A PORTRAIT OF ARTIFICIAL INTELLIGENCE (AI):

A TREND ANALYSIS OF THE VISUAL REPRESENTATION OF AI IN MEDIA

by

Nicole Hack

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Abstract

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Master of Digital Media, 2020

Nicole Hack

Digital Media

Ryerson University

What does artificial intelligence (AI) look like? A robot with red eyes, a white, plastic line worker, a cybernetic brain, a line of code? Or does it manifest through social and cultural occurrences that illustrate the complex relationships people have to emerging technologies? This article identifies themes in how AI is represented and visualized in news, and participatory media. The study uses science communication theory as well as case studies that identify visual communication as paramount in establishing inclusivity, collaboration, and education for socially driven technology. With visual media as the focus, this study analyzed two hundred media articles over a ten-year period from publications varying in size, nature, and geography. The goal of this study was to identify whether there existed a disconnect in AI literacy between text-based information and visual media that is designed for non-expert audiences. More so, how visual form is assigned to AI as an intangible, and highly representative concept and technology. The results contribute to a larger discourse on how AI is portrayed in, and by science fiction narratives. Lastly, this study adds a modern perspective to science communication research by considering participatory media, economies of attention, and emerging technologies as nuanced factors driving AI discourse, and thus its direction.

Key words:

Artificial Intelligence | Visual Literacy | AI Literacy | News Media | Visual Media | Visual Culture | Science Fiction

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1. Introduction

What does artificial intelligence (AI) look like? A robot with red eyes, a white, plastic line worker, a cybernetic brain, a line of code? Or does it manifest through social and cultural occurrences that illustrate the complex relationships people have to emerging technologies? This line of questioning is not unique to AI. Many communicators in a wide variety of science, technology, engineering and math (STEM) fields have found the visualization of concepts and ideas within their domains to be a subject of fascination, study and debate. The visual rhetoric of sciences often impacts the long-term direction or continuation of innovation, as non-specialist stakeholders such as investors, public figures and policymakers resort to these representations in making decisions about future research and development. As AI becomes increasingly inseparable from our tangible and digital lives, it is of tantamount importance that its further development is informed by a collective audience who hold holistic understandings of what is encapsulated by the term AI aided by effective visually based communication. Furthermore, the generation of forward-thinking and effective design, regulation and application must include a greater degree of diverse perspectives at all levels. The visual communication of concepts and ideas in STEM is an often well-researched and proven mechanism for productive advocacy – both for the support and rejection of innovations.

To illustrate key role of visual communication in STEM by way of an analogous example, studying the discourse on climate change identified visual communication as an important strategy in contextualizing the phenomenon as a real and critical issue requiring action (Bolsen, Palm & Kingsland, 2019; The Royal Society, 2018; Hart & Feldman, 2016; O'Neil & Smith, 2013; Shaw, Sheppard, Burch, Flanders, Wiek, Carmichael & Cohen, 2009). Strategic visual communication led to increased engagement with, and by, public audiences and influenced the actions of institutions, policy designers and local communities (Bolsen, Palm & Kingsland, 2019; Hart & Feldman, 2016; O'Neil & Smith, 2013; Shaw et al., 2009): see Figure 1 as an example. To achieve the opposite in another example, lobbyists and non-profit groups campaigned using images depicting *evil corporations* and similar extremist visualizations to enforce a mass rejection of genetically modified organisms (GMOs) (Clancy & Clancy, 2016). These images were often inaccurate, sensationalized and they appealed to fear rather than science-based evidence (see Figure 2) (Clancy & Clancy, 2016; Rodriguez & Asoro, 2012).

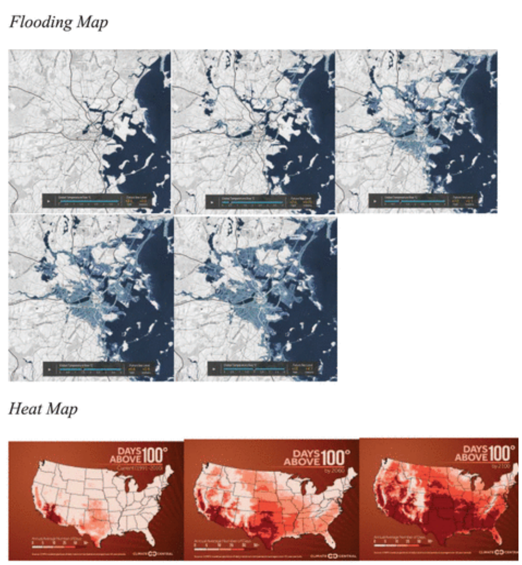


Figure 1. Images showing visual evidence of climate change occuring. Source: Bolsen, Palm & Kingsland (2019).

Figure 2. Image from anti-GMO campaign. Source: Reason.com/ Ronald Bailey. Credit: Unknown.

Similar to the above cases, images of space were proven to inform a general knowledge of astronomy using both technical and emotional appeals - often engaging non-technical viewers with entrancing renderings of a constellation that then directed attention to critical thought about the subject of the image itself (Smith, Smith, Arcand, Smith, Bookbinder & Keach, 2011). Another example in STEM was the portrayal of nuclear power in mass media, where images proved to significantly impact negative perceptions of the resource. Visual communications also helped ease, if not eliminate, long standing anxieties surrounding atomic warfare and disasters with imagery of advancement, control and eco-friendly energy (Lee & Ho, 2018; The Royal Society, 2018). In the case of nanotechnology, multiple strategies used creative and scientific visualizations to confer legitimacy on the field. Early in its development, imaginative, "visionary images" were deployed to showcase the potential the field could offer (Lösch, 2006). According to Graves (2014) more literal visualizations were also used to "argue for the validity of...knowledge claims". Visual communication held the power to influence public perceptions of nanotechnology, and as seen in other examples, instilled a scientific narrative that encouraged positive engagement and consequential advancement (Lee & Ho, 2018; The Royal Society, 2018; Lösch, 2006).

Although there is evidence that visual communication is a critical technique for discourse in STEM fields, there is a lack of substantial support for further study. Primary reservations preventing greater engagement with visual communication studies include: inconsistent definitions and theoretical frameworks within fields of emerging technologies, the complexity of framing and categorizing visual information, and the inherently subjective nature of images such that their meaning is shaped by social conventions and not defined rules (Sun, Zhai, Shen & Chen, 2020; Lee & Ho, 2018; Borah, 2017; Hart & Feldman, 2016; O'Neil & Smith, 2013; Trumbo 1999: 2000). In other words, the visual communication of STEM concepts is complicated and dynamic.

With this in mind, the question '*what does AI look like?*' is difficult to confidently answer as AI has no single commonly agreed upon definition, it has no inherent physical form, it is rapidly evolving through commercialized innovations and privatized research, and is often seen as controversial and met with polarized opinions. Adding to this difficulty is the lack of studies similar to those listed above that are dedicated to AI and its unique circumstances, such as ongoing relations to cultural imaginaries about humans-as-gods, and super intelligent robots.

As such, the topic requires a dedicated lens to supplement existing findings that are generally limited, and narrowly focused on longer-standing discussions focused on text-based analyses and examinations of AI fictions. As is the case in many STEM fields, public perception around AI is commonly gauged by assessing textual discourse in online platforms such as social media and digitally accessible news. Due to this there is a relatively comprehensive set of findings evidencing attitudinal trends in AI text-based discourse, which is largely dominated by groups in support of, and influential in the development of AI (Sun et al., 2020). However, research around the visual communication of AI, whether a primary topic or an afterthought, generally focused on AI narratives - stories where AI held an integral role in the plot of fiction, TV, movies and art. Through them the past/future of, and discourse around AI was shaped, or steered by themes present in the stories and characters within.

This study took inspiration from parallel research methods of visual communication in other STEM fields, as well as projects and workshops that called for greater attention to the visual communication of AI in particular. As limited research was done in this niche area, this study sought to generate data that could be extrapolated to better understand trends in how communicators visually represented AI in publicly accessible media. Furthermore, if visualizations and visual communication strategies of climate change, GMOs, nuclear power and nanotechnology could be used to influence public perception and behaviour, how could the same be applied to AI to help ensure increased participation from otherwise disconnected audiences and ensure directions for effective, universally beneficial innovations? More so, how can productive discussions manifest through visual media and build visual narratives on the critical issues and shortcomings in current applications of AI?

2. Review of Existing Literature

This literature review draws on existing research and STEM-based case studies relating to a variety of specializations as well as to AI specifically. These resources illustrate foundations for science and visual communication and the importance of framing visual discourse around emerging technologies. As a highly abstract concept and technology, AI requires partnership with something else to explain *it* within both expert and non-expert communities. The ambiguity, and lack of consensus of its definition and form allows for a wide array of interpretation in how to communicate what AI is, what AI can do, and what AI is currently doing. Unlike other cases where sciences faced public scrutiny, AI lacks physical evidence and instead manifests through culturally and socially subjective visualizations which challenge leading strategies for science communication. This review also aims to identify themes, differences and gaps in existing research where information sharing with, and education of, diverse audiences is of particular importance. It examines the current research landscape around public perception of artificial intelligence, as well as case studies where public opinion impacted the developments in STEM fields. Lastly, the review demonstrates the importance of visual literacy amongst professional communicators and more audiences generally.

2.1 Beyond the Deficit Model

The use of visual aids in media discourse and, in particular, visual representations of artificial intelligence (AI) are critical to explore in science communication research. It is a topic lacking a focused and modern research lens; however, it compliments a wide array of existing studies. AI presents a unique challenge in science communication as it is highly abstract in nature, and lacks a universal identity or definition, even amongst specialists. Visualizing AI is thus an exceptional task requiring speculative imagination and creativity to empower engagement with visual information. Gaining a greater understanding of communication trends in AI discourse can help developers, professional communicators, and non-technical audiences engage more effectively in critical thinking. Bridging the disconnect between these groups may benefit research in AI by fostering a conversation around productive, ethical and inclusive design, and encouraging diverse and informed interest in AI development, use, and policy building.

Before exploring research around visual media and AI, it is important to assess the foundational landscape of science communication, in particular the deficit model. This section seeks to frame historical attitudes in science communication and specify perspectives that lead popular thought.

According to the *deficit model* of science communication, there are two main components. First, it assumes that stagnancy in STEM innovation is linked to knowledge gaps in the general public who have the power to accept or reject advancements. Secondly, that public ignorance is fixable by filling knowledge gaps, and therefore progress can happen when the public *gets it*. Cortassa (2016) calls this approach the "therapeutic view" where a problem is detected, those affected undergo a therapy of some kind, which in this case is often traditional education in schools, and only then can these more informed contributors "reasonably" participate in science. This view of science communication is connected to, and is likely in response to, the related framework of scientism where it is assumed that "science is objective enough to guide policy because of its ability to transcend context-bound human values and particularized interests" (Clancy & Clancy, 2016).

The deficit model remains the prevailing structure through which science communities engage the public (Simis, Madden, Cacciatore, & Yeo, 2016; Cortassa, 2016). Despite its prevalence and continued use in practice, communication theorists generally disagree with the deficit model for a variety of reasons. Simis et al. (2016) argue that the deficit model segregates participation into two groups: experts with a perceived superiority and negative outlook on *the public*, and *others* who are seen as unnecessary-until-educated, or of lesser contributional value. While the deficit model serves as an organized strategy for communication, it is inadequate, especially for highly controversial topics such as AI, for a critical reason: people are not reasonable, and knowledge of sciences does not necessarily make them so (Garvey & Maskal, 2020; Simis, et al., 2016; Kahan, Peters, Wittlin, Slovic, Ouellette, Braman, & Mandel, 2012; Trumbo, 2000). Simis, et al. (2016) believe that STEM training - being the scientific method or process - struggles to function for interdisciplinary communication where subjectivities intersect, and irrational information processing occurs. Along with this conditioning, communication studies are not required in many STEM programs, or are included but fail to emphasize the importance of ongoing communication with the public (Simis et al., 2016; Rodríguez Estrada & Davis, 2015; Trumbo, 2000). Kahan et al., (2012) also conclude that integrating scientific process methodologies with communications is more likely to agitate the defence of subjective worldviews, proving, "...how remarkably well-equipped ordinary individuals are to discern which stances towards scientific information secure their personal interests". Cultural subjectivity, and the irrational interpolation of knowledge alongside worldviews points again to the need for more research on visualizations in media, and how they interact with the communication of AI to dynamic audiences.

The binary nature of the model is also problematic when one considers emerging participatory media platforms that support diversified communicators and audiences who promote information and stances on STEM topics. For example, Luzón (2013) discusses science bloggers, who are referred to as "civic scientists", and who have varying levels of education or authority on a topic and generally strive to reach non-technical audiences. Civic scientists use an array of communication strategies that go beyond trying to improve knowledge, as the deficit model seeks to do, and attempt to frame knowledge within relevant audience context and social occurrences (Rigutto, 2017; Luzón, 2013). Participatory media has allowed anyone to contribute to the visualization of science largely because of technology that is capable of designing visualizations of "...complex scientific concepts at a high level of detail" (Rigutto, 2017). Similarly, Rodríguez Estrada & Davis (2015) highlight the increased need for user-centric design work in science communication, which prioritizes the subjective needs of dynamic audiences, over the communicator's wish to operationalize knowledge amongst the public. On top of this, Kahan et al. (2012) note the particular importance of including "culturally diverse communicators" who can empathize with cultural groups who may hold unique relationships to technology, or to the practitioners themselves.

Considering AI specifically, the lack of wide-spread diversity presents another way the deficit model is inept as a communication strategy for AI. According to West, Whittaker & Crawford (2019), AI research and development has shifted from the academic to the private sector which overwhelmingly lacks gender and racial diversity at many levels. As well, information about AI in the news is increasingly sourced from industry reports and company publications which may lack objectivity and perspectives from these disproportionately absent minorities (West, 2019; Ashwell, 2016). Zhang & Dafoe (2019) conducted a sentiment analysis of perceptions of AI with a particular focus on the demographics of participants. Their findings showed that most participants were supportive of AI, however that those with higher levels of education, education in STEM, men, and those with incomes of $100,000/per year or higher disproportionately made up this group of supporters (Zhang & Dafoe, 2019). The demographic commonalities within the private sector, and in ratios of public support for AI suggests that the polarizing consequences of the deficit model are likely prevalent in AI communication as well.[1] For example, *otherness* may manifest when certain applications of AI are hailed as more important by affluent groups in positions inaccessible to or unpopulated by minority groups. Political clustering also leads to the prioritization and protection of worldviews over scientific reasoning, which discourages social deviance and dialogue (Kahan et al., 2012), and, for AI, is arguably a cause of perpetuated biases.

With this said, trends suggest that practitioners are moving away from the deficit model, favouring instead collaboration and participation with the public (Rodríguez Estrada & Davis, 2015; Kahan et al., 2012; Stocklmayer, 2007). Stocklmayer (2007) recommends experiential learning be integrated into STEM programs to teach communication skills and to better understand "...the public and its relationship to science". For AI this may mean, for example, the elimination of harmful biases against non-male and non-Caucasian persons in impactful products am AI-driven services. The general lack of diversity in AI development, and thus AI communication and participation requires greater exploration. More so, there must be greater consideration of the visual communication of AI, and its deployment in the media to understand how, or if these demographic trends are reflected in visually rich information that is accessed by non-technical audiences.

[1] According to Sun et al., (2020) AI discourse in newspapers (text-based) neglected to include voices from "ordinary citizens, leaving the task of framing to industry, and political stakeholders.

2.2 Visual Science Communication

This section explores some leading frameworks in science communication that identify the roles and abilities of participating groups, and the relevance of visual communication theories specifically.

While science communication is an ongoing and growing field of study, visual communication in STEM remains an especially niche focus. While it is niche, many theorists have noted its importance and the close relationship it has to public perceptions of science (Bolsen, Palm & Kingsland, 2019; The Royal Society, 2018; Hart & Feldman, 2016; O'Neil & Smith, 2013; Trumbo 1999: 2000). Historically, visual aids have been produced and used by STEM practitioners for a variety of reasons, be it to explore conceptual ideas, or to communicate them to a variety of audiences. This inside-to-out perspective neglects to include the social relationships audiences have to STEM fields and more so the roles those relationships play in communicating meaning and information. A study was conducted by Bucchi & Saracino (2016) that confirmed a disconnect between participants' ability to identify famous figures in STEM using text and using visual aids such as portraits of scientists, images of space, or diagrams of atoms. Their findings showed that younger participants with higher levels of education were more successful in identifying these figures with text-based prompts, but that participants over 60 with lower levels of education were less successful with the same task. However, the visual aid prompts resulted in a high rate of success across all participant groups regardless of age or education. The significance of these conclusions was that although text-based communications follow explicit grammatical rules - however still subject to interpretation - images are more inclusive and effective for engaging universal audiences.

There are many theories that frame the process of science communication through visual communication, or that are fundamental to it. For example, Luzón (2013) highlights Cloître & Shinn (1985) and Hilgartner's (1990) continuity model where communication has 4 levels: intraspecialist (expert), interspecialist (expert community), pedagogic (education), and popular (mass media). This process is linear and lends a lot of authority to experts and expert communities to deploy "simplifications" or "distortions" which may disproportionately benefit different groups (Hilgartner, 1990). Hilgartner's (1990) notion of "appropriate simplification" and "distortion" is exceptionally relevant to the visual communication of science. Specifically, he notes the impossible nature of identifying where distortions happen and that "the boundary between genuine and popularized knowledge is ambiguous, flexible, and dependent on the context" (Hilgartner, 1990). To this point, more research is needed on how visual media in STEM communication is distributed, edited, stored and recontextualized amongst participatory platforms, especially where accessible editing tools (ie., photoshop) and low consideration for citation practices seem to impact the visuals used, or how they are distorted.

Trumbo (1999) argues that more attention should be paid to this field of study in both academic and industrial communities. Trumbo's (1999) framework of 'visual literacy' is organized into three components: visual thinking, visual learning, and visual communication. Visual thinking refers to the creative process often used by scientists to explore ideas in conceptual stages of research. The results of this process, for example, are the visualizations of the molecule, the atom, and DNA's double-helix (Trumbo, 1999). An important consideration is that the process of visual thinking is often cerebral and subjective, which for the purposes of mass communication may end up being "loose" or "underdeveloped" (Trumbo, 1999). As Hilgartner (1990) notes about the popularization of science knowledge, visual aids are also vulnerable to processes of oversimplification, distortion or decontextualization.

The second component of Trumbo's (1999) framework is visual learning, which refers to the process of learning design theory to create or learning from a visual aid. Some theorists, such as Rodríguez Estrada & Davis (2015), Tufte (2001) and Frankel & Depace (2012), saw it necessary to create guidelines for STEM practitioners to effectively use visual aids when communicating their work. While there are resources that cater to qualitative information, the majority focus on visualizing quantitative information. This specialization on quantitative information, such as graphs and charts, becomes problematic when science or technology lacks a worldly form and visualization technology requires subjective input (Trumbo, 2000). This unique circumstance is true for AI. Unlike tangible fields in STEM, such as biology or computer engineering, AI, even as a term, is representative of a concept - human intelligence - and not a thing. As it is intangible, AI's visual identity becomes parasitic by taking the form of a host such as a robot, a self-driving car, or other visualizations subjected to visual thinking. Another level of consideration in regard to AI is that chosen visualizations often parallel social contexts and subjects consequential to the use of the technology and not just AI as an independent device. With this said, both 'hard' and 'soft' visuals are inevitably distilled through a creative process, and are especially prone to manipulation when they reach popularity; thus it is of tantamount importance to expand scopes of STEM communication research (Mehta & Guzmán, 2018; Trumbo, 1999: 2000; Hilgartner, 1990; Cloître & Shinn, 1985).

The last component of Trumbo's (1999) visual literacy framework is visual communication. It refers to the visual media a scientist, science communicator or non-expert may use to share information and knowledge. Trumbo (1999) notes that visuals, like text-based language, belong to cultural histories with "encoded" assumptions and connections, but lack the same rule structure as verbal communication. In the case of AI, this is especially important to consider because all representations of it are constructed, not recontextualized as one may see with an enlargement of a plant cell or virus. Visual media is also often complementary to textual information and lacks due consideration in education and academic research despite being a critical and valuable resource in communicating STEM research and innovations (Lee & Ho, 2018, Hart & Feldman, 2016; Rodríguez Estrada & Davis, 2015; Trumbo, 1999). As evidence of this gap, *framing*, a concept discussed by Druckman (2001: 2015) and Lee & Ho (2018), concerns the perspective communications take on as a result of a communicator's choice and identification of what was most important. For example, AI might be framed as *job automation* or as *job enhancement*, as well as *discriminatory* or as *unbiased* - in both cases the prior suggests good, and the latter, bad. This is not to say that either perspective is inherently correct, but that the choice of framing can impact perceptions of the topic in question. The communication of nuclear power is an example where negative framing was based on a single anomalous catastrophe, yet it held heavy influence when exploring its eco-friendly potential (Vossen, 2020). The study of framing is often linked exclusively to textual information and through perspectives of reoccurring stakeholders which Sun et al., (2020) and Lee & Ho (2018), for example, identified as being a shortcoming in STEM communication. Lee & Ho (2018) connected the theory of framing to image analyses to better understand photographic-textual relationships and how visual media in particular influenced public perceptions held in valence news frames.[2] Their conclusion, and that of many other researchers, was that across both textual and visual communication in STEM, fundamental challenges arise as a result of inconsistent definitions surrounding the subjects themselves and

[2] *Valence news frames* is a term appropriated from Schuck & de Vresse (2006) that is used to describe binary and polarized subjects often seen in STEM fields

unclear theoretical structures. Varying perspectives must be investigated in greater detail independently, as well as in tandem with verbal content to account for increased complexity in how information is consumed, distributed, and framed.

With this in mind, it is also important to expand the field of visual communication to consider functionalities of modern media platforms, new technologies, and evolved audience behaviours. For example, the attention economy refers to the phenomenon where information competes for the attention of bemused, and overwhelmed audiences (Franck, 2019; Lee & Ho, 2018). Due to this phenomenon, Rigutto (2017) asserted that importance should be placed on an image's attractiveness and ability to captivate to increase the likelihood of receiving attention, although Lee & Ho (2018) note that alough images may often be "attention grabbing [in] nature", they are unlikely to influence "biases in cognitive processing and decision making". Click-bait media, for example, intentionally uses provocative and often dishonest text and media to draw attention to itself, and thus regularly leads to sensationalization, "fakes", and misinformation because citations are lost, and images are manipulated and taken out of their original context (Rigutto, 2017). Communication fields have also had to adapt to participatory media becoming more compact and rapid and keep up with content demands and attention (Franck, 2019).

2.3 Artificial Intelligence in the Media

Cercone & McCalla (1984) studied news hype around the inevitable future of AI in our society almost forty years ago. Now, there is another surge in news coverage of AI as innovations and new applications emerge that have the potential to radically affect our society. Some of these innovations have already been applied in critical areas such as healthcare and security globally.

Many researchers, for example Chuan, Tsai & Cho (2019), have acknowledged the clear connection between public perception, media influence, and policy development in shaping understandings of AI. Given this situation, many content analyses mapping attitudes in the media have been generated in recent years.

One such study was conducted by Garvey & Maskal (2020), who did a sentiment analysis of over three thousand news articles with AI-focused topics using a Google analytic tool. The analysis showed that the news discourse around AI was generally positive, which contradicted their assumption that attitudes were largely negative. In response, they created the concept called "Terminator Syndrome," which refers to the tendency to unjustifiably conclude that news coverage is biased against AI because of a few sensationalized and negative sources. Due to their extremism they are weighted heavier than the more numerous positive ones. They note that the use of *Terminator* is not just referencing the human-annihilating robots of the movie franchise of the same name, but also refers to how "unchecked beliefs can terminate broad public engagement on AI before they even begin" (Garvey & Maskal, 2020). In relation to the preponderance of positive AI news coverage, another study by Brennen et al., (2018) concludes that the largest influencers of AI news are industry sources (i.e., companies), and recommends that a greater diversity of source material inform journalistic production as long as the "public implications of AI remain unclear"[3]. For example, since industrial leaders in AI generally support self-regulation, despite the general consensus that government intervention is needed, it is important that the media not overly rely on industry sources when covering AI topics (Ouchchy, Coin, & Dubljević, 2020). Recalling the practice of framing used by Druckman (2001: 2015) and Lee & Ho (2018), a possible reason behind the saturation of positive sentiment in the media is the regularity of sourcing information

[3] Note that Garvey & Maskal (2020)'s study is based on American content while Brennan et al., (2018)'s study is based on UK perspectives.

from private sectors. These providers most likely frame information in a positive light so as to encourage support for company visions and objectives.

There is unanimous public concern about work automation that focuses on robotics-based AI (Ouchchy et al., 2020; Zhang & Dafoe, 2019; Chuan et al., 2019; Brennen et al., 2018). The Brookfield Institute for Innovation + Entrepreneurship (BII+E) investigated the Canadian policy perspective of AI in a series of reports, one of which notes that "42 percent of the Canadian labour force is at risk of being affected by automation in the next decade or two" (2016). Other research shows that AI-based automation will likely need government intervention as the steady implementation of systems deepen existing wealth gaps (Dietterich & Horvitz, 2015). The focus on robotics presents an interesting support for Garvey & Maskal's (2020) Terminator Syndrome. Many forms of AI are not connected to robotics, yet the predominant AI concerns addressed in news media around work automation focus on robotics. The reason for this predominance may be two faceted: in response to the looming threat of job losses from automation, it may perhaps be easier for both journalists and their audiences to rely on science fiction tropes and imagery of sentient robots as a way of visualizing who or what is taking away people's jobs. With this in mind, it should be pointed out that the above studies focus on text-based indicators to make these conclusions, and, if at all, only marginally note the importance of visual media in influencing public perception.

2.4 Existing Projects & Current Discussions

There are projects that provide valuable insight and guidance to this research on visualizations of AI that address both the roots of representation, and the functional use of visual aids in science discourse. One is a collaborative workshop between the Leverhulme Centre for the

Future of Intelligence and The Royal Society whose findings are transcribed in a report titled *Perceptions and Portrayals of AI and Why they Matter* (2018). Hosted by the AI Narratives Project, the workshop included 150 specialists from an array of academic fields such as film and anthropology as well as industry professionals. Four workshops were hosted over the period of a year between 2017 and 2018. The first three explored the following themes: identifying prevalent AI narratives, cases of successful science communication strategies, and the relationship between AI narratives and technology development. The final workshop debated the conclusions of the preceding three with an interdisciplinary group of scholars and leaders of industry. The overarching focus of the project was on AI narratives in films, spoken stories, novels, TV shows, and so on, specifically in the UK and Western, or English-speaking societies. The report takes a general stance on AI narratives, and often compounds the analysis of visual narrative with text-based ones. The conclusions of the report heavily inform the design of this trend analysis, specifically, the lack of diversity in representations in AI discourse, and the (in)accuracy of AI functionalities suggested by mainstream visual media.

Another, more functional project that inspired this trend analysis was a collaborative workshop between graphic designers and AI developers organized by an open source graphic organization called the Noun Project and a data company called Essence. The workshop--an *iconathon*--tasked participants to design icons that represent concepts in AI. It took place in 2019 and the end result was a series of free vector graphic icons that are hosted on the Noun Project's website (see figures 3 and 4, below). The graphics represent highly technical concepts such as false positives, unsupervised learning, and natural language processing, in an attempt to normalize a standard for visual communication related to technical AI.

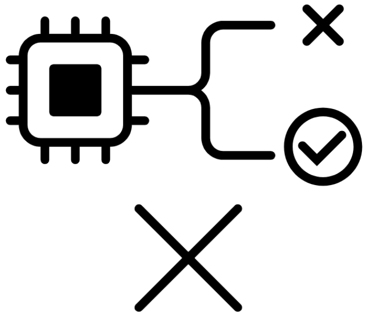


Figure 3. Icon representing a 'false positive' in AI processes. Credit: Essence & the Noun Project. Source: The Noun Project

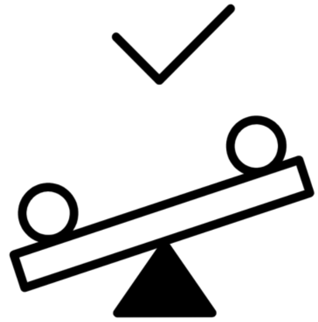


Figure 4. Icon representing 'confirmation bias processes'. Credit: Essence & the Noun Project. Source: The Noun Project

3. Methodology

This study is built on the work of multiple visual and communication theorists. A major contributor to the methodology is The Royal Society's 2018 report on narrative representations of AI mentioned above. This study sourced 200 samples of text-based publications that discussed AI in a variety of contexts. See Table 1 below.

Table 1. Categorization of AI Subjects in Sample Base

Category	Description	Key Words
Media and Creative Industries	• This category refers to articles subjected on AI in the media or in creative fields such as fine art or music production. • Examples include: social media, fine art, music production and advertisement.	• Art • Social media • Creativity • AI narratives
Security, Surveillance and Defense	• This category refers to articles subjected on AI for security, surveillance and defense. • Examples include: militarization, cybersecurity, facial recognition and personal privacy	• Military • Weapons • Cameras • Facial recognition • Cybersecurity
Medicine and Healthcare	• This category refers to articles subjected on AI in medical and healthcare contexts. • Examples include: virology, hospital care, medical records, healthcare innovations and medical procedures	• Hospital • Healthcare • Medicine • Illness • Surgical tool
Human Resources,	• This category refers to articles on the topic of AI industry, including those who work in AI fields, companies	• Designer • Private industry • CEO

Business and Global Affairs	leading AI work, and political influencers. • Examples include: Major AI developers, CEOs, company stakeholders, trade deals and global competition.	• Politician • Nationalism
Society and Culture	• This category refers to articles subjected on AI in social or cultural contexts. • Examples include: projections of AI's impact on society, discussing who benefits from AI, effects of AI on communities and usage of AI narratives.	• Diversity • Communities • Policy • Government • AI narratives
Technology and Innovation	• This category refers to articles on AI innovations and products. • Examples include: releases of new products and new applications and experiments.	• Commercialization • Entrepreneurship • Conference • Presentation • Experiment

The 200 articles were accumulated from a ten year period - 2010 to 2020 - to illustrate the changing trends and evolutions in how AI is visually represented in media. 10 samples each from 20 publications of varying focuses, sizes and participatory natures were used to reflect a diverse range of discourse styles. Data was collected using a Google Form for organizational purposes. The form consisted of a series of prompt questions which sought out the following information.

3.1 About the Publisher, Article, & Author

The identity of the publishing body is an important consideration for this study, specifically, the reputability and type of publication, year of publication and country of origin. The intent of the article itself was also taken into consideration and was categorized as educational, reportative, or opinionated. Considering that diversity is such a critical issue in the study of AI communication, the gender of the author and their job title was also recorded. Note that the gender identifications were based on self-reported identifications. If a male, female, or other gender identification status was unclear, it was noted as N/A.

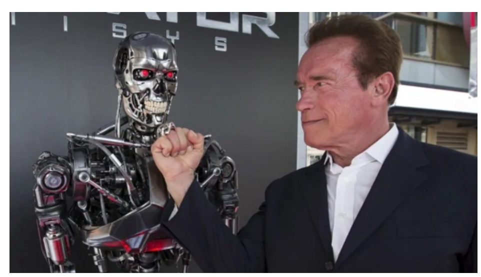
3.2 Gauging Distortions and Credibility

Another observation from the analysis of existing research was the importance of the authorship of visual aids in science communication for determining the credibility of AI-related visualization. Thus, this survey sought out trends relating to the degree to which images and other visual aids in AI news articles were or were not derived from a cited and credible AI source. The other indicator of credibility was the use of informative captioning to contextualize an image. Note that a visual with a caption was only marked as having one if the content was descriptive with rich information about the visual--not just stating a name or a place.

3.3 Content of the Visual Media

This portion of the analysis focuses on disseminating the details in the visual aids. Firstly, the number of visual aids included in the article was recorded, counting every visual directly intended for the article, but not ads or other augmented information. For example, header images and in-text graphics were counted. The media type of the visual aids, referring to the method or tool it was created with, was identified. These types include: photographs, digital illustrations, screenshots, videos, social media posts, charts/graphs/diagrams, infographics, .gifs, logos/icons, scenes from TV shows and films, hand-drawn illustrations, and maps. The description of these categories can be seen in Table 2.

Table 2. Descriptions and Examples of Visual Media Medium Types

Medium	Description	Example
Photograph	• Photographs often captured a real-world occurrence, like a conference or an event, where actual people and robots interacted. • To be coded as a photograph, the foundation or major components of the image had to at least appear to be generated with a camera. • Figures 5 and 6 show what constitutes a photograph. Both images are samples analyzed in the study.	 *Figure 5. A photograph of a service robot service food. Credit: ChinaPhotoPress/Getty. Source: Canadian Business.*  *Figure 6. A photograph of Arnold Schwarzenegger with a Terminator statue. Credit: Mario Anzuoni/Reuters. Source: CBC News.*

Digital Illustrations

- Digital illustrations refer to complex designs that creatively represent people, places and things. They are also generally disconnected from specific contexts but provide emotional, or subjective connections to the content.

- Figures 7 through 9 that were analyzed in the study and coded as Digital Illustrations and represent other similarly crafted visual media in the same category.

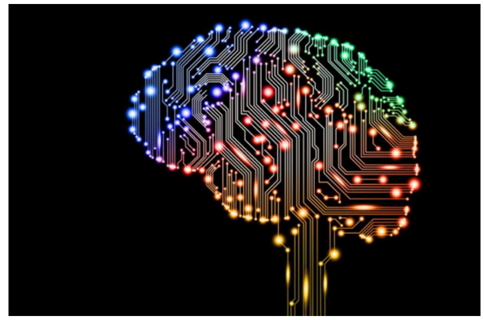


Figure 7. A digital illustration of a human brain constructed with colourful circuits. Credit: Unknown. Source: Betakit.

Figure 8. A digital illustration of a skygazing sentient robot Credit: Pete Ryan. Source: The Economist.

Figure 9. A digital illustration of a sentient robot surrounded by animated code. Credit: Jimmi/Shutterstock. Source: Live Science.

Screenshots

- Screenshots included images or graphics that were appropriated from a screen, meaning they were never printed out and do not exist in the real world.

- Figures 10 and 11 showcase samples that were coded as screenshots. Figure 10 is of a digital chatbot with a sentient facade called “Maya”. Figure 11 showcases how an AI algorithm processes text to images.

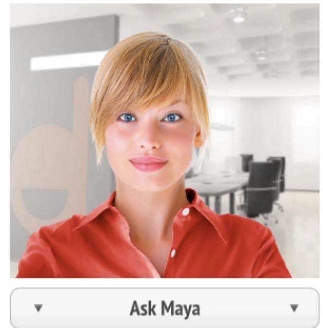


Figure 10. A screenshot of a digital Chatbot. Credit: Unknown. Source: TechCrunch.

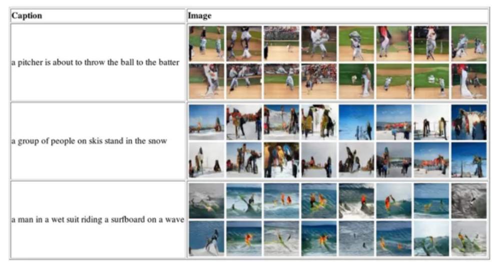


Figure 11. A screenshot of a visual description of an AI process. Credit: Scott Reed, Zeynep Akata, Xinchen Yan, Lajanugen Logeswaran, Bernt Schiele, Honglak Lee. Source: The Verge.

Videos

- To be coded as a video, the media file must be motion based and have certain features like play, pause and volume control.

- An example of such a sample would be an embedded YouTube file or an internally hosted video as seen in Figure 12.

Figure 12. A screenshot of a video presentation of an AI product. Credit: CNET News. Source: The National Post.

Social Media Posts

- Social media posts, like screenshots, are appropriated from a screen; however, the content is exclusively sourced from a social media site such as Twitter, Instagram or WeChat.
- They may be both embedded and interactive, or a static screenshot. Figure 13 is an example of a social media post

> *A bit of a pit stop for lunch!!!! Come to Campbellton to pick him up at the information Center. They are open until7 pic.twitter.com/R4SV7H7l9y*
>
> *— Jean-Pierre Brien (@BrienPierre) July 28, 2014*

Figure 13. A screenshot of a social media post embedded in an article. Credit: @BrienPierre. Source: The National Post.

Charts, Graphs and Diagrams

- Charts, graphs and diagrams showcase quantitative information that is often numerically based.
- To be coded as a chart, graph, or diagram it may have also been explanatory in attempting to disseminate knowledge about how something (like a process) functions.
- See Figures 14 and 15 as examples of charts, diagrams, or diagrams.

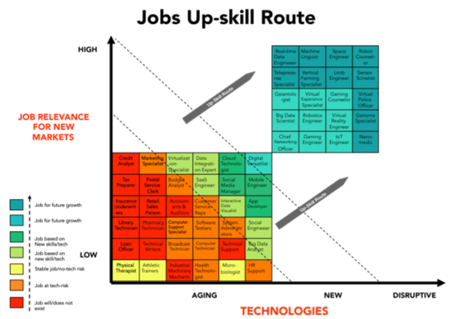


Figure 14. A chart outlining specific information. Credit: Unknown. Source: Medium.com.

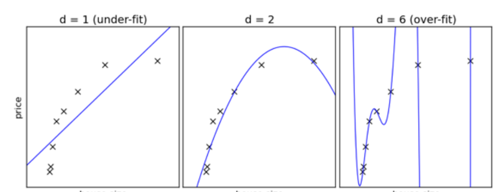


Figure 15. A graph explaining a process. Credit: Unknown. Source: Medium.com.

Infographics

- Infographics are similar to charts, graphs, and diagrams however they also include text content and are generally designed for non-expert audiences.
- Figure 16 is an example of an infographic

Figure 16. An infographic about job automation. Credit: Unknown. Source: Medium.com.

Gifs

- Gifs are looping, motion based visual aids that don't require action from the viewer.
- To be coded as a Gif media type, the aid had to take on Gif properties such that it is short, never-ending, and of a short narrative or sequence.
- Figure 17 is an example of a Gif.

Figure 17. Screenshot of a Gif of an Amazon warehouse embedded in an article. Credit: The Economic Times/Amazon. Source: Medium.com

Logos or Icons

- Logos or icons were represented in samples that clearly showcased a company's logo, for example Facebook's lowercase "f", or a symbol that is easily identifiable or recognizable.
- Figure 18 is an example of a Logo or icon.

Figure 18. "Google" logo that was embedded in an article. Credit: The Economic Times/Amazon.

Scenes from TV Shows and Films

- Scenes from TV shows and films refer to stationary clips from a cinematic or televised sequence. This is similar to screenshots; however, to be coded in the category, the content must be explicitly of a narrative production.
- Figures 19 and 20 showcase two samples that were coded as a scene from a TV show or film.

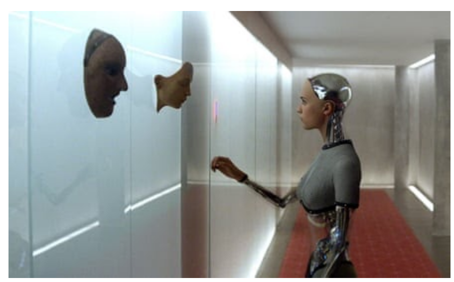
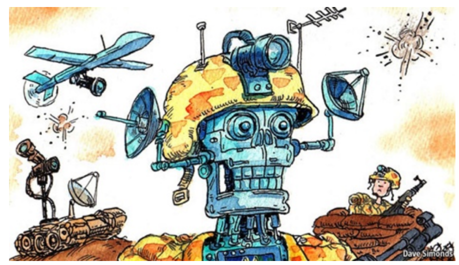
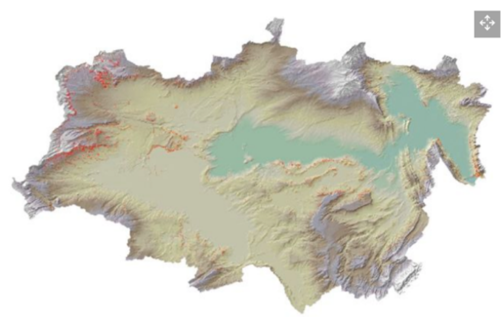


Figure 19. Capture of a scene from Ex Machina. Credit: Allstar/FILM4/Sportsphoto. Source: The Guardian.

Figure 20. Capture of a scene from The Simpsons. Credit: The Simpsons/Disney. Source: Medium.com.

Hand Drawn Illustrations	• Hand-drawn illustrations refer to images or designs that appear to have been handcrafted originally. These were generally drawings or paintings that were on a traditional canvas or paper. Figure 21 is an example of a hand drawn illustration.	 *Figure 21. Illustration of a militarized sentient robot. Credit: Dave Simonds. Source: The Economist.*
Maps	• Maps are coded as such if the visual media takes on the form of a geographic location, like the birds eye shape of a country. • Figure 22 is an example of a sample that was coded as a map.	 *Figure 22. Screenshot of a birds eye view map for fossil-finding. Credit: Robert Anemone. Source: LiveScience.*

If there was more than one visual in the article, which was the case for many samples, all instances were recorded, which sometimes resulted in multiple mediums listed for one article.

The study also sought to identify if any women and/or persons of colour were present in the visual media. This is related specifically to photographs where actual persons are present. The inclusion of this inquiry is in response to multiple confirmations that AI fields lack diversity of both non-male genders and persons of colour. These analyses are primarily rooted in text, so this study seeks to either confirm or contradict these conclusions as it pertains to visual communication.

Beyond real-world visual media, the study considered the content of the visual media broadly to understand what things, people, places, and concepts were being visualized and/or represented in news media. Content was framed as *what is included in the visual media* as well as *how are those things depicted.* Here, the study sought to differentiate real-world visuals from digital renderings of the content. Additionally, the role of the visual media was considered to gauge its purpose in being included in the article. This prompt was broken into decorative, informational (quantitative), informational (qualitative), or combinations of all three. The purpose of this is to frame intentions to sensationalize AI, to disseminate knowledge, or to promote AI narrative in social and cultural contexts.

Next, this study asked what relationship the visual media had to AI specifically. Was it trying to visualize AI as a person, place or thing? Was it illustrating a social instance where AI was encountered through something else? Or does the visual media showcase AI through worldly icons? This section investigated the parasitic nature of AI and how visual communication has adopted the role of defining what AI is by visualizing it. In addition, if the visual media did not attempt to represent or visualize AI, what subjects were used in the visual discourse? Another component of this study was to identify any trends in how corporate entities who currently lead AI development were included in the visual media. Major entities include Facebook, Google (and its subsidiaries), Amazon, and Microsoft.

As argued in The Royal Society's (2018) report, visualization and comprehension of AI through narratives remains a prevalent source of context for many audiences. As such, this study also considered the use of both pop culture and non-pop culture intellectual properties in news media. Pop culture referred to creative narratives around AI such as novels, movies, television shows, comic books, and so on. Non-pop culture intellectual properties referred to products and services that exist or that are emerging in AI developments such as personal helpers (ie., Alexa or Pepper), weaponry (ie., US military), or industrial robotics (ie., Amazon warehouses). Regardless of the visual media's relationship to real, or narrative intellectual properties, the study considered the inclusion of anthropomorphized figures in the visual media. This referred to sentient robotics, or visualizations of sentient figures with robotic elements. The purpose of this component of the study was to identify the prevalence of representation of AI through robotics to compare findings to prominent fears and concerns for work automation.

3.4 Subjective Observations of the Visual Media

While much of the above information was subject to interpretation, this section of the survey is explicitly designed to reflect subjective interpretations of the visual media. Components include identifying predominant colour schemes which were coded as temperatures and brightness. Temperatures were organized as hot (harsh reds), warm (soft pinks and oranges), cool (soft blues, greens and greys), and cold (dark blues and blacks). This information was collected to identify trends in colour palettes which, according to design and colour theory, communicate mood, emotion and tone. The extremity of colours can also indicate how sensationalized a visual aid is. This is important to consider as the nature of narrative visual media is inherently designed to appeal to worldviews and emotions.

Another element of analysis was the presence of a utopic or dystopic tone in the visual media. Again, this component is highly subjective so for the purposes of this study, *utopic* in the context of visual media was defined as projecting a bright, friendly, and optimistic tone, whereas *dystopic* projected a dark, sinister, ominous, and malicious tone. The inclusion of this component is in response to sentiment analyses conducted that identify the tone-trends of AI discourse in textual media. It sought to identify if perceptions of AI match conclusions that discourse around AI is generally positive and pro-AI. If not, what juxtapositions or contradictions do visual aids in news media provide audiences? The study also included prompts to gauge levels of sensationalization of visual aids in news media. *Sensationalization* refers to both the editing of worldly images (ie., photoshop) as well as spectacular renderings of AI, or AI contexts to make the visual more appealing, eye catching, or dramatic. To support that prompt, another was included to rate how *friendly* the visual was. This primarily referred to how cartoonish, soft-edged, playful, or childlike the media was.

The deficit model remains a prevailing strategy for science communication, yet AI development and public information largely comes from private entities that are generally (currently) self-regulated. As such, the study sought to know if visual media promoted explanatory knowledge sharing over narrative appeals to social instances related to AI. Thus, the final consideration in the study was if a stage of AI was clearly identifiable. The criteria for this was based on the BII+E report titled *Intro to AI for Policymakers: Understanding the Shift* which defined the three types of AI: narrow (weak) AI (capable of conducting one task), Artificial General Intelligence (AGI: "notional concept" where AI can performs as a human brain does), and artificial super intelligence (ASI: "hypothetical" stage where AI surpasses human abilities).

4. Results

4.1 About the Publisher, Article, & Author

The sample database was composed of 200 AI-centric articles containing visual media that were published in this past decade. The nature of the publishing bodies ranged from academic magazines, blogs, industry researchers, online magazines, thematic websites, and established news organizations (see Figure 23).

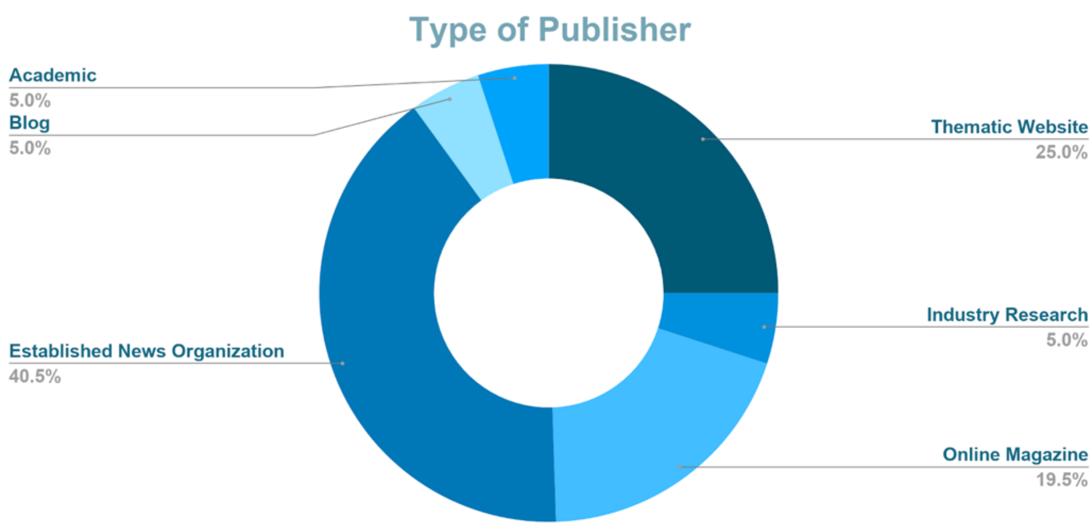


Figure 23. Pie chart illustrating composition of publication types.

The specific publications included: The New York Times (USA); The National Post (Canada); The Washington Post (USA); The Globe and Mail (Canada); CBC News (Canada); The Guardian (UK); The Economist (USA); Betakit (Canada); Brookfield Institute (Canada); Canadian Business (Canada); Engineering and Technology Magazine (UK); Forbes (USA); Live Science (USA); Medium (USA); MIT Technology Review (USA); Reuters (Canada); TechCrunch (USA); The Financial Post (Canada).

Overall, 60% of the sample articles were written by men, while less than a quarter were authored by women (see Figure 24). Also, a large percentage of the articles had authors with gender-neutral, generic identities which made it impossible to assign a gender. For example, the author credit would be given as “Staff Writer” or a company name who contributed for a special reason. This abnormality was also apparent when recording the job title of the authors.

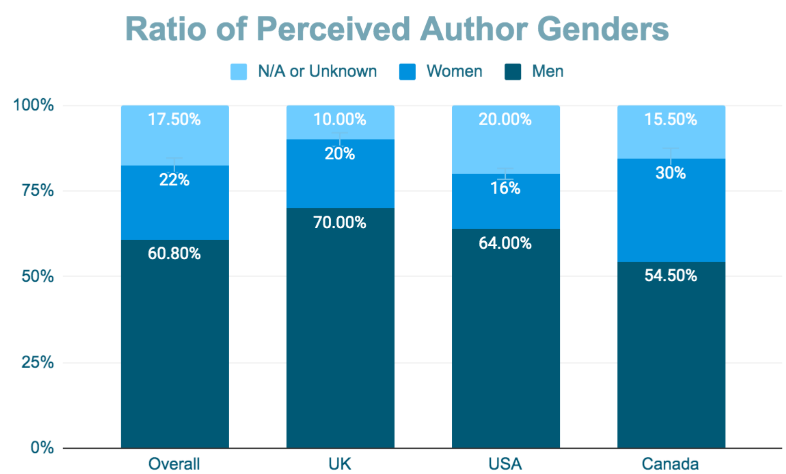


Figure 24. Stacked column chart illustrating gender ratios of sample authorship.

When broken down by geographic origin, these percentages changed slightly. However, male authorship remains predominant overall, especially when one considers that the unknown samples probably include male authors. As a note, Canadian and USA publications composed 90% of the samples so although the UK suggests a significantly high male ratio, a greater sample base may be needed to confirm that trend.

The job titles of these authors were generally much more diverse (see Figure 25). The most common identifier was the absence of one--meaning that their role, and thus relationship to the publication, is unknown. It was also common for an author to have multiple titles, or contradictory reports of what their title was. The second most common identifier was that of "Writer or "Author", followed by "Contributor".

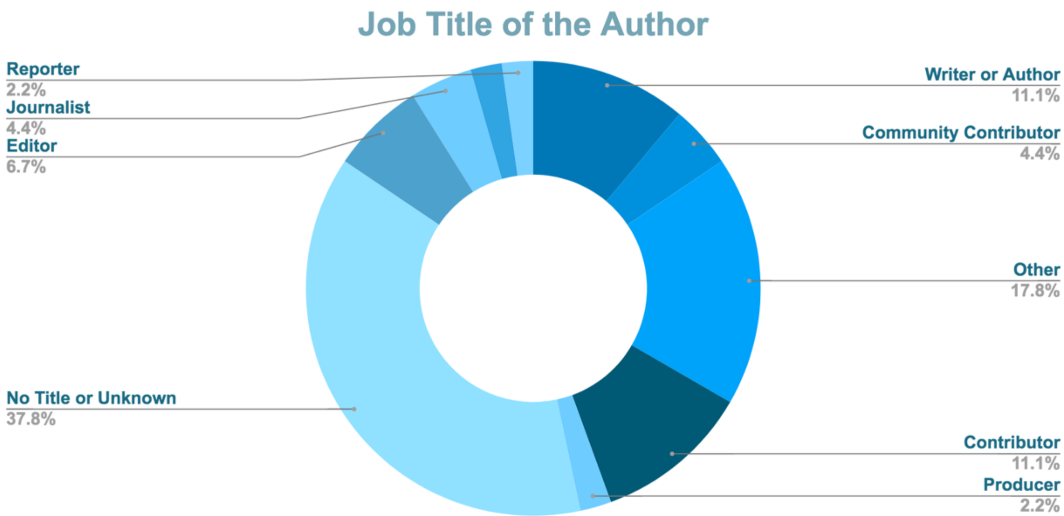


Figure 25. Pie chart showing the composition of job titles.

4.2. Gauging Distortions and Credibility

Overall, approximately 60% of articles cited all visual aids used, while 40% of them did not provide citations to all of their visual media. Of the 60% that did cite their visual media, the majority did so by stating a combination of an individual creator's name and an organization: for example, the name of a photographer and where the author sourced the image from like a university or company. However, the most common way to cite visual media - used in about 50% of cases when all media was cited - was to only name the original creator. There were also articles that cited some media, and not others. This partial group composes about 19% of citations recorded. This was often true for videos, header images, and social media posts.

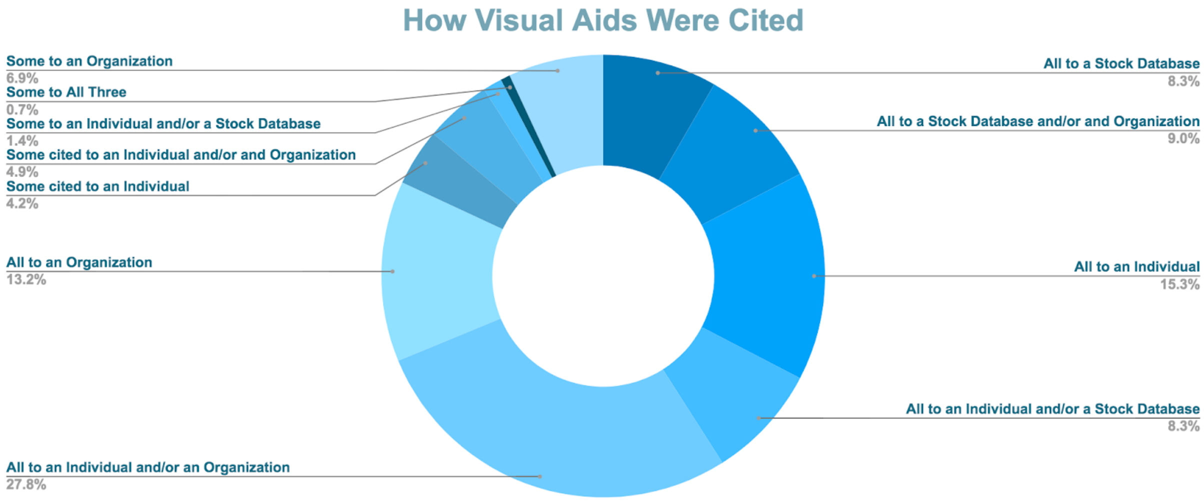


Figure 26. Pie chart showing common citation styles for visual media.

There were three ways which visual aids could be structurally organized in the article: header, embedded, and both. Of all sampled articles, 93.5% had a header image, either on it's own or with other media throughout. This meant that only 6.5% of articles only had embedded visual aids.

Another important result from this study was the identification of captioning patterns (see Figure 27). Among all samples, just under 40% provided captions for all visual aids, and 12.5% captioned some. However, half had no captions to their visual media at all.

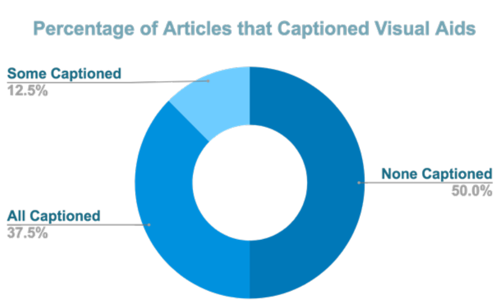


Figure 27. Pie chart showing how many articles captioned their visual aids.'

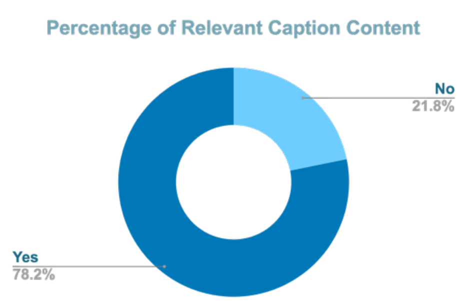


Figure 28. Pie chart showing patterns in the relevance of caption content as it pertains to the visual aids.

The relevance of the captions was also considered in this study to see if they contributed to a viewer's comprehension of the visual aid, or if it introduced additional context. Of the samples that did caption the visual aids, about 20% of them contained information that was irrelevant to the content of the visual media. The other (approximate) 80% of those samples created captions that meaningfully speak to the visual aid (see Figure 28): for example, explaining an event that a photograph is documenting, or explaining the actions of a robotic product. The captions that did not meaningfully contribute to the visual aids were often used to ask a speculative question, or to state something that was related to the subject of the article but did not fit in any sequence within it.

4.3 Content of the Visual Media

Figure 29 illustrates the most common quantity of visual aids included in the sampled articles. Having one visual aid was the most common practice, however many contained multiple visual aids. In total, this study accounted for 417 visual aids.

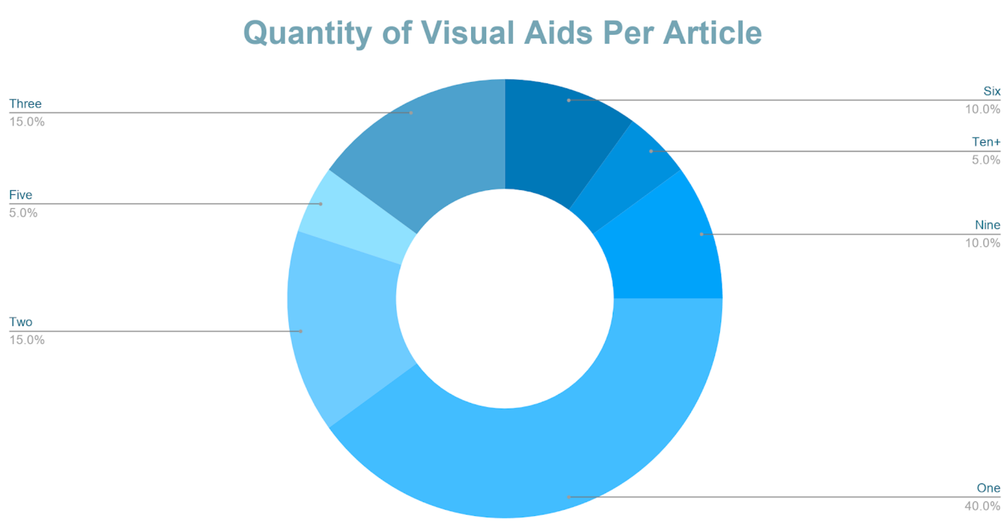


Figure 29. Pie chart illustrating trend in how many visual aids are used in AI communications.

Using visual media as a header - being a large image prefacing the rest of the text-based content - was the most popular way of organizing the visual content. Specifically, nearly 93% of articles used visual media in the introduction before, or in tandem with the title. About 31% of articles included a header image as well as additional content throughout. Only around 7% only used visual media throughout the text and did not have a header image.

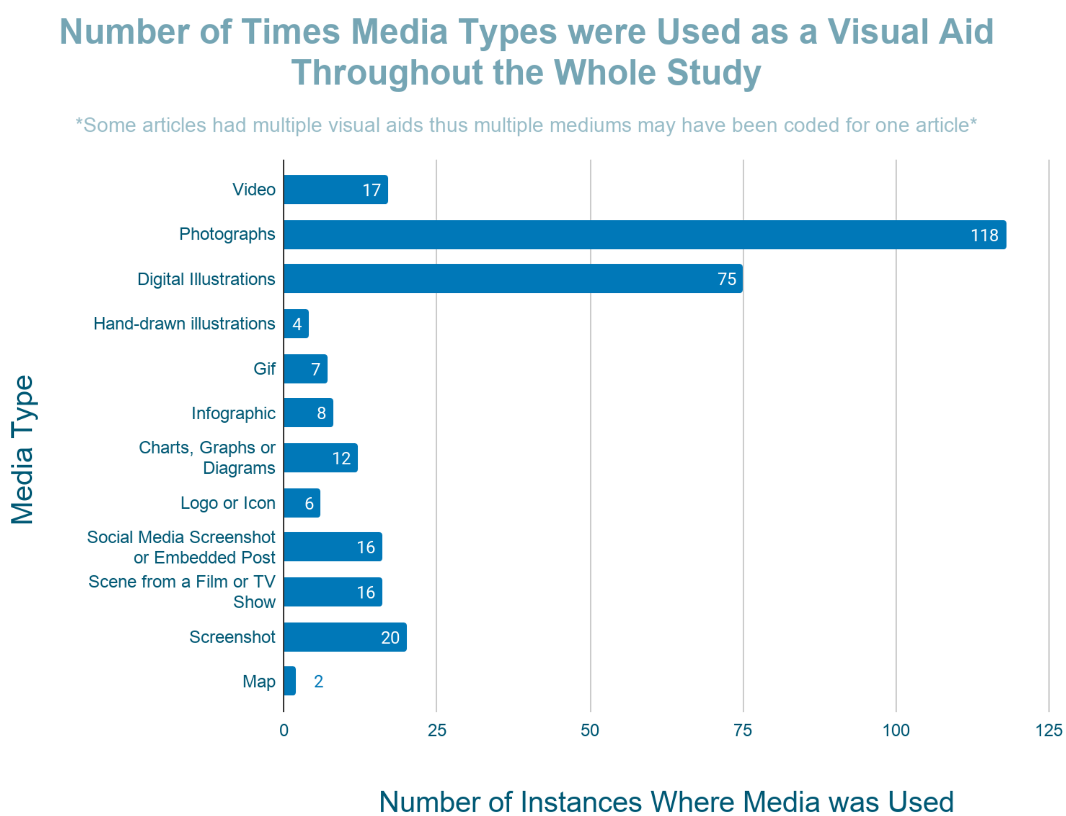


Figure 30. Bar graph showing how many instances certain media types were used in the whole study.

Many different kinds of media were seen in the study but there were some types of media that were more prevalent (see Figure 30). The most used media format was photography. Photographs were identified as being used 118 times. Digital illustrations were the second most common media type that was used, appearing 75 times. Screenshots (not of social media posts) were the third most used format, followed by videos which were embedded in the article.

The most common description of the visual content in the samples was *actual people, places, and things* which were often represented by photos of significant people, videos of a product operating, or social media screenshots (see Figure 31). The next most common subjects were *creative renderings of people, places and things* which collectively accounted for about 25% of recorded subjects. The samples that were coded as either were also, primarily, digital illustrations where something was artistically represented. Other cases where visual aids were coded as creative renderings of people was when an author demonstrated the use of AI on topics like deep fakes, and facial recognition.

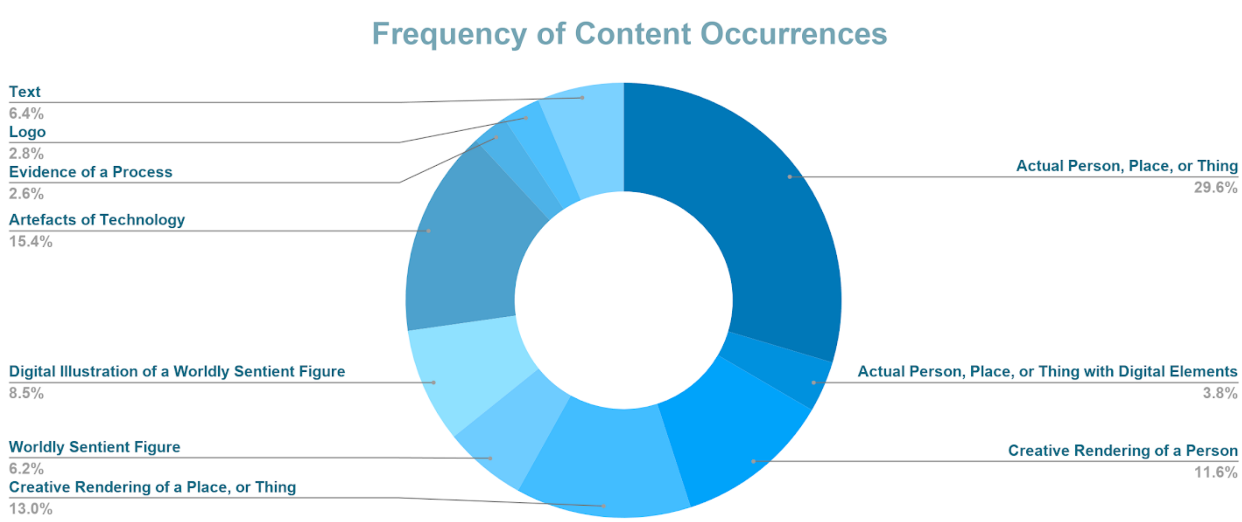


Figure 31. Pie chart illustrating the most common types of content as coded in the data collection process.

Another observation worth noting in this category is that just under 15% of recorded subjects contained a sentient element in them, whether it was a representation of a human-like form, or actual thing that resembles human form. The term 'worldly' – exchangeable with 'real-world'- refers to robotics where the subject of the visual media is real, mainly robots that take on human characteristics and mimic mannerisms of people. *Artefacts of technology*, composing about 15% of content, included literal devices like a phone, a computer, or a circuit as well as digital, but real things like a line of code.

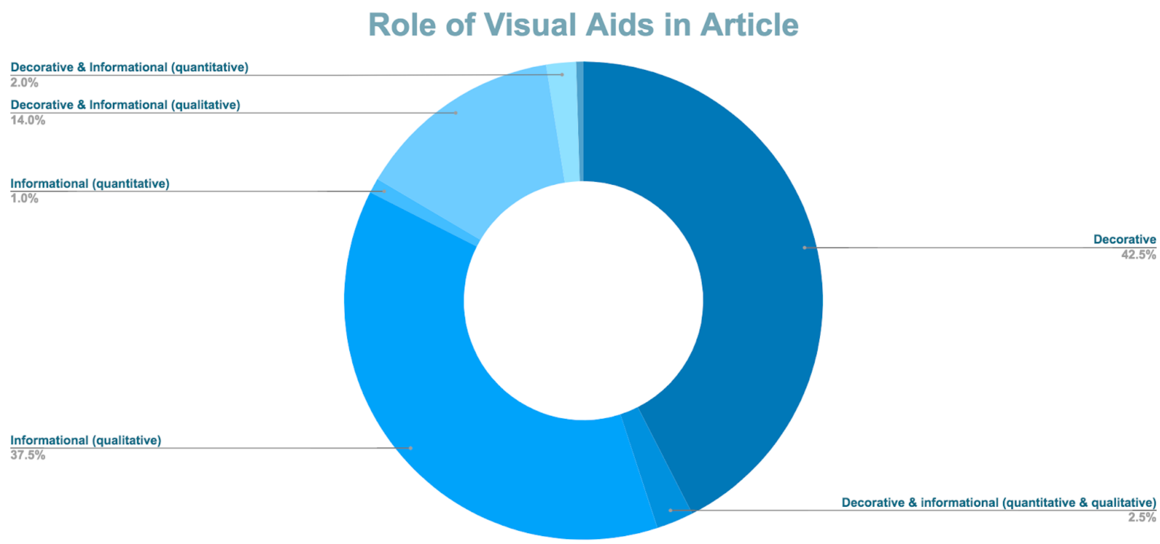


Figure 32. Pie chart outlining trends in what roles visual aids have in samples.

As seen above in Figure 32, most of the samples included visual media for decorative purposes --being the aids did not contribute knowledge or information beyond visual appeal. Many samples contained more than one visual aid, thus the conjoined codes, such as *decorative & informational (qualitative),* frame the roles of all visual aids in the article. A slightly lesser amount included informational visual aids that provided qualitative information. These aids provided additional social or subjective context and/or related immediately to the content of the article. For example, evidence of human-robot interaction, headshots, or recordings of interviews and announcements contributed to this category. Notably, 61%, in varying combinations, had decorative visual media, while just over 5% provided quantitative information like numerically based charts, or graphs. Of articles that contained only one visual aid that was structured as a header, 62.5% of them were coded as being decorative while 37.5% provided qualitative context. Articles that contained a header image and embedded media more often showed variety in what ways they contributed to information in the article. Just over 40% of them provided qualitative information, another 46% were a mixture of being decorative and adding qualitative or quantitative information. Although header-less articles accounted for a small percentage of samples, just over 46% of those visual aids were decorative. The second and third largest role-type was qualitative information, followed by a combination of qualitative and quantitative.

While the above information speaks to the role in information sharing the visual media provides, the relationship to AI specifically was also taken into account. Figure 33 showcases the most common relationships between visual aids and AI.

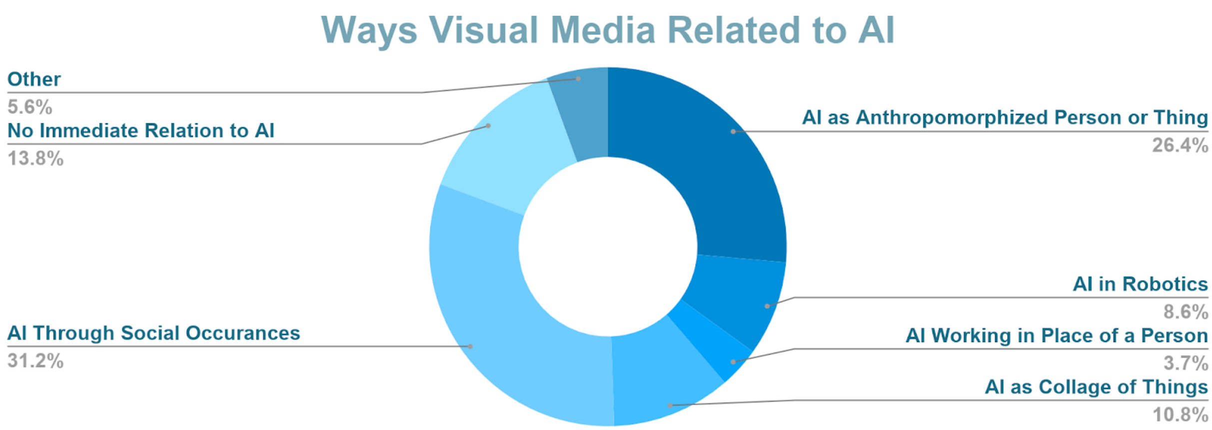


Figure 33. Pie chart highlighting frequent relations visual media had to AI specifically.

The most common way the visual aids related to AI was through social occurrences which would have manifested as, similar to qualitative context, conferences, interviews, or social interaction with an AI product or AI-centric group. In other words, samples that were coded in this grouping framed real, social relationships to AI. The second most common relation to AI was through anthropomorphization, or depictions of sentient bodies, however only 8.6% showed actual robotics. Another interesting conclusion is that a significant amount of visual media didn't have any immediate relation to AI. Almost 70% of articles that included these kinds of aids primarily gave them a decorative role, while the remaining 30% provided qualitative context. Being even more decoration-focused, every article with visual aids that collaged things together had a decorative element or were only included to decorate the text. For clarity, a *collage of things* refers to visuals, often digital illustrations, where worldly things, for example circuits or a human brain, are creatively compounded together.

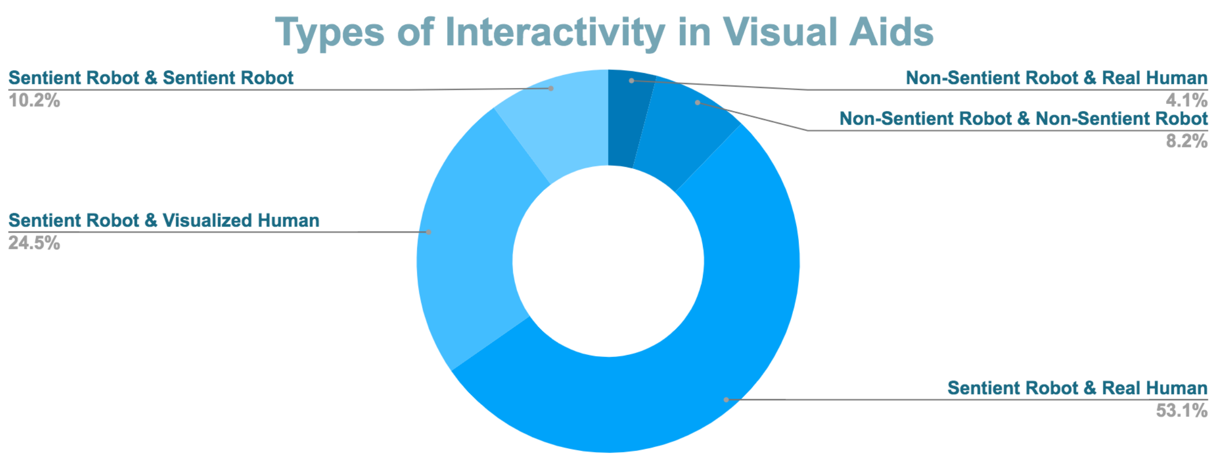


Figure 34. Pie chart highlighting the ways that humans and robots interacted in visual media.

About 24% of the samples included human and/or robotic subjects that were often interacting with one another. Figure 34 highlights the most common ways that they interacted with one another within the visual media. The most frequent interaction was between a sentient robot, including digital renderings and tangible robotics, and a real people. This was often seen when a person challenged a robot in a task, like a game, or in manufacturing lines. The second most common interaction was between a sentient robotic figure and a creatively rendered human being. These were often abstracted to a degree and highlighted very advanced relationships between the two subjects --suggesting capabilities well beyond weak AI. As an example, a common interaction was a sentient robot and human handshake which implied cognitive equality and intellectual partnership. It was also common to see two sentient robots interact with each other without the presence of an actual person in the visual media.

The study also sought out how frequently visual media made reference to intellectual properties (IP), as well as household names and figures. Around 45% of samples made some kind of connection to IPs and significant figures in some way. Figure 35 outlines the exact visual media made connections to these categories 45%. Half referred to an AI-related product or service which often included software, video games, or a tangible robotic product. This category did not include references to companies themselves, only their commercial or experimental outputs. Significant people were also a common thing to reference. Here a *significant person* refers to a someone who may be acclaimed as important but may not be a household name amongst technical and non-technical audiences. *Significant public figures*, such as CEOs or political figures like Jeff Bezos, Elon Musk, or Donald Trump, were only referenced 12.3% of the time within this grouping. Lastly, 15% included references to fictional, AI-related IPs. These were unanimously represented by AI-narratives including TV shows, novels, and films.

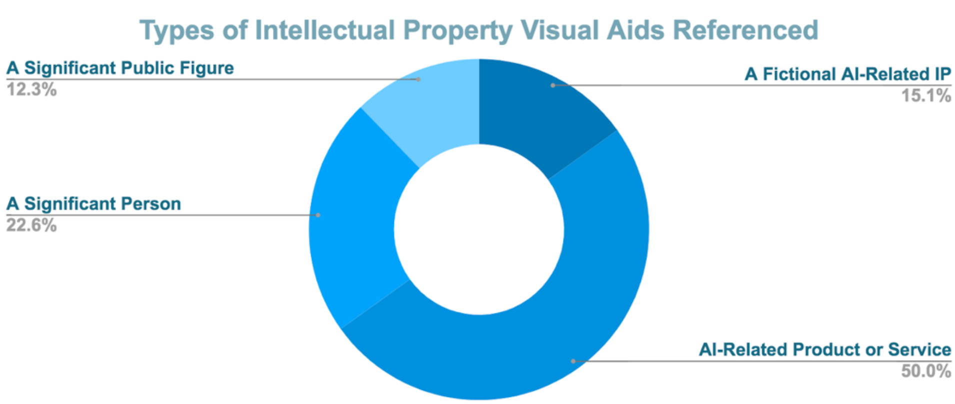


Figure 35. Pie chart highlighting the kinds of IP and significant figures samples referenced the most.

4.4 Subjective Observations of the Digital Media

The presence of diverse representation in visual aids was studied to investigate if the oversaturation of whiteness and masculinity persisted in visual communication like in journalistic authorship, and in AI industries (see Figure 36).

Only photographs where a person's face was clearly visible, and an assumption could be made about their identity were included in this analysis. The total amount of applicable samples was 77. Subjective assessments were made to identify people in the photographs as either female or as a person of colour which may also include white-passing individuals and relies on conventional indicators of femininity. Additional context, such as captions when available, were considered when assessing these criteria.

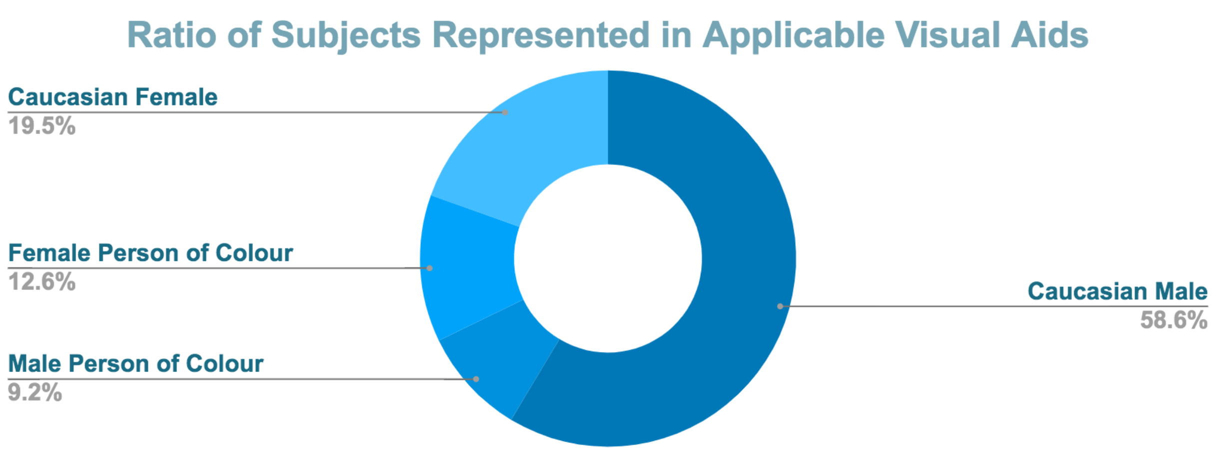


Figure 36. Pie chart showing how common non-white and non-Caucasian persons are represented in photos.

Almost 60% of photographic subjects appeared to be white men. The second most represented group was white women who accounted for about 20% of subjects. Female persons of colour and male persons of colour only represented 12.6% and 9.2% --less than a quarter of subjects.

Now considering visual design, there were no exceptionally predominant temperature schemes in the visual aids. Cold temperatures were the most common making up around 29% of all recordings however warmth accounted for 28%, heat for 22%, and cool for 21%, so the differences are minor. When considering predominant shades there is however a clear dominance. Just over 46% of samples had predominantly light visual aids, while only 26% were dark, and 28% of articles had a mixture of both. Showing a similar majority, Figure 37 highlights trends in how seemingly utopic or dystopic visual aids appeared to be.

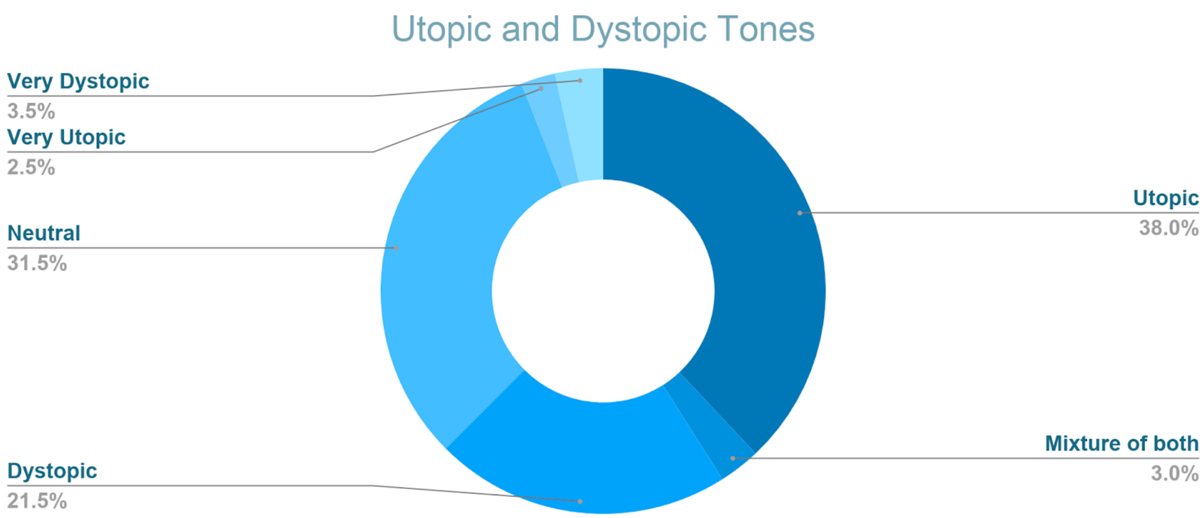


Figure 37. Pie chart highlighting common levels of dystopian and utopian tones.

To be coded as utopic, the visual media had to have had a sense of optimism shown through bright colours, rounded shapes, and inviting designs. On the other end, dystopian-seeming media was coded as such if it was predominantly dark, jagged, and threatening suggesting negative consequences and a bleak future. Neutrality, which reflects neither end of this spectrum, is also more apparent than dystopian tones. However, of the extremes dystopian tones are slightly more common than the exceptionally utopic ones.

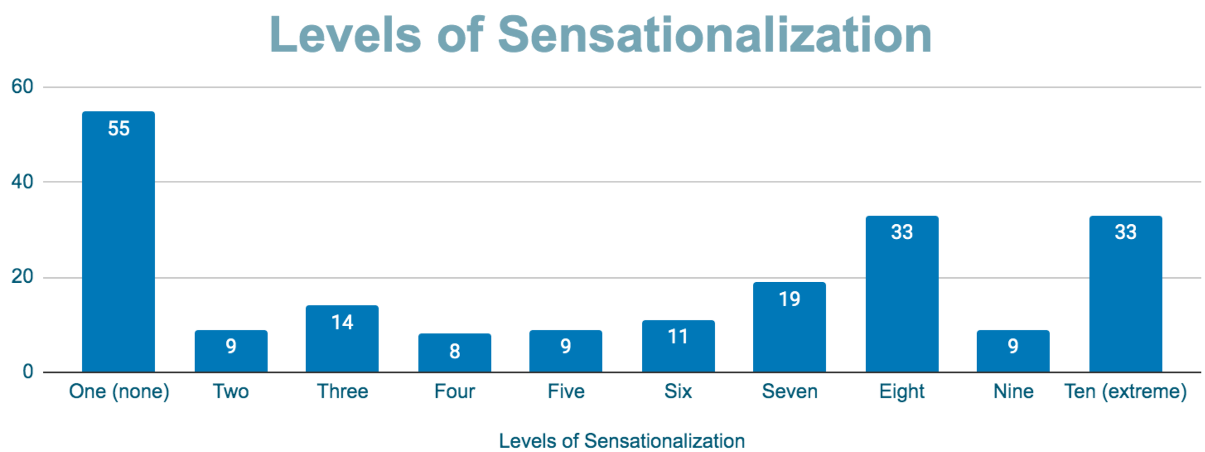


Figure 38. Bar graph showing trend in sensational media.

The level of sensationalization was also recorded in an attempt to frame commonness of ‘click bait’ media that may contribute to polarization. As seen in Figure 38, a ranking of 1 found that the visual showed little or no evidence of sensationalization. This meant it appeared to be a realistic, unaltered, or reasonably edited visual aid. Articles coded in the mid-lower spectrum of this scale had indications of playful editing or strategic framing, such as a photograph taken from a slightly dramatic, but ultimately unnecessary angle to communicate qualitative information. The mid-high range included media that was often collaged together in an unnatural way or had alarmist or dramatic components. At the far right are visual aids that are entirely dramatic, explosive, and were clearly designed to catch attention through unrealistic and sensational graphics. The result of this particular observation shows a valley of relative neutrality that is bed-ended by polar opposite styles.

5. Discussion

Findings from this study confirm some assumptions about how AI is visually communicated in the media; however, other themes emerged that were surprising. Some of the more predictable results included the prominence of male authorship, a regular practice of not citing sources of visual media used in articles, and a common depiction of AI as anthropomorphized entities. The less predictable and more interesting findings were that photography was the most common type of visual media, and AI narratives and the depiction of AI in robotic form were not as common as had been initially presumed.

5.1 AI in Robotics and Intellectual Properties

A surprising finding was the uncommon use of AI-lead narrative intellectual properties such as the *Terminator* films or the TV series *Star Trek: The Next Generation* (for example, the android character Data). Overall, they represented only 15% of intellectual property references. When conducting initial research on this topic, it was assumed that these types of AI narratives were responsible for, or deeply tied to public fears and hopes about AI and would feature prominently in AI media coverage. While such narratives may have a significant role in shaping the cultural imaginary around AI, media coverage of AI seems cautious about amplifying the concern of these narratives when discussing AI developments. Communication professionals may be exercising responsible journalistic practice by providing real rather than imaginative or speculative visual information to supplement written information. These findings show that imaginative AI narratives play a role in visual communication, although a less common one than may be presumed, and, when they are included, their use is carefully contextualized by authors. It is also important to note that in most publications, there was one, or a small number of authors who covered AI topics. This means that these findings reflect the habits and trends of a limited number of authors.

Another surprising finding was that visual media rarely represented AI through actual robotics or through visual evidence of work automation, despite the predominant social anxiety around job loss by automation. Of the articles that spoke directly about job automation - 43 in total - 59 visual aids were used. Of those, about 40% were digital illustrations and 38% were photographs, which contrasts slightly with the larger trend that photos were the most prominent medium. This suggests that the topic of automation in particular has a higher probability of being inaccurately or ineffectively distilled through visual information as it is highly subjective. A parallel to this conclusion may be the protesting that occurred towards GMOs where visual campaigns hyper-focused on fear-inducing visualizations of illness, and unnatural animal hybrids (Clancy & Clancy, 2016). A major difference in this comparison is that the visual communication of GMOs was highly organized by groups and organizations, which isn't necessarily true for AI, at least within the confines of this study.

The findings also showed low levels of captioning of visual material; however, of the ones that did provide captions, a surprising number of the captions enriched the visual media and contributed significantly to knowledge and comprehension. The content and medium type of these rich captions were largely accompanying photographs and videos, and contained real people, places, and things, and suggest a positive trend in that authors are attempting to provide as much context for the visual information as possible. On the other hand, the ones that did not have meaningful captions were most often imaginative, visualized renderings of AI such as digital illustrations.

In these samples it was uncommon to see subjects interacting; however, in the ones that did indicate subjects interacting, the most common depiction was a real human interacting with an unworldly and anthropomorphized robotic figure: Figure 42 is an example of this. Harrison (2003) broke down an analytical framework for assessing visual media which was built on top of semiotic theories. In discussing components of the "interpersonal metafunction" Harrison (2003) notes that "images representing the use of...technology are frequently at a low visual angle to the viewer...this means the viewer holds the power over the technology, not only in terms of choosing to use the technology, but also being able to understand, control, and manage it" (Harrison, 2003). This conclusion appears to be generally untrue amongst the samples featured in this study. Figures 39 through 44 highlight images that are emblematic of themes in visual aids where automation was a subject of the article. They are also examples that contained literal, or concrete evidence of technology.

The majority of these samples position the subjects at a medium or high angle or positions the viewer beneath the RP(s) (represented participant) (Harrison, 2003), meaning the viewer is looking up to, or straight at a subject. According to Harrison (2003), creating these visual angles suggests an equal or authoritative relationship between the RP and the viewer. Here, it may imply that the robot (representing AI) is as intelligent as, or is more intelligent than, its human counterpart, or that AI is imitating human cognition, as seen in Figure 39. The challenge with this design trend is that the visual discourse of and about AI in automation contexts suggests that AI - insinuating no clear type of AI - has capabilities that exceed what is currently possible. Consequently, this misrepresentation may lead to unproductive dialogue, and perpetuation of fears and beliefs about AI that were onset by AI narratives.

Figure 39. Image of a person working alongside sentient robots performing similar tasks.

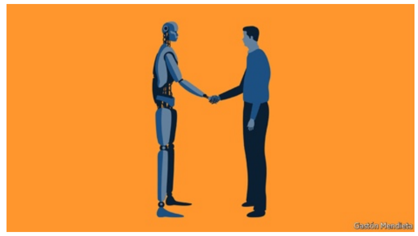


Figure 40. Digital illustration of a human and robot shaking hands. Credit: Gaston Mendieta. Source: The Economist.

Figure 41. Digital illustration collaging and layering human profiles & abstracted circuits. Credit: Getty. Source: Wired.

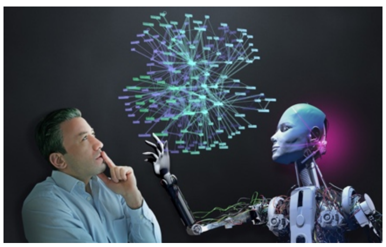


Figure 42. Photo & digital illustration showing human and sentient robot collaborating. Credit: @Devrimb. Source: TechCrunch.

Figure 43. Photo of people watching a robot with human features perform a task. Credit: Sally Ryan. Source: New York Times.

Figure 44. Illustration of a robot serving a person a hot drink. Credit: Joost Swarte. Source: MIT Technology Review.

5.2 Commercial Subjects of Visual Media and Implications

Projects that inspired this study were the Noun Project's Iconathon and the Royal Society's workshop on AI narratives. Together, they represent two perspectives on the value and function of visual communication in media coverage of AI. The first perspective is to visually educate what AI does in a technical context - similar to the deficit model, however only key concepts are elaborated on and are designed in a quickly recognizable way. Secondly is the imaginative perspective of AI that takes a cultural, story-driven angle to frame AI as a social concept. In other words, the first perspective focuses on visualizing concepts that exist in AI processes, while the second focuses on using visual communication to frame human-to-technology relationships. What this study revealed is that there is a much more complex perspective that needs attention from visual communicators. This is the representation of actual, real-world interactions with AI and the consequences that come from applying commercial, and more mainstream AI products to social situations. This subject does not focus on the technical or the imaginative components of AI, but instead represents visual information not requiring visual thinking. Trends from this study show fewer attempts at visualizing AI as a *thing* or trying to explain how it works. Instead, it documents the utilitarian ways mass audiences relate to AI through commercial and industrial products, AI-related services, and entrepreneurial figures and innovations. This trend in visual media usage may be tied to the increased privatization of AI research and industry because innovations have made AI products and applications both more mainstream and integrated into digital identities. The connection to commercialization may also be tied to fewer depictions of experimental AI - story-bound, or real - which often hint at polarizing consequences of dystopian or utopian worlds.

6. Conclusions & Next Steps

This study showed that although the visual communication of AI is a niche subject in STEM communication, it requires dedicated attention to help steer public engagement, and encourage productive discourse around AI. The scope of this study was intentionally broad to illustrate a holistic overview of the topic. Due to this, there are many factors that require additional attention, or that require new perspectives to offset, unintentional, but inevitable biases.

6.1 Narrowing the Scope and Isolating Critical Areas

As this study's goal was to create foundational conclusions, the scope limited more magnified assessments of subject categories. Considering that support for particular areas in AI design and research is disproportionately weighed towards private industries and their interests, deeper analyses can be conducted on targeted industries or discourse subjects - bringing contextual themes into focus. As an example, AI in healthcare contexts are often more personal and community based, while AI in military contexts concern globalized and political issues. Creating micro assessments may help identify how certain fields within AI are represented differently, and how those disparities impact dialogue, perceptions and effective advancements. This would be more discernable alongside qualitative research where subjective perspectives are accounted for.

6.2 Introducing Qualitative Assessments and Additional Perspectives

More research is needed to connect findings from this study directly to public perceptions of AI and to identify if certain strategies are more effective in generating or encouraging inclusive and effective advancements. Qualitative studies will incorporate feedback from audiences including those in non-technical, professional communication, and AI-expert groups. In theory this will confirm or contradict the assumption that visual communication strategies have influence on perceptions of AI. Doing this may also define visual relationships and contribute to building robust theoretical frameworks for the visual communication of AI. This goal is important for operationalizing AI as an emerging technology that lacks definition and "is more sophisticated as compared to other emerging technologies in human history" (Sun et al., 2020)

Including AI-experts in the next steps of this research can help demystify *AI* as an umbrella term encompassing a myriad of types and stages of technology. Questions that require an expert lens might include: how is machine learning visualized differently from natural language processing, or neural networks in publicly accessible media? Is it possible to discern types of AI within currently used visual media at all? Or, do trends in visual communications accurately depict stages of AI discussed in their accompanying texts? In a similar sense, input from professional communicators should be sought out to understand their decision-making processes in choosing certain visual aids over others and methods for sourcing images.

Seeking input from general and non-technical audiences is another critical component of next steps. In this there must include a wide range of demographic categories considering that relationships to technology and the interpolation of visual information are both tied to cultural subjectivities and learned worldviews. Going forwards, a similar trend analysis like this one should consider perspectives from non-Western communicators as well.

6.3 Building New Frames

Next steps should include the development of new and visual-based frames that are independent from the utopic/dystopic binary and commercialized AI. This is to build dialogue around outputs like poorly designed algorithms, and the lack of diverse contributions in data sampling and processing[4]. More critical frames, such as *AI as racist*[5] *and masculinized,* or, *AI as a cultural feedback loop*[6] should be created in visual narratives to increase awareness and dialogue around actual problems facing AI right now - moving away from oversaturated voices and unproductive narrative fantasies.

1.1. Additional Considerations

There are additional factors to consider within the design of this study. For example, the articles that were used as samples were sourced through advanced Google searches and, when available, in publication archives. This method was required because the databases normally used for analyses of news material generally only contain text content and not accompanying images. The Ryerson University Library had similar limitations that restricted the capacity to examine articles with a focus on visual media. Primary archival sources for images that are similar to the function of text databases are stock sources[7] that host limited categories of AI imagery. This research challenge supports many of the conclusions that visual communication studies require increased attention and dedicated consideration.

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[4] Zou & Schiebinger (2018) highlight source data that many AI developers use that gives precedence to Western cultures, for example labelling "a photograph of a traditional US bride dressed in white as 'bride', 'dress', 'woman', 'wedding', but a photograph of a North Indian bride as 'performance art' and 'costume".

[5] Obermeyer, Powers, Vogeli & Mullainathan (2019) conducted a study that proved algorithm-supported medical information systems patronized black patients disproportionately to white patients. This meant black patients were more likely to receive a lesser quality of care comparatively to white patients in the same, or improved condition.

[6] 'Cultural feedback loop' is appropriated from Zou & Schiebinger (2018).

[7] Examples of stock image sources include Adobe Stock, Shutterstock, Getty Images, and Alamy.

7. Appendix

Table 3. List of Articles Used in this Study

Publisher	Article Title	URL to the Article
Betakit	*"Report: Canadian Job Opportunities in AI Have Grown By Nearly 500%"*	• https://betakit.com/report-canadian-job-opportunities-in-ai-have-grown-by-nearly-500/
	"Only One Canadian Company Places on The List Of Top 100 AI Companies in The World"	• https://betakit.com/only-one-canadian-company-places-on-list-of-top-100-ai-companies-in-the-world/
	"Robots Will Take Over the World (If You Fund Them on Kickstarter)"	• https://betakit.com/the-robots-will-take-over-the-world-if-you-fund-them-on-kickstarter/
	"Tech for Good: IoT Can Extend Healthcare into the Home"	• https://betakit.com/tech-for-good-iot-can-extend-healthcare-into-the-home/
	"MARS Report Says AR, AI and IoT are the Next Three Major Tech Sectors"	• https://betakit.com/mars-report-says-ar-ai-and-iot-are-the-next-three-major-tech-sectors/
	"Denmark's Oldest Healthcare Company Opens Innovation Lab in Markham, Its First Outside of Europe"	• https://betakit.com/denmarks-oldest-healthcare-company-opens-innovation-lab-in-markham-its-first-outside-europe/
	"'AI is not Magic': Shifting Perceptions of Artificial Intelligence at Evoke 2019"	• https://betakit.com/ai-is-not-magic-shifting-perceptions-of-artificial-intelligence-at-evoke-2019/

	"Element AI's Yoshua Bengio Says Canada is at the Forefront of the AI Revolution'	• https://betakit.com/element-ais-yoshua-bengio-says-canada-is-at-the-forefront-of-the-ai-revolution/
	"Element AI Global Talent Report Finds Canada has Third-Largest Concentration of AI Researchers"	• https://betakit.com/element-ai-global-ai-talent-report-finds-canada-has-third-largest-concentration-of-ai-researchers/
	"When it Comes to Machine Learning, is Privacy Possible?"	• https://betakit.com/when-it-comes-to-machine-learning-is-privacy-possible/
Brookfield Institute	*"Decoding AI's Implications for Public Policy"*	• https://brookfieldinstitute.ca/commentary/decoding-ais-implications-for-public-policy/
	"AI Futures Policy Lab: Toronto Pilot Summary"	• https://brookfieldinstitute.ca/report/ai-futures-policy-lab-toronto-pilot-summary/
	"AI Futures Policy Labs: Shaping the Future of AI Policy in Canada"	• https://brookfieldinstitute.ca/commentary/ai-futures-policy-labs-shaping-the-future-of-ai-policy-in-canada/
	"Intelligence Gathering: Examining the Impact of Automation on Ontario's Workers"	• https://brookfieldinstitute.ca/commentary/intelligence-gathering-examining-the-impact-of-automation-on-ontarios-workers/
	"Superclusters: Canada's $950-Million Commitment"	• https://brookfieldinstitute.ca/commentary/superclusters/
	"Rise of the Robots: Why the Future of Jobs in Canada Isn't All Doom and Gloom"	• https://brookfieldinstitute.ca/commentary/the-rise-of-robots/
	"Solving the Puzzle of AI Adoption"	• https://brookfieldinstitute.ca/commentary/solving-the-puzzle-of-ai-adoption/
	"Surfing the Fourth Industrial Revolution	• https://brookfieldinstitute.ca/commentary/surfing-the-fourth-industrial-revolution/

	Mapping Automation"	• https://brookfieldinstitute.ca/commentary/mapping-automation/
	"README.txt: Introducing into the Dataverse, the Article Series"	• https://brookfieldinstitute.ca/commentary/readme-txt-introducing-into-the-dataverse-the-article-series/
Canadian Business	*"How Tech Startups are Bringing the Digital Revolution to Hospitals"*	• https://www.canadianbusiness.com/innovation/digital-health-care/
	"Don't Make These Mistakes When Investing in AI"	• https://www.canadianbusiness.com/lists-and-rankings/best-managed-companies/dont-make-these-mistakes-when-investing-in-ai/
	"How Artificial Intelligence is Transforming Financial Risk Management"	• https://www.canadianbusiness.com/investing/artificial-intelligence-due-diligence-risk-management/
	"ALL Intelligence is Real, Including the Artificially Made"	• https://www.canadianbusiness.com/blogs-and-comment/all-intelligence-is-real-including-the-artificially-made/
	"What Will Society Do for the People Whose Jobs are Taken by Robots?"	• https://www.canadianbusiness.com/innovation/what-will-society-do-for-the-people-whose-jobs-are-taken-by-robots/
	"The Future is Automated"	• https://www.canadianbusiness.com/technology-news/the-future-is-automated/
	"Nearly Half of the Jobs in Canada are at "High Risk" of Automation"	• https://www.canadianbusiness.com/lists-and-rankings/best-jobs/canada-job-automation-risk/
	"Here's Why We Shouldn't Fear Artificial Intelligence"	• https://www.canadianbusiness.com/innovation/should-we-fear-artificial-intelligence/
	"The Biggest Hurdle for A.I. May be Philosophical"	• https://www.canadianbusiness.com/blogs-and-comment/the-biggest-hurdle-for-a-i-may-be-philosophical/

	"How Deep Genomics is Fighting Cancer with Artificial Intelligence"	• https://www.canadianbusiness.com/innovation/how-deep-genomics-is-fighting-cancer-with-artificial-intelligence/
CBC News	*"How Two Small Canadian Companies Compete for AI Talent"*	• https://www.cbc.ca/news/technology/canada-artificial-intelligence-companies-montreal-talent-1.3890556
	"Is AI Overhyped? Researchers Weigh in on Technology's Promise and Problems"	• https://www.cbc.ca/radio/thesundayedition/the-sunday-edition-for-february-23-2020-1.5468283/is-ai-overhyped-researchers-weigh-in-on-technology-s-promise-and-problems-1.5468289
	"Sex Doll Creator Defends His Plans for Artificially Intelligent Dolls"	• https://www.cbc.ca/radio/asithappens/as-it-happens-thursday-edition-1.3232220/sex-doll-creator-defends-his-plans-for-artificially-intelligent-dolls-1.3232222
	"Artificial Intelligence, Human Brain to Merge in 2030s, Says Futurist Kurzweil"	• https://www.cbc.ca/news/technology/artificial-intelligence-human-brain-to-merge-in-2030s-says-futurist-kurzweil-1.3100124
	"After Years Hidden in the Background, Artificial Intelligence is Getting Pushy: Don Pittis"	• https://www.cbc.ca/news/business/artificial-intelligence-intrusive-1.4667165
	"Machine Intelligence Lessons from Science Fiction: Don Pittis"	• https://www.cbc.ca/news/business/machine-intelligence-lessons-from-science-fiction-don-pittis-1.3196170
	"Artificial Intelligence Probably Won't Kill You, but it Could Take Your Job: Don Pittis"	• https://www.cbc.ca/news/business/ai-machine-learning-employment-future-1.4047837
	"AI Could Destroy Humans, Stephen" "Hawking Fears: Should You Worry?"	• https://www.cbc.ca/news/technology/ai-could-destroy-humans-stephen-hawking-fears-should-you-worry-1.2864576
	"Transforming Health Care: How Artificial	• https://www.cbc.ca/news/health/artificial-intelligence-health-care-1.5110892

	Intelligence is Reshaping the Medical Landscape"	
	"Hawking, Musk, Wozniak Warm of Military Artificial Intelligence Arms Race"	• https://www.cbc.ca/news/trending/hawking-musk-wozniak-warn-of-military-artificial-intelligence-arms-race-1.3169193
Engineering & Technology Magazine	*"Technological Singularity and Transhumanism – New World for Old"*	• https://eandt.theiet.org/content/articles/2014/01/technological-singularity-and-transhumanism-new-world-for-old/
	"Humanoid Robot Can Read Facial Expressions and Interact with People"	• https://eandt.theiet.org/content/articles/2015/04/humanoid-robot-can-read-facial-expressions-and-interact-with-people/
	"Honda Unveils Updated Humanoid ASIMO Robot"	• https://eandt.theiet.org/content/articles/2014/07/honda-unveils-updated-humanoid-asimo-robot/
	"AI Algorithm Cracks CAPTCHA Turing Test"	• https://eandt.theiet.org/content/articles/2013/10/ai-algorithm-cracks-captcha-turing-test/
	"Kinect Developers Win Top UK Engineering Award"	• https://eandt.theiet.org/content/articles/2011/06/kinect-developers-win-top-uk-engineering-award/
	"Trial and Error Advances Artificial Intelligence in Robots"	• https://eandt.theiet.org/content/articles/2015/05/trial-and-error-advances-artificial-intelligence-in-robots/
	"How Utilities are Profiting from Big Data Analytics"	• https://eandt.theiet.org/content/articles/2014/01/how-utilities-are-profiting-from-big-data-analytics/
	"How AI is Being Used to Help Fight Crime"	• https://eandt.theiet.org/content/articles/2020/03/how-ai-is-being-used-to-help-fight-crime/
	"Neuromorphic Computing: Bringing Brain to Bear"	• https://eandt.theiet.org/content/articles/2014/03/neuromorphic-computing-bringing-brain-to-bear/

	"Activist Reignites Case Against Police Use of Facial Recognition"	• https://eandt.theiet.org/content/articles/2020/06/activist-reignites-case-against-police-use-of-facial-recognition/
Forbes	*"Google's Artificial Intelligence Machines Are 10% Smarter Than Google Engineers. Or Maybe Not"*	• https://www.forbes.com/sites/gilpress/2015/11/04/googles-artificial-intelligence-machines-are-10-smarter-than-google-engineers-or-maybe-not
	"93% if Investors Say AI Will Destroy Jobs, Governments Not Prepared"	• https://www.forbes.com/sites/johnkoetsier/2016/11/10/93-of-investors-say-ai-will-destroy-jobs-governments-not-prepared/#558925627cef
	"A Series of Unfortunate Tech Predictions – Artificial Intelligence and IoT Are Inseparable"	• https://www.forbes.com/sites/theopriestley/2015/12/08/a-series-of-unfortunate-tech-predictions-artificial-intelligence-and-iot-are-inseparable/#4e1eae137548
	"The Teen, The Billionaire and the Revolutionary Search Tool"	• https://www.forbes.com/sites/parmyolson/2012/02/22/the-teen-the-billionaire-and-the-revolutionary-search-tool/#747774125928
	'How Artificial Intelligence Can Lighten the Load for Customer Service Representatives"	• https://www.forbes.com/sites/forbestechcouncil/2020/06/02/how-artificial-intelligence-can-lighten-the-load-for-customer-service-representatives/#1300077e46dd
	"10 Powerful Examples of Artificial Intelligence in Use Today"	• https://www.forbes.com/sites/robertadams/2017/01/10/10-powerful-examples-of-artificial-intelligence-in-use-today
	"Why Your Brain Isn't a Computer"	• https://www.forbes.com/sites/alexknapp/2012/05/04/why-your-brain-isnt-a-computer/#3cfcd02313e1
	"The Age of Artificial Intelligence in Fintech"	• https://www.forbes.com/sites/falgunidesai/2016/06/30/the-age-of-artificial-intelligence-in-fintech/#744cb3b65028
	"The Future of Artificial Intelligence in the Workplace"	• https://www.forbes.com/sites/vishalmarria/2019/01/11/the-future-of-artificial-intelligence-in-the-workplace/#57d467f173d4

	"Elon Musk, Silicon Valley Elite Launch 'Open Artificial intelligence' With $1 Billion'	• https://www.forbes.com/sites/ericmack/2015/12/11/elon-musk-sam-altman-peter-thiel-others-launch-open-a-i-with-1-billion-donation/#1d952ff41a32
LiveScience	*"The Roots of Creativity Found in the Brain"*	• https://www.livescience.com/39671-roots-of-creativity-found-in-brain.html
	"Can Humans Survive?"	• https://www.livescience.com/9956-humans-survive.html
	"Earth's Largest Dinosaur 'Walks' in New Computer Simulation"	• https://www.livescience.com/40820-dinosaur-movement-digital-model.html
	"Artificial Intelligence Helps Spot Fossil Sites"	• https://www.livescience.com/17203-artificial-intelligence-fossils.html
	"Image Gallery: Snapshots of Unique Ape Faces"	• https://www.livescience.com/15495-image-gallery-snapshots-unique-ape-faces.html
	"Humanity Must 'Jail' Dangerous AI to Avoid Doom, Experts Say"	• https://www.livescience.com/18760-humans-build-virtual-prison-dangerous-ai-expert.html
	"Intelligent Robots Will Overtake Humans by 2100, Experts Say"	• https://www.livescience.com/29379-intelligent-robots-will-overtake-humans.html
	"Fab 4 Math: Computer Maps Beatles' Musical Evolution"	• https://www.livescience.com/47061-musical-progression-algorithm-analyzes-beatles.html
	"Your Brain Waves Could Predict if an Antidepressant Will Work for You"	• https://www.livescience.com/brain-waves-depression-treatment.html
	"9 Super-Cool Uses for Supercomputers"	• https://www.livescience.com/6392-9-super-cool-supercomputers.html
Medium	*"Artificial Intelligence; Devastation or Salvation?"*	• https://medium.com/real-ventures/harnessing-ai-for-good-6e0dc971c13e

	"What is Artificial Intelligence?"	• https://machinelearnings.co/how-to-prepare-your-career-for-artificial-intelligence-driven-automation-1bb153759b3b
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10. Glossary

Table 4. List of Terminologies

Term	Description
Invisible sciences	• Concepts, fields, or things within STEM that lack tangible form. Non-AI examples include climate change or wind power where interactions and consequences are visible, but the root phenomena are not.
Non-technical	• A person who does not have a formal education in, or thorough understanding of STEM concepts. This may include persons belonging to a social sciences, fine arts, or business backgrounds.
Visual media	• Images, icons, vector graphics, photographs, designs, graphs, charts, videos, and so on.
Visual representation	• Graphic-based renderings used to identify an abstract concept or intangible thing.
Science communication	• A categorical term including job titles, activities, and creative practices where scientific concepts are distilled for information sharing.
Visualization	• The result of converting a non-visual concept or thing to a visual form.
Science visualization	• Concepts or things within STEM fields that have been visually depicted using creative thought and/or technologies.
AI Narratives	• Narratives, or stories that have AI as a central character, theme, or plot component and that commonly manifest through novels, films, and TV shows.
Represented participants (RP)	• Harrison's (2003) terminology for the subject of an image as an active element in a viewer's relationship to, or experience of the image