AI4media
ARTIFICIAL INTELLIGENCE FOR THE MEDIA AND SOCIETY

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AI for the Media Industry
A Strategic Research Agenda from the AI4Media consortium

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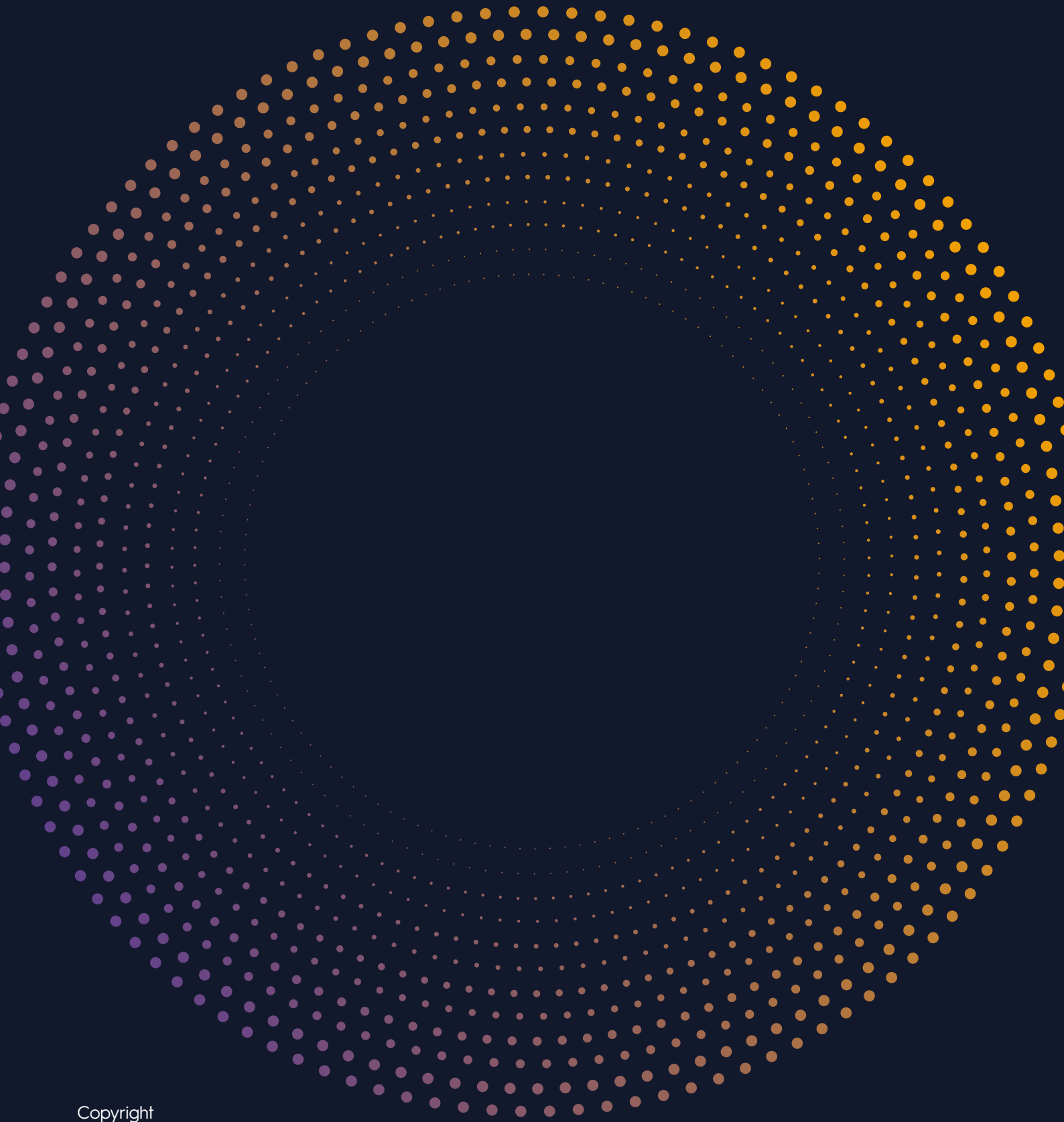

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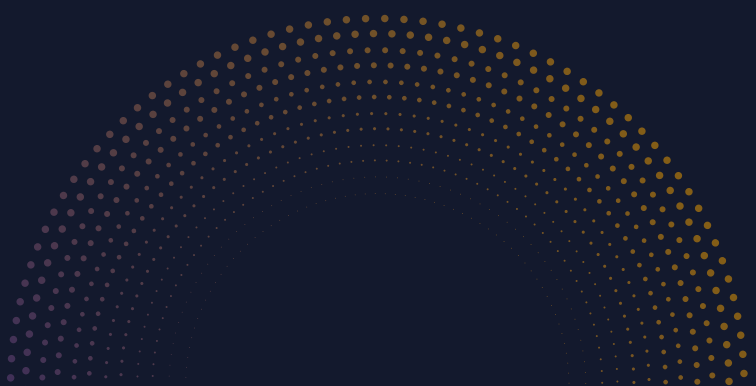

1. Foreword

Following a series of breakthroughs in the field of Artificial Intelligence, new technologies are emerging which are ushering a wave of revolutionary innovations in nearly all aspects of business and society; from transportation to finance, the fight against climate change, the media industry, journalism and politics. In all facets of economic and social life, AI is disrupting existing practices and creates significant opportunities for economic growth and societal prosperity while also involving considerable ethical challenges and risks.

Motivated by the opportunities, challenges, and risks that the wide use of AI brings to media, society and politics, AI4Media is building a wide Network of researchers across Europe and beyond, with a focus on delivering the next generation of core AI advances to serve the key sector of Media, making sure that the European values of ethical and trustworthy AI are embedded in future AI deployments, and reimagining AI as a beneficial enabling technology in the service of Society and Media.

This Strategic Research Agenda is a key contribution towards building this European Network of Excellence focusing on AI for the Media and Society. The objective is twofold: on one hand, it lays out the strategic plan for AI4Media's R&I activities, presenting the main research themes to be tackled by the consortium, explaining the current challenges, the research directions that need to be pursued to address them, the media industry applications, and the potential impact of this research. We hope this would be useful for AI researchers, media practitioners and policymakers. The second objective is to initiate and engage in discussions and debate with the broader community that could result in additional contributions for future versions of this Agenda, thus making it a living document depicting the current status of AI research and applications for Society and Media.

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2. Executive Summary

AI4Media's vision is that of a **European Network of Excellence in Artificial Intelligence for the Media, Society and Democracy** that will glue together the pieces of the currently fragmented European AI landscape and promote a unique brand of European Media AI. AI4Media will build a network of experts, including both leading researchers in media AI from academia and research as well as top European media companies that use AI to enhance their operations and business opportunities. Together, they will address significant technical, legal, ethical and application challenges, aiming to address pressing needs of the media industry and significant societal problems.

The Media are already benefiting from AI advancements and AI-driven applications that can significantly facilitate, enhance or transform important tasks, including smart assistants, smart recommender systems, content personalisation, automatic content creation, multi-modal content search, multilingual translation, disinformation and manipulated content detection, social media analysis and trend detection, online debate analysis, forecasting and decision support-systems, and many more. Further **advances in AI have the potential to transform the media industry** and revolutionise how operations run and how content is created, delivered and consumed while they can also offer trustworthy solutions with a societal impact, aiming to improve political participation, increase social cohesion, equip citizens against disinformation, and encourage healthy debates and social interaction.

To realise this enormous potential of AI will require breakthroughs in several domains such as:

→ **Machine learning** (ML), aiming to address important challenges of current ML techniques, including learning with few data, learning on-the-fly, transfer of knowledge and optimal AI architectures. In addition, research should also focus on distributed AI systems running on heterogeneous devices but also disruptive technologies currently at the laboratory stage such as Quantum-assisted Reinforcement Learning.

→ **Content-centered AI technology**, valuable for the media industry and marketable as end-user services, such as multimedia metadata extraction, summarisation, and clustering, automatic audiovisual content generation and enhancement, linguistic analysis, and media-specific core technologies to improve learning performance.

→ **Human and society-centered AI technology**, to equip citizens and media professionals with a set of tools that can be used to counter the effects of media manipulation and disinformation, enhance the understanding of online debates, support the analysis of perceptions of social media and the effects of online data sharing, and improve local news understanding without being limited by language barriers.

→ **Trustworthy AI techniques**, that aim at providing a framework for the development of the technologies mentioned above that guarantees their suitability with respect to democratic and ethical values. Research should focus on issues of robustness against threats and malicious attacks, explainability of AI decisions, fairness and mitigation of bias of AI models, and techniques for privacy-preserving AI.

These AI advances will be integrated and evaluated in **real-world use cases**, aiming to address significant challenges currently faced by different media industry sectors and to highlight how AI applies throughout the media industry value chain, from research and content creation to production, distribution, consumption/interaction, performance and quality measurement. The use cases cover a variety of media and societal topics such as **disinformation, news research and production, organisation of media archives and content moderation, game design, human-machine artistic co-creation, and social science research.**

In parallel to delivering the next generation of AI research at the service of media, AI4Media aims to establish a **Media AI Observatory** to monitor the legal and technological landscape as well as the impact of media AI on the society, economy and democracy. The Observatory will provide an overview of the existing EU policy and legal initiatives and their impact on future AI research for the media industry, will analyse ethical, societal, environmental and economic concerns, and will provide easy access to leading experts in this domain.

Implementing our vision of **AI as a human-centered, trusted, and beneficial enabling technology in the service of media and society**, requires supporting in practice the next generation of AI talent in Europe by offering opportunities for top AI education and skill development while also supporting entrepreneurship and innovative ideas. To this end, AI4Media will establish the **International AI Doctoral Academy**, a joint ICT-48 instrument to support world-level AI education and training for PhD/postdoc AI researchers. In addition, it will provide **mobility opportunities** for young researchers and media professionals. And lastly, it will fund and **support SMEs, start-ups and research labs** that want to develop innovative applications and research for the Media. These activities will further strengthen the European AI research community.

There is overwhelming agreement that AI will drive the majority of innovation across nearly every industry sector in the next decade. The media industry should be ready to exploit new AI advances but also mitigate possible risks, in order to enjoy the full potential of this technology and transform the industry. The AI4Media Network of Excellence aims to play an important role in this transformation, by bringing together leading research and industry players in this domain to strengthen the competitiveness and growth of the European media industry and increase Europe's innovation capacity in media AI. This Strategic Research Agenda crystallises AI4Media's research and innovation activities to materialise this vision.

3. Introduction

AI4Media aspires to become a European **Network of Excellence in Media Artificial Intelligence** that will:

→ deliver the next generation of AI research and training at the service of media, society and democracy,

→ make sure that the European values of ethical and trustworthy AI are embedded in future AI deployments in the media sector,

→ reimagine AI as a human-centered, trusted, and beneficial enabling technology in the service of Media and Society.

The ambition of AI4Media is to **put together the pieces of the currently fragmented European AI landscape** and establish the EU as a strong international competitor through a **unique European brand of Media AI**. To this end, the AI4Media network brings together Europe's leading researchers in AI media research, including both AI researchers that develop AI algorithms and tools for the media but also legal experts and social scientists whose research activities focus on the media sector and/or AI technology. In addition, top European media houses and content-related companies offer their unique perspective on industry challenges and needs, guiding research and innovation in the project.

This concentration of expertise makes AI4Media uniquely placed to drive forward AI science and its application in the media domain. Together, this community will build a new generation of AI technologies for the media sector that address real industry needs, are easily integrated in real-world media workflows, are aligned with European societal values and concerns, and adhere to European principles of Trustworthy AI. Reflecting this approach, this **Strategic Research Agenda** (SRA) provides a framework for coordinating AI4Media research and innovation activities.

The AI4Media Strategic Research Agenda comprises the following elements:

→ Development of an **AI for Media Observatory** to monitor the AI policy/regulatory landscape, AI societal impact, and AI technology trends, providing insights, analyses and recommendations for policymakers, industry and researchers.

→ **Research on four core AI areas** that will help reinforce and extend Europe's expertise in AI for Media. These include: new machine learning paradigms, trustworthy AI, content- centered AI, and human/society-centered AI.

→ **Real-world case studies** showcasing how to transform AI research into practical applications for the media industry with concrete impact to society and the economy.

→ **AI education and AI skills development** through the establishment of a prestigious European PhD programme on AI, a flexible mobility program, and open calls for funding research labs and SMEs working on media AI.

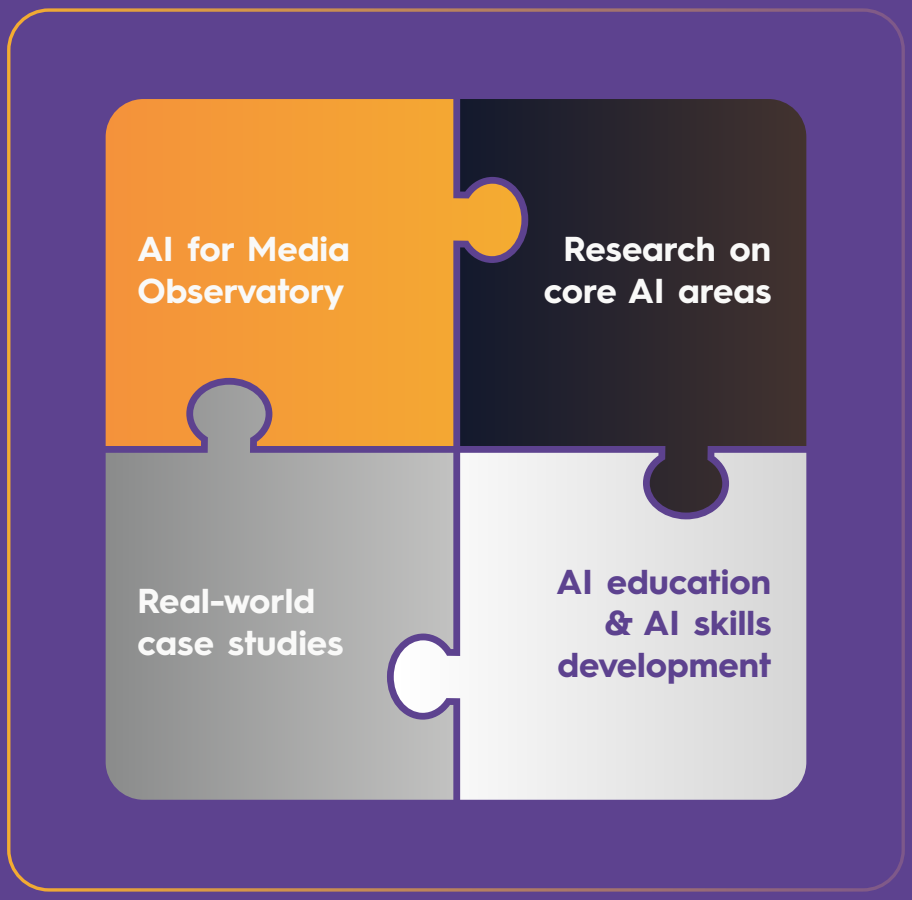


Figure 1

In addition, the document provides context for the SRA by providing an overview of the AI for Media landscape, discussing opportunities and challenges, while also providing more insights on the vision and ambition of AI4Media to become a European Network of Excellence on Media AI.

The AI4Media SRA was produced following a co-creation process that built on the AI4Media Description of Action and the **AI4Media Roadmap of AI for the media industry**, including a state-of-the-art-analysis; a public survey addressed to AI researchers and media professionals across Europe and beyond; a consultation with representatives from the media industry, AI research community and policymakers; dedicated mini workshops, interviews and surveys with media professionals. The Strategic Research Agenda will be a 'live' document, which evolves as the work progresses, responding to emerging industry and research needs and challenges and considering the expertise of the Network participants.

4. Background: AI for the Media Sector

4.1 Media AI landscape

The world is changing. Following a series of breakthroughs in the field of Artificial Intelligence, new technologies are emerging which are ushering a wave of revolutionary innovations in nearly all aspects of business and society; from transportation to finance, the fight against climate change, the media industry, journalism, and politics.

AI is disrupting existing practices and creates opportunities for accelerated technological progress and global economic growth and development, promising to make our professional and personal lives easier through increased automation[1], to provide solutions for and achieve breakthroughs in major world problems like poverty[2], climate crisis or cancer[3], to ensure equitable access for all[4], to increase productivity, innovation and creativity[5], to empower communities and strengthen democracy[6], and to create a safer and better world for all.

Although the potential of AI seems unlimited, it also comes with a considerable amount of ethical challenges and risks. While it can generate value for business and prosperity for society, it also gives rise to a host of serious consequences, some of them visible (e.g. violation of personal privacy by unauthorised user profiling, discrimination against underrepresented groups of citizens, manipulation of public opinion through disinformation, violation of fundamental rights like the freedom of expression through questionable moderation choices, just to name a few) but also many others that we do not fully grasp yet[7]. In order to safely and responsibly enjoy the benefits of AI, we should at the same time be ready to mitigate its various risks. This necessitates a greater focus on issues of trust, ethics and accountability, besides the pursuit of technological progress and economic growth.

Such a human-centric, trustworthy and ethical brand of AI is particularly relevant to the media sector. Digital media permeates most aspects of human and social activity and is intertwined with information exchange and knowledge transfer. Machine vision and visual content understanding were some of the first fields to exhibit significant breakthroughs in the evolution of AI, including advances in audio/music analysis and generation, text and language analysis, and modelling of social trends. The media market is already benefiting from AI-based support across the value chain: for media newsgathering, production, distribution, and delivery as well as audience analysis. This includes a range of tools and services for processes such as information analysis, content creation, media editing, content optimisation, audience preference analysis, and recommender systems[8].

1 J. Marsh, The Intelligence Revolution: 4 ways that AI makes life easier (2021): https://dataflog.com/read/10-ways-automation-makes-life-easier-everyone/

2 J. Bennington-Castro, AI Is a Game-Changer in the Fight Against Hunger and Poverty. Here's Why (2019): https://www.nbcnews.com/mach/tech/ai-game-changer-fight-against-hunger-poverty-here-s-why-ncna774696

3 C. Luchini, A. Pea, and A. Scarpa. Artificial intelligence in oncology: current applications and future perspectives. Br J Cancer 126, 4–9 (2022): https://doi.org/10.1038/s41416-021-01633-1

4 C. Martinez, Artificial Intelligence and Accessibility: Examples of a Technology that Serves People with Disabilities (2021): https://www.inclusivecitymaker.com/artificial-intelligence-accessibility-examples-technology-serves- people-disabilities/

5 B. Dickson, The Artist in the Machine: The bigger picture of AI and creativity (2020): https://bdtechtalks.com/2020/04/22/artist-in-the-machine-ai-creativity/

6 K. Johnson, How AI can empower communities and strengthen democracy (2020): https://venturebeat.com/2020/07/04/how-ai-can-empower-communities-and-strengthen-democracy/

7 B. Cheatham, K. Javanmardian, and H. Samandari, Confronting the risks of artificial intelligence (2019): https://www.mckinsey.com/business-functions/mckinsey-analytics/our-insights/confronting-the-risks-of-artificial- intelligence

8 F. Tsalakanidou et al, "The AI4Media project: Use of Next-generation Artificial Intelligence Technologies for Media Sector Applications", Proc. AAAI 2021: https://doi.org/10.1007/978-3-030-79150-6_7

AI technologies are expected to disrupt the media and entertainment industry through advances in content synthesis, analysis, and distribution, but also by offering new deeper insights into the complex and rapidly evolving social processes that unfold online and offline, by sensing citizen activities, interests and opinions. AI technology could help shape the media experience for users by enabling new ways of being informed, being entertained, being creative, interacting with content, communicating with other people all over the world, etc.

AI will also transform the existing workflows of the media industry[9] by automating routine or tedious processes (from content creation and content search to automatic analysis of legal documents to ensure compliance with copyright standards); developing AI assistants that can support media professionals in their daily tasks (e.g. when writing an article or creating visual assets for a new game); improving audience analysis and user profiling to offer better content and services to users; offering advanced forecasting capabilities and other decision support tools that will facilitate better short-term and long-term business decisions by management and staff.

AI technologies can support the relationship between media providers and their audiences, helping to align with the needs of media users and citizens. The use of AI can also cut down operating costs and ultimately free up resources that can be directed to support work of better quality and increased creativity. Moreover, AI can create opportunities for the better realisation of public values, such as media diversity, freedom of expression, and inclusiveness while it can help legacy media to be more competitive in a digital marketplace that is currently dominated by large platforms.

Empowered by AI-based support across the value chain, the media have the power more than ever before to nurture a democratic society, to improve our lives and support our creativity. However, at the same time, they can lead to polarisation and crisis, amplified by the use of the same AI. For example, there is increasing concern that the power of social media platforms combined with the large-scale automation capabilities offered by AI could prove to be detrimental to individuals, society and democracy. These concerns are fueled by the events of the last few years, where disinformation campaigns were found to have played an important role in shaping public opinion and the results of elections around the world.

4.2 Overview of main opportunities & challenges of media AI

As mentioned above, the media & entertainment industry (news, film/TV, music, games, social media, advertisement, publishing etc.) is already benefiting from AI advancements that can significantly facilitate, enhance or transform important tasks across the media industry value chain, including but not limited to: automation of existing tedious workflows; automatic content enhancement and creation; personalisation of content and services via enhanced user profiling; improved content recommendations; accurate audience analysis for enhanced audience targeting, content/ services development and increased advertisement revenue, at the global but also at the local level; improved accessibility to content thanks, for example, to automatic language translation; accurate forecasting about different businesses aspects; and more efficient decision making in general.

9 Dataiku, Ink., The AI Disruption in Media & Entertainment (2020): https://content.dataiku.com/ai-media-entertainment/ai-media-entertainment

In the following, we briefly discuss the main opportunities for the use of AI in the media sector but also relevant challenges. This summary is based on the state-of-the-art analysis conducted as part of deliverable **D2.3** "AI technologies and applications in media: State of Play, Foresight, and Research Directions", which reviewed and analysed in depth a large number of roadmaps, surveys, review papers, research papers and opinion articles focusing on the trends, benefits, challenges, and risks of the use of AI in different media industry. This analysis revealed a landscape where the opportunities for the use of AI are enormous while the variety of tasks across the media supply chain that AI can improve, assist, automate, expand or create is limitless. AI can have a truly transformative influence on the media sector, reinventing the business model of media organisations, establishing new ways of work and increasing the productivity and creativity of the workforce, and finally transforming and enhancing the user experience across platforms. At the same time, the use of AI in the media comes with significant challenges and risks that should be efficiently addressed to enjoy the benefits of this technology.

Opportunities for the use of AI in the media sector

In the following, we briefly summarise the areas in which there is the greatest opportunity for AI to have a significant impact in the media industry by offering solutions in some of the most pressing problems of the industry. The transformative role of AI has already started to manifest in many of these areas, with important breakthroughs over the last few years.

Automation of tedious tasks and AI assistants for increased productivity. Media workflows often include tedious or boring tasks, requiring a lot of resources. Some examples include searching large audio-visual archives or the Internet to locate information that can help a fact-checker verify the validity of some statement, analysing large volumes of documents for investigative journalism, producing subtitles or voice dubbing in different languages, producing content summaries, moderating content, etc. AI can help media professionals do their job more efficiently either by completely automating some tasks (e.g. content labelling or multi-lingual translation) or supporting professionals in more creative tasks (e.g. by offering automated suggestions, editing or enhancing content, answering questions, offering predictions about user engagement with content, etc.).

Content & services personalisation. With tons of content and a large variety of services available out there for the audience to enjoy (from news to films, music, games, books, graphics, etc.), media companies are in a constant battle against competitors for the audience's interest, trying to minimise churn rates, maximise user engagement with their content, and attract new users. To win the race, media companies invest large amounts of money to personalise their content and services and thus satisfy each customer's unique preferences, experiences, needs and moods. Elaborated profiling based on the continuous collection and analysis of user preferences, behaviours, and actions is already widely used in many media sectors (e.g. gaming industry, social media, advertisement, streaming services, etc.), however the trend is moving towards more elaborated approaches that also consider what happens to the user or in the world at the moment. Personalisation encompasses content suggestion, content presentation, interaction with content or personalisation of content itself (e.g. personalised movie trailers).

Automated content creation. One of the biggest issues of the media industry is the ever-growing demand for new content. During recent years, AI advances, especially in the areas of generative AI, computer vision and natural language processing, have offered several solutions in this direction by enabling the automatic synthesis of new content based on the use of existing text, video, audio files, or images. The applications are already numerous: procedural content creation for games, deepfakes for the film industry, robot journalism, automated summaries for books and films, creation of new music, generation of script and visuals for advertisement, creation of art etc. Automated content creation can increase productivity and creativity in the media industry but also provide new ways of creativity for the general public.

Content indexing and search. The sheer volume of content generated everyday by the media industry nowadays is unprecedented: news items, films, books, music and songs, advertisements, social media posts, reviews, user generated videos, etc. This creates considerable challenges when it comes to efficient content labelling, search & retrieval processes, especially in the case of video and audio, and stands in the way of efficient content monetisation. AI promises to lift these obstacles by exploiting advanced video, audio and natural language analysis for content (e.g. detection and recognition of faces, voices, objects, places, dates, context etc.) that will enable automatic content labelling and will move beyond simple text queries to support visual search, complex voiced questions or search based on images & sketches. This will allow fast and efficient search on large audio-visual archives as well as on the Internet for both media professionals and users aiming to find content that fits specific criteria (e.g. belongs to specific era, shows a specific person, involves a specific type of event – from earthquakes to music concerts-, includes specific human activities etc.). It will improve automatic content recommendation by offering suggestions that match user interests with the actual 'content' of the content, and it will allow media companies to more effectively exploit existing content and profit from it.

Multilingual NLP. Natural language processing has witnessed a true revolution during the last few years with large language models like GPT-3. NLP is expected to become increasingly mainstream in the media business through applications such as conversational agents and virtual characters, creative writing, robot journalism, interactive storytelling, voice search for image/video/audio, sentiment analysis in social media, voice dubbing, or multi-lingual translation. Multilingual translation in particular will be a real breakthrough, breaking language barriers and allowing, on one hand, content creators to reach new audiences worldwide but also to exploit creatively the wealth of content available online (which is currently out of reach because it is in other languages) and, on the other hand, helping audiences and users to communicate freely and benefit equally (and more democratically) by the content created all over the world.

Audience analysis. Understanding what the audience wants or needs or how the audience feels is a top priority. AI and data science have already transformed audience analysis by allowing large-scale collection and analysis of user behaviours, emotions, actions, interactions with content, providing unprecedented insights to audience needs, wants and moods, allowing media companies to more effectively target different audiences and monetise their content. In addition, trend detection allows media companies to react in real- time to what is happening around the world and adapt accordingly.

Forecasting. Predictive analytics can facilitate short-term decisions but also the design of long-term strategies. Accurate predictions with regard to, among others, content engagement and monetisation, user behaviours, sales or churn rates, ad revenue, industry trends etc. can decisively improve decision-making mechanisms in the media industry, allowing for a timely reaction and efficient adaptation to a fast-changing reality.

Challenges for the use of AI in the media sector

The previous analysis reveals the vast potential of AI to bring positive change to the media industry sectors. However, with high potential also come significant challenges and risks.

AI explainability. Currently, AI systems are mostly black boxes, without being able to explain why they predicted the success of a film or verified the authenticity of a video. In order to fully adopt and trust such AI systems, media professionals but also users need to understand how such systems work. Explainable AI aims to do just that, increasing transparency and increasing trust and adoption of AI-enabled applications.

AI robustness. Performance of AI algorithms may be hindered by many reasons, including malicious adversarial attacks but also poor performance when dealing with data different from those they were trained with. To ensure robustness, tools that help fortify AI models against attacks, predict new types of attacks, and ensure that the models perform as well in the real-world as they do in a sandbox are increasingly necessary.

AI bias and AI fairness. AI systems often exhibit bias against specific groups of people, including racial bias, gender bias, etc. due, for example, to prejudiced hypotheses made when designing the models or due to problems of diversity and representation in training data. AI bias can lead to bad business decisions or discriminate against groups of users. A prominent example for the media sector is bias that may be embedded in large language models. Such models are trained with large amounts of Internet data that are produced in the biggest countries, in languages with higher linguistic footprint, and by communities with large representation, or mainly by men[10], thus resulting in models that fail to capture changing social norms or the culture of minorities and underrepresented groups and which will eventually discriminate against such groups or produce language that is not attuned to changing social norms[11,12]. To address similar problems, new techniques have been proposed aiming to enhance fairness of AI models.

Privacy concerns. AI applications like recommender systems or content personalisation are based on the collection of vast amounts of data about user's preferences, behaviours, actions, as well as user generated content. Obviously, this creates a lot of concerns about privacy and how this data may be used. To address such concerns, the EU has proposed regulations like the GDPR while companies are starting to explore solutions that will enhance the privacy of the users and their data.

High-quality data for AI training. Large volumes of real and high-quality data are required for training AI models for the media industry. AI researchers are faced with significant challenges when it comes to this issue: low dataset diversity, lack of regionally relevant data (smaller languages/ dialects, locally relevant named entities, etc.), complex data gathering processes, closed datasets, GDPR concerns, dataset bias, and proper benchmarking.

10 Such models usually get trained with data scrapped by sources like Wikipedia or Reddit where women are significantly under-represented. According to this Guardian article, women are less than 20% of the contributors of Wikipedia; according to Statista, women represent only 37% of Reddit users worldwide.

11 K. Hao, MIT Technology Review, "We read the paper that forced Timnit Gebru out of Google. Here's what it says" (2020): https://www.technologyreview.com/2020/12/04/1013294/google-ai-ethics-research-paper-forced-out- timnit-gebru/

12 E. Bender, T. Gebru, A. McMillan-Major, and S. Shmitchell, On the Dangers of Stochastic Parrots: Can Language Models Be Too Big? In. Conf. on Fairness, Accountability, and Transparency (FAccT '21), March 2021.

AI skills. One of the reasons hindering the adoption of AI in the media industry is the lack of relevant skills by media professionals and challenges in recruiting AI experts. To overcome this obstacle AI training and education are necessary for media professionals as well as raising awareness about AI and its potential across an organisation. Collaboration of the media industry with academia/research but also with other media organisations or industries on AI topics of common interest would also be beneficial.

AI strategy. Many media companies still do not have a clear AI strategy that will allow them to efficiently adopt AI in the workplace, recruit or train staff, make investments in specific technologies, pursue useful collaborations and fully exploit AI's potential for the media.

AI applications for different media industry sectors

The applications of AI for the media industry are numerous. Figure 2 attempts to summarise the relevant applications per industry sector, focusing on news, film/TV/streaming, music, games, social media, advertising, and publishing. As can be seen, each sector has its own unique needs (e.g. fact-checking for newsrooms or AI-based casting for films) but most of the applications aim to satisfy similar needs, e.g. the need for content personalisation or automated content creation (whether this is music, films, ads, books or games), better recommender systems, enhanced understanding of users, etc.

News

- Robot journalism/automated reporting
- Fact-checking
- Content verification (deepfake detection)
- Content archiving & search (video, image, text, etc.)
- Automated transciptions
- Multi-lingual content translation
- Social media analysis for trend detection
- AI assistants for journalists (for editing/writing/visuals)
- Augmentedj journalism (using drones, wearables, voice, VR for novel content creation and delivery)
- Recommender systems
- Personalised content creation & delivery
- Chatbots to assist subscribers/audience
- Content moderation (e.g. comments on articles)
- Compliance with copyright standards
- Audience analysis
- Sentiment analysis of user content
- Hyper-targeted advertising
- Forecasting (subscriptions, trends, sales, content monetisation)

Film/TV/Streaming

- Personalised programming
- Content recommendation
- Content personalisation (e.g. personalised movie trailers, user-driven storylines, interfaces etc.)
- Automated content generation (script, voice, video, CGI, deepfakes, trailers, video highlights, live commentary, captioning, etc.)
- Multi-lingual translation
- Content enhancement (e.g. film restoration)
- AI-based casting
- VR-enabled user experiences
- Sentiment analysis (from social media, product reviews, surveys, etc. but also using in-room sensors) to measure audience engagement with specific content
- Chatbots to assist subscribers/audience
- Audience analysis
- Churn prediction
- Dynamic product placement and advertising
- Programmatic ad buying
- Hyper-targeted marketing
- Forecasting (sales, subscriptions, trends, audience engagement, residual payments, content monetisation)

Music

- Automated content creation (music, singing voices, sounds, music clips etc.)
- AI creativity assistants for music creators and users
- AI-enabled real-time feedback for artists/creators
- Audio indexing and search
- Demixing
- Content recommendation
- Content personalisation (e.g. music matching our mood)
- Chatbots to assist subscribers/audience
- Customer base segmentation
- Forecasting (sales, music trends, audience engagement, residual payments to talent, content monetisation)

Games

- Generative game design
- Procedural content generation (graphics, music, etc.)
- Sentient AI agents / virtual characters
- Player profiling
- Personalised games dynamically adapted to players
- Personalised marketing
- Multi-lingual translation
- VR-enabled user experiences

Social media

- Reccomendation engines
- Content personalisation
- Enhancde content search
- Multi-lingual translation
- Automatic ad placement
- Chatbots to assist users
- Trend detection
- Opinion mining
- Content moderation
- Monetisation of user generated content
- Forecasting (ad sales, user engagement with content, content monetisation, trends, revenue)

Advertisement

- Emotion-based advertising
- Hyper-targeted advertising
- Programmatic ad buying
- Customer base segmentation
- Multi-lingual translation of ad content
- Chatbots to assist consumers/users
- Market forecasting (sales, campaign success, content engagement, etc.)
- Automatic content generation (ad scripts, ad videos, ad graphics, promotional material, etc.)

Publishing

- Automatic content generation (book summaries, user review summaries, graphics, imagery for children's books, voice for audio book etc.)
- Content editing
- Content indexing & search
- Content personalisation (e.g. personalised e-books or audio books)
- Content recommendation
- Multimodal interactive experiences (e.g. for e-books)
- Multi-lingual translation of content
- AI assistants to support publishers, editors, graphic designers
- Improved accessibility for impaired users
- Audience segmentation
- Detection of trends in content consumption/production
- Identification of users /prosumers (authors, fans, influencers, trend-setters etc.) and monitoring of community dynamics
- Co-creation and distributed mentoring in fanfic communities
- Copyright management
- Forecasting (sales, trends, content appeal, etc.)

Figure 2: A summary of AI applications for the media and entertainment industry.

5. Context: A European Excellence Centre for Media, Society and Democracy

Motivated by the challenges, risks and opportunities that the wide use of AI brings to media, society and politics, AI4Media aspires to become a **Centre of AI excellence and a wide Network of researchers across Europe and beyond**, that will

→ deliver the next generation of AI Research and Training at the service of media, society and democracy,

→ make sure that the European values of ethical and trustworthy AI are embedded in future AI deployments in the media sector,

→ reimagine AI as a human-centered, trusted, and beneficial enabling technology in the service of Media and Society.

The ambition of AI4Media is to connect the fragmented European AI landscape and establish the EU as a strong international competitor through a unique European brand of Media AI. To achieve its overall ambition, AI4Media will be based upon 6 main pillars, as shown in Figure 3.

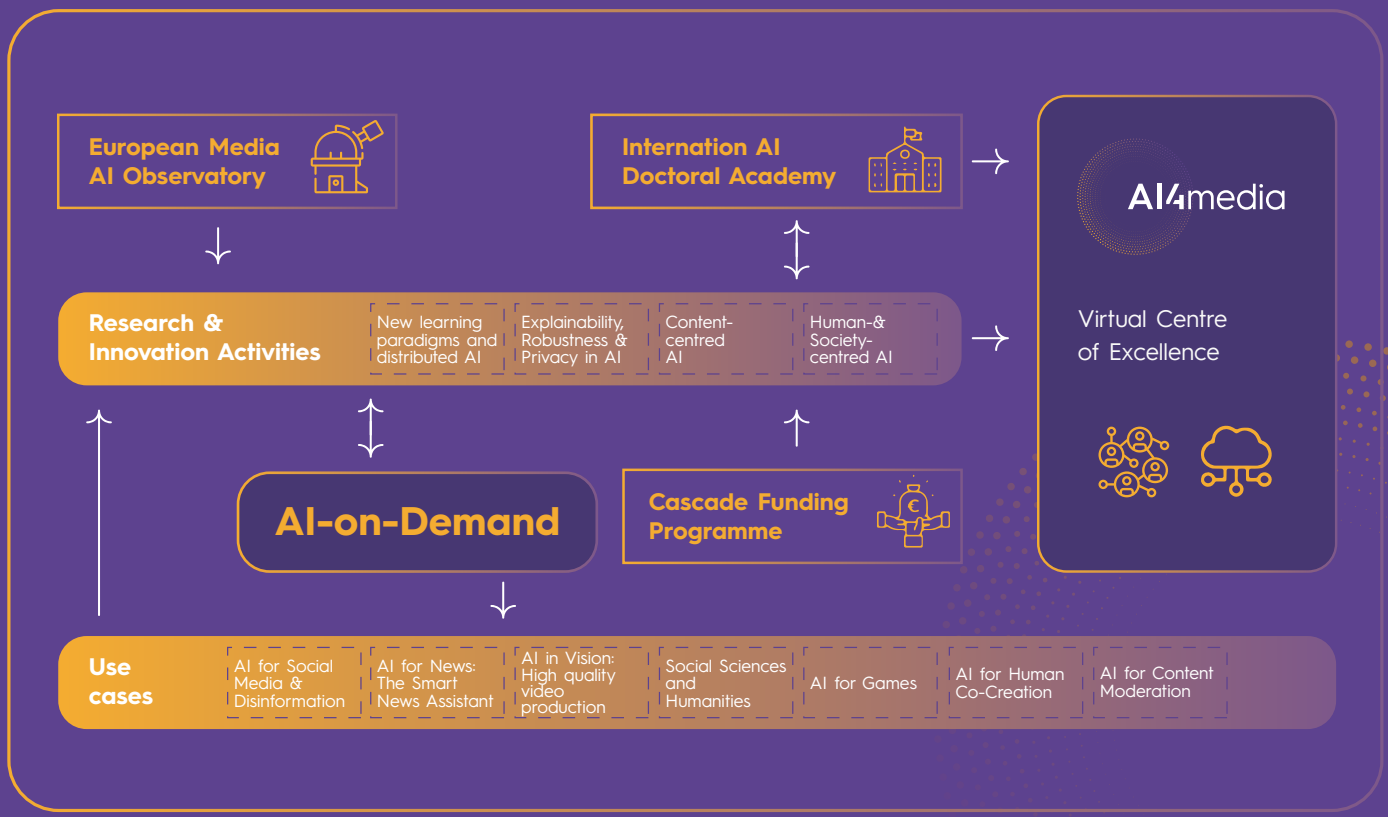


Figure 3: The AI4Media pillars

→ A **European Media AI Observatory** that will set a research and innovation agenda for media AI, monitoring the disruptive potential of emerging technologies for the society and economy and offering relevant policy recommendations.

→ An **intensive research and innovation activity plan** in four core areas of Media AI where Europe can acquire a competitive advantage: (1) emerging machine learning paradigms and AI at the Edge; (2) AI fairness, explainability, robustness, and privacy; (3) AI for multimedia content analysis and creation; and (4) Human-centered and Society-centered AI technologies. The technologies to be produced as a result of this research will enrich the AI4EU platform.

→ A **portfolio of seven use-cases**, aiming to directly apply the technologies developed in the project to strengthen the European Media sector and society. The use cases that will be implemented through the close collaboration of AI researchers, media companies and user groups of media professionals aim to bring AI expertise to real-world applications of the media industry, by exploiting mature technologies developed as a result of the core AI research performed within the project. Covering a variety of topics such as disinformation, news research and production, media moderation, organisation of audiovisual archives, game design, human-machine co- creation, and social science

→ A targeted **programme of cascade funding** to increase engagement of external actors in AI research and applications and build an ecosystem around the network, in turn benefiting from it and bringing innovation to the market. The programme will include two open calls, funding in total 20 research or application projects with up to 50K euros per project.

→ An **International AI Doctoral Academy** that will nurture a new generation of AI talent by offering educational courses, student exchanges, AI mellontology symposia, summer schools, etc. Building upon collaborations between prominent academic institutions and the industry and cooperating with other networks of excellence to capitalise on aggregated expertise and resources, AIDA aims to achieve European academic excellence and industry relevance, attract young talent and provide incentives for it to stay in Europe.

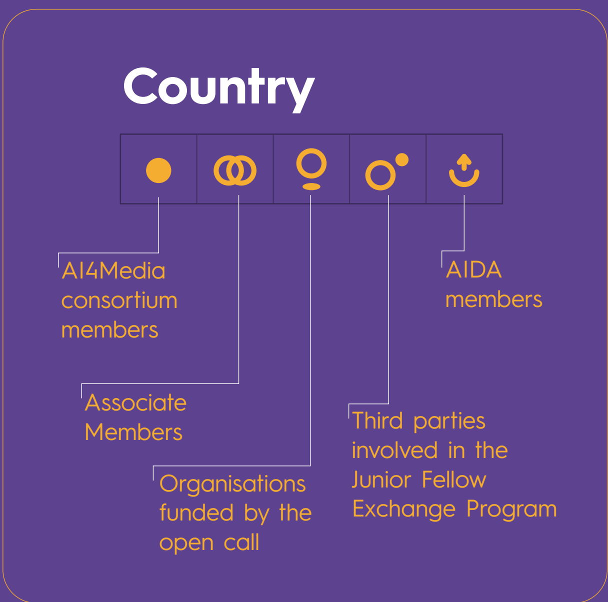
→ The **AI4Media Virtual Center of Excellence**, which will function as a portal for all Media AI research and innovation activities in Europe, aiming to glue together the pieces of the fragmented European AI landscape.

→ The **AI resources** developed in the project will be published in the AI Catalogue of the **AI-on- Demand platform** while selected AI components will be integrated in the **AI4EU Experiments** marketplace.

The AI4Media network

The AI4Media vision is to become a European Powerhouse of Media AI. Motivated by a shared desire to establish European leadership in the development and deployment of AI for the media sector, AI4Media has established a network of excellence that connects leading researchers, ICT industry and top media organisations across Europe.

The AI4Media network currently consists of **30 partners** (9 universities, 9 research centres, 12 industrial partners) and more than **60 associate members**, aiming to bring together the currently fragmented European AI landscape in the field of media, and foster deeper and long-running interactions between academia and industry. The network also includes research organisations and SMEs either funded by the project's open calls or participating in research exchanges as part of the AI4Media Junior Fellows Exchange Program.



Country	AI4Media consortium members	Associate Members	Organisations funded by the open call	Third parties involved in the Junior Fellow Exchange Program	AIDA members
Australia		1			
Austria	1	5		2	2
Belgium	2	1		1	2
Bulgaria	1	2	1		1
Cyprus		1			1
Czech Republic				1	2
Denmark	1	3	1		2
Estonia					1
Finland					1
France	4	7		1	6
Germany	3	4	3	3	8
USA		2			
Greece	3	5	3		4
Hungary					3
India		1			
Ireland	2	1		1	2
Israel			1		1
Italy	4	1	1		11
Lithuania					1
Luxembourg					2
Malta	1				1
Netherlands	2	2			3
Norway		2			
Poland		1			2
Portugal	1	1	1	1	1
Rep. of Korea		1			
Romania	1	5	2		1
Singapore		1			
Slovakia		1			2
Slovenia		1	1		
Spain	1	6	3	5	9
Sweden		1			3
Switzerland	2	5			3
UK	1	1	3	2	2

Unique selling point

AI4Media brings together a critical mass of top AI researchers, media professionals, social scientists and legal experts to create a Network of Excellence and a European Powerhouse in Media AI that will deliver the next generation of AI technologies for the Media Industry and will reimagine AI as a human-centered, trusted and beneficial enabling technology that can be used to offer innovative solutions to major challenges facing the media, the society and democracy.

Next generation AI for the Media

Core research

Multi-modal content

Human and Society in the centre

New generation of machine learning systems

Trustworthy AI solutions

Real-world applications

Fact-checking & verification

Automated game design

News production automation

Content moderation

Human-machine artistic co-creation

Impact of policy & regulations

Monitoring of EU regulatory landscape

New policy recommendations

Societal concerns

Analysis of media AI impact & societal concerns

Education & training

AIDA ARTIFICIAL INTELLIGENCE DOCTORAL ACADEMY

Junior Fellows Exchange Program

6. European Observatory for Media AI

6.1 Context and need

The world needs to be able to make sense of AI developments and their impact on individuals, society, and economy. The fragmented European AI landscape is in even greater need of an institution that will monitor, aggregate, study, and interpret relevant information.

To this end, AI4Media combines expert technical knowledge, industry experience, socio-economic analysis, and legal analysis to monitor technological and industrial developments of media AI, assess their impact on society and the economy, and align with policy recommendations, self-regulatory initiatives and ethical considerations.

Research in this direction includes:

→ analysis of regulatory and policy landscape in Europe and beyond;

→ analysis of AI for media technology trends and exploration of relevant opportunities, challenges and risks for the industry;

→ analysis of the societal, political, and economic impact of media AI technology and applications;

→ development of policy recommendations to address the challenges encountered by media companies and AI researchers.

This research is conducted in the context of Work Package 2.

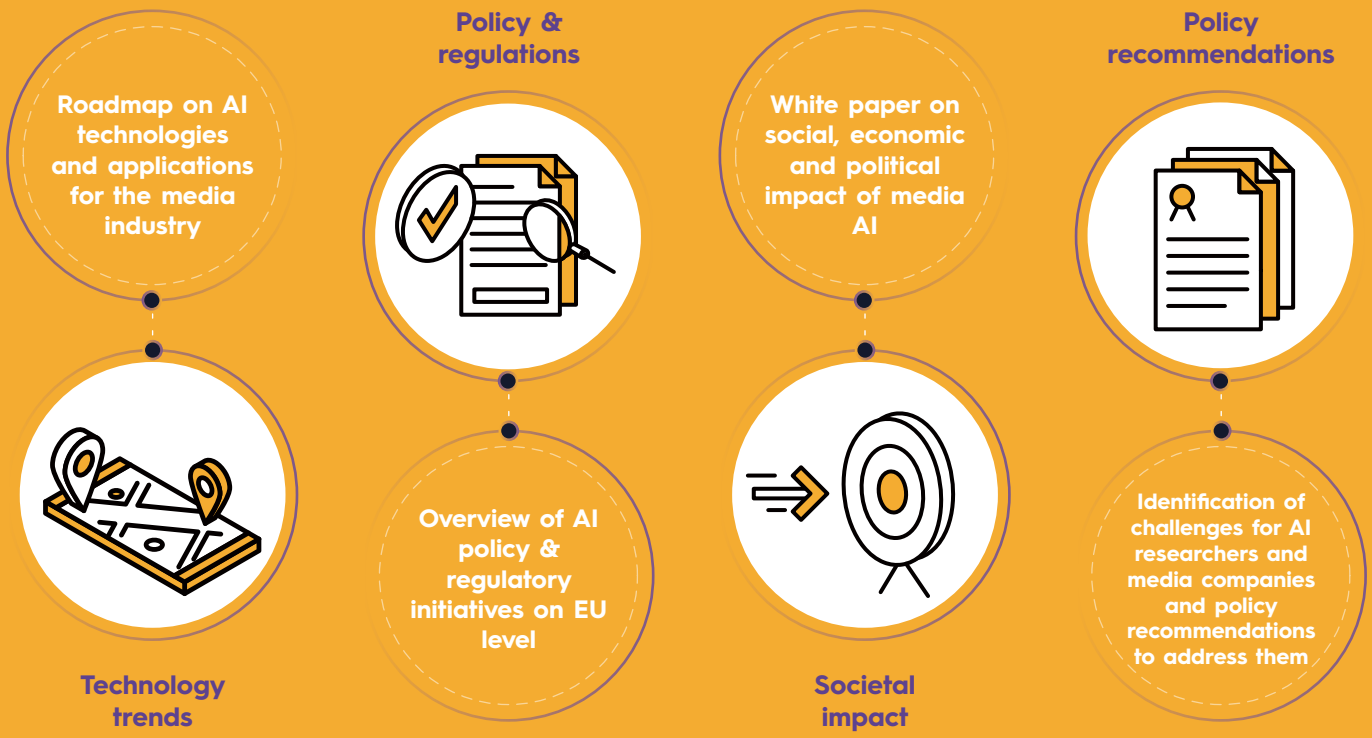


Figure 4: Media AI Observatory - main research directions

These research efforts will culminate in the establishment of the **European Media AI Observatory**. Building upon the joint effort during AI4Media and using the project as a jumpstart, the Observatory will remain after the project completion as a long-term point of contact for European actors. Through the Observatory, media, research, and policy organisations will be able to acquire policy, technology, and application analyses and recommendations. Beyond the 4-year research agenda set by AI4Media, the Observatory will serve to maintain the gains established during AI4Media in the long run.

6.2 Research directions

Monitoring of EU and international AI policy and regulatory initiatives with a focus on the media sector

→ Challenge

The fragmented nature of EU and international policy and regulatory initiatives on AI triggers a hard-to-understand framework that requires analysis and explanation, especially concerning their impact on research activities that involve the development of tools and applications for the media. In addition, forthcoming EU policy and regulatory initiatives could potentially have a profound impact both on media-related AI research but also media companies' commercial and non-commercial activities.

→ Research

The focus is on monitoring and mapping the landscape of EU and international AI policies concerning AI ethics initiatives, including trustworthy AI, Intellectual Property rights, Safety and Liability regimes, use of AI in education, culture, and audio-visual sector, the AI Package including the AI Act proposal, the Digital Services Act Package, and the Data Package. Complementing this comprehensive mapping, the potential impact of the anticipated EU regulatory initiatives on the field of AI for the media will be also explored and analysed.

→ Expected impact

The mapping and ongoing monitoring of the AI policy and regulatory landscape allows AI researchers and the media industry to understand which legal framework affects them and in what way. Additionally, the analysis of potential gaps in these frameworks can be utilised by EU policymakers to affect and improve both legislative proposals that are in the process of adaptation at the moment but also forthcoming initiatives.

Roadmap on AI technologies & applications for the media industry

→ Challenge

While the media industry is already benefiting from AI advancements that can transform important tasks across the media value chain, the adoption of AI brings significant challenges and risks for the industry and society. Mapping the highly complex and evolving landscape of AI technologies for the media is a challenging task that has only been partially addressed, by focusing on specific sectors or aspects, thus failing to accurately grasp the whole picture.

→ Research

For the analysis of the AI for Media landscape, a multi-dimensional and multi-disciplinary approach is required, involving European AI researchers and media professionals. Three main tools are used: (i) a multi-disciplinary state-of-the-art analysis of relevant roadmaps, surveys, review papers and opinion articles performed by AI experts, social scientists, ethics and legal experts and media industry practitioners; (ii) a public survey targeted at AI researchers and media professionals; and (iii) development of a series of white papers on the future of AI for the media, focusing on different AI technologies and applications and on different media sectors.

→ Expected impact

By offering an in-depth look on media AI, the aim is to help i) the media industry discover the opportunities offered by AI to transform media workflows, assist media professionals and enhance the user experience in different sectors; ii) AI researchers to understand industry needs and recognise emerging research trends; and iii) social scientists and policymakers to comprehend facilitators, challenges and risks of media AI, resulting in more effective policies.

Analysis of critical societal concerns of media AI impact

→ Challenge

The media industry is rapidly adopting AI solutions across different parts of the media cycle (e.g., producing content, curating and distributing content, or moderating the engagement with media content). While several existing reports have focused on the implications of AI more generally or on specific applications or sectors, there is a need to gain a more informed and detailed overview of the potentials and challenges faced by the media sector as a whole when adopting AI, aiming to better understand the impact of media AI.

→ Research

To study and discuss the impact of media AI, two steps are envisioned: first, a systematic literature study of papers and reports from both industry and think tanks as well as academic journals, aiming to provide an overview of the state of discussion of AI for media, including the specific concerns raised in these discussions (technical, political, social, or economic). Second, a series of workshops with media industry representatives that focus on specific challenges identified in the literature review, aiming to qualify and expand on the initial literature based insights.

This research will lead to a whitepaper analysing the impact of media AI in society and the media sector specifically, identifying challenges and providing recommendations.

→ Expected impact

The literature study provides a 'reader's guide' for media professionals, AI developers working in the media sector, and researchers interested in AI and media. Identifying concrete challenges and providing recommendations for each challenge, it can help inform policy work, help professionals navigate in the AI landscape, and produce awareness of these challenges and the potential societal impacts of AI in media.

The industry workshops provide an opportunity for the media sector to directly engage with these challenges and in a more fine-grained manner identify where and how these challenges affect them and what responsible solutions to these challenges might be proposed. They, as a result, become active participants in shaping the agenda for responsible AI in the future.

Delivery of policy recommendations for media AI

→ Challenge

The current European legal landscape lacks the specific provisions, regimes, and policy framework concerning the use of AI applications and tools in the media sector. This absence of guidance creates important challenges for accomplishing the EU's vision on Trustworthy AI.

→ Research

To provide comprehensive pilot policy recommendations to meet the demand for clarification on AI use in media, we first need to identify the challenges for the use of AI applications in the media sector: challenges for media companies, for academia and researchers but also legal and societal challenges. The identification of challenges is based on the work performed under the previous research themes: overview of EU policy/legislative landscape, overview of landscape of AI technologies for the media, public survey on media AI, and overview of media AI impact.

The next step is to formulate a set of useful pilot policy recommendations to address the identified challenges, following a co-creation process that involves consultation with experts from different backgrounds: technology experts, social scientists, legal experts, media industry stakeholders, civil society representatives, policymakers.

→ Expected impact

This research will help raise awareness in the media sector about the importance of AI ethics. It will also help policymakers understand the challenges within

the media industry and academia and act accordingly while drafting legislation, policy frameworks, and regulations. While focusing on Europe, there is potential to also inspire other legal regimes in an affirmative way.

Establishment of the Media AI Observatory

→ Challenge

Currently, the information (case studies, journal articles, etc.) about AI in the media sector is scattered across multiple sites and platforms, which makes it difficult for media professionals, researchers and policymakers to efficiently navigate this information landscape. Equally, the growing amount of information produces the need to offer overviews of what challenges are the most urgent at this time.

→ Research

AI4Media will establish a Media AI Observatory aiming to monitor, aggregate, study, and interpret relevant information on media AI related topics, with the purpose to support a better understanding of media AI developments and their impact on society, economy, and people. The observatory will enable this in three ways.

First, by offering an information one-stop-shop, where relevant content relating to AI for media will be curated, categorised and made searchable according to both genres (e.g., blogs, reports, news, forecasts, surveys, etc.) and on topics (e.g., trends, disinformation, policy etc.). Second, by providing an 'expert directory', where relevant experts in the field can be featured and contacted by, for example, the media industry or civil society. This will help stakeholders navigate this landscape of not only information but also experts. Third, by producing online filmed interviews or roundtable discussions with relevant experts, which can help provide easy overviews of what the core challenges of AI in media is at the moment and enable access to expert opinions in an easily digestible format.

→ Expected impact

The Observatory will positively impact the access to relevant knowledge on AI for media for industry, policymakers, researchers and civil society, by collecting it on one platform and also providing easy access to contact relevant experts in the field.

6.3 Expected outcomes

- **→ Overview & analysis of the AI policy initiatives on EU level**
- **→ Roadmap on AI technologies and applications for the Media Industry**
- **→ Online survey on AI for the Media Industry**
- **→ White paper on the social, economic, and political impact of media AI technologies**
- **→ Pilot policy recommendations for the use of AI in the media sector**
- **→ Media AI Observatory (to be launched in early 2023)**

Unique selling point

The AI for Media Observatory will become a reference point for monitoring EU policies and regulations, technology trends, and impact of media AI. It will also provide insights, analyses, and recommendations to policymakers, media industry, and research organisations from a multi-disciplinary panel of experts.

7. Main themes for core media AI research

To deliver the **next generation of core AI research for the media industry and society** and reinforce and extend Europe's expertise in media AI, the AI4Media consortium focuses its efforts in four crucial areas of core AI research:

- New machine learning paradigms and AI at the Edge;
- Trustworthy AI, exploring AI robustness, explainability, fairness and privacy;
- Content-centered AI, focusing on multimedia content analysis and creation;
- Human-centered and Society-centered AI technologies, focusing on the analysis of online debate, information production and consumption, and social media experience.

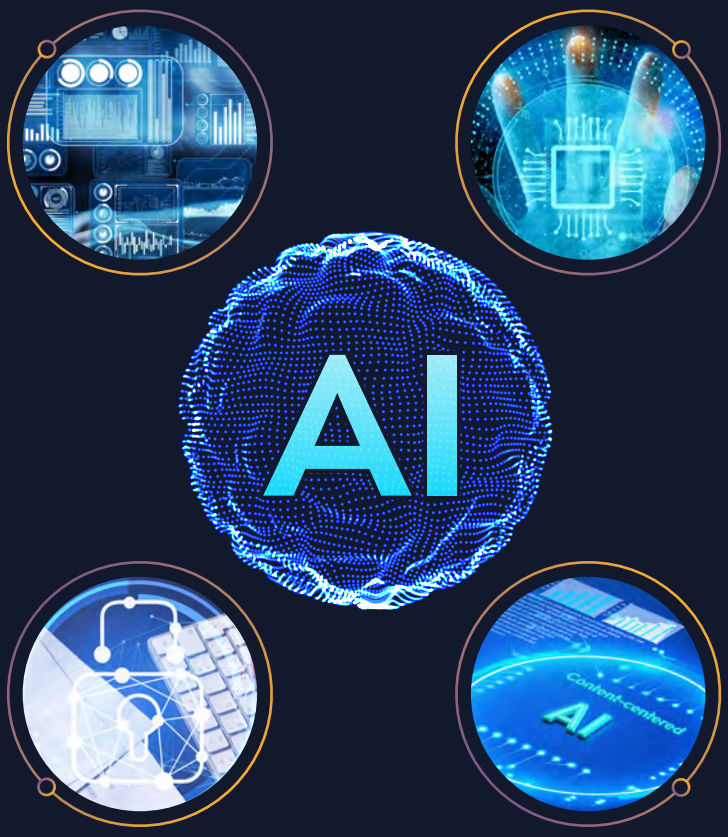
These research themes are explored in the context of Work Packages 3, 4, 5, and 6, respectively. Each research theme comprises several research directions, aiming to keep up with existing and emerging AI research trends but also address the needs and challenges of the media industry (Figure 5).

New learning paradigms & distributed AI

- Lifelong and on-line learning
- Manifold learning and disentangled feature representation
- Transfer learning
- Neural Architecture Search
- AI at the Edge, decentralised and distributed learning
- Deep quality diversity
- Learning to count
- Quantum assisted reinforcement learning

Trustworthy AI

- Legal and ethical frameworks for trusted AI
- Novel methods for ensuring AI robustness
- Novel methods for explainable and interpretable AI
- Privacy- and security-enhanced federated learning approaches
- Methods for detection and mitigation of bias affecting fairness in recommender systems
- Benchmarking of AI Systems



Human- & society-centered AI

- Policy recommendations for content moderation
- Manipulation and synthetic content detection in multimedia
- Hybrid, privacy-enhanced recommendation
- AI for healthier political debate
- Detection of perceptions of hyper-local news
- Measuring and predicting user perception of social media
- Real-life effects of private content sharing

Content-centered AI

- Media analysis and summarization
- Media content production
- Content representation, indexing and retrieval
- Language analysis
- Music analysis
- Learning with scarce data
- Computationally demanding learning

Figure 5: Core AI research for the media - Main research themes and research directions.

7.1 New Learning Paradigms and Distributed AI

7.1.1 Context and need

In the context of the current AI revolution, several core AI technologies that challenge the existing learning paradigms need to be explored. Models that adapt and learn on-the-fly, families of models that "teach" each other, algorithms that are able to learn from very few data and algorithms that are able to replace humans in selecting the optimal AI architecture to train for a given task, are all research propositions that have already begun to give promising results and may alter the way AI works in the very near future.

Distributed AI systems working on heterogeneous devices and powered by advanced communications like 5G challenge the paradigm of cloud computing which aggregates user data, centralises computation, and feeds the results back to user devices. AI at the Edge is often hailed as the next major evolution of AI, opening a window of opportunity for Europe to acquire a competitive advantage. Disruptive technologies currently at the laboratory stage, such as Quantum-assisted Reinforcement Learning, should also be explored as they are emerging.

In the following, we summarise the main areas of research interest under the New Learning Paradigms research theme. The aim is to efficiently address the current limitations of learning approaches and improve learning performance and speed.

7.1.2 Areas of research interest

Lifelong and on-line learning

→ Research challenges

Lifelong/on-line learning enables deep neural networks to learn from streams of data, while storing only a limited footprint of past data. The main challenges are to: (i) make the data streams usable for the training of deep learning models, (ii) maintain a good performance level for both past and new data, and (iii) update deep models without full retraining.

→ Research directions

The first challenge can be addressed by proposing novelty detection methods, which make use of past knowledge to label new data, notably by incorporating contrastive learning techniques to differentiate between classes. The second challenge can be tackled by reducing the bias towards new data, which occurs due to imbalance in their favour. The proposed techniques focus on past data in order to boost their deep representations, and thus make the lifelong learning process both stable and plastic. The third challenge can be addressed by reusing knowledge encoded in past models as much as possible in order to reduce the complexity of the lifelong/on-line training process.

→ Expected impact

The knowledge relevant to the media sector evolves fast and models used to extract it should be able to follow this pace. Lifelong/on-line learning techniques can be used to: (i) make sense of large and unlabelled streams of data, (ii) classify new entities in real-time via a fast update of the underlying deep models, and (iii) identify potentially problematic content via out-of-distribution detection.

Manifold learning and disentangled feature representation

→ Research challenges

Learning features manifolds of unstructured data (e.g., images) where semantic concepts lie is paramount for systems that recognize and synthesise new data (e.g., for helping media practitioners) but hard without manual labelling and supervision. Unsupervised manifold learning using rich multimodal pre-trained models aims at raising these limitations, and allowing for discovery of meaningful and useful factors without subjective and laborious human labelling.

→ Research directions

These challenges can be tackled along two research lines. First, by optimising in an unsupervised manner (i.e., without the need of laborious human labelling) controllable generative paths allowing for intuitively

controlling the generation of media content. Moreover, by incorporating recent pre-trained Vision-Language models (such as CLIP) that can serve as a cheap and rich source of supervisory signals towards the discovery of controllable generative paths, allowing generation controllable by guidelines given in natural language.

→ Expected impact

Research in this area allows for generative methods (e.g., of facial imagery) that are more controllable by taking advantage of vast pre-trained Vision-Language models. This may help in creating more robust and democratised models/datasets by enhancing/augmenting datasets with controllably generated samples of under-represented classes.

Transfer learning

→ Research challenges

Training a neural network usually requires very large computational and energy costs, which can be un-assumable for some media practitioners. Transfer learning research aims at lowering these costs by studying the reuse of already trained AI models for new tasks in new domains, thus avoiding training neural networks from scratch when possible.

→ Research directions

These challenges can be tackled through two research lines: (i) methodology studies, and (ii) creation of robust, reusable models. Methodology studies compare the AI models' performance, computation time, and/or power and energy consumption in diverse domains and tasks, when applying different transfer learning methods. The second research line is focused on training AI models that are as easily reusable and adaptable as possible, by learning domain-invariant knowledge or using domain alignment techniques when reusing models.

→ Expected impact

Transfer learning methods allow more media outlets and professionals to easily and successfully reuse and adapt existing AI models for their specific needs, such as face and person detection, image labelling and classification, information retrieval or image and video manipulation tasks.

Neural Architecture Search

→ Research challenges

Neural Architecture Search (NAS) has been successfully used to automate the design of deep neural network architectures; however, why these architectures work well, how similar are the architectures derived from different search strategies, how to design and access the search space in an efficient and unsupervised way, and how to fairly evaluate different auto-designed architectures remain open research challenges.

→ Research directions

Parameter sharing based OneshotNAS approaches can significantly reduce the training cost of AI models. However, there are still two issues that need to be solved in the development of lightweight NAS: i) the performance of the network sampled from the supernet is inconsistent with the performance of the same network trained independently. The solution is to investigate a better evaluation strategy and an improved ranking of candidate performance; ii) the existing performance prediction benchmarks do not yet focus on the evaluation of networks from the perspective of different search spaces. The way to go is to propose solutions which are learnt for practical real-world applications.

→ Expected impact

Investigating NAS in the "real-world" has received limited attention. Our research will allow searching for an optimal deep neural network architecture on an entirely novel task or dataset, facilitating the deployment of such models in the media sector. We will establish a set of best practices and look into optimal architectural patterns, augmentation policies, and hyperparameter selection.

AI at the Edge and distributed learning

→ Research challenges

AI at the edge makes it possible for AI applications to run at end devices (e.g., smartphones) aiming to protect user privacy and scaling computations to the network. Challenges are due to i) user device limitations, e.g., limited computing power and storage, ii) network limitations such as delay and unreliable intermittent communication, iii) limitations of the distributed learning paradigm such as limited data per device and convergence issues during training, and iv) security issues that arise both from participating users (e.g., model/data poisoning attacks) and coordinating nodes (e.g., reconstruction attacks).

→ Research directions

An important line of research is the adaptation of AI models to the limitations of end user devices, which is crucial for the deployment of AI at the edge. This approach includes (a) compression of trained models to fit on mobile devices, (b) efficient learning and inference from limited data, such as by focusing only on the data samples that are most useful to learning subject to resource constraints, as well as (c) support of lightweight AI paradigms under limited resources, for instance to train within edge devices.

At the same time, it is important to focus on collaborative learning among devices, which safeguards the privacy of personal data and enables scaling computations to the whole network. Approaches that both rely on coordinating nodes (federated learning) and are completely decentralised are relevant. It is also important to develop the necessary software tools and middleware to train and deploy AI models directly at user devices.

→ Expected impact

AI-at-the-edge will enable AI applications at mobile devices that are highly useful to media professionals while foregoing centralised services. This is key to protecting journalists and their work, as it lets them maintain privacy and control over their personal data, especially if they are working under authoritative regimes. Potential applications involve processing multiple types of data, ranging from text for fact-checking, sound for synthetic speech detection, and image / video for deepfake media detection.

Deep quality diversity

→ Research challenges

Evolutionary computation has been particularly powerful in numerical optimisation tasks, where a clear optimal solution exists. However, in subjective domains such as media and games, evolution driven by objectives alone is not sufficient. Quality-diversity (QD) algorithms are a trending new solution to this but the challenge of defining appropriate dimensions for both quality and diversity is almost as challenging as the search task itself.

→ Research directions

The problem of defining appropriate dimensions for quality and diversity in QD algorithms and searching efficiently along these dimensions is expected to be addressable via deep neural network architectures. On the one hand, deep networks can transform exploration, aiming for both diverse and high quality outcomes. The representation learning power of deep networks can be used as a way to define diversity along latent vectors provided by trained models.

On the other hand, QD algorithms can benefit optimisation of neural network weights (and possibly architecture) as well by promoting networks that output diverse results along one or more subjective dimensions. Moreover, normal backpropagation towards minimizing error can be coupled in sequence or in parallel with QD search to ensure that QD does not over-explore.

→ Expected impact

By coupling deep learning and QD evolutionary search, both of which are particularly popular solutions in their respective subfields of computational intelligence, we expect important breakthroughs in both subfields. Specifically, these approaches are expected to lead to novel media pipelines that produce unexpected but valuable artistic output such as visual art constrained by a semantic prompt but driven towards visual diversity (e.g. colors present).

Learning to count

→ Research challenges

When the "unlabelled" (i.e., new) data are different in nature from the training data, the trained classifiers are not accurate at estimating class proportions in new data. Research on learning to quantify (LtQ) aims at developing methods for estimating class proportions in new data even when these new data substantially differ from the training data.

→ Research directions

These challenges can be tackled in two main ways, i.e., (i) developing new LtQ methods, and (ii) developing robust experimental protocols for testing these methods on data. New LtQ methods can be built by studying the different ways in which unlabelled data may be different from the training data, and by building different LtQ methods each tailored to these different ways. The new experimental protocols to be defined must be able to generate test data that simulate the different ways in which unlabelled data may be different from the training data.

→ Expected impact

LtQ methods allow one to train estimators of the class proportions in new data. This is useful in all application contexts in which we are interested in aggregate data (rather than in individual data), such as the social sciences or political science; in these cases, predicting to which class a data item belongs is less interesting than estimating the fraction of data items that belong to a certain class. Additionally, prediction at the aggregate level is often interesting when privacy preservation is important, since it allows inferring interesting knowledge at the aggregate level while preventing undesired inference of knowledge about individuals.

Quantum-assisted reinforcement learning

→ Research challenges

Reinforcement Learning (RL) and other AI methods are computationally demanding tasks. Their development in recent years has been motivated by powerful hardware advances that have created new hardware systems custom fit to execute these methods. Following this line, having access to novel technologies of computations will allow the execution of more powerful algorithms and processing of larger sets of data, which is currently limiting their development.

→ Research directions

Quantum computation is currently being explored as a potential candidate to provide high performance capabilities in the next few years. This task requires the study of its performance on given datasets, but also the development of novel methods and algorithms.

We will explore Quantum algorithms used in the training of a RL model and the potential interaction of conventional computers with Quantum computers in solving hard problems such as model training. We will provide new hybrid algorithms and strategies tested in advanced computational systems – including real Quantum Hardware – that may elucidate the role that Quantum computation will play for AI applications.

→ Expected impact

Current ML systems are powerful combinations of hardware and algorithms. This is the result of a long process of development based on conventional computational processors. As a technology with a potentially large impact on any computationally hard problem, Quantum computation has to follow a similar track. Current efforts in Quantum ML are identifying the limitations of classical ML methods on which Quantum technologies can provide an advantage. Candidates include large scale problems of either classical or Quantum datasets, with applications to the media (e.g. multispectral image processing)

Unique selling point

AI4Media will provide the AI community with a set of novel open source tools covering new learning paradigms, including learning at the edge and quantum assisted learning, that can be easily integrated within existing AI pipelines and can be used by the community for implementing their use cases.

7.2 Trustworthy AI

7.2.1 Context and need

Trustworthy AI aims at providing a framework for the development of ML technologies, which guarantees their suitability with respect to Europe's democratic and ethical values. Trustworthy AI is typically divided in four broad dimensions, namely AI robustness, AI explainability, AI fairness, and AI privacy.

Privacy-promoting AI, in the spirit of the EU General Data Protection Regulation can support and empower the streamlining of the EU policy for the protection of citizens' private information. Robust AI techniques help protect intelligent systems from malicious attacks which could cause financial damage or social upheaval, or even compromise critical security sectors. Establishing approaches that evaluate, systematise, and ultimately increase the explainability of AI systems helps build trust between consumers and service providers, but also contribute to social cohesion and the democratic process, by providing a solid foundation upon which socially critical sectors (such as the news sector) can better guarantee the quality of provided information. Algorithmic fairness aims to ensure that the fruits of AI are shared equitably and discrimination/bias against individuals or groups is prevented.

AI4Media brings together the leading edge of Trustworthy AI research in Europe to deliver tools that can assist the ML community in building more robust, fair and explainable AI models for the media industry while simultaneously respecting the privacy rights of EU citizen's data upon which these tools rely on. Concretely, this consists in i) testing the reliability of fact checking AI models against various sources of attacks and building adequate defence systems to reduce the spread of fake news; ii) augmenting classification tools such as Deepfake detectors with explainable algorithms to assist human curators in understanding why a particular piece of media is not genuine, iii) guaranteeing that a fair and balanced set of opinions are expressed in the content recommended to users; and iv) protecting personal data gathered to produce these tools using various obfuscation techniques such as differential privacy.

In the following, we present the main areas of research interest under the Trustworthy AI theme. The aim is to ensure that AI can be trusted to behave ethically, lawfully and offer accurate results.

7.2.2 Areas of research interest

Analysis of legal & ethical frameworks for trusted AI in media environments

→ Research challenges

There are many ethics guidelines both on EU and international level concerning the trustworthiness of AI systems. However, these guidelines do not adequately provide how and in what ways the principles outlined could be applicable to specific sectors, especially concerning the use of AI in media. Media professionals and AI researchers would benefit from an in-depth analysis of these guidelines and from recommendations on how to apply them in media environments.

→ Research directions

Four research lines will be pursued: a) investigation of the principle of "lawfulness, fairness, and transparency" of GDPR to identify uncertainties and gaps with regard to media applications (e.g. the exact limits, scope, and feasibility of the so-called "right to explanation" of the data subjects); b) monitoring of upcoming revisions to legislation relevant to GDPR; c) analysis of the legal data protection framework for the use of AI in media environments aiming to identify areas in which the law could be complemented by self-regulatory measures (including a possible European Digital Media Code of Conduct); d) investigation of the ethics of using big data, its impact on individuals, and safeguards to ensure people are aware of the ways their data is being utilised.

→ Expected impact

Policymakers and the media industry will benefit from the literature review, legal analysis regarding the existing gaps, challenges and opportunities, and policy recommendations based on this analysis. The media industry could also benefit from the practical ethics guidelines that would raise awareness and provide legal certainty on AI use in media.

AI robustness

→ Research challenges

Adversarial AI, aimed at enhancing the robustness of AI models against malicious threats, has been successfully used to highlight vulnerabilities in existing

models as well as increasing their defences against attacks. However, the ability to guarantee the robustness of an AI model to the public is a moving target since new attacks are consistently discovered for which new defence mechanisms must be thought of. Additionally, the ability to communicate to the public the degree to which such a model is safe is an ongoing challenge which needs to be addressed.

→ Research directions

In addition to new attacks continuously arising, the field of AI itself is changing very fast with new types of models, in need of novel defence strategies. Generative AI models, for example, are of particular importance to the media industry. This industry is specifically affected by these types of models both with respect to i) their ability to generate DeepFake content purposely aimed at fooling factchecker models as well as ii) their ability to generate benign illustrations which can be hijacked by attackers to produce inappropriate content. For these reasons, research should also focus on the degree to which existing defences protect generative models from such attacks.

Besides enhancing the robustness of new models, novel approaches must be investigated to establish robustness evaluation methods as part of scalable continuous ML production pipelines. This involves developing adaptive evaluation methods capable of adjusting defence methodologies applied on demand based on the type of attack anticipated.

→ Expected impact

The emergence of generative AI models is of critical importance for the media sector as it promises to provide AI enhanced tools for content producers while also challenging the ability of the industry to identify whether content was genuine or synthesised maliciously as a deepfake. The ability therefore to properly communicate and provide guarantees to the public on the robustness of AI tools being used in this industry will be extremely important.

AI explainability

→ Research challenges

In concert with the growing introduction of AI mechanisms as key decision-making tools in critical domains of our society (e.g. banking, legal, etc.), explainable AI provides individuals with insights about automated decision-making decisions delivered by these previously inscrutable black-box models. Although the number of newly developed interpretability techniques has seen an exponential increase over the past decade, the ability to provide reliable and usable explanations to users supporting a growing variety of AI models remains a major challenge.

→ Research directions

To address AI explainability challenges, we focus on: 1) contributing to the creation of a unified literature covering the exponentially increasing number of newly developed techniques; 2) addressing the need for explainability in novel ML tasks, such as decision-making systems, caption generation, attention mechanisms etc.; 3) evaluating existing explainable methods in terms of their robustness, reliability and impact; 4) evaluating the usability of existing methods with respect to the users along with the types of controls that can be provided.

→ Expected impact

Interpretability stands as a bridge between AI and user social interactions. The need for model reliability (i.e. the generation of explanations that assign meaning to AI decision-making) is thus critical in improving the user's acceptance of a model's decision. For example, regardless of the accuracy of an AI model detecting DeepFake content, any decision must be accompanied by an explanation in order for this decision to be accepted by fact-checkers and journalists.

AI fairness

→ Research challenges

In parallel to the rapid technological development and assimilation of AI technology in every aspect of our lives, the field of AI Fairness has grown recently to address a tendency of some models to exacerbate existing societal inequalities. Although the ability to enhance the performance of AI models so as to make predictions fairer for arbitrary protected attributes has been demonstrated on multiple occasions, these methodologies have yet to be deployed in numerous sub-fields of AI as well as existing deployed models.

→ Research directions

To address AI fairness and AI bias challenges, we will investigate the incorporation of fairness metrics and methodologies within established and novel AI domains such as recommender systems, machine unlearning and federated learning. Models trained within the context of federated learning for instance, by definition are influenced by updates provided by various nodes in a network. This can cause the resulting aggregated models to perform well for dataset attributes held by most nodes but poorly on arbitrary protected attributes of a local node. Introducing fairness metrics directly as part of the algorithms used to produce these aggregate models is thus paramount to protect minority attributes. Finally, bias is addressed in the context of recommender systems, both in the sense of detecting and mitigating respective AI bias and of developing proposals to avoid the reinforcement of human bias (filter bubbles) via recommenders.

The ability to incorporate fairness capabilities to previously trained models is also of significant importance as it removes the need to re-train the increasingly expanding set of models already in use. For this purpose, we explore how domain adaptation neural networks can be modified to answer the question of fairness and bias mitigation in decision systems.

→ Expected impact

Although AI and its benefits are now well established, the potential negative biases of AI systems such as recommender systems or NLP systems towards specific groups or individuals are less understood. Furthermore, the methodologies addressing these biases have yet to be systematically deployed. The ability to incorporate this dimension of AI in model production will guarantee all members of society are treated equally and provided with the same quality of AI support.

AI privacy

→ Research challenges

AI and Big Data have created a need for Privacy-Preserving AI (PPAI), which aims at avoiding input, membership and attribute inference attacks, or model poisoning attacks, applying Privacy Enhancing Technologies (PET) such as Differential Privacy, Homomorphic Encryption, and Federated Learning to achieve their goals. Apart from individual research challenges related to e. g. computational and memory overhead, a core challenge is to adapt and combine PET in an application-specific manner that considers the specific (and often conflicting) application requirements related to privacy, performance, computational overhead, and utility.

→ Research directions

PET are provided as general-purpose tools (e.g. DiffprivLib, Locally Private Graph Neural Networks) and for selected media-specific privacy challenges, including: (i) privacy protection for image classification; (ii) the use of Differential Privacy for recommenders, which may deal with sensitive information such as political preferences, e.g. if news recommendations are based on user feedback; (iii) a proof-of-concept for Secure Federated Learning (SFL) using media content, in which a common AI model can be trained in a decentralised manner, leaving data "on-prem" with the participants, while avoiding inference and model poisoning attacks using Differential Privacy and Homomorphic Encryption.

→ Expected impact

The research aims at solutions that have the potential to "unlock" and improve important media use cases. For example, privacy-aware content recommendation can help media companies / broadcasters to improve user retention and exploit archive material. The SFL prototype can serve as a "template" for common AI training, allowing media companies / broadcasters to exploit assets in a collaborative yet sovereign manner.

AI systems benchmarking

→ Research challenges

Currently there is a growing need for platforms and tools that allow for a higher degree of fairness when comparing different models and methods developed by AI researchers. The automation of the processes involved in creating and maintaining an AI benchmarking competition on a given topic is a vital step in creating a reproducible environment for testing AI models, while also reducing the workload of benchmarking organisers and participants. Furthermore, most of the currently developed platforms only offer tools that measure the accuracy-based performance of AI models, without giving any attention to other important performance

factors, like computational complexity, processing time, hardware resource requirements or task-specific data analysis that could relate to the subjectivity or to the impact of the human factor on the provided data.

→ Research directions

These challenges can be addressed by building a novel platform that creates an Evaluation-as-a-Service environment where interested researchers can upload their data and create, maintain and run their specific benchmarking tasks. This novel platform will encourage task organisers to address the research challenges related by providing them with a set of tools that allows them to easily measure the complexity-related metrics, along with the more traditional accuracy- based metrics, giving a more complete overview of the performance of the proposed AI systems, as well as providing them with tools that allow data visualisation with regard to the subjectivity of the proposed training and testing datasets.

→ Expected impact

These new approaches for the benchmarking of AI systems will allow for a better understanding of the real-world performance of neural models, helping both task organisers and task participants by providing them with more reliable insights into performance and data. Furthermore, in the production stage, interested parties can choose to implement systems by using two-dimensional accuracy-complexity analysis, instead of just accuracy-based analysis.

Unique selling point

AI4Media will provide the AI community with a set of novel open source Trustworthy AI toolsets that can be easily integrated within existing AI pipelines and used to enhance the Robustness, Explainability, Privacy and Fairness of models being built by the community. We leverage the technical expertise of AI researchers along with the insights and experience of key media industry players using these technologies in real-life settings.

7.3 Content-centered AI

7.3.1 Context and need

Content analysis in its various forms has been one of the most widely recognised fields of application for the new generation of AI technologies. Most breakthroughs in AI have become possible thanks to the rise in quantity and availability of large amount of multimedia data[13]. AI systems are asked most of the time to understand highly complex and multimodal data. The huge growth in data availability requires powerful and scalable algorithms to perform summarisation and understanding in multiple domains.

From applications such as object recognition and video segmentation to audio analysis and media synthesis, novel technologies have led to major breakthroughs, opened new markets, and transformed society. AI4Media brings together the world-class expertise available in Europe and participating in the consortium, to advance such technologies and provide foundations for solid use-cases. Technologies that are valuable for the media and news industry, and also marketable as end-user services, such as multimedia metadata extraction, summarisation, and clustering, automatic audiovisual content generation and enhancement, linguistic analysis, and media- specific core technologies to improve learning performance. Within this context, one important focus within AI4Media will also be learning with scarce data and the use of transfer learning, which is key to apply AI when large annotated datasets are not available.

In the following, we summarise the main areas of research interest under the *Content-centered AI* research theme. The aim is to develop novel AI-driven approaches for content analysis and new content creation and address challenges in textual, visual, and audio media and multimedia processing and production.

7.3.2 Areas of research interest

Media analysis

→ Research challenges

The challenge in media analysis is to move from simple annotation of images and videos with class labels – a long-researched topic – to a deeper understanding of the message that a media item can convey. This involves, for instance, jointly performing more than one analysis tasks; or

13 Krizhevsky et al., 2012. Imagenet classification with deep convolutional neural networks. In Advances in neural information processing systems (pp. 1097-1105)

understanding the events that unfold in a video segment; and, furthermore, providing explanations for these analysis results.

→ Research directions

We will explore various directions that contribute to the goal of deep understanding of media items; these include, for instance, jointly performing optical flow and instance segmentation to improve the results of the latter; exploiting bottom-up information from video, such as detected objects, for recognizing complex events and for grounding the event recognition decisions; and, combining deep learning with symbolic semantic reasoning for the curation of cultural media assets.

Acknowledging the importance of high-quality training data for learning how to perform various analysis tasks, we will also work on the development of novel AI tools for creating, curating and managing media datasets.

→ Expected impact

Media analysis contributes to making non-textual content searchable and findable. This has a profound impact on both the general public – just think of the impact that, similarly, text search engines had and continue to have – and the various media professionals that work with content archives or need to assess if and where a media item had previously appeared (e.g. for media verification purposes).

Media summarisation

→ Research challenges

AI-based media summarisation is a relatively new research area that has quickly gained a lot of momentum. The main challenge is to automatically generate summaries that match the best the user's needs. This requires not only introducing objective criteria, such as the diversity of the generated summary, but also exploiting multimodal data and taking into account the individual user's query or intent.

→ Research directions

The main focus is on the investigation of unsupervised learning methods, i.e., methods that can learn to generate a summary of an input video – be it either in the form of a shorter version of the video or a static summary comprising a number of key-frames – without requiring ground-truth summaries for training. The reason for investigating this direction is that ground-truth summaries are scarce, expensive to produce, and greatly affected by the idiosyncrasy of the human who generates them.

Explainability of video summarisation methods is also investigated, in order to gain a better understanding of how complex AI architectures for summarisation work internally. This will provide useful insights for extending the use of multimodal data – beyond just the visual modality that is traditionally employed – and for performing query-driven summarisation, i.e. exploiting a natural-language description of the user's expectations.

→ Expected impact

Automated media summarisation contributes to easier access to information for all, i.e. helping to consume and understand the gist of a media item in a limited amount of time; and, to the editorial and creative process of distributing content that is suitable for and appealing to its intended audience, e.g. enabling journalists and programme producers to easily generate video highlights.

Media content production

→ Research challenges

Given current advances in AI and deep learning, we expect that, in the future, AI-supported content production will be the norm in any professional media creation pipeline. Open challenges to address include: how to move from simple synthetic content generation to complex video creation; how to support video delivery and automated shooting via trajectory forecasting; how to create high quality content using real-time content restoration.

→ Research directions

To support video archival reuse, we will focus on methodologies able to enhance existing videos; this involves deepening the knowledge of Generative Models such as GANs and deep super resolution architectures and artefact removal. Generative Models are also a fundamental technique to allow the creation of novel visual content via manipulation of existing imagery to the prompt based content generation. Finally, to deliver fully automated cinematography, core research direction involves the study of a set of forecasting problems among which multiple trajectories prediction.

→ Expected impact

We expect to provide disrupting new technologies for the media production sector. As media professionals are in need of more and more support from AI based tools to compete in an environment where the appetite for new content only increases, delivering new methods for the generation, acquisition and delivery of multimedia content will significantly benefit media organisations, content providers, and users.

Content representation, indexing and retrieval

→ Research challenges

Multimedia content is distributed across modalities (visual, audio, text, etc.), with each modality carrying its own specific piece of information. Interactive media search solutions combining initial text-based retrieval with efficient browsing and exploration functionalities of other media modalities are needed for the development of efficient content retrieval systems for the media sector.

→ Research directions

To exploit all possible modalities together, one of the main challenges is defining how to learn the best representation of input data. Either each modality is associated with a specific representation and is processed separately to be later combined in a fusion schema, or a common global description is processed by a unique general decision model.

Both lines of research should be explored in order to design better information retrieval systems for media data. Considering each modality separately allows dedicated methods which require smaller models. The fusion schema merging all specific modality descriptions into one could allow integrating prior or expert knowledge into the final decision. On the other hand, Transformers provide a new way to process all modalities together in one model, exhibiting impressive performances. However, they require a considerable amount of training data, computation and memory resources while integrating prior knowledge into such models is an open question. New learning paradigms can reduce training time and thus allow fast model update iterations to provide more precise and more relevant retrieval answers.

→ Expected impact

While media companies are the ones producing the content, they currently lack accurate, fast and reliable tools to exploit and thus monetise this content. The media and entertainment industry would directly benefit from next generation search engines that would allow to search: audio-visual archives to support a news story with selected videos; the internet to find content that users like or need; music with specific characteristics to match with film scenes or a textual story maybe matching some of the lyrics; 3D content to find visual assets for a game level, etc.

Language analysis for the news industry

→ Research challenges

Natural language processing methods allow us to characterise news topics and opinions in news platforms and social media. The main challenges in this field are: (1) the ever growing number of new topics and public personalities that emerge in the news and that need to be detected by the algorithms; (2) the fine grained opinions expressed in those documents that need to be accounted for when performing document retrieval.

→ Research directions

The first challenge can be addressed by designing models that can be adapted to a new domain rapidly. We will therefore rely on transfer learning and pretrained language models that have gained a lot of interest during the last couple of years. The second challenge can be tackled via fine grained representation learning that takes into account opinions expressed about all entity mentions in the documents. Named entity recognition can be used to extract topics and entity mentions and on aspect-based sentiment analysis techniques to extract the opinions.

→ Expected impact

Fine-grained news representation can be used in recommendation systems to better filter content and to provide a way of bursting opinion bubbles by allowing end users to select different opinions on the same topic. These representations can also be used by news providers in their information system to assist them with document retrieval and background research.

Music analysis

→ Research challenges
The challenges of music analysis arise from the inherent subjectivity of music annotations, the use-case-dependence of tag/class taxonomies, as well as the lack of well-annotated large-scale datasets. Similarly, it is hard to train and to evaluate music similarity algorithms based on deep embedding representations due to ill-defined and subjective similarity concepts and low annotator agreement.

→ Research directions
To address these challenges two lines of research will be pursued: a) exploiting domain-specific similarity (rhythmic/melodic/harmonic/timbral) based on conditional similarity networks (CSN), and b) using disentanglement learning for music similarity and training deep audio embeddings, which capture different music concepts such as genre, mood, and instrumentation, and can also be used for music structure analysis, i.e. to identify segments in music recordings, which are homogeneous with respect to one or multiple of the disentangled music properties.

→ Expected impact
Music similarity and structure analysis based on disentangled music concepts allows for an easier integration into already existing expert-annotated music catalogues. Furthermore, concept disentanglement and uncertainty measurement better reflect the subjectivity of users' preferences and will help to increase the acceptance of automatic annotations.

Learning with scarce data

→ Research challenges
Deep learning-based algorithms for multimedia content analysis need a large amount of annotated data for effective training. But in many real-world applications in the media domain, it is not possible or not viable to gather and annotate such a large training data. This may be due to the prohibitive cost of human annotation, ownership/copyright issues of the data, or simply not having enough media content of a certain kind available (e.g., emerging events, locally relevant concepts). Therefore, there is a clear need for novel methods to train models with scarce data.

→ Research directions
There are a variety of approaches to deal with data scarcity, therefore the research directions pursued in AI4Media for this task reflect this diversity. Specifically, we investigate unsupervised and semi-supervised learning (e.g. semi-supervised learning for fine-grained visual categorisation), biologically-inspired learning (e.g. content-based image retrieval with Hebbian Learning), sample-efficient methods (e.g. few-shot object detection in images), domain adaptation (e.g. for traffic density estimation and counting), clustering (e.g. deep clustering with diversity-enforcing constraints) as well as dictionary learning and curriculum learning.

→ Expected impact
The media sector will benefit from novel methods for training with scarce data, as AI techniques can then be applied to problems for which it has not been possible (or economical) to use it before due to the scarcity of data or cost of annotation. E.g., it makes semi-automated tagging of broadcaster archive content doable not only for common object classes (person, vehicle etc.) but also for very specific classes (like a face mask).

Computationally demanding learning

→ Research challenges
Current deep learning approaches generally downsample input data (e.g. images) to manageable sizes (e.g. 200 to 500 pixel images), which while successful may cause critical losses of information. Tasks like, for example, person identification or detection in video, deep fake detection or image and video enhancing are very detail-oriented tasks, highlighting the need for computationally demanding approaches.

→ Research directions
The challenges of AI-based image and video enhancing (super-resolution) can be approached by an exhaustive benchmarking of state-of-the-art AI super-resolution models, both with quantitative metrics and a qualitative human eye test. The detection of synthetic image and video enhancing can be tackled by training deep learning models with previously synthetically upscaled images and videos. Given the lack of existing training data for

this task, we will also work on developing a dataset formed by original and AI-upscaled images at the same resolution.

→ Expected impact

Computationally demanding learning will grant more tools to media outlets to detect, for example, deep fakes and other forms of media tampering, helping fight misinformation. It will also allow more methods of information extraction, for example assisting in person detection and identification in image/video.

Unique selling point

AI4Media will provide novel methodologies for multimedia content analysis, summarisation, and production, spanning all modalities: text, image, video and audio. The developed tools will be easily integrated into existing content-centric AI pipelines in order to allow the academic and industrial communities to develop their media-related use cases.

7.4 Human-centered and Society-centered AI

7.4.1 Context and need

Online platforms are a central source of information for citizens, contributing to the shaping of the public debate and affecting societal practices and norms. The core role of AI technologies in online platforms and media provides both incredible opportunities but also significant challenges. Media AI technologies can be applied to improve political participation, equip citizens against disinformation, and encourage healthy debates and social interaction. Inversely, they can be exploited to misinform citizens, to bias political debates, and ultimately to weaken European democracies. Media organisations and citizens should be equipped to understand the role of AI in the news creation and distribution cycle in order to benefit from the opportunities offered to them while avoiding malevolent usages.

Technologies for multimedia manipulation detection can help stem the tide of disinformation, while automatic analysis algorithms can provide political opinion mining, argument mining, and local news understanding. Multilinguality is particularly important in the European context in order to enable comparative understanding of common points and differences between the way the same topics are presented in various EU countries. User perception measurement algorithms support personalisation but also detect biases and enable "bubble-bursting" by favouring diversity and novelty in recommender systems. The research proposed for this theme builds on the AI4Media advancements on new learning paradigms, trustworthy AI, and multimedia content analysis, and complements them via specific methods oriented toward societal- and human-oriented aspects of AI.

In the following, we summarise the main areas of research interest under the Human-centered and Society-centered AI research theme. The aim is to develop novel methods and tools to better understand the factors underpinning online debate, information production and consumption, and social media experience and put AI to the service of citizens and societies.

7.4.2 Areas of research interest

Content moderation

→ Research challenges

In recent years, the main issue with regard to content moderation has been revolving around determining who should decide which content should be removed, for which reasons, when and how. In this context, the question of 'what should be the model for content moderation: can the problem be addressed through self-regulation (such as codes of practice, codes of conducts), or is there a need for a hard-law EU regulatory instrument?' has been prominent.

→ Research directions

We focus on monitoring and analysing the changing landscape of content moderation, especially in the face of automated content recognition technologies powered with AI tools, exploring how algorithmic content moderation could challenge freedom of expression and other fundamental human rights. This involves a comprehensive analysis of the EU regulatory framework on online content moderation, including the e-Commerce Directive, the Digital Services Act, the Digital Markets Act, the Audio-visual Media Service Directive, and the Copyright in the Digital Single Market Directive and also an overview of future research directions on content moderation.

Based on this analysis, guidelines and policy recommendations will be provided for the development of content moderation algorithms, the design of content moderation policies, and the formulation of regulations that respect fundamental rights without limiting the public debate.

→ Expected impact

Along with our policy recommendations to address media AI challenges, this research is expected to provide clear guidelines for content moderation to AI researchers and media companies. Another expected impact is to create awareness in policymakers regarding fundamental rights challenges and other relevant challenges that strict content moderation policies pose, especially when the use of AI tools for content moderation is implicitly or explicitly imposed in regulations.

Manipulation and synthetic content detection

→ Research challenges

The continuous refinement of Generative Adversarial Networks (GANs) and the recent advent of diffusion-based generative models and Neural Radiance Fields (NeRF) have led to versatile media generation capabilities of unprecedented quality and realism. The continuous appearance of improved generative models and media post-processing pipelines make it extremely challenging to build universal detection methods that can quickly adapt to new developments and can handle real-world challenges and adversarial settings.

→ Research directions

One of the most important challenges pertains to addressing the problem in a continuous learning setting under the assumption that generative models will be continuously improving and the detection models will need to adapt accordingly and timely. Moreover, a big challenge stems from the susceptibility of detection models to adversarial attacks and post-editing operations calling for increasing the robustness of deepfake detection models. The above two directions should also be approached from a multimodal perspective, i.e. the combined analysis of audio and video content.

As a means to tackle the scale of the problem, deepfake detection models will also need to considerably improve in terms of efficiency and compute performance, with the ultimate goal of making it possible to detect synthetic media on end users' devices. To increase users' trust on deepfake detection, much progress is also needed on the front of deepfake detection explainability, fairness and transparency, i.e. tool outputs should be understood by media professionals and should not discriminate against specific demographic groups.

→ Expected impact

The proposed research will equip the media sector with capable and trustworthy synthetic media detection tools and will ensure their fact-checking readiness and capacity. Being able to rapidly verify the authenticity of online media is key in times of crisis or during key events (e.g. wars, natural disasters, elections) when the scale and sophistication of disinformation campaigns increases. Trust in media content is crucial, else we run the risk of turning into a zero- trust society, doubting even solid evidence and facts.

Content recommendation systems

→ Research challenges

Recommenders are a powerful tool for media applications, but their development and use increasingly requires addressing trust aspects, including (i) privacy, especially if sensitive information is processed or can be inferred; (ii) transparency, allowing users to understand the inner working of recommendation, especially regarding the processing of user data; (iii) bias, both in the sense of detecting and mitigating problematic AI biases (e.g. sample bias), but also in the sense of the interaction between recommenders and human biases, especially confirmation bias, which can lead to filter bubbles.

→ Research directions

Differential Privacy will be used for recommender systems to protect user/usage data, aiming at news recommendation as an example where sensitive information regarding political preferences can be inferred. Another important line of work will focus on detecting and mitigating bias in recommenders, including addressing potential socio-demographic bias in GANs, providing new formalisations for fairness and bias, and proposing respective benchmarks and evaluations. Moreover, proposals on

how to deal with filter bubbles that may evolve from recommenders enforcing human bias (confirmation bias) will be developed, by leveraging evaluation metrics for diversity, novelty and serendipity, in addition to standard utility metrics. Finally, improvements regarding explainability of recommenders will be a key element that promotes several of the aforementioned aspects, especially in the sense of transparency and control of how user data is used and processed.

→ Expected impact
Detecting and mitigating biases in recommenders and improving privacy and transparency addresses key requirements from media companies, which means that providing relevant solutions will significantly improve technology adoption in the media domain. In addition, the provision of insights into how recommenders can be designed and evaluated in a way that is less likely to reinforce confirmation bias is a step toward addressing a problem that already has strong implications for political discourse and democratic processes.

Online political debate analysis

→ Research challenges
The main challenge when analysing online political debate is the lack of ground truth, because i) it is impractical to label the amount of data that is being processed, ii) human behaviour is not easily categorizable, iii) misinformation labelling may not be persistent throughout time, and iv) there are no standard metrics to evaluate the healthiness of discussions.

→ Research directions
The healthiness of online discussions on social media can be evaluated by developing a set of discussion health metrics for Twitter debate like measuring discussion ephemerality, estimating the number of bots and bot-generated content, and also monitoring topic-wise public opinion and sentiment analysis. Additionally, the external video content of the tweets will be studied for deep fake presence, and the influence of Twitter discussions on media and vice versa for specific topics will be investigated. To this end, a dataset containing Twitter discussions will be created focusing on various Covid-related topics.

→ Expected impact
Political debate analysis tools can be integrated in existing media platforms and tools, allowing journalists and media outlets to have access to discussion health metrics (e.g. offensiveness, amount of bots, ephemerality). This in turn will allow them to report more trustworthy information and have a better understanding of public opinion and polarisation.

Analysis of hyper-local news

→ Research challenges
Local newspapers are one of the key sources of information for citizens, who are concerned about concrete issues affecting their everyday lives. In Europe, there are hundreds of local news sources over many languages. Many of these local news organisations face challenges on how to adapt to technological trends like AI due to economic and cultural issues.

→ Research directions
AI4Media aims to advance the understanding of the local news information ecosystem across European countries, and develop technology that accurately analyses local news. To identify patterns in news treatment across countries and topics, data is collected from online newspapers across multiple European countries and NLP methods are used to characterise main local actors, themes, and sentiment expressed about specific topics of value for citizens, like for example the attitudes towards Covid-19 vaccination. Furthermore, the problem of how news stories are framed is studied, and machine learning methods are developed to detect specific news framing categories, adapting methods proposed in media studies.

→ Expected impact
Understanding how news sources present and discuss local news plays a role towards promoting information of quality of local value. In this sense, this research will provide a point of comparison to other news sources on topics with significant societal impact like health, where misinformation can result in increased risks and negative outcomes for citizens.

User perception of social media

→ Research challenges
The main challenge in the analysis of social media data is represented by the inherent subjectivity of this particular domain and of the concepts included in it, like interestingness, aesthetic appeal, memorability and emotional impact. This not only creates uncertainty in the training data, but also leads to performances that are lower compared with other domains.

→ Research directions
We will explore several avenues for mitigating this problem. One of the most important methods of increasing system performance, and therefore system reliability, is the use of early and late fusion systems. By using the predictive power of more than one individual system, we can ensure that data processing tackles both the multi-modality of the social media data and that each modality is processed by one or more specialised and targeted systems. While it is important to acknowledge that fusion systems usually involve more processing needs, we will also focus our research on fusion optimisation, attempting to reduce the computation requirements of the fusion systems.

→ Expected impact
The analysis of social media data and its impact on viewers via AI methods can create a useful set of attributes that can be attached to each media sample (is it memorable? is it emotional?). This can allow for a faster navigation of this data and for better results to queries, as well as provide tools that can help content creators better understand the impact of the content they generate.

Real-life effects of private content sharing

→ Research challenges
When posting content online, users are aware of the sharing context. However, this content is then analysed using AI methods, and results can be used in contexts which were initially unforeseen, with a different interpretation. Citizens are entitled to know how their personal data are used, particularly when inferences have an effect on impactful real-life situations.

→ Research directions
The starting hypothesis is that user awareness about data sharing can be raised by providing understandable feedback about the potential effects of automatic inferences. Focus is on the impact of personal photos sharing since they are pervasive in online platforms. A combination of automatic visual object detection and photographic profiles rating and ranking is proposed to implement user feedback. User profiles are rated in impactful real-life situations, i.e. searching for a bank loan, an accommodation or a job, by comparison to a large set of user profiles which were also rated in the same situations. All inferences are performed on the users' mobile devices in order to preserve their privacy.

→ Expected impact
This research raises user awareness regarding the use of their data by online platforms, and by associated third parties. This is important from a societal point of view since informed users will share their personal data in a more responsible manner. Importantly, the practical impact of such research would be amplified if similar solutions would be adopted by online platforms.

Unique selling point

AI4Media will provide citizens and media professionals with a set of AI technologies that can be used to counter the effects of media manipulation, the understanding of online debates, the analysis of perceptions of social media, and the effects of data sharing. These technologies will be integrated in real-life use cases via a tight collaboration between research teams and media industry professionals. The proposed technologies will be open sourced in order to maximize their societal impact.

7.5 Expected outcomes

- **Open access scientific publications** on topics related to the four research themes
- **Open access software** for machine learning, multimedia content analysis and trustworthy AI
- **Open datasets** for media AI research

8. Use cases in media, society and politics

8.1 Introduction

Seven media-related use cases are explored, informed by emerging market opportunities and urgent industry challenges (Figure 6). They cover a variety of topics such as disinformation, news research and production, media moderation, organisation of audiovisual archives, game design, human-machine artistic co-creation, social science research etc. The use cases aim to address significant challenges currently faced by different media industry sectors and to highlight how AI applies throughout the media industry value chain, from research and content creation to production, distribution, consumption/interaction, performance and quality measurement.

Figure 6: The seven AI4Media use cases

The use cases are realised through close collaboration between AI researchers and media professionals (European media organisations or content related companies). Driven by use case requirements, tools and systems used by media organisations are upgraded with novel AI functionalities resulting from the research activities along the main research themes described in Section 7. The use case systems and platforms that are used as the basis for AI4Media's demonstrators cover a wide range of system types (from internal Content Management Systems and tools to fully-deployed Software-as-a-Service solutions) that address a variety of media processes in different industry sectors. As such, the resulting demonstrators showcase the potential uses of AI in the media industry, including aspects of human-centric, ethical and trustworthy AI. They highlight how AI applies throughout the media and content value chain (Figure 7) and how different types of media players aim to address user and business needs with novel AI solutions.

The use cases are developed in the context of Work Package 8.

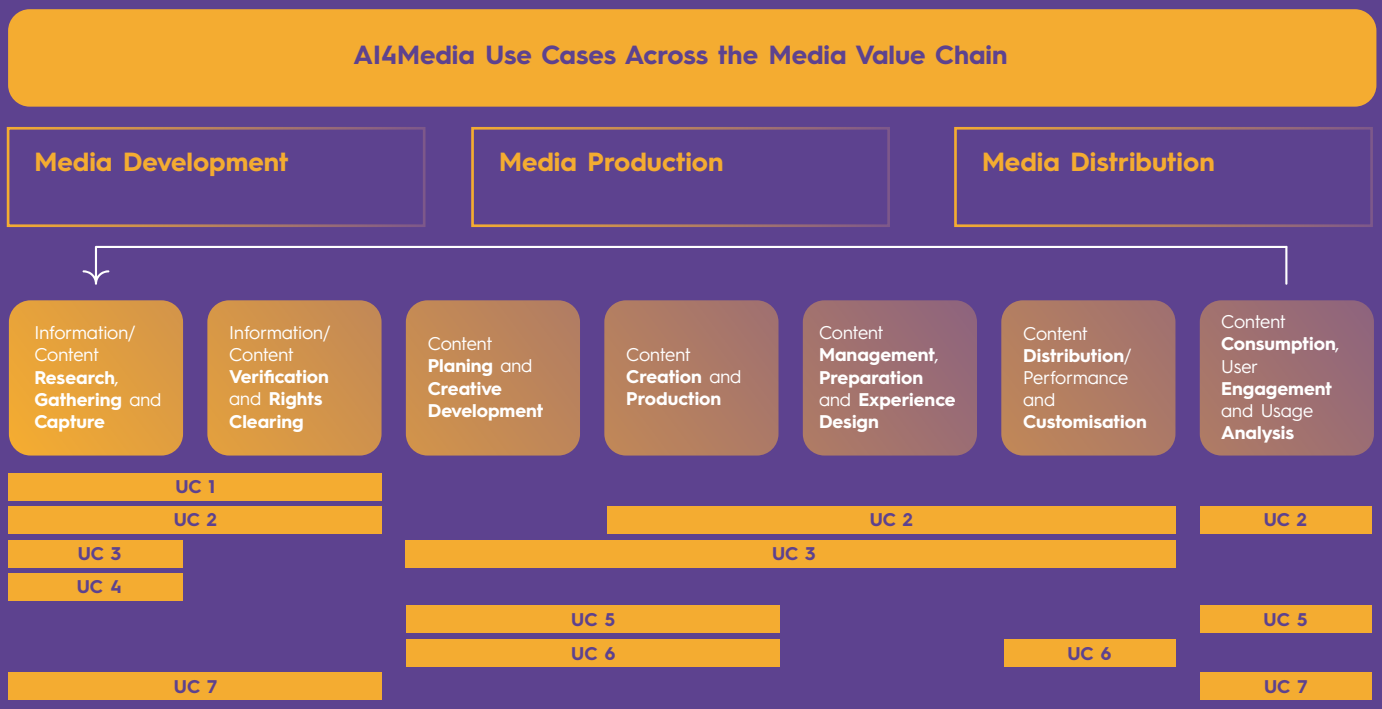


Figure 7: The seven AI4Media use cases and their relevance to the media and content value chain

8.2 AI4Media Use Cases

8.2.1 UC1: AI for Social Media and Against Disinformation

→ Challenges

For the news media industry, it remains a challenge to keep up with increasing volumes of manipulated social media content, synthetic media, and disinformation. Another challenge is related to the dynamic advancement in technologies and techniques used to produce and spread such disinformation related content.

→ User needs

The key actors in counteracting disinformation in the news media industry are content verification specialists, fact-checkers, and journalists. Although they have tools to support this largely manual and complex content verification workflow, there is a need for more specific and AI-powered support services that can be easily integrated into existing systems.

→ Integration of novel AI functionalities

New types of AI functions that can support journalists with the detection, analysis, and verification of disinformation refer to content/account verification and the analysis of disinformation related narratives. This includes AI multi-modal and multi-lingual tools for the detection and verification of synthetic or manipulated media (e.g., text, photos, videos, or audio), analysis of social accounts or tools for identifying patterns and communities in social media discussions. AI tools based on NLP and network science methods could also support journalists and fact-checkers by automatically detecting false claims or flagging suspicious content, detecting cross-platform disinformation campaigns and coordinated inauthentic behaviour networks, predicting the impact/virality of disinformation, and tracking the spread of disinformation across platforms and languages.

→ Expected impact on media, society and democracy

The provision of AI-powered support functions for human decision-making in the content verification workflow can make this complex task more efficient, easier to conduct for non- experts and more impactful. This has the potential to strengthen the role of news media organisations in counteracting disinformation and detecting synthetic media.

Unique selling point

Going beyond stand-alone prototyping, UC1 integrates and tests a set of AI-powered functions in the user context of existing tools for content verification, and the wider business needs of news media companies, including aspects of Trustworthy AI.

8.2.2 UC2: AI for News - The Smart News Assistan

→ Challenges

The fast changing digital news environment poses a significant challenge for the news industry. Journalists experience a lot of pressure as they are required to create trustworthy stories in many different formats in order to be able to respond to the changing habits of media users. This use case focuses on integrating AI-powered tools in journalistic workflows, aiming to reduce the time spent on tedious and repetitive tasks related to news creation.

→ User needs

Journalists are getting their stories from a lot of different sources (social media, mailing, other media, etc.). In order to create relevant and trustworthy stories there is a need for monitoring assistance and factchecking tools. In addition, the fragmented media landscape requires news creators to be present on an increasing amount of diverse (social) media platforms. Since every platform has its own way of storytelling, support in semi-automatically creating different formats of the same news story is needed.

→ Integration of novel AI functionalities

Several new AI-based modules can be integrated to facilitate news creation: tools to perform image forensics including user interfaces for improving understandability of AI results; graph- based network analysis tools to categorise and detect (disinformation) websites and assess URLs coming up during the research phase of writing a news story; tools that based on the story can suggest images or videos to automatically compile new short videos, allowing the journalist to make corrections and additions and do a final edit; tools that provide a diversity score to help write balanced stories; tools that help journalists monitor and follow stories spreading on social media.

→ Expected impact on media, society and democracy

Building a hybrid human-machine news workflow by integrating AI-driven components in critical creative news processes is a complex and not straightforward challenge. By creatingprototypes and making the technology tangible, newsrooms can understand AI functionalities better. That could help them create relevant, trustworthy stories that reach a broader audience.

Unique selling point

UC2 will interweave smart AI-driven tools in day-to-day journalistic workflows aiming to optimise tedious and repetitive tasks involved in news creation and create opportunities for new story formats to reach wider audiences.

8.2.3 UC3: AI in Vision - High quality Video Production and Content Automation

→ Challenges

This use case aims at demonstrating how emerging AI-based technologies can support Public Service Media (PSM) in the transition from its traditional business to the modern digital era. The main challenges to be faced are related to the exploitation of AI's potential to underpin and speed up content production processes and to enhance existing audio-visual content, coming from various sources such as broadcasters' archives and social media.

→ User needs

The main user's needs are related to the exploitation of the immense amount of produced and archived audio-visual content in innovative ways, the need to discover and explore relationships between content and external knowledge, and the need to define and implement innovative ways to produce content. Although substantially targeted at the "Journalism" and "Infotainment" subdomains, this use case represents a good example of the generic integration of AI tools in a modern TV production environment.

→ Integration of novel AI functionalities

The strategic AI functionalities mostly requested in a modern TV production environment are those able to describe, characterise and index content under an as much complete and context- independent manner as possible. This is key in order to catch up with the dynamism and continuous evolution of the media market in terms of new content interaction models and new business domains through efficient means to access and use assets at hand. The work nowadays accomplished by documentalists is still based on the former need to preserve content for archival

purposes, and hence the corresponding annotation and indexing mechanisms suffer from this limitation. Therefore, AI tools that allow to obtain "latent" context-independent descriptions (and corresponding indexing functionalities) make it possible to exploit different takes on available content and feed new applications and services with less effort.

→ Expected impact on media, society and democracy
When a huge patrimony of content like that being preserved and produced by PSM is made exploitable by unprecedented means and unequalled possible perspectives, citizens have certainly a direct benefit in terms of increased, more appropriate, unbiased, and timely knowledge about what's happening around them. As a consequence, the impact on the underlying democracy mechanisms cannot but generate a positive effect.

Unique selling point

Considering the whole production process rather than individual steps in the value chain, UC3 allows to better understand and evaluate the impact of AI technologies at full scale in the typical workflow of a modern TV production environment.

8.2.4 UC4: AI for Social Sciences and Humanities

→ Challenges
A challenge that scholars in social sciences and humanities (SSH) encounter is that manual media investigation methods do not scale across large collections thus limiting their research scope. While various AI solutions are emerging to address this, in many cases they are not tailored to specific SSH research needs or are not considered as transparent or trustworthy enough to enable rigorous investigation and interpretation of the resulting AI analyses.

→ User needs
SSH researchers require tools with easy-to-use interfaces that allow them to approach media content investigation through concepts from media theory such as framing, discourse analysis and narrative theory. This presents an interesting challenge for AI tools as these concepts are largely dependent on the specific context of investigation and are difficult to translate into technical specifications.

→ Integration of novel AI functionalities
Various existing AI techniques can be tailored to enhance SSH research workflows, including: (i) identification of identical audio/video/image elements across multimedia content to track reuse and framing, (ii) NLP techniques to support comparison of opinions, political viewpoints and emotions on a selected topic, (iii) performing queries by text, images or sound to find identical or related segments in audiovisual collections, (iv) use visual and audio clues to identify narrative elements (e.g. conflict, dialogue, etc.). The configurability of parameters in AI tooling is a key consideration for implementation allowing researchers to experiment with different settings, which enables them to better understand and trust the provided results.

→ Expected impact on media, society and democracy
AI tooling for SSH research will help scholars to perform data analysis on both a macro and micro level so that they are better equipped to investigate biases and issues around framing and representation in media. Being better able to identify these issues on a larger scale will help spread awareness and possibly prevent these issues in the future. Also, providing scholars with a better understanding of the requirements for trustworthy AI, the general trust in these tools and therefore their correct use, will improve.

Unique selling point

UC4 not only provides scholars and journalists with the opportunity to use state of the art AI techniques to research broad societal questions on framing, representation and bias, it also hands them the tools to set their own configurations to fulfill their exact needs.

8.2.5 UC5: AI for Games

→ Challenges

When it comes to the use of AI in the game industry, there are two major challenges: i) leveraging and integrating AI methods to support and automate the creation, testing, and verification of modern video games; and ii) allowing practitioners in the video game industry to leverage AI in their production flow in ways that support existing paradigms and interdisciplinary collaboration.

→ User needs

The cost/labour intensity of video game development is increasing due to competition and quality requirements. Practitioners in video game production have a strong need for automating manual and repetitive tasks, e.g. playing through games each time an iteration or content addition is completed. AI methods must be deployed in ways that are readily available, fit in existing workflows in tools for non-AI-expert users, and apply to highly variable game designs.

→ Integration of novel AI functionalities

The game industry can benefit from AI in the following ways: i) integrating AI-based methods for automatic game playing into readily deployable tools, while maintaining generality across varying game designs and interaction schemes, for instance through modern Quality-diversity search algorithms or imitation learning; ii) using the methods to generate play data that characterise games in terms of functionality and performance, reducing the need for manual labour.

→ Expected impact on media, society and democracy

The successful application of AI in video game production will allow for more sustainable and efficient game development processes in the industry. It will also provide opportunities for improving the working conditions of quality assurance testers by providing them more varied and skilled work opportunities.

Unique selling point

UC5 presents the opportunity to provide an underserved part of the game industry, quality assurance workers, with tools and workflows for automation, which will improve working conditions, bring games faster to the market, and de-risk game productions.

8.2.6 UC6: AI for Human Co-creation

→ Challenges

The integration of advanced AI tools for audio generation, and their interaction with non-expert users to create novel music, is a difficult challenge addressed from both a technical and an artistic perspective. Bringing to non-experts the possibility to use novel tools has the potential to enhance their capabilities to explore new artistic territories.

→ User needs

The target is an audience composed mainly by non-expert users of AI technology. These users however require the control of the full potential of these novel tools, mainly generative models, developed in a rather technical or even academic environment. As such, they are not robust and prepared for easy use.

→ Integration of novel AI functionalities

The goal is to integrate components developed for the generation and manipulation of audio tracks. The generation is performed by a collection of generative models, whose training can be performed under the supervision of the final user, or used after training performed elsewhere. Along the training, integration includes tools that may enhance the otherwise lengthy process. Additionally, generated audio files are manipulated to obtain information about their quality, and by extension of the overall generative process. This information can be used subsequently to further proceed in the content creation as a creative process.

→ Expected impact on media, society and democracy
Bringing powerful AI tools to a novel audience raises a number of questions difficult to address in an artistic environment, but we expect to expand the general use of these tools with easy to use integrations. With this, on one hand there is a positive impact on the community of artists and creators gaining access to novel creative tools, and on the other hand this serves as an excellent testbed and benchmarking platform for AI tools.

Unique selling point

UC6 develops an environment for the interaction of state of the art AI tools with advanced creators of music and explores the potential interaction between human creativity assisted by generative tools.

8.2.7 UC7: AI for Content Organisation and Content Moderation

→ Challenges
Implementation of powerful AI-powered image and video processing solutions requires investment in powerful GPU hardware, as well as machine learning specialists to finetune the solution for the media organisation's needs. Non-technical staff often have unrealistically high expectations that exceed the current capabilities of AI-based automated image and video organisation. A fast and accurate AI must be developed to overcome the hurdles to the efficient and cost-effective organisation of live streaming and videos that will be the prevailing media formats in the future.

→ User needs
Novel, creative methods for image/ video content (re)organisation are critical for the adaptation and survival of media companies in the era of user-generated content. Because of the high cost of professional content creation, there is a need for it to be re-purposed and re-used so it is economically viable. Investing in AI-enhanced tools for image/video re-organisation will make media companies better prepared for the future and the challenges it holds.

→ Integration of novel AI functionalities
To address user needs, the following AI functionalities are useful: tools for image/video analysis that will be able to understand context and properly understand abstract concepts; tools for fast and accurate identification of problematic content (propaganda, violence, infamous symbols, etc.); tools for real time analysis of multiple live streams and various video formats; tools optimised for fast and inexpensive analysis of big amounts of media content, including user generated content.

→ Expected impact on media, society and democracy
We aim at helping the media sector to smoothly and cost effectively transition and adopt AI automation by providing algorithms that consider the specificity of current digital content and thus minimise the efforts by a single media company to develop, train and adopt AI models. Media companies will be eased in organising, reusing and optimising their visual content while making sure it is safe for every member of the society and that the rule of law is followed.

Unique selling point

UC7 develops an automated visual content (re)organisation demonstrator integrating advanced deep learning techniques for tagging, categorisation, and facial recognition of media content to help media companies make sense of their exponential growing visual content and aid them in their efforts to showcase safe and politically correct visual content.

8.3 Intersection of AI4Media Use Cases & AI Research Themes

Table 1 illustrates the intersection of AI4Media Research Themes and the AI4Media Use Cases. Together, these lay the foundations for a new generation of AI methods and applications that will benefit the European media industry, society and democracy.

8.4 Expected outcomes

→ Real-world use case demonstrators based on tools and systems used by media organisations, which have been upgraded with novel AI functionalities.

→ **White papers for the AI4Media use cases** aiming to align AI research with media industry needs.

	UC1 AI against Disinformation	UC2 AI for News	UC3 AI in Vision	UC4 AI for Social Sciences	UC5 AI for Games	UC6 AI for Co-creation	UC7 AI for Content Organisation and Moderation
New learning paradigms							
Lifelong learning		●	●	●		●	●
Manifold learning	●	●		●	●	●	●
Transfer learning	●	●	●	●	●	●	●
Neural Architecture Search		●	●			●	
AI at the edge	●	●	●				
Deep quality diversity			●		●		
Learning to count	●	●	●				●
Quantum assisted RL			●				
Trustworthy AI							
Legal framework for trusted AI	●	●	●	●	●	●	●
AI robustness	●	●	●	●			●
AI explainability	●	●	●	●	●		●
AI fairness	●			●			
AI privacy	●			●			●
AI benchmarking	●		●	●			
Content-centered AI							
Media summarisation	●	●	●				
Media analysis	●		●	●			
Media content production		●	●		●	●	
Content representation, indexing and retrieval	●			●	●		●
Language analysis	●		●	●			
Music analysis				●	●		
Learning with scarce data			●	●			
Computationally demanding learning			●	●			●
Human-centered and Society-centered AI							
Content moderation							●
Manipulation and synthetic content detection	●	●		●			●
Content recommendation	●	●		●			
Political debate analysis	●		●	●			
Analysis of hyper-local news	●	●		●			
User perception of social media			●				
Real-life effects of private content sharing	●			●			

Table 1: AI4Media research themes and their connection to the seven use cases

9. AI education and AI skills development

Europe has no lack of talent. Through excellent Universities and higher education institutions but also new start-ups and SMEs, there is an abundance of young people with enormous potential. The ability to attract and retain top AI talent in Europe is crucial both to the effectiveness of the AI4Media research agenda and the success of European AI more broadly.

In support of this goal, the AI4Media Center of Excellence, aims to educate and improve skills of early career researchers and entrepreneurs that seek to work on media AI by introducing three initiatives:

- **The International AI Doctoral Academy**
- **The Junior Fellows Exchange Program**
- **The two AI4Media Open Calls**

9.1 International AI Doctoral Academy (AIDA)

→ Challenge

The academic standards of PhD acquisition in the AI domain vary among European universities. As a result, the set of typical scientific skills acquired during a PhD, as well as the transferable skills (e.g., communication, mobility, interpersonal), depend on the host institution's standards and practices. The aim of AIDA is to trigger a leading academic critical mass in Europe, so that excellence in AI research is achieved and industry focus is ensured.

→ Objective

The main objective of AIDA is to provide opportunities to PhD candidates/Postdocs/AI professionals hosted in AIDA academic/research/industrial institutions for scientific upskilling in the AI domain. The AIDA program will be a vehicle for providing access to top-quality academic material, in various formats, including academic courses (tutorials, short courses, semester courses, summer schools), free-access to thematically organised academic material (presentations, review-papers), and lectures on hot AI topics **(AI Excellence Lecture series)**.

→ Opportunities & target groups

AIDA engages with academic professors, PhD students, junior/senior postdocs and AI professionals that are affiliated with AIDA members, or with well-recognized external professors in the wider AI domain. In AIDA terms, people from the above-mentioned target groups may act as AIDA Lecturers or AIDA students, on occasion.

AIDA Lecturers organise/upload academic offers, in the form of AIDA courses or other academic materials. AIDA offers a seal of Excellence to these materials with its curation processes, together with robust course dissemination services through AIDA channels that maximise course registration and impact. In case the lecturers are junior/senior postdocs, they may offer a course to AIDA to obtain teaching experience. On the other hand, AIDA students get the opportunity to attend quality AI courses delivered by distinguished AI lecturers worldwide, which increases their scientific skills. For each AIDA course they participate in, they may request and obtain their personal AIDA Certificate of Course Attendance, which strengthens their CV.

→ Expected impact on AI research and media industry

AIDA's expected long-term impact on AI research in Europe is the reduction of the variance in the typical academic skills obtained by AI PhD between the participating organisations, by the definition of commonly accepted academic curriculum and excellence PhD acquisition standards. The media industry and research organisations can benefit though AIDA by upskilling their own personnel and/or by hiring new personnel from the AIDA student pool.

Unique selling point

AIDA is a pan-European non-profit umbrella organisation that specializes in AI PhD education, uniting a leading academic mass in Europe to promote AI excellence and democratisation of education materials to PhD students among its members and beyond.

9.2 AI4Media Junior Fellows Exchange Program

→ Challenge

While AI is quickly reshaping the media industry landscape, media companies still face significant challenges in recruiting personnel that are skilled in AI. At the same time, AI researchers often lack insights on media industry needs. On top of that, mobility and collaboration between AI labs has yet to reach its full potential despite initiatives such as ELLIS. To establish Europe as a media AI powerhouse, it is necessary to promote exchange programs that will focus on AI research or applications for the media industry.

→ Objective

The Junior Fellows Exchange Program was launched in June 2021 to facilitate mobility of young researchers working on AI for media & society. It aims to develop new skills, improve diversity, increase visibility, and strengthen the impact of media AI through exchanges of researchers and media professionals between academia, research institutions, and media industry. Each exchange is expected to produce tangible open access outcomes (e.g. publications, software, datasets) on media AI while enabling the spread of expertise and skills across Europe and building strong collaborations between AI labs and/or media companies.

→ Opportunities & target groups

The Junior Fellows Exchange Program offers research exchange opportunities for PhD students, MS students, and early career postdocs but also senior researchers that want to improve their skills and knowledge in AI for the media and society. Each exchange involves one Fellow, one Sender institution, and one Host institution, with either the Sender or the Host being an AI4Media partner. Exchanges can be physical, virtual, or hybrid. The travel and living costs of physical exchanges are partly covered by the AI4Media mobility budget.

The topics of exchanges are relevant to the research directions use cases of AI4Media, extending existing AI4Media research and applications through the delivery of novel algorithms, software and datasets. Emphasis is put on promoting exchanges between media companies and AI labs to strengthen industry/research collaboration. These involve either AI researchers that seek to better understand media industry needs and gain practical experience on how to transform AI research into applications for the media or media professionals that seek to improve their AI skills and understanding.

→ Expected impact on AI research and media industry

The program is expected to contribute to the creation of a critical mass of early career researchers with a deeper understanding of media industry needs and significant experience in media AI research through their engagement with top media AI research labs and media companies in Europe. Both AI labs and media companies will benefit from the flow of novel ideas and the spread of media AI expertise and skills across Europe.

Unique selling point

The AI4Media Junior Fellows Exchange Program facilitates exchanges of early career researchers that want to improve their skills and knowledge in AI for the media and society by collaborating with top European AI researchers and media companies to conduct innovative research that considers industry needs.

9.3 AI4Media open calls

→ Challenge

AI is already a well-established but continuously evolving field, with applicability in various industries, including media and its many inherent areas. It is safe to assume that there are many promising ideas for AI research and solutions that often do not materialise due to the lack of opportunities and incentives that facilitate the growth of such ideas. Financial support to third party programmes (FSTP) is one such tool that can enable these ideas to grow.

→ Objective

The main objective of the AI4Media open calls is to engage entrepreneurs, companies (from start-ups to midcaps), academia and research organisations that develop and integrate applied research in the field of AI, to develop new and innovative research and applications for AI. The developed research and

solutions will contribute to the enrichment of the pool of research and technological tools to be made available – via AI4Media – on the AI-on-Demand platform.

→ Opportunities & target groups

The AI4Media project will run two open calls, funding a total of 20 projects. Each open call is divided into two tracks: Research and Application. Eligible entities include entrepreneurs, companies, academia and research organisations, which can apply to either track.

The projects funded in each track have submitted proposals addressing one of the many challenges defined for each open call. The challenges are prepared by the AI4Media consortium partners and are aligned with and complement the project's research and demonstration activities, as well as the AI4Media Roadmap on Media AI. The 20 projects funded will each receive up to €50,000 in equity-free funding, in addition to tailored training in the form of a bootcamp, business support to help promote project results, dedicated coaching support, and general promotion and visibility opportunities.

→ Expected impact on AI research and media industry

In addition to the direct impact that the funding opportunity has on the growth of the 20 participating entities, the integration of the developed research and solutions (e.g. related to music, recommendation systems, web traffic prediction, comment filtering, and others) in the AI-on-Demand platform will enable new research and applications to stem from those developed through the AI4Media open calls.

Unique selling point

The AI4Media open calls will fund 20 projects led by industry or academia entities with up to €50,000 equity-free funding to develop new research in AI or innovative AI applications for the media sector.

10. Building the European Media AI Ecosystem

To advance its research agenda on media AI, AI4Media aims to establish a wide multi-disciplinary network of top AI research labs, social science labs, legal/ethics experts and media or media- related companies and start-ups across Europe that will closely collaborate to build excellence and create a European powerhouse on Media AI, aiming to benefit the media industry, the society and the economy.

The AI4Media consortium members, associate members, and organisations funded by the project's open calls already constitute a critical mass of more than 100 organisations from academia, research and industry, working together to produce excellent research and innovative applications for media AI, examining AI through a multi-lense including technology, industrial application, legal and ethical aspects, and socio-economic impact.

The concentration of knowledge and expertise in AI4Media makes the Network uniquely positioned to lead media AI research in Europe and to build collaborations on this topic. Besides supporting high-quality research, the project also supports engagement with industry to translate AI knowledge into practice; collaborations to spread AI expertise across research domains and countries; and training and education activities to develop the next generation of European AI talent.

→ Engaging industry to translate AI knowledge into practice

Solutions to major AI problems will come from the collaboration of the research community that studies fundamental questions and the industry that has vast amounts of data, domain knowledge and compute.

As explained in section 8, AI4media aims to increase innovation in the media industry by translating mature research outcomes into industrial real-world applications through seven use cases. The use cases will be implemented in collaboration with well-known large European news media organisations such as DW in Germany, RAI in Italy and VRT in Belgium as well as rising SMEs in the media sector like modl.ai, a game development company in Denmark, and Imagga, company developing solutions for content management in Bulgaria.

In addition to the seven use cases, AI4Media will further support innovation acceleration activities through a programme of two open calls that will provide funding and support to SMEs and start-ups developing innovative AI applications for the media industry.

→ Collaborating to spread AI expertise across research domains

While AI4Media focuses on media AI, many of each research directions, including core ML research, analysis of multimedia content and trustworthy AI, have numerous applications in many other industry domains as well. To help build a European AI lighthouse and promote cross-domain and multi-discipline collaboration on AI, AI4Media has already identified complementary European initiatives with whom the Network could collaborate.

AI4EU, AI4Europe: To ensure that AI4Media's work is shared widely across the European innovation ecosystem, AI4Media closely collaborates with AI4EU and AI4Europe by:

- → Enriching the AI-on-Demand platform with AI4Media AI assets and integrating AI4Media components and pipelines in the AI4EU Experiments Marketplace.
- → Adopting, extending and operating the AI-Café, an online forum initially founded by the AI4EU project to gain insights into the European AI scene. Participants get the chance to share knowledge and experiences and meet stakeholders from various areas of AI research and application.
- → Participating in the AI4EU Technical Governance Board, through partner FhG-IAIS that also hosts and manages the AI4EU Experiments.

ICT-48 projects: AI4Media has already established important collaborations with TAILOR, ELISE, Humane AI, VISION CSA projects, aiming to create a

European AI lighthouse. Complementing each other's expertise and know-how, the ICT-48 projects are well-positioned to establish Europe as an AI powerhouse, addressing the needs of different industries and approaching AI using a multi-disciplinary approach that considers research excellence, industrial needs, societal and economic impact, and legal-ethical issues. Collaboration with ICT-48 projects spans different activities such as:

- AIDA foundation, management and operation.
- Organisation of cross-cutting events like Theme Development Workshops and AI Mellontology Symposia.
- Development of a joint ICT-48 research agenda.
- Creation of a map of European AI excellence.
- Exchange of knowledge, expertise and best practices on a variety of topics from research to mobility and industrial collaboration.

vera.ai[14]: vera.ai is a Horizon Europe RIA that seeks to build professional trustworthy AI solutions against advanced disinformation techniques. Several AI4Media partners are members of the vera.ai consortium. Such synergies can be leveraged to expand the reach of A I4Media's (trustworthy) AI technologies for the media sector with a focus on disinformation and to exchange research outcomes between the two project communities.

European Digital Media Observatory (EDMO) and EDMO (multi)national Hubs[15]: EDMO brings together fact-checkers, media literacy experts, and academic researchers to understand and analyse disinformation, in collaboration with media organisations, online platforms and media literacy practitioners. EDMO's Hubs form a European multidisciplinary community aiming to actively detect, analyze and expose disinformation campaigns across Europe. Several AI4Media partners are members of EDMO and the Hubs. We aim to take advantage of these connections in order to promote AI4Media's outcomes and establish further collaborations in this area.

European Broadcasting Union (EBU)[16]: Through being a member in the EBU and/or specific working groups, some of the AI4Media media partners liaise with other public service media organisations in connection to selected AI & Media topics.

COPEAM[17]: To ensure its geographic reach in Southern Europe and the Mediterranean, AI4Media has forged a collaboration with COPEAM - an association of audiovisual players, including public service radio and TV broadcasters and professional and cultural associations of Balkans, North Africa and Middle East. The association is focused on training activities, knowledge sharing and awareness raising campaigns to which the AI4Media consortium will be contributing.

Better Images of AI (BIOAI)[18]: BIOAI advocates for the use of more representative and diverse imagery to be used when illustrating AI. One of its core activities is a repository of better images of AI that anyone can use, starting with a collection of inspirational images. The initiative explores what these new images might look like, and invites people from different creative, technical and other backgrounds to work together to create them. The initiative complements AI4Media's goal to demystify AI for the general public.

→ Supporting the next generation of AI talent in Europe

AI4Media supports in practice the next generation of AI talent in Europe by founding and managing the International AI Doctoral Academy, a joint instrument to support world-level AI educational and training activities for PhD/postdoc researchers. In addition, through its flexible Junior Fellows Exchange Program, the Network offers mobility opportunities for young researchers and media professionals while its open call funding scheme supports SMEs, start-ups and research labs to develop innovative applications and research for the Media.

→ Establishing the European AI infrastructure

To build the European AI Ecosystem, significant investments on AI infrastructure are required by the European Union and European industry. This should include the development of open AI platforms and resources similar to the AI-on-demand-platform (AI-ready data repositories, AI software and AI integration frameworks, AI testbeds); sustained community-driven challenges that will move the research forward in selected fields; national AI research centers and European research networks

14 https://www.veraai.eu/

15 https://edmo.eu/ and https://edmo.eu/edmo-hubs/

16 https://www.ebu.ch/home

17 http://www.copeam.org/

18 https://betterimagesofai.org/

conducting multidisciplinary research, developing open resources and providing AI training; and mission-driven AI labs, acting as living laboratories for AI development in areas of great societal impact, allowing collection of data and development of algorithms to tackle real-world problems.

11. Conclusion

This is the first version of the AI4Media Strategic Research Agenda which focuses on the use of AI technology in the service of the media, society and democracy. The Agenda presents four main research pillars focused on developing novel learning paradigms, trustworthy AI methods, multimedia content analysis and production tools, and human and society-centred AI applications for the media industry. The Agenda explores how the results of this research can be integrated in seven media-related use cases, informed by emerging market opportunities and urgent media industry challenges.

The AI4Media Strategic Research Agenda also proposes a Media AI Observatory to monitor the legal and technological landscape as well as the impact of media AI while at the same introducing three initiatives (AI Doctoral Academy, Junior Fellows Exchange Program, and Open Calls) to advance AI education and skills development and to support entrepreneurship. Opportunities for collaborations that will help build the European Media AI Ecosystem are also discussed.

The Agenda should be seen as a snapshot of the current situation with regard to AI technology for the media industry and the research activities of the consortium. As AI and its applications for the media are advancing fast, new high-impact research areas and applications will be unveiled that will need to be explored. The Strategic Research Agenda will be updated to reflect these developments.

Table of Abbreviations and Acronyms

ABBREVIATION	MEANING
AI	Artificial Intelligence
AIDA	International AI Doctoral Academy
BIOAI	Better Images of AI
CSN	Conditional Similarity Networks
COPEAM	Permanent Conference of Mediterranean Audiovisual Operators
DL	Deep Learning
DW	Deutsche Welle
EBU	European Broadcasting Union
EC	European Commission
EDMO	European Digital Media Observatory
EU	European Union
FhG-IAIS	Fraunhofer Institute for Intelligent Analysis and Information Systems
FSTP	Financial Support to Third Party
GAN	Generative Adversarial Network
GDPR	General Data Protection Regulation
GPT-3	Generative Pre-trained Transformer 3
GPU	Graphics Processing Unit
ICT	Information Communication Technology
LtQ	Learning to Quantify
ML	Machine Learning
NAS	Neural Architecture Search
NeRF	Neural Radiance Field
NLP	Natural Language Processing
NN	Neural Network
PET	Privacy Enhancing Technologies
PPAI	Privacy-Preserving AI
PSM	Public Service Media
QD	Quality-diversity
R&I	Research and Innovation
RAI	Radiotelevisione italiana S.p.A.
RIA	Research and Innovation Action
RL	Reinforcement Learning
SFL	Secure Federated Learning
SME	Small and Medium Enterprise
SRA	Strategic Research Agenda
SSH	Social Sciences and Humanities
VR	Virtual Reality
VRT	De Vlaamse Radio- en Televisieomroeporganisatie nv

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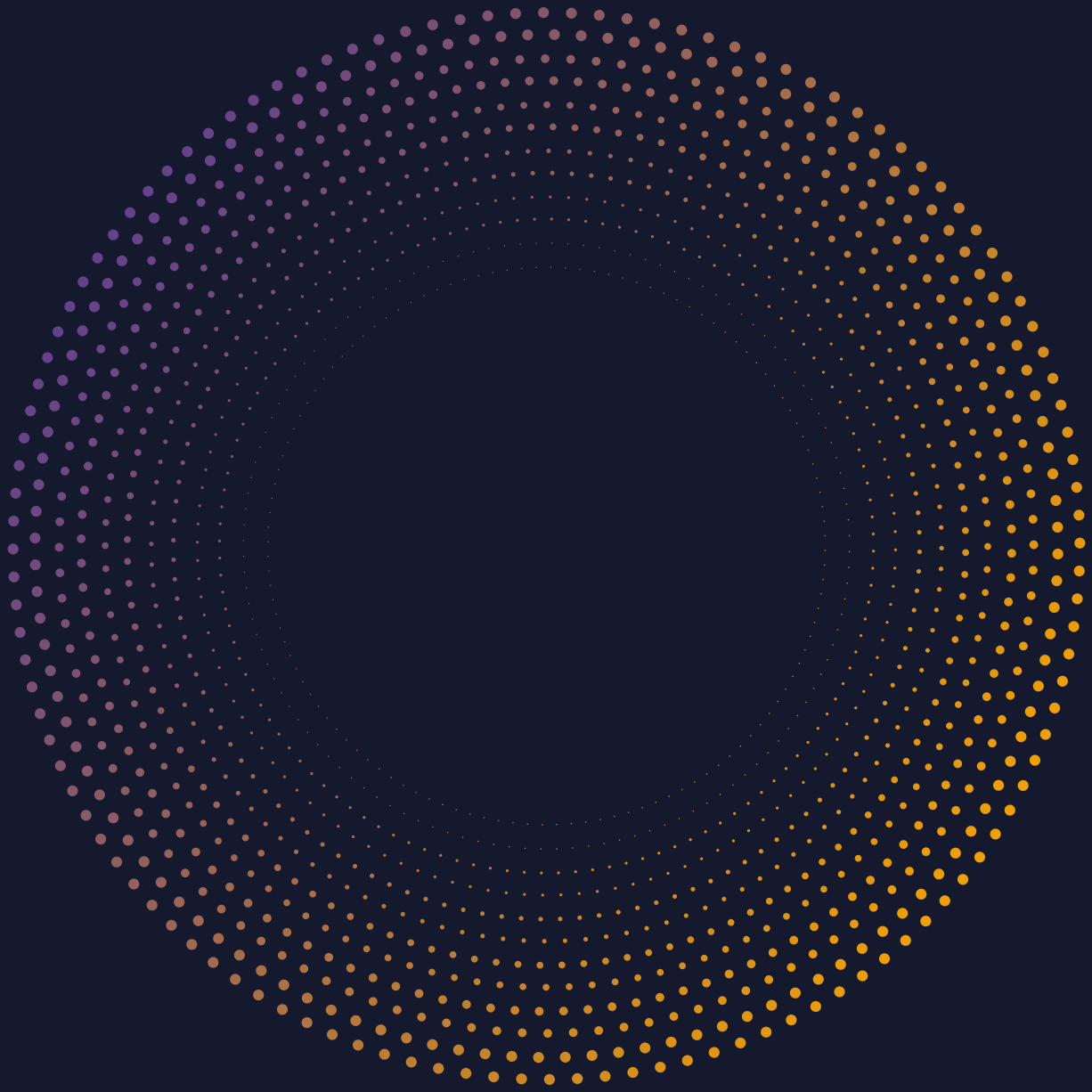

Our Consortium

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