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Research paper



Case-Based Reasoning Approach to Map Similar Cases for Accident Injury Claims

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Abstract

The procedures of getting compensation from a legal claim are time-consuming. Legal practitioners spend the time to retrieve the similar or relevant past cases to support their claim for a case. The process to map the past similar cases to get the best claim is even more challenging. Thus, this study aims to help the legal practitioners in their work to speed-up the process of claiming for compensation in an accident case. Consequently, it helps those who need and worthy of the compensated money. This study developed a Legal Advisor of Accident Cases system using a CBR approach which outlines three primary objectives; (i) to identify similar past cases features to the case in-progress; (ii) to design an intelligent component to assist legal practitioners in finding similar cases to support an injury claim case; (iii) to develop a prototype of the legal advisor system that can be used by legal practitioners to speed-up the case settlement. Data for this project has been collected from a law firm cases and a series of interview sessions with legal practitioners. It reused the past cases and aligned with the legal procedures. The system performance with an efficiency rate of 75% has been achieved. It has a potential to be extended to cover a wide area of legal claims.

Keywords: *Accident claim case; Case-based reasoning; Knowledge-based systems; Legal advisor system.*

1. Introduction

The growth of interest in artificial intelligence (AI) has progressed in various fields. The applications of AI support many areas of expertise such as medicine, manufacturing, education, health, and law [15], [16], [17], [18], [19]. Case-based reasoning is one of the approaches which map the new problem to the existing cases [6], [5]. It emulates the decision-making abilities of the human expert who often refers to similar cases based on their experiences [6].

AI research in the field of law has been progressing for more than twenty years [1], [2], [5]. In a legal system, legal practitioners need to study past cases, connect, reason, and provide pieces of evidence to make a sound case and win an argument. Consequently, in an accident claim cases, they must find past strong cases as the claim bases to ensure they have a chance to get a handsome compensation. Many types of research have been conducted to assist legal practitioners in minimizing time spent over searching past cases in supporting new cases arguments.

The knowledge-based system architecture in legal advising consists of three main components; (i) a knowledge base to keep the case facts, (ii) user interface explanation facilities, and (iii) an inference engine. The system's knowledge representation scheme has unique attributes [15]. It connects cases and legal claims features, and related legal policies. The inference mechanism algorithm uses this information to infer reasoning and create solutions [2].

In Malaysian environment, an individual who is involved in an accident needs to file a claim for getting compensation for vehicle damages or injuries suffered. The victim will hire a lawyer (legal practitioner) to get the settlement. In the case which involved several or major injuries, lawyers would bring the case to the court [3]. The chances of getting a higher settlement are higher than direct settlement are one of the reasons the lawyers choose this action [3]. However, in the case of minor injury claims, the direct settlement is regularly offered by the insurance company. In such cases, the time taken to receive the compensations is faster than court settlement. In major injury cases, the process of bringing a case to the court requires several steps that may extend the time of receiving the compensations.

Figure 1 illustrates the process of getting an injury claim. When the victim files a new case, the lawyer must get the statement from the client who filed the claim. They also retrieve the facts and features of the cases from the filed police report. Based on case features, the lawyers then search and retrieve the most similar cases from the Malayan Law Journal (MLJ). The search matches the features of the cases onto the MLJ cases. Similar cases with the highest compensation are referred to as the base of the claim.

Based on this process, the most time-consuming step is the search and mapping of the claim to the records in MLJ. A reasonable search provides them with a good base. Consequently, the poor search resulted in a weak base for the injury claim. Therefore, this study attempts to develop a system to reduce the time taken to search for similar cases in MLJ based on the case facts and the compensation amount.

We organize this paper as follows; the next section presents the case-based reasoning literature followed by the methodology in section III. Section IV discusses the results and findings, and finally, in Section V, the paper is concluded.

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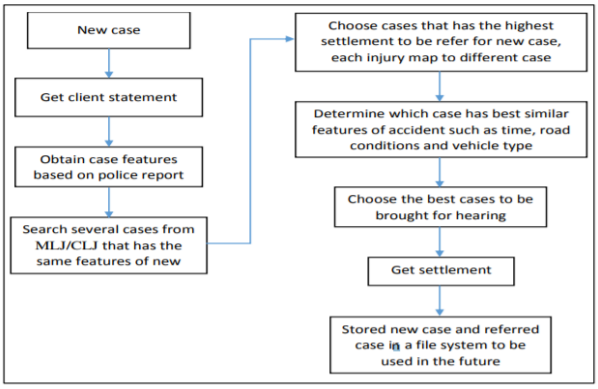

Fig. 1: The injury claim process.

2. Case-Based Reasoning

Case-Based Reasoning (CBR) is one of the methodologies to solve problems [11]. It combines the technique of problem-solving and machine learning. When a case is solved, the solution is kept to solve future cases. On the contrary, the system recognizes and memorizes the cause of failed cases to avoid the same occurrence repeat in the future [11]. CBR uses prior knowledge and associates the knowledge-based support. It imitates the human reasoning behaviour. CBR originates from the idea of using specific similar past experiences to solve a new problem [11].

The application of CBR is used in the mental health domain, specifically for anxiety disorder diagnosis. An example of such application is a prototype of a decision making support system for diagnosing anxiety disorder based on a different level of expertise. The system overcomes the limitations of a rule-based system which is based on specific knowledge acquisition [12]. Gebreaml [14] developed Legal Decision Support Expert System (LDSES) to facilitate users for decision-making processes in legal processes. Due to the vast knowledge base, LDSES includes a pre-processor to lower the time consumed to retrieve the stored cases [14].

3. Methodology

This study undergoes four stages as shown in Figure 2. The first stage of the project is the project preliminaries. We gather all the related information on the domain and identify the primary expert for the study. In addition to the findings from the literature and Malayan Law Journal (MLJ), we seek direct guidance from a law firm, Yahaya Ahmad & Co located in Sungai Petani, Kedah. Several interviews and document observation sessions have been conducted. During the session, we examine the sample of case documents, a sample of police reports, and MLJ entries.

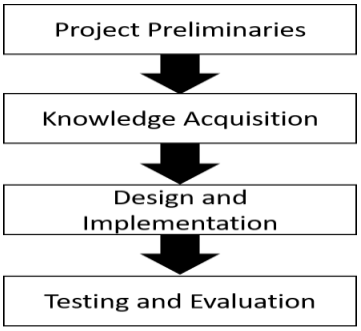

Fig. 2: The stages of the study

We compare between two techniques which are used by most legal advisor knowledge-based systems, the rule-based and case-based reasoning. From the findings, case-based reasoning method is the preferred method.

3.1. Knowledge Acquisition

We extract the primary information on the features of the claim cases from the statistics and examples of MLJ. MLJ serves as the primary source of the study. It provides a supportive structure of information of the project data based on the past years' data. We represent the information and knowledge gathered from the interview sessions, examined documents, and sample cases. Figure 3 illustrates the knowledge representation schema in semantic network format.

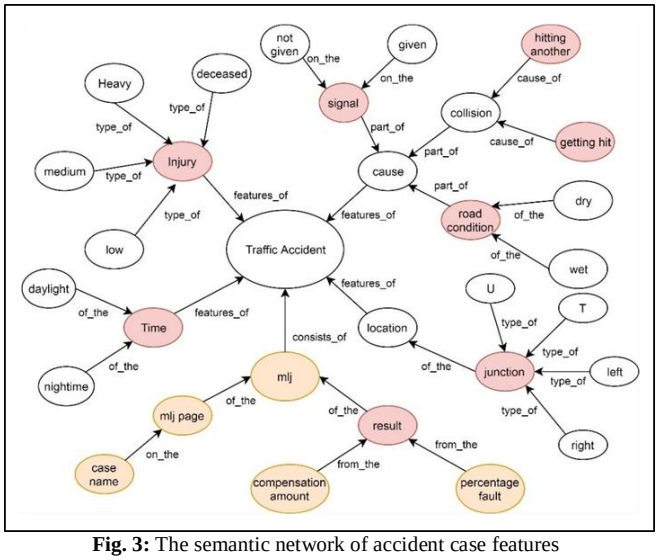

Fig. 3: The semantic network of accident case features

Based on Figure 3, the features of accident cases vary, and it depends on specific criteria of how it occurs. Each accident can be determined and searched by these features and its condition. We retrieve and analyze the sample of actual cases and to extract the key features of claim cases. We enter the cases details into a text file. At the early stage of this study, the lawyers identify the cases key features. These features become the attributes in the case base. We later use it to calculate the similarity between the cases. Table 1 shows the extracted key features and their definition from the experts that are used as attributes in the prototype.

Table 1: The key features of cases and their definition.

CASE FEATURES	DEFINITION
Case Name	Clients' name and year of the accident occurred. (Example: Syafiqah 2014)
Time of Accident	The specific time the accident occurred. It indicates whether the accident occurs during day time or night time (Example: yes/no)
Road Condition	The road condition where the accident occurred. (Example: dry/wet)
Road Junction	The location where the accident occurred. (Example: T,4, U, no/left/right)
Being Hit by Another Vehicle	The specific spot where client being hit at (Example: front/rear/side/no)
Hitting Another Vehicle	The specific spot where the client hit another vehicle (Example: front/rear/side/no)
Turning Signal	Indication whether the client or other vehicle give turning signal (yes/no)
Injuries Sustained	Injury sustained (suffered) by the client (Example: low/medium/high/deceased)
Malayan Law Journal	Which MLJ the new case refers to (case name, ID)
MLJ Page Number	The page of the referred case
Case Result	The result of the referred case by court order (win/lose) (MLJ)
Percentage of Guilty	The estimation of the percentage of how much the client is guilty (0%-100%)
Compensation Received	The total compensation received from the past cases

3.2. The Case-Based Reasoning Cycle

The development of the system follows the CBR cycle. In general, the CBR cycle consists of four main phases; Retrieve, Reuse, Revise and Retain. The design of the system architecture reflects these phases. Figure 4 shows the phases and Figure 5 illustrates the proposed system architecture. In a typical sequence, the process starts with the 'Retrieval' procedure. Retrieval procedure searches for past cases that is almost identical to the features of the new case. The eight features designed for the system are as shown in Figure 5. Consequently, the retrieved case forms a proposed solution that serves as a basis for the second CBR phase, 'Reuse'. Based on the rank of the most identical (similar) cases query, the best case is selected. Users review and can reuse the best matched (similar) solution by presenting it to the court. The accurate case recommendations give a good chance for the client to get better or same compensation value as the selected case.

In the case a new feature or criteria arises, adaptation of the case is required. The new progress of the case is then updated in the 'Revise' phase. There are few categories of adaptation in CBR. Consequently, the derivational adaptation is used. To produce a new solution, derivational adaptation allows users to reuse the case facts of the referred case. Therefore, for example, the similar retrieved past cases can be re-used with different injuries. It allows the use of the new proposed solution.

In 'Revise' phase, the proposed solution also must consider differences between the new problem and the problem of the retrieved case. The new proposed solution proposed will be revised by an expert (either human or machine) for it to be accepted or rejected. In claiming for the compensation in the accident cases, the result ordered by the court determines whether the case is won or otherwise. If the total compensation is as expected, the case can be accepted as a referral case in the future.

In the last phase, the 'Retain' phase stores the revised proposed solution in the case repository. The new derived solution is kept in the case repository to facilitate the future diagnosis of new case. In storing the new solved case in the case base, the input is the same as the new case input with additional of the case percentage, compensation received and the case name.

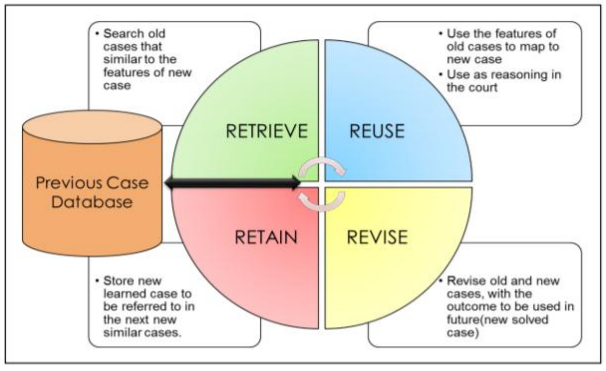

Fig. 4: The CBR cycle for the Legal Advisor System for Accident Cases

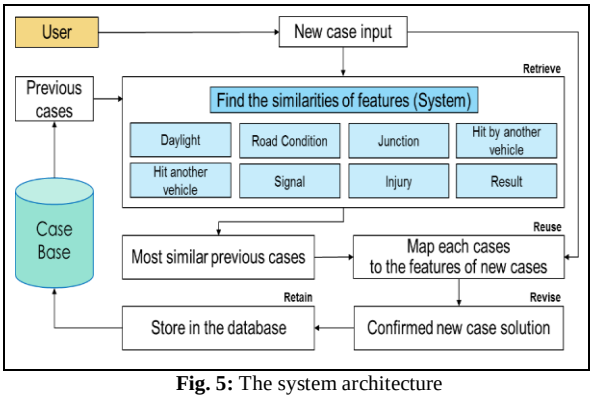

Fig. 5: The system architecture

3.3. System Architecture

Figure 5 illustrates the proposed system architecture. We first retrieve the selected case features from the new case. We map the new cases to the database of past cases extracted from the MLJ. The main purpose of the mapping is to calculate the percentage of the similarities of the features between these cases. Next, the similarities percentage is ranked and we retrieve the case with the highest similarity. Consequently, each case features are examined to increase the chances for the client to get a high settlement from the judge [3]. Later, the system retains the validated official results of the trial for future re-use.

3.4. Development Tools

The earlier CBR systems were based on simple distance metrics. The much newer CBR applications use more sophisticated, knowledge-intensive similarity measurement [8]. In this study, myCBR has been used as one of the tools for developing the simulation. MyCBR is an open-source software tool for building case-based applications. It is a similarity-based retrieval tool developed by the Competence Center CBR, German Research Center for Artificial Intelligence, Germany and School of Computing and Technology, University of West London, UK.

MyCBR provides a compact and user-friendly environment for a developer in building prototype of a CBR application with fewer resources is the reason this software has been chosen. It was designed based on communication between the system, the user knowledge engineer, and end-user. Knowledge representation that contains the vocabulary, the knowledge taken, test case data and the similarity measures is defined on every CBR knowledge containers [9]. The application Protégé acts as an interface while the plug-in of myCBR extends the usability of Protégé with additional tabs to access the myCBR modules. In this project, Protégé tool is used to model the knowledge. Protégé of Java based Open Source program that enabling the user to add new module easily by only plug-and-play [10]. The main advantage of Protégé is it provides the data structure and user interfaces for representing vocabulary and CBR functionality that can be added easily into the current Protégé applications. MyCBR runs as a plug-in within Protégé for supporting the application development of this project. The plug-in involves three modules which are:

- Modeling tools

Tools to create domain models and case instances; and add the missing functionality for defining similarity measures.

- Retrieval GUI

Function to analyze the quality of the defined similarity measures. It is the user interface of prototype CBR applications.

- Retrieval engines

To execute the similarity-based retrieval.

3.5 The Case-Based Reasoning Cycle

Retrieval GUI in myCBR act as retrievals and calculating the matching results for new case inserted. Figure 6 shows a sample of "QUERY RESULTS" of the overall retrieval result based on the similarity of the cases.

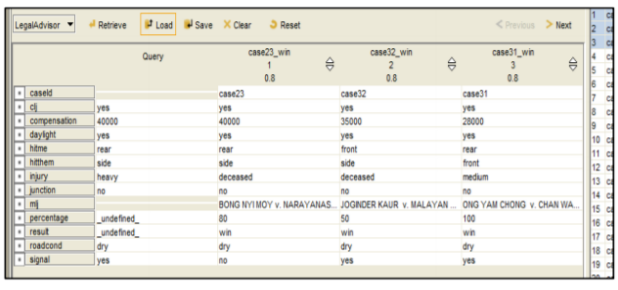

Fig. 6: myCBR retrieval module

4. Results and Findings

The prototype was tested with solved cases that have been referred to the MLJ. Closed cases are the cases that have been solved and the client has received the result of the case along with the compensation. Eight closed cases are tested in testing the system efficiency. The similarity percentage value is obtained from the retrieved case. It is scaled from 0 to 1 and later is converted into percentage numbers.

We have conducted ten experiments to new and solved cases. Every input that the user key in is evaluated using the case similarity formula for case-based reasoning. The cases output was evaluated and validated by the domain expert. In this paper, we present two of the evaluated past test cases, Case A and Case B.

Case A received the highest total compensation of RM400,000.00. The expert evaluation of the case is almost similar to the system which it had referred to case13 with similarity percentage of 90%. The evaluation of Case A yields a percentage of 92% similarity to Case26 and Case2. But due to the highest compensation is from Case26, it is chosen as the best similar case so that the clients would receive the best compensation value. The case output is shown in Table 2 and Figure 7.

Table 2: The Output of Case A

Case	Output 1	Output 2	Output 3
AS 2010	Case26	Case2	Case13
Similarity (%)	92% (0.92)	92% (0.92)	90% (0.90)

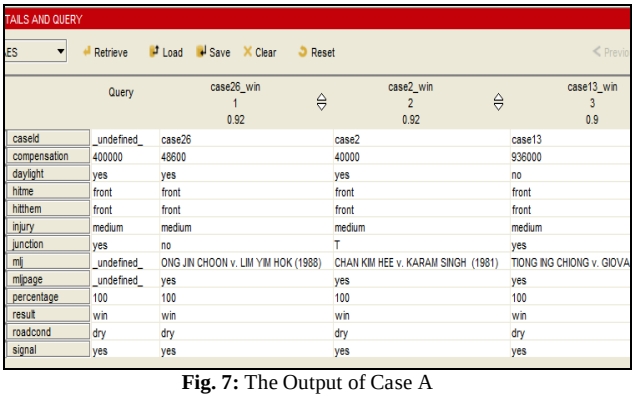

Fig. 7: The Output of Case A

While Case B, is the case with the lowest compensation from all the case that has been solved in the firm. The total compensation received by the client is RM 10,000.00. The expert evaluation is similar to the system which it had referred to case12. The system evaluation shows that Case12 has a similarity percentage of 95%. The case output is shown in Table 3 and Figure 8.

Table 3: The Output of Case B

Case	Output 1	Output 2	Output 3
SP 2013	Case12	Case35	Case39
Similarity (%)	95% (0.95)	93% (0.93)	89% (0.89)

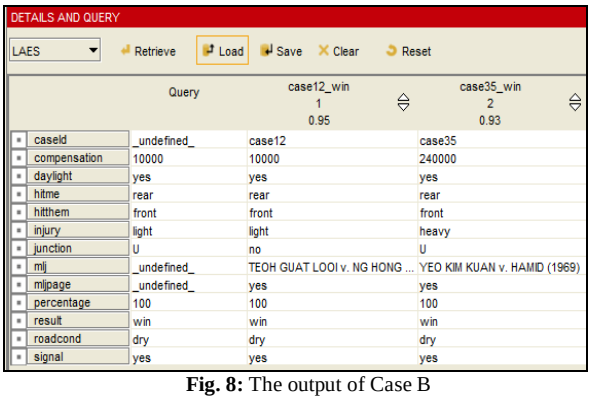

Fig. 8: The output of Case B

Based on the tested solved case above, we concluded that the system is delivering the results as expected. In this testing part, it imitates the second and third phase of CBR cycle when the retrieved case can be reused and then the case referring has the same outcome respectively. In total of eight test cases, we concluded that the system is delivering the performance and efficiency of 75%. It is concluded that the system is reliable in recommending users to find past cases that have the similarity to the new cases before the court trial.

5. Conclusion

The project demonstrated the use of CBR approach solution to speed-up the process of claiming for compensation in an accident case. The project facilitates the process of retrieving similar cases to allow the lawyers to compare among the cases. The system produces case similarity between the current and past cases. The results that produce the most similar cases with the highest compensation are revised as the solution for the new cases. Consequently, the system helps user to retrieve the best past cases and improve the chances to obtain a higher compensation. The revised cases are stored for the future use. The development of this project limits the accident cases to the cases which involved a car and motorcycles. Hence, it is limited to only one database that allows one user at a time. For the past cases, the compensation received is retrieved based on the currency values of the time the case was trialed.

The system can be upgraded to a hybrid system that applies other intelligent techniques that can provide a more accurate recommendation based on the case features input. Moreover, it will be an added advantage if the system can automatically process the police report according to the selected case features. Hence, the system needs to receive user input based on the police report of the new case to get past case recommendations.

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