RADemics

Shortest Path Algorithms for Personalized Learning Optimization

Madhu Shree R, Vijay Kumar Dwivedi
EAST POINT COLLEGE OF ENGINEERING AND TECHNOLOGY, GOVERNMENT ENGINEERING COLLEGE AMBIKAPUR

Shortest Path Algorithms for Personalized Learning Optimization

[1]Madhu Shree R, Assistant Professor, Department of Computer Science and Engineering, East Point College of Engineering and Technology, Bangalore, Karnataka, India. Madhu19.1997@gmail.com

[2]Vijay Kumar Dwivedi, Assistant Professor, Department of Mathematics, Government Engineering College Ambikapur, Chhattisgarh, India. dwivedi.vk69@gmail.com

Abstract

Personalized learning systems have emerged as a transformative approach in modern education, offering tailored learning experiences that adapt to the individual needs, preferences, and progress of students. One of the most effective ways to optimize these systems is by utilizing shortest path algorithms, which allow for the dynamic and efficient design of personalized learning paths. This chapter explores the application of shortest path algorithms in educational contexts, focusing on their use in modeling learning paths, optimizing curriculum design, and adapting to student progress in real time. Key algorithms such as Dijkstra's, Bellman-Ford, A*, and the Floyd-Warshall algorithm are analyzed for their applicability in different learning environments, from static curricula to dynamic, real-time adaptive systems. Challenges in implementing these algorithms, including scalability in large-scale education systems, the handling of complex, non-linear learning environments, and the integration of learner characteristics, are thoroughly examined. Additionally, the chapter discusses the balance between algorithm complexity and practical classroom application, emphasizing the importance of designing efficient and user-friendly systems that can be seamlessly integrated into existing educational technologies. By providing a comprehensive overview of these techniques and their challenges, this chapter contributes to the ongoing development of adaptive learning technologies that can enhance educational outcomes and support diverse learner needs.

Keywords: Personalized learning, shortest path algorithms, Dijkstra’s algorithm, adaptive learning systems, curriculum optimization, real-time data processing.

Introduction

Personalized learning has rapidly gained prominence as a key approach to enhancing educational outcomes in modern systems [1]. Traditional educational models often adopt a one-size-fits-all approach, where all students are expected to follow the same curriculum, pace, and learning path [2]. This method does not account for individual differences in learning speeds, strengths, and areas of difficulty. Personalized learning aims to address this gap by tailoring the learning experience to the specific needs, preferences, and progress of each student [3]. This individualized approach allows students to work at their own pace, receive targeted interventions [4], and access resources that match their current level of understanding, resulting in a more engaging and effective educational experience [5].

One of the most significant challenges in personalized learning is the design and optimization of learning paths [6]. In large and diverse educational environments, students are presented with vast amounts of content, learning materials, and assessments [7]. Mapping the most effective route through these resources for each student, considering their unique needs, can be a complex task [8]. Shortest path algorithms provide a powerful solution to this problem by identifying the most efficient routes through a network of learning activities [9]. By representing learning tasks and resources as nodes in a graph, with edges indicating dependencies or logical progression, shortest path algorithms can dynamically calculate the best sequence for each learner, optimizing their educational experience and ensuring they reach their learning objectives as efficiently as possible [10].

The application of shortest path algorithms, such as Dijkstra's, Bellman-Ford, A*, and Floyd-Warshall, offers numerous benefits in optimizing personalized learning systems [11]. These algorithms are well-suited for identifying the shortest and most efficient paths in a graph, where nodes represent educational tasks and edges represent dependencies between them [12]. In adaptive learning systems, the algorithms continuously update students' learning paths based on their interactions with the system, ensuring that they are constantly presented with material that aligns with their progress [13]. This real-time adaptation allows for a flexible and dynamic learning experience [14], where students are neither overwhelmed by difficult content nor under-challenged by tasks that are too easy. Instead, the learning path can be optimized to provide the right balance of challenge and support [15].