4D Data in Mobile AR Camera View

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Executive Summary

AR experience developers must juggle many constraints when designing for mobile device users. In this paper we describe an approach deployed to address the needs of users with limited screen real estate and network bandwidth, yet who wish to visualize portions of very large, complex server-based data sets with a time element. We used existing geospatial services and standards with mobile, and demonstrated how they can be utilized for accessing globally standard 4D meteorological data. Commercial cloud services were used to process and deliver the data to a variety of mobile devices around the world.

As next steps, we seek feedback on the approach and recommend that the community of mobile network operators, 4D data providers and AR developers get involved in the project to conduct further tests, including interoperability experiments, and provide additional implementation experiences towards the preparation of an international standard.

The problems

Users have gone or are going mobile, using their smartphones for a wide variety of activities and returning to their desktop or laptop computers more rarely. Some services and applications are optimized for mobile. Unfortunately, there remain many providers of highly valuable data that do not adapt their services to mobile constraints and users that do not adjust expectations for mobile platforms.

Since few people were using Augmented Reality regularly on desktop or laptop platforms, AR experience development tool providers and experience developers have long focused on and must build within mobile platforms and networks constraints. Even as mobile platforms for advanced data visualization, such as AR, are improving (faster processors, especially GPUs, greater use of higher precision sensors, higher resolution and larger dimension screens) and mobile networks for connecting mobile devices to cloud resources are expanding, significant obstacles remain.

Digital information, when anchored in some manner to attributes of the real world, can be considered “raw content” for AR experiences. Most people who would like to test or regularly experience AR on their mobile devices are confronted by one of two basic “content” issues:

- Shortage: There’s no information available for their context (no one has developed and attached the assets for the real world attributes and the precise set of preferences stipulated by the user) or
- Excess: There’s too much information available (information overlaps, interferes with other information and results in cognitive and visual overload).

This project addresses both of the above issues.

First, we live in a “big data” world. There may be valuable information available for any context and it could, in some way, be anchored to real world features and user preferences/contexts. However, the data are not accessible to the AR client software or are not furnished in a format that is suitable for transmission to and viewing in camera view.

What if mobile AR systems were able to access data sets that already include a real world attribute? The real world attribute might be algorithmically recognized by comparing the live video stream with the features of the real world extracted from digital photographs. Or it might be a geospatial reference that is compared with the user’s position and orientation. An increasing amount of data generated by machines or humans (social media) and stored on servers have a geospatial component and a time stamp.

In this project, meteorological data associated with a universally-recognized coordinate reference system, as well as having a finite time element (shelf-life), serve as our sample geo-spatially referenced big data set.

Using the meteorological data, the second problem, that of having excessive data for visualization in AR view, can also be examined and solutions explored. Sometimes the obstacles to having data visualized in AR-assisted services stem from the manner providers prepare and transmit their data. Traditionally, in meteorology, data is processed and delivered in batches covering vast geographic extents. Other obstacles may be due to the manner the data are requested from a service and/or explored once delivered.

We believe that challenges with data shortages and over-abundance, as well as data serving and utilization on mobile can be addressed intelligently for 4D data. We also believe that the proposed solutions can be backward compatible, hence, applicable for 2D and 3D data.

Background

In early 2009, Wikitude’s developers connected their request interface to the geospatially-referenced Wikipedia data set (a subset of the entire Wikipedia). By tapping the world’s open, Web-based collaborative encyclopedia project, they provided users with a way to automatically filter millions of Wikipedia records by using the mobile device position and orientation.

In response to a request, the Wikitude client application receives from the Wikipedia Web services, a label (the name of the entry) and a URL to the entry’s Web page. The user can select to see/read the entry in a Web browser. This information is “point” based, meaning that the Point of Interest has a single instance and no volume. Many geospatial-referenced point data sets are similar to Wikipedia and could be available for AR services.

Fourth dimension

In contrast to point-centric geospatial information, a lot of geospatially-defined data sets describe volumes. A body of water, a building and meteorological data are examples of such 3D data. In the case of a building, there may be a 3D model associated with the date of construction, another with the date of remodeling and a third when the building was expanded. Hence, the building is a dynamic object with respect to time. Meteorological forecast data is expressed in grids of evenly spaced points. The data in forecast grids are processed in batch mode using some of the world's largest supercomputers based on models of terrain and many other factors. Professional users of the data set receive and can open the batched data on workstations and prepare visualizations for a wide variety of applications.

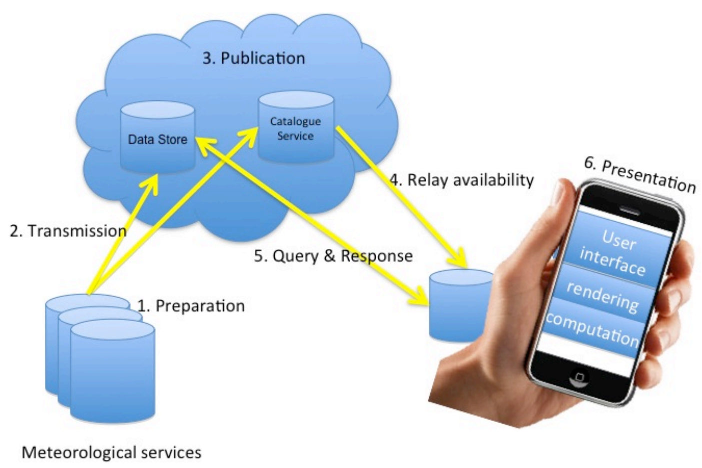
Four-dimensional data describes a volume with properties that change over time. An animation is a 4D data set, although unlike the other examples, the geographic position also moves with time. As processors become more powerful and the ability to create and use 4D data increases, there's been an increase in awareness about its uses. For example, 4D data can be used to describe traffic in intelligent transportation systems, point clouds of all sorts of spaces (urban, marine, etc.) and meteorological conditions.

Potential applications and directions for further research for 4D data could include cultural heritage (making a place look like what it used to look like) and medical (comparing the activity of an organ in the past with its levels in the present).

4D Data with Mobile AR

Most of what humans perceive and call "reality" is 4D. Augmented Reality is tightly synchronized with the real world. Reality is continuous and continuously changing, not, as has often been represented in the past, 2D data points in layers.

In order for the data in this project to be served to the mobile device according to the unique conditions of the user (position and orientation), it must first be processed.



During the data processing phase the large batched mode data is processed into a set of data tiles using the same Spherical Mercator projection naming structure utilized by Google Maps, Open Street Maps and others. The raw data within the tiled files is maintained in the same format as the source data, but with changes to the file header information that describes the geographic extends and 'read-method' for the tile.

This 'tile-chopping' process is repeated for each time-slice that is available for the given dataset, with the new set of tiles stored in Unix (or POSIX) time-coded directories.

In the second phase, the data is published in the cloud and registered within the Awila data catalogue that allows the mobile clients to be 'aware' of the physical location from where to retrieve the data, the geographic extents that it covers and various semantic information on how to display it within the clients.

Within the project we managed to decouple the raw data provision from the graphical information required to display the data (color, size, model etc). The primary reason for doing this was to eliminate duplicate display information from within each of the 9,878 tiles that made up one time-slice, thus reducing the overall dataset size and, therefore, required bandwidth. The display information was stored within the data catalogue, transmitted only once, with specific display information (direction, size, etc.) generated dynamically on the client from the raw data values.

When the Awila client application has the mobile user's context (i.e., the geospatial coordinates from the GPS), it requests the data set from the cloud server, creates the data-points and applies the specific styling information before rendering it in the correct location and orientation on screen.

At this point the user is free to explore the 4D content in their own way – this includes tools to allow them to 'lift' off from ground level, up to 500m altitude, giving them the ability to alter their perspective on the data.

Given the time-indexed nature of the data, the user also has a time scroll control, which allows viewing each of the time-slices for their location.

Benefits

The approach developed in this project offers data "coverage" in the manner analogous to the map coverage service already widely adopted for geospatial data.

The data requested and sent to the mobile are in a format that is relatively easy to process. The format does not describe individual point coordinates with a list of attribution and display information, but as a regular geospatial grid of raw values that enables high compression and fast client-side processing.

By utilizing a non-localized, tile-based approach which is common to many other cloud-based services, application developers can become, or are already familiar with, ways to quickly and easily ingest the data into their applications.

In order to protect valuable data and the provider's business value, the approach assures the data provider that they are delivering only to approved customers (who have, for example, paid a subscriber fee) via the service 'catalogue'. Providers also have the ability to retain control over data quality and styling, whilst allowing the user a choice in how they have this information presented to them.

Mobile-friendly data services need to use context for reducing the limited resources they consume. The proposed approach will aid in reducing the transmission of unwanted/un-needed data, saving the network provider's bandwidth capacity, the memory on the mobile device and the processing requirement of the mobile device.

Finally, the proposed approach provides the data in the area around the user and device, while leaving open the possibility that an application developer permit the user to adjust many important user preference parameters.

Conclusions

Although the project we describe above uses AR to visualize 4D data over the real world and we have qualitative reports indicating that the approach is highly intuitive for users, the lessons learned in this project are applicable beyond AR-assisted use cases or visualizations. The principles we have demonstrated are broad enough to be useful for many types of 4D data.

How people use 4D is entirely up to developers of services and applications.

We believe that through the establishment of a specification defining the preparation, request, transmission and viewing of data "cubes," based on OGC standards for 2D and 3D data services, there can be a broader market for all complex data services on mobile devices.

This approach is sound in a business context as well.