New Imaging Frontiers: 3D and Mixed Reality

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Abstract
For the first time since computers are around, the major pieces of the puzzle are in place to deliver interactive 3D to the average end user. Yet, with the exception of games and some e-commerce applications, the take-up of 3D remains slow. This paper surveys current issues related to the potential of 3D for IST applications and gives an overview of activities most relevant to 3D research. The EU’s 6th Framework Programme is also briefly discussed and orientations for the integration of imaging and 3D research are proposed.

Introduction
Is 3D the future of the web, TV and mobile applications? Looking at the spread of audio and video over the web in the past few years and remembering that the quest for new types of media as part of differentiation strategies is unstoppable, one might be tempted to agree. This would seem to be a natural progression just like when sound was added to silent movies and color surpassed black-and-white TVs. For the first time since computers are around, the major pieces of the puzzle are in place to deliver interactive 3D to the average end user. Advances in key Web3D technologies, bandwidth, and processing power give us the ability to deploy interactive 3D. Recent advances in 3D computer graphics and especially in graphics cards are boosting 3D across the board. 3D graphics libraries provide high-level data structures that can be easily reused. Exchange formats such as VRML, X3D or MPEG4 enable distributed applications and a world-wide access to 3D content, increasing the number of potential users and future 3D applications in a wide range of areas such as E-Commerce, entertainment and virtual prototyping. There is a wide range of hardware/software configurations ranging from mobile devices over standard PCs to graphics super computers. Looking back, games and film production have been the largest markets for 3D graphics, but the untapped potential of the Web presents real opportunities for 3D technologies.
Yet, with the exception of games and some B2B applications, the take-up of 3D remains slow. Although technical advances have laid the foundation for wide spread use of interactive 3D, there is still a significant lack of design experience and dedicated tools that allow a seamless integration of interactive 3D components in current multimedia applications. The reasons may be found in the following observations: a lack of attractive content for 3D and VR applications; a shortage of useful applications for which 3D is proven to be beneficial; a plethora of representation formats and standards and probably a lack of understanding of how users perceive 3D’s added-value.

Content is Key
As users ask themselves how they can benefit from 3D, the lack of compelling content remains a key problem. 3D modelers still do not have enough experience with Web development. Tools are not intuitive enough to help bridge the gap and shorten the learning curve. Image capture and 2D to 3D conversion tools are still insufficient. The efficient repurposing of valuable 3D assets is underdeveloped. Security and IPR protection are also issues that limit in some cases the spread of 3D content. It is necessary to involve content expert users (i.e. designers) in 3D applications research. Authoring tools capable to produce reusable and flexible 3D components and able to configure and compose them would be most helpful in rapidly constructing virtual environments and interactive 3D applications. Models for highly interactive and dynamic content in virtual worlds are needed to help inexperienced users develop 3D/VR/AR content applications. Reusability, extensibility, composability of 3D environments and cost efficiency are essential elements. Interdisciplinary teams are needed to reuse existing solutions by adapting and combining elements to new applications. Content should be developed for VR and virtual 3D environments in
special application areas such as medicine, training & education, manufacturing and entertainment.

**Killer-Apps wanted**

Some businesses are successfully adopting 3D on the Web for B2B applications. For consumers, e-commerce is currently the most successful application for 3D on the web. Internet shoppers have been reported to spend 50% more time in the part of the site that offers interactive 3D images. But it is unclear whether 3D is really impacting profits, and what the prospects are. Other candidate applications include distance learning, medicine, customer service, gaming, and entertainment. We have yet to see effective interactive 3D visualizations of Web sites or desktop and data interfaces, to help people organize their work, data, thoughts and presentations.

In terms of 3D performance and successful applications, games are very far ahead. In a way, if one wants to know where the rest of the world will be in 3 years, he just needs to look at games. Although they are mostly operating in a closed environment, games can play a “pull” effect on other 3D and VR applications. They offer some of the best environments for the introduction of artificial intelligence in virtual and mixed worlds. Digital story-telling for role-playing games is a popular subject in conferences. Games research involves issues of machine learning, heuristic search, knowledge representation, data-mining, networking, and path finding. Social aspects of computer games and research on how humans play games receive a lot of attention. With the opening of some game engines, the academic world is getting involved in some aspects of games developments and general scientific contributions resulting from the study of games start to be produced.

The availability of attractive applications will determine whether 3D on the web will thrive or just become a niche technology. No matter what software is required or how slow the application is at the beginning, there is ground to think that if there is a compelling reason for people to use a new technology, they will go through the trouble to get it. The current success of digital music on the web provides the best example to date.

**Standards are a must**

Enjoying 3D on the web today often requires downloading of a new viewer every time the application changes. A widely accepted standard is needed to make it possible to create content compatible with multiple viewers. There are key developments in XML, VRML, X3D, and Java applets, and open standards are poised to become an essential ingredient for fully integrating 3D into the Web as we know it today.

**Users know better**

After the novelty of the first fancy 3D demonstrations wears off, how will consumers really want to use 3D on the Web, on TV and on other platforms? Usability in 3D, virtual and augmented reality worlds is still a basic research question making qualitative and quantitative evaluation of 3D/VR/AR applications necessary. How do consumers use 3D sites? Does 3D really adds value? Does 3D help in getting the message across and where is the business potential? These are some of the essential questions that need to be answered for 3D to become mainstream on all delivery platforms.

**IST contribution**

The IST Programme [1] and the Action Line “Mixed Reality and New Imaging Frontiers” [2] in particular are there to help answer these questions and develop the standards, the applications and the authoring tools necessary to ensure that 3D is eventually successful (see also [22], [23]). Mixed Reality (MR) was chosen as a central theme because it captures some of the essential ingredients of today’s post-computer-revolution society. The frontier between real and virtual is increasingly blurred, be it in film making, TV, games, shared communication spaces or even parts of the global economy.

For what concerns imaging, MR is considered to be an enabling technology for the future of media, noting that most attractive and modern media exploit some form of mixed reality. MR represents the convergence of research fields such as computer vision, computer graphics, and coding. It is intrinsically multi-disciplinary and constitutes therefore a good framework for collaborative projects. After important investment of community research in audio-visual representation and coding over the past 10 years (MPEG etc…), many significant activities in computer graphics, visualization, VR and computer vision, MR is a natural evolution in terms of combining the realism of real world pictures with the flexibility of computer graphics. The following surveys some of the current key research activities. Examples of applications are interleaved for illustration purpose.

**Key technologies for 3D**

**Pushing the limits of 3D rendering**

Although graphic cards have made tremendous progress over the past few years, the quality of current VR presentation systems still leaves much to be desired, especially with respect to physical realism. In such systems, the shape of objects can be judged correctly, but
not the properties of their surface materials. A realistic impression would depend on an accurate rendition of object surfaces, the display of which is a major weakness of current VR systems, and on the availability of advanced global illumination techniques. Solving this problem requires the acquisition of reflectance properties by measuring real materials. Current BRDF (Bi-directional Reflectance Distribution Function) databases still have fundamental limitations in terms of calibration, accuracy and measurement in spectral space.

High realism visualization for car industry and architecture

The techniques and standards for the measurement of reflectance properties enable suppliers and customers from various industrial sectors of the European industry to better collaborate through digital mock-up procedures. Time to market will be shortened and collaboration among supplier industry and the global acting automotive or building industry will be made more efficient. Simulating safety relevant aspects in automotive industry as well as in architecture will make elaborated safety tests more affordable [3].

A project has been launched to develop a complete VR-system that would not suffer from these shortcomings. This will involve the development of an automatic acquisition system completely covering all viewing and lighting angles that might occur during runtime rendering of real world objects textured by such data. The project will also further the state of the art in texture mapping, LOD (Level of Details), occlusion culling, light simulation and real time visualization and tone mapping. This is expected to offer totally new possibilities for the end users, especially for the automotive supplier industry, as the system will allow suppliers to present new materials and solutions in a virtual prototype before actually producing a physical prototype. This may also ultimately lead to a completely new generation of computer graphics systems.

Capturing 3D and creating attractive worlds

Advances in computer vision and active 3D-acquisition technology are opening new avenues in high-realism virtual world creation. The vision of an interactive video system able to provide tele-reality, immersive scenarios, and the impression that the user is navigating in a real 3D environment is taking shape. This will allow navigation with arbitrarily movements and new images synthesized from viewpoints that were not previously recorded. A system is currently being developed in which computation is proportional to the number of output pixels rather than to the number of geometric primitives as in conventional graphics. It is a trade off between geometry computations and image data in which extremes are full 3D models on the one hand and pure plenoptic models on the other. It will allow implementation of systems that produce high-quality 3D imagery with much less hardware than used in the current high-performance graphics systems. It will enable new classes of applications in entertainment, virtual tourism, telemedicine, tele-collaboration, and tele-operation. It is likely to impact areas such as telecommunications, content management and e-commerce.

Accidents Inspection Tool

An accident site is a hostile environment in which time to collect data is lacking and helpers have to respect a set of priorities such as the treatment of injured passengers and the re-establishment of traffic. A tool that would permit to shoot a video of the accident site, enabling an off-site in-depth analysis (such as simulating the point of view of a car driver involved in the accident, or visualize the accident site from different views including from positions which were not previously recorded in detail because of the time pressure) would be precious [4].

Tele-medicine assistance tool

Proper preparation of a surgical operation is obviously vital. An in-depth visual inspection of the areas that are going to be operated on is essential. For critical surgery operation, generating a new data source that will enable the experts to examine the received video as if it would be a 3D model (although no explicit 3D model would be built) would be precious.

It would allow pre-operative visualizations of liver tumors with regards to anatomical structures (vessels, segments) for inter-operative correlation and communication between surgeons and radiologists [4].

Post-production, special effects and authoring tools

Content, be it for TV, streaming or interactive applications is today increasingly sophisticated, often made of a mix of real and virtual elements. Digital effects have become more and more common for film, for the production of TV programs and commercial video-clips. Latest advances in the fields of image processing, computer vision and computer graphics have enabled the filmmaking industry to merge synthetic and natural content with a stunning level of realism and progressively decreasing costs.

The insertion of virtual objects into real scenes is a common post-production activity that still requires a significant degree of manual intervention. These tend to be implemented using specialized proprietary systems, tailored to particular applications. There is no general-purpose real-time approach to virtual content insertion. Producing the required metadata in a standardized way
would enable the deployment of high-quality generic virtual content insertion systems and would facilitate advanced features such as the casting of shadows of virtual objects onto real objects or the registration of the feet of virtual characters on the ground. The addition of preview facilities would facilitate planning concerning camera trajectories and lighting. The addition of visual feedback, positional and synchronization cues would ease the performance of actors in blue studios. This type of research requires information on camera position, orientation and field-of-view, depth information that can be used to create a 3D model of the scene and depth-sensing cameras to create a 3D model of the front view of an actor.

Tools are needed for a synergetic, interactive, symmetric and seamless mixing of reality and virtuality in linear and nonlinear production. It is necessary to integrate technologies for a high-end photorealistic reconstruction and authoring of 3D environments, which will be suitable for a wide range of extreme modeling situations and set extensions. This will allow mixing of real and synthetic live action in a virtual studio with offline real and synthetic content, while offering a real-time preview of the final result and will open the way to a novel WYSIWYG approach to production, which will give back the director the full control over the filming of live (real and virtual) action. Research is also needed to provide tools for tracking in unknown environment in real time. This will lead to a new generation of chroma key products [5], [6].

As mixed content becomes the rule, it is essential to facilitate the creation and modification of mixed reality (MR) applications. This will enable users, not only expert researchers, to use MR for their applications as well as to create and modify these MR applications with the support of dedicated tools that foster an efficient authoring process. The benefit will be a more widespread use of MR, the ability to transfer MR into different application domains, the exploitation of synergies between different MR methodologies and the establishment of authoring itself as a new application domain for MR. This may result in a more efficient communication of ideas, innovative user interfaces, means to deliver rich, complex content. One current action within the IST program aims at producing best practice examples for using MR in applications, establishing a production process for developing and modifying MR content with design recommendations and specifications of MR gems, MR components, MR frameworks and dedicated MR authoring tools [7].

Animation and Virtual Humans

Virtual humans is a research domain concerned with the simulation of human beings on computers. It involves representation, movement and behavior. There is a wide range of applications: film and TV productions, ergonomic and usability studies in various industries (aerospace, automobile, machinery, furniture, etc.), production line simulations for efficiency studies, clothing industry, games, telecommunications (clones for human representation), medicine, etc. These applications have different requirements. The sheer complexity of the simulated subject, i.e. the human body, combined with the multitude of applications and requirements, make virtual humans a vast research domain comprising numerous research topics. Current research topics concerning body models are realistic appearance and high compression rate that will allow fast modeling on wide area networks. Regarding behavioral animation, the goal is to develop a behavioral model suitable to control virtual actors and its use to create specific human behaviors in which continuity and fluidity of the motion is guaranteed. Standards are paramount if one is to provide synthetic content for networked applications. Both within Web3D and MPEG-4 standards, there are special working groups that are responsible for defining standard techniques for representing and streaming virtual human information [8].

Next generation portals [9]

The next generation of portals on the WWW is likely to integrate intelligent agents embodied in realistic avatars. This will enable new user-friendly interfaces providing easier and more natural access to resources and services that will borrow from computer games. The necessary technology is currently under development and includes:
- Animation of realistic synthetic faces and bodies;
- Software agents capturing human characteristics and learning user profiles;
- Intuitive interfaces for navigation and interaction in information spaces;
- Delivery of information with QoS monitoring.

Human-computer interaction is now increasingly empowered with enriching affective components. Emotions are recognized as an important factor in problem solving capabilities and intelligence. Various actions have been launched to enrich interactions and applications with an affective dimension and to implement toolkits for affective computing. They will lead to a set of components addressing affective knowledge acquisition, representation, reasoning, planning, communication and expression. They introduce drama, story-telling and live interactive dialogue capability into Virtual Environments. They will
contribute to the generalization of 2D and 3D virtual environments shared by synthetic characters and users featuring “anthropomorphic” personality-rich service assistant based applications [10], [11].

**Augmented Reality**

Among novel imaging technologies, Augmented Reality (AR) appears particularly exciting since it allows to combine in real-time the flexibility of computer graphics with the realism of video images. Because they support radically new ways to visualize the world around us, some see AR systems as the new telescope and microscope of the 21st century. AR systems are able to provide intuitive environments, supporting natural interaction with virtual objects while sustaining existing communication and interaction mechanisms. With AR, it is possible to use real world objects as tangible interfaces to make 3D environments attractive even to non-experts. A typical AR setup involves see-through displays, non-intrusive object tracking mechanisms and intuitive user interface mechanisms.

<table>
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<tr>
<th>AR-based interior design and e-Commerce</th>
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<td>An interactive desktop system, where the end-user can easily integrate 3D product models (e.g. furniture) into a set of images of his real environment, taking consistent illumination of real and virtual objects into account. A mobile AR-unit, where 3D product models can be directly visualized on a real site and be discussed with remote participants, including new collaborative and shared augmented technologies. This platform can be used by the furniture industry and retail centers to present their products in an adequate way via Internet. 3D e-Commerce can be brought to the environment of the customer by means of augmented reality [13].</td>
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<th>Enhanced interactive TV experience</th>
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<td>The advent of broadcast digital television (DTV), the advances in 3D-visualisation and image processing, and emerging standards such as MPEG-4, which allows the efficient communication of rich multimedia material including video-audio and synthetic visual objects, open the door to new possibilities in TV viewing. A system will provide TV viewers an enhanced TV viewing experience during the coverage of sports events. It will allow selection and modification of the viewpoint, interaction with visual objects and display of additional information (score, background information on athlete), visualisation of synthetic objects in combination with live video (hockey pucks or tennis balls leave trails - synthetic athletes ) and 3D animations of events. This meets the needs of broadcasters and set-top-box manufacturers for a competitive advantage in the emerging interactive TV business. It will also enhance the user experience by adding personalisation and user-friendly interactivity features [14].</td>
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Up to now, most research and commercial endeavors in the field have been geared towards the entertainment and Internet industries and very little research has been done on AR techniques for industrial, communication, cultural or design applications. The lack of AR tools adapted to such applications causes industries to have a “wait-and-see” attitude. Other factors that tend to limit the take-up of AR in new sectors include the cost of building models and the lack of widely accepted standards making most systems incompatible with one another or with existing VR- and CAD-systems.

A sizeable cluster of projects is addressing these issues and will contribute to a broader take-up of AR. They intend to overcome the limitations of current AR-solutions by developing easy-to-use methods for 3D reconstruction and camera registration, by improving camera tracking using vision methods and by developing tools to reconstruct illumination and material data from images. This will lead to seamless integration of virtual and real scenes through consistent illumination between real and virtual objects in interactive update rates. Some projects include psychophysical evaluation and new tools to adjust the augmented visualization to the brightness conditions of the real environment for see-through systems. Others concern tangible and intuitive interfaces for the manipulation of 3D objects. For some applications, an important element is the addition of multi-user capabilities to guarantee consistent views among participants and network based persistence mechanisms that will ensure accessibility anytime and anywhere.
narrative design of fictional spaces (e.g. frescos-paintings) by rendering realistic 3D simulations of virtual flora and fauna (humans, animals and plants) in real-time in an AR environment. The system will include a mobile AR on-site guide based on immersive wearable computing and a middleware architecture. It is a good example of an interdisciplinary project involving computer vision, computer graphics, user interfaces, human factors, wearable computing, mobile computing, computer networks, distributed computing, information access and information visualization.
Cultural applications of AR

Visiting an archeological site has so far been a low-tech experience. This is about to change thanks to AR. A European consortium is already able to provide the users the experience of a tour in a cultural site with the ability to view the natural environment, to visualise 3D reconstructions of monuments and be assisted during the view by a multimedia guidance system. Cultural site visitors are provided with a see-through Head-Mounted Display (HMD), earphone and mobile computing equipment. A tracking system determines the visitor’s location within the site. Based on the visitor’s profile and his position, audio and visual information is presented to guide and allow him/her to gain more insight into relevant aspects of the site.

Another consortium takes this further and is working on the 3D reconstruction of ancient frescos-paintings through the real-time revival of their fauna and flora, featuring groups of virtual animated characters with artificial life dramaturgical behaviors, in an immersive AR environment. Historical world-class frescos-paintings will be ‘brought to life’, through lively 3D animated revival of their content, superimposed on their real environment. Ancient characters of the frescos (including humans, animals and plants) will be revived and simulated in real-time in 3D, exhibiting in a new innovative manner their unique aesthetic, dramaturgical and emotional elements. This promises to be a new breed of innovative edutainment experiences not unlike those in which story tellers would conjure up visions of events and places, providing their listeners with an impression of realities (often augmented realities) elsewhere in time and space. Mixing aesthetic ambiances with virtual augmentations and adding dramatic tension, can develop narrative patterns into an exciting new edutainment medium in which users are transported in fictional and historical spaces [15], [16].

Coding and standards

Open standards are an essential ingredient if 3D is to become ubiquitous in Web, TV and mobile applications. In a multi-networks and multi-platforms environment, efficient transmission and scalability of 3D content is a must. Compression of 3D models and other geometric datasets used in computer graphics, virtual reality, video games and CAD/CAM is essential for many scientific, engineering, and medical applications. The importance of coding standards should not be underestimated. In some cases, they have created entirely new forms of entertainment and new business models. MPEG-2 Layer 3 (MP3) audio coding is a case in point. MPEG-4 is poised to have the same effect on video distribution.

For 3D, new advances in compression will allow existing applications such as e-commerce, collaborative CAD/CAM, video games, and medical visualization to use larger and more complex models over the Internet than they can use today. In the relatively new field of 3D video coding for 3D-TV, as 3D transmissions should fit within the current bandwidth provisions, the current target for the additional bandwidth requirement for the depth enhancement layer is around 20%. This is a challenging target but it will enable a 2D backwards-compatible coding framework.

Industrial applications of AR

As a sign of maturity of the technology, the use of AR in industrial applications is currently being demonstrated in several projects. In some manufacturing industries, one might think that AR and Mixed Reality have the potential to be the next wave of innovation following CAD and robotics. Among the R&D activities, a set of AR tools is currently under development for automated reconstruction of industrial installations, animation of mixed reality scenes, manipulation of mixed objects by virtual humans, automated view selection and camera hand-over. The potential of AR for training, documentation, planning and maintenance applications will be proven [17].

Standards are needed to make it possible to create content compatible with multiple viewers. The VR community has recognized the growing success of XML, compared to the very limited success of VRML. An XML-compliant 3D standard for the web (X3D) extends the capabilities of VRML and provides a means of expressing the geometry and behavior capabilities of VRML using XML. Building on this, MPEG-4 provides a toolkit of multimedia solutions that developers can use to deliver audio, video, 2D and 3D graphics over a variety of networks and broadcast connections. The MPEG-4 Animation Framework eXtension (AFX) will provide enhanced visual experiences in synthetic MPEG-4 environments. Interoperable tools will collaborate to produce a reusable architecture for interactive animated contents. They will provide higher-level descriptions of animations (e.g. inverse kinematics), enhanced rendering (e.g. multi-texturing, procedural texturing), more compact representations (e.g. piecewise curve interpolators, subdivision surfaces) and low bitrate animations (e.g. using interpolator compression and dead-reckoning). Important requirements are also scalability based on terminal capabilities (e.g. parametric surfaces tesselation), interactivity at user level, scene level, and client-server session level and compression of representations for static and dynamic tools. Contribution to world-wide standardization activities is a corner stone of EC support activities to R&D. Clusters of project are coordinating their actions in particular in the MPEG area.
3D Displays

Suitable 3D displays are essential for the introduction of 3D-TV to the market. Most of the existing 3D displays impose fixed viewing positions. Others include a limited form of head tracking providing a multitude of fixed positions. In between these ‘sweet spots’ an acceptable 3D impression cannot be generated, hence, none of these displays is acceptable for TV viewing. A new project develops a display, that will provide free positioning of a single viewer within an opening angle of 60 degrees. This prototype is targeted towards 3D applications in the Internet (PC) domain.

As TV viewing is typically a social experience, the use of special 3D glasses or single user displays is rather unattractive in a typical multi-user living room environment. Up till now, size, resolution and refresh speed constraints have prohibited the construction of an auto-stereoscopic multi-viewer 3D display. Some 3D auto-stereoscopic displays available today can serve multiple viewers located at fixed positions. This is not suitable for typical living room environment. In the project, a new display providing stereoscopic video to at least four viewers located at any position within 60 degrees opening angle will be produced. All viewers will simultaneously receive the same left and right views in their respective eyes. It will require a multi viewer head tracker which is a very challenging engineering task.

Human factors

With the exception of games for which technology and usage are quite mature, 3D systems are still essentially in a period of innovation with widespread experimentation. There are still essential questions waiting for an answer. Are 3D interfaces the future of abstract navigation? Do 3D interfaces provide a real advantage versus 2D? Are there fundamental aspects to 3D that limit its usage? After all, 2D has offered very useful simplifications for centuries. Instead of taking advantages of the flexibility provided by 3D, too many 3D implementation stick too much to reality. As we primarily need simple interfaces, 3D should be better than reality not be reality. Interaction with 3D is also still very open. There are no really good ways to interact with 3D.

User acceptance studies are taken into consideration from the outset in some projects by a continuous line of human factor studies. This applies to investigation into the effectiveness and functionality of a computer-mediated collaborative working system with particular emphasis on the new features and power that a true visually immersive 3D presence can bring about. This contributes to future standards for assessing 3D collaborative working systems. Since the success of 3D-TV will depend on the satisfaction of the end user, human perception studies are performed. They play a central role in translating the preferences of the consumers into technological opportunities. User control over the depth impression in 3D video has to date received very little systematic experimental investigation. This will be one of the central issues that will be addressed, looking at both basic perceptual and cognitive effects as well as ease-of-use and understanding of how the depth perception develops over time. In addition, the fundamental issue of acceptability of 2D production grammars for 3D video is investigated, requiring a much deeper understanding of how the depth perception develops over time - e.g., how tolerant viewers will be to sudden disparity changes - whilst relating these insights to existing 2D and 3D video production grammars.

3D Television

As early as in the 1920s, John Logie Baird, one of the TV pioneers, dreamed of developing high-definition three-dimensional (3D) color TV, as only such a TV would provide the most natural viewing experience. Eighty years later, these early black-and-white prototypes have evolved into high quality color TV, but the hurdle of 3D-TV still remains to be taken. Yet, 3D is expected to be the next major revolution in the history of TV and 3D-TV will generate a huge replacement market for the current 2D-TV sets. It is generally admitted that technology will progress fast enough to make a full 3D-TV application (content generation, coding, transmission and display) available on the mass consumer market before the end of the decade.

A large project has started with the aim to introduce a 3D-TV technology fully compatible with the 2D technology available today and adaptable to a wide range of different 2D and 3D displays. It is developing a 3D camera to ensure the generation of novel 3D-video content and producing algorithms to provide depth information to existing 2D content. 3D-TV transmission without a considerable increase of bandwidth will be possible and full compatibility with the existing transmission channels and digital 2D video decoders as well as scalability in depth experience and graceful degradation in the case of unexpected errors in depth will be guaranteed.

The project is based on the observation that stereovision is only one of the relevant depth cues and that motion parallax viewing is at least of same importance. The core of the system is a flexible and scalable syntax for 3D data representation, which will be open for different display types and viewing conditions. 3D video will be introduced as the combination of regular video (2D base layer) and synchronized depth information (3D enhancement layers). This will allow backward compatibility to existing 2D video services and scalability in terms of receiver complexity and depth experience. Differences in depth appreciation over age
groups will be taken into account since the viewer will be in control of his depth experience [18].
Framework Programme 6 Perspectives

The European Commission is currently proposing orientations for the next Framework Programme covering the period 2002-2006. The future IST Programme will carry forward the ‘ambient intelligence’ vision with an overall budget comparable to the current IST Programme. It will however bring major changes as far as funding mechanisms are concerned, and mainly be based on new funding instruments such as Networks of Excellence and so called ‘Integrated Projects’. The following is an extract of the current draft Commission Proposal. See [21] for details and updates.

The objective is to strive towards greater integration of research in Europe by means of focused action in priority thematic research areas to bring together the research actors and reach critical mass. It is also to promote the networking and joint action of national and European frameworks for research, and the opening up of national programmes.

Networks of excellence (NoE)

NoEs will strengthen European scientific and technological excellence by means of a progressive and lasting integration of research capacities existing or emerging in Europe at both national and regional level. Each network will aim at advancing knowledge in a particular area by assembling a critical mass of skills. The network will be organized around a core group of participants to which others may be added in order to create a virtual center of excellence. Activities will often be multidisciplinary, and oriented towards long-term objectives. In addition to these integrated research activities, the network’s joint programme of activities will also comprise integration activities as well as activities related to spreading of excellence outside the network.

The size of the network may vary according to the areas and subjects involved. On average, in financial terms, the Community contribution to a network of excellence may represent several million euros per year, depending on the number of researchers involved. The partnership may evolve when necessary, within the limits of the initial Community contribution, by replacing participants or adding new ones. In most cases, this will be done through publication of a Call for Applications. The execution plan will be updated yearly. This updating may entail the reorientation of certain activities and the launching of new ones. In the latter case, and where an additional Community contribution is needed, the Commission will identify these activities and the participants who will carry them out, by means of a Call for Proposals. The Community contribution may amount to up to 50% of the total project budget.

Since they are likely to be an essential element of tomorrow’s media landscape, it is very likely that 3D technologies will continue to be supported within FP6. There will be funding opportunities within action lines dedicated to knowledge technologies and digital content, within activities targeted at intelligent interfaces and surfaces and also within lines directed at networked audio-visual systems and applications.

The 3D research community should take up the opportunity offered by IST to develop Europe-wide networks of excellence and establish synergetic relationships with representatives of other scientific disciplines as well as industry and user groups.

Integrated projects (IP)

IPs will strengthen European competitiveness or contribute to resolve major societal problems by mobilizing a critical mass of research and technological development resources and skills existing in Europe. Accordingly, each integrated project will have the aim of obtaining identifiable scientific and technological results applicable to products, processes or services. The activities carried out in the context of an integrated project will have by definition clearly defined objectives even in the case of risky research. In general, the participants in the projects will be organized around a core group made up of the main participants.

The size of an integrated project may vary according to the themes and subjects, depending on the critical mass necessary in order to obtain the expected results under the best possible conditions. The combined activities of an integrated project may represent a financial size ranging from several million euros to several tens of millions of euros. In most cases an integrated project will comprise a set of specific actions, relating to certain aspects of the research needed to achieve the objectives pursued, of variable sizes and structures according to the tasks to be executed, implemented in a closely coordinated manner. In some cases, however, an integrated project may take the form of a single large project with a single component.

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