Augmented Reality Relating to GPS Navigation for Pilot Navigation and Orientation

Daniel de Paz

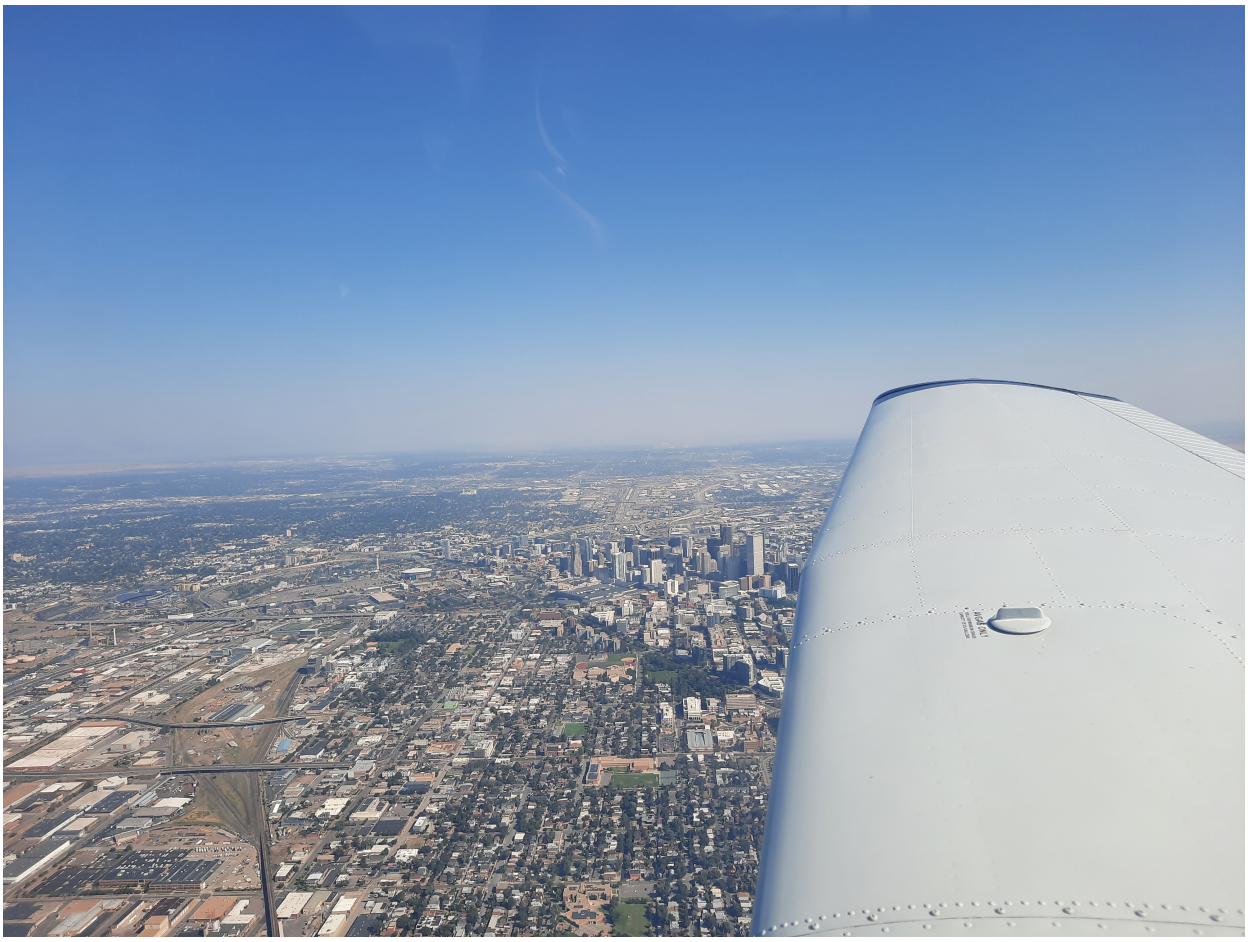

Fig. 1. Flying Over Denver

1 Introduction

Aviation is one of the most important modes of transportation in the modern era. Whether through comercial liners or recreational puddle jumpers, aviation has become a staple of transportation. Nonetheless, there is a set amount of risk involved when flying. Mechanical failure, weather, animals, and midair collisions are an inherent factor that comes with flying. Most safety systems today can help limit these risks. Modern safety procedures do an excellent job from the ground to ensure safety but from the air, safety measures can be improved upon. The goal of this project is to not only to provide a way of identifying airports using Augmented Reality via a Heads Up Display (HUD), but to do so using resources within the airplane itself and not from other sources. HUDs in the aviation industry are used in modern fighter planes to identify enemy aircraft [6]. The goal of this project is to build a prototype HUD display for airports for small commercial and recreational planes.

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2 Current Instrumentations

There are many different ways to land an airplane. When pilots are unable to land the plane visually, they can turn to multiple methods. The main landing assistant methods out there today are Instrument Landing System (ILS), GPS, Ground Based Augmentation Systems (GBAS), and Satellite Based Augmentation Systems (SBAS). While all of these systems work well in their own right, none of them are based within the aircraft itself. ILS is an analog way of lining up with the actual runway, not identifying where the runway is. This method has been widely used since it became standard in 1949. It uses lights at specified angles to direct the incoming landing path with proper decent angles and centering. If the incoming plane is at too low of an altitude, some of the lights will not be visible. If the altitude is too high, noo many of the lights are visible. The same is with centering with the runway. If too far to the left, the right lights become no longer visible [2, 3, 5, 10]. While an effective system, its main purpose is to land the planes on the runway and not identify and guide the plane to

the airport itself.

GPS can identify the location of the airport and direction of the runway but current systems don't utilize the actual surroundings in the instrument. GBAS uses GPS and a VHF radio to communicate with the aircraft and identify to growns crew the position of the aircraft [4, 7–9]. This requires the aircraft to be equipped with a VHF receiver.

SBAS is still in its development stage. It is not reliable enough to be used on a large scale. Issues such as positioning errors, weather effects, and radio interference has kept this system from being implemented globally [1].

While GPS can be useful, GPS just uses the basic map scheme without any real world features like landmarks. When flying in a dense area like a mountain range, GBAS, SBAS, and GPS can have interference due to the geological challenges in the area.

3 Project Plan

The project will be done using the AR abilities of Unity through a phone. I have no experience coding Augmented Reality but I have experience with unity so it will be a useful base to learn. Phones have multiple useful instruments that can be useful to find position, direction, and display targets. Since this is a solo project, having some stable footing to start from is essential. The project will be broken up into two parts.

The first and most important part of this project is getting a good understanding of augmented reality within Unity. So getting a basic program to display an object through the phone is the first step. Being able to display an object at a specific position while having a varying elevation and distance factor will take some time to figure out. The second part will be to find a way to pull data of locations of airports and ourselves. Once the data can be pulled, it will be added to the object for positioning. Like pinning a location on an interactive map, the HUD of the phone will have the object pop up at those locations.

4 Utilized Technology

The majority of technology utilized will be through the phone. The goal is to use augmented reality to create the waypoints. The phone will act as a Heads Up Display for the project. The phone's GPS will be used for gathering data for both location and elevation. The elevation and positioning will be needed to coordinate pin locations for the airport popups. The camera and gyroscope of the phone will also be utilized for the augmented reality to direct the location and direction of the airports and overlay it with the surroundings.

5 Methodology

The Augmented Reality interactable objects were created using Unity for use on an android. Androids have a built in camera and gps needed for location and AR mapping. The goal was to create a popup for the user to identify locations when flying a plane without having to visually identify them. The idea is that if there were an emergency, the pilots could use this to identify where a runway is without any visibility or other instruments.

Subjects would be given 30 seconds to identify a location visually and another similar location within the general area via the prototype. This was repeated 5 different times with the same participant.

After the flight, the participants answered a survey. The survey questions were as follows:

- On a scale of 1 to 10, rate the usability of the prototype
- Note any comments about the usability of the prototype
- On a scale of 1 to 10, rate the usefulness of the prototype
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- On a scale of 1 to 10, rate the identifiability of the location objects within the prototype
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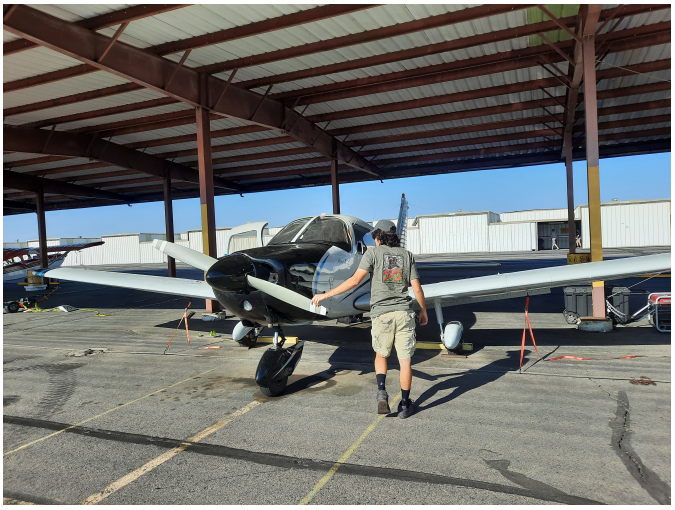

Fig. 2. Pilot doing preflight checks on the plane

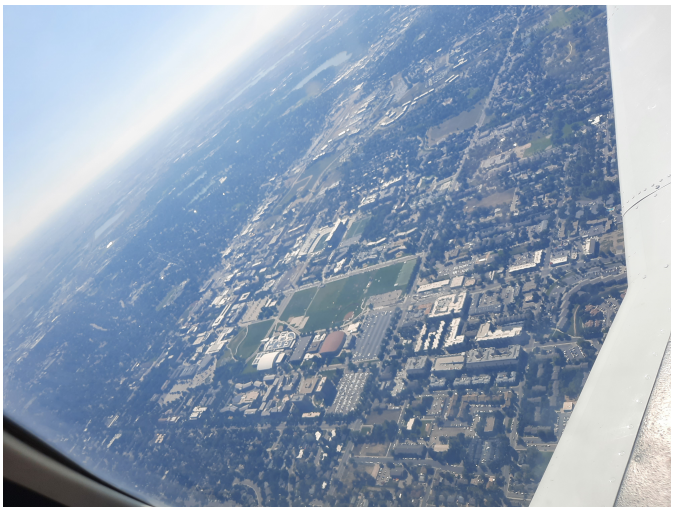

Fig. 3. Example implimentation with Colorado State as the target

- On a scale of 1 to 10, how likely would you use this prototype if it were released?
- How does the prototype compare to visual identification methods?
- Note any final opinions, suggestions, or preferable changes to the system

For this particular experiment, the plan is to use 5 subjects due to limitations in finding able bodied people to fly with. This low number is due to the researcher's limited network of willing known pilots. This small testing pool is not advised if this experiment is reproduced as a low amount of subjects can cause distorted results.

For these flights, we used small, single prop planes to fly in as seen in Figure 2.

6 Analysis

Due to weather conflicts, we were unable to fly the last scheduled flight before the deadline. Because of this, there were only 3 tested participants.

The subjects rated the usability at a 4.3 with a max of a 6 and a min of 3. Notable marks were that there wasn't a UI for actually using the product but once in the air, it was easy to look around within the plane and pan the system. Usefulness was rated a 5 out of 10. Main

Table 1. Servey of Prototype Testing

participant	Usability	usefullness	Identifiability	Likelihood of being used
1	3	4	3	1
2	4	6	6	2
3	6	5	5	3
avg	**4.3**	**5**	**5.7**	**2**

highlights noted were the ability to see markers even if they were in blindspots within the aircraft. Notable setbacks were the fact that this system is not handsfree in its current implementation.. Identifiability was rated a 5.7 out of 10. The likelihood of this prototype being used if released as is was rated 2 out of 10. Notes for the low score were due to the necessary improvements needed prior to an official release.

Notable comments for improvement of the system were as follows:

- The gps was inconsistent
- Improved usability
- A wanting for a hands free option
- Colors blend in with landscape
- An improved identifying feature for the popups

7 Limitations and Challenges

There were a plethora of pitfalls and setbacks in development and testing of this prototype. Logistically, there was major difficulty getting into the air to run the test on the pilots. Unforeseen setbacks such as weather cancellations created issues in being able to run the experiment. When in the air, factors such as visibility and air quality as well as cloud coverage and daylight also played major roles in the outcome of this experiment. These unforeseen factors drastically affected the experiment and results in ways unanticipated.

8 Future Development

In its current state, indications point to this not being a useful prototype. Improvements must be made in order to improve the usefulness of this product.

The original goal of this prototype is to identify airports for pilots in case of an emergency landing. Future developments would be to connect these location objects to a database of airports for a wider general use. This could be done by having the pilot set a route prior to takeoff so the application could pull from a database and plot nearby locations along the route.

Further development to accommodate these comments would be necessary before any real world application could be viable. In order to make the program more user friendly, a whole UI system would need to be implemented. Different color schemes could be used to contrast the landscape. Making the popups selectable before the flight could make a primary target for the system to point towards. Making the popups blink slowly could help with identifying the selected destination. Eventually this system could be used as an integrated HUD on the glass enabling hands free viewing. Having the system integrated could then use the aircraft's own instruments for guidance.

9 Conclusion

Aviation has a number of useful navigational tools. Most of these tools are ground based and not within the aircraft. By using augmented reality, this project is designed to give more control to the aircraft when it comes to navigation. Whether it is used for general navigation in complicated terrain like mountain ranges or quick navigation in case of an emergency, the goal of this project is to make navigation easier from the pilot's perspective within the airplane.

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