AI Matters

Annotated Table of Contents

Links

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Contents Legend

Book Announcement

Ph.D. Dissertation Briefing

AI Education

Event Report

Hot Topics

Humor

AI Impact

AI News

Opinion

Paper Précis

Spotlight

Video or Image

Details at http://sigai.acm.org/aimatters

Welcome to AI Matters 6(3)

Iolanda Leite, co-editor (Royal Institute of Technology (KTH); aimatters@sigai.acm.org)
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DOI: 10.1145/3446243.3446244

Issue overview

Welcome to the last issue of this year's AI Matters Newsletter!

We start with a report on upcoming SIGAI Events and Conference reports by Louise Dennis, our conference coordination officer. In our regular Education column, Todd Neller introduces the next AAAI/EAAI-2022 mentored undergraduate research challenge: AI-Assisted Game Design (AIAGD). We then bring you our regular Policy column, where Larry Medsker covers ongoing discussions on AI policy, this time with a special focus on Europe and the US.

Finally, we close with two article contributions. The first article is by our former co-editor in chief Amy McGovern, about a newly established NSF-funded AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography that she now directs. The second paper discusses the very timely topic of ways that AI can aid students in post-secondary education.

Special Issue: AI For Social Good

Recognizing the potential of AI in solving some of the most pressing challenges facing our society, we are excited to announce that the next Newsletter of AI Matters will be a special issue on the theme of "AI for Social Good." We solicit articles that discuss how AI applications and/or innovations have resulted in a meaningful impact on a societally relevant problem, including problems in the domains of health, agriculture, environmental sustainability, ecological forecasting, urban planning, climate science, education, social welfare and justice, ethics and privacy, and assistive technology for people with disabilities. We also encourage submissions on emerging problems where AI advances have the potential to influence a transformative change, and perspective articles that highlight the challenges faced by current standards of AI to have a societal impact and opportunities for future research in this area. More details to be coming soon on http://sigai.acm.org/aimatters. Please get in touch with us if you have any questions!

Submit to AI Matters!

Thanks for reading! Don't forget to send your ideas and future submissions to *AI Matters*! We're accepting articles and announcements now for the next issue. Details on the submission process are available at http://sigai.acm.org/aimatters.

Iolanda Leite is co-editor of AI Matters. She is an Associate Professor at the School of Electrical Engineering and Computer Science at the KTH Royal Institute of Technology in Sweden. Her research interests are in the areas of Human-Robot Interaction and Artificial Intelligence. She aims to develop autonomous socially intelligent robots that can assist people over long periods of time.

Anuj Karpatne is co-editor of AI Matters. He is an Assistant Professor in the Department of Computer Science at Virginia Polytechnic Institute and State University (Virginia Tech). He leads the Physics-Guided Machine Learning (PGML) Lab at Virginia Tech, where he develops novel ways of integrating scientific knowledge (or physics) with machine learning methods to accelerate scientific discovery from data.

Events

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This section features information about upcoming events relevant to the readers of AI Matters, including those supported by SIGAI. We would love to hear from you if you are are organizing an event and would be interested in cooperating with SIGAI.For more information about conference support visit sigai.acm.org/activities/requesting_sponsorship.html.

3rd International Conference on Artificial Intelligence & Virtual Reality (AIVR 2020)

Virtual online event, December 14-18, 2020
http://ieee-aivr.org
IEEE AIVR is a unique event, addressing researchers and industries from all areas of AI as well as Virtual, Augmented, and Mixed Reality. It provides an international forum for the exchange between those fields, to present advances in the state of the art, identify emerging research topics, and together define the future of these exciting research domains. Due to the COVID-19 situation, the conference will be hosted virtually this year and some parts will be streamed online for free. Please refer to the conference's website for information about registration and the program.

20th International Conference on Autonomous Agents and Multiagent Systems (AAMAS21)

Virtual online event, May, 3-7, 2021
https://aamas2021.soton.ac.uk/
AAMAS is the leading scientific conference for research in autonomous agents and multiagent systems. The AAMAS conference series was initiated in 2002 as the merging of three respected scientific meetings: the International Conference on Multi-Agent Systems (ICMAS), the International Workshop on Agent Theories, Architectures, and Languages (ATAL), and the International Conference on Autonomous Agents (AA). The aim of the joint conference is to provide a single, high-profile, internationally-respected archival forum for scientific research in the theory and practice of autonomous agents and multiagent systems.

Due to the ongoing COVID-19 pandemic, the 20th edition of AAMAS, originally scheduled to be held in London, will take place as a virtual event online. Please refer to the conference's website for information about the program and instructions for attending the conference.

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Conference Reports

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DOI: 10.1145/3446243.3446246

This section features brief reports from recent events sponsored or run in cooperation with ACM SIGAI.

2nd IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR 2019)

San Diego, USA, December 9-11, 2019
https://aivr.science.uu.nl/2019/

AIVR 2019 was co-located with the IEEE International Symposium on Multimedia (ISM), which is organized by the same IEEE Technical Committee. Together both conferences had an attendance of about 175+ participants.

Overall, IEEE AIVR received 67 submissions over all submission categories (not including workshops). Being in its second year now, AIVR slowly starts to create a community and develop its own profile. Several papers nicely demonstrated the relation between AI and VR/AR and the potential of bringing these two communities together in a unique event. Some submissions exclusively covered AI or VR/AR. A few of these were accepted because the conference reasoned that if the aim was to bring people from these communities together, it needed to be open to people who are not working in both fields yet, but whose work is of potential interest to both communities. These were not included in the main program though but presented in the special sessions or poster session.

All submissions were carefully reviewed in an elaborate process. Several rejected papers were invited to other categories. All of these were well reviewed and showed potential, but lacked a bit in depth, level, or conclusiveness in the results. Thus, they were very well suited for the newly introduced poster session and special session. The combined poster and demo session actually made a very nice and well received addition to this year's event.

Overall, the conference organization went smoothly, thanks to the experienced organization team (which also co-hosted IEEE ISM and has a long successful history of conference organization for IEEE). Submission rates were a bit lower than expected, although the community seems to grow and the event gets better recognized.

The conference was sponsored by IEEE Computer Society and financially supported by the IEEE Technical Committee on Semantic Computing (IEEE TCMC).

In conclusion, the organising committee was happy with the outcome and optimistic that the conference is on the right track and will grow in the future. The support of ACM and its three SIGs helped a lot in achieving this.

International Conference on Autonomous Agents and Multi-Agent Systems (AAMAS 2020)

Virtual Online, May 11-13, 2020
https://aamas2020.conference.auckland.ac.nz/

The Autonomous Agents and Multi-Agent Systems (AAMAS) conference series gathers researchers from around the world to share the latest advances in the field. Agents, entities that can interact with their environment or other agents, are an increasingly important field of artificial intelligence. Agents can learn, reason about others, adopt norms, and interact with humans in both virtual and physical settings. This field includes contributions to many areas across artificial intelligence, including game theory, machine learning, robotics, human-agent interaction, modeling, and social choice. While the majority of the work is academic investigations with lab-based experiments, there have also been a growing number of real-world deployments with direct impact on governmental and commercial organizations.

The 19th International Conference on Autonomous Agents and Multi-Agent Systems was originally scheduled to be held in Auckland, NZ. Due to COVID-19 travel restrictions, it was conducted as a virtual conference from May 11-13, 2020 with the videos hosted on the underline.io platform. The live stream of

the virtual conference was a single track of keynotes and a panel. It featured keynote presentations by Carla Gomes (Cornell), Alison Heppenstall (U of Leeds), Sergey Levine (UC-Berkeley), and Thore Graepel (DeepMind). The ACM SIGAI Autonomous Agents Research Award talk was presented by Muninder P. Singh (NCSU), and Dominik Peters (CMU) delivered the Victor Lesser Dissertation Award presentation. There was a Blue Sky Panel that discussed future research directions for the multi-agent systems community. The best paper of the Blue Sky track was delivered by Frank and Virginia Dignum.

Paper authors recorded 15 minute talks which were archived on the underline.io site. In total there were 847 paper submissions, 186 of the submissions were accepted as full papers (23%) and 129 as extended abstracts (16%). The top 20% of accepted papers from the main track were nominated for an expedited review process at Journal of Autonomous Agents and Multi-Agent Systems. The smaller meetings (workshops, doctoral mentoring consortium) primarily relied on Zoom; tutorials were free to view on the underline.io platform. Conference costs were covered by authors, and attendance was free for participants. During the conference, participants communicated using Discord (which supports a chat lobby, message board and a VoIP chatting system) and Online Town, a video conferencing system that allows people to hold separate video conversations in parallel by walking around a virtual conference center.

Like many other 2020 conferences, the major challenge was dealing with the COVID-19 situation. The conference negotiated the mutually beneficial agreement of returning to Auckland for AAMAS 2022 and using pre-paid venue deposits for 2020 as a down payment for 2022. After the conference switched to the virtual-only format, the conference halved the registration fee for authors and made the conference free for participants and workshop authors. The conference had 292 registered paper authors and 104 workshop registrations. On the first day of the conference, the live stream had 1318 viewers; during the first week, 3726 users watched the AAMAS conference videos. Most participants favorably reviewed the virtual conference and would like the option to attend virtually in the future.

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AI Education Matters: 2022 EAAI Mentored Undergraduate Research Challenge: AI-Assisted Game Design

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DOI: 10.1145/3446243.3446247

Introduction

In this column, we introduce the next AAAI/EAAI-2022 mentored undergraduate research challenge: AI-Assisted Game Design (AIAGD). We survey a number of AIAGD applications, provide references, and make suggestions for undergraduates to engage in this open-ended, creative research challenge.

AI-Assisted Game Design

There is a very large body of research on AI game playing agents dating back to the foundations of Artificial Intelligence (Russell & Norvig, 2020, p. 175–179). What distinguishes AIAGD from AI game play is that the results of an AI technique are applied to the design of the game itself. This can take on many forms and employ a wide variety of algorithms beyond game-tree search. Most commonly, researchers use the term to describe procedurally generated content (e.g. maps, levels) in games (Shaker, Togelius, & Nelson, 2016). However, we envision (along with others) a future of game development where AI largely takes the place of human playtesters, and suggests refinements and innovations in design.

Game Analysis for Game Improvement

Let us first motivate the benefit of AI-assistance through some common examples. Magic: The Gathering (MTG), the first trading card game, has enjoyed great commercial success since its release in 1993. Different formats of play involve different subsets of card set releases. For instance, standard format allows play of the last 1-2 years of sets. Each set is playtested by Wizards of the Coast R&D, yet in recent years there has been significant underestimation of the power of cards to "warp" the format metagame, i.e. pressure players to play fewer, similar deck types in order to be competitive. Since 2018, a record 20 cards have been banned from play in the standard format.

While some blame recent card bans on the speed with which players "solve" optimal deck construction with unprecedented online play data and analytics, one might also argue that a relatively small group of playtesters under time constraints cannot possibly anticipate all consequences of card synergies or hope to balance a format before its release. One might envision AI-assisted set design in the future that would anticipate problematic card designs and balance a set to allow diverse, viable deck types for competition, what is called a "healthy metagame".

MTG is not alone in this regard. One that is familiar with most any commercial card game can often provide examples of cards that are "over-powered" (OP), e.g. the Guild Hall card of San Juan or the Mistress of Ceremonies card in St. Petersburg, as well as underpowered cards one never wants to play. Ideally, every component and every mechanic of a game should have some reasonable use for being part of the design beyond challenging the player to discern their uselessness.

This is not limited to card games. Players of fighting video games are used to frequent patches that "nerf"/"buff", i.e. make weaker/stronger, weapons that are too strong/weak, respectively. For example, in Fortnite's July 2020 patch, the Tactical Submachine Gun (SMG) was buffed, and the Compact SMG was nerfed. Modern video game designers find themselves continually developing games, mining play data for hints of better parameter settings.

However, it would be too much to expect undergraduate researchers to make a significant contribution to AIAGD of the most complex games, so we recommend entry-level research on very simple games or puzzles (i.e. solitaire games). For example, the card game "Fowl Play" is a jeopardy card game based on

the folk dice game "Pig". In (Neller, Malec, Presser, & Jacobs, 2014), the computation of optimal play was used to seek out optimal komi (i.e. points awarded to the disadvantaged player to make the game more fair), and ultimately to redesign the distribution of cards and komi so as to very closely approximate a fair game.

AI-Assisted Game Invention

There are also research efforts to use AI to search subspaces of game design in order to create new games. The work of Cameron Browne with his Digital Ludeme Project seeks to express a wide variety of historical games according to game units called "ludemes". Browne used an evolutionary algorithmic approach to computationally design the game Yavalath (Browne, 2011, pp. 75-85). One can find interesting examples of the intersection of AI and game design in Browne's Game and Puzzle Design Journal.

As a simpler example, the solitaire card game "Birds of a Feather" (Neller, 2016), was AI-assisted in design in that statistics from an AI solver showed that (1) the "adjacent rank" portion of the movement rules brought better balance to movement types, and (2) the 4×4 tableau of cards was a sweet spot for balancing the level of puzzle challenge with a high probability of solvability given a random deal. Additionally, an AI solver helped reveal gameplay quality characteristics of deals designed to be challenging. (Neller & Ziegler, 2019)

What is the Utility?

While it is easy to see that AI techniques can aid us in optimizing design, it is important to critically think about what we are seeking to optimize. Whereas much of the work cited above concerns itself to optimal play in the sense of maximizing the probability of winning, the entertainment industry seeks to optimize game play experience, e.g. player engagement. In conversation, a video game designer explained, "We don't want an AI [player] that plays optimally, we want an AI that will create a close game that will draw the [human] player into their best play ... and then barely lose to that [human] player. That is the most satisfying experience."

So there is another sense in which AI assists in game design through adaptively shaping the quality of a player's experience. Entertainment and engagement are the watchwords of this locus of work.

Mentored Undergraduate Research Challenge

The AAAI/EAAI-2022 Mentored Undergraduate Research Challenge is to submit a paper that describes a creative application of AI technique(s) to the design of a game or puzzle. As mentioned, this can take many forms, including but not limited to:

- Existing game improvement through AI game analysis,
- New game design through AI search in a design space,
- Adaptive technologies shown empirically to improve player experience, and
- AI procedural generation of game play elements.

A team must consist of at least one faculty mentor and at least one undergraduate researcher. The mentor will be expected to guide the research and full paper writing to be submitted to EAAI-2022, and will serve as a reviewer for up to 4 other paper submissions. We recommend that the student read from sources in the most interesting locus of work described above, and *pursue simple games and simple aims first*. If you enjoy games and puzzles, enjoy the ambitious and diverse body of AI techniques, and would like to bring these together in creative expression, please form a team and contact the author of this columns with team member names, email addresses, and roles (e.g. mentor, undergraduate).

Graduate students are permitted to join teams, as long as at least one undergraduate is an active participant. Team sizes and the number of teams from an institution are not limited. However, the number of accepted papers will be limited, with peer review focused on quality of writing, evidence of creativity, and relevance to AI-assisted game design.

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AI Policy Matters

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DOI: 10.1145/3446243.3446248

Abstract

AI Policy Matters is a regular column in *AI Matters* featuring summaries and commentary based on postings that appear twice a month in the *AI Matters* blog (https://sigai.acm.org/aimatters/blog/). We welcome everyone to make blog comments so we can develop a rich knowledge base of information and ideas representing the SIGAI members.

What Can Biden Do for Science?

A *Science—Business* Webcast presented a forum of public and private sector leaders discussing ideas about the need for the president-elect to convene world leaders to re-establish 'rules of engagement' on science. Participants in the Webcast urged that a global assembly "should press leaders of the big industrial nations to open – or re-open – their research systems, while also ensuring that COVID-19 vaccines are freely available to everyone in the world." About an international summit, Robert-Jan Smits, former director-general of the European Commission's research and innovation directorate said it "would really show that senior leaders are turning the page."

Brookings Webinar on the Future of AI

On November 17, 2020, the Brookings Institution Center for Technology Innovation hosted a webinar to discuss the future of AI, how it is being deployed, and the policy and legal issues being raised. Speakers explored ways to mitigate possible concerns and how to move forward safely, securely, and in a manner consistent with human values.

Section 230

On November 18, experts from ACM's US Technology Policy Committee (USTPC) discussed the legal liability of Internet platforms such as Facebook and Twitter under Section 230 of the Communications Decency Act. USTPC panelists were Andy Grosso (Moderator), Mark Rasch, Pam Samuelson, Richard M. Sherman, and Danny Weitzner. Politico reports that "Trump for months has urged Congress to revoke industry legal shield Section 230, while its staunchest critics largely pushed to revamp it instead. But the president's more drastic call for a total repeal — echoed by Biden for very different reasons — is gaining traction among Republicans in Washington. The NYT reported Thursday that White House chief of staff Mark Meadows has even offered Trump's support for a must-pass annual defense spending bill if it includes such a repeal."

The European AI Policy Conference

AI may be the most important digital innovation technology transforming industries around the world. "Businesses in Europe are at the forefront of some of the latest advancements in the field, and European universities are home to the greatest concentration of AI researchers in the world. Every week, new case studies emerge showing the potential opportunities that can arise from greater use of the technology." The European AI Policy Conference brings together leading voices in AI to discuss why European success in AI is important, how the EU compares to other world leaders today, and what steps European policymakers should take to be more competitive in AI. "The European AI Policy Conference is a high-level forum to connect stakeholders working to promote AI in Europe, showcase advances in AI, and promote AI policies supporting its development to EU policymakers and thought leaders."

On the EU Data Governance Act

The European Commission is planning to release its Data Governance Act to facilitate data sharing within the EU. The goal is to increase data sharing among businesses, make

more public-sector data available for reuse, and foster data sharing of personal data, including for 'altruistic' purposes. While the goals of the act are commendable, many of the specific policies outlined in a draft would create a new data localization requirement, undermine the EU's commitments to digital free trade, and contradict its open data principles.

The Center for Data Innovation submitted feedback to the European Commission's roadmap titled "Legislative framework for the governance of common European data spaces." The European Commission published a data strategy in February 2020 with the goal of creating a single market for data. As part of that vision, the Commission has proposed creating "European data spaces" with clear and consistent rules across member states for access and use of data in key sectors of the economy. To that end, the Commission has invited feedback on its initial plans to propose a legislative framework that would 1) increase access to publicly held data; 2) support voluntary data sharing by individuals and organizations; 3) develop technical standards and promote interoperability to lower the cost of data sharing; and 4) support data intermediaries to share data between different stakeholders.

Possible meta solutions for policymakers to keep up with technological advances are discussed in "AI Ethics and Data Governance: A Virtuous Cycle" and the Center for Data Innovation Response to the European Commission's Inception Impact Assessment "Legislative Framework for the Governance of Common European Data Spaces"

Policy Issues from AI and Ethics

The inaugural issue of the new journal AI and Ethics contains several articles relevant to AI and Public Policy.

Jelinek, T., Wallach, W., and Kerimi, D. "Policy brief: the creation of a G20 coordinating committee for the governance of artificial intelligence" *AI and Ethics* (2020). https://doi.org/10.1007/s43681-020-00019-y This policy brief proposes a group of twenty (G20) coordinating committee for the governance of artificial intelligence (CCGAI) to plan and coordinate on a multilateral level the mitigation of AI risks. The G20 is the appropriate regime complex for such a metagovernance mechanism, given the involvement of the largest economies and their highest political representatives.

Gambelin, O. "Brave: what it means to be an AI Ethicist" *AI and Ethics* (2020). https://doi.org/10.1007/s43681-020-00020-5 This piece offers a preliminary definition of what it means to be an AI Ethicist, first examining the concept of an ethicist in the context of artificial intelligence, followed by exploring what responsibilities are added to the role in industry specifically, and ending on the fundamental characteristic that underlies it all: bravery.

Smith, P., Smith, L. "Artificial intelligence and disability: too much promise, yet too little substance?" *AI and Ethics* (2020). https://doi.org/10.1007/s43681-020-00004-5 Much has been written about the potential of artificial intelligence (AI) to support, and even transform, the lives of disabled people. Many individuals are benefiting, but what are the true limits of such tools? What are the ethics of allowing AI tools to suggest different courses of action, or aid in decision-making? And does AI offer too much promise for individuals? We draw as to how AI software and technology might best be developed in the future.

Coeckelbergh, M. "AI for climate: freedom, justice, and other ethical and political challenges" *AI and Ethics* (2020). https://doi.org/10.1007/s43681-020-00007-2 Artificial intelligence can and should help to build a greener, more sustainable world and to deal with climate change, but these opportunities also raise ethical and political issues that need to be addressed. This article discusses these issues, with a focus on problems concerning freedom and justice at a global level, and calls for responsible use of AI for climate in the light of these challenges.

Hickok, M. "Lessons learned from AI ethics principles for future actions" *AI and Ethics* (2020). https://doi.org/10.1007/s43681-020-00008-1 The use of AI systems is significantly more prevalent in recent years, and the concerns on how these systems collect, use and process big data has also increased. To ad-

dress these concerns and advocate for ethical and responsible AI development and implementation, NGOs, research centers, private companies, and governmental agencies have published more than 100 AI ethics principles and guidelines. Lessons must be learned from the shortcomings of AI ethics principles to ensure that future investments, collaborations, standards, codes, and legislation reflect the diversity of voices and incorporate the experiences of those who are already impacted by AI.

Please join our discussions at the SIGAI Policy Blog.

Larry Medsker is a Research Professor at The George Washington University, where he was founding director of the Data Science graduate program. He is currently a faculty member in the GW Human-Technology Collaboration Lab and Ph.D. program. His research in AI includes work on artificial neural networks, hybrid intelligent systems, and the impacts of AI on society and policy. He is Co-Editor-in-Chief for the journal *AI and Ethics* and the Public Policy Officer for the ACM SIGAI.

NSF AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography

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DOI: 10.1145/3446243.3446249

NSF AI Institutes

In 2019, the National Science Foundation (NSF) launched a new national investment in Artificial Intelligence (AI) to create a network of national AI institutes. Each institute will serve as a nexus of collaboration to create next-generation theory and applications of AI and to work synergistically with academia and industry. In the fall of 2020, NSF announced 5 new NSF AI institutes and 2 additional institutes funded by the United States Department of Agriculture (USDA) and the National Institute of Food and Agriculture (NIFA). Each institute is funded for approximately $20M over 5 years to make significant advances in foundational and applied AI research.

The inaugural institutes are:

- NSF AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography
- NSF AI Institute for Foundations of Machine Learning
- NSF AI Institute for Student-AI Teaming
- NSF AI Institute for Molecular Discovery
- NSF AI Institute for Artificial Intelligence and Fundamental Interactions
- USDA-NIFA AI Institute for Next Generation Food Systems
- USDA-NIFA AI Institute for Future Agricultural Resilience, Management, and Sustainability

Trustworthy AI for Environmental Sciences

The vision of the NSF AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography (AI2ES, Figure 1) is to create trustworthy Artificial Intelligence (AI) methods for diverse environmental science (ES) users that will revolutionize our understanding and prediction of high-impact atmospheric and ocean science phenomena and create new educational pathways to develop a more diverse AI and environmental science workforce. We are a convergent center with leading experts from AI, atmospheric and ocean science, risk communication, and education all working synergistically to develop and test trustworthy AI methods that will transform our understanding and prediction of the environment.

Figure 1: NSF AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography (AI2ES). See https://www.ai2es.org for more.

AI2ES has three main research foci: 1) foundational research on trustworthy AI/ML; 2) use-inspired ES research where an integrated effort tests trustworthy AI techniques in both atmospheric and ocean sciences; and 3) foundational RC research on trustworthy AI in ES, to understand user thinking, information needs, and effective communication approaches. The three research components are tightly integrated (Figure 2). To develop meaningful and novel approaches to trustwor-

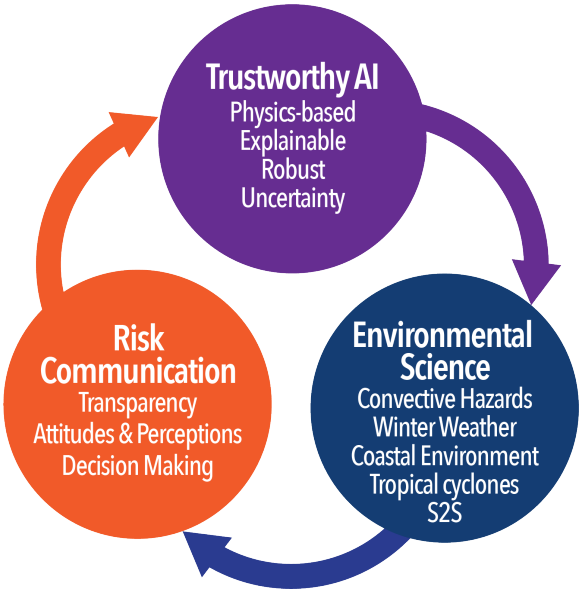

Figure 2: AI2ES foundational research in trustworthy AI, environmental science, and risk communication form a virtuous cycle.

thy AI for ES, it is necessary for scientists to have a deep understanding of the nature of AI *and* ES [2, 12, 3, 13]. They must also have a deep appreciation for the nature of ES user trust and risk perceptions, information processing, and decision making. This integrated convergent approach will enable the development of trustworthy AI systems and risk communication techniques that foster appropriate levels of trust by ES decision makers.

AI2ES trustworthy AI methods will directly address the major scientific challenges that ES data poses [4]. For example, when predicting a tornado, it is critical that the AI method correctly handle heterogeneous, multi-scale, spatiotemporal data. Most AI methods assume that samples are independent and identically distributed, yet this is not true for ES data. Fundamental fields, such as pressure, temperature, or wind, are highly spatio-temporally autocorrelated. A tornado requires multi-scale spatio-temporal factors to coalesce [6, 1, 11]. Additionally, multi-scale factors can influence the background probability of a severe storm and the intensity of the tornado, such as the position of the jet stream affecting the probability of a large-scale tornado outbreak [10, 8, 5]. Weather is also non-linear and chaotic [7], providing another challenge for AI. Training AI for high-impact weather can also be difficult due to the small number of reliable labeled examples, stemming from the rarity of events, such as tornadoes, or from the lack of humans in less populated areas to report hazards [14]. In addition, although humans reason about weather phenomena using object-level concepts such as “rear-flank downdrafts” [9], it is difficult to precisely define such objects for automated identification. Finally, as our climate changes, the fundamental driving forces behind the examples are non-stationary. All of these challenges make standard AI approaches infeasible.

Trust is a social phenomenon, and our integration of risk communication research across AI2ES activities provides an empirical foundation for developing user-informed, trustworthy AI by engaging and partnering with key environmental decision makers from communities that will be using the techniques developed. Our partnership of multiple academic institutions, NCAR, NOAA, and private industry spans the full cycle of fundamental research into trustworthy AI and enables rapid integration of trustworthy AI for increased societal impact. Environmental science provides a perfect testbed to advance trustworthy AI given its grounding in nature’s physical laws and conservation principles as well as the broad range of stakeholder feedback and high societal impact.

AI2ES also introduces novel broadening participation and workforce development activities fully integrate with AI2ES research on trustworthy AI, environmental science and risk communication. In coordination with two Hispanic (HSI) and Minority Serving (MSI) institutions, we are creating and piloting test a novel community college certificate in AI for the environmental sciences. This certificate will significantly enhance the diversity of the STEM workforce. AI2ES is also developing AI/ES training for all levels of students, including K-12 outreach and modules, and online education modules that leverage our private industry’s existing educational resources and networks. These will all be available on our website https://www.ai2es.org.

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Artificial Intelligence for Students in Postsecondary Education: A World of Opportunity

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Abstract

AI-based apps can facilitate learning for all post-secondary students and may also be useful for students with disabilities. Here we share some reflections from discussions that took place during two advisory board meetings on the use of such apps for students with disabilities at the post-secondary level.

Keywords: college and university students with disabilities, artificial intelligence apps, mobile AI apps

Introduction

Intelligent technologies (such as smartphones and tablets which incorporate principles of universal design) have the potential to increase the inclusion of students with disabilities and other diverse learners in different aspects of post-secondary education. Artificial intelligence ("AI"), which for our purposes includes "computing systems that are able to engage in human-like processes such as learning, adapting, synthesizing, self-correction and use of data for complex processing tasks" (Popenici & Kerr, 2017), is in many respects the bedrock of more universally accessible engagement, because it has the potential to permit technology to adapt to the diversity and unique needs of users. While the practical and mundane benefits of artificial intelligence systems are taken for granted by society at large (e.g. speech recognition, real-time captioning (Mathur, Gill, Yadav, Mishra, & Bansode, 2017), linguistic translation (Kapoor, 2020), or organizing tools such as calendars and "to do" lists (Canbek & Mutlu, 2016)), often overlooked are the potential benefits to specific populations who would otherwise be dependent upon third parties for support. For example, artificial intelligence has been successfully harnessed to provide people with mental health concerns an always-available, point-in-time responsive, supplementary or intermediate support system (Inkster, Sarda, & Subramanian, 2018). The available evidence at present indicates that individuals with disabilities are conspicuously excluded from AI training models and have not yet become meaningful contributors to, or beneficiaries of, the ongoing discussions surrounding artificial intelligence and machine learning (Lillywhite & Wolbring, 2020).

Despite advances in inclusive education practices, the reality is that for many of the 10%-20% (Eagan et al., 2017; Fichten et al., 2018; Snyder, De Brey, & Dillow, 2016) of students with disabilities, barriers to accessing post-secondary education continue to persist. Inaccessible websites, commonplace at some of

the world's most renowned institutions, continue to pose significant accessibility barriers (Huffington, Copeland, Devany, Parker-Gills, & Patel, 2020). In spite of increased use of automatic speech recognition, Deaf and hard of hearing students often do not have adequate access to qualified real-time captioning (Butler, Trager, & Behm, 2019). Even where captioning or interpreters are available, Deaf and hard of hearing students may lag behind their peers due to the increased cognitive load of processing the visual translation of audio information, visual attention limits associated with trying to track dispersed visual information in the classroom, difficulties engaging in discussions, and limited social interactions with peers, among other factors (Kushalnagar, 2019).

The initiative we report in this article had its genesis in prior research exploring the issue of *fairness* of AI for people with disabilities (in employment, education, public safety, and healthcare (Trewin et al., 2019)). Building on our previous research regarding the accessibility of information and computing technologies for post-secondary students (Fichten, Asuncion, & Scapin, 2014; Thomson, Fichten, Havel, Budd, & Asuncion, 2015) and the increasing use and utility of ubiquitous mobile technologies, such as smartphones and tablets in post-secondary education (Fichten et al., 2019), the question arose as to the impact and adoption of new AI-based technologies. We therefore convened an advisory group to gather input from post-secondary students, consumers with disabilities, post-secondary disability/accessibility service providers, faculty, and technology experts to explore how college and university students with diverse disabilities (visual or hearing impairments, learning disabilities, attention deficit hyperactivity disorder, etc.) could benefit from AI-based smartphone and tablet apps, and how these could facilitate student academic success. In summarizing the themes that emerged during the advisory board meetings, we hope to lay the groundwork for more in-depth and targeted initiatives to objectively evaluate the effectiveness of the tools currently being used, and to explore the feasibility and potential success of future innovations within the post-secondary education context.

The Advisory Board Meetings

We invited stakeholders from within our network who could provide insights on the use of artificial intelligence at the post-secondary level from diverse perspectives. In total, this included 38 individuals: 7 students, 3 disability/accessibility service providers, 14 faculty members (some with and some without disabilities), 9 technology experts, and 5 technology users with disabilities. Two advisory board meetings were held in May 2020, using the Zoom (San Jose, CA) videoconferencing system to accommodate for the different time zones in which the international attendees resided. Spontaneously, attendees divided themselves roughly in half into one of the two sessions. The following overarching questions were distributed in advance of the meetings and provided a framework for the discussion:

1. What AI-based smartphone or tablet technologies have you come across that are currently used by college and university students with disabilities? Which ones work well? Which ones do not?

2. What AI-based smartphone and tablet technologies are out there but are rarely considered even though they could help college and university students with disabilities do academic work?

3. What are some functions you can foresee in the future that AI-based smartphone and tablet technologies could perform to assist students with disabilities succeed in higher education? (i.e. It would be great if an AI-based smartphone and tablet technology could help a student do X.)

Summaries of comments from members of the advisory board, including the identification of specific tools and resources (see Adaptech Research Network, 2020), were then prepared. The resulting summaries, grouped and categorized by Adaptech Research Network team members according to theme and the nature of the application, are described more fully below.

Advisory Board Meeting Themes

General observations

Those who need AI the most are also the most likely not to be able to use AI: A recurring comment was that systems relying on artificial intelligence have the *potential* to open the world to individuals who cannot access information or environments in the same manner as everyone else. Unfortunately, because AI is based on training data and learning analytics derived from a generally able-bodied population, those who veer from what is viewed as 'the norm' and who have distinctive voice, facial, or movement characteristics are likely to be misunderstood (or not understood at all) by AI capture processes. As one individual described it:

> AI programs are made up of algorithms, or a set of rules that help them identify patterns so they can make decisions with little intervention from humans. But algorithms need to be fed data in order to learn those rules - and, sometimes, human prejudices can seep into the platforms.

Academic discussions surrounding the ethics of AI implementation are focused on issues surrounding the potential for discrimination or exclusion based on gender, race, language, or other identifiable characteristics. The issues of AI bias in the disability context go beyond these discussions because, unlike race or gender, there is no uniform cluster or data element that is common to everyone with a disability. Whether a particular AI integration will be useful may, for some users, depend on the degree to which additional idiosyncratic characteristics can be taken into account. In most applications, that functionality does not exist, and current research shows that the training data used to "teach" AI systems is lacking in diversity by not including individuals with disabilities (Kafle et al., 2020).

Students with disabilities may be more technologically advanced than their peers, but greater training and support is required: Students with disabilities who face daily barriers to access often develop a heightened ability to problem-solve and this can manifest through the use of technology. Past research has shown that individuals with more significant disabilities (e.g. those who are functionally blind) may actually develop more sophisticated technological capabilities than their peers. For example, Fichten, Asuncion, Barile, Ferraro, and Wolforth (2009) found that students who were functionally blind felt significantly more comfortable utilizing technology in the classroom than students who had low vision. Nonetheless, many instances were noted whereby students who could benefit from the use of AI-enabled technologies (such as Seeing AI) were simply unaware that such tools even existed. Learning that the technologies exist and how to effectively use them is, for many, a critical step in the transition from high school to post-secondary education. The lack of training is especially problematic for students who acquire a disability later in life and who do not have previous experience with the use of such devices.

Similarly, many students are unaware of the convenience and power that could be achieved by leveraging the integrated use of AI-enabled technologies. For example, the online service "IFTTT" (*If-This-Then-That*) allows users to schedule and pre-program cascading events based on triggers from web-enabled services. IFTTT could be used to detect (based on GPS data from a smartphone or a Fitbit) that a user is not in the classroom where they are expected to be according to their calendar and trigger a notification to make them aware that they are missing a class.

Current and potential utilization of existing AI tools to facilitate post-secondary learning

Chatbots

"Chatbots" – AI-enabled text-based conversationalists – are becoming common as a means of providing front-line support to users of technology and have the ability to provide quick answers to the most common questions that users might otherwise pose to a technical support agent. Chatbots have also been implemented in post-secondary institutions to provide on-demand answers to the many questions that students pose. Various universities have used AI-enabled Chatbots to facilitate the transition from high school

into university, guiding new students through the myriad of administrative matters that must be addressed at different points of the admissions cycle, such as applying for and responding to financial aid applications and enrolling/registering for courses at the appropriate time (Nurshatayeva, Page, White, & Gehlbach, 2020; Page & Gehlbach, 2017). In each case, the implementation of an AI-enabled chatbot was found to improve outcomes for first-year students, especially for those who were struggling or particularly 'at risk'. Aside from being responsive to students' point-in-time needs, these Chatbot services also permitted admissions and financial aid staff to redeploy resources to the more complex cases. Building on these past successes, several meeting attendees noted that Chatbots are also being implemented at their own institutions, primarily to support the needs of distance education students. These are being integrated into existing learning management systems (e.g. Moodle) to provide answers to common student questions such as, "When is my exam?" or "How can I organize my course documents?"

Emotional, mental health, and medical regulation

Students who experience emotional hurdles or mental health difficulties, many of which can be episodic in nature, are at a distinct disadvantage in the post-secondary environment which has traditionally lacked the flexibility to adapt to varying or changing individual needs (Arim & Frenette, 2019). Meaningful access to mental health support services has been found to be limited for many Canadian post-secondary students, despite the fact that mental health problems including anxiety, depression, and substance abuse are particularly acute among young adults age 18-25 (Nunes et al., 2014), and are especially prevalent during the current COVID-19 pandemic (Son, Hegde, Smith, Wang, & Sasangohar, 2020).

Where such support does not exist or is more limited, several AI-informed app-based tools were identified which can provide point-in-time support to aid in emotional, mental health, and medical regulation:

- *Brain in Hand* is an AI-enabled professional assistant that helps with making decisions, managing symptoms of anxiety, and responding to unexpected situations. Once the individual subscribes to this application, they gain access to a personal specialist to assist in setup, accessible self-management tools, and contact with a human support network.
- *Empower Me* is a digital coach that operates on smart glasses, to aid individuals with autism in self-regulating by helping them to understand facial expressions and emotions. Where appropriate, it draws attention to facial and eye cues.
- *SeizAlarm*, *My Medic Watch*, and *SmartWatch Inspyre* can detect seizures and trigger notifications to emergency contacts, providing information on the user's location and current status.
- *Woebot* is a mental health "chatbot" which can provide an outlet for students with depression, and has been shown to reduce depressive symptoms by employing positive thinking precepts commonly used in traditional Cognitive Behavioral Therapy (Fitzpatrick, Darcy, & Vierhile, 2017).

Many wearable technologies, such as "smart watches", can also cue in to increased levels of stress or anxiety, and provide reminders to take breaks and focus on breathing exercises in response. These tools cannot supplant the intervention of professional counselling, but may be useful in times of crises or when more structured support services are not readily available (Inkster et al., 2018).

Organizational and executive functioning aids

One of the most common areas where AI-enabled apps and tools were thought to be useful as an educational aid is in the area of personal organization and assisted executive functioning. More specifically, AI-enabled tools are being used to help coordinate the many dependent and parallel tasks that students must complete. For example, while personal assistants such as Google Assistant are, of course, capable of giving reminders, such reminders are far more helpful if they are presented in a context-aware manner (Singh & Varshney, 2019). For example:

- Aside from relying on items in an individual's calendar, AI can detect and recognize patterns in an individual's schedule and provide appropriate notifications, such as when an individual should leave for a meeting.
- For those commuting to and from work or school, *Google Maps* will often learn one's usual departure time and provide an alert indicating the expected travel time on a given day as a subtle reminder of when to leave.
- Personal assistants, such as *Siri* and *Google Assistant*, can be set to provide reminders at specific times or when reaching specific places (e.g. home, the grocery store, etc.), when the user anticipates being able to respond to those reminders.

Meeting attendees noted that while some students are using *Siri*, *Google Assistant*, *Alexa*, and other AI-enabled apps, they are often unaware of the power and context-enabled options that could be used to provide more meaningful and useful organizational assistance.

Input mediation

Entering information into a smartphone or tablet can be difficult for students who have physical or cognitive disabilities that impede interaction with the conventional keyboard. Several tools that mediate this interaction and help to improve the speed and efficiency of entering textual information were described by the team, including:

- *SwiftKey* and *FlickType* are AI-enabled keyboard applications that learn and adapt to match an individual's unique way of typing.
- *UNI* is an AI-enabled device (which requires a subscription service) that converts textual information into sign language and vice versa, including the ability to define custom and unique signs where required.
- Word prediction (which uses AI to understand context and recall common words used by a writer) is a built-in feature in most smartphone and tablet devices.
- Language processing AI applications, and linguistic revision tools such as *Antidote*, provide context-aware writing and revision assistance, which is particularly helpful for students with learning disabilities.

Accessing visual or textual information in alternative formats

For students who are blind, have low vision, or have other print disabilities such as a learning disability that impact the ability to read printed information, tools that facilitate the conversion of text into more accessible formats (e.g. audio) are particularly valuable. Text-to-speech systems that are capable of scanning a printed page of text and reading it aloud to users date back to the 1970s, with the introduction of the Kurzweil Reading Machines (Goodrich, Bennett, De l'Aune, Lauer, & Mowinski, 1979). However, over the past decade, the proliferation of AI technologies has permitted the development of far more sophisticated "computer vision" applications, allowing apps to identify or locate objects in the environment, describe scenes and photographs, and provide real-time navigation assistance.

With respect to accessing *textual* information, the team identified a number of existing "apps" and technologies which facilitate this task, including:

- *Seeing AI* or *Office Lens*, which use the cameras on smartphones and tablets to have the text that is in front of the camera spoken aloud.
- Technologies that aid in summarizing long pieces of text into a more abstract form. Available technologies do exist, such as
- SMMRY or Reddit's *AutoTLDR "bot"*, and research continues into making such automatic summaries more useful and accurate (Dangovski, Jing, Nakov, Tatalovic, & Soljacic, 2019).
- *OrCam*, a voice-activated wearable technology that uses a small onboard camera to read text.
- *Voice Dream Scanner*, an optical character recognition tool that can use the camera of a smartphone or tablet to read short texts as well as longer multi-page documents.
- *SensusAccess* provides a self-service solution to convert a range of electronic formats into electronic braille, audio MP3, DAISY, and e-book formats.

Importantly, while the above tools are all specialized programs targeted at those with specific disabilities, use of the text-to-speech

functionalities of modern smartphones, smart watches, and smart speakers can be used by any student who would benefit from bi-modal learning, or from effective proofreading, where they can listen to the text while also reading it. It is important to note, however, that the accuracy of such applications will depend on the quality of the text that is being scanned.

For accessing *non-textual* information, the following tools have been utilized:

- *Seeing AI*, which uses the cameras on smartphones and tablets to identify objects or scenes in front of the camera.
- *OrCam*, a voice-activated wearable technology that uses a small onboard camera to recognize and identify known faces, and which can also identify products based on their universal bar code.
- *CamFind*, which can identify objects in a photo or video stream.
- *Facebook* and *Twitter* now use artificial intelligence to automatically provide image captions for photos and pictures. The quality of these descriptions is improving, and this is important for all students given the increasing frequency with which instructors and academic institutions are using social media to communicate. However, it should be noted that manual alt text descriptions should continue to be incorporated to ensure that such images are accessible to screen-reader users.

For students who may be learning in their second language (or learning a second language), translation tools such as *Google Translate*, *Microsoft Translator*, or *DeepL* can also facilitate access to information. AI has increased the speed and accuracy of automated translation tools, but there remain significant limitations on these tools and the impact of context and nuance in language make it difficult to rely and trust in automated translations (Pantea, 2019).

Accessing auditory information in non-auditory formats

For students who are Deaf or who are hard of hearing, the need to access information from classroom (or online) lectures and videos through sign language or a textual format is acute. There are, however, others who may also benefit from access to information in non-auditory forms, including those with auditory processing deficits, as well as students who simply receive and retain information more effectively when it is in a written form. With the widespread and mainstream adoption of smart speakers and smartphone-based personal assistants (e.g. *Amazon Alexa*, *Google Home*, *Apple Siri*, *Samsung Bixby*), a significant amount of interest has been generated toward improving the quality and accuracy of speech recognition technologies. However, as described by in Rabiner and Juang (2008), this remains true today:

> The quest for a machine that can recognize and understand speech, from any speaker, and in any environment has been the holy grail of speech recognition research for more than 70 years. Although we have made great progress in understanding how speech is produced and analyzed, and although we have made enough advances to build and deploy in the field a number of viable speech recognition systems, we still remain far from the ultimate goal of a machine that communicates naturally with any human being.

The team described a wide range of means by which alternative representations of speech can be automatically generated:

- Public services such as *YouTube* and *Google Slides* now provide or enable the use of automatically generated captions, although the accuracy is very much dependent on the sound quality of the original production and varies significantly across languages.
- Some institutions maintain subscriptions with external service providers to generate automatic captions on pre-recorded videos.
- The *Zoom* videoconferencing service allows for real-time captioning by a meeting host, or through connections to external captioning providers (as well as enabling use of automatically generated captions). *WebEx* and *Microsoft Teams* have similar features.
- Most smartphone and tablet devices include a built-in feature to “dictate” (rather than type text) through their virtual personal assistant,

both to send a short message and for writing longer content (e.g. an email message, Office 365 Word document).

- *Just Press Record* is an AI-enabled mobile audio recording "app" that permits recording, transcription, and iCloud synchronization of voice memos across iOS devices.
- Translation tools such as *Microsoft Translator* or *Google Translate* can also be used to generate a "real time" transcript if the speaker is wearing a microphone. This permits students to both listen to the presentation and follow along with the text.

Several individuals also noted that the above tools could be used by *any* student who might, for example, want to talk through a plan, create an outline, or simply brainstorm ideas, without becoming fixated on the task of *writing*.

Concerns over privacy and security have led some to eschew the use of these built-in speech-to-text features (which rely on cloud-based technologies, where audio is sent to a remote processing center for analysis, and the text returned to the user's device) in favor of "on-device" solutions (such as *Dragon Naturally Speaking*), even though such technologies are less advanced and have a lower overall accuracy.

A separate concern was identified regarding the linear nature of audio recordings, and the inherent difficulty for anyone in locating specific information within such a recording. It was suggested that AI and speech recognition may provide an answer to this problem by permitting a user to "search" audio for specific words. While no specific application or technology was discussed, this approach is actually being used and further developed to predict positive COVID-19 test results based on audio recordings (and key words such as smell and taste) from telemedicine assessments (Obeid et al., 2020).

Consistent with existing empirical evidence (e.g. Rohlfing, Buckley, Piraquive, Stepp, & Tracy, 2020), it was noted by individuals that mainstream speech recognition technologies do not work especially well for those with a voice or speech disorder, those who have strong accents, or who have any other condition which significantly impacts on the ability to clearly vocalize and articulate words and sounds. However, some individuals suggested that, given the learning capability of these systems, those experiencing more gradual changes in their vocalization ability may afford the AI an opportunity to learn these changes over time, and therefore not experience the same degree of disconnect. Moreover, specialized speech recognition applications such as *Voiceitt* (formerly known as *Talkitt*), which are designed specifically to learn and understand non-standard speech patterns, are being actively developed (Ibrahim, 2016).

Navigation and environmental exploration tools

Finally, the role of AI-enabled GPS and navigation "apps" was discussed, largely in respect of individuals who are blind or have low vision, for whom the ability to travel independently has been associated with greater self-confidence, stronger employment outcomes, and more successful independent living (Vaughan, 1993). Several AI-enabled tools were described as being of assistance to independent travel, including:

- *AIRA (Artificial Intelligence and Remote Access)*, a subscription-based service that pairs AI-enabled analysis with a sighted assistant (using the video camera on a smartphone) to guide individuals through the physical environment.
- *BlindSquare*, an AI-enabled GPS navigation app that provides outdoor navigation assistance, with the feedback, amount and nature of information being tailored to individual user needs and that which is most likely to be useful at a given point in time.
- *Microsoft Soundscape* uses AI to enable navigation through the physical environment using a series of 3D audio cues.
- *Nearby Explorer Online* is a free GPS application that helps students who are blind navigate the physical environment. Specific or favorite locations can be marked to provide more contextual information.

For other users, *AXS Map* uses artificial intelligence and crowdsourced accessibility information to help locate accessible businesses

(with wheelchair ramps) and nearby accessible washrooms.

Future AI-based smartphone and tablet technologies

Probing exhibited a variety of single responses to novel ways to use AI; their frequency is too low to report here. However, what came up more frequently were calls to improve upon existing applications of AI. By far, improving and optimizing AI for captioning/live transcriptions/notetaking was raised most as holding more promise to assist post-secondary students with disabilities. The section "Accessing auditory information in non-auditory formats" above provides an excellent view of the current state of this area. While auto-captioning exists, so has the popularity of the term *Craptions*, to refer to the fact that while machines can produce captions based on speech recognition, their quality is still not where it needs to be. The #NoMoreCraptions Campaign (3PlayMedia, 2019) speaks to this problem.

The other reoccuring comment relative to improving existing AI use related to AI for assisting with organization/routine setting. This does not come as a surprise given that the largest numbers of students with disabilities have cognitive, attention deficit or learning disabilities where organization and structure are among the factors largely critical to their success (Fichten, Havel, Jorgensen, Arcuri, & Vo, 2020).

Implications for AI Developers

There are numerous implications from this discussion. First, AI developers need to include individuals at the "edges" and not just those that fit the dominant section under the normal curve (Treviranus, 2018). In the case of post-secondary students with disabilities, this means that studies are carried out in an accessible manner using oversampling of individuals with different disabilities. Also, students with disabilities need to be included in the design of AI apps from inception, as proposed by the universal design paradigm (Story, Mueller, & Mace, 1998, Chapter 3). This results in less work - and less expensive work - down the line when poorly designed apps need to be retrofitted for accessibility.

AI developers often set out to address a need within a targeted population (e.g., tools that facilitate the conversion of text into more accessible formats for students who are blind or have low vision) without recognizing that there could be a broader application. Awareness of this may not only increase the number of end-users who can benefit, but funding for product development may be easier to obtain.

When it comes to AI based apps, developers should underscore the need for accessible training documents, including those available through *YouTube* and *Google*, to sensitize post-secondary students to both the *existence* and the *potential* of AI based mobile apps that can help them in their learning.

Finally, students with disabilities should be viewed as valuable stakeholders in the area of AI development. Not only can they suggest the need for the development of AI apps for novel uses, but also what improvements are needed for existing applications of AI.

Conclusion

Assembling an advisory board of stakeholders representing students, disability/accessibility service providers, faculty members, technology experts, and technology users with disabilities from five countries resulted in an extensive repository of information regarding AI apps, not only in terms of what's out there that is being used, but how it is being used and by whom. Along with this comes advice about what AI apps would be welcome in the future and which existing apps need to be upgraded.

University and college students with disabilities make up a large proportion of post-secondary students. Twenty years ago, we noted a trend for technologies intended for non-disabled students to be adopted – and used in novel ways - by students with disabilities (Fichten, Barile, Fossey, & De Simone, 2000). More recently, we noted a similar trend for the cross-use of technologies intended for non-disabled students to be used by students with disabilities (Fichten et al., 2014). Now we have taken our first steps to gather comparable information on the use of artificial intelligence apps by college and university students with and without disabilities.

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