UAVAR: An Augmented Reality Supported Unmanned Aerial Vehicle Application

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ABSTRACT
In this paper, we present the work on using Unmanned Aerial Vehicles (UAVs) in inspection scenarios. UAVAR is an Augmented Reality (AR) application for mobile devices. It integrates AR technology to enhance the application of UAVs. Although there is existing research on the use of UAVs in different industries such as the agricultural sector, power and utility industries, continued development is worthwhile as AR technology will reduce users’ inputs and increase their productivity. Our goal is to increase inspection work efficiency. A demonstration has been implemented to present the concept based on using Global Positioning System (GPS) to automatically display Point of Interests (POIs) labels in real-time, and to edit image footage. For example, adding labels of key points, inserting problem icons and adding text messages.

Author Keywords
Augmented reality, unmanned aerial vehicle, GPS, Visualization

ACM Classification Keywords
H.5.m [Information interface and presentation (e.g., HCI)]: Miscellaneous

INTRODUCTION
Many industries are researching the influences of fast-paced development of technology. New technologies are radically modernizing the use of remote sensing in agriculture. In order to cost-effectively gather crop health information without waiting for satellite passes or paying the high costs of manned-aircraft flights, more and more low cost UAVs are widely used to support the professional agriculturalist. Information can be collected easily at resolutions up to inches per pixel, which provides the incredible detail. Data captured on a frequent basis not only help farmers and agronomists to map the health and vigor of crops, orchards or vineyards, but also to observe how those crops, orchards or vineyards are changing over time.

The use of UAVs for precision agriculture, farming, and crop management is rapidly expanding globally. These UAVs provide the unique advantage of being able to provide live data from a range of sensors in order to perform in-depth analysis of crop health, and immediately identify issues with crops allowing users to take action, and increase yields for return on investment. GPS, combined with auto-return and land functionality, ensures ease of use.

Currently, farmers must look back and forth between the display streaming video from the UAV and a separate display showing a Google map in order to reconcile the information from the live view and the map. This wastes time and is potentially open to human error when they need to identify POIs.

In other industries, such as those that involve large-scale heavy construction projects where certain issues may not be noticeable to the human eye or are hard to access, the opportunity to identify issues earlier is clearly beneficial. For example, the inspection of inaccessible or hard-to-reach areas could be done remotely by using a UAV. The UAV could, for example, quickly scan for cracks and other signs of deterioration much faster and more accurately than would otherwise be possible.

This paper describes a new iOS application, UAVAR, which automatically identifies and labels POIs within the live streaming video from the UAV. This application contributes both a new application of AR and a new mathematics for the relationship among the UAV’s GPS, camera gimbal, and the field of view information. UAVAR is not intended to help the pilot fly the UAV but rather to help the operators view the UAV video to gain the information during the flight. It also offers a quick real-time footage editing function in order to improve inspection work efficiency.

RELATED WORK
AR has been a research field for more than two decades (Pickarski 2006; Schmalstieg et al. 2002) since AR was first demonstrated by Ivan Sutherland in 1965 (Sutherland, 1965). AR technology directly or indirectly attaches elements augmented by computer-generated sensory input such as video, graphics or GPS data, to the real-world view for the user. For example, Google Glass allows the user to see a digital image beside or on top of their view of the world. This technology has particularly useful applications, and impacts how and when a job can be executed. The ability to access this type of information without the use of a mobile device, or a trip to the site office, could deliver increased productivity and specificity onsite. The possibilities for AR are not limited to wearable technologies like Google Glass. The same sort of information display could be built into things like windshields of onsite vehicles, for example. Much research has been conducted in order to establish guidelines for using these technologies.

Research on the progress of pervasive technology and fast development in tracking algorithms has explored the concept of an AR browser being used on a mobile device in either outdoor or indoor environments. AR browsers already implement the concept of multi-media browser in the real world, either in terms of their specific user interfaces or their system architectures. In 1997, the Touring Machine (Feiner 1997), a prototype mobile AR application based on a tablet equipped with external GPS and an inertial tracking system, provided users with tour information about their surroundings in the campus. An information space called the Real-World Wide Web browser (Kooper and MacIntyre 2003) merged the World Wide Web with the physical world by using AR. The ARGON AR browser (Blair et al. 2011) presented a new data format (KARML) for creating and authoring interactive 2D or 3D content based on existing web standards.
Different conceptual ideas of adding different layers of information were proposed for augmented web browsers (Ryong et al. 2009). The main data items of AR browsers are geo-referenced or object-referenced POIs. Geo-referenced information comes in a variety of forms, such as textual or pictorial data, or more rarely in the form of video, audio, or 3-D media (Hohi 1999). There are some popular open-source AR browsers such as Junaio1 Layar2 and Wikitude3, which only discover and view the contents related to physical objects around the users’ current locations. Langlotz et al. (2014) discussed the important challenges and varied research approaches to be addressed in order to achieve the next-generation AR browsers.

**OUR APPROACH**

The proposed application is designed to instantly provide an eye-in-the-sky image of objects of any type and/or size objects and to monitor the infrastructures. The high definition video camera transmits live streaming back to the base screen. A flight plan can be set either to scan an entire particular area or to follow specific waypoints. The UAV will auto land when low battery is detected, and with a ‘home’ function can be returned at any time.

We chose the DJI Phantom3 Professional which is a multi-rotor UAV as our aircraft. It has a vision positioning system so that the information can be gained from the GPS sensor and can complete complex calculations in real time. We use the Software Development Kit (SDK) and combine the AR technology to build our application – UAVAR. The remote controller is used not only to pilot the UAV but also send the live steam video to the mobile device. All the information associated with the POIs, including the names, the latitude and longitude coordinates, images, texts, and so on is stored in the database. When the UAV flies near the POIs, the detail of these POIs with the latitude and longitude coordinates can be gained from the database. UAVAR then creates labels that are scaled so that the closer POIs have larger fonts and displays them on the live streaming video from the UAV. The operator also can edit image footage such as adding labels to key POIs, inserting problem icons and adding text messages. These information is then stored in the database.

**Figure 1:** The screen captures of the application that labels building.

We implement a demonstration by using these equations. Several labels of the POIs were built to test the application. As shown in Figure 1, the screen captures present the label positions combined with the UAV imagery.

**CONCLUSION**

UAVAR is being developed for iOS devices, it delivers a more efficient work experience and is easy to use. UAVAR not only allows UAV operators to view AR such as geographic POIs during a flight, but also offers a quick real-time footage editing function. Future work on this application will focus on evaluating the positions of labels and their fonts and colors. Some new editing features may be added. AR technologies may be implemented for use in precision agriculture and improves the functionality of current UAV inspection industry technologies.

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