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Akinyemi Sadeeq Akintola

Universidade NOVA de Lisboa, Portugal

Adaptive AI Systems in Education: Real-Time Personalised Learning Pathways for Skill Development

Abstract: This survey paper examines the transformative potential of adaptive AI in educational environments, focusing on real-time personalised learning. With the growing emphasis on tailoring educational experiences to individual learners, adaptive AI systems represent a groundbreaking shift in the delivery of responsive, personalised pathways. By synthesizing advances in AI-driven educational frameworks—such as the integration of Large Language Models (LLMs), Reinforcement Learning, Multi-Armed Bandits, and generative AI techniques—this paper provides a comprehensive analysis of how these technologies support dynamic learning trajectories that evolve in response to learners' unique preferences, challenges, and goals.

The survey reviews methods where AI systems, including virtual teaching assistants and intelligent tutoring systems, utilise real-time data on students' interactions and performance to adapt instructional content and feedback, fostering deeper engagement and skill mastery. The integration of LLMs to create individualised prompts and adaptive feedback mechanisms has led to notable improvements in learning efficiency and retention. Reinforcement learning models and restless Multi-Armed Bandit frameworks further enhance the system's adaptability by prioritising skill interdependencies and optimising intervention strategies based on user performance data.

Moreover, this paper addresses key challenges in adaptive AI deployment, such as ensuring pedagogical accuracy, managing computational demands, and navigating ethical considerations in privacy and equity. By examining these adaptive AI theoretical foundations, technological implementations, and empirical outcomes of these adaptive AI systems, this survey highlights their capacity to support real-time personalised learning, ultimately paving the way for more efficient and inclusive educational models in diverse learning contexts.

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Biography: Akinyemi Sadeeq Akintola is a Graduate Researcher who recently completed his graduate program in Data Science and Advanced Analytics at the Universidade NOVA de Lisboa, Portugal, and also a Smart Analytics Customer Engineer at Google, leveraging nearly 20 years of experience to address complex data and AI challenges. Sadeeq brought a robust background in Software and Data Infrastructure Development across Retail, Manufacturing, Finance, and Government. His industry experience spans roles at prominent firms, including FMDQ Exchange, KPMG, and Microsoft, where he led transformative projects in Data Engineering and Advanced Analytics. At Google, he supports customers in harnessing the full power of Google Cloud for data-driven decision-making, providing cutting-edge solutions for enterprise-grade analytics and AI Integration.

Sadeeq's research and professional interests centre around the intersection of core AI/ML, Retail Analytics, and Artificial Intelligence of Things (AIoT), with an emphasis on scalable real-world applications. He actively contributes to the tech community as a mentor, guiding startups through renowned accelerators in the UK and Africa. His research at Universidade NOVA de Lisboa's NOVA IMS focuses on AI and solutions that drive innovation in Financial Inclusion and Business, helping to shape the future of data-driven strategies across industries.