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INDOOR NAVIGATION SYSTEM USING AR

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Electronics and Communication

Harish M M	1MS18EC035
Anwesh Shetty B	1MS18EC012
Amith K N	1MS18EC008
Anjana Prasad M	1MS18EC011

Under Guidance of

Dr. Reshma Verma

Assistant Professor, Department of E & C

Department of Electronics and Communication

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www.msrit.edu

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CERTIFICATE

This is to certify that the dissertation work entitled **"INDOOR NAVIGATION SYSTEM USING AR"** is carried out by **Harish M M (1MS18EC035), Anwesh Shetty B (1MS18EC012), Amith K N (1MS18EC008) and Anjana Prasad M (1MS18EC011)** bonafide students of Ramaiah Institute of Technology, Bangalore, in partial fulfillment for the award of Bachelor of Engineering in **Electronics and Communication** of the Visvesvaraya Technological University, Belgaum, during the year 2021 -2022. It is certified that all corrections / suggestions indicated for Internal Assessment have been incorporated in the thesis. The thesis has been approved as it satisfies the academic requirements in respect to dissertation work prescribed for the said degree.

Guide	HOD	Principal
Dr. Reshma Verma	**Dr. Maya V Karki**	**Dr. N V R Naidu**
Assistant Professor	Professor and HOD,	Principal,
Department of E & C	Department of E & C	RIT, Bangalore
RIT, Bangalore	RIT, Bangalore	

Name & Signature of Examiners with Date: -

1) Dr. S. Sethu Selvi

2) Dr. Deepali Koppad

DECLARATION

We hereby declare that the Project entitled "Indoor Navigation Using AR" has been carried out independently at Ramaiah Institute of Technology under the guidance of **Dr. Reshma Verma, Assistant Professor, Department of Electronics and Communication, RIT, Bangalore.** We hereby declare that work submitted in this thesis is our own, except were acknowledged in the text and has not been previously submitted for the award of the degree of Visvesvaraya Technological University, Belgaum or any other institute or University

Signature of Students:

1. Harish M M (1MS18EC035)
2. Anwesh Shetty B (1MS18EC012)
3. Amith K N (1MS18EC008)
4. Anjana Prasad M (1MS18EC011)

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ABSTRACT

Although various solutions have been suggested for indoor navigation systems, most methods require the support of external physical hardware infrastructure. Due to the increase in complexity and cost of set-up of supporting hardware requirements, scalability will always be an issue with such systems.

In our project, we present the design of a smartphone based indoor navigation system. The proposed method uses on-device sensors, Camera and AR SDK, for easily creating indoor maps and providing an indoor location's information for navigation and localization. The system has been implemented and tested, and the results indicate that the approach is useful for navigation in indoor environments.

Our Project presents a common service framework for indoor navigation, including indoor mapping, indoor positioning, route planning, and travel assistance. Within these structures, we focus on augmented reality (AR) solutions for travel assistance. AR helps users walk through multi-storey buildings by displaying directional paths or markers under the camera image, making it impossible for users to know where they are. Our augmented reality solution is based on. It can operate without any infrastructure and without relying on GPS. The augmented reality visual interface and integration with A*algorithm are the main novelties of our solutions, which have been experimentally tested and performance of it has been observed.

ACRONYMS

AR	Augmented Reality
SDK	Software Development Kit
QR	Quick Response
GPS	Global Positioning System
SLAM	Simultaneous Localization and Mapping
GLONASS	Global Navigation Satellite System
LIDAR	Light Detection and Ranging
TOF	Time of Flight
RSS	Received Signal Strength
RF	Radio Frequency
WiFi	Wireless Fidelity
NFC	Near Field Communication
VR	Virtual Reality
RGB	Red Green Blue Image

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INTRODUCTION

Introduction

Existing roaming systems can be broadly divided into two main categories, internal and external. Many outdoor navigation techniques use satellite-based navigation systems such as GPS, GLONASS, etc. to locate things in any outdoor space. Such techniques work best for open Areas which have a clear line of sight on satellites, but will not work well in the indoor environment.

Over the past few years, internal navigation systems have become a popular research topic. To detect an object, this RF-based such as LIDAR, TOF cameras method tests the received signal strength (RSS) in multiple reference areas. However, such a system requires extensive hardware support and is not easily expanded. Large availability of mobile devices with WiFi, Bluetooth, ZigBee, NFC etc. and AR SDKs opens up a whole new way of indoor navigation techniques.

However, the approach is plagued by problems such as relying on external signal distribution, fluctuations in sensor values. Challenges in developing any local in-house design and navigation system include map production, in-house localization, client platform software development. In this project we present the design of the end-to-end solution that allows for map production, local indoor design and navigation with the help of an off-the-shelf smartphone. The smartphone app is a standalone product.

Augmented Reality is one of the most powerful booming technologies that narrows down the digital world with the real-world environment, thus enhancing the modern human perception of reality. The unpopular reality of taxpayers we find to be very useful on a daily basis when placed on a locally based technology. However, this technology is limited to popular buildings or outdoor areas and will not be able to provide indoor information. Detection of current location using GPS is limited when it comes to indoor locations.

Augmented reality is a technology for object recognition Visually overlays information about the object on the display Screen above the image of the object. Object identification It depends on pattern recognition. This technology requires a huge database Of the pattern and computational power to identify an entity. Altitude Reality adds a layer of digital information-videos, photos, sounds- Directly to objects in the world around us using a camera Connect with more people with sensors on smartphones and tablets Meaningful content in our daily lives.

AR Concept enables users See the real world with additional digital information on top the current image of the real world he/she sees. This AR-technology can be enforced to a broad variety of fields to simplify our day-to-day activities. It is being used in many fields like military, medical industry, museums, etc. Identifying a location, which is either in an indoor or outdoor environment, is probably one of the perfect fits where augmented reality is applicable.

Problem Statement

With the appearance of GPS gadgets, people are capable of discovering their modern-day area within their line of sight with satellites. There additionally exists a hybrid method of the usage of a GPS device and augmented reality, wherein GPS is used to discover the area in an exposed open area and augmented reality shows corresponding meta-records approximately the area. A huge wide variety of cellular packages are to be had withinside the marketplace nowadays to recognize the records in approximately public places. These packages employ the phone's virtual compass and GPS info to show records approximately the modern-day scene captured with the aid of using the camera. To broaden an android software for smartphones which allows the consumer to navigate via unusual indoor surroundings the usage of Augmented Reality as an interface.

Motivation of the work

In large indoor spaces like shopping malls, we often get confused and find it difficult to identify our place of interest. There is a limitation for the GPS device to pinpoint your position when the user is in covered areas such as shopping malls, airports, train stations, multi-story buildings, apartments, etc. To overcome this limitation, there are alternative ways of getting location information from others to obtain sources than the satellite. Such alternative sources of information include QR codes, barcodes, etc. These sources of information contain data such as geographic coordinates of that particular location in an encrypted form.

Existing systems do not usefully provide the user with the location-based information. Most systems provide the user with the location information on a custom indoor location map that is not easily understood. Augmented Reality can bring better usability in indoor location tracking. The following sections of the document derive an indoor positioning technique that is

made more usable by augmented reality. The proposed solution provides more information than a user sees to easily identify a location in covered environments.

Objective

The present navigation technique does not provide the exact location in the covered areas such as shopping malls, airports, train stations, multi-story buildings, apartments, etc. the main idea of this Project is to overcome this flaw with the present GPS Navigation technique by using the new and booming technology AR Core and Unity Software which is an artistic tool for Building the indoor maps which is used for the indoor navigation purpose. And using some kind of codes such as QR codes, barcodes, etc. instead of the use of satellites for getting the information of the interested location.

Nowadays, smartphones play an important role in day-to-day life. This idea of ours uses smartphones as the key device for navigation so it can reach all people in an affordable way. Since there are no requirements of the high-end hardware it uses the modern-day mobile camera and Google's AR Core App which is easily accessible by everyone.

Scope

Augmented reality is as of now augmenting the versatile gaming market. Since first experience with the tech customer market, augmented reality has performed at a high speed and beaten gauges unfailingly. Alluded to related to VR regularly, AR is a historic innovation that utilizes projected pictures through a cell phone screen to copy an item existing in a 3D space that it doesn't have in all actuality.

Let me take a tour you around how AR helps in mobile technology:

Gaming

Pokemon Go, one of the best instances of AR, urges users to head outside and visit new areas. Besides, the application enables trainers to utilize their Pokemon and fight different coaches they meet, all things considered. It is an exquisite method for consistently interweaving reality and the advanced world at the same time. The diversion, a Phenom of the portable market and a wondrous help for Nintendo, has created over $1 billion in income through its IAP model. That is sufficient proof to help the possibility that mobile gaming and augmented reality fit together superior to nutty spread and jam. Pokemon Go still has a large number of players worldwide and has appeared to remain well known even with the forceful versatile gaming turnover rates.

Transportation

Have you ever faced issues in traveling to any unknown places once you land or step out of your train bus/car. Fear no more, AR has got you covered! If you have a travel app with AR, you can easily point at the transportation object to get the route, direction, next stoppages and places to visit. This will make your journey more enjoyable. Plus, you can turn a metro map into an interactive guide in multiple languages.

Food Catering

Now a day restaurants and other catering facilities are already using AR solutions for their benefits in various ways:

• AR games to lure new clients

• Interactive 360 view of every dish, correct size, portion, ingredients

• Using navigation to provide information about the restaurants, bars and cafes nearby

Travel and Tourism

AR can be used in exploring various tourist destinations and attractions. It literally transforms classic city into exquisite ones. Worth watching, I

must say! You can also travel back in time, see the evolution of the landmarks in time perspective, get fun guides and enjoy the 3D models of places.

AR can bring any non-existent objects into life. Museums nowadays are creating visual tour exhibitions and guides to educate visitors in a memorable way. It has been fascinating people in a never seen avatar.

Hospitality

Have you imagined how games can interest and encourage people, especially the younger ones to stay in a particular hotel. AR, exclusively gets it for you. Engage yourself with interactive games and better displays.

You can use Augmented Reality to create all-round room tours along with pricing and accommodation details. This will be a good way to advertise the hotel and engage guests to try total hotel services. Plus, it can also help to turn one-time guests into regular guests. Just get your Tablet or smartphone, open the hotel app and point to a certain marker, and get all the information you want.

Technological innovation brings in new experiences every time. With AR tech in usage, this is much truer than anything. Augmented Reality in various industries such as Tourism, Gaming can come handy in a lot of things we might not have ever imagined. The future truly lies in Augmented Reality.

LITERATURE SURVEY

Localization and indoor Positioning

Din, Marina & Jamil, Norziana & Maniam, Jacentha & Mohamed, Mohamad A. (2018). Review of indoor localization techniques. International Journal of Engineering and Technology (UAE). 7. 201-204. 10.14419/ijet. v7i2.14.12980.

This paper gives great insight about different location and indoor positioning techniques. And Explains steps involved in the positioning and helps to understand the coordinate system. techniques for positioning involve steps are Signal measurement and position calculating. For signal measurement there are multiple methods like RSS (received Signal Strength) and time-based methods like time of Arrival, time difference of arrival and Round-Trip time. For Position calculation we use mainly triangulation method.

Takeaways from this paper is that we use position calculating methods using the sensors movement as mentioned in paper and calculating and updating the position repeatedly using different source or methods

Billa, Arlind & Shayea, Ibraheem & Alhammadi, Abdulraqeb & Abdullah, Qazwan & Mardeni, R. (2020). An Overview of Indoor Localization Technologies: Toward IoT Navigation Services. 10.1109/ISTT50966.2020.9279369.

This paper gives a broader view on use of different technologies in indoor positioning and localization. It explains more about what all the different methods can be used to identify the position of the object in a real time environment corresponding to the 3D coordinate system such as WLAN, WiFi, BlueTooth and many more its pros and cons of each of these technologies. It also gives insights about use of SLAM techniques to localize the object or position the self-using different sensor data.

It helped us in understanding the working of Sensors in Mobile and gave us the idea to increase the accuracy of the position by frequently updating the position using the existing and pre-defined tags in the in Environment like QRCodes or BarCodes. We finally chose the Hybrid method suggested in the above paper which seems cost effective as mentioned and also easy to implement and debug.

Augmented reality

Nowacki, Paweł & Woda, Marek. (2020). Capabilities of ARCore and ARKit Platforms for AR/VR Applications. 10.1007/978-3-030-19501-4_36.

This paper , they have performed evaluation of various functionalities of AR technology such as detection flat surfaces, imaging of detected flat surfaces/special points, positioning any number of 3D objects on stage, choosing scene lighting based on the actual lighting conditions, support for shadows cast generation by virtual objects, measure the distance between 2 points, saving information about detected planes (and special points) to a file, measurement and display of frames per second during operation, measurement and save information on app startup time. It has been evaluated on different devices which includes both Android and IOS devices and devices performance has been recorded.

From this paper we learned that AR Core can be used for plane detection, saving the detected planes and rendering virtual objects in real life. We learned how much memory usage is done devices while running these apps that require AR core support.

Navigation path

T. Goto, T. Kosaka and H. Noborio, "On the heuristics of A* or A algorithm in ITS and robot path-planning," Proceedings 2003 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2003) (Cat. No.03CH37453), 2003, pp. 1159-1166 vol.2, doi: 10.1109/IROS.2003.1248802.

In this paper based on many large data set, they calibrate a near-optimal heuristic as a constant function for guiding efficiently. The network search is a classic problem, but it is still meaningful in ITS (Intelligent Transportation System) or a robot path planning is considered as the main purpose for finding the optimal path. In ITS, we want to pick up the optimal (shortest) route between two locations in a huge road map. In these cases, the data or amps are very huge and the time for calculating the optimal(shortest) path for between the two nodes (desired location) is very critical and most important and time consuming. Many types of graph search algorithms such as Dijkstra (A* with no heuristics) and A* algorithms have been theoretically analyzed. Especially, several kinds of roles of heuristics have been deeply and mathematically analyzed. Some systems adopt the algorithm Dijkstra or A* in order to select the optimal path between two positions quickly. Since this paper involves a larger dataset and it is mainly considering the outdoors, the author wants to find the optimal path in less time. Since heuristics of Dijkstra and A* are too conservative, they spend much calculation time in spite of selection of the optimal path. Here the author is interested in time so he compromised in the optimal path and tends to save time.

Since, in our project we are going with indoor mapping we are interested in the optimal path rather than time since it has less data or small map as it is indoor navigation. So, in this paper the author compares Dijkstra, A*, A algorithm and shows that A* is better in findings the optimal path compared to the other so we came to conclusion that we will use A* search Algorithm for finding the optimal path between two interested locations.

Zheng-hong Hu and Jin Li, "Application and implementation of a* algorithm in picture matching path-finding," 2010 International Conference on Computer Application and System Modeling (ICCASM 2010), 2010, pp. V5-224-V5-228, doi: 10.1109/ICCASM.2010.5619180.

This paper analyzed A* search algorithm applied to the game in detail, and pointed out the composition of the estimated function. Combined with

practical application, the paper gave its realization. The author of this paper analyzed the use of the A* search algorithm by applying this to a game. This paper analyzed rules about Picture Matching and the breadth first searching algorithm. Based on those, it gave the application of A * algorithm applied the game, and offered the corresponding data structure and the program improvement. It could use O(N+L) time to complete the shortest path-finding and adapted the game's request well. A * algorithm is a kind of algorithm which calculates the shortest path-finding and it unifies the heuristic and the formalized method, used for many video games.

Takeaways from this paper is that the A* algorithm is the algorithm which gives the sweet spot between the time consumed for the computation and the accuracy of the optimal path between the two interested nodes.

Unity Docs

Unity Docs helped us understand Unity workspace that combines artist friendly tools with a component-driven design that makes game development pretty darn intuitive. Both 2D and 3D development is possible in Unity, with 2D physics handled by the popular Box2D engine. Unity uses a component-based approach to game dev revolving around prefabs. With prefabs, game designers can build objects and environments more efficiently and scale faster.

Methodology

The main methodology which leads this application to work involves the following,

1. Google ARCore

ARCore is Google's platform for building augmented reality experiences. Google ARCore includes different APIs that are used to sense the environment using just a smartphone's RGB camera and understand the world and interact with it. Google ARCore considers key capabilities like Motion Tracking, Environmental Understanding, Depth Understanding, Light Estimation and User Interaction to provide a feature called Simultaneous Localization and Mapping (SLAM).

Simultaneous Localization and Mapping (SLAM) is the concept of constructing or updating a map of a simulated environment while simultaneously keeping track of a user's location within it in real time. We used this to keep track of the user's movement and replicate the same in the 3D model of the building and further use it to update the path to the destination.

2. Nav Mesh

In Unity, a NavMesh represents an area where the center of the user object can move. The object here can be a point, or a circle with size, the two are equivalent. In our application, the Nav Mesh is constructed based on the blueprint of the building and includes all the walls, doors and other objects that the user can't pass through. This allows us to estimate only the area where the user can walk through.

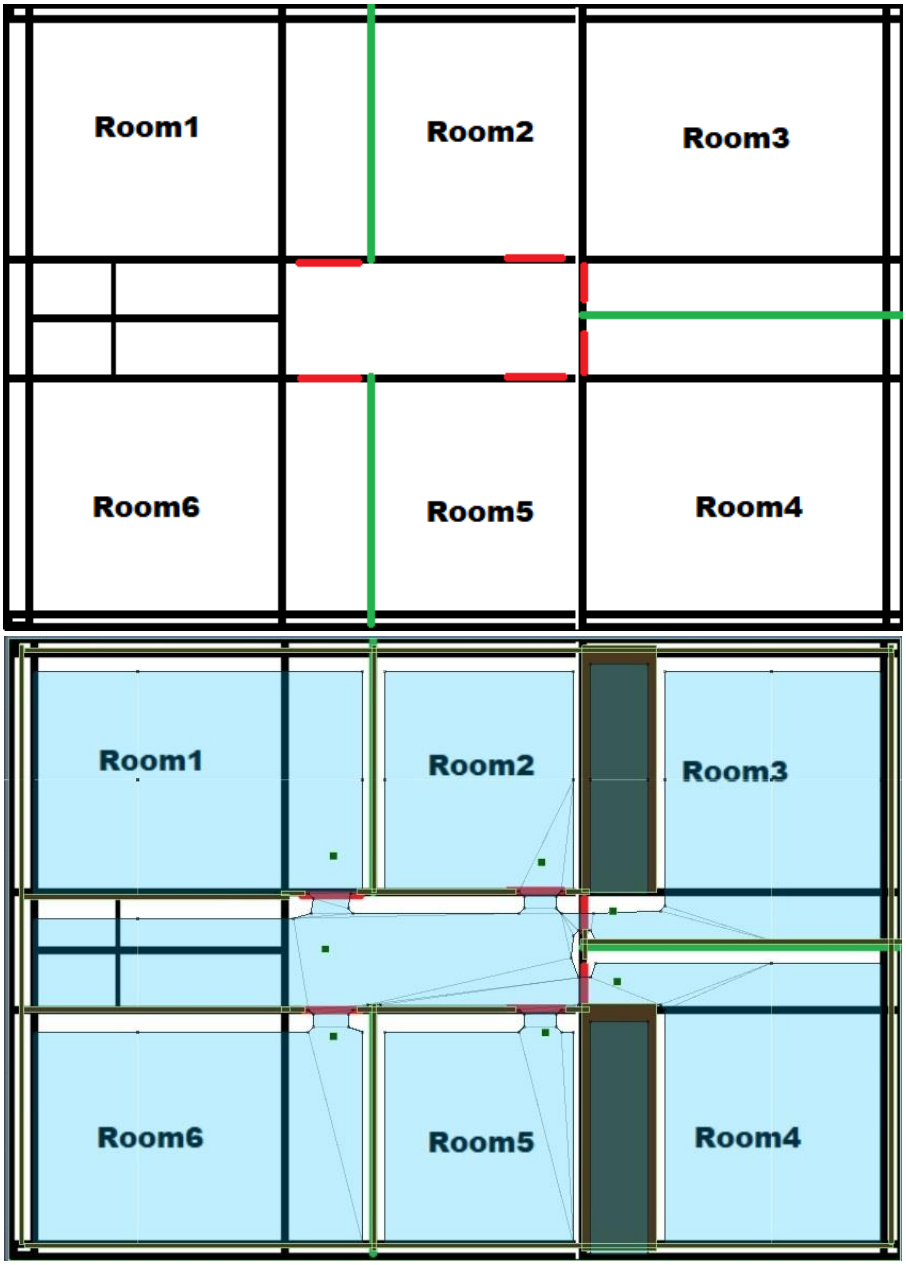


Figure 1: Floor Plan and corresponding Navigation Mesh

3. A* Algorithm

A* is an informed search algorithm, or a best-first search, meaning that it is formulated in terms of weighted graphs: starting from a specific starting node of a graph, it aims to find a path to the given goal node having the smallest cost (least distance traveled, shortest time, etc.). It does this by maintaining a tree of paths originating at the start node and extending those paths one edge at a time until its termination criterion is satisfied. A* is like Dijkstra's Algorithm in that it can be used to find a shortest path. A* is like Greedy Best-FirstSearch in that it can use a heuristic to guide itself. In the simple case, it is as fast as Greedy Best-First-Search. The secret to

its success is that it combines the pieces of information that Dijkstra's Algorithm uses (favoring vertices that are close to the starting point) and information that Greedy Best-First-Search uses (favoring vertices that are close to the goal). The navigation system in Unity allows us to create objects that can intelligently move around the game world, using nav meshes. It uses A* Algorithm built-in with its path finding.

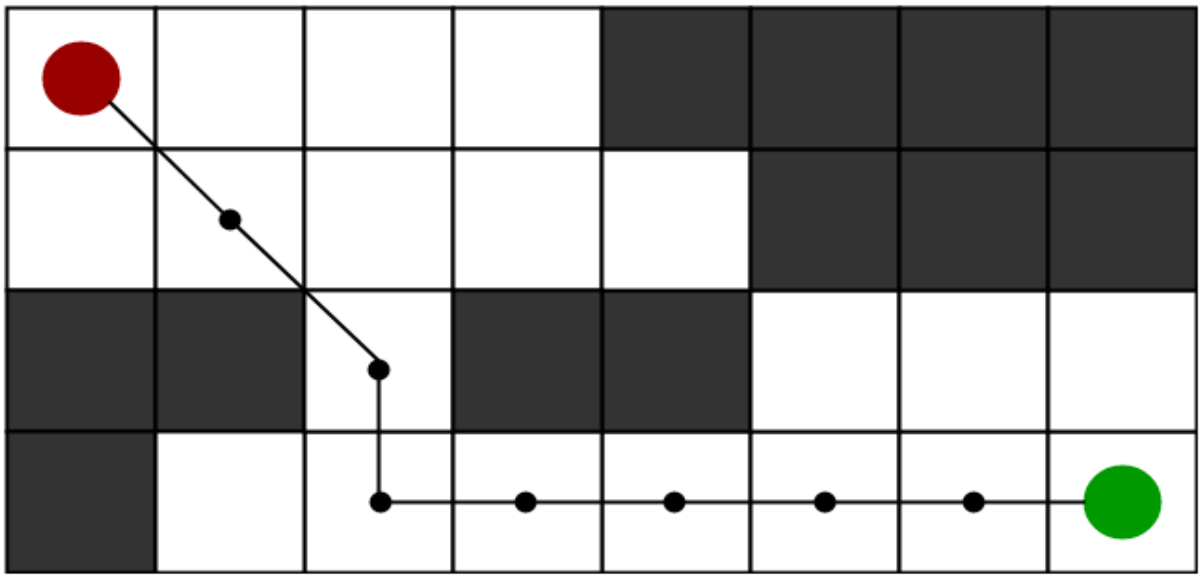


Figure 2: A* Algorithm

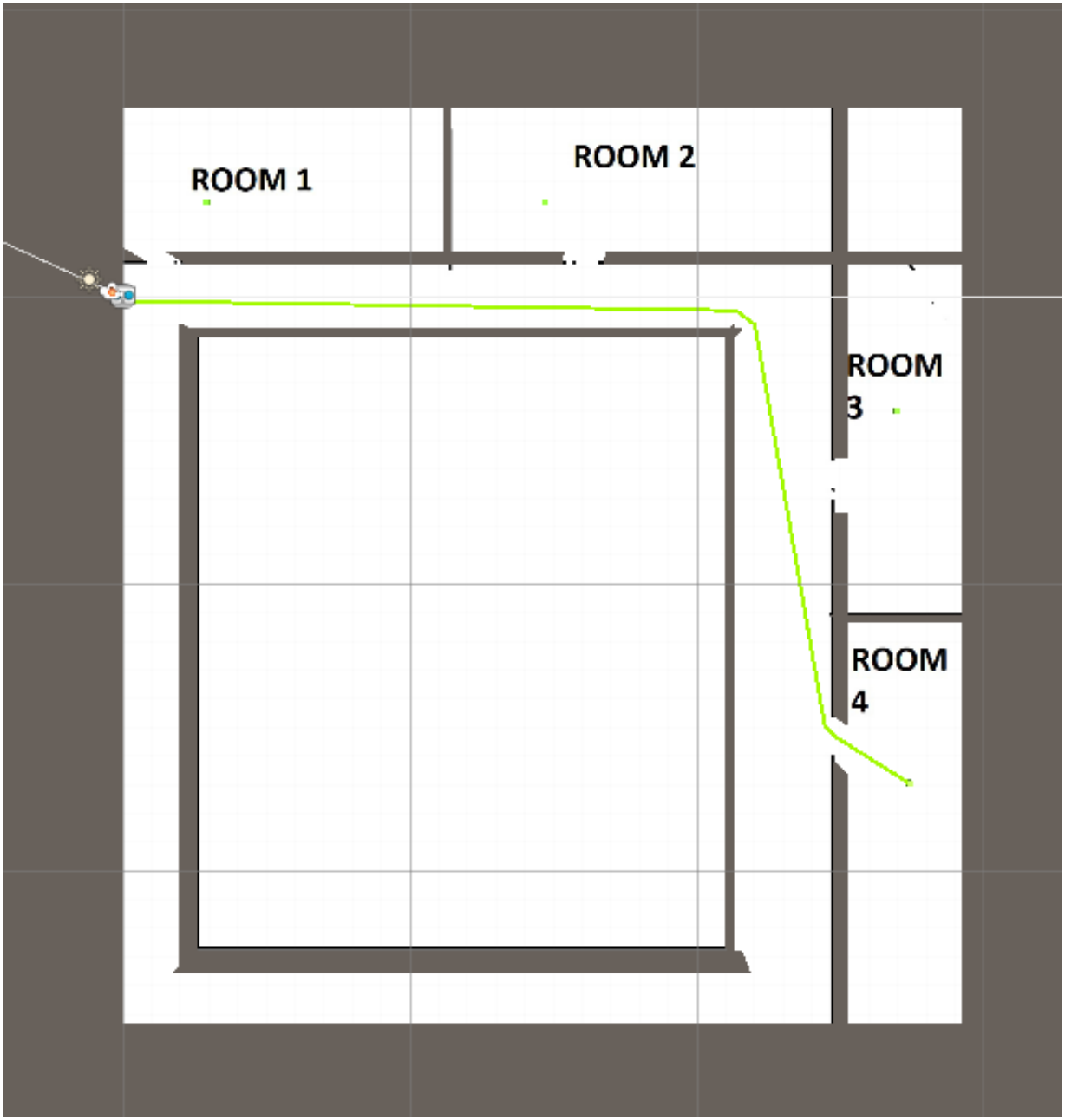


Figure 3: A*algorithm

A* Search algorithm is one of the best and popular techniques used in path-finding and graph traversals. In simple terms the algorithm can be expressed as:

F = G + H.

Where, F is the parameter which is the sum of the other parameters G and H and is the least cost from one node to the next node. This parameter is responsible for helping us find the most optimal path from our source to destination. G is the cost of moving from one node to the other node. This parameter changes for every node as we move up to find the most optimal path. H is the heuristic/estimated path between the

current code to the destination node. This cost is not actual but is, in reality, a guess cost that we use to find which could be the most optimal path between our source and destination.

The Pseudo-Code of the Algorithm goes like this.

```
let the openList equal empty list of nodes
let the closedList equal empty list of nodes
put the startNode on the openList (leave it's f at zero)
while the openList is not empty
    let the currentNode equal the node with the least f value
    remove the currentNode from the openList
    add the currentNode to the closedList
    if currentNode is the goal
        You've found the end!
    let the children of the currentNode equal the adjacent nodes
    for each child in the children
        if child is in the closedList
            continue to beginning of for loop
        child.g = currentNode.g + distance between child and current
        child.h = distance from child to end
        child.f = child.g + child.h
        if child.position is in the openList's nodes positions
            if the child.g is higher than the openList node's g
                continue to beginning of for loop
        add the child to the openList
```

Working

3D Map of Environment is created using Unity Engine

Locations are labeled as Initial position, destination 1, destination 2 etc.

QR codes for each destination are generated and placed at corresponding destinations.

When Indoor Navigation App is launched it checks whether the device supports AR Core Framework and asks for camera permissions.

QR Code is scanned to localize the position of the user with respect to the pre-built environment.

It asks the user to move the device slightly on either side to detect the plane and checks whether features of the detected plane match with any of the features of any plane of the pre-built map.

Users have to select a destination to where they want the app to navigate them.

Once the destination has been selected A* algorithm is applied and the nearest path to destination is calculated keeping in consideration the obstacles present in the map.

AR Core renders the line-renderer on to the UI of the app that shows the line/path to be followed from user's current position to destination selected.

Once the user reaches the destination a Toast message "You have reached your destination" is shown.

Now the user can scan the QR Code for that particular destination to once again localize his position with respect to map and can repeat the above-mentioned steps, user can also change the destination in between and A* algorithm is designed in such a way that it recalculates the path from user's current position to new destination.

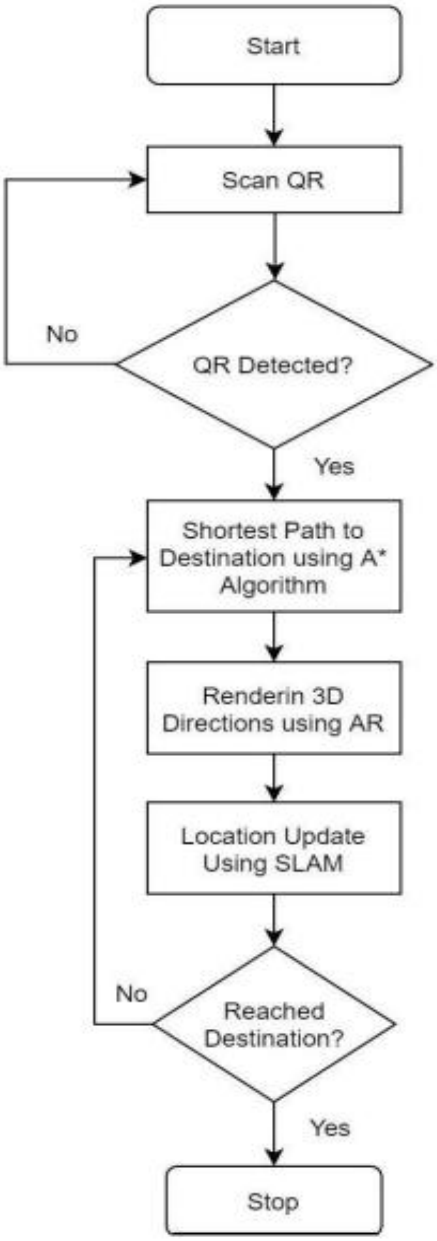


Figure 4: Block diagram representing the workflow of application

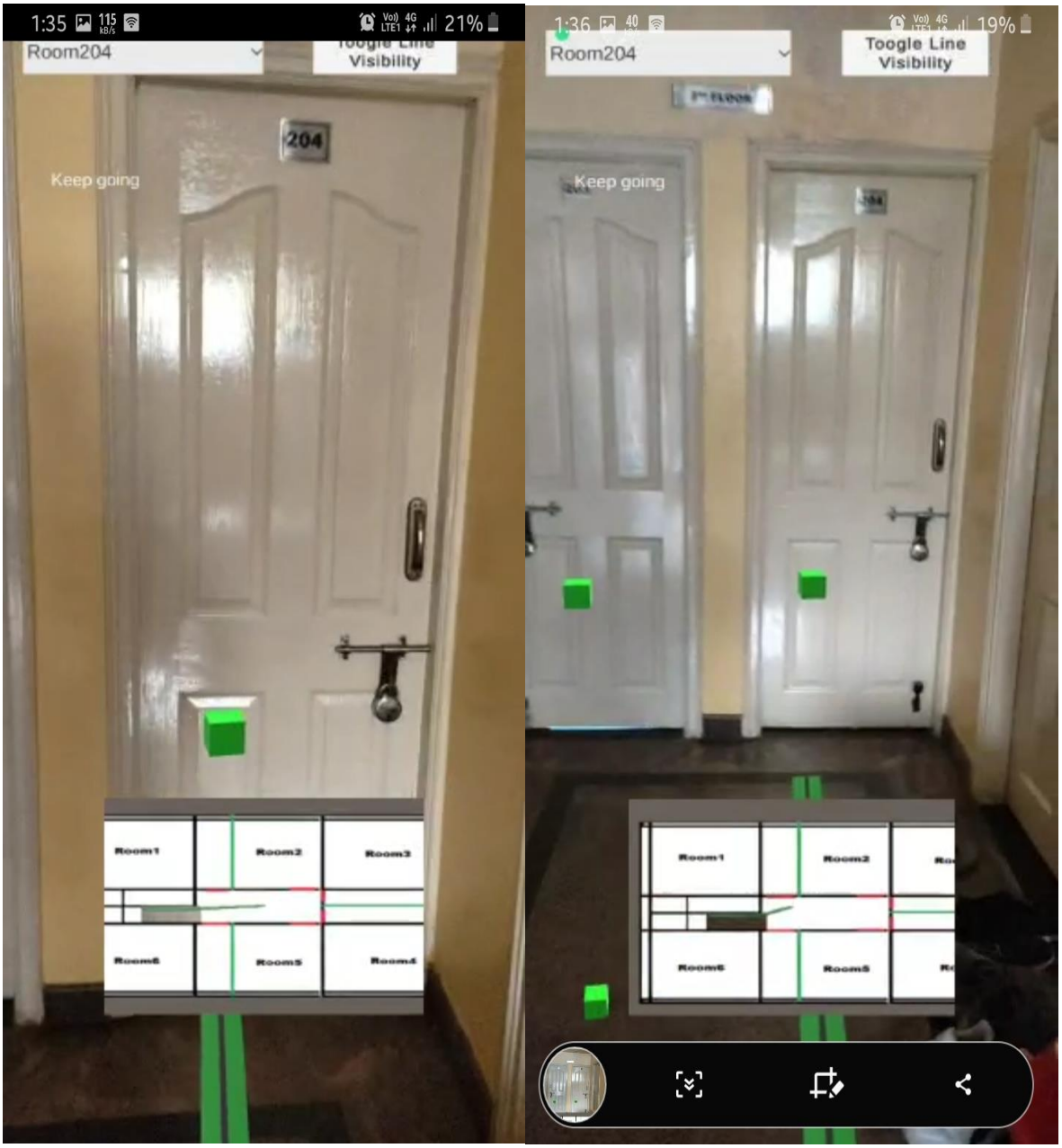


Figure 5: Screenshots of App

RESULTS & DISCUSSION

As a proof of concept, we developed an application for smartphones to allow indoor navigation, based on the use of Augmented Reality fiducial markers (QR code) or paths. Navigation tests were performed with 3 different environments Figure 5.1 shows selecting the destination location and Figure 5.2 shows strategic placement for the fiducial markers.

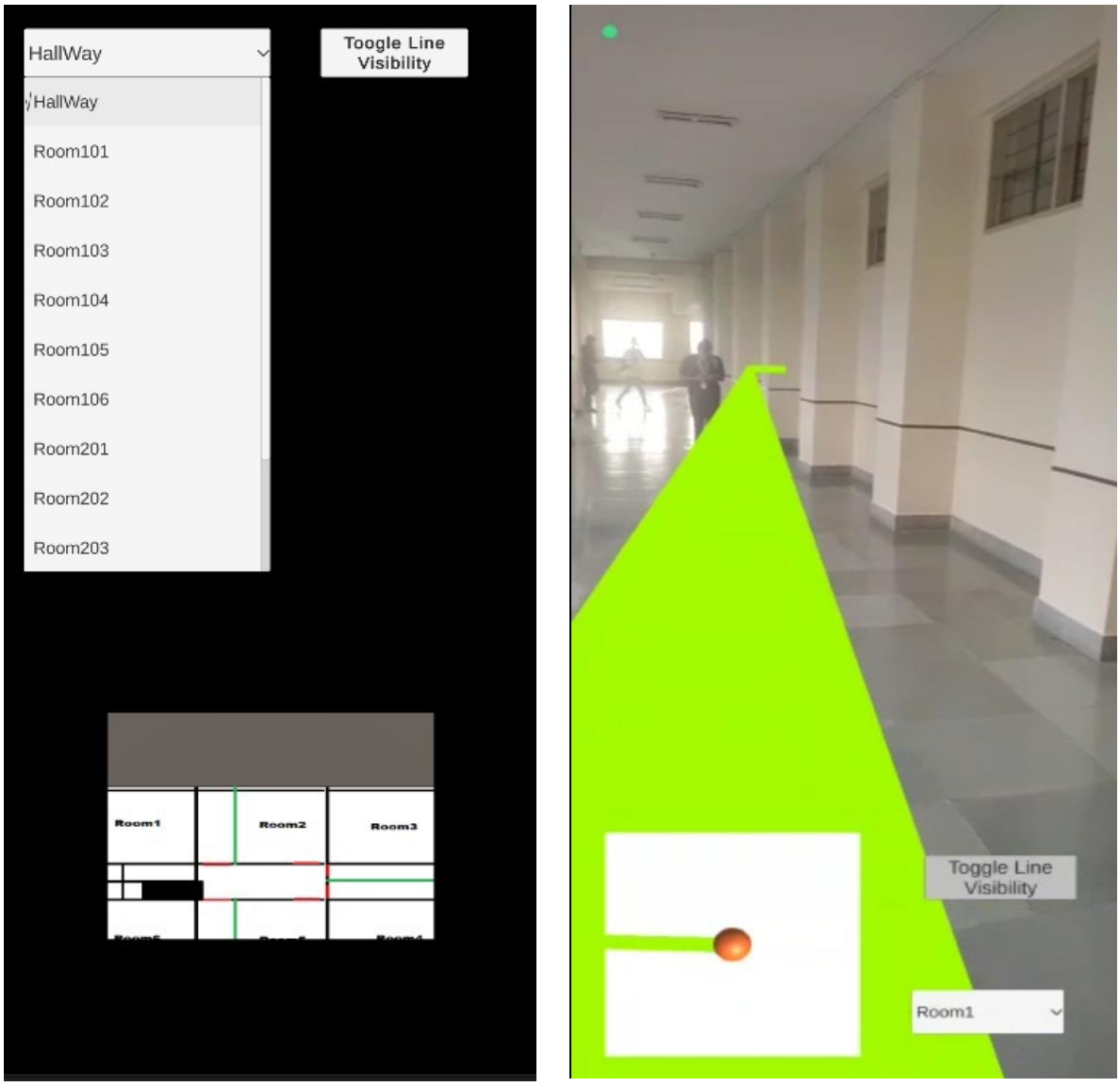


Figure 6: UI of our App and its working in real environment

When using the system, the user expects to visualize routes of interest containing best access. The starting point has been fixed at the location where the QR code is scanned. After starting the application, the user can select the desired environment and then the desired destination point, as shown in Figure.

Once the final destination is selected, the interface presents the direction that the user should follow to reach the destination via the best obstacle-free route. When passing by a marker which would prompt the presentation of the direction to be followed for the best route from that point on.

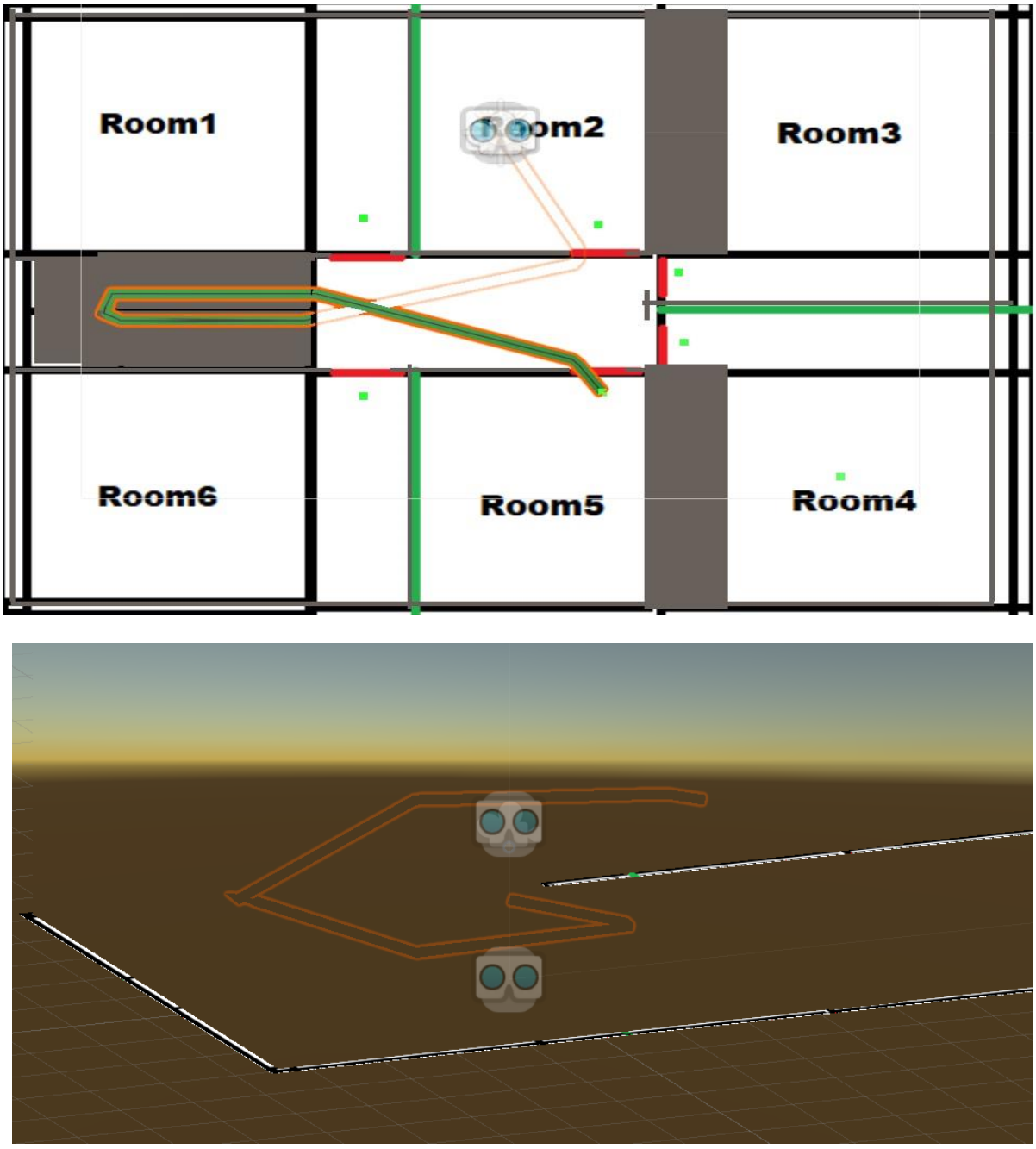


Figure 7: Top view of path and side view of Path

Table : Comparison of the Algorithm using the Grid 90X90

Component	A* Algorithm	Dijkstra Algorithm
Path Length	193	193
Time	2.1 s	2.4 s
Computed Blocks	3238	4633

Table : Comparison of the Algorithm using the Grid 50X50

Component	A* Algorithm	Dijkstra Algorithm
Path Length	98	98
Time	2.1s	2.3s
Computed Blocks	891	1952

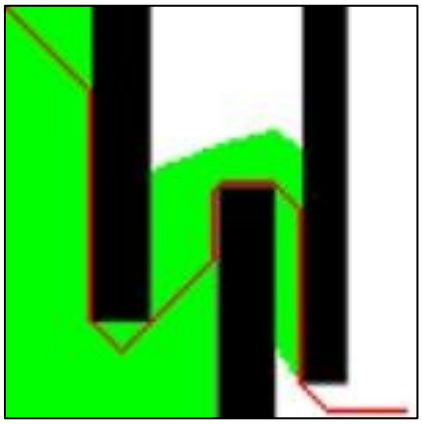
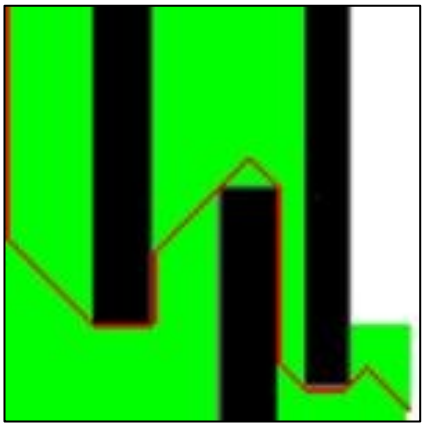
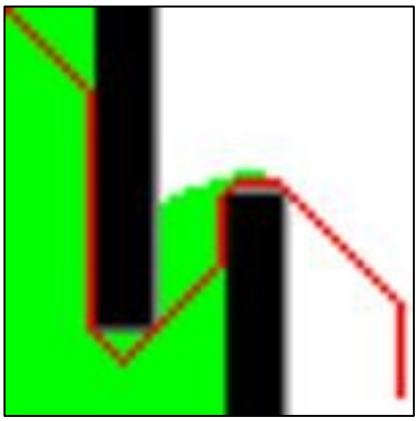
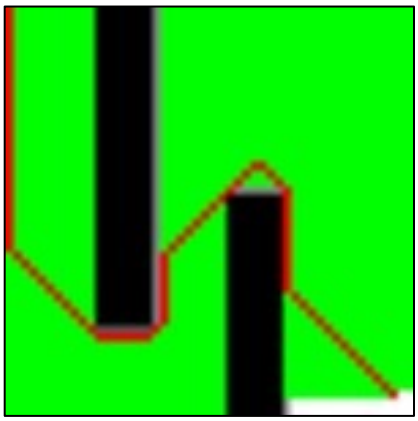
	A* Algorithm	Dijkstra Algorithm
90X90 Grid		
50X50 Grid		

Figure 8: Comparison of A* and Dijkstra algorithm

Based on the results of this evaluation conducted, it can be concluded that:

1. A*, Dijkstra, and Breadth First Search can be used to find the shortest in Maze Runner Game.

2. A* is the best algorithm in pathfinding especially in Maze game / grids. This is supported by the minimal computing process needed and a relatively short searching time.

3. The use of the right algorithm can make the game better in terms of computing process, memory usage, and computing time.

From the above results we came to a conclusion that the A* algorithm is the best Algorithm to find the shortest path to interested destination path.

CONCLUSION & FUTURE WORK

In order to perform tests, a case study was conducted with the collaboration of two volunteers, in an indoor environment. At first, a block map was configured into the system. The user could select a point of interest by touch. During the navigation process, the application indicates the direction that the user should follow until his/her final destination. It is believed that the proposed system can be of great use to various individuals with physical deficiency, by helping them with orientation and mobility. This fact has the potential to facilitate the lives of these individuals, without the need for external help, since the system provides them with greater accessibility. As future work, we intend to add new modules, as for example, the visualization of information relevant to individual wheelchair users to incorporate new resources, such as personalized configurations for each user.

We can propose this to use in different areas such as hospitals, industries, corporate offices. We may also vary the path as per the interest of the user like if a user is Physically disabled, he or she can optimize the path suitable for him or her like avoiding stairs and other obstacles.

References

1. Nowacki, Paweł & Woda, Marek. (2020). Capabilities of ARCore and ARKit Platforms for AR/VR Applications. 10.1007/978-3-030-19501-4_36.
2. T. Goto, T. Kosaka and H. Noborio, "On the heuristics of A* or A algorithm in ITS and robot path-planning," Proceedings 2003 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2003) (Cat. No.03CH37453), 2003, pp. 1159-1166 vol.2, doi: 10.1109/IROS.2003.1248802.
3. Din, Marina & Jamil, Norziana & Maniam, Jacentha & Mohamed, Mohamad A. (2018). Review of indoor localization techniques. International Journal of Engineering and Technology (UAE). 7. 201-204. 10.14419/ijet.v7i2.14.12980.
4. Billa, Arlind & Shayea, Ibraheem & Alhammadi, Abdulraqeb & Abdullah, Qazwan & Mardeni, R. (2020). An Overview of Indoor Localization Technologies: Toward IoT Navigation Services. 10.1109/ISTT50966.2020.9279369.
5. Zheng-hong Hu and Jin Li, "Application and implementation of a* algorithm in picture matching path-finding," 2010 International Conference on Computer Application and System Modeling (ICCASM 2010), 2010, pp. V5-224-V5-228, doi: 10.1109/ICCASM.2010.5619180.
6. Permana, Silvester & Bintoro, Ketut & Arifitama, Budi & Syahputra, Ade. (2018). Comparative Analysis of Pathfinding Algorithms A *, Dijkstra, and BFS on Maze Runner Game. IJISTECH (International Journal Of Information System & Technology). 1. 1. 10.30645/ijistech.v1i2.7.