Chapter 62
3D City Modeling and Visualization for Smart Phone Applications

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ABSTRACT

Smartphones with larger screens, powerful processors, abundant memory, and an open operation system provide many possibilities for 3D city or photorealistic model applications. 3D city or photorealistic models can be used by the users to locate themselves in the 3D world, or they can be used as methods for visualizing the surrounding environment once a smartphone has already located the phone by other means, e.g. by using GNSS, and then to provide an interface in the form of a 3D model for the location-based services. In principle, 3D models can be also used for positioning purposes. For example, matching of images exported from the smartphone and then registering them in the existing 3D photorealistic world provides the position of the image capture. In that process, the central computer can do a similar image matching task when the users locate themselves interactively into the 3D world. As the benefits of 3D city models are obvious, this chapter demonstrates the technology used to provide photorealistic 3D city models and focus on 3D data acquisition and the methods available in 3D city modeling, and the development of 3D display technology for smartphone applications. Currently, global geoinformatic data providers, such as Google, Nokia (NAVTEQ), and TomTom (Tele Atlas), are expanding their products from 2D to 3D. This chapter is a presentation of a case study of 3D data acquisition, modeling and mapping, and visualization for a smartphone, including an example based on data collected by mobile laser scanning data from the Tapiola (Espoo, Finland) test field.

DOI: 10.4018/978-1-4666-2038-4.ch062

INTRODUCTION

In the past, visualization of 3D information was limited to personal computers. Today, the increase in the capabilities of mobile devices (powerful processors, abundant memory, and open operation systems) provides possibilities for users to utilize 3D information for purposes such as navigation and location-based services (LBS). "Future developments in navigation and other location-enabled solutions will rely heavily on 3D mapping capabilities," said Cliff Fox, executive vice president, NAVTEQ Maps, in November, 2010 (NAVTEQ). Many location-based service agencies (e.g. Google, Nokia (NAVTEQ), and TomTom (Tele Atlas)) are currently expanding their products from 2D to 3D. In 2007, Google was the first to introduced panoramic images (360°) of street views (2D) in the company's Google Earth (GE) service. In December of 2010, their products were expanded to 3D street views and 3D buildings. After several months, in April of 2011, collaborating with Microsoft, Nokia launched Ovi Maps 3D where currently twenty cities are available in 3D views. Intense competition is usually an indication of heavy user demand. This has created a practical need for rapid 3D geographical data acquisition and modeling. The 3D laser scanning market is also expected to double by 2015 (Geospatial World, 2011).

Currently, there are two primary means for 3D geographic data acquisition: photogrammetry and laser scanning. Photogrammetry is the technology of deriving 3D data from 2D images by mono-plotting (using the existing height model), stereo-imagery interpretation or multi-imagery block adjustment. According to different vehicle platforms for optical sensors, 2D images can be separated into several categories: satellite images, aerial images, and terrestrial images as well as image video sequences. Methodologies for 3D modeling from satellite images can be found in numerous publications, and the following is a representative sample of such documents (Baltsavias, Pateraki, & Zhang, 2001; Baltsavias, Zhang, & Eisenbeiss, 2005; Fraser, Baltsavias & Güen, 2002; Grün, Zhang & Eisenbeiss, 2005; Jacobsen, 2004; Lee, Shan & Bethel, 2002; Poli, 2005; Sörgel, Szhulz, Toennessen & Stilla, 2005; Sörgel, Thoennessen, Brenner & Stilla 2006; Sörgel, Michaelsen, Thiele, Cadario & Thoennessen, 2009; Toutin, 2004; Zhang & Grün, 2006). Content on 3D modeling using aerial images has been presented by the following (Ahmadi, Zoej, Ebedi, Moghaddam & Mohammadzadeh, 2010; Baillard, Schmid, Zisserman & Fitzgibbo, 1999; Baltsavias et al., 2005; Bescoby, 2006; Le Besnerais, Sanfourche & Champagnat, 2008; Collins et al., 1998; Cord, Jordan & Cocquerez, 2001; Fischer et al, 1998, Fradkin, Maitre & Roux, 2001; Grün & Wang, 1998a; Jaynes, Riseman & Hanson, 2003; Jung, 2004; Kim, Park, Kim, Jung & Kim, 2004; Mayer, 1999; Paparoditis, Cord, Jordan & Cocquerez, 1998; Peng & Liu, 2005; Suveg & Vosselman, 2004; Tournaire, Bredif, Boldo & Durupt, 2010). Literatures on 3D modeling using terrestrial images have been contributed by the following (Fraser, 1996; Fraser & Cronk, 2009; Grün, Remondino & Zhang, 2004; Luhmann, 2010; Remondino, 2006). Papers related to 3D modeling using image sequences can be obtained from the following sources (Bethmann, Herd, Luhmann & Ohm, 2009; Cornelis, Leibe, Cornelis & Van Gool, 2008; D'Apuzzo, 2003; Fitzgibbon & Zisserman, 1998; Forlani, Roncella & Remondino, 2005; Pollefeys et al., 2008; Remondino, 2002; Remondino, 2004; Tian, Gerke, Vosselman & Zhu, 2010). However, despite the research efforts focused on photogrammetry over many decades, the level of automation is still relatively low.

The current technology in laser scanning (LS) offers an alternative solution for the acquisition of 3D geographic data. LS is also referred to as Light Detection And Ranging (LiDAR) because it uses a laser to illuminate the earth's surface and a photodiode to register the backscatter radiation. Typically, the time it takes for the laser beam to reach the target and come back to the source (de-

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