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Semantic Reinforcement Learning Model for Education Question Answering

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Abstract: ***Research methodology is a general strategy used to describe the stages of completing a scientific research project. The research stage describes the methods/techniques needed to find new phenomena or knowledge as the goal of research. So that the methodology is an important aspect in the process of completing the research. This study designed a model for question - answering based on semantic reinforcement learning. The aim is to provide knowledge about the stages or research process of the question - answering model design so that in the future it can be developed into a system. The results of the model design are expected to improve system performance in the future.***

Keywords: Research Methodology, Design Methodology, Question Answering, Reinforcement Learning, Semantic Parsing

1. Introduction

Research is a process of studying and analyzing a phenomenon in a systematic, objective, critical, data - based, investigative, or scientific investigation of a particular problem to find a solution [1]. So research is an effort to gain new knowledge to solve problems. New knowledge can be new ideas and new techniques for solving current problems in new environments. The research aims to obtain information on a hidden problem or truth that has not been discovered so far, through the establishment of scientific principles [2]. In an academic institution, research is used for diligent and systematic investigation of an object, to find or revise facts, theories, and applications [3]. The process of systematically studying and analyzing phenomena towards an object requires an appropriate methodology to obtain good results.

The methodology is a general strategy that describes the stages of a research project that will be carried out, by identifying the methods that will be used to complete the project [4]. Methodology in computer science consists of methodologies formal, methodology experimental, methodology building, methodology process, and methodology model [5], [4] so that needs to choose the right method to achieve the goal.

2. Related Work

There are several past research on research methodology in computer science and information systems [6], and [7] conducted a literature review survey of research methodology to know the main methodology in research computer science [8] adopted the concept of the structure of the model methodology as a research methodologyin computer science. In [4] defines several computer science panel research methodologies including methodology modeling, and also [9] explaining research methods is the most important aspect of conducting research projects.

In addition to the model reinforcement learning and semantics approach in the question and answer system, such as [10], [11] use approach reinforcement learning to reformulate the question correctly to get the right answer, as well [12], [13] use reinforcement learning as a framework for generating multi - documents automatically by analyzing the reward function to update the appropriate feature weights so that it becomes a summary of answers to complex questions. Whereas [14], [15] use various algorithmsand reward functions, and simple embedding features in reinforcement learning to create summary sentences for multi - documents automatically.

While the lambda calculus (LC) method is a model of semantic parsing which can make a connection between the subject and object of the sentence by taking the verb as the root of the sentence [16], and [17] using LC for transducing natural language utterances into formal meaning representations.

But this study uses methodology modeling to design a semantic reinforcement learning model as a method for education question - answering research that will be used in further system development, using calculus lambda as a semantic parsing algorithm that is used to get the logical form of a question, while reinforcement learning uses the reward function of the state - action - reward - state - action (SARSA) algorithm to process the answers to questions from an extracted document.

3. Design Methodology

3.1 Research Process

The research process is a sequence of stages of research activities that need to be carried out in designing the QA model, as shown in Figure 1. There are six (6) stages in this research, namely literature review, problem statement, data

collection and data processing, QA designmodel, validation model, and evaluation model, and ends with conclusions.

1) Literature review

This stage conducts a literature review study on the results of previous research and theoretical studies related to the research topic, to help researchers to determine the research object and determine the method to be proposed in making this QA model. At this stage, we conducted a literature review of the lambda calculus method as a capable semantic parsing algorithmto form logical questions or answers in natural language [17], as well as the state - action - reward - state- action (SARSA) algorithm is a method of reinforcement learning used by agents to perform actions from one state to another by obtaining a reward value [18], where this value is obtained from each state that has been visited as a result of candidate answers to questions that have been classified, can be seen in sub - discussion 2.

2) Problem statement

It is a research target that needs to be completed, namely the reinforcement learning approach which has been used so far to generate multi - documents into a summary or sentence, and semantic parsing is used to form logical questions or answer sentences that can be combined to obtain a QA model that is capable of providing the right answers.

3) Data collection and data processing

The data needed in this research is a dataset of educational questions by determining the entities and SOP documents for prospective new students in the form of diagrams described in the text which will be used as datasets. Then the dataset is divided into three (3) parts, namely the training dataset is used for model development, the validation dataset is used when conducting model validation and the testing dataset is used when evaluating the model.

4) Design QA model

This stage will design a QA model based on semantic reinforcement learning to analyze questions and analyze answers to the question and SOP datasets, based on their respective stages, which can be seen in sub - sub - discussion 3.2

5) Design validation and evaluation QA model

The validation and evaluation model design describes the process or stages that need to be passed to validate and evaluate the QA model, which can be seen in sub - sub - discussion 3.3

6) Conclusion

The conclusion is a summary of the results of the proposed QA design model so that in the future it can be developed into QAS

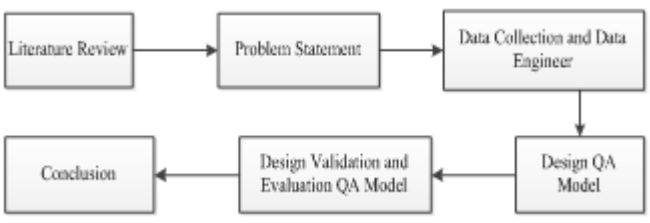

Figure 1: Research process

3.2 Design Model

The design of the semantic reinforcement learning model for education question - answering research (E - QAR) has several main parts, including question processing, document processing, and answer processing where the model is the big picture as shown in Figure 2.

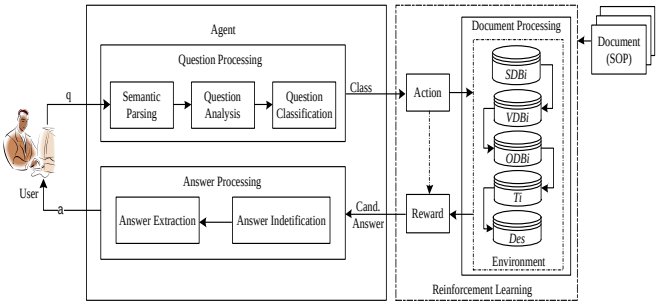

Figure 2: Designmodel semantic reinforcement learning for E – QAR

3.2.1 Question Processing

The questioning process is needed to classify questions asked by users in natural language, as shown in Figure 3.

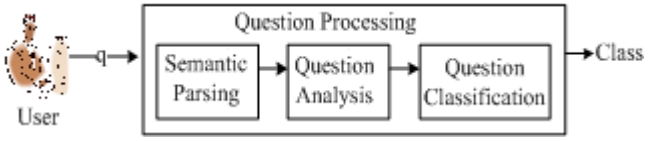

Figure 3: Proses question classification

An explanation of the question classification analysis process in Figure 3 is as follows:

a) Semantic parsing

Semantic parsing is used to transform natural language sentences into special or formal meaning representations so that they can be processed by computers, computer formal representations of meaning [19], [17], [20] using the lambda calculus (LC) method which can make a relationship between the subject and object of the sentence by taking the verb as the root of the sentence [16], [17].

b) Question analysis

Question analysis is the first stage of any QA system whose accuracy results have a significant impact on the information retrieval and answer extraction stages [21], [22]. Word embedding is a method for analyzing questions by representing words from natural language (NLP) into a vector representation of low - dimensional real numbers that can be understood by a computer [23], [24]. In this study, we will use the Fasttext algorithm as a refinement of word2vec for representing words from natural language (NLP) into vector representations of real numbers [25], [26], [27].

c) Question classification

This study will use the method BERT to classify questions into several classes like what, who, where, why, when, and how, becausethe method as a model pre - trained language designed to consider the context of words from the left and right together with a simple conceptual, yet empirically

robust, can improve accuracy in some NLP tasks such as question and answer systems [28], [29].

3.2.2 Document Processing

Document or text processing will begin with pre - processing, namely, tokenization, stop word removal, and POS tangging of documents and storage and providing indexes in directories based on the grammatical structure of each sentence, as shown in Figure 4.

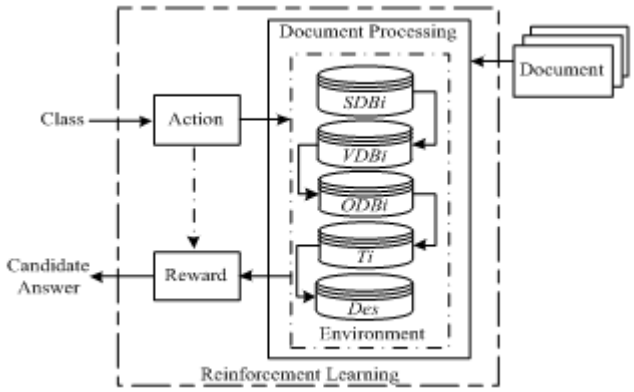

Figure 4: Document processing

Please note that after the SOP is pre - processed, it will be stored in a directory and provided with an index. *SDBi* is used to save the subject of the sentence, *VDBi* is used to save the verb or verb of the sentence, *ODBi* is used to save the object of the sentence, *Ti* is used to save the position of the verb in a sentence, and *Des* is used to save the adverb of the sentence. These directories are in an environment that makes a state that will be visited by an agent in the form of a question from the classification results. The algorithm used by agents to carry out actions from one state to another is the SARSA algorithm which is part of the reinforcement learning algorithm. By using the concept of the SARSA algorithm [30] the agent performs actions from one state to another by obtaining a reward value, where the value is obtained from each state that has been visited. The agent will get a value of 1 (the index value of the directory) if the action result from a state gets a positive reward and if the reward value is negative it will get a value of 0.

Agents will not take action on every state in the environment, if the results of the classification of questions with all entities have previously been processed, then the agent will immediately match the previously processed reward values to make candidates the answers to the questions.

3.2.3 Answer Processing

The process of analyzing the answers to the questions must of course begin with the classification of the questions as described in sub - sub - section 3.2.1. Then these types of questions will become agents to take action against the state in the environment to obtain a reward value, as described in sub - sub - discussion 3.2.2. The reward value obtained will be sent back to the agent as an answer to the question, and then the agent will carry out the answering process through two (2) stages, namely identifying answers and extracting answers, as shown in Figure 5.

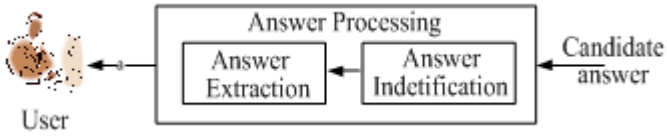

Figure 5: Answer processing

An explanation of the answer process in Figure 5 is as follows:

a) Answering identification

Identification of answers using approaches TF - IDF for Mrank the answer candidates [31], [32], as well as measuring the similarity between the two strings, in this case measuring the similarity of classified questions and answers candidate paragraphs using an algorithm jaro - winkler distance [33], [34]

b) Answering extraction

Extract answers by performing a detailed analysis of relevant texts or documents and matching them with representations of the question filesclassified to get one answer as a candidate [22], [35] using the cosine similarity approach then sorted according to the probability of truth as an answer [36]

3.3 Design Validation and EvaluationModel

Design validation and evaluation modelare carried out to determine the validity and accuracy, precision, and recall of a model being developed [37]. This study uses semantic reinforcement learning modelwhich in the future will be implemented into a question - answer system. The model can be validated using the K - fold cross - validation method [38] according to the rules as done by [38], [39]and evaluation of the performance model developed with the confusion matrix approach [16]. The model validation and evaluation process will be carried out through several stages as shown in Figure 6 below

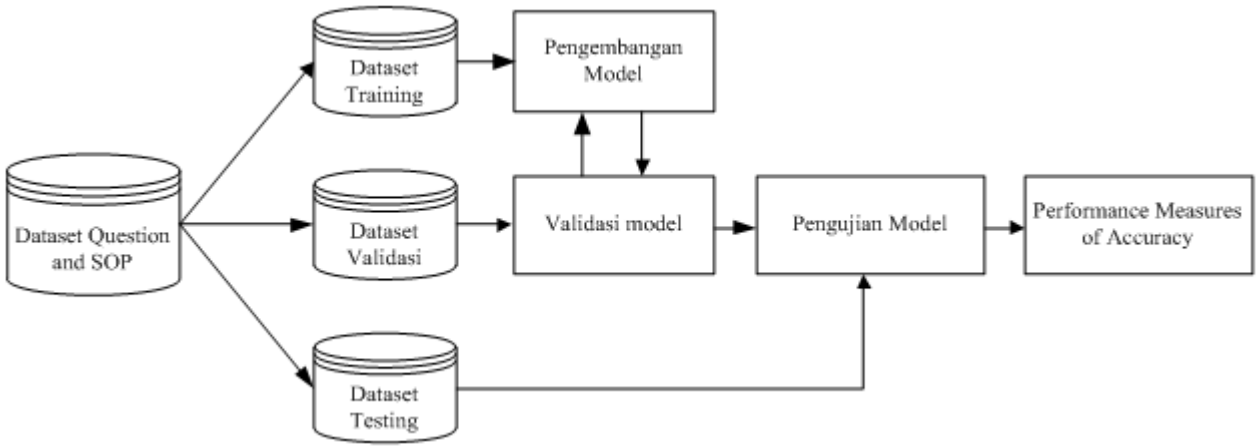

Figure 6: Design validation and evaluation QA model

Several components will be involved in the model testing process as shown in Figure 6, including:

1) Dataset
The question dataset and SOP dataset will be processed into three (3) sub - datasets namely, the training sub - dataset, validation sub - dataset, and testing sub – dataset

2) Sub - dataset training
The training sub - dataset will be used in the process of developing a question - and - answer system model with a dataset portion of 50% of the sample of the total dataset.

3) Sub - datasetvalidation
The validation sub - dataset is used to carry out model validation tests that have been developed with the portion of the dataset for model validation containing 25% of the sample of the total dataset.

4) Sub - dataset testing
This sub - dataset will be used to evaluate the performance of the model that has been developed with the portion of the dataset for model performance evaluation containing 25% of the sample of the total dataset.

5) Model development/model design
The development of the question and answer model will start from the question analysis process, document processing (SOP), and the answer analysis process as described in sub - sub - discussion 3.2.

6) Validation model
Model validation will be carried out to ensure the working process of the model that has been built using the k - fold cross - validation method with validation sub - datasets to carry out validation as carried out by [38], [39].

7) Evaluation performancemodel
The developed model will be evaluated for its performance using a confusion matrix evaluation, to know the accuracy value [40], [41], [42]precision [43], andrecall [41], [42]of the model in conducting question analysis, document processing (SOP) and analysis of answers carried out by the model.

4. Conclusions and Future Work

The scientific methodology is a stage or strategy as a guide for completing a scientific research project. One of the research methodologies in computer science is modeling methodology which can be used to design a model by involving various methods, approaches, or algorithms before being applied to a system.

Thus the model methodology is an important aspect in the process of completing scientific research, so in this article the methodologymodel is used to design a semantic reinforcement learning model for education question answering using several methods and approaches, to produce a reliable model. So that the design of the model that has been produced is used as a reference to test the validity and performance in carrying out its duties.

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