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Live Anaglyphic Camera Recordings: A Software System for Real-Time Recording of Stereoscopic Image-Sequences and Videos

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Abstract. Anaglyphs are one of several methods of stereoscopic imaging used in a wide range of applications: from popular film and television entertainment to scientific celestial imaging. Two single views of one scene are differently coloured and merged to one anaglyphic image, by superimposing one upon the other. Anaglyphic projection is a simple and cost-efficient way to create stereoscopic images in comparison to full-color techniques. Anaglyphic projection is thus especially valuable with regard to future low cost applications for educational use in schools; students are introduced to the techniques of stereoscopic imaging, 3D perception, CSCW, virtual and augmented reality (VR, AR) or telepresence. The goal of the LARC project introduced in this contribution was to generate anaglyphic image streams for diverse applications in real time using standard equipment (e.g. one computer and two cameras). The concept and the realization are discussed and a first prototype is presented.

Introduction

Anaglyphic images are a well-known method for the production of stereoscopic images. It is one of the oldest techniques in the field of three dimensional imaging, first introduced in 1853 by Wilhelm Rollmann [Rollmann, 1853].

Two single views of one scene are complementary dyed: one view is dyed red and the other one green or blue. Both single views are merged to one image by superimposing one upon the other. Anaglyph glasses, which have a red filter and a green (or blue) filter as lenses, divide the merged image, so that one eye only receives the red information and the other one the green/blue information. The human brain puts together the information from both sources and this result in a three dimensional impression of the scene.

Anaglyphic photography was most popular in the 1950s and 1960s since it was used for three dimensional movies in the cinema. With the growth and improvement of other technologies like LCD shutter glasses or polarization based projection, the anaglyph technique has been replaced in many applications. Nevertheless, anaglyphic imaging is still a living field of research [Ideses, 2004; Wei, 1999]. Furthermore it is still an interesting way for generating stereoscopic images, especially in a cost-efficient and technically simple way [Vollbracht, 1997] (see Figure 1) e.g. for video-based collaboration or low-cost virtual and augmented-reality and telepresence applications, where color is less important than 3D perception.

The technical goal in respect to these applications was to realize an application which was able to generate a stream of anaglyphic images in real time. Therefore the image streams of two cameras have to be captured and processed. Furthermore it had to be possible to adjust the displacement of the streams of the single images. This was important because of the following two aspects:

- The three dimensional perception depends on the distance between camera(s) and scene and the parallax between the cameras. So it is necessary to be able to adjust the displacement of the image streams against the distances.

- Different users/ viewers have different parallaxes. Therefore, it is also necessary to adjust the displacement of the streams to individual demands.

The application to be developed was designed to run with standard equipment, so that the method could be used on a low cost basis as most schools for example are equipped with.

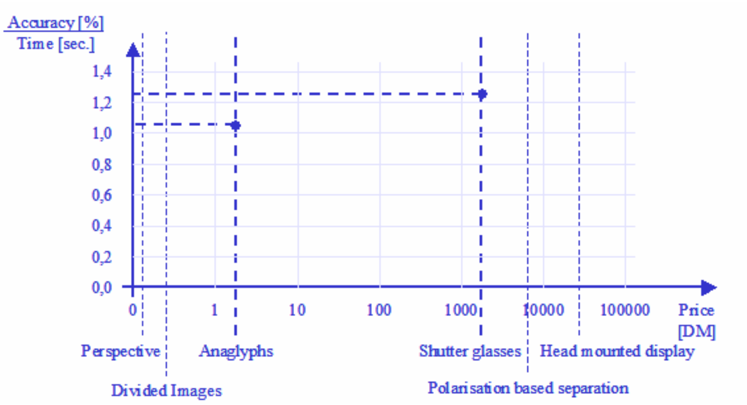

Fig. 1. Comparison of price and efficiency of stereoscopic techniques [Vollbracht, 1997].

Live Recording of Anaglyphic Images – The LARC-Software

The development of the intended application took place in several steps. One goal for the project was that the final application should work either as a stand alone or as an Internet based application. This influenced the decision to use Java™ and the related APIs for the development platform. The preconceptions about the performance of Java applications had to be considered. For the first step, that meant considering the following basic questions:

- Is it generally possible to handle two cameras in parallel to capture the image streams?

- What speed (frames per second) is feasible to insure the real time demands?

- Is it possible to synchronize the image streams in a stable manor?

- Is it possible to dye the image streams separately?

- Is it possible to recombine the dyed image streams to an anaglyph image stream?

Besides the basic questions about the technical feasibility, the question about the quality of generated anaglyph images with the so far chosen technical environment had to be verified.

Each of the mentioned tasks was solved successfully in single test arrangements. The initial results supported further use of the chosen development platform. The results from the single tests influenced the architecture of the software (see Figure 2).

The specific API in the Java™ environment for handling media is the Java Media Framework (JMF). The first released version of the JMF is from 1998 and the actual version is V.2.1.1, but the Java Media Framework is still in progress [Eidenberger, 2004; deCarmo, 1999]. In the current version, it is not possible to handle two (USB-) cameras with the Java Media Framework in one Java™ Virtual Machine. Therefore, the LARC software runs on two parallel running virtual machines.

The main part of the LARC software runs in the first virtual machine. This part connects the first (USB-) camera to the capture device manager. After establishing this connection, the main part then starts the second virtual machine and its respective software. This software tries to establish the connection of the second (USB-) camera.
The LARC software must assure the transmission of the image stream between the two virtual machines. This communication protocol was chosen to be based on RTP (Real Time Protocol), which guaranteed real time abilities that, for example, TCP/IP can not offer.

The next step was to develop an individual codec within the Java Media Framework for dying the two captured image streams. When the red information was eradicated from the image stream captured by the software in the main VM, it resulted in a green/blue image stream. The same procedure resulted in a red image stream when the green/blue information was eradicated. Then it was necessary to displace both dyed image streams in the horizontal direction. Finally, the streams were combined as an anaglyphic image stream and displayed in the GUI of the application.

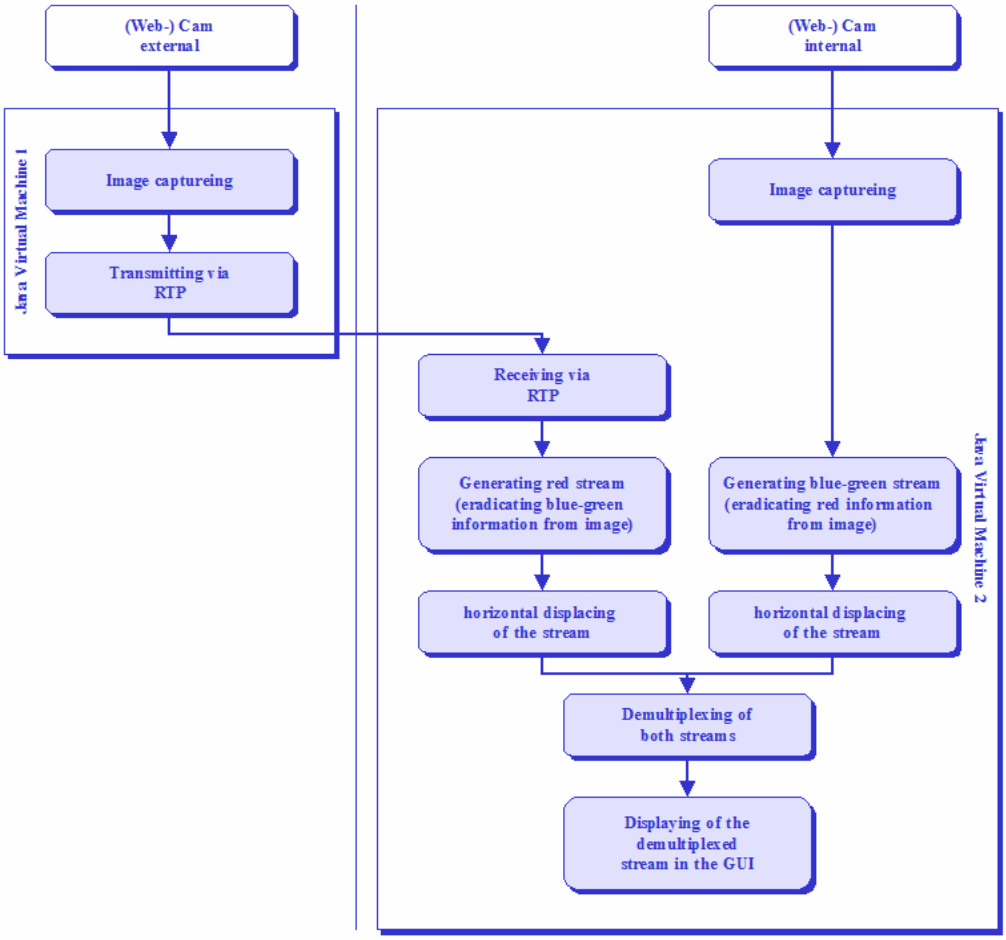

Fig. 2. Architecture of the LARC software.

Results

The architecture (see Figure 2) has been implemented for a test, where the solutions of the single tasks as mentioned above were integrated into the final software version. During the implementation, it became evident that it was necessary to deviate from common conventions of Java™ programming and to use a native compiler instead of the standard compiler of SUN Microsystems™.

The first version of the LARC software was compiled with the SUN compiler and ran on a 1.5 GHz AMD™ CPU with 512 MB RAM. It performed with a frame rate of about 10 frames per second (fps). An improved frame rate of circa 18 fps (on the same computer) was realized by optimizing the JMF codec and its algorithms. The improved software was compiled with the native compiler of Excelsior LLC (www.excelsior-usa.com). Upgrading the computer to an Intel Pentium 4, 3.06 GHz and 1 GB RAM resulted in a further increase of speed (22 fps). The real time demands were therefore fulfilled.

Two aspects, arising from the momentary state of the Java Media Framework, make the individual adaptation of the software somewhat inconvenient. The first aspect is that it is so far not possible to automate the choice of the cameras. Each time the software is started, the user has to choose between both cameras. This is a result of the implemented handling of capturing devices of the current Java Media Framework. The second aspect is that changes in the parameter of a Java Media Framework codec can not be done in the running codec. This means that the anaglyph codec has to be stopped to adjust the horizontal displacement of the images streams and afterwards it has to be started again. Both aspects only occur when starting the first adaptation of the software for a new scene. Once started and calibrated, the software runs stable at the above mentioned performance.

Fig. 3 & 4. Two examples for Anaglyphs generated by the LARC software.

The LARC-Software in Educational Applications

3D-visualization techniques have proven fruitful in numerous application contexts [Bryson 2002]. These techniques are not confined to scientific research. Rather, they have been applied in many industry systems. Due to the ubiquity of 3D-visualization techniques, it is important to introduce students early to such applications. In addition, the K-12 curricula offer various ways to implement 3D-visualization software tools for educational use.

- Computer science. Anaglyphic imaging and stereoscopic visualization are especially well-suited to introduce students to image processing. Furthermore interaction in VR and AR can be presented and practiced to give them a first impression of how to navigate, orientate and work in virtual environments.

- Biology. Anaglyphic imaging and the LARC software supports the illustration of the mechanisms, potentials and restrictions of the human visual system and spatial perception.

- Natural sciences. Many applications based on stereoscopic imaging are used in physics and chemistry to illustrate e.g. how molecules and atoms are composed (e.g. University of Halle, Germany (www2.chemie.uni-halle.de/org/ak_friedemann/stereo_pres.html)). Here, the anaglyph techniques imaging and the LARC software represents a promising way to introduce students to the spatial organization of natural structures.

- Social studies and the arts. Introducing techniques like telepresence and virtual conferences supported by three dimensional spatial perception helps to illustrate the artistic as well as the social dimension of modern digital media.

In most of the aforementioned cases the anaglyphic technique will be adequate, or even the method of choice. For economic reasons most schools are unlikely to buy professional systems, especially since such systems will not be used constantly [Vollbracht, 1997] (see Figure 1). With a low cost solution like the LARC software this gap could be closed.

- The LARC software was designed to be easy to use (see Figure 5). To benefit form the software right from the start, it is not necessary to be familiar with any theory of stereoscopy.

- Just two buttons are essential to know: the “Start” button and the “Stop” button.

- The “Tools” button for the configuration of the cameras becomes important only for calculating the stereo base.

- The combo box “Resolution” helps the user to adjust the image size(s) recorded by the cameras.

- To adapt the anaglyphic image to the individual perception, the horizontal displacement of the single views can be influenced with the slider at the bottom of the LARC GUI.

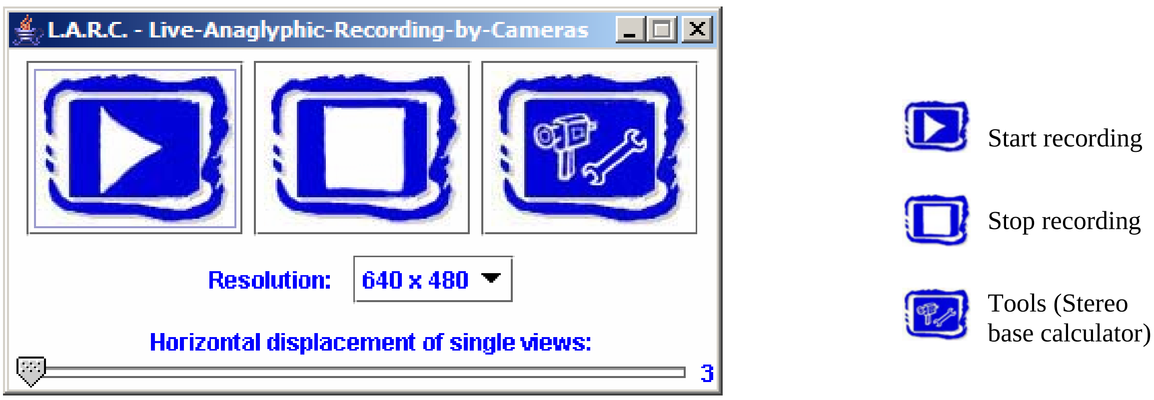

Fig. 5. The GUI of the LARC software.

Further Work

The development of the LARC software shows that it is possible to generate an anaglyphic image stream in real time. The quality of the received anaglyphic image stream is satisfactory. A test with several users showed, that the viewers perceived a real-time video scene in 3D.

The future step for the LARC software will be implementing the anaglyphic stream for Internet streaming. Currently the system is restricted to display the stream on the same computer where the images are stored or captured. Internet streaming would offer the use of the software in a wider range of application areas [del Rio, 2003]. This would allow to control and use the cameras through the internet.

We expect that the system can be used for a wide range of interactive applications like video-based collaboration or low-cost augmented-reality and telepresence applications, where color is less important than 3D perception. Many of these applications can be expected be of high educational value.

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