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Sensible Things that Communicate

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Gaining depth - Time-of-flight sensor fusion for three-dimensional video content creation

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Abstract:
The successful revival of three-dimensional (3D) cinema has generated a great deal of interest in 3D video. However, contemporary eyewear-assisted displaying technologies are not well suited for the less restricted scenarios outside movie theaters. The next generation of 3D displays, autostereoscopic multiview displays, overcome the restrictions of traditional stereoscopic 3D and can provide an important boost for 3D television (3DTV). Then again, such displays require scene depth information in order to reduce the amount of necessary input data. Acquiring this information is quite complex and challenging, thus restricting content creators and limiting the amount of available 3D video content. Nonetheless, without broad and innovative 3D television programs, even next-generation 3DTV will lack customer appeal. Therefore simplified 3D video content generation is essential for the medium's success.

This dissertation surveys the advantages and limitations of contemporary 3D video acquisition. Based on these findings, a combination of dedicated depth sensors, so-called Time-of-Flight (ToF) cameras, and video cameras, is investigated with the aim of simplifying 3D video content generation. The concept of Time-of-Flight sensor fusion is analyzed in order to identify suitable courses of action for high quality 3D video acquisition. In order to overcome the main drawback of current Time-of-Flight technology, namely the high sensor noise and low spatial resolution, a weighted optimization approach for Time-of-Flight super-resolution is proposed. This approach incorporates video texture, measurement noise and temporal information for high quality 3D video acquisition from a single video plus Time-of-Flight camera combination. Objective evaluations show benefits with respect to state-of-the-art depth upsampling solutions. Subjective visual quality assessment confirms the objective results, with a significant increase in viewer preference by a factor of four. Furthermore, the presented super-resolution approach can be applied to other applications, such as depth video compression, providing bit rate savings of approximately 10 percent compared to competing depth upsampling solutions. The work presented in this dissertation has been published in two scientific journals and five peer-reviewed conference proceedings. %In addition, the super-resolution approach has been granted patent protection.

In conclusion, Time-of-Flight sensor fusion can help to simplify 3D video content generation, consequently supporting a larger variety of available content. Thus, this dissertation provides important inputs towards broad and innovative 3D video content, hopefully contributing to the future success of next-generation 3DTV."