Investigating Knowledge Tracing Algorithms and Learner Simulators for Training Adaptive Recommendation Agents in Education

Daniel Farrell, Master of Science in Computer Science

University of Dublin, Trinity College, 2021

Supervisor: Prof. Vincent Wade

The research and implementation of intelligent agents for recommending educational content to students has long been hindered by three major necessities: a suitable knowledge tracing algorithm, the possession of extensive historic learner data, and an access to an abundance of human learners.

As there is a lack of comparative analyses investigating knowledge tracing algorithms through experimentation, engineers are often left wondering which algorithm is best suited for their educational recommender systems. This paper seeks to provide clarity by conducting an in-depth comparative analysis of modern knowledge tracing algorithms, namely: Bayesian Knowledge Tracing (BKT), Bayesian Knowledge Tracing with Forgetting (BKT+F), Performance Factors Analysis (PFA), and Deep Knowledge Tracing (DKT).

Typically, in order to develop educational recommendation systems, large amounts of historic data and human learners are required. However, this dissertation investigates a solution for training these recommendation systems without having access to these resources. To do this, this dissertation puts forward the design and implementation of a robust simulated learner with the ability to answer exercises and to build up skill levels through practice, all facilitated through knowledge tracing algorithms. As they mimic human learner behaviour, learner simulators can be used to interact with and train agents for recommending educational exercises.

To prove this works, this dissertation implements a recommendation agent trained entirely using learner simulators. It is then shown that learner simulators carrying out exercises following an adaptively recommended learning path experience larger improve-

ments in tests scores to those following a randomly assigned learning path. It is found that learner simulators following an adaptive learning path can improve their test scores by 33% using just 9 educational exercises, however this takes 15 exercises to accomplish following non-adaptive learning paths.