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Networked & Electronic Media Initiative,

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joint

Position Paper on Networked 3D Multimedia

Introduction

3D technology is expected to change the way we interact with other people, audiovisual information, and technology. This will in turn affect many domains of modern society, ranging from entertainment, education to medicine and engineering, and might help addressing major societal and economic concerns we are facing. However, wider acceptance of 3D technology is conditioned by solving challenges on the levels of technology, human factors and community/organization. This Position Paper on 3D networked multimedia aims to explain these challenges, to present a common vision on how to address them and identify gaps where further research is needed to develop new and better technology and business models, ultimately for the benefit of users across Europe.

Scope

This paper addresses research areas that allow users to experience 3D media and to actively use 3D technology to: (i) interact and collaborate with other people, (ii) interact with information generated by humans or technology (e.g. automated experiments, ambient sources, interaction logs), (iii) interact with technology (e.g., robots, remote controlled vehicles, etc.), and (iv) to interact with the physical and virtual world or their combination. All this requires significant investment both in technology and infrastructure. The technical areas that need to be addressed are 3D capture systems, efficient 3D formats for compression, storage, transmission and delivery of the captured 3D video, sound and metadata, 3D display and media rendering technologies that allow for different possible human interaction (eg. 3D EPG). 3D display is a very wide term, but bodies like the ITU-R make the distinction between first and second generation systems. First generation '3D' includes 'plano-stereoscopic' systems which provide left and right eye signals. Second generation '3D' include systems which record the 'object wave', and thus provide a more immersive and realistic experience to the user. There are also systems which lie between the two. This document considers both generations and intermediate systems.

Furthermore, we need to understand users' view on these technologies. More specifically we have to investigate different user aspect related to the usage of 3D technology and new ways of interacting by and with this technology. This includes investigating the needs, behavior and experience of the users' and their communities as well as understanding societal impact. This research has to be done with users' participation. It also has to include research and development use cases and new business models exploiting the results of 3D research and development, as they affect the acceptance and success of these technologies on the long run.

Impact

In terms of the amount of information generated, 3D will have an impact similar to that we have seen when passing from Black&White televisions to color and HD TVs, however the change is much bigger in case of second generation technologies.

3D content availability, networked and mobile 3D devices enable people to have brand new experiences, such as exchanging 3D sensitive content, join in 'shared space' experience, move around (and within) sports action by selecting the appropriate desired viewpoint, search data and information sets in new (3 dimensional) ways – and probably many more things; gaming will probably be the leading application for coming years within younger generations, however other applications, such as 3D transmission of medical images that allow remote diagnostics, play also an important role. There is, thus, an enormous social usage dimension that will influence the types of demands put on networks, connectivity, access and display devices. This will require investments in new infrastructure equipment and delivery architectures.

There is a close link between the social demand and social acceptance of a technology, and the economic and technical drive creating that technology. A new technology might languish unused for decades until an additional enabling technology or shift in social perception occurs, at which time there is a sudden increase in investment in the technology, user demand for development and improvement arises and an industry is created. We have yet to see this shift in public acceptance or demand for 3D media. 3D movies are seen as novelties, take-up of 3D home displays is disappointing, and the volume of 'made for 3D' content is very small. For the technology to gain traction, there needs to be a popular application which is only possible with 3D presentation. This may, for example, occur through immersion; shared spaces and productions in which the viewer becomes part of the action rather than a passive observer. For such new formats to be possible, more efficient delivery formats, faster and lower latency networks and truly immersive viewing platforms are necessary. But additionally, the creative professionals need to develop new production skills which move beyond simply adding 3D effects to a 2D workflow, but create new forms of artistic expression, thus creating the unique selling proposition that drives public demand for 3D technologies. There is thus a challenge for technology investment to include a socio-economic dimension, looking to emerging applications as well as technologies, encouraging each to grow and cross-fertilize with the other. Creative professionals at all levels of development, from innovative students to those with many years of traditional experience need to be an integral part of the development cycle, and should have a significant role in the shaping and directing of the emerging technology solutions.

Most of the proposed achievements below are 'soft' results, including content, content creation methods, processes, software components and platforms for various purposes along the chain, measurement methodologies, all of which can be easily taken up and exploited by European SMEs and large companies. In terms of hardware, there are companies both in the capture and display area that are considered world leaders in their respective area, especially in the high-end of the market. Thus these are in a good position to exploit the latest R&D results foreseen in the 3D field.

Importance of 3D content

Critical content is rarely available, and most of the content available nowadays is essentially plano-stereoscopic content. User acceptance and adoption of 3D technology/services is highly dependent on the existence of appealing content. Therefore, more 3D content production needs to be promoted, and consequently new 3D content creation technologies along with the investigation of 3D content quality evaluation and user experience metrics require funding and international cooperation that can be provided through EC funded research projects. This applies both to natural content capturing (robust camera setups, more compact and more capable 3D cameras, 3D reconstruction from widely placed cameras, 3D audio devices, etc.), synthetic content creation (e.g., exploiting acceleration techniques for rendering the same content from a number of viewpoints) as well as post-processing (understanding the consequences of traditional 2D workflows and post-processing effects on 3D vision and find 'replacements' that work in 3D, introduction of depth-aware post-processing, content adaptability for universal access, image retargeting, etc), or the combination of both natural and synthetic content to enhance the immersive experience. Especially in 3D, the seamless integration of theses domains (sample-based real-world data and computer generated content) will become essential. New formats for scene representation, manipulation and rendering are required. Regarding model based rendering of real scenes, allowing the user to move in the scene and choosing his/her viewpoint requires very good and accurate models. In the case of streaming from 3D camera, the viewpoint and the camera have the same location and a complete image as seen from the camera is produced. Missing information not captured by the camera is not necessary in this case. However, if the user is allowed to move around the scene the information has to be complete, but building such complete 3D representations without resorting to synthetic models representing this reality is challenging. Efficient processes for making complete models of a real scene from video based sensors, especially when this has to be done without any optical markers, is today a major challenge on its own, which needs significant research effort. Furthermore, techniques to compress and transmit this data need to be devised given the bandwidth limitations of physical communication channels, also considering radically novel compression techniques not rooted in 2D video compression.

Regarding industrial usage of 3D visualization, huge amount of synthetic content exist in CAD and other systems, which are fairly complete and accurate models of human made structures and objects. On the other hand, producing high-quality models of the world "as-is", i.e. digital models of real 3D objects and structures is a great challenge, as current 3D sensor devices can produce millions of 3D points in a few seconds. To deduct useful, clean and structured information from such 3D point clouds, further coordinated research is necessary to design novel systems and applications using advanced technology (e.g. laser scanners, structured light in combination with camera devices, etc.).

We can also expect that for a significant time – if not forever – 2D and 3D content will co-exist. We ere used to project our world onto 2D (photos, newspapers, books, advertisements, signs, etc.), so 2D and 3D content will need to be "merged" and presented in combination. This is interdisciplinary research that also involves biologists and psychiatrists to find out how humans perceive mixed 2D / 3D worlds.

New business models for 3D

Positioning versus pure 2D and working business models for 3D should be developed, applications that can compensate for the increased cost of 3D production / transmission should be found. Key industrial players are encouraged to seek such applications, taking leadership in specific areas of 3D. Applications providing unique experiences, like live 3D sport and cultural events, should be identified and promoted. Emerging business models will benefit from advanced technology to support widespread 3D content dissemination and open accessibility by citizens, researchers and industry. Seamless access to 3D enabled services over the Internet and mobile networks will drive users into new multimedia experiences, which can give rise to new developments and business opportunities. This requires specific funding for developing enabling technologies associated with market research. A critical factor in the future 3D business is the ability to share the already deployed HDTV delivery infrastructures with 3D content and also the existing population of HDTV receivers (with appropriate updates) to consume 3D content. Therefore, successful deployment of large scale 3D services and applications is dependent on accurate evaluation and forecast of the necessary investment in new technology while taking the maximum benefit from the existing one. The potential for research and development of novel 3D technology in industry and medical fields is also seen as a driving force to create new business models and market development.

Specialized 3D platforms for specific application areas

Different application areas with different requirements for 3D must be clearly identified. Specialized end-to-end 3D platforms need to be researched and developed such that they can be embedded into the everyday life and work flow or establish new practices. Prominent examples include 3D immersive communications and tele-presence (3D capture and optional reconstruction, spatial sound, live transmission and display, all in a convenient way for the user), simulation (interfacing to existing simulation platforms, immersive 3D displays), medical visualization (interfacing to existing systems, PACS, compact 3D displays with very high resolution and color range), digital signage (easy and fast 3D content creation, easy content distribution, maintenance-free and robust 3D equipment), industrial and scientific visualization (seamless interfacing to existing systems, real-time rendering of complex 3D models, real-time ray-tracing exploiting the advantages of 3D visualization), 3D visualization of virtual worlds (providing fully immersive experiences by interfacing to existing and new virtual worlds) and building and construction applications (using the buildingSMART standard and the IFC format, with a high potential for reusability in culture, tourism and training applications).

Common formats and interfaces

As 3D content is expected to be delivered to highly heterogeneous terminals over a variety of means, such as packaged media and networks with and without guaranteed quality of service, common formats that support view scalability (without excluding other types of scalability) and error resilience are extremely needed. Although there are live standardization activities in the ITU and MPEG standardization bodies, 3D technologies today tend to use vendor specific tools, formats and interfaces, which makes the creation of vendor independent 3D platforms hard, if not impossible. For example, the creation of a 3D set-top-box that accepts live 3D transmission in a common format, and plays it on all commercially available 3D displays is not yet possible without interface and format conversions, but is a requirement for widespread adoption. Standardization activities, such as those in the ITU and MPEG bringing all key players in the 3D field together, should be strongly encouraged and supported, seeking for advances that bring future generations of 3D systems to reality, such as multiview systems and its succeeding generations. Multiview plus Depth standard is foreseen to be the way forward, yet research needs to be done to find common formats that are backward compatible with legacy standard and high definition television.

Smooth introduction of future generation 3D services is desirable in the sense that existing terminals should not be totally excluded from accessing the "richer" 3D content (preventing awareness of the new content). For this, coding standards that allow scalability are preferred, for example, AVC-based 2D TV systems can play the 2D part of the 3D content.

Measurement of Quality of Experience of 3D solutions

Quality of experience is a crucial success factor of new 3D services. Although there are some factors and initial measurement devices in this field, there is still no common way and procedure to compare 3D integrated solutions where displays play a major role. Although the recently published SID IDMS standard (icdm-sid.org) contains standardized measurements for 3D displays, these need to be taken up by the industry. However, evaluation of 3D solutions requires measuring not only objective features of different 3D solutions, but also measuring the perceptions of these solutions by the end-users - end-user's experience. Each manufacturer highlights the features and advantages they have, but there is no common way to make an objective or formal subjective assessment of 3D quality that is acceptable and meaningful for an everyday user. Such measurement methods need to clearly indicate the advantages and disadvantages of using 3D displays over a 2D display in specific application scenarios. Working towards a common framework (not necessarily the same for all kinds of 3D technologies) to measure the quality of 3D integrated solutions, taking into account not only the technological elements, but also the environment and the content displayed should be supported. The work done in SID ICDM-3D, 3D@Home and QUALINET are of the first initiatives in this domain, organizations involved in 3D are all welcome to contribute. Objective Quality measures are also needed to understand the overall impact of a complete technology chain on the users' quality of experience.

Reduce the cost of good 3D equipment

Although devices and technologies for creating 3D vision have been available since 1852, and there were several periods in time when 3D came to prominence, it never really became mainstream. Cheap 3D solutions, such as anaglyph, did not spread to the homes, mainly because of their poor quality. Active and passive glasses based systems are now considered the most popular in home and cinema systems, respectively, both having specific limitations on user experience. Higher level solutions, such as multi-view, volumetric or light-field 3D displays are not spreading rapidly partly because of the lack of 3D content, the price of 3D TV sets and the lack of supporting infrastructure in many places. Therefore, research on making high-quality 3D display and spatial audio solutions cheaper to make them more affordable should be supported by research programs in order to potentiate higher user acceptance of 3D multimedia technology and market development.

New 3D displays should be adapted to the special needs of the user in different use cases: Many people watching; Personal display; Portable display; Interacting with 3D content – individual; Interacting with 3D content – collaborative work. Moreover, current 3D displays that do not require users to wear glasses still offer limited viewing angles and thus further research effort is necessary to overcome such limitations, which is also a constraining factor for user adoption of 3D technology.

3D Media Internet

The Internet is not 3D-enabled up to now. The user quality of experience of current 3D Internet technology lags far behind the one of installed 3D applications. Neither can browsers handle 3D-objects (a proprietary viewer can, but 3D is not yet integrated into the DOM, nor are PC user interfaces). Here significant progress has been made recently but needs to be pushed further by the research community. Still, a broad uptake of '3D Media Internet' depends on a significant improvement of the user quality of experience, which should not significantly differ from the quality offered by similar 3D services installed on the user's device. Infrastructure consisting of 3D content distribution and adaptation strategies plus parallel processing capabilities should be developed to provide the user with the best possible balance of visual fidelity of large 3D objects, interactivity in 3D Internet applications and network load. With TVs getting more and more web-like functionality (streaming video, music, photo, web browsing, XML3D) enhancing 3D Media Internet technologies affects even more users and thus becomes more important in the near future.

Network

Although modern networks and broadcasting technologies are much faster and reliable than some years ago, transmission of 3D content, especially in ultra high resolution (4K or 8K) or multiview streams, demands very reliable and adaptive protocols and technologies. Such networks should support monitoring all parameters and QoS metrics that may interfere 3D transmission on the full path from the provider to the end user. The desynchronization of multiple 3D streams may corrupt quality of experience much more than just a desynchronization of audio and video. Networks should also migrate to content awareness, where user may choose both the content and the required quality, and the system automatically selects the best location based on various factors (distance, bandwidth, etc.). Moreover, a network that is aware of user's display technology may automatically propose adequate format or codec – or transparently send the content for real-time conversion. Wireless networks are also next challenge because of much more susceptibility to interferences.

Roadmaps

When more advanced 3D solutions will appear in the consumer market is a question interesting for all players in the 3D field. In this Position Paper we do not attempt to predict this, rather refer the interested reader to existing roadmaps prepared by groups of experts:

- Roadmap for 3D, Immersive, Interactive Media Technology by 3D, Immersive, Interactive Media Cluster (www.3diim-cluster.eu)
- 3D Eco-System Diagram and 3D Technology Matrix by the 3D@Home Consortium (www.3dathome.org)

Final remarks

There should be a seamlessly evolution from 2D to 3D enabled applications and services in a way similar to the evolution from B&W to color TV (scalability). Therefore, early adoption of 3D systems should be promoted by stimulating 3D content production with widespread user access and also thorough investigation of 3D human factors that affect user acceptance and adoption. Additionally, seamless integration and convergence of consuming platforms (e.g., Internet, mobile devices, TV broadcast, VOD, etc.) should be envisaged by EC research projects. Interactive 3D media systems providing richer immersive environments require joint research efforts from the different technological elements present in the chain, from acquisition, processing and/or compression, networking and display.

Conclusions

- The demands put on networks, connectivity, access and display devices due to 3D services require investments in new infrastructure equipment and delivery architectures to support 3D.
- More 3D content production needs to be promoted, and new 3D content creation technologies along with 3D content quality evaluation metrics require funding and international cooperation through EC funded research projects. Creative professionals should be seen as essential contributors to the development of new content production concepts that will drive take-up of and investment in the emerging technologies.
- Efficient processes for making complete 3D models of a real scene from video based sensors needs significant research effort to be funded.
- Immersive 3D real-time communication (ie. 3D tele-presence) and its supporting techniques still need a significant amount of funded research, before it can be used in a commercial setting

- Techniques to efficiently compress and transmit live 3D data given the bandwidth limitations of physical communication channels should be researched, considering radically novel approaches.
- To deduct useful, clean and structured information from 3D point clouds, further coordinated research is necessary to design novel systems and applications using advanced technology.
- Positioning versus 2D and working business models for 3D should be developed, applications that can compensate for the increased cost of 3D production / transmission should be found. Key industrial players are encouraged to seek such applications, taking leadership in specific areas of 3D. Applications providing unique experiences, like live 3D sport and cultural events, should be identified and promoted.
- Seamless access to 3D enabled services over the Internet and mobile networks requires specific funding for developing enabling technologies.
- Specialized end-to-end 3D platforms need to be researched and developed jointly with the industry, such that they can be embedded into existing work flows or establish new practices.
- Standardization activities, such as those in the ITU and MPEG bringing all key players in the 3D field together should be strongly encouraged and supported, seeking for advances that bring future generations of 3D systems to reality, such as multiview systems and its succeeding generations.
- Working towards a common framework to measure the quality of 3D integrated solutions, taking into account not only the technological elements, but also the environment and the content displayed should be supported.
- Research on making high-quality 3D display and spatial audio solutions cheaper to make them more affordable for users should be supported by research programs.
- Overcoming the limitations of current 3D displays necessitates further research effort.
- Infrastructure consisting of 3D content distribution and adaptation strategies plus parallel processing capabilities should be developed.

Contributors

Péter Tamás Kovács, Pierre-Yves Danet, David Wood, David Luigi Fuschi, Ionnais Pratikakis, Guido Becker, Luc Desimpelaere, Paul Walland, Atanas Gotchev, Dave Stefanowicz, Damien Allliez, Thorsten Herfet, Jean-Dominique Meunier, Goran Miljkovic, Amela Karahasanovic, Tor Dokken, Jim Clarke, Carl Debono, Paulo Nunes, Christos Politis, Pedro Amado Assunção, Bård Krogshus, Karsten Müller, Christian Hoene, Paul W. Walland, José Manuel Menéndez, Maciej Glowiak, Benoit Michel