Strategic Research and Innovation Agenda

2020

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The **NEM Initiative** (New European Media Initiative) was established as one of the European Technology Platforms under the Seventh Framework Programme, aiming at fostering the convergence between consumer electronics, broadcasting and telecoms in order to develop the emerging business sector of networked and electronic media. In order to respond to new need and requirements of the Horizon 2020/Horizon Europe programs, the NEM initiative enlarged its focus towards creative industries and changed its name from Networked an Electronic Media Initiative to New European Media, dealing with Connected, Converging and Interactive Media & Creative Industries, driving the future of digital experience.

Executive Summary

The NEM Strategic Research and Innovation Agenda 2020 (SRIA) is the 2020 version of the roadmap for the media technology research, development and innovation developed by the New European Media (NEM) technology platform and it is driven by its vision[1] recently published.

This document contains a set of relevant research and innovation topics considered as key topics by the NEM community to be taken into account by the European Commission in the definition of the next Horizon programme. These topics represent the interests of the community in terms of collaborative research for the period 2021-2027. In particular, thirteen topics have been elaborated and organised under four different categories: Future Media Formats, Future Media Networks, AI for Media and Content and Future Media Applications and Challenges.

Each topic is self-contained in a category subsection and follows the same structure as current topic descriptions in H2020 calls: specific challenge, scope, expected impact and implementation.

[1] https://nem-initiative.org/wp-content/uploads/2020/04/nem-vision2030.pdf

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1. Future Media Formats

Even though "New European Media" comprises new formats in all facets of media (visual, aural or textual) we feel that the most significant changes and consequently the most challenges research questions are on visual media, especially video. This makes even more sense when considering that NEM originates from networked media and already today video makes up the largest part of all data distributed in networks.

Video is rapidly changing from a 2-Dimensional pixel-based representations of visual content towards multi-Dimensional representations. The SRIA topics "5D Light Field Video" and "Volumetric Media" describe these really revolutionary changes. The same changes are observed in the aural domain where audio is moving towards spatial representations and object-based audio. The whole value chain, from capturing over processing and distributing down to rendering of visual content will be affected.

Volumetric capture and rendering will provide for unprecedented immersion and interactivity, and light field technology will replace classical image-based capturing and rendering. 3D point clouds or rays in 3D space rather than 2D-pixels on a plane will be the dominating atomic unit. And other than in classical imaging those atomic units will not necessarily all be taken at the same time, adding a further dimension to the research space. Adding the time hence increases the number of domains by one, turning point clouds into 4D and light fields into 5D. A really challenging but inspiring research and innovation topic!

1.1. 5D Light Field Video

Specific Challenge: We are on the verge of change on how visual content is captured, processed, transmitted and rendered. And for the first time in history the interpretation of visual content converges towards a common ground of captured, natural content and synthetically generation content: the so called light field as an assembly of rays in space and time. There is a cornucopia of unsolved problems whose solution is required to turn light field video into a representation of content comparable to TV content and CGI. Especially for captured natural content, however, Europe always has played dominant role: Whether the Nipkow disk, the cathode ray tube or the invention of the interlace scan, Europe has led the evolution of visual content generation and distribution. And despite the fact that the theory of light fields has been developed in North America and the first commercial undertakings have been established in Silicon Valley, Europe again has built a very solid knowledge base: Several camera manufacturers, a cinema-quality facility for volumetric capture and research projects up to ERC level.

The specific challenge in the next years is in the appropriate capturing, representation, processing, encoding, storing, distributing and rendering of light field video content (each ray then has four spatial and one temporal co-ordinate and hence is a 5D light field video). This is a huge thematic complex, but has the possibility to once again have Europe play the dominant role in a technology that might fundamentally change the way we create and consume visual content.

Scope: The scope of this research topic extends from physical means to capture light fields (camera rigs, plenoptic cameras or assemblies of plenoptic cameras, mobile phone

photographs and videos) over means for processing them (spatial, angular and temporal view interpolation or object / mesh reconstruction, mostly based on Deep Neural Networks), encoders (extending current video coding concepts like H.265 and MPEG-I, but also completely new codecs including autoencoder-based solutions) down to rendering methods (VR goggles but also new forms of holographic or light field displays). Since representing visual content in a more general way than (2D) pixels over time is new, the overall demand for research and innovation is huge and hence there should be different calls over the duration of Horizon Europe, each of them specific in its focus and foster European academia and economy.

Expected Impact: Representing visual content by assemblies of rays rather than by pixels has the potential to change the whole signal processing chain and hence affects a huge and global market. Research in the domain of 5D light field video has the potential to significantly impact:

- The market of capturing devices. Whether out of multiple viewpoints generated by mobile phones or out of super high resolution camera rigs, extraction of the plenoptic function in space and time is a very hot research topic. New results, but also market innovation based on the already achieved results can be expected in the coming years from European camera manufacturers producing a wide range of cameras from small industry cameras up to cinematographic cameras. The impact can manifest Europe in a leading position.
- Light field video coding. New video coding techniques are required, especially when it allows for a very flexible allocation of temporal vs. spatial. MPEG video coding has always been led by European partners, which should be continued in the age of light field video.
- Ray tracing for rendering has always been a strength in Europe. Many algorithms implemented in current ray tracing engines and reflected in GPU-hardware stem from European academia. Even thorough many differences exits, light fields to a large extent are based on the same interpretation and representation of visual content. Hence there is a great potential to in an unprecedented way unify the worlds of capturing natural content on the one hand and synthetically generate content on the other. All XR application need such a unification, so that the potential impact is on joining forces between the video and the CG communities.
- Many problems especially in 5D light field video are completely unsolved at the moment. Analog to the good old interlace there will be a balance between spatial and temporal resolution, but this balance will presumably be dynamic (compared to the fixed interlace scanning system) and far more complicated (arbitrary sub-framing). Consequently, signal processing techniques like view and frame interpolation have to be completely rethought and current coding schemes have to be adapted.

Implementation: Given the continuous and rapid evolution of the light field video landscape and technologies, the proposed topic should be addressed through Research and Innovation Actions (RIA), requesting a contribution between 3–5 Mill. € each. Projects should target a TRL 4–5, and as such should be validated through demos with users or in relevant environments.

1.2. Volumetric Media

Specific challenge: Augmented, Virtual and Mixed Reality (collectively: eXtended Reality - XR) are new mediums posed to transform the ways in which people experience ubiquitous digitised activities like communication, collaboration, and entertainment. XR technologies place and immerse the user in environments that blend realities through digitisation. Be it virtual or real environments, augmentation is achieved by spatial technologies, presenting digital content as an emulation of reality and aligning it with the real world and/or users' physical actions and movements, or embedding real humans and scenes within virtual environments.

At present, human presence and interaction in XR environments are mostly limited to avatar representations and unnatural interfaces like mouse, keyboards, or other controllers, which constitute very abstracted approximations of reality and detract from naturalness and immersion. In order to realise the full potential of XR and increase its acceptance by the public, more natural modes of presence and intuitive interaction technologies must be developed. This is imperative for the further evolution of human-centric applications in particular, such as XR conferencing, virtual movies production, mixed reality live TV broadcasting, immersive multiplayer gaming, intangible cultural heritage preservation, and remote healthcare, in which avatar representations and controller-based interactions are severely limiting factors.

Volumetric video technologies allow users to be captured and placed in XR (be it in real-time or off-line), allowing for their realistic representation, more natural and efficient communication, intuitive interaction with the environment or other users, and improved immersion. The inclusion of volumetric video can help make XR more accepted, accessible, and relevant in the future interactive media landscape. However, a number of technical and practical challenges must be overcome before it can be widely adopted.

The challenge is to improve volumetric video capabilities, and support and expand the European ecosystem of interactive technology providers.

Scope: To fully develop and exploit volumetric video in conjunction with interactive technologies it is necessary to 1) improve its performance while lowering the costs of technology, 2) facilitate interaction with XR environments, 3) allow for the capturing of scenes of increasing complexity (i.e. more users, integration of real objects, etc.) and 4) develop efficient and scalable methods for storage, post-production processing and manipulation of XR experiences. In addition, in the context of the European Digital Single Market, real progress is required with respect to the standardisation of volumetric video, which is an highly inhibiting factor for widespread adoption. Hence, proposed solutions should address one or more of the below:

- Improved volumetric video performance, by:
    - Achieving better visual quality, higher frame rates, and/or lower latency.
    - Expanding the capturing space and/or capturing more people in the same space.
    - Developing methods to optimise processing, rendering, encoding, compression, transmission, delivery, decoding, and/or storage of volumetric video content at any device.

- Ergonomics of interactions with virtual content in AR environment and advanced interactions based on volumetric video, through the recognition and use of gestures, body posture, facial expression and/or emotions. Such interactions include locomotion, object manipulation, communication, system control, or other.

- Volumetric video content manipulation, either in real-time or offline, including:
  - Semantic classification and segmentation.
  - Reskinning, recolouring, or relighting.
  - Rigging and animation of volumetric assets to allow for additional body movement besides the captured one
  - Partial object replacement to reduce artefacts, e.g. mouth, eyes
  - HMD removal.
  - Improved/seamless emplacement of volumetric video into a virtual environment.
  - Mesh reconstruction from point clouds, especially in occlusion zones
  - The temporal tracking of animated point clouds for moving objects.

- Develop new standards for generic 3D content encompassing the various forms of volumetric media (e.g. light-fields, multi-view video, explicit geometric representations) that will facilitate interoperability for different devices, presentations means and data formats across the entire creative / content creation ecosystem.

Expected impact: Increase in the adoption and acceptance of human-centric interactive technologies.

- Improved user experiences in human-centric XR and interactive entertainment.
- Strengthening European research and innovation capacities to develop future interactive software and hardware.
- Support of the existing European ecosystem of interactive technologies providers by offering new capabilities and synergies.
- Increase in market opportunities in the interactive technologies sector for European SMEs.

Implementation: Given the continuous and rapid evolution of the volumetric video landscape and technologies, the proposed topic will be better addressed through Research and Innovation Actions (RIA), requesting a contribution between 3 to 5 M€. Projects should target a TRL 4-6, and as such should be validated through demos with users or in relevant environments.

2. Smart Media networks

The future Smart Network and Services has the ambition to design and deploy a scalable, robust, secured, distributed, high-performance, energy-efficient and environment-neutral ubiquitous digital infrastructure, providing also next-generation network based media services for processing, orchestration, synchronization. This is essential to enable and promote the Next Generation Internet (NGI) and future media services taking advantage of technologies such as Artificial Intelligence and Machine Learning, Data Analytics, High Performance Computing, Security etc., including also business layer enablers. AI and networks will be

more and more entangled relying on new business requirements: new future smart networks must be able to "support a plethora of services, which have a vast variety of Quality of Service, Quality of Experience demands, while assorted content and media types are exchanged with the user equipment from an E2E perspective".

Some of the main opportunities on the media delivery and consumer side include reliable on-demand and ubiquitous delivery of high-fidelity live and non-live media content and advanced search as an assistance to browse through lengthy content and specific segment retrieval based on a user-defined topic. Some of the main opportunities on the media producer side are new applications for faster and easier content creation (e.g., automatic generation of a sport highlights summary video based on the full game) and automatic captioning and subtitling based on the original media material. Looking to these trends, NEM is proposing to focus on the subset of Key research and innovation topics that need to be addressed to achieve this global goal.

2.1. 5G and Future networks for content and creation distribution ATAWAD, including coding/decoding

Specific Challenge: 5G and future networks beyond 5G (SNS: Smart Networks and Services) would be used in both content production and content distribution, and therefore we foresee a significant impact on the media services delivery and user devices. Production and distribution requirements are substantially different and must be considered separately. Media and content services will take advantage of 5G and future networks beyond 5G capacities in terms of latency, reliability, jitter, data rate, mobility, user density, positioning, and user equipment speed. These parameters can be activated in the network using slices. There are many different production use cases such as news gathering, broadcast live events, on-site live events, audience services in a venue, wireless studio, media files transfer which have an impact on the future networks beyond 5G (Smart networks & Services.).

On another hand, there are also different use cases in the distribution chain such as live/linear TV & radio, on demand TV & radio, hybrid radio & TV, UGC, andVR/AR which required specific network capacities such as bandwidth, reliability, resilience, security, coverage.

Recent studies show a basic trend regarding the decreasing use of conventional TV screens in favor of personal equipment Smartphones/Tablets/Laptops. This change in content consumption means that there can now be as many programs viewed simultaneously as individuals in the home. The primary beneficiaries of this disruption are the mobile / tablet apps and OTT services from Entertainment & Media.

Scope: The objective is to develop technologies which help consumption and interaction of new media content thanks to the next generation networks. The main technological locks for the acquisition, transport and rendering of 3D physical objects are:

- Open source development of the 2 media&content network slices
- Specification and development of the slice-application APIs
- Optimization of the media&content cloud storage
- Optimization of the network usage according to the device used

Expected Impact: 5G and beyond 5G networks will be implemented all over Europe, Media&content application should take advantage of their capacities in order to:

- Facilitating access to content and media using new generation of networks
- Contribution to the development of technologies that help ATAWAD concept
- Helping adoption of immersive technologies in vertical sectors
- Boosting media&content consumption

Implementation: In order to achieve the objectives, the following types of actions are needed to ensure concrete collaboration among media and 5G networks:

- RIA projects are needed to specify and develop network media slides and APIs
- IA projects are needed to develop prototypes and test them through pilots and experiments on several use cases
- CSA is needed to prepare and push media&content requirements to the future Smart Network and Services.

2.2. Personal and Usage Data Management and Exploitation for Media

Specific Challenge: The media and CCI sector business models and value chain have already experienced digital transformation being one of the first examples of new digital ecosystems in data-based and algorithm-based economy. We live in a world where everything is or will be connected, software becomes embedded in almost everything, data and content are created almost everywhere becoming an essential input fueling data and algorithm-based economy.

The new generation networks (such as 5G and beyond 5G) and user devices (IoT) will enable the media sector, both in production and content distribution, to provide even more personalized and individualized media services. Already known changes in content consumption, regarding lower usage of collective devices (such as TV screens) in favor of personal devices (Smartphones / Tablets / Laptops) are confirming the ongoing changes.

New media services are going to be more and more based on personal and usage data analytics, and data is becoming drivers in an interconnected network of living and nonliving entities governed often by algorithms. Individuals are going to interact and link with the ever-increasing number of connected objects (e.g. connected cars, smart speakers, wearables, etc.) that are likely to produce flows of information and/or content. Diversity and complexity of such data and content sources will require a huge effort, in management and exploitation, from media and CCI sector.

Scope: The infrastructure for greater access to personal and usage data including tools that create, ingest, transmit, manage, store, secure, trace, govern and account the lifecycle of that data are essential for the future development of the media and CCI ecosystem. New types of data exploitation and new types of partnerships amongst participating stakeholders will be enabled including industry, SMEs, national and European authorities and institutions, research entities and lastly private individuals.

Europe needs initiatives that succeed in limiting concentrations in personal and usage data management and exploitation, without compromising the technological innovation and development, fostering creation of infrastructures facilitating the circulation of personal and usage data along the value chains and value webs. Significant technical challenges such as interoperability, data verification and provenance, quality and accuracy, accountability,

transparency, portability, user control, decentralized data processing architectures, privacy-preserving technologies have a direct impact on the data-based economy.

Europe needs initiatives for the development of trusted European data sharing frameworks, building upon existing initiatives, instruments and investments (such as DIHs), to enable new data value chain opportunities in managing and exploitation of personal and usage data.

Expected Impact: Improvement and development of innovative trusted personal and usage data exploitation for the media sector by:

- Facilitating legal access to personal and usage data related to content and media services deployed over new generation of networks;
- Boosting European data-driven economy with personal and usage data exploitation driven by end-user awareness, control and benefits;
- Adoption of data-driven personalized services in various applications enabling new generation of ecosystems and value chains;
- Contribution to the development of new technologies for personal and usage data management;
- Appropriate and innovative regulation framework for personal and usage data exploitation.

Implementation: The following types of project are needed to ensure future European media sector empowered by personal and usage data exploitation:

- Research and Innovation actions involving media sector players, end-user communities to investigate topics of interests, propose and demonstrate new ways and solutions for exploitation of personal and usage data for media sector – 6-8 M€, 24 - 30 months;
- CSA to facilitate stakeholder discussions to establish white papers, recommendations, roadmaps regarding both technical and regulatory topics related to personal and usage data exploitation for media – 2-2.5M€, 24-30 months;
- Innovation actions – looking for trials and pre-commercial prototypes and solutions – 4-6M€, 24 -30 months;
- Innovation actions - establishing media technologies platforms for experimentation by media stakeholders, having open calls for community through cascaded funding, demonstrating new ecosystems and value chains – 4-6 M€, 24-36 months & 5-8M€, 30-42 months for projects with cascaded funding.

2.3. Network Based Media Services

Specific Challenge: Video technologies are constantly evolving towards the enabling of new advanced hyper-realistic formats and distributed services. Relevant examples are immersive multimedia environments (XR), with applications ranging from traditional media and entertainment to others such as manufacturing, automotive, video surveillance. In such contexts, a large number of end-users can be provided with heterogeneous media content via different networks, systems and devices However, such a scenario involves a huge volume of data and very high processing requirements. The challenge is to explore and adopt new solutions to reduce the computational complexity and bandwidth for the end-user devices, contributing to a higher mobility, scalability, interoperability and more lightweight resource at the end-user side.

Scope: Innovative solutions 1) to enable next-generation network based video services by means of new developments in terms of processing, orchestration, synchronization or cloud /edge/fog computing; 2) to move the most demanding CPU/GPU based operationsto the network 3) to facilitate the integration of new media formats and modalities; 4) to increase the scalability, robustness and adaptability of media services by means of network based solution, while overcoming bandwidth, delay processing and hardware requirements; 5) to contribute to a higher interoperability between technologies, networks, platforms and devices; 6) to identify and enable new use cases that are not possible or very costly to provide by current technologies, and that can provide a societal and economic impact.

The proposed solutions are expected to be demonstrated in real scenarios, and being evaluated to determine the provided benefits in terms of resources consumption, performance and user experience.

The objectives are:

- Addressing the network processing of one, or more, of the following immersive video representations: 360º, Stereoscopic, Volumetric Video and Computer Graphics, giving particular importance to those representations involving a large amount of data (i.e. volumetric video formats as point clouds or meshes) or requiring a large amount of processing operations (i.e. Computer Vision applications or geometrical manipulations).
- Optimize the resources usage of the client devices, maximizing quality and resolution and minimizing latency and processing time. The outcome of this objective will bring advances in terms of virtual environment quality.
- Assessing the advantages of the developed solution over the final user experience.

Expected Impact: The proposed solutions will contribute with the generation of the following improvements:

- Specification of new technological advances to enable next-generation network based media services

- Develop new scenarios and services with the support of network-based technology, and validate the provided benefits in key sectors and use cases, in real operational environments.
- Encouragement and spreading of using AR/VR devices in industrial working environments
- Contribute with new standard-compliant solutions that can actually contribute to current and future standardization contributions.
- An enhanced and enriched media ecosystem, maximizing the available resources and interoperability
- Improvement of the technological transfer from European technological players to the media value chain.

Implementation: Considering the increasing advances and the consequent demand of resources needed to support the XR experiences, this topic should be addressed with a

Research and Innovation Action (RIA). The RIA should involve media sector entities, the XR research community and the networking telecommunications industry. Projects should target a TRL 5–6, and as such should be validated through demos with users or in relevant environments. 3-5 M€ per project with a duration of 24 - 36 months.

2.4. Energy optimization for content creation, transmission, processing and storage

***Specific challenge*:** With a growing concern on the considerable energy and resources consumed by live event coverage (even of profitable events); new production models are taking advantage of multi-access edge computing (MEC, following the trend towards cloud-based architecture, but exploiting the advantage of being located in close proximity to the end users) and novel network capabilities to reshape the way productions can be done. Mainly, applying Software Defined Networking (SDN) and Network Function Virtualization (NFV) and their related infrastructure and other features as low latency, proximity, location awareness, high bandwidth, and real-time. Softwarization of content production, despite potential benefits, leads to a new challenge regarding energy consumption, due to the foreseen dense deployment of computation capabilities that are required.

The efficiency of a MEC operation depends on the efficient deployment of the hardware resources to deliver the required workload. MEC operators select servers based on the need to deliver a specific workload or group of workloads. Those workloads will have specific capacity requirements (and typically may be bound by them), service profiles and can be mapped and analysed for the purposes of optimizing placement of the workload in the data center for the sake of targeting toward green solutions with higher energy efficiency. In particular, server virtualization is key to consolidate applications from multiple applications to one server, with an objective to save energy usage.

However, little understanding has been obtained about the potential overhead in energy consumption and the throughput reduction for virtualized servers in MECs.

***Scope*:** SDN and NFV are enabling the replacement of specialized hardware and fostering the evolution to fast deployment of mobile services, among them, media-based are the most challenging. The computational power involved makes it essential to incorporate energy efficiency studies in their deployment. From them, quantifying the energy consumption within computing platforms is of great importance towards the development of robust energy management guidelines. Finally, all this should be aligned with decarbonisation processes, the integration of renewable energy along with green and sustainable energy storage system, in a way that is possible profiling services, understanding their needs and restrictions, and recommending procedures and services deployment modes according to their energy consumption implications.

***Expected impact*:** Research and development will result in designing an up to date set of concepts, methods and tools that respond to the emerging need for efficient energy management procedures employing machine learning and control-theoretic techniques, within the MEC paradigm; specifically, by providing energy saving strategies for sustainable computing and networking within edge systems through dynamic resource management.

They will contribute to generating new knowledge and capabilities and serve for the purposes of effective and sustainable implementation and deployment of innovative media technologies (both services and infrastructures), boosting the European leadership.

Implementation: Efficient energy management can be integrated as a horizontal topic for any content creation and AI and other high energy demanding media applications, or addressed through Research and Innovation Actions (RIA), requesting a contribution between 3 to 5 M€ with a duration of 24 - 36 months. Projects should target a TRL 5-6, and as such should be validated through demos in relevant environments.

2.5. Cybersecurity

Specific Challenge: Cybersecurity, which includes Media and Content security, is one of the most complex issues that organizations must deal with, in any networked environment. The challenges they need to face include compliance to regulatory requirements, business decentralization & mobility, reliance on web and smart phone technologies, risk assessment, privacy aspects, trusted information sharing, and an increasing number of new threats & security-unaware users. The services and technology solutions for media and content offered by telecommunications manufacturers and service operators are designed to address the business security issues primarily related to the provision of resilient connectivity solutions. Within a mobile network today, the provision of mobile connectivity services is somewhat bounded by the perimeter of the commercial barriers of the service or network provider. User Identity in this case, is primarily used for the availability of service and for associated user billing. Next Generation media and content services, especially considering a 5G and beyond 5G view, will spread across multiple mobile network services providers and traverse a number of cloud based transformational services (routing, transcoding, etc). As such, we move from a world of human managed information, to a richer offering of services that may carry and transform our information. A unique approach ensures the trustworthiness of information under the umbrella of a secure seamless information environment, in full alignment with core business requirements.

Scope: Conventional perimeter security solutions are no longer considered sufficient in highly dynamic and contextual networks for media and content. Network providers need to be committed to assist their information based customers in responding to increased new demands, in particular, in the following major areas:

- Supporting both resilient transport and support for informational, media and content - based security;
- Security Information & Event and Trust Management and Measurement e.g. reputation;
- Continued support for new modes of Web and Email Security (dnsec, etc);
- Network Admission Control;
- Scalability (i.e. with respect to sizing, performance, capacity planning, stability, etc.). Scalability also has "horizontal" inter-relationships with other concepts, such as QoS, dependability and resource management;
- Availability of content anytime, anywhere, any device;
- Trusted services and applications - simple, secure, fast, and reliable;

- Full user control and awareness of what data can be available in the context-aware environments in which ubiquitous, user friendly services are based on real user requirements and needs;
- Digital rights-management / protection technologies across the entire value chain for complex, composite polymorphic infrastructures;
- Regulatory aspects with respect to protection against unwanted material, deep fakes, attacks, denial of service, intrusion, misuse, etc.;
- Consistent mechanisms and functionality for security of networks and security that are universal, transparent (visible), understandable (easier and more natural), easy to use, effective, revocable (by all parties) and accessible;
- Privacy aspects – Privacy by Default, Privacy by Design, ease of use of identity management systems;
- Effective controls (e.g. parental controls) over access to unacceptable content;
- Maintenance of confidentiality by business associates, and integrity in their handling of business issues including payments; without this, no viable business is possible;
- The concept of Digital Assets represents much wider implications than information management in general: it includes management of Intellectual Property Rights (IPR), Digital Rights Management (DRM), copyrights, confidentiality (non-disclosure to unauthorized persons), integrity (non-alteration of content, accidentally or maliciously by intruders) and availability (the availability of licensed users to use these assets without being hindered by unintentional or malicious acts);
- Content Ownership, licensing, transfer must be provided in a non-ambiguous and transparent manner, in which there is no doubt as to the provenance (place or source of origin) of the content and clear ownership of the content, which could then be licensed and/or transferred by the owners;
- Adherence to the General Data Protection Regulation (GDPR) is an important concept for media and content provision, as it states specific rights for individuals when it comes to the protection of their personal data and some will require technical and methodological approaches. The main technical requirements of the GDPR from the media and content perspectives are: End-2-end data protection; Proper technical & organisational measures (e.g. DPIA – Data Protection Impact Assessments); Accountability of personal data protection measures; Privacy by design / privacy by default; Explicit & clear consent; Data rectification; Data erasure; and Data processing;
- Hands-on education & training is needed in order to make sure that the media community is aware of tools, policies and threats;
- Green security for media and content is especially important to address, as the mode for watching media and content is moving towards low power devices such as tablets and phones.

Expected Impact: Research and innovation actions addressing the challenges above mentioned should lead to the following impacts:

- Establishment of proper security posture to mitigate risks and facilitate growth in media and content sectors;

- Assured business continuity while providing the basis for an efficient and secure deployment of new services with converging security functions/capabilities in a "Software Defined" approach;
- High-quality results with low Total Cost of Ownership and high performance;
- Proofing all valuable business assets under the umbrella of a secure, seamless, privacy and trust- preserving environment.
- Reducing capital and operational expenses required for the acquisition and maintenance / administration of a security product.

Implementation: Considering the wide scope of the cybersecurity topic, strong consideration for a Coordination and Support action (CSA) to coordinate and support the activities of a number of RIAs to undertake the research and innovation that is required. It is suggested there is one CSA covering the cybersecurity in media and content topic and at least 4 RIAs to cover the technical work in addressing the challenges and scope. Suggested budgets: CSA -1M€ and RIA budget 3-5 M€ per project; Suggested project durations: CSA and RIA - 24 - 36 months.

3. AI for Media and Content

Artificial Intelligence (AI) and its application towards Hyper-personalisation is transforming the way people work, live and entertain themselves although the full potential of AI still needs to be further exploited within ethical boundaries. It is expected that the impact on media and cultural and creative industries (CCI) will be huge but needs strong research & innovation support to benefit from these new opportunities. It will also re-shape the concept of creation and affect the operation and business models across the media and cultural sectors.

To anticipate these changes, the NEM community identified two main challenges: one specifically related to "AI and content", and one dedicated to "AI and hyper-personalisation for Media Access services". Both will boost research & innovation actions, although the second one also promotes the need for coordinated support actions.

These are essential in order to foster both personal and usage data analytics, interconnectivity, and user-generated content (UGC), which will boost creativity and sharing data openly. In the future AI based tools will be developed, such as automatic translation from speech to subtitles, from text to Sign Language, and from Sign Language to text. These actions are essential to maintain Europe's position as the World leader in accessibility and for social and societal challenges.

3.1. Artificial Intelligence and Content

Specific Challenge: AI is currently considered an innovation enabler whose full potential is still to be discovered. Its impact in many sectors will be very strong, and media technologies will not be an exception. In particular, the CCI will greatly benefit from the new opportunities that AI will bring, re-shaping the concept of creation and affecting the operation and business models of the CCI sector. These changes will result in the emergence of new professional profiles, new types of companies, new stakeholders and services, new risks and new socio-economic factors. Among all those elements, UGC will be one of the main driving forces,

given the number of users generating information, boosting creativity and sharing data openly.

The effective and efficient integration of disruptive media technologies and solutions in the CCI ecosystem where policy design relies strongly on the capability to generate, use, share and improve/augment media data, without bias and whilst fulfilling the GDPR at cross-border level. The link with activities and the lines of action carried out by international forums, such as the BDVA, are key in understanding and properly evolving future media achievements.

Scope: UGC will be one of the enablers that will favour growth, around a set of technologies and workflows that will expand its presence in the market, these include:

- The automatic generation of metadata, describing not only the audio-visual content, but also allowing different databased to be completed and linked.
- The presence of bots that interact with users transparently, providing new and more complete services with natural language, which is adapted to users and their needs.
- The automatic generation of content, which facilitates creative processes and helps in the enrichment of new models and techniques for artistic expression. Interaction with users also enables the contribution of new concepts to the value chain.
- Profiling users, in order to understand their needs and preferences, recommend new procedures, services, modes of work as well as the creation and consumption of content according to their restrictions and/or possibilities.

Expected Impact: Research and development produce an up to date set of concepts, methods and tools that respond to the emerging disruptive media technologies. These solutions can be used in support of UGC users, researchers, planners, stakeholders and policy makers. They will contribute to generating new knowledge and capabilities and serve for the purposes of effective implementation and deployment of innovative media technologies, boosting the European leadership in the CCI ecosystem.

Implementation: Given the rapid evolution that AI is having in the area of UGC, Research and Innovation Actions (RIA) proposals are expected in this topic, requesting a contribution between 2 and 4 million euros each. The overall budget for this objective is 10 million euros.

3.2. Artificial Intelligence and Hyper-Personalisation for Media Access Services

Specific Challenge: Artificial Intelligence and Hyper-Personalisation are transforming the way people work, live and entertain themselves.
By taking into account the current state-of-the-art and the relevant techniques based on AI in general, and deep learning in particular, the specific challenges in the next years for the media and CCI ecosystems are multiple and request to develop AI tools in order to:

- Fluidize/streamline the circulation of audiovisual (or video) programs through machine translation, while humans focus on the quality of work, for example.
- Encourage synergies and convergence between subtitling and the development of multilingualism or the integration of foreigners (migrants for example).
- Develop AI tools for automatic translation from speech to subtitles, from text to Sign Language, and from Sign Language to text.
- Develop AI tools for robust automatic translation of subtitles (multi-languages).

- Develop think-tanks and do-tanks in order to maintain Europe's position as the World leader in accessibility and thus for social and societal challenges.

This is a huge area for qualitative research with the opportunity for Europe to play the dominant role in technology that might fundamentally change the way we create and consume visual content access services. The future technical challenge is to transform and improve this further. The automatic translation solutions provided by AI and deep learning tools will allow for an explosion of content, compliance with digital accessibility legislation, and the reduction of production costs.

Scope: The scope effectively eliminates all automatic captioning providers that do not meet any of the points in the above definition. The economic interest is therefore fivefold:

- The automation of the adapted subtitling chain will allow productivity gains that reduce unit costs and increase the volume of processed data.
- The production of multilingual subtitles will allow a wider international commercialization of the audiovisual contents produced.
- The decrease in subtitle production costs will make captioning accessible to many new content producers for whom the cost makes captioning impossible.
- In broadcasting, the improvement of Sign Language production and Audio Description for content (videos and books) with the facility to deliver dialogue and ambiance elements of the soundtrack separately, enables robust subtitling performance across genres and increasing interoperability, allowing users to consume personalised automatic live subtitles anywhere.
- Web access developments allow the commercialization of existing prototypes e.g.: subtitle renderer, inlay/screen overlay (incrustation) of Sign Language interpreter, advanced audio functions, improvements to the quality of automatically generated subtitles, reliable Speech-To-Text technologies, improved avatar based signing services and integrate additional accessibility services into existing online platforms.

Since representing visual content access services is new, the overall demand for research and innovation is huge and hence there should be different calls over the duration of Horizon Europe. Each of them specific in its focus and foster European academia and economy, and address simultaneously social and societal challenges (inclusiveness, access for all, nobody left behind).

Expected Impact: AI and hyper-personalized services should be appropriate, commensurate with the capabilities and performance of the individual, including the needs of everyone.

Successful projects in this area should solve the problems mentioned above and positively impact on societal levels, markets and regulatory issues, and on social solutions for people with specific needs. The problem solving concerns cinema and television, the CCI ecosystems with advertising, the world of performing arts, education and training, and potentially corporate and institutional communications.

In terms of market impact and regulatory issues, new research, development and innovation(R&D&I) projects should have the potential to change disruptively the circulation

of programs, the transfer of language and multilingualism. Moreover, regulation clearly favors market opportunities. Therefore public/private projects, and especially think-tanks and do-tanks should anticipate future needs and guarantee transparency and go-to-the market approaches for the innovations.

In order to maximize the usage of media services by persons with some functional limitations, including persons with disabilities or foreigners and migrants, the services should be available through more than one sensory channel and should be accessible in a consistent and adequate way for users' perception, operation and understanding. This includes the adaptability of content presentation and interaction, when necessary providing an accessible electronic alternative and or augmentation.

Implementation: Given the continuous and rapid evolution of the IA and personalizing landscape and technologies, the proposed topic should be addressed through Research and Innovation Actions (RIA) and Coordinated Support Actions (CSA). This includes projects requesting a contribution between 3–5 M€ each, a number of 3–5 RIA projects and 3- 5 M€ with a number of 1-2 CSA projects. RIA projects should target a TRL 4–5, and as such should be validated through demos with users or in relevant environments. CSA projects should implement think-tanks and do-tanks with all players involved in the RIA projects and external actors. This allows the fostering of European media and CCI excellence, anticipation of future trends and societal challenges through technology, and aims at becoming sustainable after the project time. The overall budget for this objective hence is 20 M€, of which 15 M€ for the RIA and 5 M€ for the CSA.

4. Future Media Applications and Challenges

The European media ecosystem is currently facing several and quick transformations. These are reshaping the way in which media is perceived and deployed in our everyday life. The media sector is at the forefront of innovation and provides services and products that can really change our habits and routines. This is the case for relevant media applications such as social extended reality or immersive technologies. In addition to that, media technology is not conceived as a specific sector specific but is more a technology enabler serving future innovative applications. In line with this, NEM supports the participation of media stakeholders in multi-disciplinary projects to elaborate and experiment with media services and technology in key industrial sectors. It is also very relevant that the development of new media technologies may result, depending on their usage, potentially harmful for European values and democracy. In particular, NEM highlights the importance of fighting against disinformation through the use of advances in technology and ad-hoc approaches developed by innovative European media players.
Accordingly, NEM proposes to focus on the research and development of future media applications, through 4 particularly challenging topics: 'Social eXtended Reality', 'UX: Immersive and Interactive technologies for content and creation', 'New European converged and social media technologies for other vertical sectors' and 'Disinformation'.

4.1. New European converged and social media technologies for other vertical sectors

Specific challenge: Establishment of new European converged and social media as a significant technology enabler and a core sector serving future innovative media services and applications as well as novel applications to be created by other industry vertical sectors. Different solutions and applications coming from the media and content sector are seen probably by all vertical application sectors, such as Transport, eHealth, Automotive, Energy, Factories of the Future, etc., as significant enablers for design of the sector-specific services and features. For example, to implement remote surgeries (related to eHealth sector) in practice, or so-called drivers bird view (Automotive) in an efficient way, surveillance and accessibility services (Smart Cities, Smart Homes), production in hostile environments and remote interventions, security and disaster relief services, etc. it will be necessary to use technologies created and already in use in the media and content sector. Therefore, there is a need for an efficient exchange of information and knowledge among the media/content and other sectors. The best method to enable this exchange and collaboration is through joint undertakings and projects with participation of media and social media technology partners as well as various vertical sectors.

Scope: The stakeholders participating in such projects should bring expertise, prototypes, and products created for and used both in media and social media, to elaborate and experiment their usage by other so-called vertical industry sectors. The media/social media technologies in this respect are applications and services, maybe also devices, mainly dedicated or already in use to create and distribute digital content of different kind. The media technologies mentioned in this context might or should rely on generic and media specific enabling technologies, such as immersive and interactive technologies (VR/AR etc), which however should not be developed under this objective scope. On the other hand, the participating vertical sectors should bring expertise and knowledge from their dedicated areas as well as basic requirements on the media technologies to be investigated in the projects and later on included in their portfolio of services and applications. The range of vertical sectors which might be involved in such collaborative projects can be considered as infinite, so that some prioritization on the sectors to be addresses can be done before corresponding calls for project.

Expected Impact: Successful projects in the area have to ensure significant contributions in establishing the European media industry as a global key player and enhance opportunities for various industrial vertical sectors along the following specific expected impacts:

- Readiness of European media industry to enhance capabilities of other industry sectors.
- Establishment of European media sector as a significant technology enabler.
- Enlarged co-operation among media and other industry sector in joint R&I projects.
- Definition of media strategy and technology roadmap for other industry sectors.
- Enhanced business and co-operation models for media and other sectors.

Implementation: The following types of project are needed to ensure concrete collaboration among media and other industry sectors:

- Standard Research and Innovation actions involving both media and verticals (at approximately same level of involvement), to investigate synergies on particular topics of interests and concretely demonstrate added value of the joint approach – 4-6M€, 30-42 months.

- Research and Innovation projects establishing experimental media technologies platforms for experimentation by vertical sectors, within the joint projects, and also calling for additional contributions from the community through cascaded funding – 3-4M€, 24-36 months and 5-8M€, 30-42 months for projects with cascaded funding.
- A CSA to facilitate public community discussions among the media and other sectors, to establish joint research and innovation agendas and roadmaps – 2-2.5M€, 24-30 months. Innovation actions – looking for pre-commercial prototypes and solutions – 4-6M€, 30-42 months.

4.2. Social eXtended Reality

Specific Challenge: Remote communication, a form of mediated social communication that enables collaboration and shared experiences, allows people who are not physically present in the same location to communicate in real-time. It positively impacts society in many ways, such as reducing environmental pollution, travel cost and fatigue, supporting rich collaboration by connecting talented people around the world, brings families closer and improves the availability of high-quality education and healthcare around the world. In remote communication and telepresence, we aim for the perceptual illusion of non-mediation. While avatar-based social VR recently emerged as the newest form of telepresence to share a virtual world, such solutions do not provide the feeling of being present in a mediated environment. If participant in an XR-enabled remote communication session are to be volumetrically represented, absolute photorealism is required to create the illusion of the remote person's physical presence in the local space, as well as a shared understanding of verbal and non-verbal cues (e.g., posture, gaze, pointing). For high-quality communication and interaction between users in remote locations, we should take into account all factors needed for humans to feel each other's presence. Recent research has shown that mediated haptic communication is modulated by a range of technological (affecting the 'feeling') and human (e.g., attribution, expectancy, sense of presence) factors, making effective (convincing) solutions to mediated social touch far from trivial. It is likely that mediated social communication including touch can contribute significantly to a feeling of social presence in the context of collaborative tasks performed in shared virtual environments, and thereby significantly reduce the need for travel.

Scope: The scope of this research topic spans the following topics:

- Technology, such as photorealistic and volumetric human representation in a format that can be easily captured, compressed and transported to current and upcoming XR devices to allow for shared and collaborative 6-DoF experiences; the orchestration and spatio-temporal alignment of haptic and tactile data with the corresponding volumetric media; HMD removal and eye-gaze, to look each other in the eye; scalability and mobility, i.e. allowing large groups of people to join a remote communication session, regardless of their location and XR interaction device.
- Evaluation, such as performing adequate evaluation of different aspects of communication in social XR both subjectively (e.g., self-reports) and objectively (e.g., physiological sensors); the synchronicity between the different sensory signals that is required to achieve a coherent multisensory experience; the bandwidth required to optimally convey relevant social cues (e.g., gaze direction, eye contact, prosody, facial

expression, non-verbal sounds, gestures, body posture, orientation and proximity, social touch, collaborative haptics, pupil size, eye blinks, etc.); the development of Quality of Experience (QoE) metrics for social XR, measures that maximally describes the quality of the mediated social communication experienced at different affective (sensory, perceptual, and decision making) processing levels, and guidelines on the synchronization (in-)tolerance of visual, auditory, and haptic social cues, and on how to deal with typical internet networking effects.

- Applications, such as the use cases of social XR? What are the requirements for building such social VR applications?
- Ethics, since social XR raises privacy concerns and ethical risks when the boundary between the real and the virtual world is blurred. What are the ethical considerations conducting research on social XR or using it as a research tool? What are the risks that are foreseeable with the widespread use of social XR (e.g., long-term immersion, neglect of the social and physical environment, content, and privacy)?

Expected Impact: There is a strong need to make communication and remote collaboration as transparent as possible. This means that the interface should appear to be imperceptible and almost non-existent to the user, which can be achieved by increasing the quality of auditory and visual XR media, decreasing transmission delays and adding multiple sensory modalities like tactile and haptics. Such a situation can be enabled by a social, shared and networked XR environment for remote communication and collaborative interactive experiences, where participants get the feeling of being in the presence of, and interacting with, other persons at a remote location. Research in the domain of shared and social XR has the potential to significantly impact:

- The market of capturing devices. European camera manufacturers that develop small industry cameras up to cinematographic cameras can manifest a leading position.
- The market of telecommunication infrastructure and service providers. European telecom operators can distinguish themselves and validate investments in 5G and cloud/edge infrastructure.
- The software market and virtualized infrastructure providers. European cloud/edge and virtual machine infrastructure providers can leverage their infrastructure to support and enable large-scale shared and social XR services.
- The market of XR application developers and service providers, as social XR platform and functionality allow them to build a multitude of communication-based services.
- The market of XR rendering devices. Communication (e.g. in combination with entertainment and gaming) can be the distinguishable service to support mass adoption of XR devices.

Implementation: Given the continuous and rapid evolution of the XR landscape and technologies, the proposed topic should be addressed through both Research and Innovation Actions (RIA) and Innovation Actions (IA), requesting a contribution between 3–5M€ each and a number of 3–5 projects. RIA projects should target a TRL 3–5, and as such should be validated through demos with users or in relevant environments. IA projects should target a TRL 5-7, and as such should be validated and demonstrated in relevant environments or as prototype in operational environments. The overall budget for this objective hence is 30M€.

4.3. UX: Immersive and Interactive technologies for content and creation

***Specific challenge*:** The RXs (extended realities: virtual, augmented or mixed) enable users to interact with cognitive and sensorimotor activities that would not be possible in the real world due to the cost or time requirements for constructing the corresponding real environment, the related risks of the activity in real situations (physical exposure, risk of errors) or to be situated in an imaginary world.

By 2025, it is estimated that the RX market will reach the current PC market level, estimated from $80 to $110 billion. The predicted key drivers of growth are CCI, tourism and e-commerce in the B2C market, health, training, and industry in the B2B market.

In that perspective, it is awaited that technology choices between virtual, augmented or mixed reality will be specified by the needs for the activity (type of immersion, gap with the real situation), rather than by the availability of know-how. In B2B, the technology environment will have to meet with the individual abilities to perceive, understand and interact within the prescribed activities in order to validate the industrialists or academics experimental aims.

Scope: In order to design adapted environments and to promote users experiences in RX, it is still necessary to improve or develop their immersion conditions:

- Allow cheaper and faster access to a range of graphical and audio quality 3D RX environments, which colours, brightness, contrast, textures, and spatialized sound characteristics will foster a natural human perception.
- Facilitate interactions by developing the capability to adapt to users' sensorimotor perceptions and abilities in RX environments:
    - Natural movements and displacements
    - Synchronized sensorimotor perception
    - Natural vision conditions with or without equipment (caves vs headset or smart glasses)
    - Adjusted and enhanced sensorimotor perception, especially in touch mode or by force feedback
- Stimulate the less addressed senses (olfactory and gustatory)
- Broaden interaction contexts to collaborative activities: remote and multi-users mode
    - Identification of avatars, restitution of emotions and non-verbal expressions, including lip reading
    - Representation of remote activities
    - Seamless remote interactions
- Investigate new interactive dimensions
    - Brain machine interfaces

These new conditions will enable the diversification of RX use cases. Users will be able to immerse themselves in more suitable environments and to carry out potentially longer activities without taking the risk of cognitive-sensory impact (cybersickness and depersonalization).

***Impact*:** Improved interactions in RX will open the access to wider ranges of activities in the mutual interest of users, academics and industrials of all sectors. European research centres will expand their positions on crucial RX expertise. For example, new research projects are already focused on the use of RX to alleviate psychoneurological disorders, or perceptual-

motor disabilities. Education professionals are working on new learning methods in RX, and industries are starting to foster innovation acceptability through RX familiarisation.

***Implementation*:** Given the market growth prospective, the needs of applications and the fast evolution of the UX technologies, Research and Innovation Actions (RIA) requesting a contribution between 3-5M€ seem appropriated. This contribution should serve the fields of technological design of environments and their artifacts, interaction units, and the labs of psychophysiological evaluation of users.

The projects should target a TRL 4-6, to meet with the need of validation through research experimentations, before being tested on larger scales demonstrations with use cases and users in order to validate both the UXs relevancy and its correspondence with psychophysical user characteristics.

4.4. Disinformation

***Specific Challenge*:** As reported in the work programme 2020 "Upholding a strong and vibrant democracy in Europe is a question of legitimacy and trust. Democracy is a core value of our Union, together with fundamental rights and the rule of law. However, European democracy faces multiple challenges, both from outside and from within. To respond to this, the Commission will present a European Democracy Action Plan to help improve the resilience of our democracies and address the threats of external interference in European elections. The aim will be to counter disinformation[2] and to adapt to evolving threats and manipulations, as well as to support free and independent media."

Disinformation is confirmed as a top priority of the EC and the issue of a trustable and fair media ecosystem is strictly related to democratic values. Including disinformation in the formal communication on the work programme 2020 follows the strategy recently implemented by the European Commission thought different actions. In 2018 the EC created a High Level Expert Group on disinformation, funded a coordination and supporting action called SOMA to establish an European observatory on social media and disinformation, opened a dialogue with the platforms (e.g Facebook, Twitter, etc) to incentivize a policy of data access for scientific purposes with a common Code of Practice.

Disinformation is a major issue that must be taken into account seriously both from academic community and from technology developers in the media sector. Resources and new approaches are needed to understand and counteract the emergence of disinformation spreading. Indeed, the main problem, as reported by Reuters (2018) is "we currently know little about the impact that false news has on people's attitudes and beliefs, which is often the underlying concern".

***Scope*:** As mentioned by the High Level Expert Group it is crucial to "promote continued research on the impact of disinformation in Europe to evaluate the measures taken by different actors and constantly adjust the necessary responses". For this reason the scope of this research topic has the objective to enlarge the knowledge we have on the phenomenon,

[2] Following the definition adopted by HLEG established by the European Commission in 2018, disinformation means "all forms of false, inaccurate, or misleading information designed, presented and promoted to intentionally cause public harm or for profit".

experimenting ad-hoc tools and reduce the negative effects of the disinformation on society. Indeed, we must understand and measure the impact of disinformation, in order to provide specific and ad-hoc solutions to respond to the problem. Secondly, because the more we know about the phenomenon the better our opportunities will be to anticipate future challenges opened by the platforms or by other technologies that now or later will reshape our capability to interact with information.

Expected Impact: Improving the study of disinformation will result in several and different expected impacts. Impact could be visible on different actors: political institutions, scientific institutions, researchers, media stakeholders and, broadly speaking the citizens.
Some examples of the expected impact that could be achieved due to additional research effort include the following:

- Increased trust in institutions
- Increased trust in science
- Reduced polarizations of opinion's
- Improved critical thinking
- Improved methods and technologies for detection of disinformation
- Increasing media literacy and digital literacy skills
- Improved transparency of media ownership
- Fostering the transparency of online advertising

Implementation: The following types of project are needed to ensure concrete collaboration among media and other industry sectors:

- A research and Innovation project dedicated to the study the impact of disinformation, adopting combined qualitative and quantitative approaches. 5M€ covering 36 months.
- A research and Innovation project dedicated to study methods and technologies for detection of disinformation 5 M€ 36 months.
- A Research and Innovation project addressed to develop new approaches and methods to develop critical thinking (among adolescents but also among adults). 5 M€ covering 36 months.
- A CSA that will sustain the work of the SOMA Observatory to enlarge the network of collaboration among researchers, journalists and fact-checkers. 3 M€ for 36 months.

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