Abstract

Automatic recognition and analysis of tree using stereo vision

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In the framework of the WoodStock project an automatic sensor-based forest inventory system is developed for localization and analysis of single trees by use of the Integral Positioning System (IPS). The project is a cooperation by the German Aerospace Centre (DLR, Institute of Optical Sensor Systems), Eberswalde University for Sustainable Development (HNEE), asis Soft- und Hardware GmbH, terrestris GmbH & Co. KG und Umwelt Engineering GmbH.

To achieve accurate and autonomous navigation without the need for continuous external reference, the German Aerospace Center developed the multi-sensor system IPS (Grießbach, et al., 2012). The basic configuration is integrating an inertial measuring unit (IMU) for navigation, a stereo camera system for deduction of disparity maps by use of the semi-global matching algorithm (SGM). Furthermore an optional GPS device provides external position references.

On the basis of the IPS-box mounted on a forest vehicle, this master thesis introduces a new algorithm for automatic recognition and analysis of trees for the development of a mobile single-tree forest inventory. The algorithm is demonstrated by means of derived disparity images and recorded GPS trajectory in an experimental Scots pine stand.

In the first step, the derived disparity images are used for tree recognition. By knowledge of the camera model and external system orientation based on the GPS trajectory, disparity maps are transformed into 3D object point clouds in a world coordinate system. The absolute tree position and diameter at breast height (DBH) of all captured trees is determined automatically and identic tree datasets are fused. The quality assessment on behalf of reference forest stand data is demonstrating the capability and performance in tree recognition and analysis. It is furthermore demonstrated, that the determination of exterior orientation by means of inertial navigation data is essential for reliable localization.

The deduction of single-tree based parameters prior to harvesting is valuable for forest management, harvesting companies and wood industry (Scott, et al., 2002). Single-tree based inventories are traditionally performed on ground with manual measurement methods as shown by Hyyppä, et al. (2009), requiring much labor time for data collection (Holopainen, et

al., 2004).

Sensor based approaches are still under development, e.g. the detection and measurement of trees using airborne imagery and Airborne Laser Scanning (ALS) as shown by Korpela, et al. (2007), Xiaowei, et al. (2010) and Hyyppä, et al. (2012). Due to the airborne viewpoint, mainly the crowns of upper-story trees can be evaluated. The direct measurement of diameter at breast height (DBH) as well as stem shape and quality is not possible (Xiaowei, et al., 2010). For these measurements, a terrestrial single-tree inventory is essential. In several investigations and one commercial application Terrestrial Laser Scanning (TLS) is used for 3D reconstruction and inventory of the forest (Bienert, et al., 2006) (Simonse, et al., 2003) (Pál, 2008). As shown by Bienert, et al. (2006), these approaches however lack of automation and mobility on larger areas due to elaborate point cloud fusion in a multiple scan mode.

In contrast to traditional forest inventory systems as well as shown research based on Terrestrial Laser Scanning (TLS), the demonstrated approach will facilitate a mobile acquisition of detailed forest stand parameters as it can be mounted on vehicles. Due to the automatic functionality and accurate navigation, the system enables small- and medium-scale data collection, imposing an innovation of single-tree forest inventories in the future.

In the first chapter, the WoodStock project as well as the tasks of this master thesis is presented. Subsequently, the concepts and procedures of single-tree as well as area-based inventories are illustrated. As conclusion, a set of system-related and functional requirement for a terrestrial sensor-based single-tree inventory is given. The following sections are introducing the IPS sensor system as well as the discipline of Computer Vision for provision of a theoretical background. In the second chapter the developed algorithm is demonstrated in detail. Furthermore an overview of the technical devices and test area is given.

The derived results and quality assessment are shown in the third chapter and discussed in the subsequent chapter 4. In the final conclusion (chapter 5) an evaluation of the developed algorithm as well as the used sensor system is given.

Keywords: Stereo Vision, semi-global matching (SGM), Integral Positioning System (IPS), object recognition, digital image processing, single-tree forest inventory, photogrammetry, remote sensing, computer vision, inertial navigation, Global Positioning System (GPS)