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PREFACE

Terrestrial 3D laser scanning is the latest technology in electronic distance measurement. It can obtain measurements at tens of thousands of points per second. Land surveyors are adopting the technology because of the dramatic increase in productivities and relative ease for 3-D presentation. Applications of terrestrial 3D laser scanning include topographical surveying, as-built surveying, facility management, 3D imaging and modeling, forensic investigation, environmental protection and restoration, historical preservations and architectural design. Currently there is no textbook dedicated to this subject although some remote sensing and surveying textbooks do have discussions on it.

This text is intended for students in land surveying and civil engineering related areas though students in other fields that use terrestrial 3D laser scanning may also benefit. It is written for a one-semester, 3-units course with two hours of lecture and three hours of lab, using Trimble™ GX 3D laser scanner, PointScape™ field software and RealWorks Survey™ post-processing software.

The materials include twelve modules of lectures and thirteen labs.

The first module gives a historical review of the evolution of EDM from Geodimeter to 3D laser scanning and discussions include geodimeter, tellurometer, total stations, GPS, and 3D laser scanners. A comparison of the two types of 3D laser scanning (airborne and terrestrial) is given. 3D laser scanning applications as well as its impact on land surveying are discussed.

The second module discusses the theoretical background about how distance is measured in 3D laser scanning. The impact of temperature, atmospheric pressure and humidity on the index of refraction are compared using the CFF, Edlen and Ciddor methods. Laser fundamentals including the lasing process, structure of a lasing device and laser properties are discussed. The two measurement methods, time-of-flight (TOF) and phase-shift, are explained. This module ends by discussing the major components of a terrestrial 3D laser scanning system.

The third module discusses two factors affecting the performance of 3D laser scanning: reflectance (albedo) and beam divergence. The objective is to help students realize the impact of these factors on measurement range and accuracy of a scanner so that they can plan scanning operations accordingly. The reflectance of commonly encountered surfaces in scanning such as soil, vegetation, concrete and asphalt is discussed. The impact of water, organic carbon contents and surface roughness on surface reflectance is also considered. For beam divergence, beam diameter as a function of wavelength, initial diameter and distance is studied.

The fourth module is based on a survey of 3D laser scanner vendors about their hardware and software specifications and performance by the magazine *Point of Beginning* (POB). The objective is to give students an opportunity to compare the performance of 3D laser scanners and associated software from different vendors so that they can make an informed decision when acquiring a 3D laser scanning system. The survey covered more than 40 aspects on hardware and around 40 on software.

Module 5 introduces the RWS environment and the three modules in the software, namely Registration, OfficeSurvey and Modeling. Basic operations such as displaying the point clouds and images and performing measurement in the 3D View windows are demonstrated. In addition, cloud-based registration and target-based registration are discussed.

Module 6 gives students some theoretical background about cloud registration and georeferencing, mainly coordinate transformations. Students will also learn to use the Georeferencing feature in RWS

Module 7 shows the steps to perform 3D laser scanning following the traditional surveying flow with PointScape. A detailed flowchart is presented about the traditional surveying flow. Detailed field operations of this approach with PointScape are discussed.

Modules 8 through 10 present the OfficeSurvey™ module of RWS. OfficeSurvey provides the tools for data filtering as well as many data processing functionalities. Some of the features discussed include segmentation, sampling, subproject creation, contour generation, profile/cross-section creation, polyline drawing, mesh creation, volume calculation, image matching, and ortho-projection.

Module 11 covers the Modeling module of RWS. Topics include cloud-based modeling, geometry creation and geometry modification. The Inspection tool in the OfficeSurvey module is also introduced.

Module 12 discusses data export and working with AutoCAD Land Desktop. Three types of exports are discussed in this module: point cloud coordinates to .asc (ASCII) files, geometries to .dxf files and photo images and ortho-images to .tif files. In addition, the process of importing .asc and .dxf files into AutoCAD Land Desktop is given in detail.

Labs 1through 4 deal with laser safety, equipment setup and configuration, field operations and PoinScape™. These four labs do not exactly conform to the lecture modules and some lecturing is needed in the lab.

Labs 5 through 13 match the lecture modules well and lecturing in the lab is usually unnecessary. Based on the author’s experience, students prefer to spend more time on hands-on work in the lab.

At end of each lecture module, a list of questions/problems is given and these can be assigned as part of the homework.

AKNOWLEDGEMENT

Partial support for this work was provided by the National Science Foundation's Advanced Technological Education (ATE) program under Award No. 0702995. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

The author would like to thank Daniel Torres for assistance in preparing the manuscript and Abide Tabrizi, Gwen Gee, Tim Redd, Jerry Miller, James Crossfield, Nikos Mourtos, Akthem Al-Manaseer, Steve Choy, Steve Danner, Ann Johnson, Don Marcott, James W.

McCoy, Nick Soffiotto, Thomas Taylor and Wei Zhou for their involvement with the NSF project. The author would also like to acknowledge the support of Trimble Navigation, Ltd .