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Automatic Question Generation Using Natural Language Processing

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ABSTRACT

Natural language processing (NLP) is a field in artificial intelligence that seeks to build intelligence into software so that it can skillfully behave like humans. Handling large classes along with courses that are cumbersome can sometimes be highly challenging and time consuming to lecturers most especially when it comes to setting of examination questions and marking of examination scripts. Hence, this study develops an automatic question generation system using the techniques of natural language processing. The system is aimed at easing the efforts of lecturers in setting questions from voluminous texts and also provides a good avenue for answering them. The system was developed using C#.net on the .Net platform.

Keywords: Automatic question generation, Natural language processing, C#, Artificial intelligence.

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1. INTRODUCTION

Natural Language Processing (NLP) is a theoretically motivated range of computational techniques for analyzing and representing naturally occurring texts at one or more levels of linguistic analysis for the purpose of achieving human-like language processing for a range of tasks or applications (Liddy, 2005). NLP is a vibrant field of interdisciplinary Computer Science research. NLP seeks to build intelligence into software so that software will be able to process a natural language as skillfully and artfully as humans (Bitter, Elizondo, & Yang, 2010). It is also a subfield of linguistics and artificial intelligence (AI). It studies the problems inherent to the processing and manipulation of natural language (NL). The ultimate goal of NLP is to make computers understand statements written in human languages (Linckels & Meinel, 2011).

Question Generation is the task of generating questions from various inputs such as raw text or semantic representations. It is an attempt towards structuring the potential educational text which is available everywhere on the internet (Agarwal, 2012). Yao et al. (2012) also defined question generation as the task of generating reasonable questions from an input, which can be structured (e.g a database) or unstructured (e.g a text). Question asking and question generation are important components in advanced learning technologies such as intelligent tutoring systems, and inquiry-based environments (Graesser et al., 2001). Automatic question generation then refers to the generation of questions using a computer with reduced human input i.e. the user needs not bother about how the questions are generated. Automatic question generation is a worthwhile enterprise, with applications in dialogue systems (Walker, Rambow, & Rogati, 2001). and educational technologies (Graesser et al., 2001). Agarwal (2012) divided questions into two broad types which are **Questions based on their presentation** and **Questions based on answer scope.**

1.1 Questions based on Presentation

According to Agarwal (2012), there are various possible ways to present a question. He reckoned that questions could be classified based on their presentation styles which would include *fill-in-the-blank questions* and *wh-type questions*. He continued further to state that fill-in-the-blank questions could be of two types: questions with alternatives and questions without alternatives. He also went further to state that if a question sentence with one or more blanks are given with four alternatives to fill them, then such questions are called *cloze questions.* However, a question sentence without an alternative is called an *open-cloze* question. *Wh-type* questions, on the other hand, are questions that begin with wh-words such as what, why, when, who and where among others.

1.2 Questions based on Answer Scope

Here, questions are categorized based on their answer scope in the article. Basically, length of the answer span decides, in which category a question belongs (Agarwal, 2012). In Question Generation Task and Evaluation Challenge (QGSTEC) 2009, questions were classified into three different scopes:

1.) General Scope: These are questions whose answers cover an entire input paragraph
2.) Specific Scope: These are questions whose answers cover a phrase or less
3.) Medium Scope: Questions whose answers cover one or more clauses or sentences.

2. SYNOPSIS OF NLP

The first recognizable NLP application was a dictionary look-up system developed at Birkbeck College, London in 1948. Jones, (1994) in her abstract, Natural Language Processing: A historical review, divided the history of NLP into four phases, with distinctive concerns and styles. She defined the first phase of work in NLP as lasting from the late 1940s to the late 1960s, the second phase from the late 1960s to the late 1970s and the third to the late 1980s, with the fourth phase to the end of the century. According to her, the first phase was defined by Machine Translation, the second phase flavored by Artificial Intelligence (AI), the third phase Grammatico-logical while the fourth phase has focused on lexical and corpus data.

According to Liddy, (2005), research in natural language processing has been ongoing for several decades dating back to the late 1940s. She stated in her publication, Natural Language Processing, that Machine translation (MT) was the first computer-based application related to natural language. According to her, while Weaver and Booth started one of the earliest MT projects in 1946 on computer translation based on expertise in breaking enemy codes during World War II, it was generally agreed that it was Weaver's memorandum of 1949 that brought the idea of MT to general notice and inspired many projects. He suggested using ideas from cryptography and information theory for language translation.

Research began at various research institutions in the United States within a few years. Liddy explained that early work in MT took the simplistic view that the only differences between languages resided in their vocabularies and the permitted word orders. Systems developed from this perspective simply used dictionary-lookup for appropriate words for translation and reordered the words after translation to fit the word-order rules of the target language, without taking into account the lexical ambiguity inherent in natural language. This produced poor results. The apparent failure made researchers realize that the task was a lot harder than anticipated, and they needed a more adequate theory of language. However, it was not until 1957 when Chomsky published Syntactic Structures introducing the idea of generative grammar, did the field gain better insight into whether or how mainstream linguistics could help MT (Liddy, 2005).

The goal of NLP is to accomplish human-like language processing. The choice of word 'processing' is very deliberate and should not be replaced with 'understanding'. For although the field of NLP was originally referred to Natural Language Understanding (NLU) in the early days of Artificial Intelligence (AI), it is well agreed today that while the goal of NLP is true NLU, that goal has not yet been accomplished (Liddy, 2001). A full NLU, system would be able to:

i. Paraphrase an input text
ii. Translate the text into another language
iii. Answer questions about the contents of the text
iv. Draw inferences from the text

While NLP has made serious inroads into accomplishing goals 1 to 3, the fact that NLP systems, cannot of themselves, draw inferences from text, NLU still remains the ultimate goal of NLP.
There are various uses of NLP in our society today. Part of which are Machine Translation, Database Access, Information Retrieval, Extracting data from text, Spoken Language Control Systems, Spelling and Grammar Checkers, Question-Answering and Dialogue Systems among others.

NLP is chosen for this work because of its fundamental technique for processing language for several subtasks, such as morphological analysis, parsing and word sense disambiguation among others (Copestake, 2004).

3. MATERIALS AND METHODS

Figure 1 shows the steps involved in developing the test or question generator.

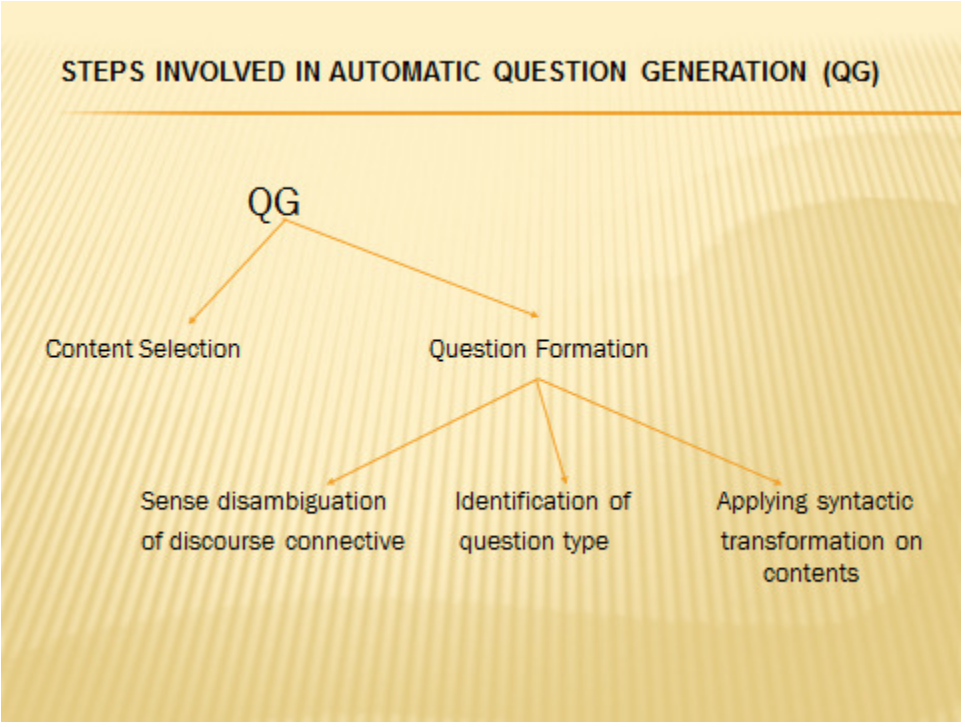

Figure 1: Steps of Automatic Question generation (Source: Argawal et al., 2011)

3.1 Content Selection

This involves identifying the discourse connectives (DCs). Discourse connectives are words that link two sentences (in the case of inter-sentential connectives) together or link two clauses (in the case of intra-sentential connectives) together. Examples of intra-sentential connectives include: because, since, although, when. The discourse connectives are stored in an array in the application code. On identification of any of the discourse connectives, the system breaks the sentence into two arguments. Argument1 involves the words (or phrase or clause) that exists before the discourse connective while argument2 involves the words that exist after the discourse connective.

3.2 Question Formatting

After selecting the content from which questions are to be generated, the following steps are carried out to generate the questions:

i. Sense disambiguation of discourse connective

Sentences exhibit discourse relations/senses such as:

a. Temporal: Relating to time e.g *since, when*
b. Causal: Being or involving cause e.g *because, since, when*
c. Concession: Reluctantly giving in e.g *although*
d. Contrast: Comparing between items e.g *although*
e. Instantiation: citing an example or giving an instance e.g *for example, for instance*

As seen from the illustration above, some sentences exhibit multiple senses. Hence, the need for sense disambiguation i.e identifying which precise sense a sentence exhibits. For example, examining the discourse connective "***since***". Its discourse relation is: temporal, causal. Hence, it can take the temporal sense and ask a 'when' question in the presence of keywords that represent time, year, start, begin, end and date among others. Anything asides these, a 'why' question is asked.

ii. Identification of Question Type

Table 1 shown below can be used as a guide to know which kind of question to ask in what type of situation

Table 1: Discourse Connective, Sense and Question-type (Source: Argawal et al., 2011)

Discourse Connectives	Sense	Q-type
Because	Causal	Why
Since	Temporal Causal	When Why
When	Causal + temporal Temporal Conditional	When
Although	Contrast Concession	Yes/no
As a result	Result	Why
For example	Instantiation	Give an example where
For instance	Instantiation	Give an instance where

iii. Applying syntactic transformation on contents

At this stage, we already have the question type, auxiliary and the content. The following transformations then take place:

a) a. If the auxiliary is resent in the sentence itself, then it is moved to the beginning of the sentence; Otherwise, auxiliary is added at the beginning of the sentence

b) b. If a wh-question is to be formed, the question word is added just before the auxiliary. In case of Yes/No questions, the question starts with the auxiliary itself as no question-word is needed

c) A question mark is added at the end to complete the question

4. CONTEXT DIAGRAM OF THE SYSTEM

A context diagram identifies actors or user roles from any documentation available. It also identifies the information that each external entity sends to the system and receives from the system. Figure 2 below shows the context diagram for the Automatic Test/Question Generator System:

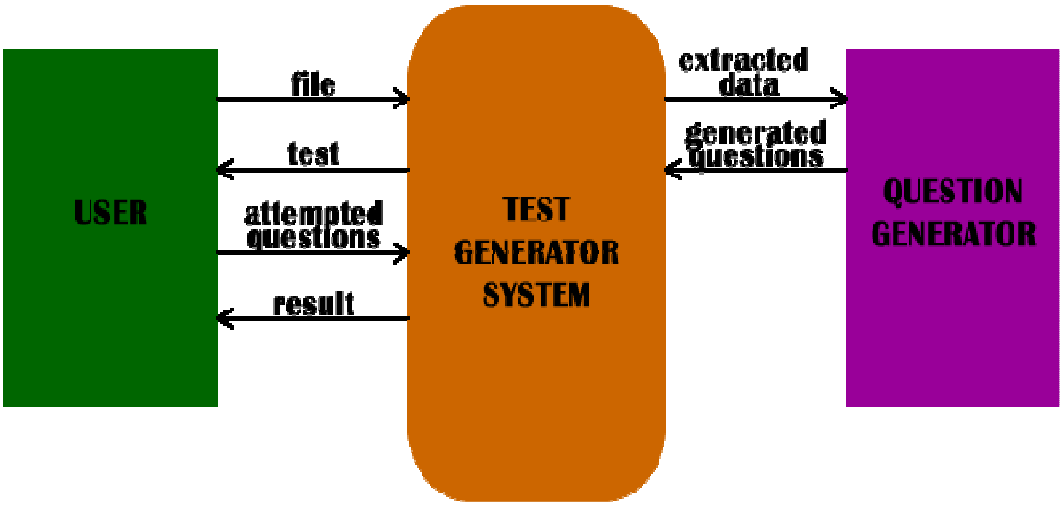

Figure 2: Context Diagram for the Automatic Test/Question Generator System (Source: Folajimi and Omojola, 2013)

The above figure shows that the user selects the file and passes it to the Automatic Test Generator system. The system then passes the text contained in the file to the question generator (as NLP works with only text). The question generator then processes the text and comes out with the generated questions. It passes the questions to the Automatic Test Generator System which the user interacts with. The system outputs the generated questions to the user in form of a test. The user attempts the questions and sends them back to the system. The system then processes the submitted answers by the users and then outputs the result to the user.

5. IMPLEMENTATION AND DISCUSSION OF RESULTS

The system was developed using C#.net on the .Net platform. Hence, it is an application suited only to the windows operating system. Below are some of the screenshots from the automatic question generator system.

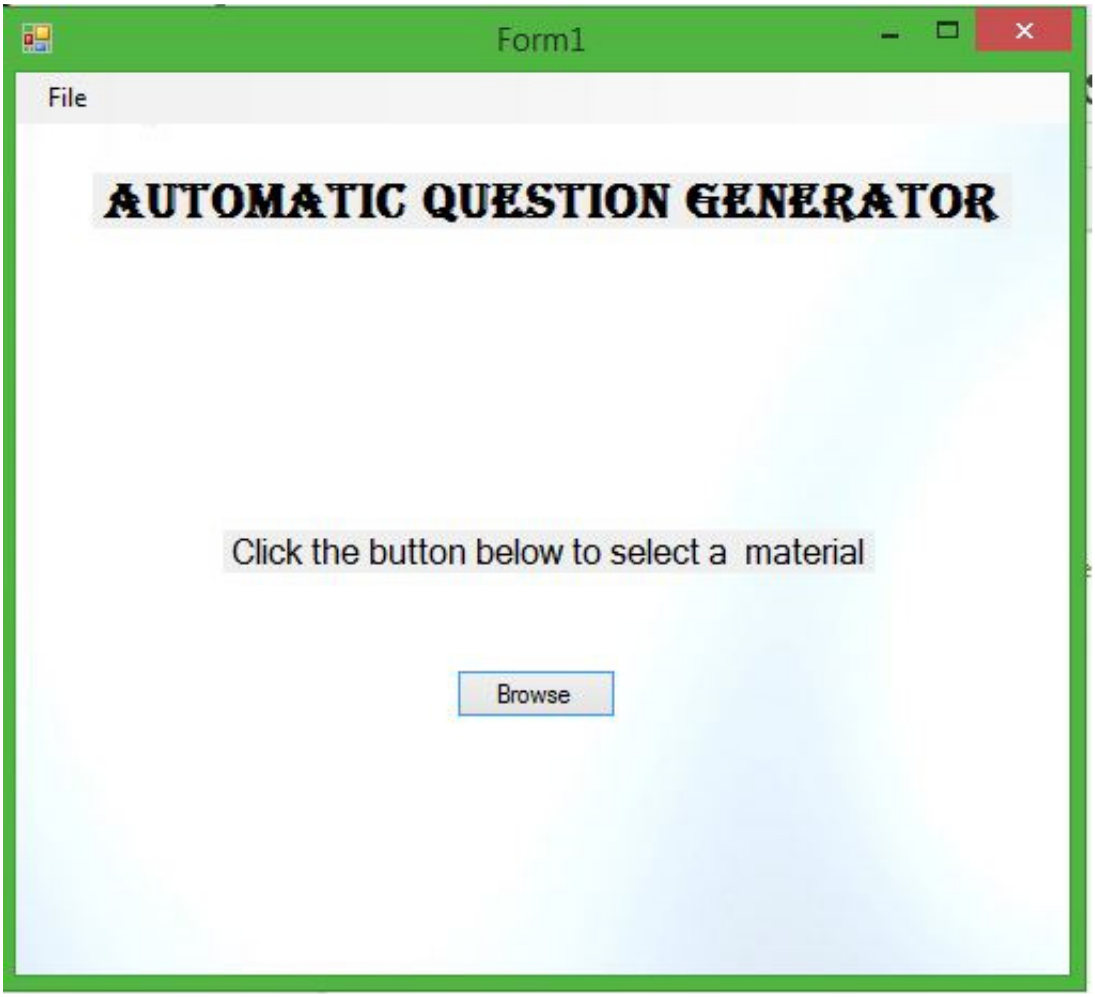

Figure 3: The Home Page

Figure 3 shows the homepage of the application. It contains a 'Browse' button which enables you to click to select a material from any location on your system.

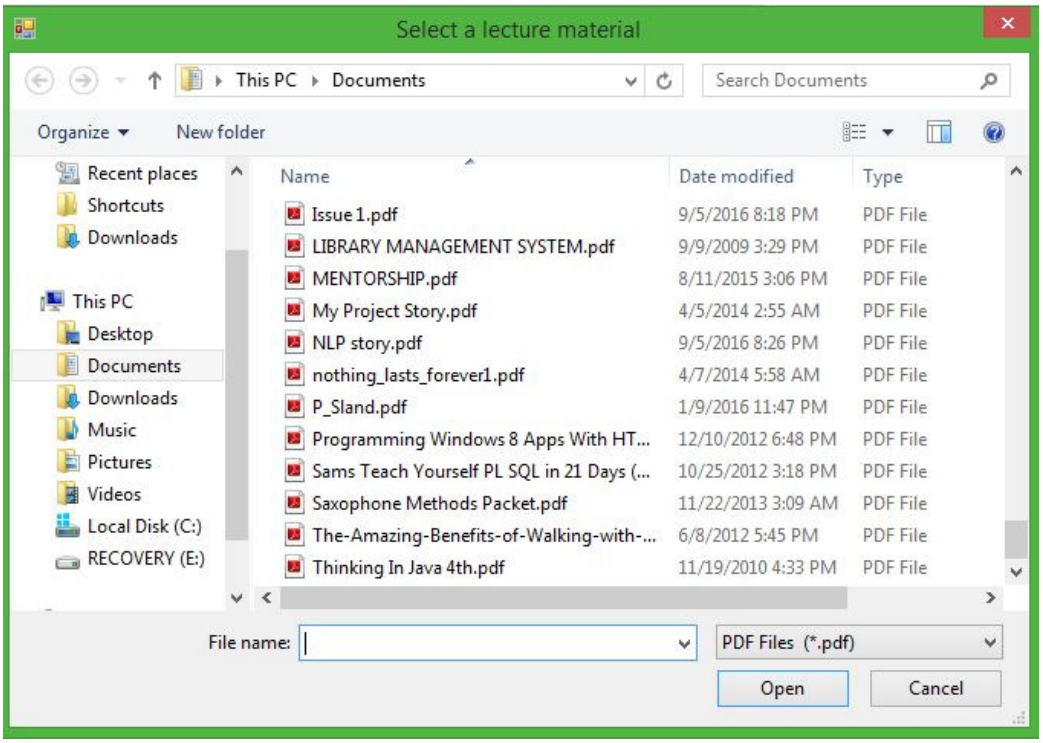

Figure 4: Screenshot of where to select file

The browse button allows one to select a material from any location on the computer system. However, this study handles only applications in .pdf format.

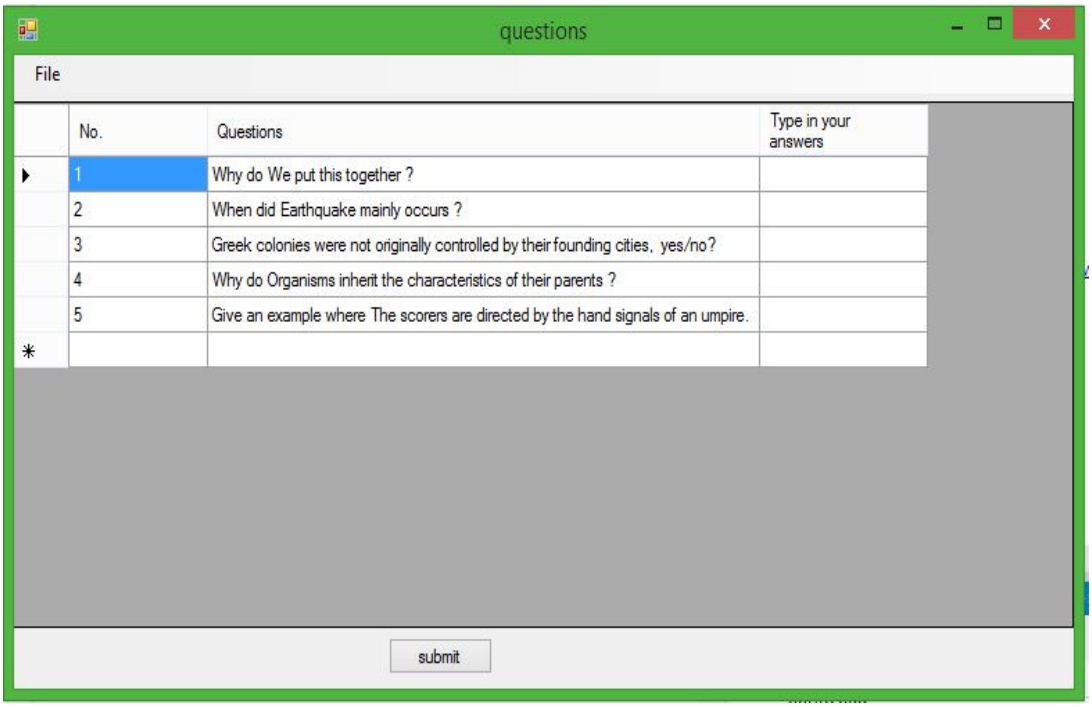

Figure 5: Generated Questions

Figure 5 shows the generated questions and the space to answer the questions. This happens after a material from the system has been selected. It generates questions from the materials and presents it in a form of test and also gives the facility to answer the questions.

On submitting the answers, it grades immediately and gives the overall percentage mark. This actually saves the lecturer's time and lessens his/her burden while dealing with voluminous texts and large classes.

6. CONCLUSION

Natural Language Processing is a vibrant and active field of computer science research that aims at granting computers the artificial intelligence needed to process languages as skillfully as human beings. However, this goal hasn't quite been achieved maximally and as such, this makes NLP a very rich area for research for anyone interested in the research field

Even though several works have been done on different types of texts, this study has made use of pdf files alone because of its focus on teaching materials.

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