

VISION TEACHLETS – WEB-BASED VISUALISATION OF ALGORITHMS IN PHOTOGRAMMETRY AND IMAGE ANALYSIS

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ABSTRACT:

The paper describes concepts and the realisation of vision teachlets for an interactive visualisation of algorithms in the field of photogrammetry and image analysis.

A series of web-based teachlets is being developed, which allow students to learn photogrammetric techniques without any temporal and spatial limitations. The teachlets are meant as an addendum to a lecture series, not as a stand-alone learning tool. Currently there are four vision teachlets accessible on the E-Learning webpage of the Chair of Photogrammetry at TU Dresden, which will be further extended:

- Cross correlation for finding homologous points in pairs of images
- Least squares matching of homologous points
- Space resection
- Morphological operations

The teachlets are developed platform independent in Adobe Flash and Java. The paper presents the features, the technique and the usage of these vision teachlets and will give an outline on our future activities in the field of E-Learning.

1. INTRODUCTION

The content of teaching in photogrammetry consists largely of methods and techniques, which are based on mathematical algorithms and image analysis methods. Traditionally, the algorithms are explained in lectures theoretically and examples are shown. In this way, the lecturer is restricted to the common presentation tools (PowerPoint, AVI-movie, Blackboard, OHP), whereby the interaction and thus the learning effect is often limited. Moreover, the individual speed of learning of students can be considered only insufficiently. In student exercises and project work the students use mainly commercial software packages, where the photogrammetric techniques are implemented, but their interior functionality is not open for the user.

Experience has shown, that the learning effect is much better, if students can 'play' with algorithms interactively in a visual environment (Höhle, 1997). The interaction is given through the possibility of uploading own (image) data and changing control parameters. The visualisation of the whole procedure, including intermediate steps and iterations as well as the results of the algorithms in a web-based tool allows the students to obtain a better understanding of complex algorithms. Furthermore, the use of own input data (e.g. digital images, laser scanner data) may increase the motivation of students significantly.

The advantages of interactive learning tools are also confirmed by (Shortis & König, 2008), which analyse a significant trend in education towards interactivity due to an improvement of the effectiveness and depth of learning. One example of a web-based digital photogrammetric software is presented by (Grussenmeyer et. al., 2002), which was developed in Java and is mainly dedicated to architectural photogrammetry and close range photogrammetry.

2. E-LEARNING PLATFORM

Students use more and more internet technologies for education purposes. They are used to discuss their experiences in web based forums, wikis and blogs. In order to consider this, our E-Learning platform is extended by a web forum, where students can communicate to each other, get in contact with teachers or report technical problems. Other students can benefit from these discussions and teachers are able to derive suggestions for the improvement of the E-Learning modules. In this way, the web forum serves as a simple evaluation tool. The development of more specific evaluation tools for the E-learning platform, particularly for the developed vision teachlets, will be implemented in future work.

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The screenshot displays the 'cross correlation' teachlet interface. At the top, the TU Dresden logo and navigation menu are visible. The main area is titled 'E-LEARNING » TEACHLETS » KREUZKORRELATION'. It features two side-by-side aerial images of a city street scene. The left image has a green bounding box, and the right image has a red bounding box. Below the images is a control panel with the following elements: 'options' section with 'window size' (values 21, 41, 61), 'image pair' selection, 'visualization mode' (two graphs), 'delay' (1 ms), and 'speed' (100). There are 'Start', 'Stop', and 'Restart' buttons. To the right of the control panel is a large empty box, and below it, the text 'cross correlation coefficient 0.9833 (highest 1)'. On the far right, a 'NAVIGATION' section has a 'zurück zum E-Learning-Portal' link, and a 'TEACHLETS' section lists 'Kreuzkorrelation', 'Least Squares Matching (LSM)', and 'Mathematische Morphologie'.

Figure 1. Implementation of the vision teachlet 'cross correlation' on the E-learning platform (<http://www.tu-dresden.de/ipf/photo/e-learning>)

In addition to the vision teachlets, a viewer for 3D point clouds as well as a video viewer is available on the E-Learning platform of the Chair of Photogrammetry at TU Dresden. As one of our main research topics is the automatic analysis of terrestrial and airborne laser scanner data, the 3D point cloud viewer offers students and teachers a simple possibility to visualize 3D point clouds or results of point cloud processing algorithms. The video viewer allows for presenting video tutorials (e.g. screen videos explaining how to control a vision teachlet) or photogrammetric results, generated by students in exercises and seminars (e.g. virtual reality animations).

One main goal of the developments is to connect the different E-Learning modules to a suitable network. This means to define interfaces between the vision teachlets themselves and vision teachlets with the video and 3D point cloud viewer. This also means to connect the E-learning modules with the lectures and seminars. For example the vision teachlets contain links to the corresponding positions of the lecture manuscripts, which are also available online for the students. Vice versa, the vision teachlets are introduced in the lectures.

The E-Learning platform aims to have a logical structure and a consistent design. Fig. 1 shows the vision teachlet "cross correlation" implemented on the E-learning platform of the Chair of Photogrammetry, presented using the corporate design of TU Dresden.

3. VISION TEACHLETS

The vision teachlets are developed platform-independent, which means they work on each popular Web browser (e.g. Firefox, Internet Explorer, Safari, ...) and operation system (e.g. Windows, Linux, Mac OS) without any uncommon plug-in. Therefore they are generated in Java or Adobe Flash, since these are widely-used techniques (see section 4).

Basic features of the existing vision teachlets and those which are still being developed are:

- Import possibilities for user data (digital images, 3D point clouds, etc.)
- Visualisation of the data (plausibility check)
- Possibility to change control parameters
- Visualisation of intermediate steps of the algorithms
- Control of processing speed (slow-motion function)
- Visualisation of results
- Export possibilities for results (graphical/numerical)
- Explanations, literature references

The modules are not access controlled. They are open for each web user, particularly students from other courses and universities. It is planned to implement a user registration in order to be able to document the usage of the teachlets to be considered for further developments.

The teachlet design is not clearly defined in the current status. Due to the different algorithms and developers it is hardly possible to define homogeneous specifications regarding

usability and design. The definition of such specifications is therefore restricted to a minimal overlap (e.g. colours, font sizes).

In the following, 4 different vision teachlets, which are currently available, will be presented as examples.

3.1 Cross correlation

The vision teachlet “cross correlation” (Fig. 1) is developed in Adobe Flash. It visualizes the principle functionality of cross correlation using different image pairs. It calculates the correlation coefficient matrix of a image template – defined in a first image – with a second image. Therefore it can be used to find corresponding points in image pairs.

Currently the user can choose between 6 different image pairs. The upload possibility of user data will be implemented in a next step. The user is able to control:

- size of the image template
- position of the image template in the first image
- visualisation mode of correlation coefficient matrix (linear, logarithmic)
- speed and delay of the algorithm (slow-motion function)
- search direction (linear, helical).

3.2 Least squares matching

Unlike the previous vision teachlet, this teachlet is produced in Java. Therefore the user has to install the Java environment on his computer and activate it in the web browser. The teachlet (Fig. 2) calculates the parameters of a least squares matching. In an iterative algorithm the geometric transformation parameters (translation, rotation, scale, shear) are processed between an image template of a reference image and an image template of a search image by minimising the least-squares sum of pixel value differences between both images. The positions of the image templates can be selected manually. Features of the teachlet are:

- upload possibility of image pairs
- controlling of the size of the image template
- controlling of the maximum number of iterations (in case of a failing convergence of the iterative process)
- visualisation of the convergence in a diagram (translation parameters exemplary)
- visualisation of the template deformation

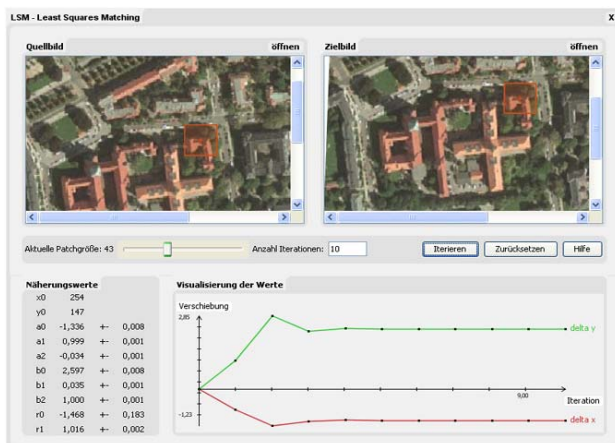


Figure 2. Vision teachlet ‘Least squares matching’

3.3 Space resection

This teachlet (Fig. 3) is realised as a Java Applet. It calculates the exterior and interior orientation, as well as (if desired) additional camera calibration parameters in a least squares adjustment. The user can either chose between two available projects or upload own data. There are examples for user data (coordinate file, parameter file) available for download which define the data format. The teachlet integrates the following features:

- two example projects
- possibility to upload user data
- possibility to select parameters to be estimated in the adjustment
- definition of approximate values
- possibility to select or deselect points
- display of exterior, interior orientation parameters as well as additional camera calibration parameters
- visualization of image coordinate residuals for each iteration step (scalable length) as overlay of the original image (if available)

This vision teachlet contains several information buttons behind each parameter explaining the scientific background of the algorithm. It is planned to implement a tool for interactive image point measurements as well.

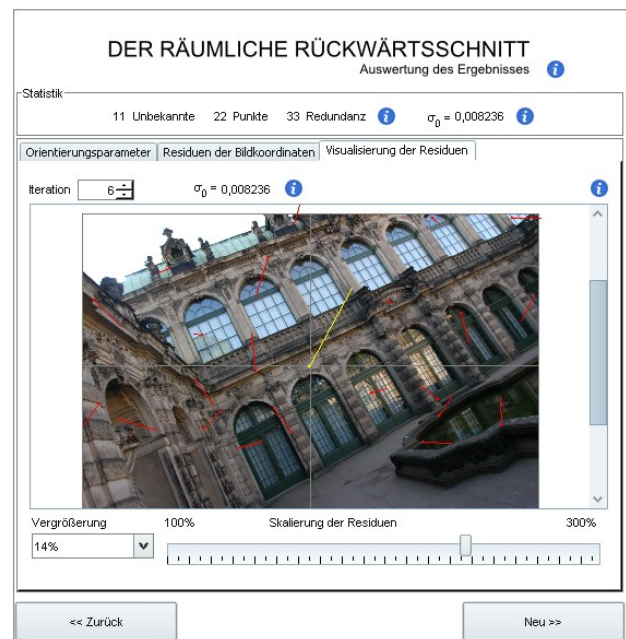


Figure 3. Vision teachlet ‘Space resection’

3.4 Morphological operations

This vision teachlet (Fig. 4) is developed in Adobe Flash and visualizes the functionality of different morphological operations (dilatation, erosion, opening, closing) as well as the functionality of connectivity analysis. It is possible to select pixels manually which are white (on black background) in order to draw 2D objects with arbitrary shapes. The upload of user data (images) and subsequently the implementation of the

binarisation of these images is planned. The following parameters can be controlled by the user:

- size of the image grid (number of columns and rows)
- delay of the algorithm (slow-motion function)
- shape of the morphological structure element (cross or square)
- size of the morphological structure element
- type of morphology
- connectivity neighbourhood (4 or 8 pixel)

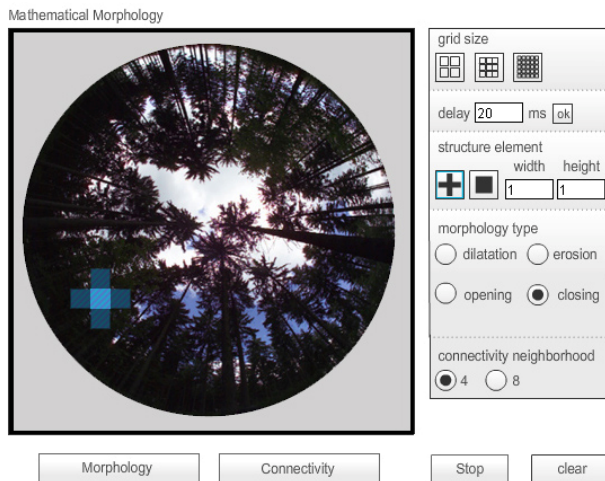


Figure 4. Vision teachlet ‘Mathematical morphology’

3.5 3D Viewer and video viewer

As an extension to the vision teachlets presented above there was a viewer for 3D point clouds developed in Adobe Flash (Fig. 5). The viewer allows for an interactive navigation in the point cloud (translation, rotation, zoom). The point clouds are produced e.g. in student exercises with a terrestrial laser scanner. The performance of this Flash viewer is currently limited to ca. 5000 points. Therefore the possibilities of the Java 3D technology for a web-based point cloud viewer is currently investigated. It is planned to implement data analyse functions (e.g. measuring of distances, filtering, 3D object fitting).

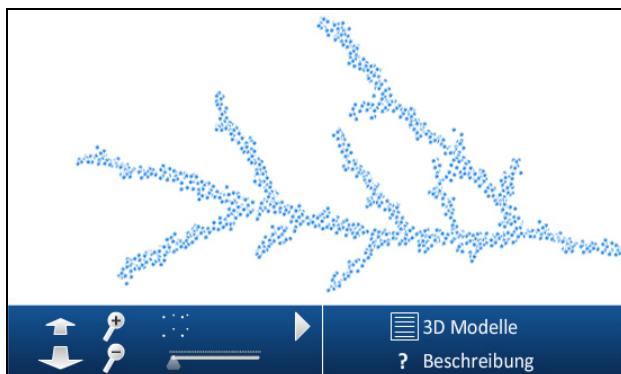


Figure 5. Interactive 3D Viewer (showing a laser scanner point cloud of a branch)

The video viewer was also developed in Adobe Flash. The user can switch between several videos which can be uploaded to the web server via an simple user interface. The video viewer shows photogrammetric products (e.g. virtual reality animations) or screen videos (e.g. vision tutorials which document the usage of vision teachlets) together with a description of the video in text form.

4. TECHNICAL BACKGROUND

Currently we use Adobe Flash and Java to implement the teachlets since both formats are platform and browser independent allowing a wide user base to see the teachlets. Flash is available on over 99% of user clients (Adobe Systems, 2009), and comes with a huge set of given functionality that makes it easy to interact with the user (e.g. user interface components). On the downside, Flash uses Actionscript as a programming language for which many freely available photogrammetric algorithms are not available and therefore need to be converted.

Java is enabled on about 90% of user clients (The counter.com, 2009), and some free photogrammetric algorithms are already available. Using Java, teachlets can be integrated on the web page as applets, or they can be opened as stand-alone applications using Java Web Start.

In future work we will also investigate in other techniques to write and integrate applets such as Microsoft Silverlight, Adobe Shockwave and JavaScript.

5. FUTURE PROSPECTS

5.1 Vision teachlets under development

There are different vision teachlets under development which will be integrated within the E-learning platform shortly. These teachlets visualize the following algorithms:

- Hough transform
- Relative orientation of stereo images
- Epipolar line geometry

Other algorithms are planned to be implemented in future work:

- Image rectification
- Camera calibration
- Spatial intersection
- Direct georeferencing of aerial images
- Multispectral classification

5.2 Features to be implemented

The future developments will focus on interfaces between the vision teachlets, on upload and download possibilities for user data, on more homogeneous design and usability as well as on integrated evaluation tools in order to allow for specific improvements of the E-learning modules.

6. CONCLUSIONS

The presented platform can be characterized as our first steps in the field of E-Learning. It is used to gain experiences regarding the technical background and the effectiveness in its usage in the photogrammetric education. It is still in an experimental status and will be further developed in future work.

7. ACKNOWLEDGEMENT

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