Editorial Note: From Conventional AI to Modern AI in Education: Re-examining AI and Analytic Techniques for Teaching and Learning

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ABSTRACT: With the rapid development and significant successfulness of various deep learning techniques in artificial intelligence (AI) in recent years, the connotation of AI has been transformed from traditional rule-based or statistical learning models to deep learning models. Such a transformation of AI has led to a significant evolution in both academic and industrial fields. To understand the potential impact of AI evolution for future teaching and learning, it is necessary to re-examine the opportunities, research issues, and roles of AI in education as modern AI enables the possibility of playing vital roles in education, which are not only limited to intelligent tutors/tutees but also intelligent learning partners or policy making advisors. Motivated by the recent transformation and trends in AI in education, this special issue, including 12 research articles, aims to launch an in-depth discussion on re-examining AI and analytics techniques in teaching and learning applications.

Keywords: Modern AI, AI transformation, Deep neural networks, Analytic techniques, AI in education

1. Paradigm shift of AI

There have been various definitions of the term "artificial intelligence (AI)" in the community of computer science. Different from "human intelligence," AI refers to "computers that mimic cognitive functions that humans associate with the human mind, such as learning and problem-solving" (Russell & Norvig, 2009, p. 2). Russell and Norvig (2009) argued that AI could be defined from the perspective of the intelligent agent, which can perceive the percepts from the external environment and take actions through the effectors to adapt to the environment changes or achieve certain goals. Moreover, Poole and Mackworth (2010, p.1) defined AI as "a system that acts intelligently: What it does is appropriate for its circumstances and its goal, it is flexible to changing environments and changing goals, it learns from experience, and it makes appropriate choices given perceptual limitations and finite computation."

Although AI is not a new term, the meaning of modern AI has changed compared to conventional AI techniques. (Chen et al., 2020b). Recently, modern AI has tended to refer to the Deep Neural Networks (DNN) based techniques developed in recent years (Yosinski et al., 2014). DNN-based AI and analytic techniques have led to a significant evolution in both academic and industrial fields. With the rapid development of modern AI and analytics techniques such as convolutional neural networks (CNN), generative adversarial networks (GAN), reinforcement learning (RL), and so on, which are based on DNN paradigms, in recent years, there have been a huge number of innovative applications in various domains. For example, long short-term memory (LSTM) techniques have been exploited for predicting stock market prices (Sirignano, & Cont, 2019); CNN techniques have been adopted in surveillance systems, and in self-driving cars (Hu & Ni, 2017; Chen et al., 2017) and RL methods have created some famous AI applications such as Alpha GO (Silver et al., 2016).

2. Modern AI in education: Gaps and directions

The research studies about applications of "AI in education" have been conducted for several years. However, the integration of "AI in education" (AIEd) focuses on the use of traditional AI techniques based on rule/statistic-based models to facilitate teaching and learning in education in the past few years. Due to the evolution of AI techniques from rule/statistic-based to DNN-based models in recent years, there has been a limited number of studies on the integration of "modern AI and education" which are based on DNN-based models for teaching and learning. As reported in Chen et al. (2020b), there are only two studies on Modern AI in education (i.e., deep learning in education) among all 45 highly cited AIEd studies in the recent decade. However, the overall trend of AIEd studies has rapidly increased in recent years (Chen et al., 2020a; Hwang et al., 2020). In other words, the potential power of modern AI and analytics applications in education has not been fully exploited or released. The underlying reasons can be divided into two aspects: (1) there is a knowledge gap between AI experts and

educational researchers; and (2) it is quite challenging to integrate the two areas and identify an intersection of valuable applications. To be more specific, AI experts typically do not have knowledge of pedagogical methodologies or in-depth experiences in the classroom, while it is unrealistic to ask educational researchers to be equipped with domain knowledge of modern AI techniques.

From the perspective of education technology, Johnson et al. (2016) published a horizon report which claimed that (i) "Bring Your Own Device" (BYOD) and "Learning Analytics and Adaptive Learning" can be achieved in the near-term (i.e., 1 year or less); (ii) "Augmented and Virtual Reality (AR/VR)" and "Makerspaces" can be achieved in the mid-term (i.e., 2 to 3 years); and (iii) "Affective Computing" and "Robotics" can be achieved in the long-term (i.e., 4 to 5 years). The modern AI applications can facilitate the better adoption of these education technologies in the following aspects:

- Providing modern AI-based learning analytics and adaptive learning. For example, AI-based agents can collect personal information and predict learners' preferences or learning paths (Xie et al., 2017; Almohammadi et al., 2016; Zou et al., 2020; Wang et al., 2021).
- Facilitating modern AI-based interaction in VR/AR learning environments. For example, AI-based games in VR/AR can better foster learners' immersion and interaction compared to games without AI (Rahimi & Ahmadi, 2017; Hammedi et al., 2020).
- Supporting affective computing/robotics with highly accurate modern AI models. For example, some deep neural networks can be adopted for analyzing bio-feedback signals such as EEG or brainwaves, which are collected from affective computing devices (Goh et al., 2017; Chen et al, 2021).
- Developing innovative learning applications with modern AI techniques. For example, some recent AI-techniques such as generative adversarial networks (GAN) can create new images, videos, or styles (Mao et al., 2019), which can be employed in drawing learning (Jin et al., 2019; Sorin et al., 2020).

In addition to the above modern AI-enabled applications in education, the transformation from conventional AI to modern AI has led to the reconceptualization of pedagogical innovations. Yang (2021, p. 106) has proposed that precision education, which refers to "identify[ing] at-risk students as early as possible and provid[ing] them with timely intervention through diagnosis, prediction, treatment, and prevention," is a new challenge for AI in education. Yang et al. (2021) have further developed a conceptual framework by re-organizing precision education as one of the core components of human-centered AI in education, the other components of which are smart learning analytics and smart assessment. By considering the potential applications of modern AI techniques in education, Hwang et al. (2020) have defined a role framework for AIEd, which can be categorized as "intelligent tutor," "intelligent tutee," "intelligent learning tool/partner," and "policy-making advisor."

3. The Published papers of this special issue

There were 42 submissions to this special issue. After an initial screening and two rounds of double blinded review, 12 research papers were accepted for publication in this special issue, which can be further divided into five categories. These five categories are (i) AIEd systematic review; (ii) modern AI applications; (iii) smart learning environments; (iv) AI-driven interventions; and (v) teaching/learning innovations for AI.

One paper conducted a systematic review of modern AI in education: the paper authored by Fengying Li, Yifeng He, and Qingshui Xue, entitled "Progress, Challenges and Countermeasures of Adaptive Learning: a Systematic Review."

Four papers have integrated modern AI models such as DNN, LSTM, and BERT for educational applications: the paper authored by Chia-An Lee, Jian-Wei Tzeng, Nen-Fu Huang, and Yu-Sheng Su, entitled "Prediction of Student Performance in Massive Open Online Courses Using Deep Learning System Based on Learning Behaviors"; the paper authored by Albert C. M. Yang, Irene Y. L. Chen, Brendan Flanagan, and Hiroaki Ogata, entitled "Automatic Generation of Cloze Items for Repeated Testing to Improve Reading Comprehension"; the paper authored by Owen H.T. Lu, Anna Y.Q. Huang, Danny C. L Tsai, and Stephen J.H. Yang, entitled "Expert-Authored and Machine-Generated Short-Answer Questions for Assessing Students' Learning Performance"; and the paper authored by Changqin Huang, Xuemei Wu, Xizhe Wang, Tao He, Fan Jiang, and Jianhui Yu, entitled "Exploring the relationships between achievement goals, community identification and online collaborative reflection: A deep learning and Bayesian approach."

Three papers discuss the development of smart learning environments, employing Artificial Intelligence of Things (AIoT) or intelligent agents/robots for improving cognitive and affective factors of learners: the paper

authored by Beyin Chen, Gwo-Haur Hwang, and Shen-Hua Wang, entitled "Gender Differences in Cognitive Load when Applying Game-Based Learning with Intelligent Robots"; the paper authored by Jian-Hua Han, Keith Shubeck, Geng-Hu Shi, Xiang-En Hu, Lei Yang, Li-Jia Wang, Wei Zhao, and Qiang Jiang, entitled "Teachable Agent Improves Affect Regulation: Evidence from Betty's Brain"; and the paper authored by Chuang-Kai Chiu and Judy C. R. Tseng, entitled "A Bayesian Classification Network-based Learning Status Management System in an Intelligent Classroom."

Two papers investigate the effects/factors of adopting AI-driven interventions: the paper authored by Youmei Wang, Chenchen Liu, and Yun-fang Tu, entitled "Factors affecting the adoption of AI-based applications in higher education: An analysis of teachers' perspectives using structural equation modeling"; and the paper authored by Lanqin Zheng, Lu Zhong, Jiayu Niu, Miaolang Long, and Jiayi Zhao, entitled "Effects of Personalized Intervention on Collaborative Knowledge Building, Group Performance, Socially Shared Metacognitive Regulation, and Cognitive Load in Computer-Supported Collaborative Learning."

Two papers discuss AI teaching and learning innovations: the paper authored by Ching Sing Chai, Pei-Yi Lin, Morris Siu-Yung Jong , Yun Dai, Thomas K.F, Chiu, and Jianjun Qin, entitled "Perceptions of and behavioral intentions towards learning artificial intelligence in primary school students"; and the paper authored by Chun-Hung Lin, Chih-Chang Yu, Po-Kang Shih, and Leon Yufeng Wu, entitled "STEM-based Artificial Intelligence Learning in General Education for Non-Engineering Undergraduate Students."

4. Conclusion

As discussed in the previous sections, the recent breakthrough of modern AI techniques has led a revolution in education. Such a transformation not only involves technical changes in the adoption of modern AI techniques in education, but also reconceptualizes the pedagogical framework in the future. By organizing this special issue, we can clearly foresee that modern AI in education is one of the core research topics in education communities. Furthermore, we can observe the rapid development of the integration of modern AI and education, which have established a mutually driven relationship: the development of modern AI techniques provides a great number of educational applications, while educational innovations have created a critical need for AI-enabled systems.

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