatest challenges in the model of realistic Artificial Intelligence (AI) in simulated virtual tour environments and computer games is agent movement. Path-finding techniques are usually employed as the basis of any Artificial Intelligence movement system. In this work, A* search algorithm is used to find the shortest path between the source and destination on the map and even three-dimensional environment simulation. Saleh Alija (2015) said that this path-finding algorithm could be applied to different application areas. These include games and virtual tours, driverless vehicles, robot motion, and navigation.

Optimization is required in reducing travel time while maximizing the purpose of the visit. Path-finding algorithm (Pathak, et al., 2013) stated that it is usually related to finding the shortest path, but there are other probabilities that may have to be solved differently. These include finding any path in a three-dimensional simulation with navigational support, finding a path with maximum coverage of any area, with minimal disclosure, and finding the set of paths with the maximum capacity to get as many units as possible to the destination.

Surigao del Sur State University-Lianga Campus (SDSSU-Lianga Campus) has two land areas for instruction, research, extension, and production purposes. The land area used in this study is where the academic heart of Lianga Campus is situated, with a total land area of 6.79 hectares. This land

area is where the physical plant and facilities are strategically positioned (Figure 1). However, new students, visitors, and other people have a hard time finding the specific place they want to visit inside the campus. There are maps and signs at some points of the campus, but it does not help provide them ways to arrive at a minimum time at their destination.

Figure 1. Aerial View of SDSSU-Lianga Campus

Figure 2. Location map of SDSSU-Lianga Campus

The researchers were motivated to build an Android Application with A* algorithm (or A* search algorithm), which is very helpful for freshmen, transferees, and visitors to orient themselves in searching for buildings, rooms, or offices inside SDSSU-Lianga Campus. This application provides a solution by giving routes in a much more detailed location than static maps

of the campus (Figure 2) and being able to determine the optimized shortest path to traverse avoid any confusion during its visit. The A* algorithm helps the user find the shortest path in avoidance of any obstacle through the Artificial Intelligence being applied on the application.

In-game development today (Dorren & Xu, 2011) its effort is focused on optimizing the A* algorithm and on aiding in solving real-world problems. The Android application determines the mobile functionality so that the application can be installed. A mobile-based tour guide (Sayyad & Shinde, 2016) provides a portable tour guide with augmented information for more intelligent, instructive, and client-specific experiences with expanded reality. Thus, the researchers are interested in this study to reduce the effort to walk all over the campus, as seen in Figure 2, in searching buildings, offices, and rooms and to give an accurate destination to the said people.

SDSSU–Lianga Campus can benefit from this application, especially during its campaign for enrollment providing information regarding facilities and amenities to different secondary schools and to parents who are looking for an institution for their children.

FRAMEWORK OF THE STUDY

This study adopted the Input-Process-Output (IPO) Model. Figure 3 shows the general flow of the study from a modeling profile up to elaborating the application and testing the virtual tour guide functionality. The modeling profile shows the location, outline, and data of SDSSU-Lianga Campus physical plant facilities based on the actual Campus map. The second stage of the diagram illustrates the development of the virtual tour guide mobile application with the use of the Mobile Application Development Life Cycle for mobile devices methodology by Padmaraj. At this stage, data are being collected to have inception, and these data will be determined or analyzed. After the analysis, analyzed data was adapted into a system with the use of a context flow diagram and developed with the working prototype until the project could be tested and deployed to the users. This process is very vital for the development and elaboration of the mobile application.

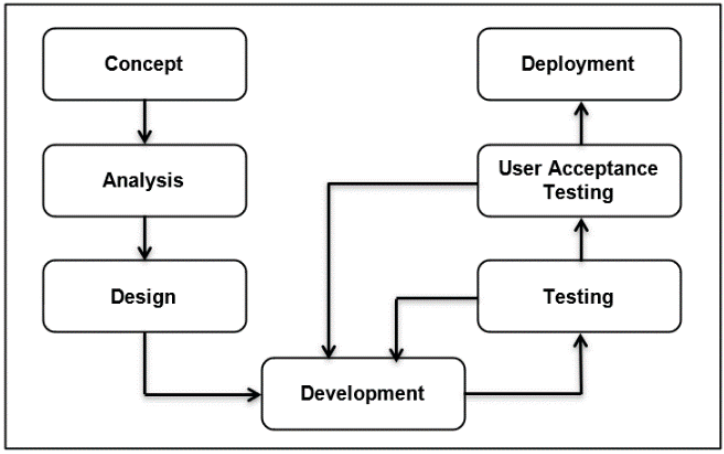

Figure 3. Conceptual framework of the study

The mobile application must be fully functional to attain the output stage that is the SDSSU-Lianga Campus Virtual Tour Guide application based on A* Algorithm. This campus virtual tour guide is simply known as *VirGu*.

The whole process determines the overall performance of VirGu to establish its effectiveness and functionality.

OBJECTIVES OF THE STUDY

The main objective of this study is to develop the SDSSU-Lianga Campus virtual tour guide mobile application with the use of the A* algorithm. Specifically, it aims to (1) design an Android application virtual tour guide with the use of Unity 3D and C# programming languages, (2) apply an A* Algorithm for efficient path-finding virtual tour guide, and (3) test the effectiveness and functionality of the newly developed application.

METHODOLOGY

For the development of this virtual tour guide android application, this study adopted Padmaraj (2012) methodology, which is Mobile Application Development Life Cycle, as shown in Figure 4. It would specifically be used for the project concept, analysis, design, development, testing, user acceptance testing (UAT), and deployment.

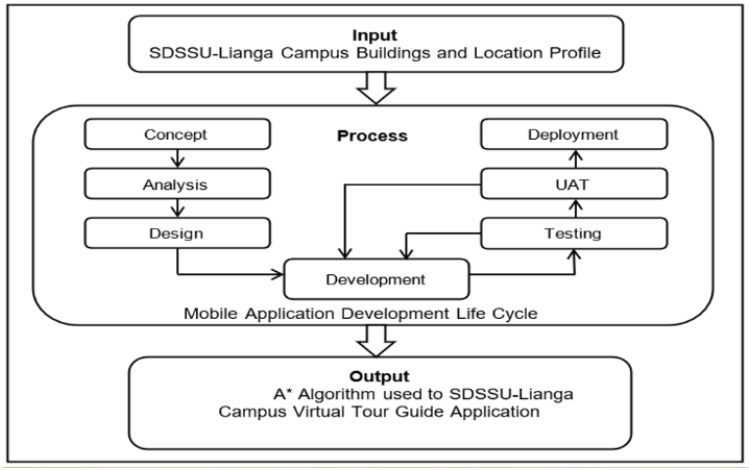

Figure 4. Mobile Application Development Life Cycle

First is the concept stage, where all about defining, refining, and enhancing the conceptualized before ideas are enhanced once again to create a more creative application. Consultation and data gathering for the inception of a more elaborated application supports the very important resources for the researchers to produce an accurate, advantageous, and efficient application.

The gathered data, information on A* algorithm, programming languages, budget, etc., needed for the development of this mobile application were analyzed in the next stage. The intended graphical user interface, databases, actual map of the SDSSU-Lianga Campus, navigational control, compatibility of the hardware to use, and accessibility to share for those with a lower version of mobile devices were also tackled to produce possible solutions.

The design stage focuses on the application architecture, user interface, functional features, and import requirements. Flowcharts, context data flow diagrams, and system architecture are some of the processes involved during this stage.

During the development stage, a 64-bit processor computer is used in developing the proposed virtual tour guide or VirGu. This is used since using 3D programs, simulated environment requires more than 32-bit processing control. The A* algorithm is applied, which is very appropriate for the shortest pathfinding. This algorithm can be found in Unity 3D software, which

is called navigation mesh. Figure 5 illustrates how the A* algorithm works on achieving the shortest pathfinding in a virtual tour guide application.

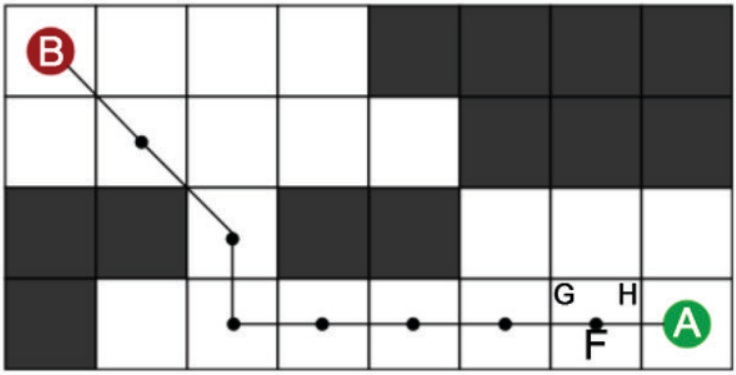

Figure 5. The A* Algorithm graph

The graph shows a lot of squares, which can be called the grid of nodes. The white nodes represent the walkable area, and the black nodes represent the obstacles. The graph has two different point nodes, A as the starting node and B as an end node. In every node, the distance between two nodes is one (1) and its distance between two diagonally nodes is the square root of two (√2). A node has a corresponding value for the following cost movements; G cost calculates the distance from the starting node, H cost calculates the distance from the end node, and F cost is the sum of G cost and H cost. To reach the end node, the starting node would choose the nodes that have the lowest value of summed F cost, excluding the obstacles. Software applications used for the design and development of VirGu are shown in Table 1.

Table 1. Software applications

Area of Utilization	Software Required
Operating System	Windows 7 (64-bit) or Windows 10 (64-bit)
Development Tools for Android Development	SDK tools r25.2.5 for Windows 64-bit JDK version 8+ for Windows 64-bit
Simulation Development	Unity 3D (64-bit) version 5 and above
Program Integration	Mono Develop-Unity with the use of C# language

In this development stage, the working prototype is developed that validates the functionality and assumptions during the design phase. When project development is done, it is a built-in Android platform through Application Provider Kit (APK) file format. To test its efficacy, the users installed the virtual tour guide application on their Android mobile devices. The users used the application to search school rooms or offices and were able to roam the University through a virtual tour guide application without any effort.

The testing stage is aimed to reduce bugs and failures of VirGu. This includes processes such as test plan, test execution, and test analysis. Every function of the system is tested, leading to test execution to test if there is no error or bug in the program codes. For test analysis, the project is examined to see if it meets the objectives of the study. If the developed system needs modification, it would be returned to the development phase for updating and undergo the three processes again to finally meet the requirements of the proposed system. Then, the Application Package Kit (APK) is built and ready now for User Acceptance Testing (UAT).

UAT is the phase of application development in which the application is tested in the real world by the intended audience. The researchers let the user tests the developed virtual tour guide via Android application to make sure it can handle the required tasks in real-world scenarios according to its proposed required specifications. During this phase, there are some functional errors noted or some requirements are not met. Thus, researchers fixed the recorded errors and made some modifications to the application. The main goal is to satisfy the needs of the clientele, who, in the first place, set the requirements. After modification, it was passed to several testing evaluations and until the developed mobile application was ready to be deployed to its users.

There are 180 research respondents to test the VirGu application. The number of respondents was composed of faculty and staff of the said Campus, new students, and visitors of the Campus. These number was calculated using Stratified Random Sampling, which is discussed in the statistical treatment of the data section.

A development-evaluative research method is adopted in assessing the effectiveness and functionality of VirGu. The study used convenience sampling and frequency counting to get the mean in each criterion. To measure the design performance and maintainability of the application,

a structured questionnaire was given to respondents for evaluation. Data were interpreted using the following arbitrary intervals:

4.21 – 5.00 = Excellent
3.41 – 4.20 = Very Good
2.61 – 3.40 = Good
1.81 – 2.60 = Fair
1.00 – 1.80 = Poor

When VirGu has been tested and accepted by users, the application is migrated to production environments. With the APK file format, it is easy to install on any Android mobile phone and can be shared through SHAREit.

RESULTS AND DISCUSSION

This application aims to produce a convenient method of having tour experience in SDSSU-Lianga Campus without going inside the University and orient the people who have the purpose of visiting the University.

Objective 1. Design an Android application virtual tour guide with the use of Unity 3D and C# programming languages

The simulation of a three-dimensional environment application is designed in the Unity 3D software, coded in MonoDevelop Unity using C Sharp programming language, and built on Android mobile phones. The application was developed with the use of development tools such as Software Development Kit and Java Development Kit to enable applications to be created for certain software platforms and packages like the Android Package Kit (APK).

Figure 6. The main menu

The prototype (Figure 6) has a main menu with buttons. The upper right button displays the information about VirGu. The second button displays the tips when taking a tour, the Start Tour button, which then displays Figure 7, and the Quit button to terminate the application.

The Start Tour menu also has three buttons: the Free Tour, Custom AI Tour, and Back. The free button (Figure 8) is a self-guided tour where the user is the one who manipulated the tour. Custom AI (Artificial Intelligence) Tour button is where the user selects a specific destination, and this AI agent will go to the selected destination while determining the shortest path in a 3D environment. The back button will close the Start Tour panel and go back to the Main menu.

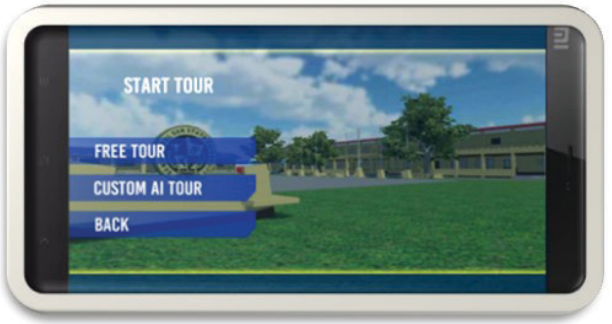

Figure 7. Start Tour menu

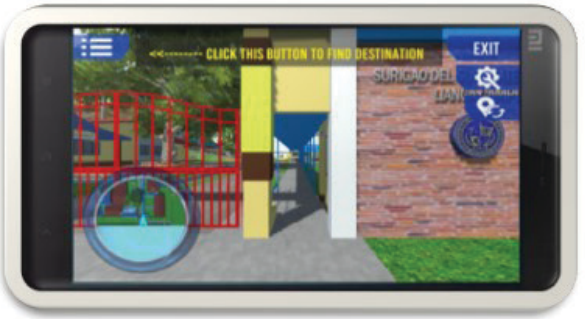

Figure 8. Custom AI Tour interface

When the Free button is clicked, another interface is loaded (Figure 9). There are two controls: (1) joystick enables the First Person Character to walk, and (2) swipe control to turn its vision around. For buttons: (1) Exit button closed the tour scene and back to Main Menu, (2) Settings button for personalizing tour control, and (3) Set Location button to set position into the default position.

Figure 9. Free Tour interface

Objective 2. Apply an A Algorithm for efficient path-finding virtual tour guide*

The Intelligent Campus Tour environment is where the initiation of the A* algorithm in which location relates to roads. In pathfinding, there is a navigation system involved. This navigation system creates a character or an agent that can intelligently move around the campus using navigation meshes that are created automatically from the scene geometry. Every function has a different target position, whereby if that destination is selected, the agent approaches the selected target. The simulation must have a character controller to have a real-world tour. It is simply a capsule-shaped collider that can be told to go in some direction from a script and to move this character. When there is a touch event detected, the character makes some movements like walking and turning around. It also carried out movement by avoiding collisions.

Objective 3. Test the effectiveness and functionality of the new developed application

The study was evaluated by 20 faculties, 20 staff, and 106 new students who examined the effectiveness and usability of VirGu or the mobile tour

guide application with A* algorithm to the simulated environment of SDSSU-Lianga Campus. The total grand mean resulted to 4.56 interpreted as Excellent both evaluation from faculty and staff and freshmen and transferees. An app like this provides information that makes the visit more convenient and informative (Arado, 2017). The A* algorithm (Xu & Van Doren, 2011) is optimized in some ways that it provides the shortest path between the visitor's current location and the destination. It provides multiple optimum and load-balanced paths that are discovered when there are multiple targets.

Table 2. Faculty and Staff and Freshmen and Transferees evaluation of VirGu

Criteria	Faculty and Staff Mean	Freshmen and Transferees Mean	Interpretation
Design			
1.1 The design of the system	4.70	4.75	Excellent
1.2 The graphical user interface of the mobile application	4.43	4.55	Excellent
1.3 The graphics use of the system	4.45	4.58	Excellent
1.4 The organization of information on the screen	4.58	4.50	Excellent
1.5 The navigational structure of the system	4.48	4.47	Excellent
1.6 The texture and patterns in the application background	4.50	4.53	Excellent
Design Criterion Mean	4.52	4.56	Excellent
Performance			
2.1 The usability of the application	4.60	4.66	Excellent
2.2 the correctness of the direction	4.68	4.56	Excellent
2.3 The navigation control of the application	4.63	4.57	Excellent
2.4 The character in application gives exact place in the scenario	4.53	4.50	Excellent
2.5 The application has a complete function and capabilities	4.55	4.56	Excellent
Performance Criterion Mean	4.60	4.57	Excellent
Maintainability			

Criteria	Faculty and Staff Mean	Freshmen and Transferees Mean	Interpretation
Design			
3.1 The accessibility to share with other smartphones	4.73	4.71	Excellent
3.2 The adaptability to the system environment	4.50	4.57	Excellent
3.3 The application can easily detect errors	4.43	4.55	Excellent
3.4 The application is effective to complete the task and scenarios	4.63	4.45	Excellent
3.5 The convenience to navigate feature of the mobile application	4.58	4.51	Excellent
Maintainability Criterion Mean	4.57	4.56	Excellent
Grand Mean	4.56	4.56	Excellent

CONCLUSION

A* Algorithm used to Virgu carried out satisfaction to users. Virgu permits new students, faculty, and staff access conveniently the physical plant and facilities of the University Campus through their Android phones. Significantly, A* algorithm lessens the tour time and effort of the user while maximizing the purpose of their visit through navigating the shortest path towards their destination.

ACKNOWLEDGMENTS

Special thanks go to Surigao del Sur State University and IASPER, Inc. Also, for the consistent support from Richard J. Ballena and Jayven T. Sasarita.

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Gunning Fog Index:	12.09
Flesch Reading Ease:	44.99
Grammar Checking:	93/100
Plagiarism:	1%