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A Technology Roadmap for the Creative Industry

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CRe-AM

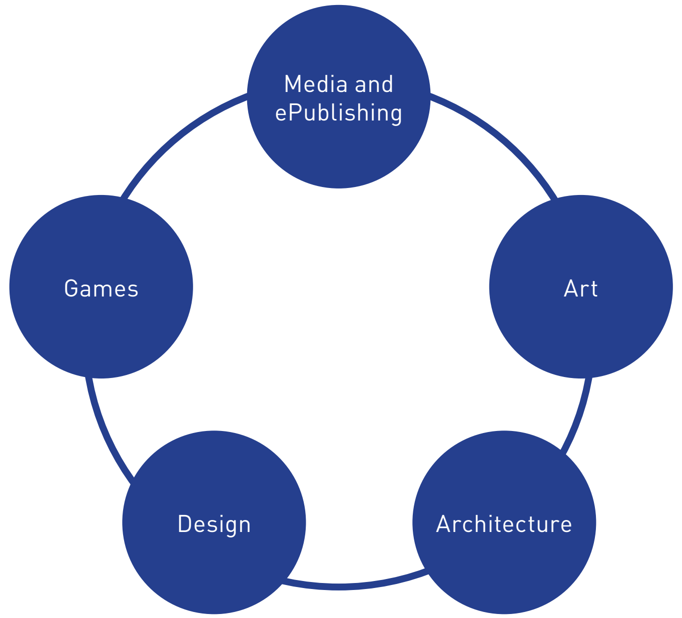
The Creative Research Adaptive Roadmap Project (CRe-AM)

Responding to the current cultural, technological and economic challenges faced by the Creative Industry, the Creativity Research Adaptive Roadmap Project (CRe-AM) is a 2 years EU-funded project that aims to engage a broad cross-section of creative industry partners, research centres and technology providers in a collaborative roadmapping effort to aid strategic planning and recommendations for the future.

The project involves creators who currently use ICT tools in their everyday creative practices, and engages them in a collective dialogue with ICT researchers and developers. The objective is to empower creators by giving them access to new forms of facilitation, enhancement, and contextualization of the creative process and its outputs.

The focus is the future ICT R&D agenda, which will develop new tools for supporting the creative processes as well as enhance and improve existing tools and platforms to be more adapted to, or to better care for, the needs of specific creators' groups. The project aimed at forming a critical mass of ICT and creative communities working together. The main target users are individual creators and professionals, as well as SMEs, creative groups, communities, and institutions.

It is extremely important for the communities of artists and creators, creative professionals, technology experts and IT designers or providers, cultural institutions and creative industries to work strategically together, in order to maximize resources, share expertise and enhance creativity.



The CRe-AM Project

The CRe-AM project consortium is composed of:

University of Surrey	**United Kingdom**
Black Cube Collective	**United Kingdom**
National Center For Scientific Research "Demokritos"	**Greece**
Institut Mines-Telecom	**France**
Fluxguide Ausstellungssysteme Og	**Austria**
Lattanzio Learning SPA	**Italy**
Liverpool Hope University	**United Kingdom**
The University Of Liverpool	**United Kingdom**
Ravensbourne	**United Kingdom**
imaginary	**Italy**
Linkspace Management Services Gesellschaft MBH	**Austria**

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Introduction

The purpose of the Technology Roadmap for the Creative Industry is to integrate the results of the sector specific roadmaps previously conducted into specific technology recommendations. This cross-sector roadmap was prepared by the University of Surrey and the recommendations proposed here are presented under nine particular Technology challenges. These challenges were identified from collaborative work across the sector which collected and analysed input from the experts, creators, innovators, and ICT professionals who participated in CRe-AM events, workshops, interviews and online discussions between October 2013 and February 2016.

This roadmap provides a synthesis of the sector recommendations and proposes research directions highlighting innovative future developments in the Creative Industries across the sectors considered: Architecture, Art, Design, Games, Media and e-Publishing. By assessing their technology maturity in the short, medium and longer term, the roadmap gives orientation towards the development of new technologies in the creative Industries, and aims to provide guidance for informed policy-making.

This roadmap is designed to be accessible and usable by a wide audience, including policy makers, industry decision makers, creative associations, clusters, groups, and individual creators, as well as ICT researchers, practitioners and developers.

"These challenges reflect the visions of the stakeholders' community, and were identified using the input from more than 200 hundred visionary experts, and more than 1000 creators and professionals"

Timescale Methodology

Technology foresight is a field dealing with uncertainty.

This is not only because it makes projections about the future, but also because many technologies are researched and developed confidentially for reasons of commercial interest and patent law. The speed of development and market readiness of emerging technologies is subject to significant factors, such as investment decisions, acceptance, fashions, and marketing.

To assess the likely timescales of technology maturation in the sector roadmaps, we have adopted the "Timeline of Emerging Science and Tech" created by Richard Watson (Now and Next) and Alex Ayad (Imperial College) in 2014, which uses the following three timescales: "Present", "Probable" and "Possible". In grading the CRe-AM roadmap recommendations we deem 'Present' technologies to be viable within a window of 1-2 years from now (2015-2017); 'Probable' technologies to be viable within 2-5 years (2017-2020); and 'Possible' technologies viable in 5-10 years or beyond (2020-2025).

In addition, the CRe-AM timescale methodology takes into account research indicating that few early innovation adopters have different characteristics from people who adopt the innovation at a later stage (Rogers, 2003).

The Cre-AM validation events engaged a number of sector-specific and ICT experts who contributed to the understanding of the characteristics of the targeted communities and the grading of the timescales.

Broad sweeps across the general direction of technological trends and desires are possible, but determining when a desired technology will move from the 'possible' to the 'probable' is very difficult. However, once a technology achieves a 'probable' status it may be possible to scan across the various factors affecting its route to market and user/consumer adoption to suggest possible timeframes in which it may reach a 'present' status.

"When promoting an innovation to a target population, it is important to understand the characteristics of the target people, industries or population that will help or hinder adoption of the innovation."

Key Recommendations

Key findings of this project identify that the focus of future research should be on technologies that facilitate greater interaction and immersion and provide opportunities for new streamlined processes to help future proof the industry.

In particular, focus should be given to future technologies that will aid:

- greater personalisation
- enhanced user interaction
- user engagement and immersion
- creative online (co)working
- collaborative content production
- automated (online) production
- new streamlined ways of content production, consumption, storage and infrastructure
- archiving and digital preservation
- improved methods of content delivery
- collaborative and personalised forms of gaming
- new forms of media such as Visual interfaces, holograms, 3D vision, 3D-physical, VR/AR, as well as new, more effective tools for Digital Rights Management

Challenges & Recommendations

The CRe-AM ICT roadmap identifies a set of 9 technological challenges in the Creative Industries across all sectors and provides a number of key research directions and recommendations for each challenge.

Key

Challenges

Research directions

Challenge 1: Bespoke Technology Development

Lightweight, adaptable and flexible bespoke digital technologies and tools for easy acquisition and creation (including 3D) and for creating bespoke and more personalised experiences adaptive to user needs and desires.

Relevant sectors:

Research Directions:

1: 3D acquisition (or scanning) of data/models, and Multispectral colour & materials analysis combined with 3D scanning

New technologies need to be developed to facilitate 3D model/data acquisition (or scanning) and Multispectral colour & materials analysis combined with 3D scanning, using new materials in that people can engage with directly, perhaps through 3D-reproductions of artefacts

Timescale: Probable

Acquisition technologies:
Multispectral colour & materials analysis combined with 3D scanning can enable complex spectral and geometrical calibrations.

New VR/AR technologies:
To address the inadequate capacity of current modelling applications to approximate the feeling of an object such as touch, material, diffusion of light.

1.2 New forms of modelling and manipulation software, including management software tools for non-programmers (curators, librarians, artists etc.) to manipulate digital objects, and manipulate and use rich, multi-layered structured data files.

Timescale: Probable

Modelling and manipulation:
Instead of using off-the-shelf products, mainly thought for other applications, new modelling and management software tools for non-programmers (curators, librarians, artists etc.) are needed in order to help manipulate and use rich, multi-layered structured data files (i.e. ones which include 3D scans, 3D cameras, 3D projectors, 3D imagination, colour measurements, material descriptions and other metadata) as they become standard and replace flat files (2D images, text files etc.); and provide the capacity for users to rapidly generate multiple alternatives, explore their implications, or revert to earlier stages when needed.

Flexibility and modularity:
More customizable, modular tools to be used in composing other tool sets.

Beginner friendly programming languages
(currently, programming languages are designed for experience developers); "Natural Language" type creative development platforms and improved user interfaces within software are needed for use by people who are subject or domain experts but not programmers (e.g. teachers/artists/learners for developing learning games).

Programming Tools desired:

- A high-quality visual programming interface, along the lines of a plugin
- General-purpose visual programming languages
- Tools of programming accessible and easy to use
- New tools for facilitating ideation into design: applications, software or other tools that can quickly turn ideas to simple sketches/physical objects and enable more effective data flows between design and production
- Socialware to support use and development of applications, software and tools
- APIs offering additional features to bridge between involved apps and offer more refined ways of controlling and processing data
- Better API's, interfaces and interoperability are needed between software and fabrication technologies such as 3D printers, Laser Cutters as well as Construction/fabrication processes

1.3 Mood & Motion tracking, including Wearable tracking:

Identification of facial expressions beyond the 8 core emotional states. Such capability will require technologies and tools that can recognize more complex emotional states (emotion sensors, emotion wearable's, gesture recognition) and social value.
Timescale: Probable

Emotion Tools:
Recent advances in the fields of machine learning, IoT and artificial intelligence have enabled the development of smarter apps, which can identify facial expressions and recognize eight core emotional states – anger, contempt, fear, disgust, happiness, neutral, sadness or surprise - based on universal facial expressions that reflect those feelings.

In addition to this, emotion sensors are currently limited in their capacity to recognize more complex emotional states that might also be culturally dependent, such as confusion, interest and concentration. New sensor, wearables or wireless gesture recognition technologies are needed that would allow for crowds or groups of people to collectively modulate experiences in communal settings. This could open up potential for the more "socially inclusive" experiences.

Motion tracking technologies:
Furthermore, faster motion tracking is desirable. Currently motion tracking cannot keep up with fast movements, and current hardware isn't powerful enough to eliminate the latency that would occur in a Projection Mapping system used in a real-time AR/VR environment.

1.4 Users' behaviour modelling and personalisation technologies, including cognitive analytics (Big Data and Data Mining)

Timescale: Probable

User Profiles and behaviour
Big Data Analytics:
The resources to track and analyse all possible user behaviours and to perform face detection, recognition, and image classification are rarely available, which means designers have to develop new approaches to analytics that considers cost-benefit/risk relationships between the resources required for tracking, storing, and analysing user telemetry/metrics on one hand, and the value of the insights obtained on the other.

Broadcasting:
Automation is key for data-driven digital broadcasting services. Database architectures, machine learning and real-time visualisation give competitive edge. As audiences diversify, there is the need to rely on automated editorial, marketing and advertising processes driven by audience insights.

Behavioural data unlocks new insights by capturing the "who, what and when" of the viewer, and places it in context alongside more traditional asset based data such as plays and subscribers. Large amounts of behavioural and asset based data only becomes valuable through intelligent transformation and interpretation, enabling a better understanding of the audience and emerging trends.

The advent of cognitive analytics means the possibility to automate analytical thinking through machine learning. Cognitive analytics will be not a replacement for traditional information and analytics programs, but they will appear to be capable of improving just about any knowledge-intensive undertaking. Cognitive analytics aims to model and visualise the way human brain processes information, draws conclusions and learns from actions taken and will use technology, computing power and human interaction to process information, generate hypotheses, make conclusions and express recommendations.

Personalisation technologies to deliver personalised experiences and immersive user experiences:
There is a desire for Augmented Reality technologies that integrate and bridge with the real world. In broadcasting, there is also a desire to move away from the traditional twentieth century model of centre-to-the-margin broadcast technologies towards dynamically delivered, location and context-aware as well as highly customisable and personalisable media streamed via Internet Protocol across multiple platforms, sensors, switches and devices. This includes technologies that enable new forms of real time audience interaction – blending live narrative development possibilities with seamless integration of computer generated content with real-life content. There is also a desire for seamless communication between personal devices, wearables and sensors (e.g. in the environment) to handle both interactive content, and to dynamically deliver the most appropriate media type or format for the user's location.

Virtual Reality:
More processing power is necessary so that synchronization between the user moving their head and the picture being adjusted is as near-simultaneous as possible. It is only recently that screen and processor technology have improved in terms of price and performance such that VR is commercially viable, albeit still at high price points for the full featured solution. There is also a need of a symbiotic relationship between content and technology to overcome problems like nausea induced by the use of VR for few minutes. Smells and touch in VR are still at the prototypal level.

Mobile AI:
Advances in both Artificial Intelligence and so-called "neuromorphic" processors that have "human-like" learning capabilities.

Such technologies would enable personal devices to become more like pets or companions in their ability to respond and react to their individual owner's behaviour, tastes and interests.

New advances would allow AI tasks to be performed out to cloud servers using dedicated neuromorphic chips, since the AI could be done cloud-side, taking the burden off of individual computers.

Automated translation and automated transcription technologies:
Providing real-time translation, automated translations of content and transcriptions of media content into major languages for multiple versions of the same content.

Audience Accessibility & Experience in E-Publishing including real-time translation and Transmedia Storytelling:
There were strong desires for improving the ways in which readers engage with e-publications. In-publication search capabilities providing deeper and more extensive results would be highly beneficial and could stem from better metadata standards which could also support discoverability of content elsewhere.

Automated translations of content into various languages were considered highly desirable to open up greater audience reach beyond the home market and enable readers to experience new kinds of content. Need for making devices more intuitive; for instance, to be able to link content from the internet, automatically translate text, licences and keep track for any updating etc., which would be of great benefit to e-learning. The interoperability of content and devices was seen as one of the most important developments to retain the trust of consumers/readers and improve their experience of reading and interacting with publications. Alongside this was the importance of personalisation and customisation of content – weaving individual readers directly intonarratives and adapting their experiences according to the type of device, location and environment /situation. The role of Virtual and Augmented Reality and simulation/ visualisation technologies in transforming the nature of reading and interacting with transmedia storytelling was also considered to have significant potential. Transmedia Storytelling must adopt a new model: many-to-many, multi-dimension, quite relevant, and multi-authored. The cost and capabilities of today's digital media hardware and software makes it possible to create sophisticated, high-quality video, audio, e-book, web, and other content on the average desktop or laptop computer, which can lead into collaborative creation processes.

In addition to these technologies, there is a great potential in the application of 3D readers and the use of holograms, as well as the introduction of gamified ebooks and content which has a social element incorporated also. This can link with the development of wearable technology and the internet of things (for instance, in-car readers).

Real-time automatic translators:
There is a need for real-time translation tool overcoming linguistic, cultural and disciplinary barriers. Current machine translators work only when the text to translate adopted standardized style guides, term glossaries, and some sort of controlled language.

Additionally, there was a requirement of new Infrastructure with common reference framework for Revenue Development & Digital and IPR Rights (protecting the rights of authors, sharing, policies to online trading, taxation, and piracy. This can be a novel public space infrastructure that can be used by multiple client businesses and encourage industry-wide common practice to broaden the market for their suppliers. This should also support their users' creative industries for collaboration and social interaction to support self-expression and play beyond their own circle of family, professional and social relations.

Finally, there is a demand for new tools to support short product cycle, rapidly evolving technology and markets coherent strategic roadmap to provide confidence in future.

Challenge 2: Archiving and Digital Preservation

New archiving solutions and media and forms of collecting and conserving digital content to ensure access to reformatted and "born-digital" content, regardless of the challenges of media failure and technological change. Content production, consumption/delivery, storage and infrastructure needs to be streamlined. There is also a need to develop or refine software and tools and provide more effective forms of socialware to store, conserve, archive, and share content.

Relevant Sectors:

Research Directions:

2.1 Tagging: "Smart Metadata" new tools and methods for creating and working with metadata, to facilitate better use of digital media in the creative industries
Timescale: Probable

There is a strong desire for new kinds of comprehensive content and metadata management systems to enable multichannel publishing and to create 'content eco-systems' that extend beyond the traditional media. Content will need to become scalable across media & devices.

For example, in e-Publishing, readership is moving from interacting with a single paper book towards multimedia e-publications accessed across a variety of devices in different contexts and situations. New technologies are needed to make sure that, in the future, content renders at the right resolution and quality, independently of the specific device it is being accessed from. This **interoperability** will be key for innovation. Furthermore, making content which is compatible with their devices can be incredibly expensive (e.g. i-books), which makes it harder for smaller publishers to make content that users can actually use. Investment in tools to allow this to be done by smaller publishers is needed

Indexing Standards:
NISO (Guidelines for indexes and related information retrieval devices) and ISO (Information and documentation guidelines for the content, organization and presentation of indexes) have almost 20 years. There is the need to developing common semantic standards, which must be understood and implemented consistently (e.g. ISO standards, EDItEUR and IDPF international trade standards, local / national standards).

Metadata Standards:
Librarians rely on several metadata standards: the Dublin Core, Library of Congress, METS, MARC, and (to some degree) ONIX. All of these standards help librarians describe, locate, purchase, and recommend books (and ebooks). There is the need to define one unified Metadata Standard which also allows the description (and consequent re-use) of contents' chunks (e.g. chapter, paragraph, image, diagram, etc.)

2.2 Robust and future-proof file formats - Automatic file migration technologies to ensure preservation of digital content
Timescale: Probable

New technologies are needed to facilitate compatibility of files across different software and platforms. Digitizing: Technology should enable creators to incorporate physical artefacts (at least partially) into its design space so that their natural and experiential qualities can be fully exploited. The research needs to focus beyond merely digitizing physical objects.

New methods are needed for archiving Hybrid Representations:
Many digital artefacts are hybrid digital/physical works (e.g., robotic works) and so their content cannot be entirely contained in the bitstream.

2.3 Infrastructure, archiving, and AI / computational power: – Improved infrastructures (cloud,networking, communications) and software for manipulating complex and large structured data files. Extension and expansion of cloud storage: access points, hardware, wearables.
Timescale: Probable

Enabling new technologies are needed to allow AI tasks to be performed out to cloud servers using dedicated neuromorphic chips, thus taking the burden off of individual computers, since the AI could be done cloud-side; also new artificial Intelligence algorithms to analyse/ model/design complex datasets or systems.

Migration:
Need for automatic file migration technologies to ensure preservation of digital heritage Infrastructure and computational power:

– improved infrastructures (cloud storage, networking, communications)
– software for manipulating complex and large structured data files

Significant investment and innovation is needed in key digital infrastructure areas, such as data processing, data capturing, storage, editing and transmitting/distributing for high resolution large image files captured with 4K – 8K cameras. There is also a need to develop or refine software and tools and to provide new improved forms of socialware to store, conserve, archive, and share content.

There are many challenges in post-production, one of which is simply how to store the large image files captured with 4K – 8K cameras. One production-level camera features 42 cameras capable of 4K resolution. This captures a gigapixel image (about 500 times the size of a standard smartphone image), and shoots at 30 frames a second. One subsequent challenge of capturing images at this level of resolution will determine how to store, transmit and edit these files.

In e-Publishing, as more content becomes interactive and multimedia, publishing will change from being a business that sells static objects into one which dynamically engaged in on-going relationships with its audiences and consumers. The ability to mine data from e-Reader devices and software feedback on reading habits will require considerable resources to store and process – making the relationship between creators, publishers and readers more informed and indicating future potential for personalisation.

However, privacy issues remain significant areas of concern when data profiling users, and whilst this suggests huge benefits for the industry, it could undermine trust between readers and publishers. Technology development is much needed, but it should be centred on the needs and experience of the end user, rather than innovation for innovation's sake.

2.4 AI (Artificial Intelligence) for automatic annotation
New intelligent tools and methods for automatic annotation of digital content will enhance the use of digital media in the creative industries.
Timescale: Probable

AI for automation:
The results of the automatic annotation process are often a disconnected graph, representing an incomplete annotation, or may contain errors. Therefore, a validating and correcting step is often required, and new tools should be developed to achieve this.

Automatic video annotation:
Current automatic approach is to link a bag-of-words of low-level visual features to each of the identified concepts. Clearly there's a gap between human perception and the low-level visual features. This is referred to as the 'semantic gap'.

Automated Content Integration for Improved Discovery:
The availability of services that are specifically designed to support machine-to-machine access, including a comprehensive suite of APIs and content syndication services are still limited to few data sources (e.g. Elsevier). In addition, available APIs use non-standardised format for indexing and retrieving contents.

Challenge 3: Displaying and presenting

Technologies for presenting and engaging people with cultural artefacts.

Relevant sectors:

Research Directions:

3.1 Displays & Holograms: Development of Visualisation: technologies that are 3D to the naked eye (without 3D glasses) including laser-generated images; affordable and mobile holographic projectors and 3D displays; bigger, cheaper and high-fidelity holograms; as well as Interactivity: including touchable holograms, 3D cameras; and True holographic Displays improving the hardware (pixels) or the software (computation).

Timescale: Possible

Development of more immersive, three dimensional, and high fidelity display formats and media is strongly recommended for visualisation across the creative sectors. This direction includes hologram advances enabling them to be bigger, less expensive, and higher fidelity, as well as touchable holograms (e.g. software that relying on ultrasonic waves enabling contact with hologram to exert sense of pressure). This development path may also need to be supported by more mobile and affordable holographic projectors and 3D camera technology advancement.

Promising areas for the future are new projector technologies, electronic wallpaper screens and tools like Google glass as methods of content consumption. There is still a need for the screen, which is illustrated by the fact that screens are now more commonly being fitted with IP connection and feature on-demand TV and IP based services.

There is also significant interest in 3D screens enabling users to view high-quality 3D images without the use of glasses, and laser generated images. Development of screen and hologram technology better approximate final look and form of creations is recommended. There is a need for further development of true displays, as no technology is currently capable of achieving liquid crystal pixels with the pitches (pixel-to-pixel distance, including the unused areas, also known as dead space) and densities (pixels per area) required for 3D holography. This problem can be approached in two ways: by improving the hardware (pixels) or the software (computation). Improving hardware requires smaller and smaller pixels capable of encoding more complex information in addition to faster switching. Improving software requires fast, efficient computation and dynamical representation of high-resolution holograms on existing technology platforms.

3.2 3D scanning, 3D/4D printing, & CNC: Improve cost, access and openness, 3-D printing speeds, surface accuracy, scale, & multi-material printer (quality, variety, durability, intermixture). innovative more efficient. Large-scale 3D printing: sustainable, resilient, and intelligent.

Timescale: Probable

There is a clear need for research and development of advancing fabrication technologies and the integration of these technologies with other stages of the creative process. 3D printing is deeply limited by low quality of material and product at high cost.

Research should address the need for more durable and diverse printing materials and multi-material printers, greater printing speed, surface accuracy, and further advancement of large-scale printing. But at the same time, 3D printing technology and facilities must be developed in a way so as to be affordable and accessible to a wider range of creators and other stakeholders if the disruptive potential of this technology is to be realised. Current 3D printing is limited by low quality material/ product at high cost. Programmable materials developed for 3D printing applications to produce adaptive products whose physical properties alter when triggered by particular stimuli or that self-assemble or self-modify over pre-programmed periods of time. Currently, large 3D printers only use metals, ceramics and sand, which are mainly used for serial production of sand cores and moulds. Advances in 3D / fabrication materials is also an important research direction in its own right, although this does not strictly fall under the ICT umbrella. Specific research directions include advancing the intersection of biological material such as fungus with resistant and regenerative properties, programmable materials able to produce adaptive products whose physical properties alter when triggered by particular stimuli or that self-assemble or self-modify over pre-programmed periods of time. The lack of adequate software to model and control material properties poses a threat for the development of innovative materials, so advances in modelling capacity are also important to support this pathway.

As technologies at the creation, modelling, testing, and fabrication stages evolve three (and four)-dimensionally, better integration will become more important and yield greater benefits. Research is needed to better integrate the 3D design workflow, including the incorporation of more three-dimensional displays and interfaces as covered in 3.1. Further advances are needed to better integrate 3D scanning with 3D printing, and to automatically convert the CAD drawing into a 3D printing file as there is no way to do this currently. In terms of digitizing, further research is needed enabling technology to incorporate physical artefacts (at least partially) into its design space so that designers can still exploit its natural and experiential qualities. The research needs to focus beyond merely digitizing physical objects.

In the CNC arena, research is needed to simplify the integration of CNC machine tools with third party manufacturing management software—develop new communications interface options for CNC systems that fully comply with the open interoperability standard. New CNC technologies could focus on:

- Interface between fabrication technologies like CNC machines and the 3D design environment.
- Open architecture for removing the barriers, limitations and planned obsolescence imposed by proprietary CNC control systems

Further advancement of 4D printing is also recommended, as this technology is currently limited by high initial costs partially due to there being only a few companies currently developing techniques that support 4D. Research directions include production of larger structures that can handle more complex transformations of printed materials, as well as smaller, miniaturised models. And while deformations can be applied and reversed repeatedly, the material has been found to degrade over time, so there is the need to improve its long-term durability.

3D Data re-use and exchange:
Compatibility of the best and most modern forms of 3D file standards. Opening a 3D file designed in one vendor's CAD in another system without a format conversion process results in inconsistent or sometimes broken geometry and loss of design intent. Each 3D CAD model springs from an underlying mathematical kernel that created it, and each interprets geometry differently.

New 3D Printing technologies:

- Limits in scale, material and methods (like projecting, spraying, and pouring).
- Printers must be made smaller, easier to transport and more economical
- Lack of reconfigurability

3D scanning:
Technologies to increase the accuracy of the models and accessibility of 3D scanning

3.3 Improvements in wearable head mounted displays and addressing latency issues.

Timescale: Probable

Improving the telemetry of motion capture, gesture, eye and facial muscle tracking would help solve many of the existing latency issues experienced with current Virtual Reality technologies such as head-mounted displays (HMDs) as well as side-effects such as motion sickness which have been widely reported and have become a significant limiting factor in adoption. Such improved spatial perception capabilities would also have the benefit of providing safeguards for users when using immersive VR technologies both in public places as well as in site-specific contexts.

3.4 Augmented Reality /Virtual Reality: develop visualization and modelling capacity with feeling/ haptic sense, photorealism; Mobile augmented reality pervasive experiences integrated into the physical world.

Timescale: Possible

There is interest in applying VR & AR to visualization, modelling, and user testing with enhanced approximation for haptic sense, photorealism of actual material, and diffusion of light. Senses like smell and touch in VR are still at the prototypal level, and should be developed further.

Research should also address using Augmented Reality for physicalisation of textual narratives into the real world using AR glasses, VR, experimental body technologies, cyborg implants, and wearable technologies for performers and audience. New multisensory engagement technologies for interaction and interface may include gesture recognition, eye-tracking, biometrics, Robotic automation, and technologies that work on optical perception to produce images to get technology 'out of the way' in AR and VR.

For Virtual Reality, more processing power is needed so that synchronization between the user moving their head and the picture being adjusted is as near-simultaneous as possible. There is also a need to develop a symbiotic relationship between content and technology to overcome problems like nausea induced by the use of VR for even a few minutes. The lack of broadcast grade or even hobbyist cameras capable of capturing VR content (meaning little VR content exists) is a fundamental constraint and key reason for VR's minimal impact on TV and movies to date. Hence, VR camera development is also needed to support this pathway.

3.5 Open-source 3D complexity modelling tools and sensing systems
Timescale: Probable

This entails the development of open source versions of 3D complexity modelling tools and sensing systems. Under-financed parts of the creative sectors such as artists need better access to tools allowing them to manipulate and use rich, multi-layered structured data files (i.e. ones which include 3D scans, colour measurements, material descriptions and other metadata) as they become standard and replace flat files (2D images, text files etc.). Creators with fewer resources must currently use off-the-shelf products, not well suited to their needs, whereas open-source development would support wider access and greater specification.

Desired Modelling technologies:

- Predictive tool allowing explanation of the properties and behaviour of materials.
- Parametric Modelling technology: (a) to reshape urban planning by modelling an entire neighbourhood to determine the optimal size and shape of the various structures to make more efficient use of lots, building materials, and energy, and (b) to take human proportions and movement into account for example, does full-body physical simulations for the design of cockpits or workspaces. Parametric models can be used to simulate a body walking through a given space in a way that walking distances or ergonomics can be optimized.

Challenge 4: Interaction and Engagement

New interfaces for creation: Immersive and Interactive User Interfaces

Relevant sectors:

Research Directions:

4.1 Interaction technologies: such as sensors supporting gestural interfaces (for individuals and groups of people); making computers smart enough to reliably recognize non-verbal cues from humans in real time
Timescale: Probable

Multi-media consumption:

- The performance of multimedia for users who are mobile and switching across a range of devices needs to be supported in new ways. Alternative approaches to loss of signal, data speed and bandwidth, could take into account the users context and location to provide a "Graceful network degradation", fading away instead of stuttering or freezing. And more use could be made of the affordances of low-fi screens to create compelling new experiences where relevant, instead of constantly seeking to present content in the highest resolution possible
- With the new media consumption paradigms, nowadays there seems to be a desire for seamless communication between mobile devices and sensors (e.g. in the environment) to handle both interactive content, and to dynamically deliver the most appropriate media type or format for the user's location. Many new content formats are emerging. For instance, emotionally sensitive content which curates content based on the mood of the viewer. Furthermore, gamification was discussed as going hand-in-hand with tools that allow for audience interaction. There is however some caution in moving towards the gaming territory, as some experts believe this signals the surrender of the narrative. The inclusion and creation of social media content was discussed, for instance, being able to share or discuss content with users and friends in real time alongside broadcast (i.e. on the same screen) or the use of existing social media platforms to host extra or bonus content
- Interactive Videos - Immersive video, "Played anywhere", user-tailored experience

Sketching to reality:

- Technology translating a sketch to a tactile creation or prototype through a simple, intuitive, interface not involving a keyboard or mouse
- Advances enabling sketching input more closely approximating artistry of hand-drawing

Human machine interaction:

- Improve the ability to recognize detailed gestures to provide designers with a vast new palette for defining interactions. Gesture recognition, tapping patterns, data and vibrational communication are some of the capabilities that can enable the future of screen-less interactions
- Replace keyboard and mouse with interactive touch panel supporting multi-touch gestures

Further visions for new interfaces also focused on the idea conceptualization phase. There were strong desires for the ability to use hands to create and edit, and a shift from the mouse to haptics and sensors. There is an interest in intuitive haptic and mind-controlled tools, with a sentiment that simplicity is key to success in this area.

4.2 Multisensory engagement technologies - allowing transfer of smell, taste, touch, sound, or capture moods via brain waves, for greater immersion - adding smells and touch in VR (AR) , screen-less interactions
Timescale: Possible

- Usability, tactile features (haptic feedback), linking physical and virtual in the sense that there should be equivalence between virtual and physical in iterative processes
- Introduction of 3D in the process. The loop from virtual to real and back needs to be made to work
- Analysis/definition of analogue features of objects and their transfer to digital world, their interaction with human senses. Today's technologies support what we can see and what we can hear. But what we can touch, taste and smell still has a long way to go
- Apply VR & AR to visualization, modelling, and user testing with enhanced approximation for haptic sense, photorealism of actual material, and diffusion of light

VR issues requiring new technology:
- Capacity to approximate the feeling of an object such material, diffusion of light
- Tactile feedback technology that recreates the sense of touch by applying forces, vibrations or motions to the user.
- The field of view (FOV) is still too low, which prevents full immersion
- The resolution of the screen is too low which provides a pixelated display and a screen-door effect

Holographic 3D requirements:
- Accuracy and reliability
- Size limits
- Weight and portability
- Reduced time needed to make a hologram from the wide range of 3D data sources: CAD/CAE/CAM files, BIM models, aerial photos, radar and laser scans, and files from popular 3D data programs/formats like Maya, Sketch-up, 3D Studio Max and AutoCAD

Dimensional and sensual advances to modelling & visualisation mediums:
Interactive art installations are generally computer-based and frequently rely on sensors, which gauge things such as temperature, motion and proximity that the maker has programmed in order to elicit responses based on participant action. In interactive artworks, both the audience and the machine work together in dialogue in order to produce a completely unique artwork for each audience to observe. However, apart from the area of research of seeing/vision technology now reaching a point of enabling the recognition of some emotional states, the multisensory technologies that allow the transfer of smells, tastes or capture moods via brain waves are still in their infancy.

New technologies are needed to make computers smart enough to reliably recognize non-verbal cues from humans in the most natural, intuitive way possible: how does a computer recognize a natural gesture in real time, and what are its semantics? What roles does it play in communicating a mood? When do you use it? When do you not use it?

Investing in input sensory technologies for creation is strongly recommended. Research into improved sketching inputs, as well as gestural, and mind-controlled interfaces is recommended, as is the integration of these inputs with software and fabrication technologies. Development may involve technologies such as sensors, wearables, photogrammetry, 3D scan capture, electroencephalography (EEG), brain computer interface (BCI), and human machine interface (HMI).

Innovative 3D screens or other medium better approximating final look and form:
Overall, there is a strong desire for fabrication technology advancement, but there are limitations at the ideation/design phase of the workflow, so it is important to address current deficits with modelling software and screens, as well as ideation interfaces (see Challenge 3).

Advancing 3D modelling to improve the 3D representation of design ideas—with additional sensual properties such as haptics and material—is recommended. This may include innovations such as a more advanced 3D interface for the design of 3D-printed objects, and improved representation technologies—3D "screens" or alternate representation media are still underdeveloped. There is also interest in applying Augmented Realityand Virtual Reality technologies to present and test products for clients and customers in user research. At the digitization stage, technology should be able to incorporate physical artefacts (at least partially) into its design space so that designers can still exploit its natural and experiential qualities. The research needs to focus beyond merely digitizing physical objects.

New interfaces for creation need to be developed to improve interaction with software at the creation stage through better input sensory interfaces and devices. Physical Input devices and devices based on input sensors should be strongly supported – particularly, input devices that facilitate development of ideas, creativity and insights, beyond the traditional use of controllers such as keyboard, mouse and graphics tablet are needed, especially with emergence of 3D design that leads into Augmented and Virtual Reality editing. Sensor based input devices such as cameras, 3D scanners, 360 and 3D systems as well as material texture property capture that facilitate more immersive, enriched representations of real world features into architectural model environments are needed, especially with emergence of 3D design that leads into Augmented and Virtual Reality editing where more realistic multisensory feedback will inform presentation of designs.

4.3 Brain technologies/interfaces for designing directly using the brain
Advanced "Brain Computer Interfaces" for creation
Timescale: Possible

- Developments enhancing human senses and connecting them with technology
- Advances in cognitive neuroscience and brain imaging technologies to provide designers with the ability to sketch or model directly using the human brain

Challenge 5: IP, Security & Data Protection

New Infrastructure and common reference framework for Revenue Development & Digital and IPR Rights management (protecting the rights of authors, sharing, policies to online trading, taxation and piracy); detection of copyright violations and alerts to copyright owners; prevention of data piracy and securing data from hacking and theft. Furthermore, DRM standards, including unique identifiers and an allied metadata standard, are required.

Relevant sectors:

Timescale: Possible

Research Directions:

5.1 Watermarking
Timescale: Probable
More effective watermarking techniques need to be development to protect digital or IP rights.

5.2 Cryptocurrency
Timescale: Possible
Blockchain technologies will provide new ways to track and verify ownership through tools like smart contracts – e.g. use of the blockchain to build a worldwide ledger of art and collectibles, coupled with museum standard metadata, to provide immediate value for artists, collectors, appraisers and insurers; also use of "bitcoin-type" systems to track and control where digital resources go.

5.3 Permission-less distributed databases
Timescale: Probable
Permission-less databases with tracking systems for database handling that protects IPR.

5.4 Digital Distribution strategies and Digital royalty payment systems
Timescale: Probable
Within e-Publishing, publishers are likely to adopt a more balanced view of Digital Rights Management (DRM) that recognizes the importance of both enhancing the consumer experience and providing adequate technical and legal protection to the intellectual property rights of authors and publishers. Publishers who understand, even embrace, this critical point will be poised to prosper in the e-book market for years to come.

Furthermore, in the creative industries, a new infrastructure and common reference framework for Revenue Development and Digital and IP Rights management is needed. Linguistic barriers also inhibit progress in this domain; there is a need to create a specification language / standard vocabulary to describe DRM and related issues, and to standardize these practices. Publishers' and media creators' requirements for DRM trust infrastructures must be clearly articulated.

Digital Content Delivery | Real-time coding | Adaptive bit rate | Network infrastructure

Challenge 6: Better Digital Content Delivery/Broadcasting

New formats for content delivery represent a key area for large scale innovation: Holographic displays. Ultra HD and 8K, and 3D technology. New fibre-based transmission technology will offer stronger bandwidth that will allow for better quality content to reach the end users. The introduction of 8K etc. will offer an improvement, but not radical enough. There is still a need for the screen, which is illustrated by the fact that screens are now more commonly being fitted with IP connection and feature on-demand TV and IP based services

Relevant sectors:

Research Directions:

6.1 **Real-time video coding - unified standard for encoding videos, including 3D multi-view videos**
Timescale: Probable

6.2 **Adaptive bit rate - significant reduction in content quality variance**
Timescale: Probable

In broadcasting, there is a desire to move away from the traditional 20th century model of centre-to-the-margin broadcast technologies towards dynamically delivered, location and context-aware as well as highly customisable and personalisable media streamed via Internet Protocol across multiple platforms and devices. Adaptive bit-rate technologies will help realise this vision.

6.3 **Seamless fast network infrastructure including 5G and Internet of Things.**
Timescale: Probable

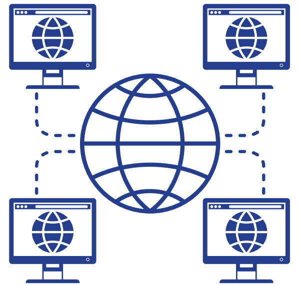
In terms of how the content will reach these delivery platforms, the potential that 5G has for the sector is cited as having massive potential in aiding innovation. When 5G coverage becomes available, it is believed that the way we consume content, and the amount of content we consume, will shift massively. Further, when all our screens will have IP connection, and can all communicate with one another, this too will change the way we consume media content.

5G and cloud computing extended with new "fog"/"mist" infrastructures can contribute to this vision.

Content tools | Open source platforms | Automated content integration | Real-time translation | Real-time collaboration

Challenge 7: New Content Production, Collaboration, & Connection Tools

Relevant sectors:



Research Directions:

7.1 **Improved/new Open source platforms for creating, sharing, searching, and collaborating - Tools that enable creative professionals to combine live performances, video and computer-generated imagery in real time.**
Timescale: Possible

This research direction brings together a number of desires for open platforms, tools and formats to advance to future of creative production. Firstly, it requires creative & collaborative real-time production platforms, technologies, and tools that enable creative professionals to combine live performances, and computer-generated imagery in real time to create imaginative entertainment, experiences, and social value, thus enhancing the user experience. There were widespread expressions of a need for much closer collaboration between content creators (including editorial) and technical developers in the design and development of tools and technologies for the media industry. There was an emphasis on the need for technologies to be developed hand in hand with their users, so that innovations in creative production tools would be driven by needs and affordances derived from working practices, sector-based knowledge and insight. In particular, there was a call for 'tactile' tools to facilitate collaboration between the different skillsets involved in media production, from creation to post-production. There was also a strong desire for open formats to become standard across the industry, streamlining many processes from content creation, editorial and post-production, through to broadcast and distribution. The development and standardization of open formats is widely acknowledged as a difficult challenge, however, and there are concerns around creating a monopoly of the market.

Open Design is a second research direction recommended in this area: democratising design by lowering costs, increasing accessibility of creative production, and closing the gap in access to technology and resources for public sector & service designers. This includes open source platforms for creating, sharing, searching, and collaborating as well as open design blueprints. There is an anticipation that new technologies will democratize design by lowering cost and increasing the accessibility of creative production. This is expected to involve more co-creation; more fluid ways to find collaborators and build partnerships; open blueprints for design artefacts; and open platforms, with which people can interact, customize, and personalize services. There is enthusiasm about the potential of open-source platforms, but also criticism that many open tools do not currently provide viable solutions. Commercial tools are typically seen to be more usable and provide better cross-platform integration. Further development of open tools and platforms to be more user-friendly, commercially viable, and have better cross-platform integration is recommended. Development also needs to address quality, intellectual property right issues, and convergence of standards and policies for integrated, open source approaches to design workflows.

Future any-to-any collaboration technologies could focus on:

- Collaboration tools to collaborate with anyone anywhere, on any device, using any workload
- Extension of rich collaboration capabilities to anyone, even if they are not using the same endpoint or system
- Simplification of the experience and extend the benefits of in-office collaboration to mobile workers and teleworkers
- Ability to share, store, distribute and collaborate with remote project teams inside a single easy-to-use application, with no hardware or software required

7.2 Automated Content Integration – and Automated Post-Production for improved discovery: Data sources and services specifically designed to support machine-to-machine access to contents, APIs using standardised format for indexing and retrieving contents, including a comprehensive suite of APIs and content syndication services.

Timescale: Probable

There was a strong desire for a range of new technologies and standards to tackle the complex processes and differences in skills in the post-production phase. The automation of logging, incorporating automated interpretation of content was considered to be highly desirable, as well as systems that could perform automated content curation. Such tools could make major improvements in collaborative workflows and practices between, for instance, producers and editors. Creating tools for directors and producers to generate automated timelines from logged media before handing over to editors was seen as having huge potential. The same was the case with collaborative production platforms that allow for interactive and collaborative tools by media creators, producers, directors, editors and distributors to address interoperability and interconnectivity.

The enhancement of tools to facilitate transmedia storytelling, and the development of a new model that includes many-to-many, multi-dimension, multi-authoring and relevant material. Across the board during validation, this was highlighted as a key issue,

and it was said to be highly innovative, suitable, adaptable, exploitable, impactful, sustainable and usable. Cloud computing, 5G and new digital Platforms (broadcasting, news online, digital library, digital museum, digital publishing base, digital television base, digital publishing and digital formatting).

7.3 Automatic Real-time translation and communication tools overcoming linguistic, cultural and disciplinary barriers.

Timescale: Possible

Tools Include:

Real-time translation tools for linguistic, cultural, and disciplinary barriers, enabling team-members and other stakeholders to collaborate more quickly and smoothly.. Technologies improving communication between engineers and designers, such as a high-quality visual programming interface enabling experimentation with new software programs in the same format, and tools relating abstract project concepts with actual requirements, features, and research.

There was particular interest in tools to facilitate dialogue between creators and new teams, collaborators, and clients at the beginning of a project—to be able integrate one's personal 'work algorithm' into a team more quickly. There was also a related desire for technology helping to interpret between collaborators in real time: translating between actual linguistic barriers or the language silos of different disciplines and cultures. Interaction and industrial design experts also expressed a pointed need for better communication between designers and engineers in particular. While this communication gap is unlikely to be resolved by technology alone, innovations allowing designers and engineers to experiment in the same format (along the lines of a plugin such as Scratch from MIT media Lab) may play a part.

7.4 Interactive, unobtrusive real-time collaboration platforms and editing tools: including story mapping etc. capabilities scalable to larger teams; Transmedia Storytelling (many-to-many, multi-dimension, and multi-authored); Improved SocialWare platforms; and Virtual communication tools.

Timescale: Probable

There is a major weakness in the area of collaboration, which should be addressed through technological innovation and accompanying SocialWare support. The desire for new approaches to collaboration and connectivity was one of the most widespread, driven both by the physically dispersed nature of teams and value chains, as well as the increasingly peripatetic nature of collaboration in the growing "Gig Economy". Recommendations in this area start at the basic level of connection platforms, such as reliable and affordable video conference calling technology, and greater compatibility of files across different software and platforms.

Taking this further, interactive, unobtrusive real-time collaboration, story mapping, editing, and communication tools are needed to support the creative process. Tools that enable creative professionals to combine live performances, video and computer-generated imagery in real time and collaborate to create imaginative entertainment and experiences are still at the prototypal stage. The gaps between the envisaged technologies and current solutions and trends is attributed to the current predominantly engineer-led approach to collaborative design. Remote collaborative story-mapping platforms are not yet good enough to replace face-to-face collaboration, presenting a major obstacle for creators increasingly working in virtual teams or partnerships. Specific issues with current virtual platforms that must be addressed include non-verbal communication deficits (i.e. eye contact), scalability for larger teams, and reliability in low bandwidth regions.

The collaborative design process envisaged by the interviewed experts is more designer-centred and ICT tools should address a number of features such as:

- Difficult to track changes and/or conflicting versions when collaborating or editing
- Online tools are still a limitation when it comes to collaborative editing, sketching, etc. One reason for this is that devices, such as tablets or PCs, can be obtrusive while interacting face-to-face (e.g., resulting in reduced eye contact with interlocutor)
- Scalability: tools for joint activities support only small teams (10 or less) and do not scale up well to accommodate larger teams
- Remote story-mapping tools are not yet performing well enough to replace face-to-face working sessions.
- Online collaboration can be difficult in locations with low bandwidth
- Cloud-enabled single solutions for designers and more creative types for the multi-user communication, virtual whiteboards and interactive brainstorming. Currently, no one tool provides complete support

Enhanced connectivity may also involve advances in cloud-based storage access and hardware such as a cloud–connected digital whiteboard, storing and transmitting data between distributed teams, or personal, cloud-based server connected to a wearable such as a watch. These advances are likely to require greater collaboration between application and technology vendors to develop integrated features, interoperability, and user focused interfaces

Finally, this research direction also requires investment in "SocialWare", including training, continuing professional development (CPD), knowledge-sharing hubs, networking, new roles, & business models to accompany successful development and uptake of hardware & software.

There was clear and widespread need for knowledge, training, support staff, and other SocialWare to accompany technological development. In the fast pace and complexity of development today, creative professionals are often unaware of relevant technologies and lack skills needed to use them—continued updates to technology-related knowledge after formal education is a weak area in some sectors. Visions included a role for "techno-design managers" to serve as intermediaries between ICT business and design, as well as knowledge repositories to find and use new technologies, new business, models and collaborative value chains, joint workgroups, a common desk for companies within extended value chains; and temporary, project-based shared workspaces. The roadmapping analysis has specifically identified gaps in SocialWare surrounding applications and operating systems, so investing supportive resources to complement these areas is recommended for the successful development of design sector technology overall. Specific SocialWare research directions include:

- Address specific bottlenecks of SocialWare for applications and operating systems to avoid reducing effectiveness in application development and collaboration
- Development of job new roles such as 'Techno-Design Managers' and 'Head of Customer Success', as well as new creative technology disciplines in education to encourage collaboration between end users and vendors as well as between vendors
- New business models and collaborative value chains to better support collaboration & SocialWare

Collaborative Games

Libraries of digital assets

Standardisation

Challenge 8: Technologies for Collaborative User-Generated Games

Relevant sectors:

Research Directions:

8.1 Collaborative game development platforms with libraries of digital assets

There is a need for open solutions supporting the co-creation of games across all the major global platforms using efficient multiplatform publishing. These solutions are required to have powerful engines and tools, intuitive workflows and fast iteration, in order to ensure the complete control during the creation and the smooth deployment of the game on multiple platforms including mobile phones, tablets, netbooks and PCs.

Timescale: Probable

New collaborative game development platforms for the web, where games are created/assembled from shareable and reusable objects that anyone can create and contribute using our web client. The platforms should provide an easy way to find various skills needed to build games (programmer, artist etc.) and forming a team and manage game content / resources with sufficient online storage, version control and, if possible, source control. Moreover, such platforms should manage asset creation flow (request for specific content like a 3D model, sound etc.).

8.2 Standardisation of game objects, dynamics and effects

Standardisation of the games objects, game dynamics, effects etc. which allow the circulation, exchange and reuse of parts of the games.

Timescale: Probable

Personalised Gaming

AI and predictive modelling

Responsive Systems

Challenge 9: 'Personalised' Gaming technology

Relevant sectors:

Research Directions:

9.1 AI, Predictive modelling, machine learning and data mining for player behaviour tracking and adaptive gameplay

Personalised games: A personalised game is a game that utilises player models and preferences for the purpose of tailoring the game experience to the individual player. The games industry is starting to embrace data analytics and use player data in more sophisticated ways. However, delivering real player insight is not straightforward. The personalisation process needs to be integrated into game design from the start of development and executed with clear focus and objectives.

Timescale: Probable

- New technology infrastructure for the combination of techniques like predictive modelling, machine learning, data mining and game theory that analyse, real-time, the performance of the gamer to predict a specific behaviour in the near future.;
- Micro-segmentation applications for segmenting a player base to understand distinct segment preferences and behaviours to guide targeted game design, appealing targeted extension packages and additional content design. This approach to players of games is not different from the traditional customer view towards applying advanced analytics for player retention, churn, and marketing response efforts. The main challenge here is represented by the new variety of data and tremendous volume and speed at which it is generated;
- Enhanced and embedded artificial intelligence: New Artificial Intelligence (AI) developments for games that go beyond the traditional paradigm of controlling non-player characters (NPC) behaviour. Here there are three other potential application areas:
  - Player experience modelling: discerning the ability and emotional state of the player, so as to tailor the game appropriately. This can include dynamic game difficulty balancing, which consists in adjusting the difficulty in a video game in real-time based on the player's ability;
  - Procedural-content generation: Creating elements of the game environment like environmental conditions, levels, and even music in an automated way. AI methods can generate new content or interactive stories;
  - Data mining on user behaviour: This allows game designers to explore how people use the game, what parts they play most, and what causes them to stop playing, allowing developers to tune gameplay;

9.2 Responsive (user-aware) and immersive systems
Engaging technologies for immersive games (raising the level of immersion):
There is an evident increasing interest in natural interfaces, virtual reality, holographic and augmented reality technologies as the vehicle for enhancing user engagement. Game developers are starting to focus on immersion issues to augment user engagement. By combining high-resolution imagery with high-fidelity sound and haptic feedback, Virtual Reality (VR) has the potential to offer almost total immersion.
Timescale: Probable

Although VR doesn't currently have the portability and accessibility of classic mobile technologies, the renewed interest and innovation in the field does reflect growing consumer demand for immersion of the game experiences. Advances in graphics, computing power and interface devices such as the Leap, Kinect, Omni, wearable devices have opened the door to a new level of sophistication of virtual reality.

- Innovations in virtual reality technology such as new virtual reality glasses (e.g. by Zeiss) and input devices, e.g. Leap, Kinect, Omni, wearable devices. Improvements in the HMD (head mounted display) to avoid physical diseases due to long uses;
- Improve existing technological device so that it can be used to create a virtual reality experience. There are consoles such as Microsoft's Kinect which have been opened (via SDK) so that it works with other devices or in new and interesting ways. One example is that of combining it with virtual reality glasses to produce a virtual reality game;
- Mobile phone apps that are based upon augmented reality which are able to connect the real and virtual worlds in order to create pervasive games;
- Total Immersion relies on rich creative content like engaging stories, great music, impactful 3D sound, and believable physics. Games developers that will incorporate those elements into their games will have already taken the first step towards real immersive games;
- Natural interfaces: better movement detection (accurate detection of the player's natural movements) for the game control;
- Mobile Augmented Reality to allow gamers to experience digital game play in a "real" world environment. Sensors in the mobile devices can enhance the players' gaming experience by providing exciting new ways to control their actions through, for instance, position and 3D movement;
- Virtual Reality with 3D-Haptic technology to experience the presence feeling and reaction feeling of touching, grasping, pushing and pulling of virtual objects that only exist in the virtual world.

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