Stereoscopic Matchmoving

Professional Workflow for the Integration of Computer-Generated Objects in Three-Dimensional Footage Using *PFTrack*, *3ds max* and *Nuke*

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Due to the relevance of stereoscopy in media landscape new postproduction workflows and techniques have to be investigated. The matchmoving process which is discussed in this thesis is indispensable for the realization of visual effects and therefore also very important for the success of stereoscopic movies. Beyond experience and knowledge the appropriate software is necessary to obtain high quality results. The theoretical part of this diploma thesis is complemented with step-by-step instructions for the integration of computer-generated objects into stereoscopic live-action footage. This workflow demonstrates the big challenges of stereoscopic filmmaking and shows how three-dimensional processes affect every stage of the production including principle photography, 3d-tracking, editing, 3d-animation and compositing. Furthermore useful solutions are given to manage any kind of problems. Previously you can only find basics but no straight principles or methods of stereoscopic matchmovings in today's literature. Therefore the realization of three-dimensional projects requires a great number of tests and big know-how to tackle difficulties. Another problem is also the big list of stereoscopic words. Sometimes there is more than one term for the same parameter or operation.

For the shooting of the stereoscopic live-action footage a Panasonic AG-3DA1 camcorder was used. The advantages of this camera are the small weight, the simple handling and the synchronization of both lenses and parameters like the zoom, aperture or focus. Due to the fact that the footage is stored on two memory cards a digitalization of the material is not necessary. Before the shooting a careful planning of the camera alignment is very important to reach the desired effect of depth. Therefore the distance between the lenses as well as the angel of the lenses focusing a point in the three-dimensional environment are the most relevant parameters for the pictorial design of stereoscopic productions. For the adjustments of parallax and convergence, how these parameters are called, the crew often uses a monitoring-system to control the three-dimensional effect already during shooting. Relating to the tracking process a precise documentation of the camera setup, the settings and measurements of the set are essential. In some cases it is also necessary to apply a number of tracking markers to reach good tracking results. Especially crosses and triangles are appropriate tracking markers. In addition also table tennis balls are used because they never change their shape, which is very important for a successful tracking. Moreover a consistent distribution of the markers on the vertical, horizontal and depth axis has to be considered. The Panasonic AG-3DA1 has the disadvantage of a fixed parallax. On that score mirror rigs or side-by-side rigs have to be used. Stereoscopic shooting with rigs contains a wide range of challenges including disparities between the two pictures based on horizontal and vertical misalignments of the cameras, focus mismatch, desynchronized stereo, as well as reflections and particles using a beam splitter. Mirror rigs allow a minimum parallax of zero millimeters, which is not possible with the assignment of side-by-side rigs. Furthermore recordings with rigs require much more corrections in the postproduction stage than recordings with 3D camcorders.

The tracking process of stereoscopic cameras is not an easy task, because it requires much more accuracy than in 2D. PFTrack, which was used in the elaborated workflow, enables different methods to solve stereoscopic shots. The left and right eye views of the scene can be tracked independently of each other. But in this case the relationship between the two cameras is ignored. Another possibility is to track only the primary view first and generate the second camera synthetically by translating the analyzed position data afterwards. If the parallax or convergence of both cameras is not constant this method does not deliver a correct result. In this case the stereoscopic tracking option has to be chosen. The tracking process is strongly influenced by motion blur, occlusion, noise, interlacing and soft focus. Another problem is often a lack of trackable features. In the workflow of this thesis useful strategies are described to deal with those problems. PFTrack offers a large range of tools to minimize their negative effect on the solution. Sometimes it is necessary to run several tests and adapt the settings of the software until the desired result is achieved. Summarized it can be said that the success of the tracking process has a big relevance on the credibility of matchmoving applications. PFTrack is a very complex and user-friendly software for the realization of the workflow described in this work. Due to the small price compared to other software packages PFTrack is also affordable for companies with low budgets.

The tasks in the 3D software are nearly identical to those of a two-dimensional project. Only the rendering process shows some differences, because two views from the scene have to be rendered. 3ds max does not offer any special tools for stereoscopic productions. There are only a few plugins, which can be bought for a lot of money. For realistic results image-based lighting, ambient occlusion and rendering with the final gathering method are very important. The long render time based on these techniques has to be noted before starting the image calculation.

In the postproduction stage the compositing software NUKE and the OCULA plugin offer a great solution for the correction of stereoscopic footage and for the parallel editing on right and left views. OCULA for example allows fixing color differences introduced by beam splitters and polarization, correcting vertical offsets or altering the interaxial distance between the two images. This plugin has revolutionized the stereoscopic movie making and was also used in the production of "Avatar" by postproduction companies like "Weta" or "Double Negative". For a comfortable viewing of the result it is advisable to create a side-by-side version instead of anaglyphs because of the ghosting and the strong influence on the colors using this method. Summarized it can be said that the large number of challenges occurring during the production of stereoscopic movies needs a careful planning before the realization starts. Beside a good concept it is also necessary to think about screen sizes and viewing distance of the spectators, as well as other criteria of displaying the movie.

Most of the findings in this diploma thesis come from the elaboration of the stereoscopic matchmoving workflow. All important tasks, challenges and differences to the integration of computer-generated objects into two-dimensional footage are demonstrated. The stereoscopy is a very big topic why it was not possible to describe each section explicitly. Most of the points which are discussed in this work could be used as foundation for other thesis. Nevertheless the most important aspects of stereoscopic productions are mentioned and useful tips for the practical realization are given. In the future it needs further studies to improve new methods, software tools and the depth perception. The described workflow for example has to be tested with other video clips and more complex matchmoving applications have to be explored. While most of the operations used for two-dimensional compositing have their fixed rules, they could not easily inherit for stereoscopic productions.

With the big success of James Cameron's Avatar in 2010 a new hype of the third dimension has begun. Nowadays stores are full of 3D blue rays and the number of 3D-TVs is getting bigger and bigger. Sport events, like the Olympic Games and the FIFA World Cup are broadcasted in 3D and most of today's commercials are already produced in a tree-dimensional way. In addition also notebooks, mobile phones and tablet PC's have this technology implemented, which was first investigated by Charles Wheatstone in 1833. The technical progress, the demand on three-dimensional vision and the big economical profit are only some reasons for the success of this technology.

Despite the high quality of today's movies, there are some problems that could not be solved yet. One of the biggest challenges is the development of autostereoscopic displays. These displays should allow the viewing of three-dimensional pictures without glasses and from random positions for more than one people. There are also some studies for a projection system that needs no glasses. Another goal of today's research is adjusting the depth perception to the natural stereoscopic vision of our eyes. The big relevance of stereoscopy requires permanent improvements and new software tools in all postproduction stages. In the tracking process there will not be big changes in the future. Tracking applications will be more user-friendly and the algorithms which are used will reach a higher level of accuracy and speed. Most of the tasks will be done automatically by the software. Relating to the work in the 3D program tools for previewing the stereoscopic result has to be implemented. The big effort of stereoscopic shooting with mirror rigs and side-by-side rigs should be reduced by fully synchronized camcorders which are able to change the interaxial distance between the lenses. Moreover also problems like color differences and focus differences could be minimized developing such a camera. By way of conclusion, it can be said that the stereoscopic business is an important part of today's entertainment but further developments have to be done to guarantee long success.