An AI Virtual Teaching Assistant with Smart Search and Feedback

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Abstract

An AI Virtual Teaching Assistant with Smart Search and Feedback has been developed and is being evaluated. It supplements the tuition from the teachers with a Q&A system with higher accuracy of question mapping based on elimination and involvement of stop words in a two-step searching algorithm. An effective and efficient method is applied to estimate the level of students, providing feedback on teaching performance.

1 Introduction

A high-quality education which dynamically meets the needs of students is always in great demand. It is desirable for students to consult the instructor whenever they encounter problems:

1. During the lecture with many students, instructors may not be able to answer all the questions from the students. The students can have more opportunities to consult the teacher if the instructor to student ratio is reduced, but it is expensive to achieve.
2. Private tutoring may be effective to provide more opportunities to ask questions, but not all students can afford to pay private tutors.
3. Students may find the answers to their questions by Internet search on many freely available resources such as Wikipedia. Yet Internet search may often be time consuming because the contents of any particular website may not match the level of the student and may also not match the syllabus of the student's course. In addition, students may not be experienced enough to filter the information from the Internet.

A custom-made online system was built to solve the problem.

An on-line system is appropriate because information technology (IT) is mature after over 30 years of development, with applications covering most businesses in the world. As broadband Internet services have become more popular and affordable, online teaching has now become an important supplement to the traditional face-to-face teaching nowadays (Tao et al. 2018). The Hong Kong

Government also subsidizes the needy families to ensure all Hong Kong students have broadband Internet access in schools and at home. The learning is therefore never be limited by place and time.

Artificial Intelligence (AI) is also employed in the system. It has been highly developing especially in the past 20 years. The applications are ubiquitous nowadays. IT systems strengthened with AI are widely applied for most businesses e.g., shopping, banking, travelling, education etc.

Our Institute has developed an Artificial Intelligence Virtual Teaching Assistant system in health science education for students to ask questions on an online system. The system was developed by a team of staff including lecturers, IT experts, AI researchers and more importantly the students, and its performance is being evaluated. The system currently provides knowledge for a course of Human Biology. It can be expanded to a larger knowledge base system and extended to other courses.

2   Background

2.1   A Human Teacher versus a Dumb Q&A Machine

The virtual teaching assistant lacking human intelligence cannot replace a human teacher. We compare the human teacher with a dumb (without intelligence) Q&A machine as follows:

Comparison between a human teacher with a dumb Q&A machine	
Teacher (with human intelligence)	Dumb Q&A machine
Available certain hours	7 days, 24 hours available
Figure out what is the exact question	Student needs to ask questions exactly matching questions bank
Look for keywords in the question	Cannot
Clarify question with misspelled keywords	Cannot
Remembers past questions	Cannot
Experience builds up	Cannot

Table 1 Human teacher vs dump Q&A machine

We can see that this type of dumb Q&A machine has only one feature better than a human teacher: it can run continuously without taking rest. However, students cannot get any feedback from the machine.

3   Objectives of the proposed AI Virtual Teaching Assistant

The main objective of the Artificial Intelligence Virtual Teaching Assistant in Health Science Project was to develop an online system to help students study the Human Biology course. We applied AI to develop an online knowledge base system for students to ask questions related to the course of human biology. The system can reduce the workloads of the consultation from lecturers, whereas the students can get help through the Internet whenever they encounter difficulties in their studies.

We aim at efficient methods to build up an effective and user-friendly system with continuous improvements with the following capabilities:

- To support teachers.

- To facilitate students' studies.
- To engage more students in study.

4   System Design

4.1   Design requirements

The system is specifically designed for the students in our college, so that the contents of the knowledge base need to match the syllabus of the intended course. We invited the students to help the development of the system to deepen our understanding of their needs and design the User Interface based on their user experience.

The main features of the system are as follows:

- The contents match to the syllabus and level of the course of our college.
- The functions match the needs of the students.
- It provides extra knowledge to supplement the lecture notes.
- Those submitted questions which are not in the knowledge base will be passed to the lecturers through this system to answer later.
- The system can enable the lecturers know the most frequently asked questions and the main problems of students.
- The system can estimate the level of the students to enable more effective feedback to the students.
- The students do not need to provide their personal information for the privacy concern so that they will not be too shy to ask questions.
- Students can ask the system 24 hours a day, 7 days a week through the Internet from anywhere.
- Students do not need to ask questions face-to-face.

4.2   The Knowledge Base Structure and The Evaluation Algorithm

Questions in the course are collected from the student helpers and are divided into different tables in the knowledge base according to the chapters of the lectures. The same question expressed in different wordings are treated as different questions in the same table but point to the common answer. Each answer and question form a separate webpage to facilitate easy maintenance. A more knowledgeable student may tend to use terminologies to ask the questions whereas a less knowledgeable student can only ask in layman's terms. Therefore, the wording of the question may reflect the student's understanding of the course. A mark is assigned by an expert for each question in the question table for the algorithm to estimate the levels of those students who will ask that question. For the same question, the expert may provide a few answers at different levels so that a student may choose the answer base on his/her level.

4.3   The Searching Algorithm

As a question is typed by a user, the system needs to search the question bank to match with the asked question so that the answer that corresponds to that question in the question bank will be provided to the user. Yet, one can use different wordings in a sentence to mean the same thing, so that almost no two people will write exactly the same sentence to ask the same question. Therefore, the probability that typed question will exactly match one in the questions bank is low.

We assume the grammar does not need to match and does not even need to be correct so that grammar does not play much role here. We assume a typed question may not be a complete sentence and is prone to spelling and grammar mistakes but will at least include some keywords.

A misspelled keyword may give no clue to the parts of speech of the intended word but can match to some possible words, which correspond to a list of questions in the questions bank. Yet, the question words like "what" and "how" are unlikely misspelled, and they do give hints to the word's parts of speech to rank the likelihood of the questions.

4.3.1. Guessing the keywords

Our AI system will map the keywords from the partly typed in question of the user to the keywords of the questions bank. For example. If the user types in "bon fractu", the system will find "bon" is part of the word "bone" and "fractu" is part of "fracture". The system will then shortlist all the questions in the question bank with "bone" and "fracture". The process is like the case that a customer goes to a shop to look for a product. The customer does not remember the exact name or brand of the product and asks for help from the shop assistant. The user provides part of the information about the product and the shop assistant is like an expert system inferring what the customer wants. Finally, the experienced shop assistant shows a list of products to the customer and help to choose. The recommended products are selected based on the interaction between the customer and the shop assistant.

The searching of the AI Teaching Assistant system is highly dependent on the keywords of the typed question. Initially, all keywords have the same weight (importance). The system simple compares the keywords of the typed question with the keywords of all the questions in the questions bank of the chapter interested. The questions in the questions bank with keywords hit will be selected and displayed on the recommended questions list. The questions with more keywords hit will have high ranks. This method can be applied very effectively when the number of questions in the questions bank is small. In our system, the number of questions in each chapter is less a thousand. The searching speed is not an issue. When the questions bank is getting larger, the searching method algorithm need to be enhanced.

In our system, the typed in question which may not be a complete sentence or just a few words will be recorded in the database when the user selects the right question from the recommended questions list and confirms to ask. The system will also remember the selected question. These two questions form a mapped pair for the AI learning later. When the system has collected enough data, it can run a machine learning process to modify the weights of the keywords of questions in the questions bank. The system will then be customized according to the user's wording of questions.

4.3.2. Shortlisting questions matched to the keywords ignoring stop words

Another factor which will affect the searching is called "noise words" or more commonly "stop words". The words such as "to", "or", "what", "how" etc. belong to these stop words. Stop words exist in many questions. They do not carry much information for searching. If "what" and "is" are regarded as keywords, then many questions in the questions bank will partly fulfil the typed question and the system will recommend many questions for the user to select. The searching will become very ineffective and inefficient. The effect is obvious when the questions bank is large.

4.3.3. Improving ranking of the questions using stop words

We have made a list of stop words in our program. However, the stop words such as "what" and "why" do carry some meaning in some cases. The question word "What" tends to ask a beginner level question and "Why" tends to ask a senior level question. To make the searching more accurate, we

divide the process into two steps. In the first step, the system ignores all the stop words on the list and only counts the number of keywords hit. The system will generate a list of recommended questions. In the second step, the system ranks the recommended questions according to the number of keywords and stop words hit. The result is that the number of recommended questions is unchanged, but the ranking is more accurate.

The choice of stop words is not simple sometimes (Sarica et al. 2020). There is not a universal stop words list which can be applied to all database searching. The choice of stop words should be updated from time to time when more questions are added.

4.4 Operations

The AI Virtual Teaching Assistant system is running online for students to access through a concise and user-friendly interface. The system needs to be logged in with a password but does not request any personal information. Its operation flow, shown in Figure 1, are explained in the following steps:

1. The user accesses the home page of the system with the web address provided.
2. When the login page is displayed, the user is requested to type in the password.
3. A new webpage will be displayed. The user can click to choose a chapter to start.
4. A dialogue box is displayed. The user can type in a question. The question is not necessarily a complete sentence or grammatically correct. The system will tolerate spelling mistakes. However, the more relevant the typed keywords, the more accurate will be the searching.
5. When the user finishes typing the complete question or part of the question and presses the "Submit" button. The system will guess the actual question that the user intends to ask. A list of recommended questions from the questions bank will be displayed.
6. When the user finds the right question to ask from the recommended questions list, the user may click to choose the recommended question to ask. The system will count the mark of the question asked. It is used to estimate the level of the user. The estimated level will be displayed when the user has finished using the system and prepare to logout the system. The user's level is estimated based on the average mark of all the questions have been asked. For example, if the user has asked 12 questions from different chapters, the total mark of the 12 questions are added and the average is calculated. The lowest mark of a question is 1 and the highest is 3, the average will be between 1 and 3. The levels of questions are judged by the experts and lecturers providing the answers, the estimated level should be taken as a reference but not an accurate prediction of the test or examination results.
7. If the user cannot find the right question from the recommended questions list, the user can change the typed question with other keywords and goes back to Step 5.
8. If the user has changed the keywords many times but still cannot find the right question from the recommended questions list. The user may go back to the main menu to select another chapter to ask. The user may click the "No matched question found". The system will ask whether the user wants to pass the question to the lecturers to answer later. If the lecturers find a new question in the system, they may answer the question and upload to the system. The user may find the question and answer in the next time.
9. If the user's question does not hit any keyword of the questions in the questions bank. The system will ask whether the user wants to pass the question to the lecturers to answer later. The procedures are the same as Step 8.
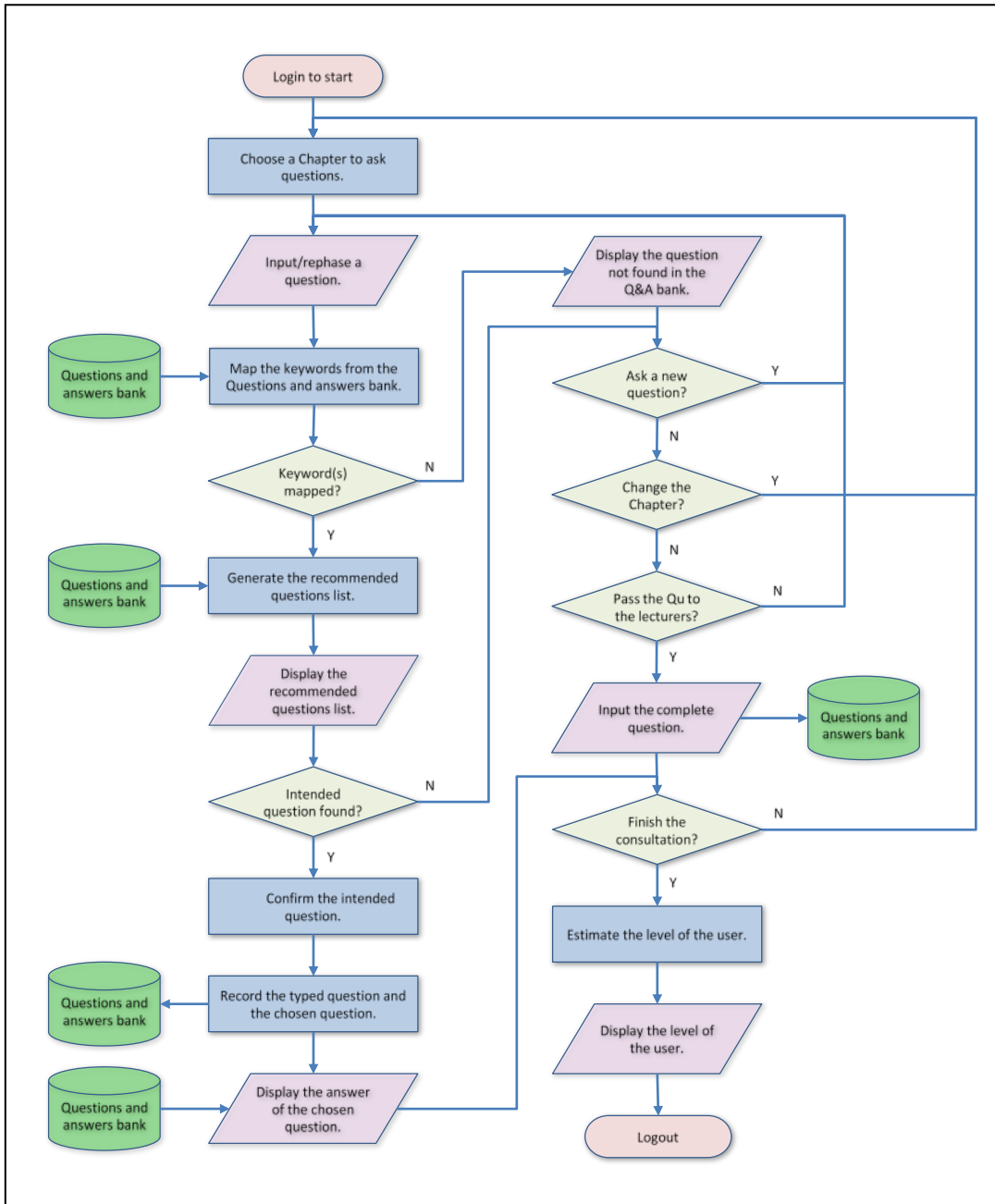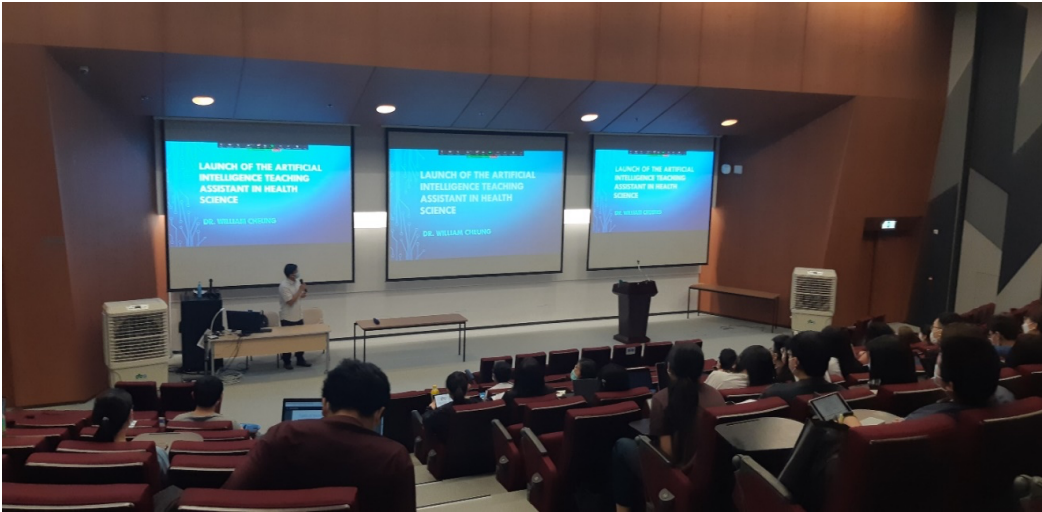
Figure 1 Operation flowchart

Picture 1 The launch of the AI Virtual Teaching Assistant

5 Deployment and Results

The Artificial Intelligence Teaching Assistant in Health Science was launched on 27th September 2021 for a group of Year 1 students from The School of Nursing to use and provide comments and suggestions. The system will be opened to more students in the college and finally to the public.

The users of the system are invited to complete a questionnaire after the trial. They are invited to comment for the following statements.
1.   The AI Virtual Teaching Assistant is user friendly.
2.   The AI Virtual Teaching Assistant guessed your questions correctly.
3.   The AI Virtual Teaching Assistant answered all your questions.
4.   The answers were suitable to your level and experience.
5.   The AI Virtual Teaching Assistant estimated your level correctly.
6.   The AI Virtual Teaching Assistant is helpful to your studies in this course.
7.   The AI Virtual Teaching Assistant should include other courses.
8.   You would like to recommend this system to your friends.
9.   Do you have any suggestion to improve the AI Virtual Teaching Assistant.
The users are invited to grade the above statements based on the following grades.
1.   Totally disagree
2.   Disagree
3.   Partly agree
4.   Agree
5.   Totally agree

Results

The following screen shot shows a case when a partly typed question is asked, and the system suggests a list of questions for the user to choose. The following screen shot shows a case when the key word is not found, and the system asks whether the user wants to pass the question to the lecturers.
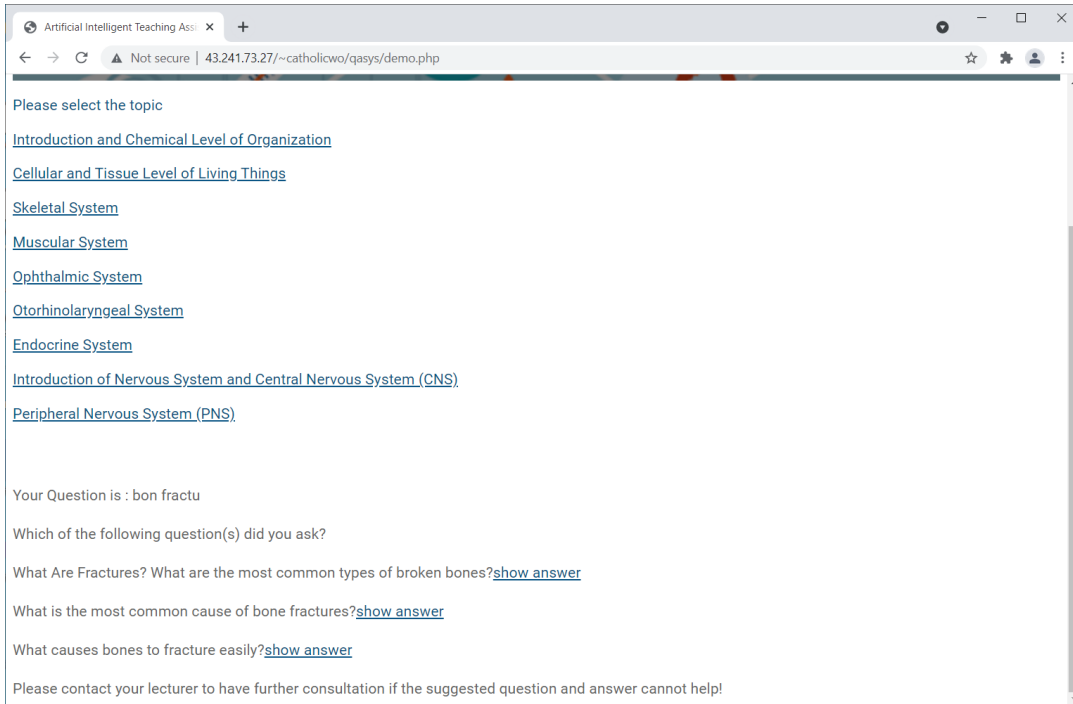
Picture 2 A list of recommended questions is displayed for the user to choose
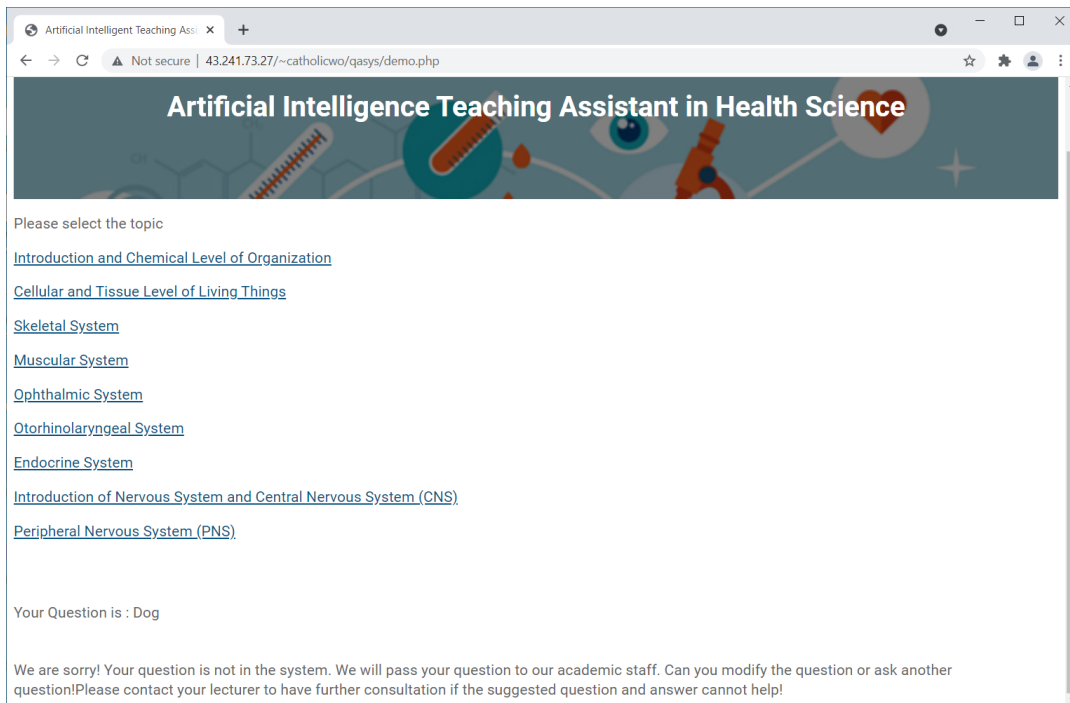
Picture 3 If the question is not included in the questions bank, the system will it to the lecturers.

We compare our system with the other similar system as shown in Table 2. Out system is Artificial Intelligence Teaching Assistant in Health Science. It is like an intelligent teaching robot assistant. It has intelligence and it can understand help the students.

Interactive TA robot to mimic human intelligence			
Capability	Human Teacher	Dumb Q&A machine	Interactive AI Teaching Assistant
Answer questions with exact match to question bank	✓	✓	✓
Answer questions without exact match to question bank	✓	✗	✓ Interactively determine the question to match at question bank
Looks for keywords in the question	✓	✗	✓
Clarify question with misspelled keywords	✓	✗	✓ Interactively correct the mis spelled words
Rank and shortened recommender list	✓	✗	✓
Remembers past questions	✓	✗	✓
Experience builds up	✓	✗	✓ Memory enables match with better ranking
7 day a week, 24 hours per day	✗	✗	✓
Direct question to another expert if needed	✓	✗	✓
Provide feedback to students	✓	✗	✓

Table 2 Human teacher vs dump Q&A machine vs AI Teaching Assistant

A large scale of evaluation is in progress. We will receive some comments from students, lecturers and the team members.

6 Future Work

During the development of this project, we had a few student helpers to suggest questions for the questions bank. However, we had only a few knowledge experts to prepare the answers. the answers bank was taken a long time to build. The questions and answers were documented in MS Word. The AI researchers and IT developers need to convert all these files to webpages (html files) and add them to the knowledge base. These processes may overload the knowledge experts and the IT developers. This is inefficient to build up a large knowledge base. More knowledge experts should be recruited. They can be the lecturers teaching the course or the senior health science students. To facilitate the work, the system needs to be upgraded. The system should allow people other than the IT developers to maintain the system. These people will be granted the permission to add new questions and answers to the knowledge base of the system. The lecturers may collect questions from the junior students and distribute the collected questions to the senior students and ask them to prepare the answers and convert

the documents to webpage format files (.html). The lecturers collect all the questions and answers webpages. The system provides an interface for the lecturers to upload the questions and answers webpages. The lecturers should encourage the senior students to help as the students can take it as exercises to revise the health science. It is beneficial to both the students and lecturers.

7 Conclusion

With the co-operation of a professional team, the Artificial Intelligence Virtual Teaching Assistant has been developed and is being evaluated. The important feature of this system is the continuous learning capability during use. The launch of the system is only a starting point of the project. The system will continue to enhance the searching efficiency and accuracy as it takes some time to collect data from the users. The system will therefore accumulate its experience to become smarter like a human being.

The questions and answers bank can be expanded to cover a wider area of the course, with more questions at different difficulty levels to be added to serve a wider range of students.

The AI Teaching Assistant provides an alternative for effective and efficient learning in helping students in their studies. It also informs the teachers what problems the students are facing. Such information gives the teachers an insight of the teaching performance to benefit both the students and teachers.

This system is applicable not only to the human biology course but also to other courses. After we have built up the system, we may continue to expand the knowledge base.

References

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