Augmented Reality Based Flight Assisting System Under Emergency Circumstances

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A thesis submitted to the Department of Computer Science and Engineering
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B.Sc. in Computer Science

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Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
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Abstract

The number of aerial vehicles have continuously increased as our technology advances and will continue to increase. However, to fly any aerial vehicle manually, the person should have a thorough understanding of GPS tracking and navigation, which narrows the field. Furthermore, each type of aerial flights comes with its own set of problems like civilian aircraft losing ATC control. Therefore, we propose a model where we introduce augmented reality to assist the pilots and drone operators during emergency situations by visualising the pathway they have to follow from source to destination.Firstly, all GPS coordinates of the determined path are taken, these are sampled where we take the coordinates after each appropriate distance from one another. The checkpoints were placed in the Unity software by a GPS AR plugin which allowed us to place them exactly in the gps coordinates taken. Then,by breshman's line drawing algorithm and Bezier's Curve on 3D plane, we connected the checkpoints by reference points, as well as generated path from diverted position to original path whenever vehicle would move away from the determined path. In our built app, when any compatible device able to use it is brought near the path, it will show the direction to destination while in the path and a warning that it has moved away from the path by how much in terms of latitude,longitude and altitude.Finally, we tested our application in real life by taking gps readings from a number of flights our drone took and applied it by placing smartphone supporting the application on drone where it flew through the same paths, Thus, in our simulation we found that our application has near desired outcome.

Keywords: GPS; Augmented Reality; Flight Assistance; Air Traffic Control ATC; Pathway Generation and Drone; Logistic Regression Analysis

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Chapter 1

Introduction

The implications of AR in our everyday lives is proving to be extremely useful. Unlike VR which focuses on the initial visual experience of the users, AR is primarily focused on the visual interactions with the users' reality space. It may not be as exhilarating as the experiences of VR which entirely shifts the user's present space into a newly designed one but rather uses the user's view to map the virtual objects for better visualization and understanding. Such a concept is vital for acquiring a crystal-clear understanding of a problem space in any given field. Most of the time, the solutions that are generated are mainly focused on the assumptions and 2-dimensional visualization but with the help of AR, the problem space can be better perceived. This leads to an accurate generation of solutions which optimizes performance in any given field.

Loss of Control In-Flight (LOC-I) is a common yet catastrophic threat that lurks in the operation of an airplane. Being one of the most common fatalities to occur in-flight during the 2014 and 2015, there are only a limited number of solutions that are available for the pilots to resort to, other than their professional skills and sheer luck. Multiple reasons can cater to the occurrence of LOC-I. Among some of the current in flight limitations there is disconnection with ATC above the ocean. Each night, airlines contact air traffic control located in Gander, Newfoundland (the last ATC facility before the Oceanic crossing begins) and provide them with a requested flight plan for any of their airplanes that will be flying across the Atlantic Ocean the following day. Gander ATC will then review the flight plan and either approve or make changes to it, based on spacing requirements, etc. So this means not being able to notify ATC about emergency situations, not being able to let ATC know current location. These factors may affect the flight path individually or even in combination to make LOC-I happen.

In times of difficulty during landing due to challenging weather, the proposed system can direct the pilots to maintain the landing path as efficiently as possible. If the conditions are too unfavourable, then the system can suggest alternate paths in order to ensure safety of the flight and avoiding any sort of disaster. Radio signals may get interrupted due to flight location in unfavourable places hence, having a system to double-check the information from the radio can help the pilots to confirm the information and proceed with the best decision.

1.1 Motivation

Airplane accidents have reduced to 50% from the year 2019 according to BBC, Aviation Industry Study, Langewiesche, W. (2019, July 1). However, the core understanding lies when we look into some of the accidents that occured due to the loss of connection with the ATC. A very much notable case is the case of MH-370 that had gone missing on their route. The airplane was last tracked by military radar on the Andaman Sea which is bounded by Indian Ocean. It was reported that according to satellite communications the aircraft flew over the south part of Indian Ocean before completely getting detached with any forms of communication. The aircraft had entirely deviated from its general route and continued to fly for 5 hours until it is believed to crash vertically in the Indian Ocean [32]. Such an incident has caused over 200 deaths and brought peril into uncountable lives. Flight deviation from the general route can be dangerous and life-threatening if not taken care of in the given amount of time. Our flight-deviation system will be able to show the path visually via AR(augmented Reality) where the pilot can see the path and also be informed if a notable deviation has taken place and how much bearing is needed to get back on track. The system will also allow information of any possible weather disruptions which may require the general route to be temporarily changed into an alternative and be a guidance for a feasible flight that will also be safe.

1.2 Problems Existing currently

In the current times, auto-piloting in the scenario of Aircraft and Aeronautical Engineering has greatly helped on board pilots to operate the aircraft. At times when the speed and bearing is steady, the pilots can assure the aircraft on auto-pilot while they stay on stand-by. Ancient auto-pilot systems were only able to keep a fixed altitude and direction but the modern systems have integrated themselves with flight management systems (FMS) to follow the route path of the flight except landing and takeoff which is only entrusted to the pilots in charge. However, what an auto-pilot fails to do is navigate itself during critical situations or detouring paths due to challenging circumstances. A route from destination A to B can have various routes which can be deemed feasible given the amount of resources the aircraft will be carrying from decision point. In cases of emergencies, the regular path may need to be postponed and an alternative route may be adjusted. Such variations in decision are not possible with auto-pilot only. It would be a helpful system if the pilots could be notified of a problem they would face and a suggestion of alternative path that will be safer to use and also have a system that would guide the pilot back to the original path if the problem has subsided.

Another possible crisis can occur when the aircraft is flying over the Pacific Ocean. When flying over an ocean, ideally the pilots inform about their positions to the ATC(Air-Traffic Control) with their specific latitude, longitude and altitude. The pilots then get the estimated time and coordinates of other planes who might be cruising in the same skies and they make sure all flying aircrafts are at least 1000 feet differed in altitude. Most of the airlines have Traffic Collision Avoidance System(TCAS) onboard that helps the pilots to get safer skies for them to fly. However, while crossing the pacific ocean, the aircrafts momentarily becomes disconnected with the ATC. This means that the aircraft will not be in contact with the Traffic Control that could guide them in their general route and warn them for any upcoming crisis. Of course, aircrafts being entirely disconnected with ATC does not mean the crisis situation is inevitable, rather, it is more susceptible to falling under human error which may lead to disastrous results (Shappell & Wiegmann, 1996) [7] .According to the Federation of Aviation Administration, more than 88% of the aviation accidents are caused by human error. Hence, it is undoubtedly a topic of discussion when the ATC, the guidance and source-keeper of the aircrafts, is absent, a crisis situation having an unfortunate outcome may increase as it is only left in the hands of human beings. The pilots and co-pilots are certainly fit to lead in the absence of ATC but in a crisis where the variables are mostly unknown and time is running out faster, it is always better to have a system companion that can show alternate solutions in a span of seconds to avoid any kind of mishap.

By implementing AR, we will be able to set a different visual representation for the pilot so they can clearly see the deviated path, every-time LOC-I occurs. This will work like an alert system that will work in alternative ways to notify them how much they have deviated from the path and how much path should be calibrated to bring them back on track. This will be done by the help of an on-board WiFi router that will be always in contact with the satellite. Through this on-board WiFi router we will access our database of the route and match those coordinates with the plane's GPS. Warning of any bad weather forecasts on the predefined route (for future works) will be given and also an alternative route will also be updated through our system. All of this will be done through an AR system that will also provide a realistic visual of their view where they will be able to see their on-going path way and will be alerted if the pathway deviated from the original position [29].This will enable the pilots to visualize the pathway object in their real-space and restore their own flight to the directed right path.

1.3 Objective

Our objective with the proposed system is to provide a path deviation detection mechanism for the pilots to visually see if the aircraft has deviated over a safety range from the original pre-defined flight path. For this, the generation of flight paths from starting point to destination is needed. Hence our system hopes to provide a flight path generation system which will aid the pilots to stay on track with the route and not get deviated. In cases of crisis in the predefined route, our route can provide an alternate path for the pilots to follow without having to fall into a challenging situation. The system will be able to connect to the on-board WiFi in case they lose connection and assist the pilots thereon. One of the many reasons why challenges are faced during a crisis is human error. We hope that our system will be able to provide a top-notch solution that will eliminate any room of error and it will be easier for the pilots to make a decision in crisis.

Chapter 2

Fundamentals of Aircraft Takeoff , Landing and Route Traffic Controls

2.1 Air Traffic Control (ATC)

There are specific routes for airplanes to follow up in the airspace just like cars have roads on the ground. When an airplane is ready to fly from one place to another it has to decide on a specific route and the pilot needs to prepare a flight plan while maintaining certain regulations. The flight plan needs to have information like - the type of aircraft it is, the model of the aircraft, the amount of fuel it has, the total weight, the number of passengers and crew members and the flight path they want to take with some other necessary information. Afterwards, the pilot needs to send that flight plan to the Air Traffic Control (ATC) and request for clearance confirming that they are ready to take off. The ATC checks if the runway is clear to let that aircraft take off clearance. Only after getting clearance from the ATC an aircraft can move from its terminal to the runway for taking off. In this whole process of moving from the terminal to the runway, the aircraft remains in constant communication with the ATC. When the aircraft is on the runway and ready to take off, ATC passes their communication channel from the Ground ATC to the Tower ATC. The Tower ATC then guides the aircraft to take off and gives it information about at what speed it should start to ascend and at which point in the airspace should it reach to connect their communication channel to ATIS or also known as Automatic Terminal Information Service.

The main task of the ATC is to coordinate the traffic of its air space. Which essentially means to ensure the safety, order and expeditious flow of air traffic. The ATC has to coordinate the movements of hundreds of aircrafts if not thousands, so that they can be at safe distances from each other and thus, ensure the prevention of any possible collision. The other tasks for ATC involves directing pilots at the time of takeoff and landing from airports as well as assisting them to navigate around bad weather. An aircraft needs to be in contact with the Air Traffic Control at all times during taxiing, takeoff, landing or when approaching another ATC zone or airspace of another country. So, the Air Traffic Control is one of the most crucial and important parts of the whole aviation process.

2.2 Air Traffic Control Boundaries

Every country has its own defined airspace. It is the space above a particular nation's territory and it is controlled by the government of that nation. So, a country has a total ATC coverage of that airspace and it is regulated by the central Air Traffic Control of that nation. Bangladesh has a total ATC coverage spanning from the total land area within its borders to a great portion of the Bay of Bengal. The central air traffic control of Bangladesh is Dhaka Tower ATC.

Figure 2.1: Bangladesh ATC Boundary

Within the total airspace boundary there can be many airports consisting of Air Traffic Controllers of their own. So, the airspace is divided into numbers of specific zones. These zones are put under the control of different ATCs of different airports. The zones are also known as Centers. The size and shape of these zones are mostly determined by the amount of air traffic within that geographic region. These ATCs operate only within their designated zones and not beyond that. The airspace of the United States of America is divided into 21 such zones. These zones are further divided into sectors known as TRACON. TRACON stands for Terminal Radar Approach Control and each TRACON has a diameter of about 50 miles. Within each TRACON airspace, there are several airports each having their own airspace with about 8 kilometers radius [36].

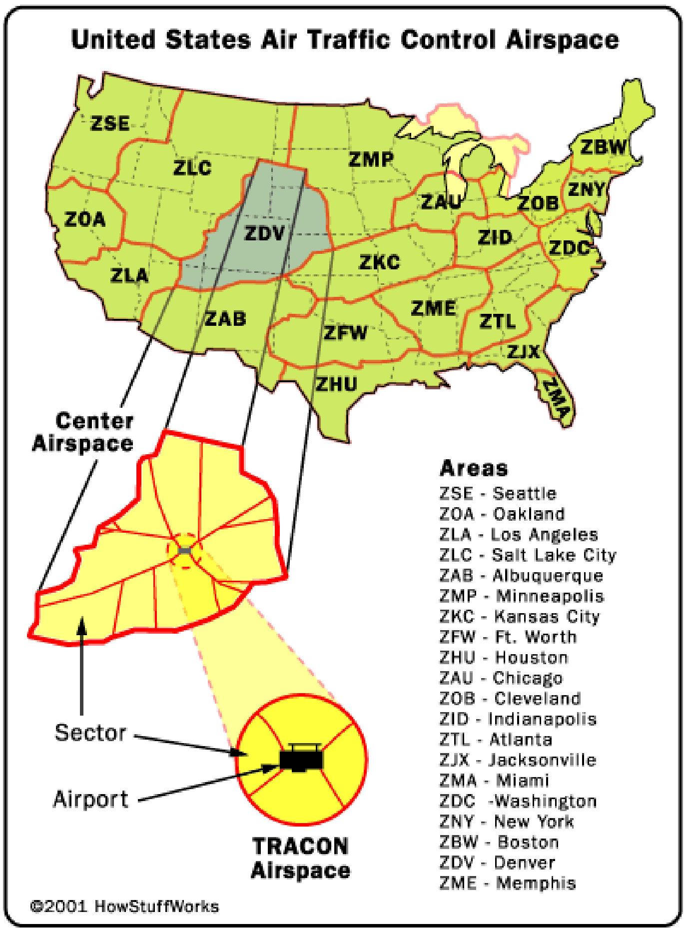


Figure 2.2: USA ATC airspace TRACON and Zones

2.3 Air Traffic Control Types

The Air Traffic Control can be divided into two parts depending on the type of flight and the class of airspace it is handling. These two types are:

1. Civil Air Traffic Control
2. Military Air Traffic Control

The Civil and Military air traffic controls have distinctive tasks and they operate differently to handle different situations.

2.4 Civil Air Traffic Control

The civil air traffic control handles the regular and commercial flights. Their job is to ensure the safety and coordination of the commercial and private planes. They do not interfere with the military ATC. When an aircraft needs clearance permission for take-off or landing, they contact civil air traffic control. Civil traffic control assists aircrafts to navigate from terminal to runway as well as during take-off, landing and en-route flight [4].

During these times, civil air traffic control uses three different channels or controllers to communicate with an aircraft based on the situation the aircraft is in. A pilot has to communicate with those three controllers using three particular radio frequencies assigned to the controllers. These channels or controllers are:

- Ground Controller
- Tower
- Air Route Traffic Control Center (ARTCC)

Each of the controllers has an essential job of the whole process of flying an aircraft from one place to another.

2.4.1 Ground Controller

The ground air traffic control plays one of the major roles of aviation. When an aircraft is ready to take-off and the pilot is done with flight planning, it cannot just go to the runway and take-off whenever it wants. Rather the pilot has to wait for the permission from the ground controller to go to the taxiway from the terminal. After reaching there, the pilot needs to wait again to get clearance from the ground controller to approach the runway. Once the clearance is given, only then can the aircraft move to the runway. All this time, the ground control checks whether the path is clear for the aircraft or if there is any other aircraft in the queue to takeoff at that moment. If everything seems alright and there is no chance of ground collision, only then the ground control gives the clearance permission to the requested aircraft [40].

2.4.2 Tower

Once the aircraft is on the runway, the communication transmission is handed over to the tower from the ground controller. The pilot has to change his radio frequency to what the tower controller is using for communication. The aircraft then becomes the responsibility of tower control. It then has to request permission to the tower control for the take-off while providing information about the aircraft and the destination it is trying to reach. Based on the information and upon checking on the runway status, tower control gives clearance permission to take-off and also informs about which path to take and at what altitude to reach before communicating again. After the aircraft takes-off and reaches the said point at the given altitude, it contacts the tower controller again to let them know their current status and the en-route path they are approaching [35].

2.4.3 Air Route Traffic Control Center (ARTCC)

After connecting to the ARTCC (Air Route Traffic Control Center), the pilot again needs to identify themselves and confirm the controller of their destination and the path they will be taking. After checking the information, the ARTCC gives them other necessary information regarding the weather status and the altitude that the pilot needs to maintain. The main job of the air route traffic center is to help an aircraft navigate through its course safely while it is en-route to its destination. In addition, giving required assistance to prevent mid-air collision with other aircraft and ensure safety is also one of their main concerns. They are responsible for the aerial safety of an aircraft as long as they are in the vicinity or zone of that air route traffic control center. Once the aircraft is about to leave their zone and enter another zone, the radio transmission is handed over to the ARTCC of that zone [8].

Figure 2.3: Ground Controller

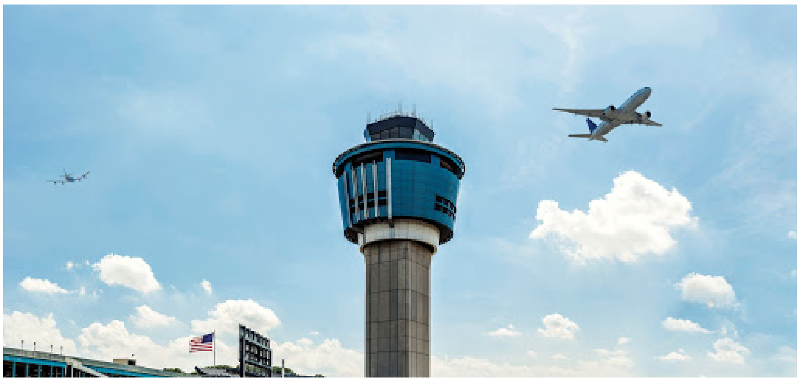


Figure 2.4: Tower Controller

All these controllers work together and control the air traffic at every moment. They are the ones responsible for the safety and coordination of hundreds of flights on a daily basis.

Figure 2.5: Air Route Traffic Control Center

2.5 Military Air Traffic Controller

The Military Air Traffic Controller handles those aircrafts that are not managed by the Civil Air Traffic Control. Military Air Traffic Controls are used by countries for protecting their airspace as well as their borders from enemy aircrafts. Ensuring safety of a country's airspace is their main concern. Military ATC deals with the coordination and safety of military aircrafts. One of their main tasks is to identify if any aircraft has gotten close to or entered their restricted airspace without any permission. If anything of that sorts occurs then they take action accordingly. They can even send a military aircraft to investigate if an unidentified aircraft or commercial aircraft seems suspicious or appears to be hostile.

Figure 2.6: Military Air Traffic Control

Chapter 3

Literature Review

In the present days, Augmented Reality is being researched into integrating it with the GPS system to improve the performance of aircraft traffic [44].The system of the present invention includes a GPS system receiver that detects the GPS signals and hence, helps to find the current position with the receiving signals. Currently this system is accompanied with an automatic dependent surveillance (ADS-B) which helps detecting the ADS-B signals from other airplanes[11]. The system of the present invention further includes an AR visor coupled to both the GPS receiver and the ADS-B receiver [33].

An aircraft navigation system is disclosed for use in missions involving unfamiliar terrain and/or terrain having hostile forces. The navigation system includes an inertial navigation system, a map of the terrain with elevation information stored in a digitized format as a function of location, a typical energy managed or narrow beam altitude meter, a visual UI, and a CPU for processing the real-time data that is fed into the system [43].

An aircraft flight navigation control system has a flight management visual unit (12), a navigation visual unit (40), logic circuit system (60) and a cursor control I/O device (70) [2]. The flight management system control display unit (12) also takes input from keyboard (30) to take the coordinates of the destination routes with keyboard input. These entries appear on a display which provides a text listing of the selected way-points [16]. Pilots have to go through extensive training processes via flight simulators and computer screens where the environment is made for the pilots to feel like the aircraft itself and AR for their practices[31].

An advanced level air-traffic management system is required to combat inefficiency of aircraft systems under difficult conditions like weather and airspace demand. This can be done by calculating the shortest path between the source-destination or within airports. This can be done by a Dynamic Programming Method like a path finding algorithm such as Dijkstra's Algorithm, A* Algorithm for an enhanced searching process etc [12]. Alternate Flight path can also be determined efficiently and calculated by a probabilistic search algorithm called Genetic Algorithm [6]. Flight planning is also dependent on other important components such as fuel consumption for a particular path. This flight planning can be optimised using parametric optimization technique,continuous time optimal control problem (using

Pontryagin's minimum principle and dynamic programming), discrete time optimal control problem, Discrete Search techniques etc [15]. A shorter path calculation can be done using Bezier Curve and generating an algorithm [22].

3.1 VR (Virtual Reality)

Implementations of VR (Virtual Reality) technology is evident in the entertainment industries, specifically in the sci-fi movies and television series [28]. VR is and has been a state of the art computer generated environment that meshes itself with the real-life space, becoming one with the real-life components. Computer games have implemented VR in order to make a new genre of games that focuses on the experience of the user rather than focusing on the mainstream interactivity of regular games.[13] This idea has also given birth to many ideas of research for neuroscientists, psychologists, biologists etc where a test subject can be made to go through an environment and their behaviour can be tracked. VR incorporated in a headset always gives an immersive experience for the users [18].
A typical VR environment can be a real-life component or an artificially made environment from scratch that allows the user to experience being in that simulated reality as their own. The level of immersion in experience of VR can be classified in three types: Non-immersive, Immersive and Semi-Immersive. Non-Immersive is the cheapest and easily acquired VR system that can run through desktops[42]. Immersive VR systems usually are the environments that are entirely simulated from scratch so that the user experiences a new setting around them. Semi-Immersive are the systems that are a concoction of both immersive and non-immersive systems.

Needless to say, VR has given scope for multiple fields of research, a new paradigm to explore and develop newer ideas and it is still going strong to this very day.

3.2 AR (Augmented Reality)

While VR focuses on the artificial simulation of the environment which the users can experience, AR or Augmented Reality focuses on creating objects that are simulated in the real world for the users to experience. AR solely builds itself into the real-world instead of creating a simulated reality like VR. Augmented Reality is believed to be a bridge between the Virtual Reality field (which is a simulation) and telepresence (which is in the real space). AR is not only immersive in experience but also interactive in nature[31].

Although the applications of AR can be of vital importance in fields just as medical industries, architecture and design development etc, the topic is fairly new and still resting at a research stage. There is less amount of work that has taken stable form implementing AR as it is still being developed and discussed within the computer graphics universe.

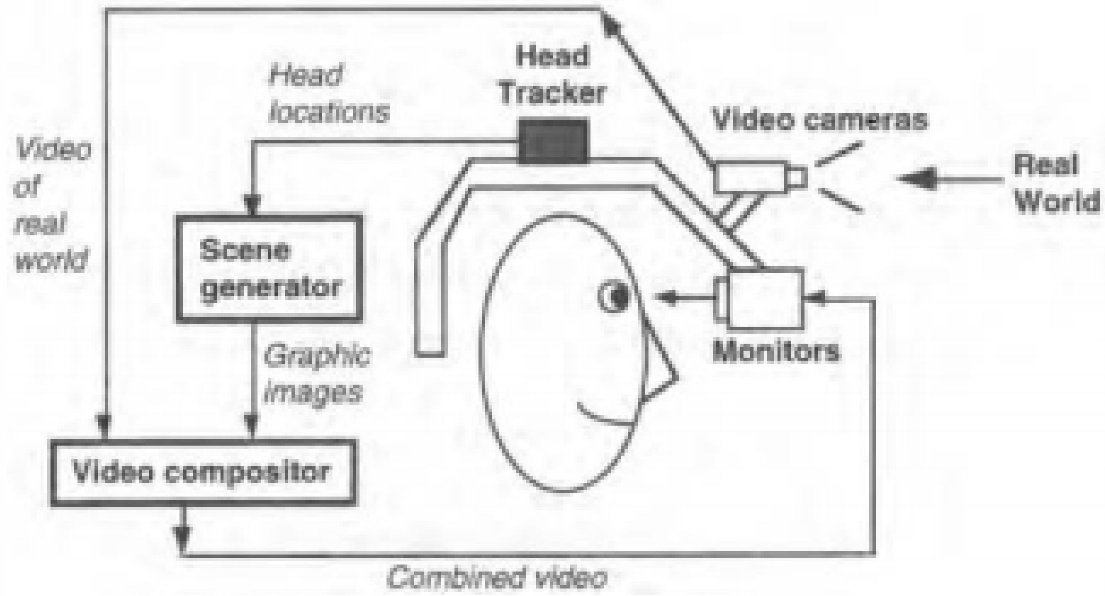


Figure 3.1: Video-transparent-glass HMD concept from “A Survey on Augmented Reality

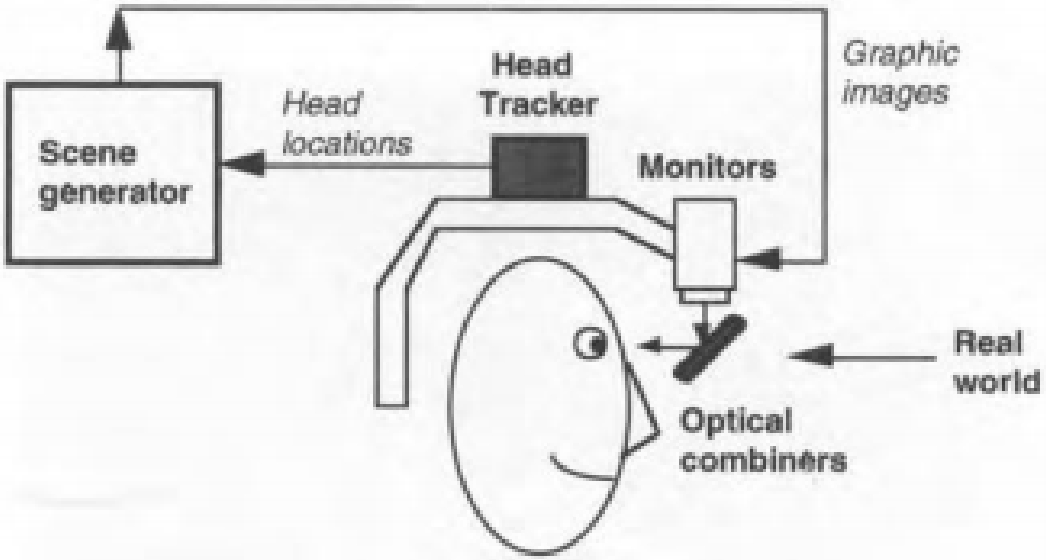


Figure 3.2: A See-through Glass HMD concept diagram from “A Survey on Augmented Reality

3.2.1 How Augmented Reality is being used (in aviation)

According to Azuma, R.T(August,1997), AR (Augmented Reality) is still at a research and development stage, however, many trial implementations and modeling has been in works with this fairly new and ground-breaking technology [5]. It has already been used in fields such as architecture, mechanics, medical industries etc. Prototypes of AR as visualization and training aid for surgeries have been proposed. 3D data set can be taken from the patients in real time via MRI etc. These data can be translated into a simulation of an X-ray. This would give doctors the ability to see the inside of the patient. Entertainment Industry has taken a leap of “screening” actors on a black screen and simulating them in 3D, real time. Military Aircraft has been using Head-UP-Displays and helmet mounted sites to simulate a visual interface where pilots can do multiple military activities such as target lock-down, detecting an unauthorized object approaching the craft etc.

3.2.2 In-Flight Wireless Communication System

An aircraft is always connected to an ATC (Air Traffic Control) while it is passing above ground. The pilot has to communicate with the ground control officers through radio. However, today in this age of new technological developments there is another connectivity that works in aircrafts. There are now two operating systems for aircraft WiFi connectivity. One is the Ground-Based and the other is the Satellite [23]. Antennas below the aircraft can connect to nearby cell -towers on a rolling basis, hence it causes the aircraft to work like a hot-spot. This enables all the people on the aircraft to be able to use the internet even when the flight is on route. However, this does not work once the aircraft has hit the oceanic region.That is the place where the second to communicate using the internet by transmitting and receiving data through orbiting geostationary satellites. We are considering using that technology to operate our system. This will enable us to connect to the internet from any place even if the connectivity with ATC is lost. At such moments of crisis, pilots can still use the system and connect to the internet to update their position and situation.

Chapter 4

Methodology

Modern aviation has come a long way since the day the first aircraft was built. Flying has now become one of the safest means of travelling around any part of the world. The odds of a person having a plane crash is very slim. The probability of a plane crashing or going down is around 1 in 5.4 million[30]. So, it can be said that flying has become really safe. However, no matter how slim that probability is, accidents still occur and claim hundreds of human lives. There had been a number of recent airplane crashes that could have been avoided if proper measures were taken at the proper time. So, this proves that there are still areas remaining for further improvement. In order to develop a system that can assist the pilots to navigate through their flight and mitigate the possibility of any flight deviation as well as help them at critical events such as when an aircraft gets disconnected from the Air Traffic Control. We have studied the process of how an aircraft flies from one place to another, how they communicate with people on the ground and what problems they face when in flight. We have also explored the different ways Augmented Reality is being used in today's world and the potential it has to be used in aviation as a solution to these problems. After analyzing other researches on Augmented Reality, Path Generation methods and algorithms and Deviation Detection, we have come up with a method of integrating all of them together along with machine learning to develop a system that can generate the predefined flight path and show a visual representation of that to the pilot. As a result, help them navigate throughout the whole flight process, from take-off to landing. The system will also help them detect flight deviation and generate corrected paths to get the deviated aircraft back on the correct track.

In our proposed model, we have used TensorFlow to train our system to predict and detect the best possible GPS point to go to from our current position. We have also used Unity Game Engine to fetch the data from TensorFlow and develop visual representation for the pilots using C# as the backend programming language. In addition, we collected real life GPS coordinates data using a drone of mode DJI Phantom 4. This data was then used to train our system to be able to predict the next best GPS point based on weather forecast.

Our system enables us to assist the flight of an aircraft in three different methods. These are:

- Generating path from Origin to Destination

- Assisting aircraft while disconnected from Air Traffic Control (ATC)
- Military Purposes

4.1 Generating Path from Origin to Destination

For generating paths from the origin point to the destination point, algorithms are used. The algorithms that we have used are the Line Drawing Algorithm and the Bezier Curve Algorithm on top of it. We have collected GPS points consisting of Latitude, Longitude and Altitude which was later sampled and converted to a CSV(comma-separated) file. Using these sample values we could get certain points. We then used the Line Algorithm. This gives a regression line going through all the points. This gives us connected straight lines creating a path that had lots of edges. Then, to smoothen that out the Bezier Curve Algorithm was used. This resulted in a smooth line that had no edge in it. This line was our predefined flight path from the origin point to the destination point.

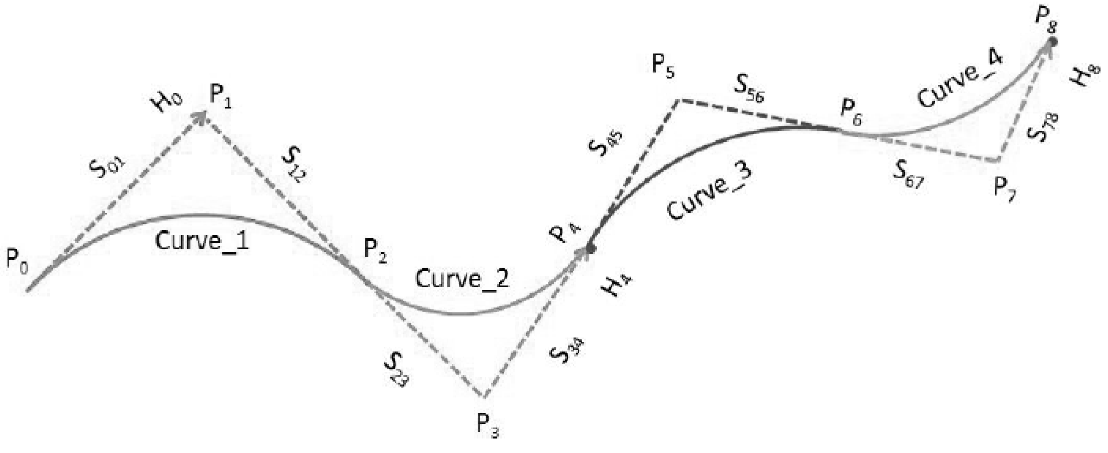


Figure 4.1: A Bezier Curve consisting of Nine points

There are 9 points (P0, P1, P2, P3, P4, P5, P6, P7 & P8). After using Line Drawing Algorithm, we get the path consisting of 8 straight lines (S01, S12, S23, S34, S45, S56, S67, S78). Each of the straight lines connects two points. Using the Bezier Curve gives 4 smooth curves.

4.2 Total Path Generation

The way a real aircraft moves from one place to another is by following a specific flight path. This flight path is complex and depends on a lot of variables. The total flight path of an airplane generally has 5 parts. These are called- Take-off, Climb, Cruise, Approach and Landing. When generating the path we need to keep each of these parts in consideration. After the take-off the pilot gets instructed to raise their altitude to a certain level. This is known as “Climb”. After reaching the said altitude it stops climbing and continues its journey following the predefined path. When it reaches its destination, it then starts lowering its attitude towards the airport which is known as "Approach". After getting landing clearance from the ATC it lands and completes its flight.

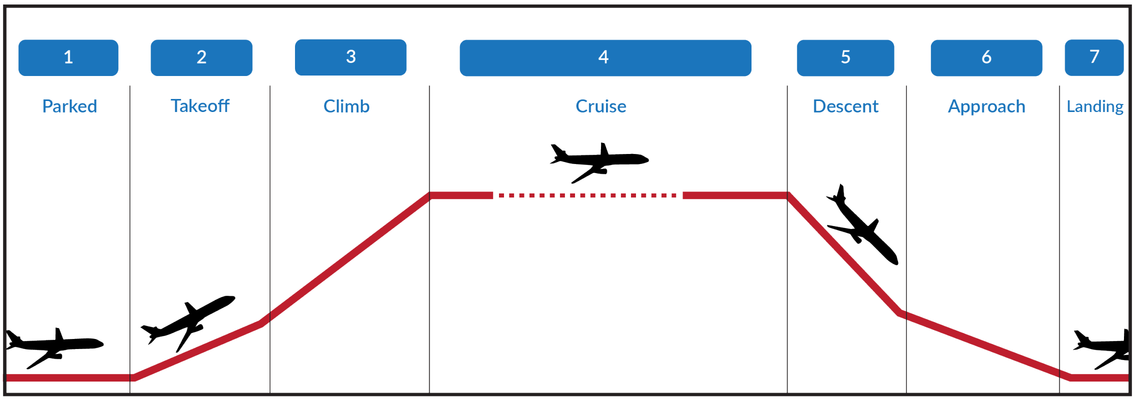


Figure 4.2: Illustration of the total flight path of an airplane

4.3 Take-off & Landing Distance

Take-off

The take-off distance is the combination of the ground run and the distance from where the aircraft lifts off the ground to until reaching an altitude of 50 ft. (in some cases 35 ft.). A study has calculated the takeoff distance based on different factors (LESHER, 1940)[1].

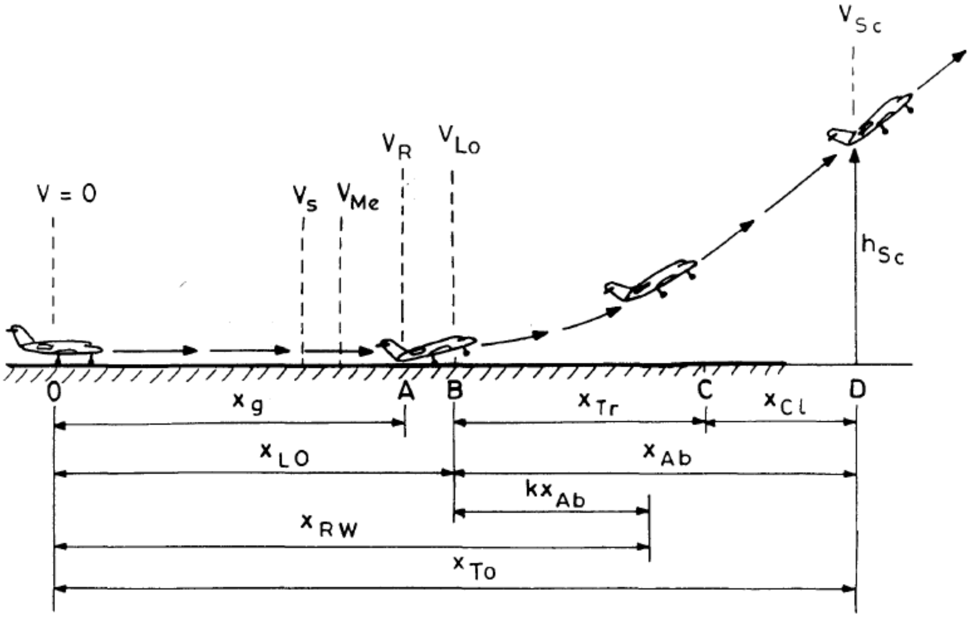


Figure 4.3: Characteristic distances and airspeeds for the takeoff phase

According to their study-

$$s = \frac{L_w}{C_{L_t}[(27m_1/V_m L_t) - .072\mu]} \tag{4.1}$$

Where, S = takeoff distance in ft., L_w = wing load, V_m = high speed at sea level, $m_1 = m$ at $v = v_1$, C_{Lt}= Given takeoff co-efficient,
μ = Co-efficient of ground friction

Landing
The calculation of the landing can be done in a similar fashion as the takeoff. At the time of the landing, the touchdown velocity should be approximately equal to the aircraft's stall speed[37].

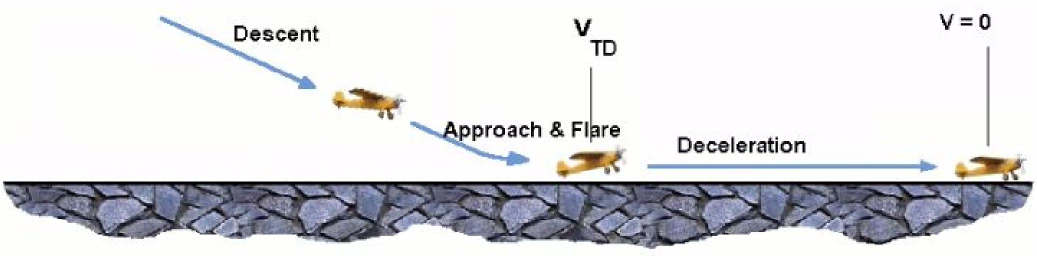


Figure 4.4: Airplane Landing

To solve the rate of deceleration on landing roll, the average acceleration approach can be used.

$$\frac{dV}{dt} = \frac{-T - D - F}{m} \tag{4.2}$$

Where, T = Thrust of Propulsion, D = Aerodynamic Drag, F = Rolling Resistance Friction, m = Mass of the Vehicle.

4.4 Assisting Aircraft while Disconnected from Air Traffic Control

The aircrafts need to communicate with the air traffic controllers all the time and update them about their positions, situations, intentions and requests. The controllers also need to give them clear instructions accordingly. Radio signal is the main communication method used in aviation. Almost all communication between the air traffic controllers and the aircrafts takes place by means of radio signal. Even radar uses radio waves to detect and determine the range, velocity or position of an object. However, radio waves can sometimes get cut off or fail to connect pilots to air traffic controllers causing Loss of Communication also known as LOC in aviation terminology. This is obviously a very dangerous situation that can even prove to be fatal if proper steps are not taken in the shortest amount of time.

Loss of Communication can occur in one of the three circumstances (Loss of Communication - SKYbrary Aviation Safety, 2020) :

- Radio Interference
- Mismanagement of communications equipments
- Malfunction of communications equipments

This can put an aircraft in immense danger if the pilot faces LOC and becomes unable to receive further instruction from ATC to follow. The pilot also cannot relay important information to the air traffic controller. This has caused a lot of accidents and near misses in the past. On top of that if an aircraft gets deviated and accidentally flies near any military airspace and fails to inform the military air traffic controllers about their intention, it may get interpreted as a security threat and prompt military intervention. So, radio communication may have some perks but it can cause huge trouble at times.

In our proposed system, we will be using the plane's wireless communication system to connect our system through the internet. It will use the internet to continuously fetch live data into the system database and update its own GPS coordinates at the time. Then it will compare these data to produce a result indicating the status of its deviation. The deviation will be shown to the pilot through the augmented reality app as well as the newly generated path to correct its course. The real time data will keep on updating in the system. Since the system will be connected to the internet with the help of geo-satellites based wireless communication, the air traffic controllers can also access the app data and get the live updates of the aircraft. So, even if the aircraft faces LOC, they can still communicate and exchange important information using the proposed system in this critical circumstance. This can prove to be life saving.

4.5 Military Purposes

In military aerial vehicles , they operate in a lot of ways. They too need to communicate with military air traffic controllers about each move they want to make and they in turn tell them where they need to go and what to do.In similar they navigate mainly relying on their GPS system. However, for the military it comes with its own set of problems like anti aircraft missiles, flying very low for stealth operation , they have to take sharp turns every now and then and their flight path could be drastically changed depending on many circumstances a military battle could bring.

Therefore, in light of this our project will try to help military vehicles in their own ways. Making sure that the flight path is not static but could be controlled by people working in military air traffic controllers, their path changing dynamically if any anti-aircraft system is detected nearby. Thus, we believe that this unique project would be of great value in the military sector as well.

4.6 Proposed Model

4.6.1 Source-Destination Path Generation Workflow

In the Unity script, our algorithm was based on this, first the source checkpoint will be noted and it will try to locate the nearest destination checkpoint.

Figure 4.5: Path Generation Workflow

These two points will be thoroughly compared where its differentiation with respect to x, y and z axis will be found out and then from these values we will know which zone it is at. Then we invoke the method of that zone which will contain an equation to that particular zone. Then we will do iteration till either x, y or z is less or greater than x, y or z of destination. A cube will be initiated at that point and there will be increment of x, y or z depending on equations of zone and loop will go on.

In addition to that, under every checkpoint and joining point, there will be a green arrow underneath which will go along the pathway and will be directed towards the total final destination. The arrows act as unique indicators which will have enough width and height to be visible that will also bend along the path. Moreover, red cubes and black cubes form the pathway where we want the device to stay till it reaches the destination.

4.6.2 Path Deviation Detection Workflow

First, the device's GPS would be collected from its own internal GPS to find where the device is in terms of latitude, longitude and altitude.

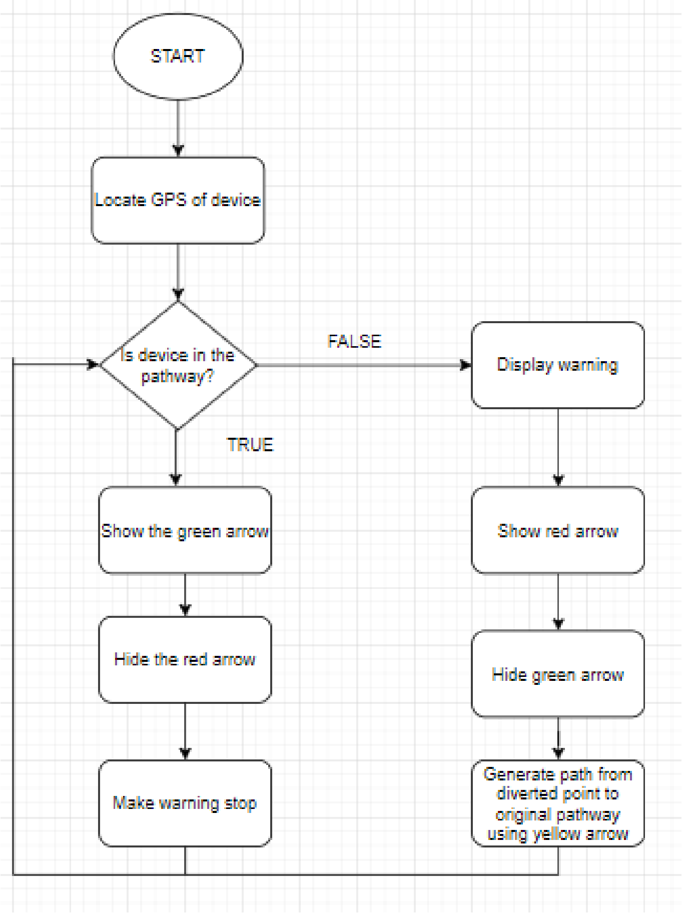


Figure 4.6: Deviation Detection Workflow

As we have discussed before, the device must be near GPS positioned objects otherwise it would not be able to view or interact. Therefore, when a device is near a pathway its pathway will be shown. When a device enters the pathway what it is doing is interacting with small cubic objects, which are also GPS based. So as long as the device is interacting with a cubic object it will be understood by the system as being in a path where these cubes will remain invisible only showing green arrows directing it to the destination. However, if the device moves away from the path in terms of latitude, longitude or altitude, it means the device would stop interacting with cubic objects in the pathway which has a default size of 1 on every axis, thus the system will understand that device is not on the pathway. Thereafter, an immediate warning would be shown that the device has moved away from the path and exactly how much in terms of latitude, longitude and altitude. Moreover, green arrows would be made invisible and red arrow would be made visible. Thus, the when device moves away from the path, red arrows are made more visible. In addition, the generated path is marked by yellow arrows and the whole process will continue as long as it is needed.

4.6.3 Path Construction Workflow During Deviation

The path generation from the diverted point to the main pathway if the device moves away from the path is something that is discussed in the Deviation Detection Fig: 4.6 flowchart that if the device moves away from its path it will generate a path connecting to the original path.

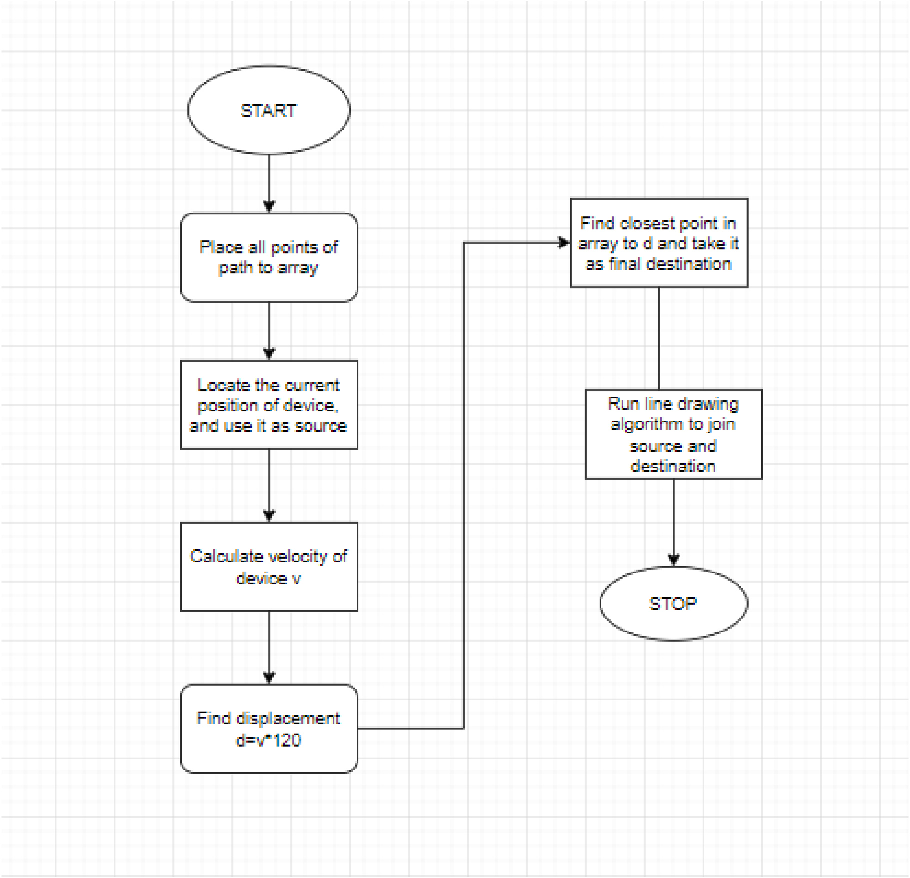


Figure 4.7: Path Construction during deviation with Line Drawing Algorithm

So, at first it is detected that the device has left the pathway, then path generation for detection is called upon, where first of all, stores all points of pathway that are the positions of red and black cubes thus forming an array. This array contains all the coordinates of the pathway. Next, by its GPS it is found where exactly the device is at, which becomes the source point. Afterwards, the velocity of device is calculated by change in position with rate of time, here the speed and direction of the device is found out, then displacement is calculated by multiplying the velocity vector by 120 seconds. The displacement calculated will allow us to find where the device will be present after 12 seconds. The closest point in the array is matched against calculated displacement, that point becomes the destination point. As by similar algorithm we discussed path is generated from source to destination thus generating towards intended pathway.

4.6.4 Path Construction Workflow During Disconnection from ATC

Air Traffic Control is vital to all planes. Moreover, all the readings and data could be gathered from ATC, and from those readings of flight path we can generate our augmented reality pathway. However, if for some reasons ATC connection is lost we made sure there are alternate ways our system will be able to generate path, we propose system where pilot will collect data from cloud ATC where all flight path has been given.

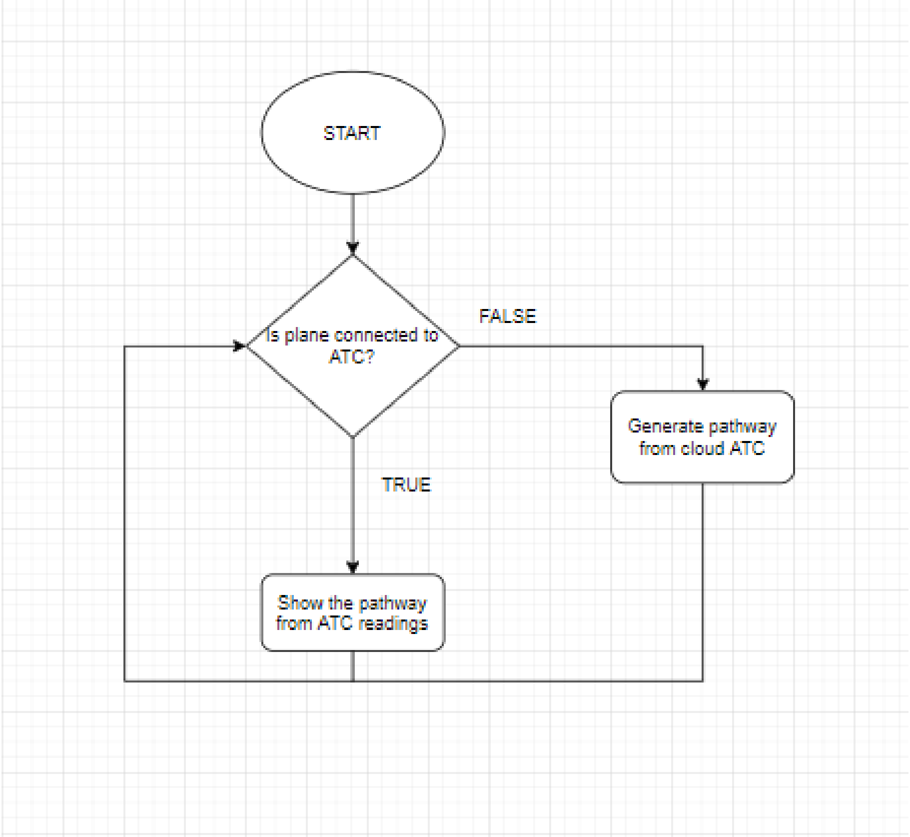


Figure 4.8: Path Construction During Disconnection from ATC

4.7 Tools Used for the Design and development of the AR system

The system is designed by considering a few requirements of devices and softwares that are needed to ensure maximum efficient output. As for starters, the data set we have used are all predefined and taken from flying a drone which is a miniature aircraft model in our system. We have collected the drone's latitude, longitude and altitude at a given time frame and have prepared a csv data file for it to be fed into our Machine Learning Model using Logistic Regression. Using Tensorflow, we have generated an APK (Android Package) from the PC and integrated the use of Unity of backend language services of C#. The software can run on devices with an API level of 23 or above. The device firstly gives permission to the system to allow the usage of its location so that the long-lat coordinates are accessible through real-time GPS Tracking. The Unity Engine takes the longitude, Latitude and Altitude coordinate to place an object using the input.location function that shows the path to the destination. In the future we can feed the data from the Aircraft database such as the Open-Sky Network Open Database, Federal Aviation Administration or from a cloud-based database, dynamically.

4.8 Logistic Regression (The Machine Learning Model)

The Machine Learning Model Logistic Regression is used for classification of binary values. In our dataset we will be having 5 columns of data where the first three are the location coordinates (latitude, longitude and altitude). The fourth column is the Weather Stress Index which consists of temperature, Wind-speed, Humidity that is acquired in real-time from the GPS tracker. The Fifth column is going to be a determined label that denotes whether that weather is safe for the aircraft flight to pursue or not and they are all binary values of either 0 for No and 1 for Yes. With the help of logistic regression, our system will be able to predict probabilities of an event happening. For example, after the system has been trained with sufficient amounts of training data, unknown data points may be fed and the system will return its prediction in either 0 or 1 or closer to either of the values. In the linear regression model, the regression line passes through the points plotted and it should be in such a way so that it is serving the closest distance to every point.However in Logistic Regression, the line y is then passed through a logit function so that it becomes a curve that can differentiate between binary values[27].

$$f(x) = \frac{1}{1 + e^{\text{-}(x)}} \tag{4.3}$$

Equation (1) represents the equation of a Logistic Regression. This is how the model is trained through Logistic Regression by using Tensorflow. The data fed then gets an accurate value against the input which then informs the users (pilots) that whether the flight path is safe or not.

4.9 Model for weather-hazardous situation

In Figure 4.3, for our hazardous weather detection, we have implemented the Machine Learning Model Logistic Regression as our Flight Safety Predictor. Firstly we compile our data from our drone flight and we sampled our data points. At the moment, due to technical dependencies, we have kept our data in a static state where our columns consist of Latitude, Longitude, Altitude and a Weather Index made of three values : Temperature, humidity and Wind Speed[14]. A variable is set to 0 and a threshold is declared for each of the three weather indexes. The variables will increment according to the threshold (if it is greater or lesser). If the sum of all the three variables are over 15 then the path is dangerous. Such data points are then fed into the model in order to train the machine so that any anonymous data point during real-time processing enters the machine, it can predict an accurate output of the flight path's safety.

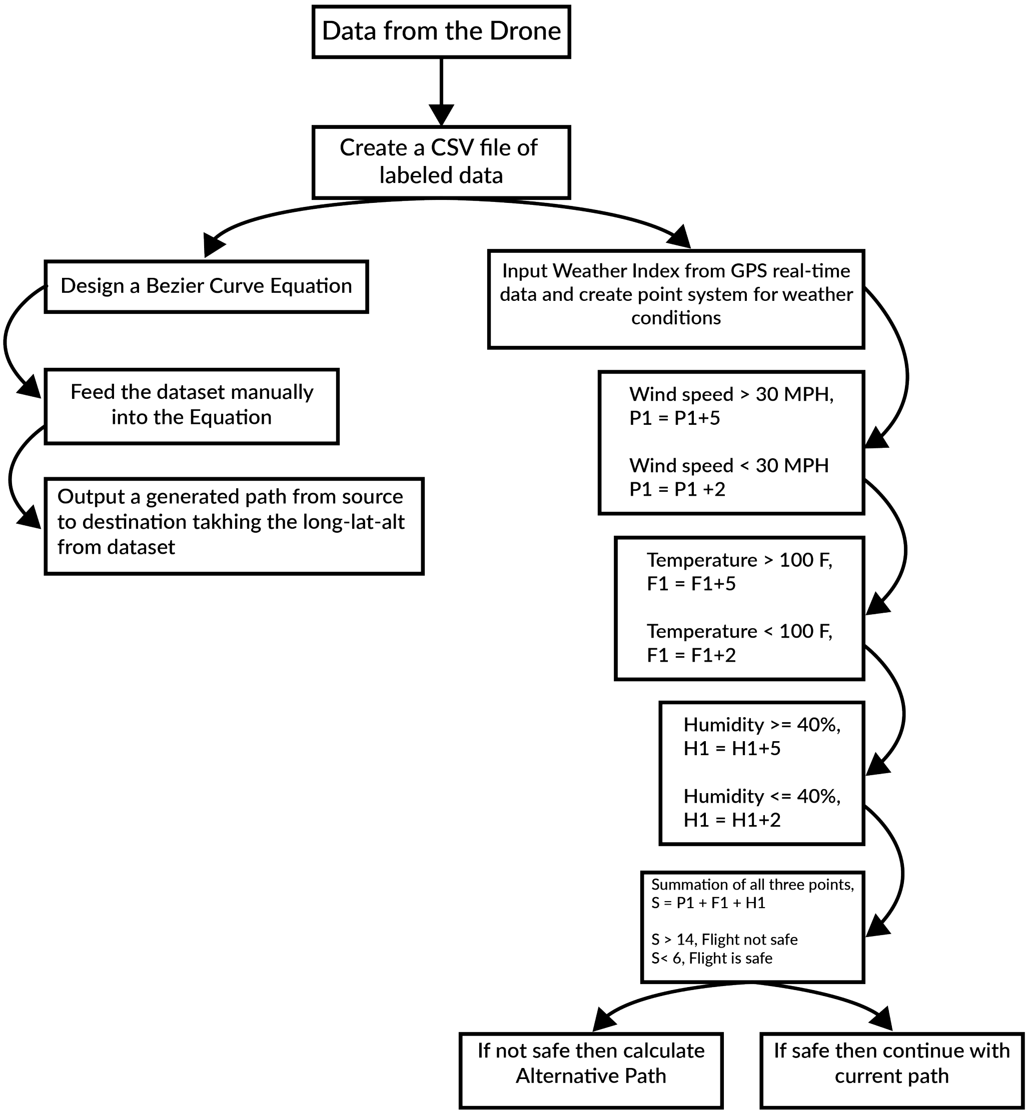


Figure 4.9: Model for Predicting Hazardous Weather on-route

4.10 Tensorflow

Tensorflow is an open-source Machine Learning and Deep Learning platform that consists of libraries that are used for complex numerical operations that are needed for a Machine learning model. There are many numerous machine learning models that can be implemented in order to get an intelligent trained machine that can solve problems, given an input. Some of the machine learning models are usually used for Classification, Perception, Prediction,Creation of new data, Understanding trends within a domain of data etc. Tensorflow has made lives of Machine Learning Engineers and Data Scientists by incorporating multiple libraries that support the uses of the models that help provide optimum solutions. Starting from scratch, large scale data can be divided into training and testing datas. These training datas can then help the Machine Learning model to get trained. If the data is labeled, then the learnability of the model becomes easier as with each prediction, the error between the predicted value and the actual value is calculated to find the percentage error. This percentage error is usually calculated by Least Mean Square calculation but it may differ according to the model that is being used. The model then tweaks its values according to the error and repeats itself on every point on the training data until the percentage error is minimized. In case of Neural Networks, the percentage error found in the end of the last layer then back propagates to make considerable changes to the weights of each node on each layer, hence increasing the accuracy of the prediction. In cases of Regression (both Linear and Logistic), the difference between the actual points from the data (y-value) and the predicted y value is the error which is calculated by Square Mean to find the Standard Error. This can further help us plot a line for the linear regression that will help us understand the trend of the data set and its behavior by calculating the Y predicted and also the Y-intercept. Tensorflow here can help with all the calculations with the help of an "estimator" API function which contains Linear Classifier. Tensorflow hence helps in revising and sorting a large scale data and prepares it for the model to run smoothly and also show a detailed graph which allows engineers to understand data better.

4.11 Algorithm Used: Bezier Curve

The Bezier Curve is a mathematical equation that generates a curve in any 3D graphical application or software such as Adobe Photoshop, Illustrator, Inscape etc [31]. It is also used to make lines and curves on CSS animations [34].The equation starts off the creation of the curve with four main points mainly the initial point P0, P1, P2 and P3. The anchor points (also known as the separating points) are the first and the last point that is, P0 and P3 and the remaining points P1 and P2 are called the handles of the curve(also known as the terminating points). These four points are responsible for controlling the curve. P0 and P3 are the static points that hold the starting and ending point of the curve. P1 and P2 are the points that give the curve its shape.The curve that is formed between P0 and P3 is going to be a parametric equation where the variable will be changing from 0 to 1. The Application of the Bezier curve is immense as the drawing and creation of a curve is needed for any application of a variety of fields. This equation is very frequently used in computer graphics, digital art, Character animation etc. The representation of the Bezier Curve's equation is as follows:

$$P(u) = \sum_{i=0}^{n} P_i B_i^n(u) \tag{4.4}$$

The Blending Function in this equation is given as follows:

$$B_i^n(u) = (\tbinom{n}{i})(1-u)^{n-i}u^i \tag{4.5}$$

Where n is the polynomial order and u is the variable ranging from 0 - 1.

Where Pi is the multiple points and Bi(n) i(u) is the blending function representative.

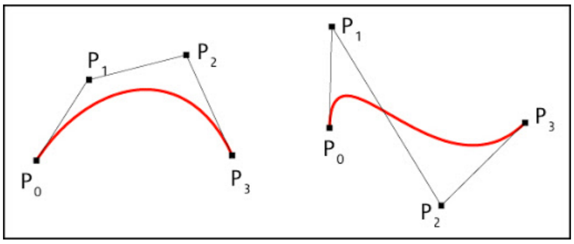


Figure 4.10: Bezier Curve with 4 Points

When the points are fetched from the dataset that will be the user's current location's Latitude, longitude and altitude, along with a weather index, they will be used as the four points in the Bezier Curve. This will help generate a pathway that will be ideal for the Aircraft to use. With the help of the Tensorflow ML model, we will be able to train our system into predicting which of the paths are safer for the aircraft to approach. The dataset will be divided into a training set and testing set and hence after the training, will be tested with the coordinates to see if the predictions are accurate.

4.12 Deviation

Before a plane takes off, the pilots prepare a flight plan. This flight plan consists of the documents needed prior to taking off. These documents consist of basic data such as departure and arrival points, estimated time started off, back-up airports in case of emergency. This document is important because it decides which path the aircraft will take. When the aircraft is on the fly, it updates its position to the ATC every hour. This updated position is considered to calculate its current trajectory or current path at that point of time. Then the current position is compared to find if there is any angular difference between the two paths. This is how flight path deviation can be measured.

We can assume X to be the latitude, Y to be the Longitude and Z to be the altitude. For the calculation of angle, we can assume Z to be constant for now. Hence, the distance, d and do, can be found by using the general distance equation(assuming the Original point O is 0,0,0).

4.13 Applications Of Our Proposed System

Radio signals may get lost during flight due to lack of coverage in a particular area or an internal system malfunction. Any information which is passed through the radio may be lost or disturbed which can cause a series of confusing instructions that can lead to a disastrous event. In order to avoid facing such situations, along with the radio signal instructions, our proposed system can assist into confirming the instructions by providing enough data and information so that even in times of radio disturbances, the pilots will be able to understand the instructions clearly and be sure of them before executing them.

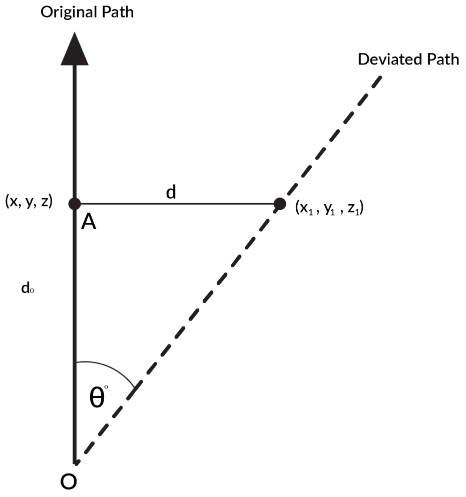


Figure 4.11: Preliminary Understanding of the Angle deviated from the Original Path

Chapter 5

Experimental Setup and Results

5.1 Hardware setup

In this section, we are going to discuss how our ideas and solution were implemented in real life application and how we achieved it. First and foremost we had to manage the dataset which comprised of creating pathways any aerial vehicle will take, we tried to make it as random as possible for best application of our project.

Figure 5.1: Drone Used

To create these we choose a number of small points whose values were set by particular Latitude, Longitude and Altitude values. These values were noted down so that they could be used later. Then, for the specification of our project, we searched for a drone that was able to interact well with the environment, could make sharp turns, whose speed was the optimum or project required. In light of all these we chose DJI Phantom 4 Pro, as our preferred drone. This drone has some pretty decent specifications. Its hover accuracy range is vertically 0.5m (with GPS positioning) and horizontally 1.5m (with GPS positioning). It was lightweight, making it convenient to travel with and take it to remote places for flying. Another main reason to choose this was because of its battery backup. Most drones have a low flight time, usually about 15 to 20 minutes. However, DJI Phantom 4 Pro has a powerful battery of 6000 mAh LiPo 2S which gives it a maximum flight time of about 30 minutes. So, it does not need any battery change for a long time. This is why we could use it for our research purpose without having to deal with the interruption of changing the battery in the middle of collecting data every now and then. Another great feature of this drone is that it can fly as far as 5 kilometers and can even extend the distance to as much as 7 kilometers if there is no obstruction.

Figure 5.2: Universal Vehicle GPS Tracker: Scout

Though we have our drone in set, we need to choose suitable GPS tracker by which we can monitor. GPS we are going must be accurate and reliable [43]. Moreover, it should resist the effects of magnetic and electric signals affecting them. Furthermore, it will be able to give its GPS value every 0.1s to get accurate as possible [9]. For these reasons, we choose Scout - Universal Vehicle GPS Tracker.

What remarkable of this is, that scout is the principal area tracker to offer GPS, Cellular, Bluetooth, vibration detecting and an accelerometer in a solitary, smaller gadget. Something other than a tracker, Scout likewise recognizes speed, heading, and keeps a background marked by late areas [26]. Scout gives exact continuous area from anyplace with its versatile assistance. Scout includes the most advanced receiving wire and GPS chip innovation and works in any condition. Moment Movement Alerts Right To Your Phone. Scout's vibration sensor will send a prompt warning upon the scarcest development and will permit you to confirm its area and watch your Scout move continuously on the guide if it's being taken. Scout will arm itself automatically after a few minutes of being stationary. The Scout also fulfills all requirements we need like purpose as we are flying drone its specifications of changing according to speed of drone is made optimum. Moreover, its light compatibility makes it easy to place it attached with drone without adding much weight to drone, thus leaving unaffected for the most part. In addition to that, it is water resistant which means water splashes would leave it unaffected which is especially useful as we were planning to use it during rain to see how much it is affected by rain. GPS coverage of device was quite excellent it could relay to devices up to 20 meters from it which is good enough for small simulation we were doing [41]. Alert system also made sure that if drone was going down it could be alerted right away that something is wrong. Technology used to make scout was also top notch that could be altered and tailored depending on its use.

Figure 5.3: Aftab Nagar

5.2 Data Set

5.2.1 Data Collection

The system that we are proposing needs to be trained with real life GPS data. So that when it gets a new GPS value, it should be able to produce a result that is accurate and reliable. Although there are several datasets of GPS coordinates that can be found on the internet, we had to make our own. That is because, we need to test our system with those values and make sure it is working correctly. For that we have collected real GPS values (Latitude, Longitude, Altitude) and created a dataset from those sampled data. We have used a drone to collect data from its recorded GPS coordinates. The drone that has been used was DJI Phantom 4 Pro. The reason why we chose this model was because it was much more affordable than other high end drones. There were cheaper options but this had more accuracy of its measurement.

We selected 4 different flight paths for collecting GPS coordinates data. Those paths consist of numerous GPS values of (Latitude, Longitude, Altitude) at every point of the flight path.

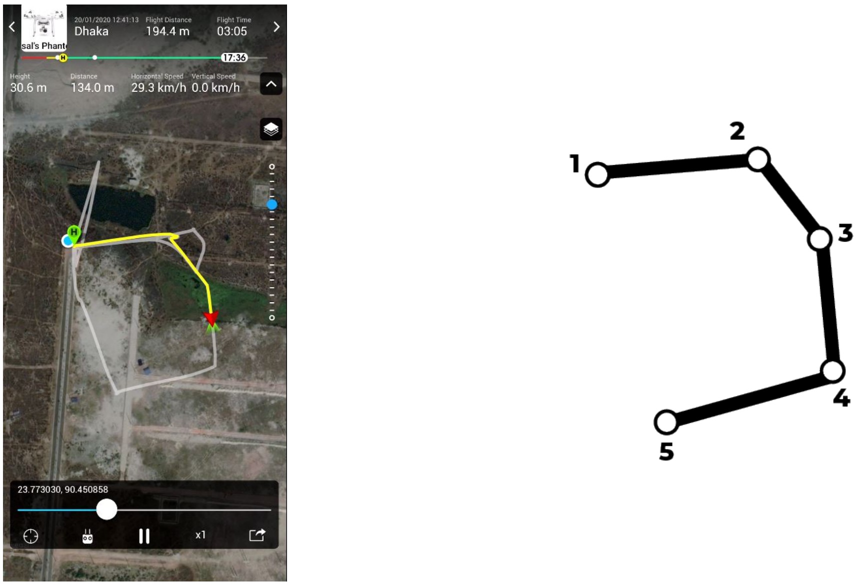

20/01/2020 12:41:13
Dhaka
Flight Distance 194.4 m
Flight Time 03:05
sal's Phant
17:36
Height 30.6 m
Distance 134.0 m
Horizontal Speed 29.3 km/h
Vertical Speed 0.0 km/h
23.773030, 90.450858

Figure 5.4: Flight Path 1

Flight Path 1: The illustrated path on the right is showing the direction the drone has been flown into. It maintained an average fixed altitude while changing the other coordinates.


20/01/2020 12:52:05
Dhaka
Flight Distance 142.7 m
Flight Time 01:21
Faisal's Pha
09:00
Height 35.2 m
Distance 124.1 m
Horizontal Speed 31.9 km/h
Vertical Speed 0.0 km/h
23.774725, 90.449752

Figure 5.5: Flight Path 2

Flight Path 2: In the second flight path we took a zigzag pattern to follow. It also maintained an average fixed altitude while changing its direction four times.

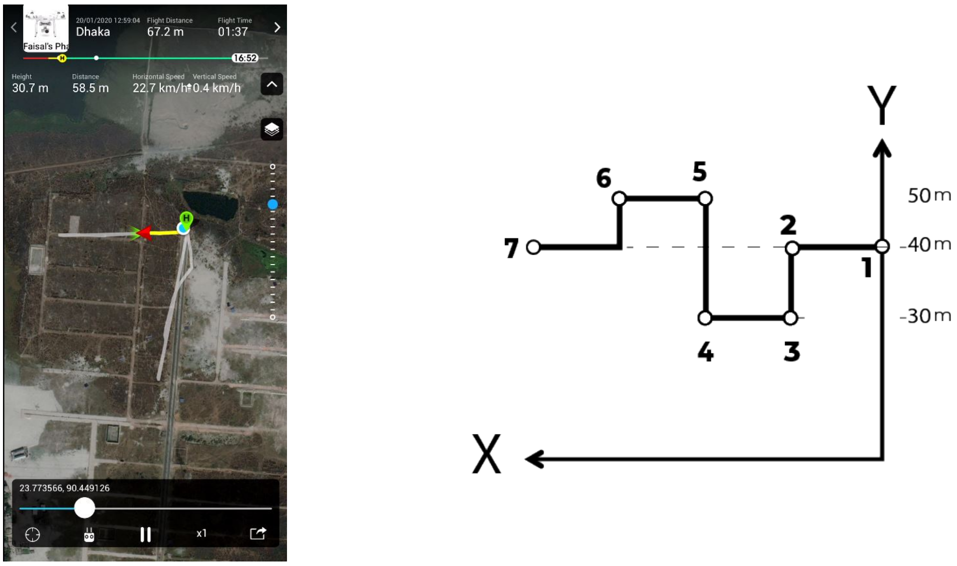

Faisal's Pha
20/01/2020 12:59:04
Dhaka
Flight Distance 67.2 m
Flight Time 01:37
16:52
Height 30.7 m
Distance 58.5 m
Horizontal Speed 22.7 km/h
Vertical Speed 0.4 km/h
23.773566, 90.449126
x1

Figure 5.6: Flight Path 3

Flight Path 3: Here we took a different method and changed our altitude while following a straight path. The side view of it is shown in the illustration on the right.

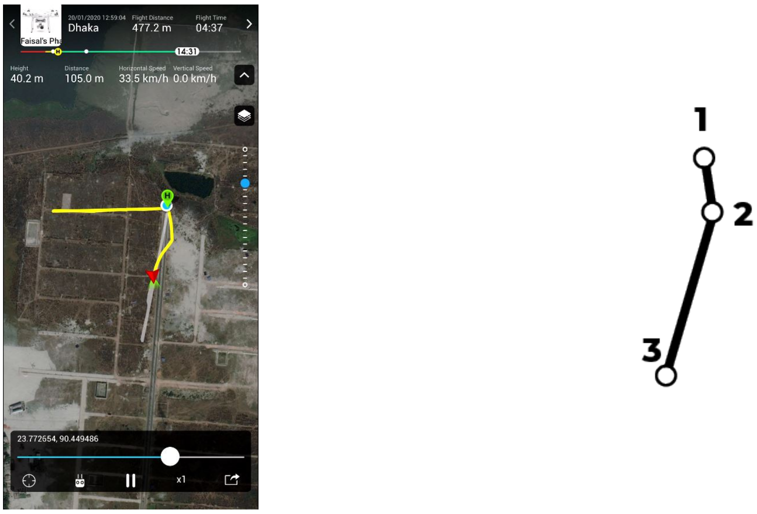

Faisal's Pha
20/01/2020 12:59:04
Dhaka
Flight Distance 477.2 m
Flight Time 04:37
14:31
Height 40.2 m
Distance 105.0 m
Horizontal Speed 33.5 km/h
Vertical Speed 0.0 km/h
23.772654, 90.449486
x1

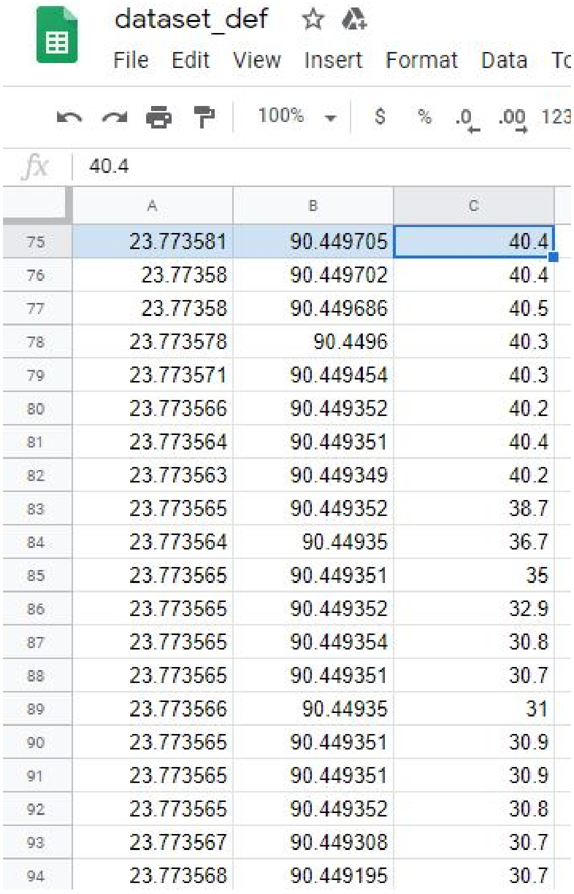
Figure 5.7: Flight Path 4

Flight Path 4: In the last flight path that we took, we just changed the direction once while maintaining the average fixed altitude. This is the simplest path we took to test the initial values.

In these flight paths, the Latitude, Longitude and Altitude was recorded on phone. That record was then used for sampling out of thousands of values.

5.2.2 Sampling

In this part we took the recordings we had and manually saved the values of Latitude, Longitude and Altitude in an excel file. We did the same for each of the flight paths. While sampling, the sampled values were taken with an interval of 2 seconds between them. Then these excel files were exported as CSV files.



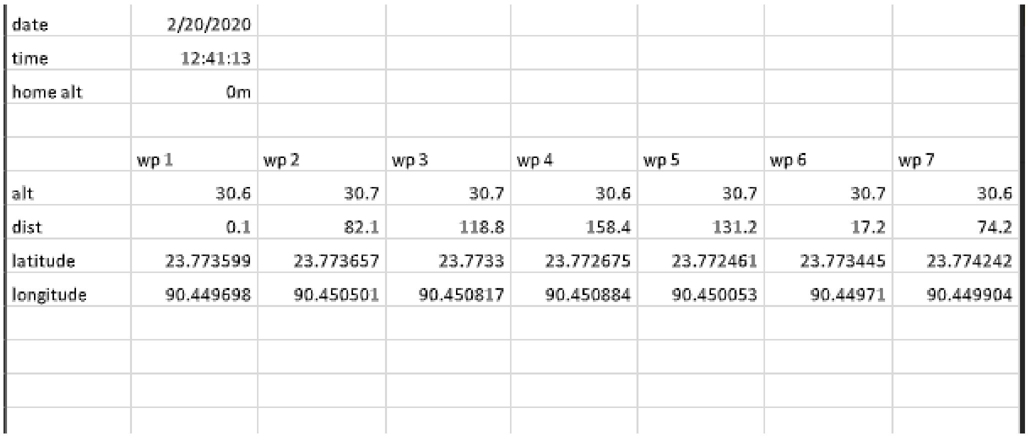
40.4

	A	B	C
75	23.773581	90.449705	40.4
76	23.77358	90.449702	40.4
77	23.77358	90.449686	40.5
78	23.773578	90.4496	40.3
79	23.773571	90.449454	40.3
80	23.773566	90.449352	40.2
81	23.773564	90.449351	40.4
82	23.773563	90.449349	40.2
83	23.773565	90.449352	38.7
84	23.773564	90.44935	36.7
85	23.773565	90.449351	35
86	23.773565	90.449352	32.9
87	23.773565	90.449354	30.8
88	23.773565	90.449351	30.7
89	23.773566	90.44935	31
90	23.773565	90.449351	30.9
91	23.773565	90.449351	30.9
92	23.773565	90.449352	30.8
93	23.773567	90.449308	30.7
94	23.773568	90.449195	30.7

Figure 5.8: Sampled Dataset with a time interval of 2 seconds

To start, we are going to discuss flight1.Here above is a screenshot of a video of our drone going through a pathway we created through points. What we did in these is take points that make a slight turn so that we can know how much effect it actually does. Moreover, it can be seen that drone paths are sometimes intersected; it was initially made so that we can see how intersected paths interact and how they really hold out in a big tide of data. Gray path indicates path drone have to cover and yellow is already covered, this keeps us track of drone flight, and such also makes the application of our ideas quite easy.

The flights done by drone gave us necessary data of flight as it gave information about every path it covered. Moreover, the data was collected every 0.1 seconds which made the collection quite hard as so much data was collected at a small period



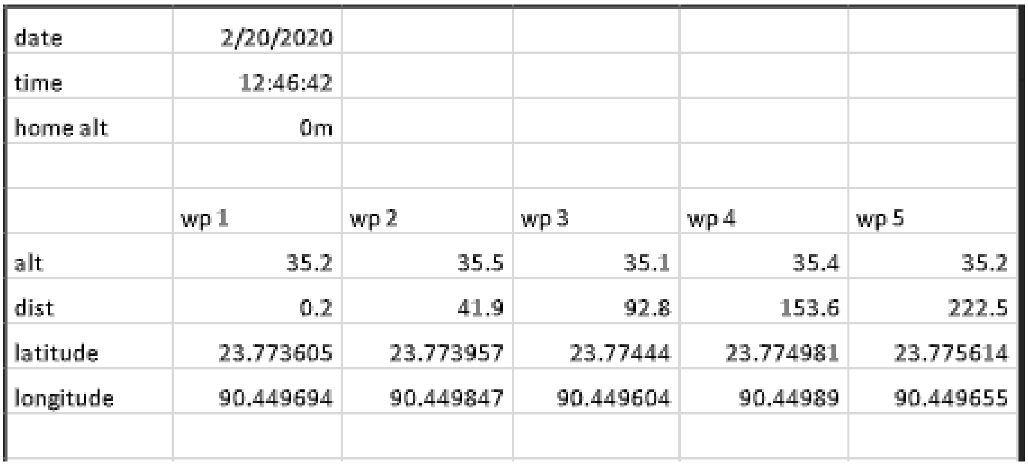
date	2/20/2020						
time	12:41:13						
home alt	0m						
	wp 1	wp 2	wp 3	wp 4	wp 5	wp 6	wp 7
alt	30.6	30.7	30.7	30.6	30.7	30.7	30.6
dist	0.1	82.1	118.8	158.4	131.2	17.2	74.2
latitude	23.773599	23.773657	23.7733	23.772675	23.772461	23.773445	23.774242
longitude	90.449698	90.450501	90.450817	90.450884	90.450053	90.44971	90.449904

Figure 5.9: First Flight

of time Therefore we had to increase it quite a bit. In short the readings we got are altitude, distance covered from its initial position, latitude and longitude which were going to be the backbone of our project. Latitude and longitude would be used to place object, altitude would be used as reference height we are going to use from standard point we are going to choose later. Wp1, Wp2 are used as indications of point used, for the first flight we got about 3000 points, which is lot, that is why we will later discuss it was quite important to sort out many of those points. The readings were accurate up to 0.1 percentage value and as we discussed above where the intersection part came, the points were kind of confusing.

Flight2 was important for a number of factors as we changed pathways quite differently than before. It followed a straight line but curved as well. The main factor was changing altitudes at different heights. The different height was quite important because the software had quite a few issues dealing with height as we were not able to factor it in so properly. The straight line that can be seen was not as straight as it seemed as the bumps up and down are not visualized from satellite image. However, our drone smoothly moved up and down, so we had less issues. This part also covers the intersection part as the curve part intersected with the straight, that was somewhat our intention as more intersection we covered more real life application of this project we can hold. The drone's operation was quite suited for the environment, it showed less issues. Moreover, the triangle pathways that were formed allowed us to experiment and examine sharp turns that would be followed later on. Further, we engaged with the possibility of going back which can be the first initial part, though civil and military planes hardly do. However, a normal everyday drone has this capability and is frequently used so that area had to be explored as well. Thus flight-2 gave a lot of good insight.

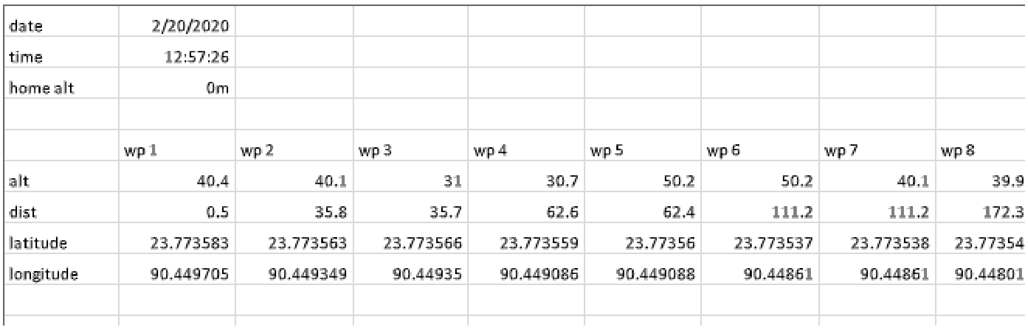
The data of flight-2 was quite essential as it gave readings focusing on change in altitude. In addition to that , it took readings of curve and sharp pathways. Here, to get accurate height we change the rate of readings slightly below 0.1sec. Because at the first time we operated it, it was not able to work properly, thus it became necessary to change the rate of readings taken .Though wp1, wp2 and other readings



date	2/20/2020				
time	12:46:42				
home alt	0m				
	wp 1	wp 2	wp 3	wp 4	wp 5
alt	35.2	35.5	35.1	35.4	35.2
dist	0.2	41.9	92.8	153.6	222.5
latitude	23.773605	23.773957	23.77444	23.774981	23.775614
longitude	90.449694	90.449847	90.449604	90.44989	90.449655

Figure 5.10: Second Flight

had the same altitude but it sharply declined in other readings. Moreover, the readings could not be more accurate if we even required it to be. The slight variation of position and altitude difference made up for all the problems associated with it. The path in yellow can be called trajectory path as it moves away but comes back. The data we did receive from this were almost consistent to the readings we had back before. The short detour also made slight adjustments to mechanical problems we had to avoid. However, all seemed to have worked perfectly as demonstrated earlier.

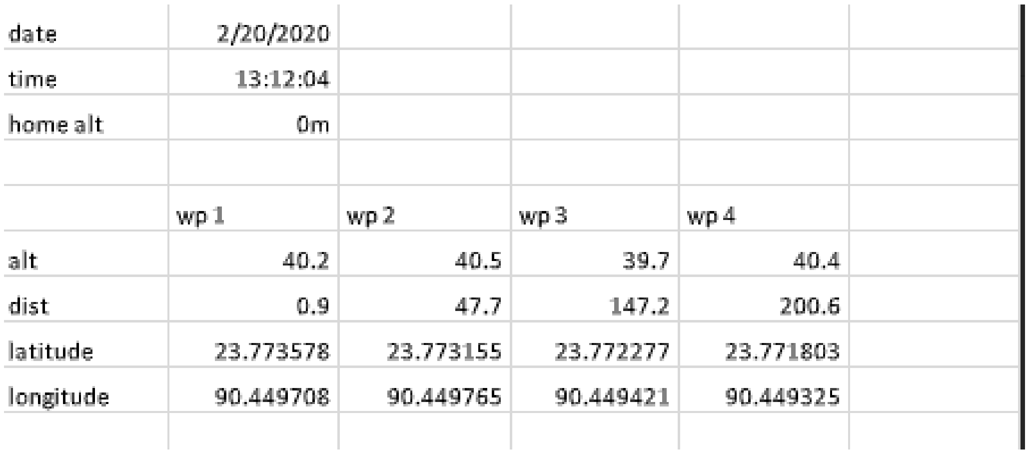


date	2/20/2020							
time	12:57:26							
home alt	0m							
	wp 1	wp 2	wp 3	wp 4	wp 5	wp 6	wp 7	wp 8
alt	40.4	40.1	31	30.7	50.2	50.2	40.1	39.9
dist	0.5	35.8	35.7	62.6	62.4	111.2	111.2	172.3
latitude	23.773583	23.773563	23.773566	23.773559	23.77356	23.773537	23.773538	23.77354
longitude	90.449705	90.449349	90.44935	90.449086	90.449088	90.44861	90.44861	90.44801

Figure 5.11: Third Flight

As we talk about the third flight it also has the same mechanisms set in place. Here again we have a few alterations, we have to talk about here and there. The altitude fluctuation over at this point is exactly on point like we wanted, the V shaped pathway is essential not only for sharp turns as we have discussed but also we made sure that drone goes through the same path while coming back thus clearing for accuracy and also covering as many possibilities as possible for it to work. The short detour is also making sure that points in place are able to make angles and change direction from there.

Lastly, the final flight we took by placing essential points. Here, however, we did make less variation in altitude so that we could see how ideas and implementation hold up. Less variation stabilized the drone making it go in a straight line. Moreover, shortcuts connected the path was to see if two paths joining and diverging affect the actuality of idea implementation. This has been made in the same location at flight 3 to hold out comparison so that we can really create standard and other as testing material. As , we believe that will make the project a lot better than it was before. Similarly, sharp turns were here as well to check it, however unlike others it was kept in the same altitude.



date	2/20/2020				
time	13:12:04				
home alt	0m				
	wp 1	wp 2	wp 3	wp 4	
alt	40.2	40.5	39.7	40.4	
dist	0.9	47.7	147.2	200.6	
latitude	23.773578	23.773155	23.772277	23.771803	
longitude	90.449708	90.449765	90.449421	90.449325	

Figure 5.12: Final Flight

The readings as we could see had more or less the same altitude. The readings varied a lot at edges where the turn was taken. Moreover, wp5, wp6 were inconsistent which we later fixed in the project. Altitude fluctuation being sufficiently decreased created stabilization which made latitude and longitude values being more accurate.

The readings we got from four flights was enough but we stumbled across another problem, we can not possibly use all the values we collected from four flights. That is why we sampled the data by taking only a portion of data, as that will reduce computational necessities and as only a few points are needed to make the entire pathway rather than taking every single value. Therefore, sampling of data points was done by following this flowchart.

At first all points were saved in excel, then we imported the excel file to net beans where we used java as the main language for the program. All imported points were stored in a particular array, each point comprising the latitude , longitude and altitude values it had when the drone was flying over them. Then, we proceeded to create another array b which had one by fourth of length array a had, this was created to store new filtered and sorted out values we are going to use in the next parts of the project. Then, we made array A go through a loop where every fourth value was taken and stored to array b, when iteration was completed the whole process stopped.

This part was one of the most essential parts of the project as it was the main point by which we can lay the foundations of how our work would proceed. The points would be made, as points by which entire pathways are generated in simulation and

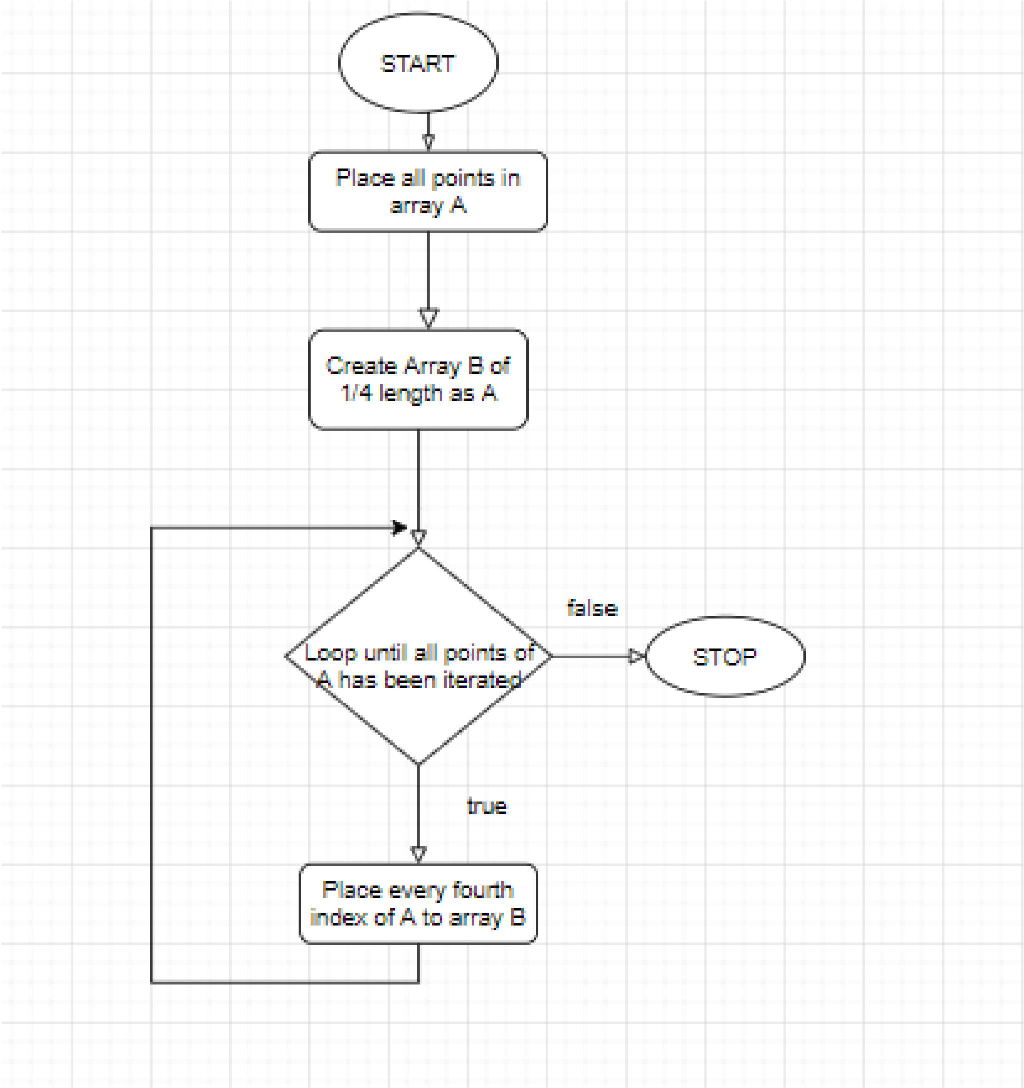


Figure 5.13: Sampling Workflow

augmented reality. Working with unsorted points created a lot of problems when we first started working on it, like the conjunction of very close points with one another made our software unable to distinguish from one another. Moreover, clustering of points is something very much discouraged in Unity software. So to make sure that software works properly and has few or little hassles when we try to complete the project. Next comes real life application, clustering would make it very hard for viewers to see clearly, as and the fact that the vehicle is on path would have a lot of bugs to points it would not work at all.

5.3 Software Setup

The cross-platform game engine is the second and most vital part, and choosing which to use is quite important, as this is where our ideas will be finalized and put to place. Every single game engine has its merits and flaws. However, in choosing we should check how easy it is to use, how much developed its Augmented Reality development is, does it support AR GPS plug-in that would be essential for our project to work. Moreover, we should check how smoothly it works, does it have any glitches and is it a reputable and trusted game engine or not. On the basis of all these factors, we chose Unity as Unity is the best app for Game development. It is successful while rendering 2D and 3D scenes. The quality offered is likewise moderately acceptable contrasted with different applications [20]. Unity is phenomenal for cross-platform development. Utilizing cross-advancement stages, a solitary content can be incorporated and utilized for some stages. A single script can be used across different scenes and platforms. Fundamentally, the technical support for Unity is effective. The technical support individuals are additionally exceptionally talented and they can be depended upon if there should be an occurrence of any specialized issues. In the event of the visual stage, Unity is exceptional [24].

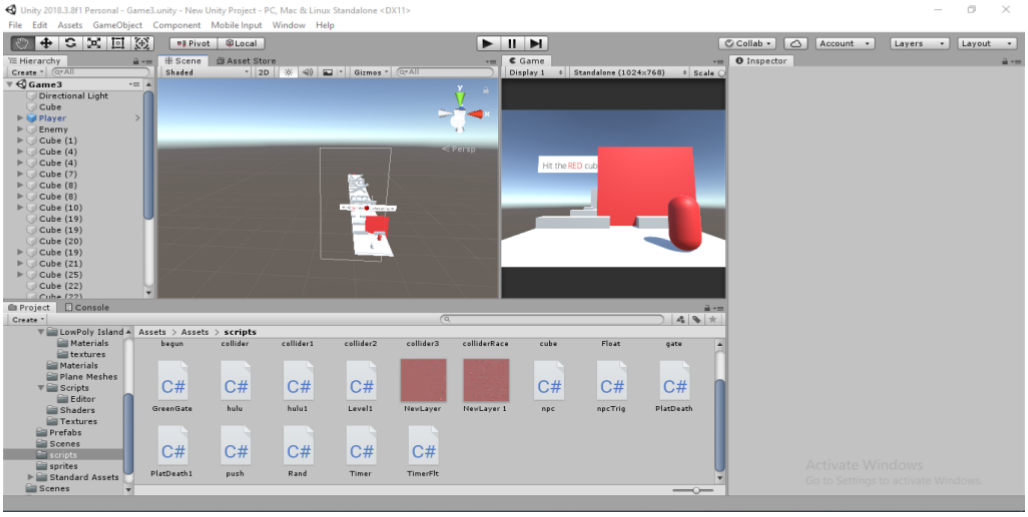
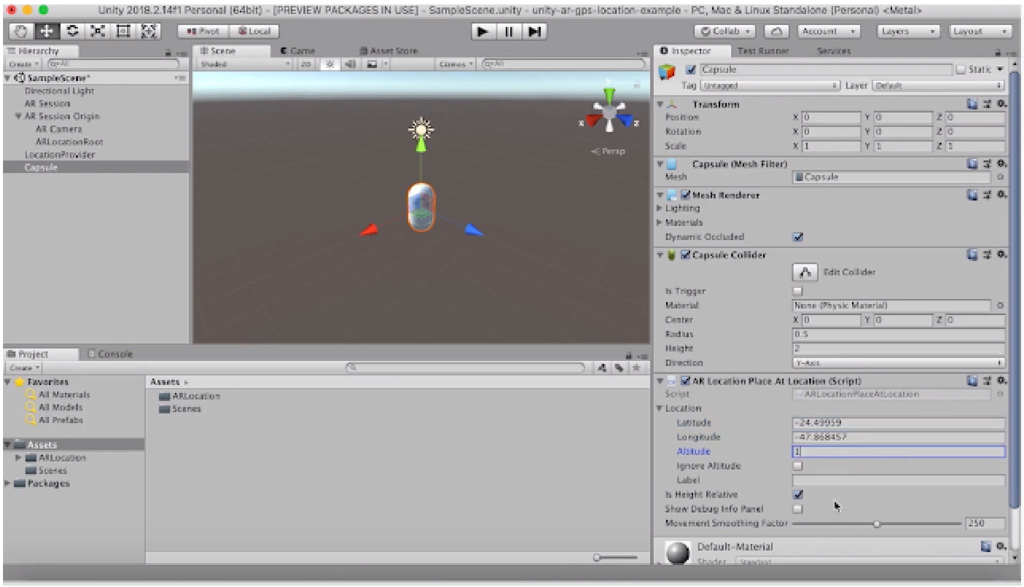


Figure 5.14: Software Workflow

After we have established the preferred game engine, the next part is how we can place points which we sorted out and stored in array b. There are a lot of built in functions and free plugins that can be used to make game and AR projects. However, to place objects at a particular geographical location is hard and not easy to do. It requires external software and unit development that can sync with compatible devices like a Smartphone [19]. Therefore, in light of all this we choose Unity AR+GPS location. This is one of the best plugins out there to accomplish our required tasks. The AR+GPS Location plugin carries the capacity to situate 3D virtual objects at a particular location in the real world by means of their GPS facilitates utilizing Unity and Augmented-Reality, where they place the object at a particular latitude, longitude and altitude value. It uses both Unity's AR Foundation and Vuforia. It works by blending the two GPS information and the AR, followed by AR Foundation of Vuforia. Its primary element is Place 3D Objects in particular the geographical location provided, which is exactly what we need for the purpose of project [38].



Capsule ☑ Static ☐
Tag Untagged Layer Default

Transform
Position X 0 Y 0 Z 0
Rotation X 0 Y 0 Z 0
Scale X 1 Y 1 Z 1

Capsule (Mesh Filter)
Mesh Capsule

☑ **Mesh Renderer**
Lighting
Materials
Dynamic Occluded ☑

☑ **Capsule Collider**
Edit Collider
Is Trigger ☐
Material None (Physic Material)
Center X 0 Y 0 Z 0
Radius 0.5
Height 2
Direction Y-Axis

☑ **AR Location Place At Location (Script)**
Script ARLocationPlaceAtLocation
Location
Latitude -24.49959
Longitude -47.868457
Altitude 1
Ignore Altitude ☐
Label
Is Height Relative ☑
Show Debug Info Panel ☐
Movement Smoothing Factor 250

Figure 5.15: Software using Vuforia

First, we have to start from the very beginning of all what we need to do, like when we start with unity it gives a blank 3D world, then we imported GPS+AR location package, which we already discussed what it does, then we import AR Foundation package that allows Augmented Reality functions to work and its sync with smartphone, then we created a basic AR Foundation scene by adding component such as AR plane and AR background to main camera which transformed it into AR camera. Afterwards we added AR location Root and AR location manager to the camera thus making it able to use GPS tracking ability of the device it is going to use to know the exact GPS location it is at and is viewing thus allowing us to see objects which we pin at particular GPS location. Finally, the last thing we need to do is to create GPS-positioned 3D object which we do creating an object could be cube, capsule or custom made, then we add AR location place at location script to it as can be seen in picture above, the script allows to place a object if variables of its latitude, longitude and altitude are given, for this we add latitude, longitude and altitude we want to place the object and then object is placed exactly at the location. Furthermore, if the AR camera goes near the location we provided for the object and faces at that point, he can view the object.

Figure 5.16: Visualization of an AR Object

Now, as we can see from the picture above that a capsule is floating at a particular geographical location , it is because that object was positioned by a plugin at a certain latitude, longitude and altitude. When device having app went to location and faced, it could be seen a capsule floating at that place.

5.4 Software implementation

As discussed in our Deviation Detection Workflow, the points sampled in array 'b' are fed through a loop and the object cuboids will be placed at all those checkpoints iterated through.

After we placed all checkpoints all across the path, the next step is to join these paths. To join the paths a small semi transparent object would be initiated based on the script that we are going to use. These small cubes would be pathways. The logic of the script would be based on Bresenham's line drawing algorithm where logic is based on by determining the points of an n-dimensional raster that would be selected in order to form a close approximation to a straight line between two points. So how it works is that, first a source point is taken and a destination point. By the gradient of two points, we know which zone the line would be at. For example, if differentiation with respect to x(dx) and differentiation with respect to y(dy) is positive and dx is greater than dy than line is at zone zero. The zones range from

0 to 1. Each zone has its own set of equations and logic on connecting source to destination point by drawing each pixel point [17].

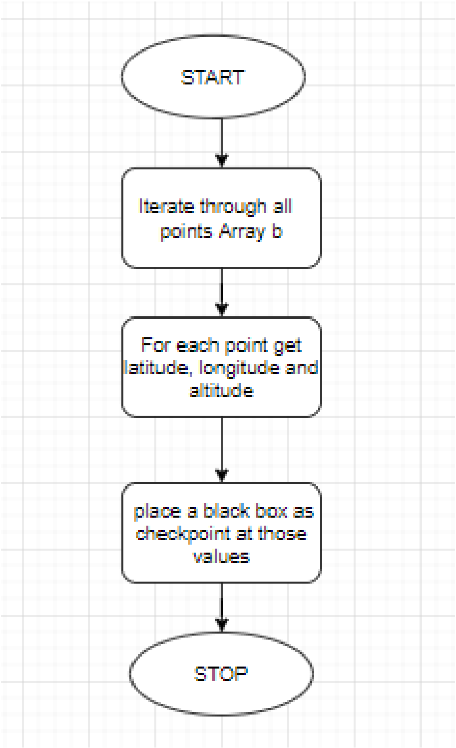


Figure 5.17: Flowchart of checkpoint formation model

However, the problem comes as how we can transform line drawing 2D algorithms to 3D platforms where pixels would be replaced by 3d cube.

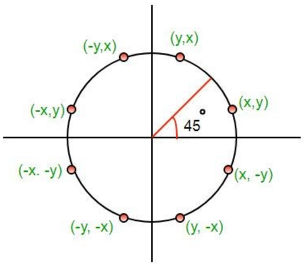


Figure 5.18: Zone Graph for Line Drawing Algorithm

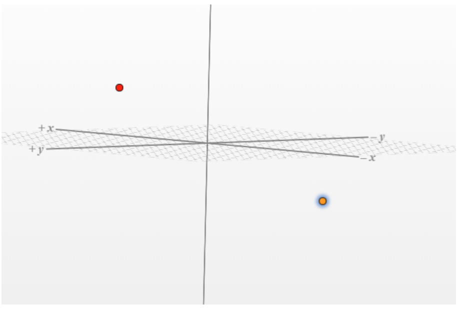


Figure 5.19: Zone Graph for Line Drawing Algorithm on 3D

First, to ensure that cubes represented a pixel in 3D it scale by default was set to 1 on its width, breadth and height. To transform the algorithm to 3D there had to be some changes, the zone was changed from eight to 24 zones and its equation consisting of differentiation with respect to x , y and z axis made it way complex. And such to connect from source to destination for 3D axis, the point had to be updated on x, y and z axis.

5.5 Results and Testing

5.5.1 Simulation of aerial flight during Take-off

The project we made for aerial flight assisting needed to be implemented on plane, but as this was a student project we ran simulation of flight to find out in theory if it can actually work. The four essential parts of flight is discussed.

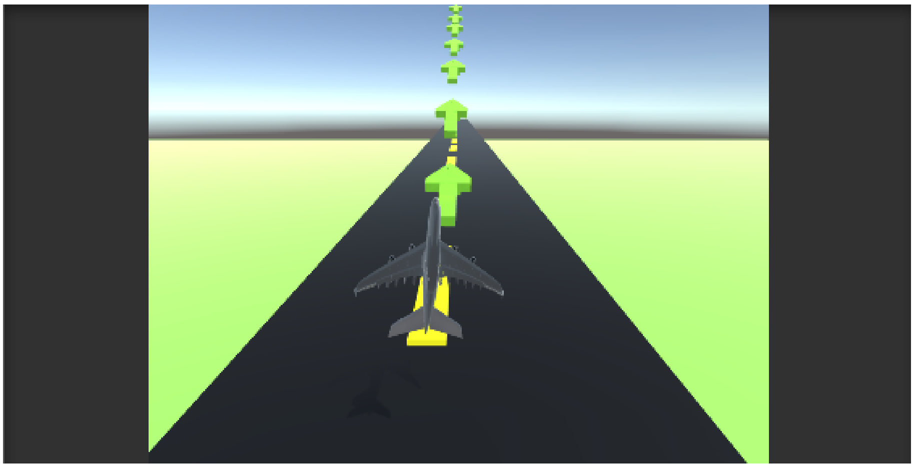


Figure 5.20: Simulated plane view during take-off

In the first part of simulation, we simulated what a pilot will view during takeoff if he is using our system. Firstly, the plane's GPS readings are taken and from those readings our system will be able to detect where device is at and where should pathway arrows would be. As, it can be seen, green arrow marking the path are placed according to their latitude, longitude and altitude, thus showing the path, pilot should follow for a successful takeoff without any problems.

Figure 5.21: Simulated cockpit view during take-off

5.5.2 Simulation of aerial flight during Cruise

There are various layers of system during flight we had to check. Here, as we can see if flight goes according to plan, the green arrows indicating path to landing position will not change and for the most part will remain the same. The green arrows has a collider which interacts with plane, if there is collision it means it is in the path, if not then it has moved from the path.

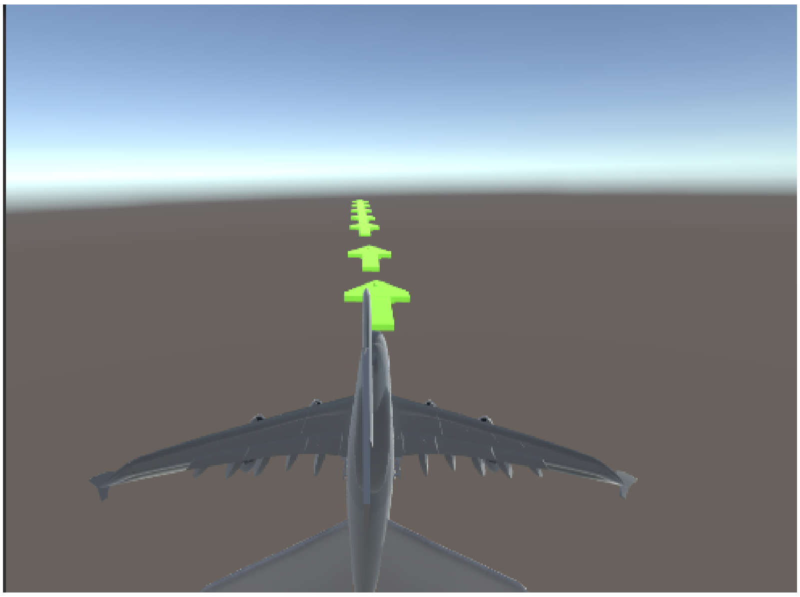


Figure 5.22: Simulated plane view during flight

Figure 5.23: Simulated cockpit view during flight

There are various layers of system during flight we had to check. Here, as we can see if flight goes according to plan, the green arrows indicating path to landing position

will not change and for the most part will remain the same. The green arrows has a collider which interacts with plane, if there is collision it means it is in the path, if not then it has moved from the path.

5.5.3 Simulation of aerial flight during Deviation

The other most important part is what happens if plane moves away from the intended path. As it has been discussed that when device moves from path, in this case if plane moves from its designated path. The first thing our system does is detect that the plane has left pathway as there is no collision interaction with pathway object, the arrows turn to red indicating that pilot is going in wrong direction and warning is also displayed that plane has left pathway and by how much in terms of latitude, longitude and altitude. Finally, a path is generated by yellow arrows from deflected point to original path.

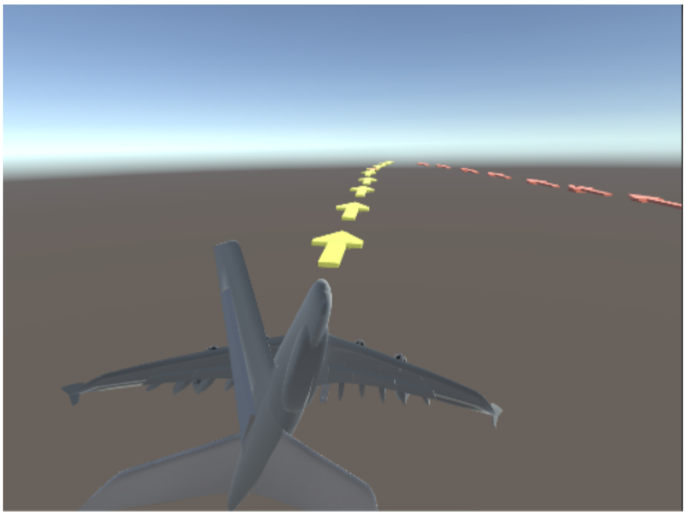


Figure 5.24: Simulated plane view during path generation due to deviation

Figure 5.25: Simulated cockpit view during deviation

Figure 5.26: Warning displayed during flight simulation due to path deviation

5.5.4 Simulation of aerial flight during Disconnection from ATC

Although on most cases planes have connection to ATC, but sometimes they don't and this can cause wide range of problems where plane may go in the wrong direction or accidentally reach another country. For these reasons, it was necessary for us to find alternate ways our system can generate pathway.

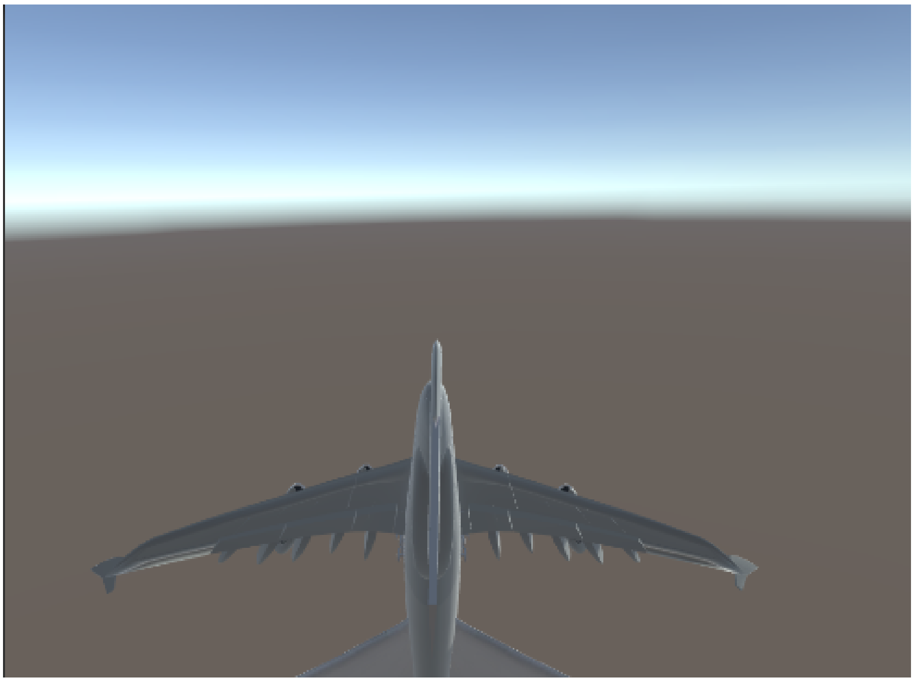


Figure 5.27: Simulated plane view during loss of ATC

In first picture, it is shown that due to loss of ATC, pathway are gone as our system cannot generate path but immediately it connects to backup cloud ATC which readily gives information required to generate path as seen from the later pictures.

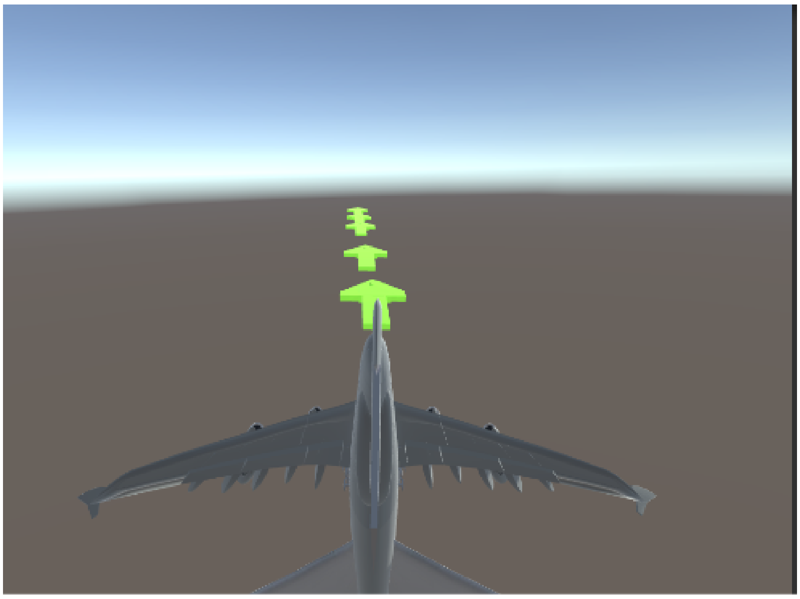


Figure 5.28: Simulated plane view during path generation from cloud ATC

5.5.5 Simulation of aerial flight during Landing

The landing part of our simulation follows the same principle as takeoff, just in this case arrows are directed downwards for a period, then arrows slowly direct towards horizontal direction. Thus, green arrows marks the path, the pilot will take for a successful landing.

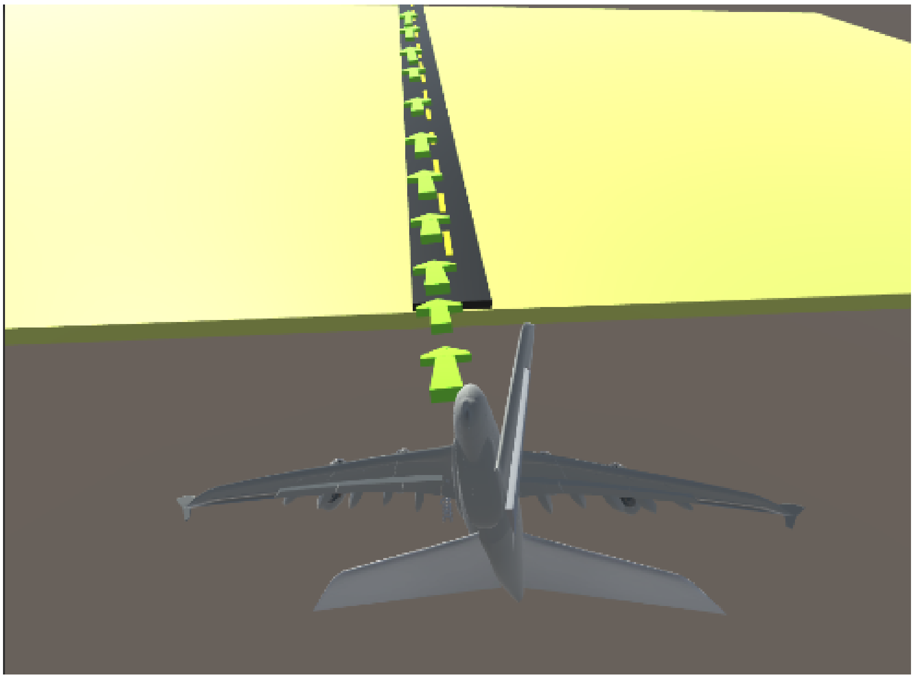


Figure 5.29: Simulated plane view during landing

Figure 5.30: Simulated cockpit view during landing

To conclude from the simulation, it has been proven that our work can work theoretically for a plane as we have been seen all possibilities plane can face during flight with our simulation, and our system showed the intended results.

5.6 Limitations

The project ideas were implemented successfully in particular environments we set up. Beyond that environment, a number of problems arise, one of the important problems is that our application can only work on very few specific Smartphones that have good API level. This causes a number of problems such as limiting the devices that can use the application and most importantly in the aviation field dealing with complex environments, a smart phone is not a preferred device to be used. By going though the plug-in that we used, we found that custom plug-in for any other device could be made [39]. Due to our limited expertise of Unity development in our team we were not able to make a custom plug-in that can use GPS reading of non smartphones and apply separate AR devices on our own.

The paths that are formed by our system are based on fixed points taken as input, thus creating a static path. However, in civil flights the path varies in mid flight due to irregular weather patterns, our system does not collect readings of weather patterns along the flight path and generate the most suitable path to the destination. This limits the use application can have on the civil aviation field.

As paths are formed by fixed points before the flight, this creates problems in applying to military fields where their flight patterns require constant change because of uncertainties of battle but our system does not allow it.

Chapter 6

Conclusion

6.1 Conclusion and Future Works

To conclude, aviation technology has improved over the number of years but in some certain sectors, the technology has become stagnant like on most parts it has little to no incorporation of virtual and augmented reality. To fill the gap , and also in light of problems a pilot may face like loss of ATC we proposed augmented flight assistance that will help pilots during emergency situations. In our system, a flight path is generated from points given as input from the source to the final destination where our system detects if a flying object is within a pathway or not and if not, then warns it and generates a path to connect it to the main pathway. In this paper, we have also discussed the limitations of our project but at same time we proposed how the ideas could be used to make lives involved in the aviation field easier and better. Thus, we believe through our proposal and application of those ideas, a pilot's job could be made easier and safer.

Currently we have fed the data statically through the data-set we have prepared since we are currently facing a technical and device dependency. However, in real-life scenario, the data needs to be fed dynamically, i.e.,from real-time GPS obtaining coordinates, water level, height etc. and cloud-based Databases of Aircraft or Web-Based Databases such as Federation Aviation Association. We plan to have the data-set at real time work at the back-end and generate an accurate prediction of flight-safety through our Machine Learning Model. In case of the path generation from source to destination, the real-time GPS coordinates will help formulate the path at real time and also suggest alternate routes in cases of crisis.
As our system does not use weather pattern right now, we decided the ways our application could be used in the future for that purpose. In our future works, we plan to collect all possible readings of multiple flights across number of years of certain flight like Dhaka to Riyadh. We are then going to study the relation of their paths with weather patterns along their flight path [21]. Afterwards, from such a vast amount of data we are plan to train our neural network using TensorFlow to find the best optimum path with the help of Bezier's Curve Algorithm [3]. As the military aviation field is unique, we plan to make application tailored to their purpose. Instead of forming path from fixed points, points will be inserted remotely by military traffic controller and our system would be able to use those points to form paths[10]. One way of making this possible would be to use restrictive cloud

access. If any cloud excel file could be given as input and if Unity could read that file, that would enable it to take information from these excel files and make checkpoints thus apply our application of forming the path [25].

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