

Learning from Quizzes Using Intelligent Learning Companions

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ABSTRACT

It is widely recognised that engaging games can have a profound impact on learning. Integrating a conversational Artificial Intelligence (AI) into the mix makes the experience of learning even more engaging and enriching. In this paper we describe a conversational agent which is built with the purpose of acting as a personal tutor. The tutor can prompt, question, stimulate and guide a learner and then adapt exercises and challenges to specific needs. We illustrate how automatic generation of quizzes can be used to build learning exercises and activities.

Categories and Subject Descriptors

I.2 [Artificial Intelligence]: Natural Language Processing, Distributed Artificial Intelligence—*Language parsing and understanding, Intelligent agents*

Keywords

e-learning; quizzes; linked data; ontologies

1. INTRODUCTION

It has long been recognised that many of the attributes of engaging game play, from the provision of multiple learning styles to intellectual challenge, can have a direct and immediate impact on learning. In today’s world, with the profusion of simulation and scenario games, teachers are able to engage their students in entirely new models of learning. At the same time, advances in mobile technologies take learning, and particularly enquiry-based learning, far beyond the confines of the classroom. The integration of a conversational Artificial Intelligence (AI) into this learning mix has the capacity to make learning within a gaming or ‘tutorial’ environment an even more engaging experience.

Computer games are extremely popular and have already spearheaded a revolution in the entertainment industry. A similar revolution is now taking place in the sphere of education - where entertainment has been married to user interaction in order to achieve something more valuable - Gaming with a Purpose. As described in [9] serious games are “all about leveraging the power of computer games to captivate and engage end-users for a specific purpose, such as to develop new knowledge and skills”.

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Many of these games are created by leveraging linked data – where the creation and curation of semantic content is an integral part of engaging users in the game, e.g. [7, 8]. One approach is the evaluation of heuristics, used to determine a ranking of facts within a specific knowledge base like DBpedia [2]. Another is quiz-based game applications described in WhoKnows [10], RISQ! [11] and BetterRelations [5], where the quiz is used as a game motivator. In this case, users – in the act of playing the game – simultaneously improve the quality of the respective Linked Data sources. For example, the Linked Data Movie Quiz (LDMQ [1]) is an application that uses the Linked Movie DataBase (LMDb [4]) to generate questions about movies, directors, and actors. The application illustrates the potential of consuming Linked Data in order to create quizzes on top of it. An extension of this approach is described in [6], which foresees multiple domains having the same mechanisms applied to different datasets which, when combined, will generate even more advanced questions.

The approach presented in this paper is similar to the examples mentioned above to the extent that quizzes are generated automatically by leveraging linked data. However, our primary focus in generating such quizzes is for a deeper learning experience. The quizzes are embedded in an environment which also features an Intelligent Personal Tutor. This Tutor controls both the execution of the quiz and also the ordering of the questions. Learning is delivered through the conversational abilities of the agent. While “hosting” the quiz, the agent will prompt, encourage, stimulate and guide the user to successful learning. As the tutor becomes familiar with the player’s abilities and aptitudes, it will adapt questions and challenges in the light of this ‘understanding’. Remembering a player’s behaviours and abilities, the agent can prompt exploration and discovery of new information. Perhaps most importantly, it will lead the player to exert control over their own learning, while simultaneously enjoying the experience. Building such an agent requires the curation of a large knowledge base of facts as well as the heuristics required in order to translate the pedagogical behaviours and habits of teachers into the agent’s personality. Linked data can be a valuable resource for such facts, but also the driving mechanism for the dialogues initiated by the tutor.

2. INTELLIGENT TUTOR

The Tutor is an agent which can be embedded in any environment that lends itself to a simulated tutor. It is trained using a set of learning exercises which become the

basis of a conversation with a student. Below, we describe how the exercises are created, either from scratch or using external resources (such as linked data).

2.1 Creating Learning Exercises

The creation of Learning Exercises involves the following steps:

1. *Concept selection.* From a preloaded ontology (manually created, or imported from an external resource), a teacher will select concepts around which exercises can be based.
2. *Question generation.* Question templates are based on the ontology structure: they join knowledge structures that are metaphorically or referentially related and combine them with natural language. See Table 2.1.
3. *Answer generation.* The teacher might define the correct answer first. Based on this definition, a set of potential distractors are generated – using a combination of the Wordnet [3] structure and the domain ontology. The teacher can then choose one or more of the existing distractors, or generate a whole new set. It is important that the answers are finessed at this stage to reflect the voice of a “good” Tutor.
4. *Agent response generation where answers are correctly and incorrectly chosen.* Perhaps more importantly for creating the “voice” of the Tutor, the teacher creates responses which (a) reward the correctly chosen answer with reinforcing knowledge or (b) guide the player who needs one or more prompts. As the purpose of this learning tool is to simulate a teacher, one of the key features of the quiz companion is that it gives useful, motivational responses when the user selects a wrong answer. Generating these answers is a manually created step, supported by a set of automatically generated templates. This step also enables the tool to rely on the memory component, and provide answers which include reference to the user’s prior performance. Just as the machine depends on the combination of knowledge structures to learn, so helping the user make conceptual connections will help them learn.
5. *Exercise planning.* The plan specifies the order in which questions are presented to the user. These are generated dynamically based on the level of concept in the ontology.
6. *Reward plan.* Rewards are intrinsic to enhanced engagement and therefore the promotion of learning. Rewards, however, need not take the form of badges or other prizes. Rather, the encouragement of the in-game agent acts as its own reward; it encourages the struggling user to learn and understand while praising and challenging the more competent.

2.2 Examples

To demonstrate how our method works, below we show sample dialogues related to two learning concepts. The third example focuses on demonstrating memory and adapting to the user.

2.2.1 Example Interaction 1, Learning concept: Energy

- **KAI Tutor:** What is the significance of energy for our bodies?
 1. Energy allows growth and repair. (Correct Answer)
 2. Energy enables movement.
 3. Energy allows us to keep warm.

Student says ‘It allows growth and repair’.

KAI Tutor: Excellent. Cells need energy to carry out growth and repair processes.

Student says ‘Enables movement?’.

KAI Tutor: Energy is necessary for movement. But it does something even more important for our bodies!

Student says ‘I’ve a feeling it allows us to keep warm?’.

KAI Tutor: That’s true. But there is an even more significant role for energy in the body.

2.2.2 Example Interaction 2, Learning concept: Cell

- **KAI Tutor:** What is a cell? (Question 1)
 1. The smallest unit of life. (Correct Answer)
 2. One of the smallest units of life.
 3. A very small organism.

Student says ‘Is it the smallest unit of life?’.

KAI Tutor: Well done. All living things are made up of cells.

Student says ‘I think it might be one of the smallest units of life.’.

KAI Tutor: You can actually go one step further!

Student says ‘A very small organism?’.

KAI Tutor: Good, a cell can be an organism. But think again about the function of cells in relation to larger living things.

Now, after going through a few other questions, KAI presents a question similar to Question 1. This allows the tutor to assess whether a student properly understood the earlier question.

2.2.3 Example Interaction 3, Learning concept: Cell

- **KAI Tutor:** What unit is described as the building block of life? (Question 11 - a re-run of Question 1)
 1. A cell. (Correct Answer)
 2. Genes.
 3. DNA.

Student says ‘A cell?’ (where student answered Question 1 correctly first time).

KAI Tutor: Great, you got this right again. Seems like you really mastered cells!

Student says ‘A cell’ (where student answered Question 1 correctly on second attempt).

KAI Tutor: Great, you got it! You’re really getting the concept of cells now!

Student says ‘A cell’ (where student answered Question 1 correctly on third attempt).

KAI Tutor: Well done. You struggled with a cell question before, but now you got it in one!

Table 1: Question Generation templates with examples

Template	Generated questions
Which - CLASS - function(PROPERTY) - INSTANCE Which - Planet - min(distanceFromEarth) - Earth	Which planet is closest to Earth?
In which - CLASS - function(PROPERTY) - INSTANCE In which - Country - find - Port Of Alexandria In which - Country - located - the Hanging Gardens of Babylon In which - State - located - Grand Canyon	In which country would you find the Port of Alexandria? In which country were the Hanging Gardens of Babylon located? In which state is the Grand Canyon located?
What - CLASS - INSTANCE What - Capital - Italy	What is the capital of Italy?
What - PROPERTY - INSTANCE What - capitalOf - Italy	What is the capital of Italy?
What - PROPERTY - modifier (INSTANCE) What - isCarried - in our (Blood)	What is carried in our blood?
What - PROPERTY - CLASS - PROPERTY - INSTANCE What - nameOf - Animal - livesIn - Lodge	What is the name of the animal that lives in a lodge?
What - CLASS What - Cell What - Planet	What is a cell? What is a planet?
What - CLASS - PROPERTY - modifier (CLASS) What - Food - provides - our (Body)	What does food provide for our bodies?
What - CLASS - PROPERTY - INSTANCE What - Factors - affect - Fitness	What factors affect fitness?
Where - INSTANCE - PROPERTY Where - Photosynthesis - happens	Where does photosynthesis happen?
Why - CLASS - PROPERTY - CLASS Why - PlantCells - have - Chloroplasts	Why do plant cells have chloroplasts?
How - INSTANCE - PROPERTY - INSTANCE Why - Cells - important	How does smoking affect fitness?

3. CONCLUSIONS

We described an approach where linked data is used to create learning exercises, led and choreographed by an intelligent tutor. In its knowledge base, the tutor has a set of pre-generated quizzes – learning conversations – together with the plan which defines question order. Context-related incentives are used to guide the user towards understanding the concept in question when their answer selection is incorrect. These agents can be embedded in any environment where learning is a desired outcome.

4. REFERENCES

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