



## AI and Journalism • Intelligible Cloud and Edge AI (ICE-AI)

This briefing note gives an overview of artificial intelligence (AI) in journalism and focuses on application of AI in the news production process. It summarises the benefits gained and future opportunities identified alongside the issues observed and potential risks posed by AI in journalism. It considers the challenges to responsible, ethical and value-aligned adoption of AI by news organisations, including issues related to laws, regulations, professional norms and values and societal expectations.

that AI was “additional, supplementary and catalytic, not yet transformational” [2: p6]. Examples of use include smart systems that monitor and alert journalists to information, assist data and document analysis, automate the production of stories and profile audiences to drive news recommendations to them.

The impact of AI-driven systems on journalism is however broader than simply the newsroom applications. The wider media ecology in which journalism operates is shifting as AI-driven

### Overview

- News organisations are using AI for newsgathering, production and distribution but relevant skills and technology are unequally distributed across the industry.
- **Machine learning** presents opportunities to augment journalism by automating routine tasks and enabling greater scale, speed and efficiency and has potential to help improve the depth, diversity and appeal of news.
- **But concerns** have been raised about legal, ethical and professional implications of its use in the newsroom due to issues of bias, ‘black box’ systems and value alignment.
- **Assessments of** the impacts and implications of AI on journalism to date are limited.

## Background

Artificial intelligence (AI) is changing journalistic practices and processes and contributing to a more structural transformation of what it means to make news [1,2,3]. Various definitions of AI abound and use of the term ranges from describing speculative notions of sentient machines to routine applications of maths, statistics and data analysis but there is a general consensus that AI refers to systems that mimic intelligent human behaviour to perform tasks that usually require human intelligence [4], such as image or speech recognition and language translation.

There are numerous applications of AI in journalism, primarily using machine learning (ML) techniques that learn from past data by identifying patterns and correlations [5]. However, use of AI is unequally distributed across the news industry and remains in early or experimental stages in most organisations [2,6] and in many developing nations [7]. A global survey of mainly technologically expert staff within news organisations in 2019 found

technologies and companies contribute to the redistribution of market power, advertising revenue, and audience attention in particular via the filtering of news [8,9]. Additionally, as AI and algorithmic systems have become more prevalent in everyday life, journalists must now report on the growing influence they

have in society – a challenging task given low levels of practitioner understanding of AI, coupled with lack of transparency from commercial providers and their extensive public relations efforts. This has so far mainly resulted in relatively uncritical industry-led coverage [10] and “shallow” engagement with AI ethics [11] except for a few specialist outlets and projects [e.g. 12,13] focusing on algorithmic accountability reporting [14].

There are clear advantages to using AI in news production (both potential, and to a lesser extent achieved) such as enhanced data analysis and improved data-driven and investigative reporting [15,16], enhanced accuracy, diversity and efficiency and increased engagement through tailoring content for user preferences. But there are also



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concerns over professional, legal, societal and democratic implications [17], which underpin debates about privacy, accountability, editorial and organisational independence, filter bubbles, gatekeeping, bias and fundamental rights as well as more practical questions of impact on employment, job quality, content standards and audience experience. To-date there has been limited research actual gains, trade-offs and undesirable impacts [18].

Additionally, journalists must consider questions of quality, diversity, creativity and relevance, which are differently valued and expressed across varied newsroom cultures. Unless otherwise funded, they must do this while operating as a business in a capitalist market environment while negotiating political pressures. Against this complex and contingent background, integrating AI - which acts to distribute cognition and control between

4th Estate

- Key drivers of deploying AI include commercial pressure to be more efficient in a competitive market and aspirations to better serve diverse audiences, particularly through personalisation.
- **Common applications** of AI include automating repetitive tasks, increasing news output volume and speed, and improving relevance for, and engagement with audiences.

## Journalism in society

Described as the 'fourth estate' to reflect its unofficial societal influence and power, the news media plays an important role in society. The history of journalism is heavily intertwined with that of technology [19,20] and in the digital age news producers have increasingly prioritised technical innovation to survive [21,22]. Journalism is conceived of differently around the world and each society's news production system reflects its political, economic, historical and socio-cultural context as well as normative ideals of journalism that conceptualise desired functions of the press. In modern western democratic societies such as the UK, these normative ideals include: factual accuracy, promotion of open debate, representation of diverse views, serving as a 'marketplace of ideas', fostering citizen inclusion and empowerment and protecting individual rights by acting as a watchdog that guards against government abuse of power [23,24].

Associated ideals of truthfulness, accuracy, impartiality, accountability, objectivity, fairness and representation find expression in professional frameworks and codes of ethics/conduct [25,26,27], enforcement through law and regulation [28] and are interpreted and transformed in everyday news production practices, which evolve and change [29,30].

humans and computational systems - causes disruption; alongside requiring reorganisation of resources and practices in order to open up opportunities to augment journalism, it simultaneously risks destabilising established mechanisms for applying these values and threatens to undermine existing processes for ensuring responsible journalism. The risks are particularly acute for public service media (PSM), which are (usually) funded by taxpayers' money and held to high standards of accountability and public scrutiny and which are developing PSM-specific AI strategies in response [31,32,33].

## Applications of AI in journalism

AI is being used across the full news production cycle for a host of tasks that contribute to newsgathering, production, and distribution, as well as for non-editorial tasks such as marketing [1-3]. Many systems designed specifically for journalism remain at the research and development or trial and evaluation stages but technology companies are increasingly serving this market [34]. Key drivers of newsroom AI are automation, propelled by commercial pressure to extract higher margins from dwindling resources [35] and personalisation, which relies on automation to profile individuals and segment audiences and offer them tailored news. AI



forms a small part of a much broader suite of techniques and technologies now used not only in computational and data journalism specialisms [38,39,40] but in everyday journalism, following a quantitative turn [36,37] and against a backdrop of the digitisation of media and public life. It is not always self-evident which systems deploy AI techniques as opposed to mathematical processes that elude the “polysemous and problematic” definition of AI [41 p.673]. The following section summarises recognised applications of AI in news production.

## AI in newsgathering

AI is being used to automate, scale up, and speed up the identification, monitoring, classification and analysis of potentially newsworthy information.

- **Intelligent character** and word recognition systems have been used to digitise documents, which can then be indexed in databases and searched by keywords, thus scaling up capacity for investigation [1,34].
- **ML-driven data** mining, using classification, regression, clustering, summarisation, dependency modelling and change and deviation detection, helps journalists find what is newsworthy in data [1].
- **NLP is** also deployed to aid document mining and analysis by enabling systematic search, summarisation, and visualisation, for instance by using tagging and clustering, as was the case in the Associated Press’ Overview project [50].

## AI in news production

AI is being used to automatically generate

### ML Systems

- ML systems ‘learn’ and improve from examples without their instructions all being explicitly programmed. They are trained to perform a task by analysing large amounts of training data and building a model to process future data.
- **Recent advances** in ML techniques - driven by improved computing power, increased availability of data, and reduced storage/ processing costs - have powered advances in other AI fields such as natural language processing/generation (NLP/NLG), facial recognition and machine vision.

- ML powers computational news discovery [42] to detect and monitor numerous source inputs (search engines, social media etc.) to identify breaking news [43,44].
- **Natural language** processing (NLP) has helped reporters find relevant tweets [45], extract and analyse them for sentiment analysis [46], and crowdsource input [47]. The growing interdependence between journalists and social media platforms has prompted concerns about problematic impacts resulting from such sourcing practices, from undue amplification, to fuelling mis- and dis-information and uncritically legitimating speech [48].
- **Machine translation** and transcription help journalists monitor and record events and translate reports for rapid global distribution - increasingly even for less well served languages that have been sidelined due to poor data sets [49].

stories, filter, discover and explore connections in data, as well as verify and fact-check information.

- Automated journalism (also termed ‘robot-journalism’) is the algorithmically-driven conversion of structured data into stories using natural language generation (NLG) [51]. It has been used primarily to convert financial and sports data into automated stories [52] and deployed extensively by news agencies [53] and trialled for election coverage [54]. These systems enable rapid story creation at scale and at relatively low cost [51, 55] but cannot undertake complex storytelling, a goal which remains in research and development [56].
- **Discrete production** tasks are also being automated, for instance suggesting headlines and topics [59], semantic tagging of content [60] and proofreading.
- **ML techniques** enable automated



verification of information [61], such as classifying witnesses [62] for credibility and veracity and debunking fake news [63] as well as aiding fact-checking [64,65].

- **Speech-to-text/text-to-speech software** and NLP and NLG systems automate the re-packaging and re-versioning of content using the same fundamental elements of a story to create multiple representations, for example turning audio to text, text into video, or one language into another [66].
- **Plans to use AI to drive object-based media** approaches to creating variable and flexible edits of news are also at the research stage as part of the BBC's move towards personalisation [57,58].
- **ML-driven summarisation** tools are being used to add context to stories and make use of 'evergreen' content [67] and to vary presentation of a story's key points for different audiences [68].
- **ML modelling** is fuelling a growth of predictive journalism [69] including data-driven election coverage and modelling Covid-19 pandemic projections and which is enabling more sophisticated prediction of aspects of social life [70].

## AI in distribution & audience interaction

AI is driving news personalisation, recommendation engines, curation of stories, communication and engagement with audiences, and news analytics.

- Recommendation engines, often driven by content-based and collaborative filtering, are being deployed on websites, in apps and for newsletters to match news content to audience members [71]. AI is also used to identify audience segments to target and to drive curation systems which generate suggestions for, or automate the allocation news stories to web indexes and front pages. A survey of digital leaders in news organisations reported that they saw automated recommendations as the most important use of AI in the short term [8].
- **News curation** apps and social media companies also use ML models to profile audiences and deliver algorithmically-filtered content using gatekeeping logics over which

news providers have no control [72,73], impacting news consumption habits and users' perceptions of news [74].

- **'Communicative AI'** such as conversational agents or 'chatbots' and social robots have been designed to engage with audiences, functioning as communicators rather than simply mediators of communication [75].
- **News organisations** are also developing voice assistants [76] and other services for smart speakers [77]. China's Xinhua News Agency has experimented with an AI-powered synthetic news anchor [78].
- **AI-powered systems** are used to analyse audience questions and expressed needs/desires [47], which can then be fed back into story generation.
- ML classifiers are being used to moderate reader comments on news websites [79] and across the digital ecosystem where news stories appear [80].
- **Editorial analytics** are widespread across the industry [81,82]. They increasingly exploit predictive ML techniques in an effort to improve audience engagement [83], for example by testing headlines and images, and are feeding into the construction of news agendas [84].
- **Finally, there** are also now also examples of content management systems that integrate AI throughout the entire production process [85] such as Chinese news agency Xinhua's 'Media Brain' [86].

## Non-editorial use of AI

Beyond the editorial process of news production, news organisations are using AI for business and marketing, for example to optimise paywalls for revenue [7], by predicting when a reader is likely to subscribe [87]. There have also been experiments in tackling bias in the newsroom [88] and analysing news output to gauge and improve representation of sources in articles [89,90].

## Benefits to journalism

The advantages and opportunities of AI for journalism are often described in terms aligned with operational and business goals such as



efficiency, scale, speed, and cost savings and some leaders in the field are reporting success against these metrics [1-3]. We are yet to see whether, and in which contexts across the broader industry, investment will equate to gains, what levels of resource allocation will be needed in the long-run, and what unanticipated impacts may arise, for instance in relation to news quality and serving journalistic ideals. A central hope in the profession is that automating tasks will free up more time for creative and investigative work [91] and there are reported examples of exactly this, for instance the Associated Press described how automating basic earnings reports allowed journalists time to digest and contextualise the information, and seek deeper analysis [3,92]. This does however depend heavily on how managers and newsrooms decide to reallocate any newly available resources and whether investment in procuring, developing and managing AI offsets those gains. For example, 27 jobs were lost after Microsoft introduced AI-driven curation to manage its website [93]. Evidence suggests use of AI can remove or reduce repetitive tasks for newswriters but may also generate new forms of 'mundane labour', for example through the need to oversee the activity of AI-driven machines as an 'algorithmic-editor-in-the-loop' able to override AI decisions [94]. It is clear that some new creative roles have been made to oversee newsroom partnerships [89] and bridge product development, editorial, and engineering [95]. Estimates have suggested only about 15% of reporters' time and 9% of editors' time is automatable using current technology [96]. However, as the implementation of AI is not yet large-scale or pervasive across the industry, whether it leads overall to job cuts or job degradation is unclear. There is also evidence that AI can be put to use to improve quality, breadth and relevance and to highlight human bias such as lack of source diversity, gaps in news coverage [1-3,97] and ultimately contribute to democratic goals and editorial missions [17,98].

## Challenges

The challenges AI poses are at times unique to the technology but also sit within a broader set of challenges related to data, algorithms, and applied mathematics and statistics in social

domains. Similarly, many of the challenges of AI in journalism map to broader concerns but others are unique to journalism or take on unique expression in the profession [99,100]. From an industry perspective, the self-reported biggest challenges to adopting AI in journalism are:

- **Cost.** AI development and procurement can be expensive and a lack of financial resources is prohibitive in a climate of shrinking newsrooms and revenues [101]. Smaller, often local news providers, and those in less affluent nations are voicing concern over being left behind [2]. This may risk worsening digital divides and increasing inequalities in news coverage and quality.
- **Limited knowledge and skills.** Most journalists have little knowledge, critical understanding, or proficiency with AI-driven tools or experience working collaboratively with those that do. This deficiency risks restricting the quality of their coverage of AI and algorithms in society as well as their ability to ensure use of AI in the newsroom is safe, responsible and aligns to their ideologies and goals. Journalists report wanting more AI training than news organisations are providing [51].
- **Cultural resistance.** There is significant pushback against automation and AI in the newsroom, often driven by the fear of losing jobs, of changing work habits, and hostility to new technology [2]. Journalists may feel like they risk losing control or the denigration of their work or may want to avoid risks due to lack of confidence using AI. Previous studies have described how earlier technological innovations in the newsroom had a de-skilling effect [102] and an increase in pace and pressure, leading to less opportunity to explain context [103].
- **Maintaining public trust.** In the current environment in which mis- and dis-information is rife, deepfakes and synthetic manipulation are on the rise, and populations increasingly get news through social media, maintaining public trust and confidence is a challenge. It is still unclear how audiences feel about increasing integration and visibility of AI in news. Reaction to automated and semi-automated news for instance appears mixed - some research suggests limited impact on credibility perception [104], other



studies improved credibility [105,106], others that it is descriptive and boring but objective [107]. As profiling, personalisation and voice intelligence rise, ensuring trustworthy privacy and data practices will be vital [108].

Challenges to adoption however only touch the surface of the array of issues and questions AI poses for journalism. These include whether certain types of AI should in fact be used at all, whether they are right for specific contexts, and considerations of how to integrate them responsibly, ethically, and in ways aligned to a professional journalistic ethos and its varying instantiations.

- **Law and regulation.** The news media carry duties and responsibilities towards users and society [109] and have a responsibility to use AI in ways that are conducive to the fundamental freedoms and values that characterise their markets and policies [17]. As algorithmic selection has become a growing source of social order and shared social reality in information societies [110, 111], concerns have been voiced about potential negative implications for democracy, particularly of recommender systems [112]. These include filter bubbles, polarisation, and fragmentation of the public sphere [113,114] and difficulty holding algorithms accountable [115]. Specific ethical and juridical issues also arise in relation to automated journalism [96,116,117], particularly concerning the legal status of automated speech and where responsibility and liability lies [117], for instance in cases of data rights, privacy and copyright breaches, as well as defamation, contempt of court and 'libel by algorithm' [118,119].
- **Value-aligned AI.** The role AI plays in journalism is clearly not simply a technical question - it is deeply social, cultural, political and economic. This raises normative questions of what one 'should' or 'ought to' do and in this case, which moral obligations pertain in the development and use of AI in journalism and how to apply ethics in practice. Value judgements are expressed in and through AI systems via data, rules, knowledge bases and optimisation decisions [120]. This presents an opportunity and a challenge to news organisations that want these systems to reflect their journalistic ethos and intentions because they must be able to a) articulate and explicate the judgments, ethical codes and values in their professional ideology b) develop appropriate mechanisms for embedding them in design and engineering decisions, including devising measurable proxies for high-level aims and c) review and updating them once these 'systems that learn' are live and evolving. Different contexts will prioritise different sets of values, depending for example on their conceptions of democracy and the role of media within it [17,18,32]. For example, PSM will need to decide on ways of using data about audiences that meet their standards of trust and accountability - that will likely differ from other news providers, which may be opaque about use of personal data or use it to make money. Different applications of AI will raise different sets of questions about how to prioritise and operationalise values and may necessitate different trade-offs between these values - all of which demands discussion and debate within industry. News organisations will need to confront broader ethical questions too. These include growing concern about the environmental impact caused by the computational power needed to run AI [121,122] as well as how developments may play into existing inequalities of news accessibility that create 'digital divides' reflecting geographic and wealth disparities, and the economic dynamics they have left some communities lacking access to quality news as seen in local 'news deserts' in the USA [123].
- **AI ethics and safety.** The question of how AI can be used ethically has led to a range of ethical principles and guidelines [124,125], including in the public sector [126,127,128] that highlight how misuse, abuse and poor design of AI systems risks causing potential harms and unintended consequences. These include bias and discrimination; denial of autonomy, recourse and rights; invasion of privacy; isolation and disintegration of social connection; and outcomes that are not transparent, explainable or justifiable, or that are unsafe and unreliable [126]. But high-level principles often hide deep political and normative disagreement [129].
- **Intelligibility.** A fundamental challenge here is understanding AI, as this underpins many other issues. The UK House of Lords Committee on AI called for the development



of AI systems that are “intelligible to developers, users and regulators” [130]. AI systems can be ‘black-boxes’ and opaque even to experts designing and deploying them (e.g. deep learning) or they can lack scrutability for non-experts, including journalists, due to technical complexity and incorporation of third-party proprietary software. This can engender a lack of agency in relation to ML and risk introducing and perpetuating bias, disrupting journalistic expertise and judgment, and undermining processes of accountability. This in turn threatens to compromise journalistic authority and legitimacy in the eyes of the public.

- **Transparency and accountability.** Transparency is a basic journalistic value but AI can challenge how it is applied in practice. This has prompted questions about how transparent news organisations can or should be about code and algorithmic processes behind stories, how best to explain this and how explaining it may impact audience trust, and which information is best disclosed, such as human involvement, data model, inferencing and algorithmic presence [131]. There are currently no agreed standards around attribution of AI automation. Full transparency may not be possible when using proprietary or complex systems, may be unnecessary or undesirable, or may conflict with other values, leading to trade-offs or a rebalancing of which values are prioritised. For instance, profit and scalability may conflict with transparency when the effort and resource needed to make data public - anonymising, formatting, and hosting data sets - is accounted for [132]. Moreover, protecting sources is a fundamental principle in journalism but it is unclear how this might work in relation to the transparency of data sources in automated processes [116]. What algorithmic transparency looks like in journalistic practice therefore is more complicated than simply ‘looking inside the black box’ [133] and equating such an ability to see with the power to hold accountable and govern [134].
- **Data governance and management.** Accountability in data-driven systems necessitates rigorous recording of data collection and processing. The quality, accuracy and integrity of data is crucial to automated journalism as is the need for legal

and ethical data collection but questions remain about the objectivity of datasets and how open to manipulation and distortion they may be [135]. This may pose risks to the credibility of news organisations. There is also a problem of ‘fact-belief’ discrepancies where auto-generated content is technically objectively true, but constructed in such a way that the reader may draw conclusions leading to an objectively false impression [51]. These issues have prompted calls for monitoring and validating procedures [99] and auditing AI and training data sets, for example for undesirable bias. Selecting data sets and deciding how to interrogate and use them is an editorial decision in this context and therefore falls under existing standards of impartiality, non-discrimination and fairness. New levels and types of editorial and institutional oversight, disclosure policies and mechanisms, and collaborative working practices will be needed to tackle these issues.

Advancing AI capabilities are likely to lead to unanticipated conflicts or ambiguities of control, power and social responsibility in relation to journalism. More work needs to be done towards delineating the risks that matter for journalism and assessing the impacts already in evidence.



## References

1. Diakopoulos, N. (2019). *Automating the News: How algorithms are rewriting the media*. Cambridge, Massachusetts: Harvard University Press.
2. Beckett, C. (2019). *New Powers, New Responsibilities – a Global Survey of Journalism and Artificial Intelligence. A global survey of journalism and artificial intelligence*. LSE Polis Report.
3. Marconi, F. (2020). *Newsmakers: Artificial Intelligence and the Future of Journalism*. Columbia University Press.
4. UK Government (2017). *Industrial Strategy: building a Britain fit for the future*.
5. Royal Society (2017). *Machine learning: the power and promise of computers that learn by example*.
6. The International Centre for Journalists (ICFJ). (2019). *The State of Technology in Global Newsrooms*.
7. Jamil, S. (2020). *Artificial Intelligence and Journalistic Practice: The Crossroads of Obstacles and Opportunities for the Pakistani Journalists*. *Journalism Practice*.
8. Newman, N., Fletcher, R., Kueng, L., Nielsen, R. K., Selva, M., & Suárez, E. (2020). *Journalism, Media, and Technology Trends and Predictions 2020*. The Reuters Institute for the Study of Journalism.
9. Brake, D. R. (2017). *The Invisible Hand of the Unaccountable Algorithm: How Google, Facebook and Other Tech Companies Are Changing Journalism*. In: Tong J., Lo SH. (eds) *Digital Technology and Journalism*. Palgrave Macmillan.
10. Brennen, J. S., Howard, P. N. & Nielsen, R. K. (2018). *An Industry-Led Debate: How UK Media Cover Artificial Intelligence*. Factsheet. Reuters Institute for the Study of Journalism.
11. Ouchchy, L. Coin, A. & Dubljević, V. (2020). *AI in the headlines: the portrayal of the ethical issues of artificial intelligence in the media*. *AI & SOCIETY*, 35:927–936.
12. ProPublica. (2015) Machine bias series - Investigating Algorithmic Injustice. *ProPublica.com*.
13. The Markup. (2018). *About Us*.
14. Diakopoulos, N. (2015). *Algorithmic Accountability: Journalistic investigation of computational power structures*, *Digital Journalism*, 3:3, 398-415.
15. Stray, J. (2019). *Making Artificial Intelligence Work for Investigative Journalism*, *Digital Journalism*.
16. Broussard, M. (2014). *Artificial Intelligence for Investigative Reporting*. Using an Expert System to Enhance Journalists' Ability to Discover Original Public Affairs Stories. *Digital Journalism* 6 (3): 814–831.
17. Helberger, N. (2019). *On the Democratic Role of News Recommenders*. *Digital Journalism*, 7:8, 993-1012.
18. Helberger, N., Eskens, S., van Drunen, M., Bastian, M., & Moeller, J. (2019). *Implications of AI-driven tools in the media for freedom of expression*. Background Paper to the Council of Europe Conference of Ministers responsible for Media & Information Society, Artificial Intelligence – Intelligent Politics. Cyprus 28-29 May 2020.
19. Pavlik, J. (2000). *The Impact of Technology on Journalism*. *Journalism Studies* (1) 2: 229–237.
20. Parry, R. (2011). *The Ascent of Media: From Gilgamesh to Google via Gutenberg*. London, Boston: Nicholas Brealey Pub.
21. Pavlik, J. (2013). *Innovation and the Future of Journalism*. *Digital Journalism* (1) 2: 181–193.
22. Hepp, A. & Loosen, W. (2018). *Makers of future journalism? The role of pioneer journalists and pioneer communities in transforming journalism*. Working Paper Series "Communicative Figurations Working Papers" No.19
23. Benson, R. (2008). *Journalism: Normative Theories*. In The International Encyclopedia of Communication, W. Donsbach (Ed.)
24. Coleman, s. (2014). *Journalism and the Public-Service Model: In Search of an Ideal*. In The Oxford Handbook of Political Communication. Eds Kate Kenski and Kathleen Hall Jamieson. DOI: 10.1093/oxfordhb/9780199793471.013.76
25. Society of Professional Journalists. (2014). *Code of Ethics*.
26. National Union of Journalists (NUJ). (2018). *Code of Conduct*.
27. Independent Press Standards Organisation (IPSO). (2021). *Editors' Code of Practice*.
28. Hanna, M. & Dodd, M. (2020). *McNae's Essential Law for Journalists*. 25th Ed. Oxford University Press.
29. Peters, C. & Broersma, M. (2017). *Rethinking Journalism Again*. Oxford: Routledge.
30. Deuze, M. & Witschge, T. (2020). *Beyond Journalism*. Polity Press.
31. European Broadcasting Union (EBU). (2020). *AI and Data Initiative 2020: Embracing Change*. [Members only access].
32. European Broadcasting Union (EBU). (2019). *News Report 2019*. The Next Newsroom: Unlocking the Power of AI for Public Service Journalism.
33. Caswell, D. (2020). *Applied innovation for BBC News*. BBC News Labs blog.
34. Perez, S., & Ha, A. (2020). *Google launches a suite of tech-powered tools for reporters*. *Journalist Studio*.





35. Lindén, C. G. (2017). *Algorithms for journalism: The future of news work*. The Journal of Media Innovations, 4(1), 60-76.
36. Coddington, M. (2015). *Clarifying journalism's quantitative turn: a typology for evaluating data journalism, computational journalism, and computer-assisted reporting*. Digital Journalism 3(3): 331-348.
37. Anderson, C. W. (2012). *Towards a Sociology of Computational and Algorithmic Journalism*. New Media and Society 15 (7): 1005–1021.
38. Cohen, S. Li, C. Yang, J. & Yu, C. (2011). *Computational Journalism: A Call to Arms to Database Researchers*, in CIDR 2011, 5th Biennial Conference on Innovative Data Systems Research, CA.
39. Gray, J. & Bounegru, L. Eds. (2021). *The Data Journalism Handbook 2: Towards a critical Data Practice*. Produced by European Journalism Centre and Google News Initiative.
40. Loosen, W., Reimer, J. & De Silva-Schmidt, F. (2017). *Data-Driven Reporting – an On-Going (R)Evolution?* Hans-Bredow-Institut, Mai 2017. Arbeitspapiere des Hans-Bredow-Instituts, No.41.
41. Broussard M, Diakopoulos N, Guzman AL, Abebe R, Dupagne M, Chuan C-H. (2019). *Artificial Intelligence and Journalism*. Journalism & Mass Communication Quarterly. 96(3): 673-695.
42. Diakopoulos, N. (2020). *Computational News Discovery: Towards Design Considerations for Editorial Orientation Algorithms in Journalism*, *Digital Journalism*, 8:7, 945-967.
43. Reuters. (2017). *Reuters News Tracer: Filtering through the noise of social media*.
44. Oda, S. (2018). *This Media Startup Is Beating the Competition With a Newsroom Run by Robots*. Bloomberg.com.
45. Diakopoulos, N., Naaman M. and Kivran-Swaine, F. (2010). *Diamonds in the rough: Social media visual analytics for journalistic inquiry*, in *Visual Analytics Science and Technology (VAST), IEEE Symposium*.
46. Diakopoulos, N. & Shamma, D. A. (2010). *Characterizing debate performance via aggregated twitter sentiment*, in *SIGCHI, 2010*.
47. Zirulnick, A. (2020). *How KPCC answered 4,000+ community questions about coronavirus*. membershipguide.org
48. Molyneux, L. & McGregor, S. C. (2021). *Legitimizing a platform: evidence of journalists' role in transferring authority to Twitter*, *Information, Communication & Society*.
49. BBC News Labs. (n.d.). *GoURMET - Global Under-Resourced MEdia Translation*.
50. M. Brehmer, S. Ingram, J. Stray & T. Munzner. (2014). *Overview: The design, adoption, and analysis of a visual document mining tool for investigative journalists*, *IEEE Trans. Vis. Comput. Graphics*, vol. 20, no. 12, pp. 2271-2280, 2014.
51. Lindén, C. G. & Tuulonen, H. (2019). *News Automation: The rewards, risks and realities of 'machine journalism'*. WAN-IFRA Report.
52. Dörr, K. N. (2016). *Mapping the field of Algorithmic Journalism*. Digital Journalism, 4(6), 700-722.
53. Ponsford, D. (2017). *First robot-written stories from Press Association make it into print in 'world-first' for journalism industry*. Press Gazette.
54. BBC News Labs (2019). *Salco - Semi-Automated Local Content: Semi-automated local stories about election results, NHS performance and more*. BBC News Labs blog.
55. Caswell, D. Russell, F. and Adair B. (2015). *Editorial Aspects of Reporting into Structured Narratives*. Computation+Journalism Symposium.
56. Caswell, D. & Dörr, K. (2019). *Automating Complex News Stories by Capturing News Events as Data*, *Journalism Practice*, 13:8, 951-955.
57. Jones, R. & Jones, B. (2019). *Atomising the News: The (In)Flexibility of Structured Journalism*, *Digital Journalism*, 7:8, 1157-1179.
58. Thomas, G. (2021). *Delivering the future of interactive and personalised media at scale with partners*. BBC R&D Blog
59. Willens, M. (2019). *Forbes is building more AI tools for its reporters*. Digiday.
60. Bhatia, G. (2015). *How newsrooms are using machine learning to make journalists lives easier*. Poynter.org.
61. Diakopoulos, N. Choudhury, M. D. & Naaman, M. (2012). *Finding and assessing social media information sources in the context of journalism*, in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 2012*.
62. Fang, R et al. (2016). *Witness Identification in Twitter*. Proceedings of The Fourth International Workshop on Natural Language Processing for Social Media. 65-73.
63. InVid. (n.d.) InVID verification plugin
64. FullFact. (2020). *How we're using AI to scale up global fact checking*.
65. Graves, L. (2018). *Understanding the Promise and Limits of Automated Fact-Checking*. Reuters Institute for the Study of Journalism.
66. BBC News Labs. (n.d.) *ALTO - a multilingual journalism tool*.
67. JournalismAi Collab. (2021). *Connecting users to quality journalism with AI-powered summaries*.
68. BBC News Labs. (n.d.) Modus: Semi-automatically creating new story modes.



69. Diakopoulos, N. (2020). *The Ethics of Predictive Journalism*. Columbia Journalism Review.
70. Pentzold, C., & Fechner, D. (2020). *Data journalism's many futures: Diagrammatic displays and prospective probabilities in data-driven news predictions*. *Convergence*, 26(4):732-750.
71. Stray, J. (2020). *How News Organizations Use Algorithms to Decide What to Show You*. Partnership on AI, Medium.
72. Bandy, J. & Diakopoulos, N. (2020). *Auditing News Curation Systems: A Case Study Examining Algorithmic and Editorial Logic in Apple News*. Proceedings of the Fourteenth International AAAI Conference on Web and Social Media (ICWSM 2020).
73. Tandoc, E. C., & Maitra, J. (2017). *News Organizations' use of Native Videos on Facebook: Tweaking the Journalistic Field one Algorithm Change at a Time*. *New Media & Society* 20 (5):1679–1696.
74. Fletcher, R. & Nielsen, R. K. (2019). *Generalised scepticism: how people navigate news on social media*, *Information, Communication & Society*, 22:12, 1751-1769
75. Guzman & Lewis. (2020). *Artificial intelligence and communication: A Human–Machine Communication research agenda*. *New media & society*. Vol. 22(1) 70–86.
76. Newman, N. (2018) *The Future of Voice and the Implications for News*. *Reuters Institute for the Study of Journalism*.
77. Bevir, G. (2019). *BBC to commercialise new voice assistant Beeb*. IBC365.
78. Baraniuk, C. (2018). *China's Xinhua agency unveils AI news presenter*. BBC News.
79. Waddell, K. (2017). *A Bot That Identifies 'Toxic' Comments Online*. The Atlantic.
80. Cambridge Consultants. (2019). *Use of AI in Online Content Moderation*. A report for Ofcom.
81. Cherubini, F. & Nielsen, R. K. (2016). *Editorial Analytics: How News Media are Developing and Using Audience Data and Metrics*.
82. Christin, A. (2020). *Metrics at Work: Journalism and the Contested Meaning of Algorithms*. Princeton UP.
83. Jääskeläinen, A. (2020). *Predicting the success of news content: An algorithmic experiment in the real world*. LSE, Polis Blog.
84. Tandoc, EC. & Thomas, RJ. (2015). *The ethics of web analytics*. Implications of using audience metrics in news construction. *Digital Journalism*, 3(2), 243–258.
85. Mishra, M. (2019). *The Role of AI In the Future of Content Management Systems*. Forbes.com
86. Ables, K. (2018). *What happens when China's state-run media embraces AI?* Columbia journalism Review.
87. Wang, S. (2018). *After years of testing, The Wall Street Journal has built a paywall that bends to the individual reader*. Nieman Lab.
88. Peretti, M. (2020) *Using AI to address bias in the newsroom*. LSE, POLIS blog.
89. Peretti, M. (2021). *How AI is becoming an integral part of the news-making process*. LSE, POLIS blog.
90. Financial Times Labs (2017). *JanetBot: Analysing gender diversity on the FT homepage*.
91. Van Dalen, A. (2012). *The Algorithms Behind the Headlines*, *Journalism Practice*, 6:5-6, 648-658.
92. Marconi, F. & Siegman, A. (2017). *The Future of Augmented Journalism: A guide for newsrooms in the age of smart machines*. Associated Press.
93. Tobitt, C. (2020). *27 jobs lost at PA as Microsoft cancels contract to use AI instead*. Press Gazette.
94. Beckett, C. (2020). *Sub-editing the machine: the new role for journalists in the age of AI*.
95. Caswell, D. (2019). *Editorial innovation in news*. BBC News Labs blog.
96. Manyika, J. Chui, M. Miremadi, M. Bughin, J. George, K. Willmott, P. & Dewhurst, M. (2017). *Harnessing automation for a future that works*. Report.
97. Ivancsics, B. & Hansen, M. (2019). *Actually, it's about Ethics, AI, and Journalism: Reporting on and with Computation and Data*. Columbia Journalism Review.
98. Stray, J. (2020). *To apply AI for good, think form extraction*.
99. Dörr, K. N., & Hollnbuchner, K. (2017). *Ethical Challenges of Algorithmic Journalism*. *Digital Journalism*, 5(4), 404-419.
100. Hansen, M., Roca-Sales, M., Keegan, J M. & King, G. (2017). *Artificial Intelligence: Practice and Implications for Journalism*. Tow Center for Digital Journalism, Columbia University.
101. Nielsen, R.K. (2016). *The many crises of Western journalism: A comparative analysis of economic crises, professional crises, and crises of confidence*. In *The Crisis of Journalism Reconsidered: Democratic Culture, Professional Codes, Digital Future*, J. C. Alexander, E. B. Breese, and M. Luengo (Eds.) Cambridge University Press, 77–97.
102. Liu, C. (2006). *De-skilling Effects on Journalists: ICTs and the labour process of Taiwanese newspaper reporters*, *Canadian Journal of Communication* 31: 695-714.
103. Avilés, J., Garcíá, A., León, B., Sanders, K and Harrison, J. (2004). *Journalists at Digital Television Newsrooms in Britain and Spain: workflow and multiskilling in a competitive environment*, *Journalism Studies* 5(1): 87-100.
104. Wölker A, Powell TE. (2021). *Algorithms in the newsroom?* News readers' perceived



- credibility and selection of automated journalism. *Journalism*. 22(1): 86-103.
105. Graefe, A., Haim, M., Haarmann, B., & Brosius, H. B. (2016). *Readers' Perception of Computer-generated News: Credibility, Expertise, and Readability*. *Journalism*.
106. Jung, J., Song, H., Kim, Y., Im, H., & Oh, S. (2017). *Intrusion of software robots into journalism: The public's and journalists' perceptions of news written by algorithms and human journalists*. *Computers in human behavior*, 71, 291–298.
107. Clerwall, C. (2014). *Enter the robot journalist*. *Journalism Practice* 8(5): 519–531.
108. Turow, J. (2020). *Journalism and the Voice Intelligence Industry, Digital Journalism*.
109. Balkin, J. M. (2018). *Free Speech in the Algorithmic Society: Big Data, Private Governance, and New School Speech Regulation*. *UC Davis Law Review* 51:1149–1210.
110. Just N, Latzer M. (2017). *Governance by algorithms: reality construction by algorithmic selection on the Internet*. *Media, Culture & Society*. 39(2):238-258.
111. Gillespie T (2014). *The relevance of algorithms*. In: Gillespie T, Boczkowski P and Foot K (eds) *Media Technologies*. Cambridge, MA: MIT Press, pp. 167–194.
112. Sørensen, J K. (2019). *Public Service Media, Diversity and Algorithmic Recommendation: Tensions between Editorial Principles and Algorithms in European PSM Organizations*. INRA 2019, September 16–20, 2019, Copenhagen, Denmark.
113. Pariser, Eli. (2011). *The Filter Bubble: What the Internet is Hiding from You*. New York: Penguin.
114. Sunstein, Cass. (2001). *Republic.Com*. Princeton, NJ: Princeton University Press.
115. Diakopoulos, N. & Koliska, M. (2016): *Algorithmic Transparency in the News Media*, *Digital Journalism*, 5:7, 809-828.
116. Carlson, M. (2015). *The Robotic Reporter*. *Automated Journalism and the Redefinition of Labor, Compositional Forms, and Journalistic Authority*. *Digital Journalism* 3 (3): 416–431.
117. Monti, M. (2019). *Automated Journalism and Freedom of Information: Ethical and Juridical Problems Related to AI in the Press Field*. *Opinio Juris in Comparatione*.
118. Weeks, L. (2014). *Media Law and Copyright Implications of Automated Journalism, in N.Y.U. J. Intell. Prop. & Ent. L.*, 4, 81.
119. Lewis, S. C. Sanders, A. K., & Carmody, C. (2018). *Libel by Algorithm? Automated Journalism and the Threat of Legal Liability*, in *Journalism & Mass Communication Quarterly*, 2018.
120. Stray, Jonathan. 2020. *Aligning AI to Human Values means Picking the Right Metrics*. Medium.
121. Strubell, E., Ganesh, G., & McCallum, A. (2019). *Energy and policy considerations for deep learning in NLP*. In *ACL*, 2019.
122. Schwartz, R., Dodge, J., Smith, N. A., Etzioni, O. (2019). *Green AI*. ArXiv.
123. Abernathy, P. M. (2020). *News Deserts and Ghost Newspapers: Will local news survive?* Report.
124. Fjeld, J, Achten, N., Hilligoss, H. Nagy, A. and. Srikumar, M. (2020). *Principled Artificial Intelligence: Mapping*. Consensus in Ethical and Rights-Based Approaches to Principles for AI. Berkman Klein Center for Internet & Society, Research Publication No. 2020-1.
125. Jobin, A., Ienca, M. & Vayena, E. (2019). *The global landscape of AI ethics guidelines*. *Nature Machine Intelligence*, vol 1, 389-399.
126. Leslie, D. (2019). *Understanding artificial intelligence ethics and safety: A guide for the responsible design and implementation of AI systems in the public sector*. The Alan Turing Institute.
127. Committee on Standards in Public Life. (2020). *Artificial Intelligence and Public Standards*.
128. Straub, G. (2019). *Scaling responsible machine learning at the BBC*. BBC blog.
129. Mittelstadt, B. (2019). *Principles alone cannot guarantee ethical AI*. *Nat Mach Intell* 1, 501–507.
130. Select Committee on Artificial Intelligence. (2017). *UK House of Lords Select Committee on Artificial Intelligence*. 2017. AI in the UK: ready, willing and able?
131. Diakopoulos, N. (2016). *Accountability in algorithmic decision making*. *Communications of the ACM* 59(2):56–62.
132. Renner, N. (2017). *As AI enters newsrooms, journalists have urgent responsibility*. *Columbia Journalism Review*.
133. Pasquale, F. (2015.) *The Black Box Society: The Secret Algorithms That Control Money and Information*. Cambridge, MA: Harvard University Press.
134. Ananny, M., and Crawford, K. (2018). *Seeing without knowing: Limitations of the transparency ideal and its application to algorithmic accountability*. *New Media & Society*. 20, 3 (2018), 973–989.
135. Myles, S. (2018). *How Can We Make Algorithmic News More Transparent?* Associated Press. Presentation at the conference Algorithms, Automation and News, Munich, 22nd May 2018.