New Sensors – New Methods of Knowledge Transfer

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Abstract: Active sensors are rapidly conquering a share on the remote sensing market and offer among others new possibilities toward automatically acquiring 3D building data. Better dissemination of information about new technological developments can possibly be achieved by short distance-learning courses. The paper describes the didactic and technical aspects of a course we have designed and conducted on airborne laser scanning and interferometric SAR. The building extraction application is a good example to illustrated the added value of short electronic-learning courses above simply publishing (digital) papers.
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1. Introduction

While LIDAR (airborne laser scanning) is already well established for acquiring 3D data of urban areas, research on "building extraction" from airborne interferometric SAR (InSAR) is still in its infancy, but InSAR is complementary to LIDAR in many aspects. We have been working on a novel approach to extracting buildings from LIDAR data supported by high resolution multi-spectral images, this for the purpose of urban land-use identification, see [1]. At ITC we have developed in parallel a distance-learning course to better transfer knowledge about active sensor technology to potential users, see [2]. The course curriculum management is through the Internet while the course material itself is either made available on our website or on a CD.

The promise of active sensors and the new generation of digital cameras, which produce multi-spectral images of high quality, high spatial resolution, and with stereo capability, is to facilitate automation of 3D information extraction. Knowledge transfer about 3D concepts, technology, and research by conventional 2D reports has its limitations. Digital reporting via the Internet offers the possibility of interactive viewing of 3D illustrations and 3D models by using VRML and a VR browser as plug-in to the web browser. The next step is then to extend uni-directional reporting to offering bi- or multi-directional communication, thus an electronic-learning (e-learning) course. Such a course can add background information, point to web-resources on fundamental concepts, provide links to related research and services, offer the possibility of interaction with the researcher/teacher and discussions with fellow course participants, provide data on-line and the opportunity to conduct practical exercises and case studies, and yet another important learning element: testing gained knowledge.

2. Building Extraction

It may be obvious for everyone who follows the publications on "building extraction" that there is neither a theory of building extraction from sensor data nor a generally best method. Qingming Zhan's approach [3] is striking because of its relative simplicity (no multi-this and multi-that or multi-the-other) and its effectiveness in detecting buildings, recognizing the patterns they form, and deriving building properties as needed for urban land-use identification. One of the problems in extracting buildings from a DSM as obtained by laser scanning or image matching of stereo pairs is discriminating between buildings and other protruding structures such as flyovers, driveways, access ramps, trees, etc. A very distinct property of a building as compared to the other terrain features, which rise above the ground surface, is that it is likely to have near vertical walls, at least partially. Another one is that if the floor space changes from the ground floor to the roof it is likely to be an abrupt change. Moreover, the roof will only be of a vegetation type in exceptional cases.

The such established simple conceptual model of a building is likely to suffice for the purpose "get buildings from laser data (and an intensity image if you have one) to distinguish between residential and industrial areas in a city". Considering the assumed properties of buildings we may be able to extract buildings from a laser DSM by slicing it at a fixed vertical interval, *eg*, of 1m; see figure 1.

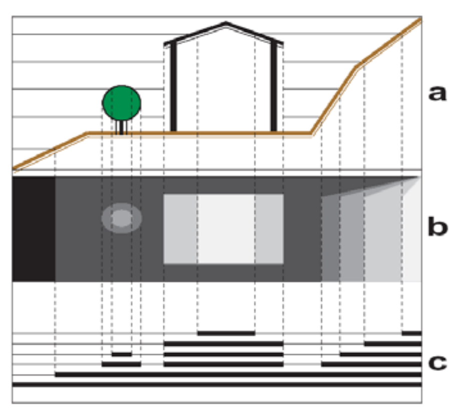

Fig. 1: Terrain cross section (a), DSM from laser scanning (b), profile through image segments at elevation layers (c)

At each elevation level we obtain a binary image. A protruding object yields a segment (image object) with pixel value 1, while open space yields background pixels, see figure 2. These image objects are then subject to reasoning, observing the vertical change of size and the shift of the center of mass of the corresponding image objects when threading them through the elevation layers.

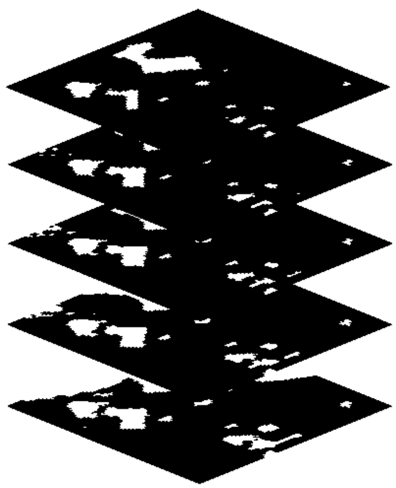

Fig. 2: Vertical segmentation of the laser DSM

Additional discrimination between buildings and trees can be attained by checking the NDVI computed from a multi-spectral image of the study area. Qingming Zhan has prototyped his concept—see [3] for a detailed description—and tested it on data from TopoSys (see www.toposys.com for company information) for two sites of very different character, Amsterdam and Ravensburg.

Figure 3 shows the results obtained for a small section of the Amsterdam test site. Buildings which are either lower (building 1 in figure 3) or higher than the elevated road (building 2 in figure 3) are extracted properly. For the total test site of 3km by 3 km a correctness figure of 96% was obtained.

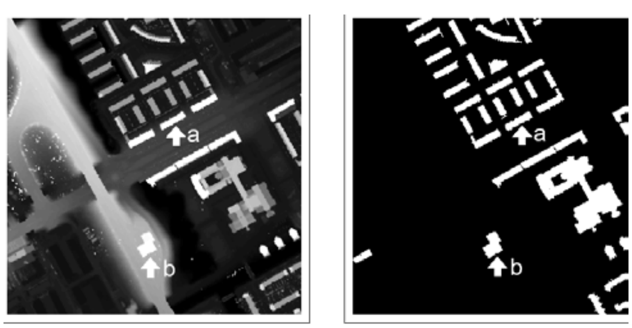

Fig. 3: Section of Laser DSM and extracted buildings [3]

3. Distance-Learning

In 2001 the OEEPE (now called European Spatial Data Research; see http://www.eurosdr.org/ for more information) decided to start an educational service with the idea to present the research results of this European organization the form of short distance-learning courses (DLC). The ITC, having an interest in distance education in the context of its decentralisation policy (see http://www.itc.nl/about_itc/mission_statement.asp for more information), joined the EuroSDR educational service initiative and developed one of three courses, which were given for the first time in October 2002, see [4]. The DLC *Airborne Laser Scanning and Interferometric SAR for High Resolution DTMs* is designed as a 40 hours learning event spread over two weeks and developed as an e-learning venture. The electronic medium allows us to utilize various forms of disseminating information, hypertext, slides, movies, interactive 3D computer graphics, and links to background and related information on the web. The course treats the concepts underlying LIDAR and InSAR, the operational aspects of the active sensor technology, data processing, accuracy and current research efforts, in particular on extracting buildings and generating a DTM in an urban area. We defined as objective that at the end of the course the participant will be able to explain the basic principles and capabilities of airborne laser scanning and interferometric SAR and describe their operational aspects and potential applications. We expect as entrance level a BSc of geo-informatics in particular basic knowledge of image processing and its underlying subjects.

What can be different, what must be different for a short DLC as compared to a workshop or seminar? A DLC can more readily cope with the expected heterogeneity of entrance knowledge by using a highly modular structure and hyperlinks to fundamental and additional information. More and more scientific journals are available on-line, so a course participant can easily consult, eg, fundamental formulae for processing laser data (*eg*, [5]) or s/he can directly check a tutorial on physics of SAR residing on some website (*eg*, www.epsilon.nought.de). Also different learning preference can easily be served by providing various routes in parallel to building knowledge. One student may prefer to read solid text, while another one browses through pictorial material with key phrases. Some may prefer reading text sequentially from paper rather than reading text from a monitor, possibly in a tree fashion, while those who learned to read and write in a computer cluster may rather do the latter. Parallel routes, however, should meet regularly at set out milestones. We can fairly safely assume that also e-learning benefits from a structure and a sequence of events (motivation for a topic, dissemination of information about the topic, interactive work by various assignments, and (self)assessment). The interactive elements (practical work on provided data in a prescribed way, case studies asking for problem solving, questions – answers, (group)discussions, reporting – feedback) are the challenging ones in distance education. The interaction must be very well prepared anticipating various possible courses of action by the students. Software to be used must be available at affordable costs, simple to use, and robust. InSAR processing, *eg*, can be done by ERDAS. ERDAS offers an evaluation license free of charge for one month (and good tutorials on how to use it), so we could include it in our course. For filtering DSMs using SCOP we used another approach. The Institute of Photogrammetry and Remote Sensing of the Technical University of Vienna prepared a guided tour through $SCOP^{++}$ processing with alternatives, input data, intermediate and final results—accessible through Internet and standby of teachers for feedback (see http://www.ipf.tuwien.ac.at/OEEPE/). It may be obvious that also distance learning needs scheduling. We used feedback from the teachers on assignments as a means for the students to assess their progress. Having completed the assignments was the criterion for "successful completion of the course". Those who achieved it, received a certificate.

Building the course as an all-in-one programmed suite, *eg*, Java based, was not an option to us because of the assumed bad cost-benefit ratio. Moreover, separating course material (*ie*, text, slides, movies, VR worlds) from curriculum management (*ie*, student administration, announcements, instructions, discussions, reporting) had two advantages for us. We could use the popular tools for producing the course material with which every teacher was familiar and we could use the material in conjunction with different e-learning software such as *FirstClass* and *Blackboard*. Our development platform was MS Office, but the aim was to provide the material as HTML documents (and VRML files for 3D graphics). The conversion from ppt and doc to hypertext can easily be done in MS Office. The only trouble is that it requires post processing. All the hyperlinks that were inserted in *PowerPoint* and *Word* must be manually edited. This can done by any ASCII text editor. The alternative to prepare the material with an HTML editor is more cumbersome. Also published papers that are available as pdf can easily be linked. The HTML format is very convenient for lateral reading (reading through chains of hyperlinks), viewing animated slides, playing movies—and all that within a web browser. The *MS Internet Explorer 6* must be used for our material because of the above sketched production method.

Fig. 4: Front page of the course on LIDAR

The course prepared in such a manner could have been run entirely off the web. We have chosen, however, to make it available on CD for reasons of flexibility and speed, as not all course elements require an on-line connection. This set-up proved robust. We had no access to Internet for a couple of days while running the course in 2002. ITC's point of presence was gone because of a fire that demolished the computer centre. We also included, a hardcopy of the text material that the students had to read, again for reasons of flexibility—the option to read in the train, in a traffic jam, or in bed was appreciated by the students.

We conducted by now the course already twice, ones as part of the OEEPE/EuroSDR educational service initiative and ones in-house for an international group of mid-career professionals, so we have gained valuable experience. The 16 participants, who followed the first course, came from all over Europe, Turkey, and India. 9 of the 16 received a certificate—which is just above the typical success rate of DLCs. The actual participation rate, however, was much higher. For the in-house DLC we could achieve a success rate of 90%. In this case the DLC was only one module of a degree course and students had to 'successfully complete' it to maintain their chance of getting the MSc awarded. From the students' evaluation of the course it was obvious that the e-learning was well received, especially by those participants that were experienced already in individualistic acquisition of information. We started the three EuroSDR courses with a joint introductory seminar. Also this none e-learning element was appreciated by the students as well as by the teachers.

Beside the lack of face-to-face contact with the students another disadvantage for the teacher is that it takes considerably more effort to prepare a DLC than an in-class course. Much more has to be anticipated and spelled out prior to the course. And reacting to students' questions and output will take more time, unless discussion are very well organised, standard answers prepared, etc. During distance learning it is more difficult to keep everyone on track and that at the same pace at certain moments. Digestible packaging of information, flexible scheduling of common events, alertness of the teachers and high responsiveness seem crucial to success of distance learning. Since overall successful, the EuroSDR courses will be offered again in spring 2004.

References

[1] Zhan, Q., Molenaar, M., Tempfli, K., 2002. Building Extraction from Laser Data by Reasoning on Image Segments in Elevation Slices. *IAPRS* Vol 34, Part 3; Graz, Austria.

[2] Tempfli, K., 2003. LIDAR & INSAR embedded in the OEEPE's distance-learning Initiative. *6th Conference on Optical 3D Measurement Techniques*. Zurich, Switzerland.

[3] Zhan, Q. 2003. A Hierarchical Object-Based Approach for Urban Land-Use Classification from Remote Sensing Data. *PhD Thesis*, ITC, The Netherlands.

[4] Höhle, J., 2003. Report on the first three EuroSDR e-learning courses. *Newsletter EuroSDR*, 2003 No.1

[5] Wehr, A., Lohr, U., 1999. Airborne laser scanning—an introduction and overview. *ISPRS Journal of Photogrammetry & Remote Sensing*, Vol 54; pp 68-82.