

Cognitive Master Teacher

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Abstract

The “Cognitive Master Teacher” is a result of discussions with teachers, members of educational institutions, government bodies and other thought leaders in the United States who have helped us shape its requirements. It is conceived as a cloud-based and mobile-accessible personal agent that is readily available for teachers to use at anytime and assist them with various issues related to day-to-day teaching activities as well as professional development.

Introduction

The Cognitive Master Teacher (CMT) is meant to be a personal digital assistant to teachers, and the current version is aimed at K-12 teachers of mathematics and English Language Arts. CMT has been designed as a professional development (PD) tool and can answer questions related to various issues that teachers encounter while performing their job. Examples of topics covered are instructional strategies, classroom management, handling of students with special needs, common core standards, best practices, and various teacher certification procedures.

The cognitive master teacher is being designed with learning and usability as desired goals, and draws upon relevant cognitive theories of learning. Of particular relevance to us are constructivist theories, especially the one proposed by Jerome Bruner (Smith 2002). Bruner’s theory broadly suggests that, given enough references around a body of information that serves as background knowledge for the learner, they will discover new facts and relationships themselves and these will serve to increase their expertise. These ideas have influenced the Concept Exploration Engine described in the next section. While there are many online tutoring systems for K-12 students, there are only a few systems aimed at teacher PD (e.g.

<http://mhpdonline.com/mhpd/>). CMT is relatively quite comprehensive. For example, if there is a question on what may be the best way to teach a particular lesson, CMT will respond by suggesting a particular strategy, provide links that can be explored further, and point to specific content and best practices that may be used in the lesson plan.

Overview of the System

The high-level architecture of CMT is shown in Figure 1. It consists of three major components, namely the Question Answering Engine (QAE), the Concept Exploration Engine (CEE), and the Content Repository (CR). The User Interface links these components and enables interaction. We now describe these components in more detail.

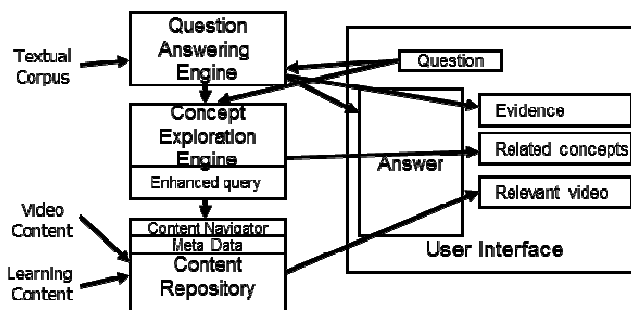


Figure 1: The high-level architecture of Cognitive Master Teacher

Question Answering Engine (QAE)

QAE uses natural language processing (NLP) to search for relevant answers. This component of the CMT is an extension of IBM’s Watson machine which beat the grand champions in the game of Jeopardy! in 2011 (Ferrucci et al 2010). More specifically, it is based on the IBM offering called Watson Engagement Advisor (WEA). WEA has

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several components that can be trained or customized to suit the application. For example, we can train WEA by providing question-answer pairs where the answers are excerpts from the text corpus that has been ingested. WEA runs multiple parallel NLP pipelines, each of which generates many potential answers. Each pipeline uses many features to rank the potential answers. In the training mode, the pipelines use sophisticated machine learning techniques to determine the relative importance of the features. This is later used at runtime to rank and select the best answer. The text corpus of CMT consists of several text books, Web pages and other information that is available from open education resources such as EngageNY and OER Commons as well as select non-profit educational organizations such as Achieve and Student Achievement Partners. To improve the performance of the system, we exploited a WEA feature that allows us to add domain-specific synonyms, acronyms and other terms.

Concept Exploration Engine (CEE)

CEE provides a set of links that contain additional information related to the concepts that may be mentioned in the question or the answer and are meant to provide the discovery-based learning experience mentioned in the introduction. To build this component of the system, we annotate (by using Wikipedia as an underlying ontology) corpora relevant to the education domain, which is the source for the answers that are returned by QAE. This is accomplished by using wikification techniques (see for example Bunescu and Pasca, 2006, Mihalcea and Csomai, 2007; Ratnov et al., 2011). After performing this step, we compute a measure of conceptual closeness between the answers produced by the QAE and nearby concepts using techniques based on the personalized page rank algorithm (see Haveliwala, 2003). The combination of the two steps mentioned above allow us to present to the user concepts that are relevant to the answers being shown by CMT. In the particular case of teaching strategies, we found Wikipedia to be a relatively incomplete source of knowledge. Therefore, further work in this area will need to address the crafting of more relevant structured knowledge data structures in order to support the type of user interaction intended for concept exploration in this domain.

Content Repository

CMT retrieves content (text and video) related to the query and displays links through which such content can be accessed. CR automatically tags and stores educational content such as class presentations, assessment questions, and videos of best practices) offline (currently text and video). The tags relate to aspects such as educational standards (e.g. Common Core State Standards or CCSS) and the instructional strategy that the content illustrates.

When the user types a question, it is forwarded to QAE which analyzes it and returns the most probable answer. CEE uses the question as well as the answer to return links to relevant concepts. CR in turn uses the results of QAE and CEE to identify and display links to related content.

Summary and Future Work

We have built prototypes of Web- as well as mobile-accessible assistants in collaboration with IBM Corporate Citizenship. Working together with the IBM Foundation and other philanthropic organizations, we plan to improve CMT by incorporating the ability to learn preferences of users and provide personalized answers over time. In the coming years, CMT will be initially piloted at several schools that have adopted CCSS and ultimately be made freely available to teachers everywhere.

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