Augmented Reality Landmark Navigation

Kevin Shen

Advisor: Norman Badler

University of Pennsylvania

ABSTRACT

Current GPS navigation is extremely accurate but is presented in a nonintuitive way. Applications like Google Maps require the user to mentally map landmarks and street names from a 2D overhead view to the real world in front of them.

This project is an augmented reality application that overlays waypoints on to a live camera feed from an Android phone camera. The app will use orientation and location data from the phone's accelerometer, gyroscope, and GPS coordinates to determine the exact orientation and location of the eye in a 3D scene. Then, the application will translate 2D directions to their coordinates in the 3D scene. Using the translated directions, waypoints will be rendered on top of the camera feed. The result is a GPS system in which the user can immediately relate the waypoints to real-world landmarks.

Project Blog: http://realgps.blogspot.com/

1. INTRODUCTION

GPS devices are widely used by drivers on mobile phones and dedicated GPS navigation devices. The user interface (UI) for current GPS navigation applications feature navigation paths overlaid on 2D maps. The camera angle may be directly overhead or at a three-quarters view of these maps. Both perspectives are nonintuitive and require the user to mentally map street names and symbols on the map to real-world streets and landmarks in front of them. This causes a delay from when the user sees the navigation path to actually comprehending and following the direction. Such a delay is not only a symptom of a non-ideal UI, but also a hazard that distracts drivers while on the road.

Augmented reality (AR) offers a new perspective through which directions may be displayed in a more quickly understood way. This application will use a mobile phone's camera to display a live video feed of the world in front of the user. We propose an AR mobile app that renders clearly visible waypoints on a live video feed of the world in front of the user.

Presenting waypoints in this way allows the user to make a faster connection between directions displayed on the screen and their location in real space. The user no longer will need to make a mental map between landmarks listed abstractly on a map (eg. “the corner of Spruce and 34th”) and real-world landmarks (eg. Green street signs for Spruce and 34th street). Instead, the user may simply use actual images of landmarks from the video feed to correlate waypoints' relative position in the real world.

Accurate GPS and device orientation data are vital for AR applications. Inaccurate data may lead to renderings in the wrong place or from the wrong perspective, making the application useless. GPS data and device orientation are subject to interference from jitter, user movement, and external obstacles such as tall buildings. Collecting and updating position and orientation data presents a significant technical challenge.

Contributions
This main contributions of this project include:

- A method to determine phone camera orientation based on GPS and sensor data
- A method to render GPS directions in 3D space
- A GPS navigation app that directs users to their destination via waypoints

1.1 Design Goals

The target audience for this project is developers involved with GPS navigation, especially on mobile platforms. Ideally, this project will provide a basis for future navigation apps to incorporate augmented reality as a means of providing a more intuitive and usable UI. This project may also be of interest to researchers in augmented reality and other branches of Human-Computer Interaction (HCI). In particular, a successful iteration of this project could be extended to in-car GPS systems or heads-up displays (HUDs).

1.2 Projects Proposed Features and Functionality

This application will have the following features:

- Calculation of precise location and orientation of the mobile phone
- Projection of GPS navigation instructions to 3D space

2. RELATED WORK

Substantial work has been done in AR and improved UIs for mobile navigation. Several key projects and products are outlined below.

2.1 Natural Feature Tracking

Stabilization of orientation data can be achieved through tracking of natural features captured by the phone's camera. Understanding the global position of features such as pipes or corners can be correlated with relative motion of the camera to determine camera orientation.

However, these methods are computationally expensive. Development of phone hardware is limited by slow increase in battery capacity and most projects for natural feature tracking require the resources of a PC, not a mobile phone [WRM*08]. These tasks have historically been outsourced to a remote server at the cost of non-realtime performance due to HTTP request time [WS09].

Several mobile SDKs optimize memory management, scheduling, and other low-level tasks associated with natural feature tracking. Studierstube ES (proprietary, [WS09M]) and Qualcomm Vuforia (publicly available for Android, [QUA]) are two such SDKs.

2.2 Orientation data via hardware sensors

Improvements in hardware sensors in current phone models has allowed highly accurate orientation tracking by combining sensor data and visual tracking [SMR10].

Recent announcements of an improved, dedicated “M7” motion-sensing chip [LAW13] and the CoreMotion API [APP] that will ship with the iPhone 5S may add additional accuracy to data collected from hardware sensors.

2.2 AR frameworks on mobile phones

Private companies have released several AR SDKs and apps of varying power for mobile platforms, including Metaio's Junaio app [MET]. Junaio supports a web API for rendering 3D models based on basic location and image recognition. Qualcomm's Vuforia supports basic image and text recognition [QUA].

2.3 AR with Commercial GPS navigation

Pioneer's experimental GPS device features navigation paths overlaid on live video [PIO]. However, such a device is meant to sit in a fixed orientation and supports 3 degrees of freedom (translation only).

3. PROJECT PROPOSAL

3.1 Anticipated Approach

This project can be broken into a series of small steps:

1. *Gain proficiency in chosen mobile platform.*

   This includes displaying a live video feed from the phone camera in a full-screen app.

2. *Obtain and sanitize orientation and GPS data.*

   Raw data must first be read from built-in APIs that access hardware sensor and GPS data. Depending on accuracy of this data, further work may be required to ensure accuracy. This may include visual tracking to improve orientation data or differential correction to improve GPS data.

3. *Understand how to create a 3D scene using the given information.*

   Given the location of the user and orientation of the camera, a 3D scene can be constructed. At this point, the video feed must be rendered in a way such that the perspective on the screen matches the user's perspective of the real world.

   Once the scene is established, the application query the Google Maps Directions API for directions from the current location to the destination. Directions are returned with lat/lon coordinates for each step. The coordinates must be projected to 3D space before waypoints can be rendered at each step.

4. *Additional calibration.*

   Fine-tuning so the perspective and camera movement feels natural should take place towards the end of the project if there is additional time.

3.2 Target Platforms

The software requirements of this project will be driven by the accuracy of orientation data readily available from mobile phone sensors and default APIs. Tentatively, we plan to use Java to build an Android mobile app. Vuforia or Junaio may be beneficial for rendering basic 3D models.

It is worth further research into the capabilities of the improved hardware sensors in the iPhone 5S, once the new model is released.

3.3 Evaluation Criteria

The results of this project can be qualitatively assessed by checking if waypoints are accurately rendered at their appropriate locations. This could be checked both visually and by navigating a path using both this app and a traditional top-down GPS navigation app while looking for discrepancies between the two.

Quantitatively, this app can be checked for a usable frame rate to ensure efficient computations are used.

4. RESEARCH TIMELINE

Project Milestone Report (Alpha Version)

- Completed all background reading
- Displaying video feed in mobile platform of choice
- Collecting and displaying raw orientation and position data from hardware sensors (accelerometer, magnetometer, gyroscope, GPS)

Project Final Deliverables

- App featuring AR waypoints
- Demo video of user using the app to display and navigate a simple path from one destination to another

- Documentation

Project Future Tasks

- Waypoints are less intuitive than full navigation paths typically seen in GPS navigation apps. Overlaying full navigation paths on streets in the video feed would be more intuitive for the user to follow.
- Live updating of navigation paths to display a new, correct navigation path when the user deviates from the original path.

Timeline

- See Figure 1

5. Method

To be completed during the course of the project.

6. RESULTS

To be completed.

7. CONCLUSIONS and FUTURE WORK

To be completed.

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[PIO] Pioneer Co. GPS Augmented Reality HUD:

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[QUA] Qualcomm Vuforia:

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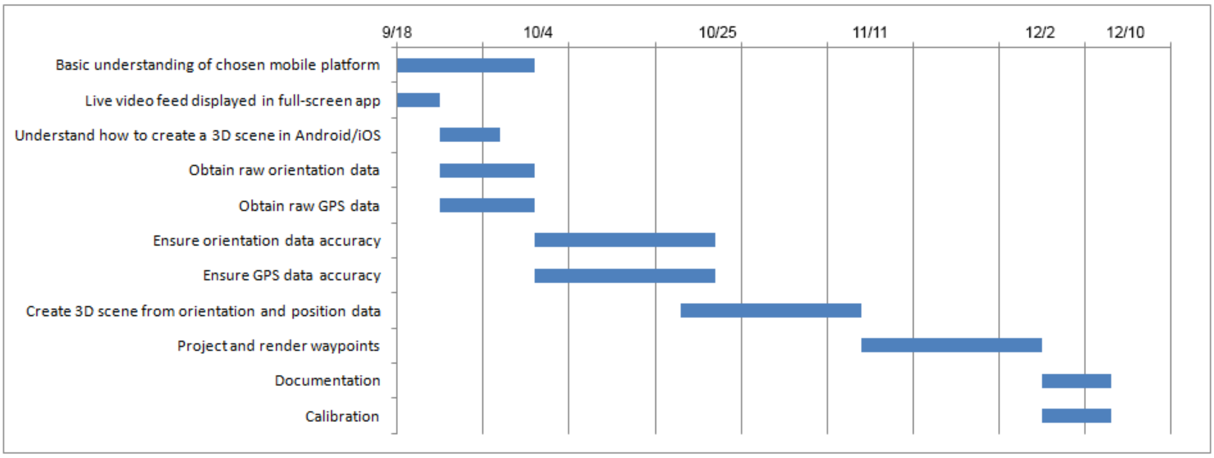

Figure 1: *Timeline*