Case-Based Reasoning via Comparing the Strength Order of Features

Liuwen Yu[1,2(✉)] and Dov Gabbay[1,3]

[1] University of Luxembourg, Esch-sur-Alzette, Luxembourg
liuwen.yu@uni.lu
[2] University of Bologna, Bologna, Italy
[3] King's College London, London, UK

Abstract. Case-based reasoning (CBR) is broadly speaking a method of giving a verdict/decision on a new case query by comparing it with verdicts/decisions of known similar cases. Similarity of cases is determined either by best distance of the query case from the known cases and recently also using argumentation. The approach of this paper is not to rely on similarity or argumentation, but to use the entire set of known cases and their known verdicts to define the relative strength and importance of all the features involved in these cases. We then decide the verdict for the new case based on the strength of the features appearing in it.

Keywords: Case-based reasoning · Strength of features · Legal reasoning · Argumentation

1 Introduction

Case-based reasoning (CBR) is broadly speaking a method of giving a verdict/decision on a new case by comparing it with verdicts/decisions of known similar cases. Intuitively, we decide on similarity of cases by giving each case a set of features and comparing the sets of features to decide on similarity. Thus, given a set of known cases with known verdicts and a new case for which we want to propose a reasonable verdict, we compare the new case with similar known cases and decide what is a reasonable verdict. Note that the above use similar cases (possibly some and not all the known cases). The reasoning is done by supplying a mechanism for detecting similarity and for using it to make such decisions. For example a verdict in a murder case can be compared to previous similar murder cases or another example the price of a flat can be compared with the prices of similar flats. Some commonly used mechanisms are for example:

1. Similarity can be detected by looking at distance between cases measured by looking at shared features [6, 11];
2. A decision can be made by building an argumentation network for similar known cases and embedding into the network the new undecided case [4, 5, 13, 15];

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3. Using regression in cases with heavily numerical features [7,9];
4. and so on [2,10].

The approach of this paper is not to rely on similarity but use the entire set of known cases and their known verdicts to define the relative strength and importance of all the features involved in these cases. We decide the verdict for the new case based on the strength of the features appearing in it.

We construct a formal model using formal components as follows.

1. A finite set $\mathbb{Q}$ of features;
2. We say that a non-empty subset E of $\mathbb{Q}$ is a case;
3. We view the set $\{+,-\}$ as positive and negative verdicts;
4. We use the set $\mathbb{K}$ defined as the set of all known cases and their verdicts, written as $\mathbb{K} = \{(E_1, \pm), ..., (E_n, \pm)\}$, to compute the strength of features;
5. A query is $(E_q, ?)$, where $E_q \subseteq \mathbb{Q}$;
6. We use $\mathbb{K}$ to define partial ordering $<_{\mathbb{K}}$ on $\mathbb{Q}$;
7. We use the ordering on E_q to answer the query.

Note that no similarity or argumentation is involved. This model works well in certain application only (legal, medical, safety, etc.) where the features are more or less independent (see Sect. 3).

The layout of this paper is as follows.

In Sect. 2 we introduce the basic definitions and three rules to compare the strength of atomic features. In Sect. 3 we devote to discussion and future work, and Sect. 4 concludes.

2 Strength of Atomic Features

In this section, we give the basic definitions, and rules for determining the strength of atomic features, and the process of obtaining a verdict for the new query.

Definition 1 (Cases and verdicts). *Let $\mathbb{Q} = \{q_1, q_2, ..., q_n\}$ be a finite set of atomic feature, different letters imply different features. A case E is a non-empty subset of $\mathbb{Q}$. $\{+,-\}$ is the set of verdicts, where $+$ means the case is with a positive result, and $-$ is the negative.*

Our model is abstract case based reasoning where the set of features is $\mathbb{Q}$, a finite set of all atoms and the cases are all finite subsets of $\mathbb{Q}$. It is not legitimate to ask where $\mathbb{Q}$ comes from and what is the meaning of the elements of $\mathbb{Q}$. In the same manner we do not ask what the arguments are in the theory of abstract arguments. There is what is called theory of structured argumentation where we put contents to argument in the same parallel we can talk about the theory of structured case-based reasoning (SCBR). See Remark 1 following Example 6.

Definition 2 (Set of Cases with Verdict). *A case completed with a verdict is written as $(E,+)$ (or $(E,-)$). Let $\mathbb{K} = \{E \mid E \subseteq \mathbb{Q}, (E,\pm) \text{ is completed}\}$ be the set of all E such that E has a verdict.*

Definition 3 (A query). *A query consists of a set of features $E_q \subseteq \mathbb{Q}$ and an unknown (that is for which there is no) verdict, written as $(E_q, ?)$.*

Example 1 (Murder case illustrating cases and queries). Consider a case where a crime was committed in the Park at noon, January 01, 2022. There are two witnesses W_1 and W_2 who claim "I W_1 (resp.W_2) was at the above time and place and I saw the accused committing the crime". W_1 and W_2 are modelled as features of this case, verdict $+$ is the accused is guilty and verdict $-$ is the accused is not guilty. Suppose we also have a third witness W_3 (i.e. another feature W_3), who clearly says "I W_3 was at the above time and place and I saw the accused definitely not committing the crime". Consider the case $E_1 = \{W_1, W_2, W_3\}$, and try to give a common sense verdict.

Consideration (*): It is reasonable to consider the credibility of the witnesses and the conflicting testimonies and decide.

Consider now another possibility for a witness, W_4, who was not at the scene of the crime but says the following: "I W_4, am a waitress who finished my job at a restaurant far away from the park and on January 01, 2022, at noon, I served lunch to W_1 and W_2". So clearly W_4 says/implies that the two witnesses W_1 and W_2 could not have been in the park at the time of the crime, and could not have seen it. Consider the case $E_2 = \{W_1, W_2, W_4\}$ that needs to reach a verdict.

The question is: Do we apply consideration (*) to this witness W_4? In other words, do we treat case E_2 the same way we treat case E_1? This may depend on our legal system. We know in Talmudic law E_2 is considered a case of conspiring witnesses (W_1,W_2) and we immediately believe W_4 and punish W_1 and W_2, so we have $(\{W_1, W_2, W_4\}, -)$[1].

Modelling this case, we have $\mathbb{Q} = \{W_1, W_2, W_3, W_4\}$, possibly $\mathbb{K} = \{(\{W_1\}, +), (\{W_2\}, +), (\{W_3\}, -), (\{W_1, W_2\}, +), (\{W_1, W_2, W_4\}, -)\}$ and possibly two queries $(\{W_1, W_2, W_3\}, ?)$, $(\{W_1, W_2, W_3, W_4\}, ?)$.

We now continue to present our model. We first assume a consistency condition of $\mathbb{K}$.

Axiom 1 (Consistency). *Two conditions for consistency of $\mathbb{K}$:*

- *There is no $E \subseteq \mathbb{Q}$, such that $(E, +)$ and $(E, -)$ in $\mathbb{K}$;*
- *For every $E, E' \subseteq \mathbb{Q}$, if $(E, +)$ (resp. $(E, -)$) and $(E', +)$ (resp. $(E', -)$) are in $\mathbb{K}$, then there is no $(E \cup E', -)$ (resp. $(E \cup E', +)$) in $\mathbb{K}$[2].*

These consistency conditions apply to a large class of applications but not to all of them, especially the second condition contradicts explanatory (information) features (see Example 6 and 7).

The next series of definitions define the notion of one feature x being stronger than another feature y.

The idea of strength of a feature x, is measured by its ability to force a verdict (as witnessed by the known cases of $\mathbb{K}$) with minimal other additional features from $\mathbb{Q}$. For

[1] In Talmudic law, conspiring witnesses are witnesses whose testimony was found to be false testimony, the testimony of false witnesses given in court is refuted - demonstrating how they were not at the scene of the purported crime - they are then sentenced to the identical punishment that was to have been meted out onto the intended victim (Devarim 19:15-20).

[2] Intuitively, $+$ and $+$ cannot make a $-$ and similarly $-$ and $-$ cases joined cannot make a $+$.

example, in a legal murder case, a confession feature represented as c, is maximal in its strength, it can on its own force guilty verdict, in contrast an alibi feature represented as a, on it own can force not guilty[3].

Definition 4 (Rule 1 dependent on $\mathbb{K}$ (Immediate Atomic Inversion)). *For every $x, y \in \mathbb{Q}$, if we have $(E \cup \{x\}, +)$ (resp. $(E \cup \{x\}, -)$), and $(E \cup \{x, y\}, -)$ (resp. $(E \cup \{x, y\}, +)$), we have $y >_{\mathbb{K}} x$, it means that y inverts x.*

It also means that y inverts x because of $E \cup \{x, y\}$, where E is a set of features not containing x and y, y always inverts x if the above holds for any E.

Example 2 (Example 1 Continued). From Definition 4, we know for Talmudic logic case E_2 that W_4 inverts W_1 and W_2. We have $W_4 >_{\mathbb{K}} W_1$ and $W_4 >_{\mathbb{K}} W_2$.

In case Rule 1 does not give us an answer for comparing x and y, we need to use Rule 2 in Definition 5 below.

The rationale behind Definition 5 is as follows. Given x and y we look at the first sets (by size) containing x, and similarly the first set by size containing y respectively which get a verdict in $\mathbb{K}$. The smaller one in size indicates which is stronger (so if x can give verdict helped by a smaller number of additional features than y can, then x is stronger). Otherwise, if they are equal in the first case just mentioned above, we continue inductively, we repeat and go to the next case in size and so on. If they are all the same for all sizes, we compare by summing up the $+$ part (this is arbitrary we could equally sum up the $-$ parts, depending on the application). We use the notation $m_i^{\pm}(x)$ to represent the number of sets $E \in \mathbb{K}$ with i elements containing x for which there is a verdict respectively $+$ or $-$ in $\mathbb{K}$. We use $\vec{x}$ and $\vec{y}$ to represent their vectors for $i \in \{1, 2, 3, ..., n\}$.

Definition 5 (Rule 2 dependent on $\mathbb{K}$ (Matrix Vector)). *Let $m_i^{\pm}(x)$ be the number of cases E containing x with i atomic features such that E has the verdicts $\pm$ respectively. For a given x we form a vector $\vec{x}$ whose i component is the pair $m_i^{+}(x)$ and $m_i^{-}(x)$, as in Table 1. To compare x and y, we look at the matrix with vectors:*

- *Case 1: If in vector $\vec{x}$ and vector $\vec{y}$, we have $m_i(x) = m_i^{+}(x) + m_i^{-}(x) \neq 0$ and $m_i(y) = m_i^{+}(y) + m_i^{-}(y) = 0$ where i is the smallest, then $x >_{\mathbb{K}} y$, respectively similarly for $y >_{\mathbb{K}} x$;*
- *Case 2: If $m_i(x) = m_i(y)$ in all the columns up to column i, then we check column $i+1$, if $m_{i+1}(x) = m_{i+1}(y)$, we keep checking if $m_{i+2}(x) = m_{i+2}(y)$, until we have either $m_k(x) > 0$ and $m_k(y) = 0$, then we have $x >_{\mathbb{K}} y$, respectively similarly for $y >_{\mathbb{K}} x$;*
- *Case 3: If $m_i(x) = m_i(y)$ for all $i \in \{1, 2, ..., n\}$, we check if $\sum_{i=1}^{n} m_i^{+}(x) > \sum_{i=1}^{n} m_i^{+}(y)$, if yes, then we have $x >_{\mathbb{K}} y$, respectively similarly for $y >_{\mathbb{K}} x$;*
- *Case 4: If we have $\sum_{i=1}^{n} m_i^{+}(x) = \sum_{i=1}^{n} m_i^{+}(y)$, then we say that x and y are not comparable with Rule 2.*

[3] Note if we have a case $E = \{c, a\}$, we may have a paradox, is the verdict guilty or not? This depends on the legal systems, some may say an alibi can be wrong but a signed confession is stronger, while other legal systems may say we do not accept confession, they can be obtained by torture.

Table 1. Matrix Vector for x and y, i is the number of the cases E containing x (resp. y), that has i atoms with the verdict $\pm$, we use $\vec{x}$, $\vec{y}$ to represent the vectors of $x, y \in \mathbb{Q}$ which are the atoms we are comparing.

	1	2	...	i	i+1	...	n
$\vec{x}$				$m_i^+(x), m_i^-(x)$			
$\vec{y}$				$m_i^+(y), m_i^-(y)$			

Example 3 (Example 1 Continued). Consider that we apply Rule 2 to E_2 in Example 1, as shown in Table 2. We have $W_1, W_2 >_{\mathbb{K}} W_3$, since when $i = 2$, i.e. there is $(\{W_1, W_2\}, +)$ in $\mathbb{K}$, but there is no such a case containing two features with a verdict contains W_3. When we consider Rule 1 and Rule 2 together, we get agreement with our intuitive discussion in Example 2, namely we have $W_1, W_2 >_{\mathbb{K}} W_3$, $W_4 >_{\mathbb{K}} W_1, W_2$.

Table 2. An example to illustrate Definition 5

	1	2	3
$\vec{W_1}$	$m_1^+(W_1) = 1, m_1^-(W_1) = 0$	$m_2^+(W_1) = 1, m_2^-(W_1) = 0$	$m_3^+(W_1) = 0, m_3^-(W_1) = 1$
$\vec{W_2}$	$m_1^+(W_2) = 1, m_1^-(W_2) = 0$	$m_2^+(W_2) = 1, m_2^-(W_2) = 0$	$m_3^+(W_2) = 0, m_3^-(W_2) = 1$
$\vec{W_3}$	$m_1^+(W_3) = 0, m_1^-(W_3) = 1$	$m_2^+(W_3) = 0, m_2^-(W_3) = 0$	$m_3^+(W_3) = 0, m_3^-(W_3) = 0$
$\vec{W_4}$	$m_1^+(W_4) = 0, m_1^-(W_4) = 0$	$m_2^+(W_4) = 0 , m_2^-(W_4) = 0$	$m_3^+(W_4) = 0, m_3^-(W_4) = 1$

Theorem 1. *The stength ordering defined by Rule 1 and Rule 2 have no loops and it is transitive, i.e.* $<_{\mathbb{K}}$ *is partial order.*

Proof. For all cases $E = \{x\}$ with a verdict $+$ and $E = \{y\}$ with a verdict $-$ in $\mathbb{K}$, if Rule 1 is applied, we have $\{x, y\}$ with a verdict either $+$ or $-$, thus, either x is stronger than y, or vice versa, there is no loop because of the consistency axioms on $\mathbb{K}$. For all cases E in $\mathbb{K}$, for all atoms $x, y \in E$, when Rule 2 is applied, if $m_i(x) = m_i(y)$, we do not decide their strength, thus, there is no loop formed by Rule 2.

We now explain Definition 6. Given x and y, Rules 1 and 2 may not be sufficient to decide which is stronger, x or y. We need another rule to be applied, this is Rule 3 in Definition 6. The idea is geometrical. x and y reside in the partial ordering $(\mathbb{Q}, <_{\mathbb{K}})$. By comparing their relative position, we know what is above each one and what is below each one, we can reach a decision. We are not going to give an algorithm for determining geometrically which is stronger because we do not know in which application area it is going to be applied.

Our intuition for Rules 1 and 2 is reasonable for any application area (where the strength is maximal to help for giving a verdict).

Note that we may not necessarily get a full linear order even after Rule 3. Recall that Rule 3 is needed because the ordering $<_{\mathbb{K}}$ (defined using Rule 1 and Rule 2) cannot compare x and y. The intuition behind Rule 3 in Definition 6 is the following: Rule 3 is a mechanism for deciding for x, y appearing in the partial order of $(\mathbb{Q}, <_{\mathbb{K}})$ whether to say that $x >_{\mathbb{K}} y$ or $y >_{\mathbb{K}} x$. We do this by looking at the sets of elements that stronger than x (resp.y), weaker than x (resp.y) and incomparable with x and use them to define whether by Rule 3 one is stronger than the other.

Definition 6 (Rule 3). *Given the partial ordering* $(\mathbb{Q}, <_{\mathbb{K}})$ *and two features* x *and* y *in* $\mathbb{Q}$ *which are incomparable with respect to Rule 1 and Rule 2 in this partial order, we define for each* $x \in \mathbb{Q}$ *(resp.for* y*), the sets* $Q_x^+ = \{z \mid z >_{\mathbb{K}} x\}$ *as the set of atoms* z *that stronger than* x*,* $Q_x^- = \{z \mid z <_{\mathbb{K}} x\}$ *as the set of atoms* y *that weaker than* x*, and* $Q_x^{\neq} = \{z \mid z \not<_{\mathbb{K}} x$ *and* $x \not<_{\mathbb{K}} z\}$*. Since we assume* $\mathbb{Q}$ *is finite, we can order* x *and* y *using the sets* Q_x^+*,* Q_x^-*, and* $Q_x^{\neq}$*, and the same sets for* y*,* Q_y^+*,* Q_y^-*, and* $Q_y^{\neq}$[4]*.*

We use Example 4 to illustrate two possibilities to define Rule 3.

Example 4. Let $\mathbb{Q} = \{u, v, x, y, z\}$, and their partial order $x >_{\mathbb{K}} z$, $y >_{\mathbb{K}} z$, $y >_{\mathbb{K}} v$, $u >_{\mathbb{K}} y$. To compare the strength of x and y, we have the following possibilities depending the application area.

1. We compare the number of features that are weaker than x and y. If $\mid \mathbb{Q}_x^- \mid < \mid \mathbb{Q}_y^- \mid$, we have $y >_{\mathbb{K}} x$. In this case, we have $\mathbb{Q}_x^- = \{z\}$, $\mid \mathbb{Q}_x^- \mid = 1$, $\mathbb{Q}_y^- = \{z, v\}$, $\mid \mathbb{Q}_y^- \mid = 2$, then we have $y >_{\mathbb{K}} x$, since there are more features weaker than y.
2. Similarly, we compare the number of features that stronger than x and y. If $\mid \mathbb{Q}_x^+ \mid < \mid \mathbb{Q}_y^+ \mid$, we have $x >_{\mathbb{K}} y$. In this case, we have $\mathbb{Q}_x^+ = \emptyset$,$\mathbb{Q}_y^+ = \{u\}$, $\mid \mathbb{Q}_y^+ \mid = 1$, then we have $x >_{\mathbb{K}} y$, since there are more features stronger than y.

Having defined relative strength of features using Rule 1, 2, 3, we now need a definition of how to give a reasonable verdict to a query $(E_q, ?)$.

Definition 7 (Enforcement). *Given a query* $(E_q, ?)$*, let* $z \in E_q$ *be the strongest as defined by Rule 1, 2, 3, we can use it to enforce and answer the value of ? as follows.*

- *Case 1: if* $(\{z\}, +)$ *(resp.* $(\{z\}, -)$*) is in* $\mathbb{K}$*, then* z *enforces* $+$ *(resp.* $-$*);*
- *Case 2: if there is no* $(\{z\}, +)$ *(resp.*$(\{z\}, -)$*) in* $\mathbb{K}$*, but* z *always inverts to* $+$ *(resp.*$-$*), then* z *enforces* $+$ *(resp.*$-$*);*
- *Case 3: z appears in a case(s) completed with* $+$ *and also a case(s) with* $-$*, then we declare* z *to be an information feature with no strength, and* z *is not able to enforce any verdict.*

We note that we postpone to deal with Case 3 in Definition 7 to future research. See more discussion on Examples 6 and 7 in Sect. 3.

Now that we know how to enforce a verdict for the query in some cases, we can give Definition 8.

Definition 8 (Verdict of new case). *Let* $(E_q, ?)$ *be a query. ? is*

1. $+$*, when all the strongest atoms in* E *which are able to enforce and indeed enforce* $+$*;*
2. $-$*, when all the strongest atoms in* E *which are able to enforce and indeed enforce* $-$*.*
3. *otherwise, we cannot give value to "?"*[5]*.*

[4] For example, if the set of elements stronger or weaker than x are more in number than the set of stronger or smaller than y, we say that $x >_{\mathbb{K}} y$.

[5] This case will depend on the application area. For example, in legal murder cases, where verdict $-$ means not guilty, we can say that if Case 1 does not hold, we enforce $-$, because it gives us "shadow of a doubt".

Example 5 (Example 1 Continued). Consider $E_1 = \{W_1, W_2, W_3\}$, we know W_1 and W_2 enforce $+$, W_3 enforces $-$, W_1 and W_2 are stronger than W_3. Therefore, the verdict of E_1 is $+$. Consider query $(\{W_1, W_2, W_3, W_4\}, ?)$, since W_4 inverts W_1 and W_2, W_4 is the strongest and W_4 enforces $-$, thus, the verdict of this query should be $-$[6].

3 Discussion and Future Work

Prakken and Sartor [12] present their model of case-based reasoning in the context of formal dialogue. They integrate case-based reasoning with rule-based reasoning, later, Prakken et al. futher model case-based reasoning with ASPIC+ framework [13]. Wyner et al. discuss the distinction between arguments and cases in different levels [14]. In this section, we mainly compare our approach with the work of Cyras et al. [4,5], which also adopts argumentation for case-based reasoning.

In the work of Cyras et al., they propose a model based on instantiated abstract argumentation, written as AA-CBR. When users query a new case, AA-CBR system only selects the completed cases whose features are subsets of the ones of the new case. Our method does not use argumentation and uses all cases with verdicts. In specific cases, Cyras et al. model can give a biased outcome, in fact the users can decide the new query outcome in AA-CBR. For our running Example 1, 2, 3, 5, to decide the verdict of the case $\{W_1, W_2, W_3, W_4\}$, AA-CBR will construct the corresponding framework as Fig. 1.

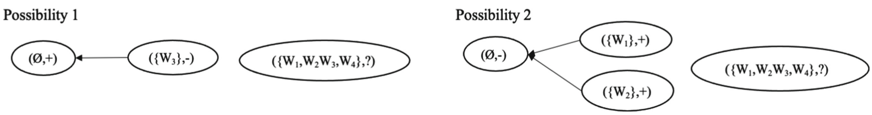

Fig. 1. Possibility 1: The $(\emptyset, +)$ represents the default verdict $+$ given by users, for such argumentation framework, the verdict of the new case is $-$ since the default case is not in the extension. Possibility 2: The default verdict is $-$, and in this case, the verdict of the new case is $+$. Thus, for this case, AA-CBR cannot provide a rational result.

We use Example 6 and Example 7 to illustrate our future work.

Example 6 (Tweety bird). Let $\mathbb{Q} = \{f, w, x\}$, and we have the following cases. $(\{x\}, +)$ says Tweety is a bird, the verdict is Tweety can fly; $(\{f, x\}, +)$ says Tweety is a bird, Tweety is fat, the verdict is Tweety can fly; $(\{x, w\}, +)$ says Tweety is a bird, Tweety is weak, the verdict is Tweety can fly; However, $(\{x, f, w\}, -)\}$ says Tweety is a bird, Tweety is weak and Tweety is fat, the verdict is Tweety cannot fly. In this scenario, the set $\mathbb{K}$ is not consistent. There is no atomic invert, but a set inverts, i.e. the set $\{w, f\}$ inverts $(\{x\}, +)$. Furthermore, we can see that feature w inverts $(\{f, x\}, +)$, f inverts $(\{w, x\}, +)$, then intuitively, f is stronger than w and vice versa. How to deal with set inversion is one problem for our future work, we are going to change the axioms.

[6] According to Talmudic law, W_1 and W_2 should be punished.

Remark 1. The perceptive reader might think that it is a big restriction for this paper, but it is not so. It is a different continuation paper, which requires serious research because it is complicated. The context of this future research is to show that nonmonotonic reasoning as a case based reasoning. The perceptive reader would expect us to justify the importance of inversion of singleton set inversion. To this end, note that in legal cases, the case based reasoning can arise from an attempt to invert a single feature.

Example 7 (Car accident in the UK). There is a car accident where a car kills a pedestrian victim. There are witnesses W_1 and W_2. W_1 says the victim was walking on the pavement, W_2 says the victim was not walking on the pavement, thus, we have $(\{W_1\}, +)$, $(\{W_2\}, -)$, $+$ means the driver of the car is guilty and $-$ means the driver of the car is not guilty. W_3 is not a witness but a linguist giving information. W_3 says W_1 and W_2 speak American English. In American English, pavement is the road, and in UK English, pavement is the sidewalk. Then we have $(\{W_1, W_3\}, -)$, $(\{W_2, W_3\}, +)$. In this case, we do not know what verdict W_3 is able to enforce (Definition 7), W_3 should be distinguished from other features, since it is additional information about W_1 and W_2.

Remark 2. Note that the story of Example 7 involves both features that are strength and features that are additional information but additional information is a property of non monotonic reasoning, so we are dealing here with a mixed model which has monotonic features with inversion and non monotonic features with information the nonmonotonicity of information changes the feature involved.

How to deal with such information of features is also one of our intended future work. This future work is the task of presenting non-monotonic reasoning as a CBR. Moreover, the ordering of features reflects the preferences over them, is preference in argumentation a special case of case-base reasoning? If our model can be used for preference management in argumentation and hence to manage burdens of persuasion is also one of the future work [1,3,8].

4 Conclusion

In this position paper, we propose a new approach for case-based reasoning, different from the most existing approaches which select similar cases to give a verdict of a new case, we consider the entire set of known cases and their known verdicts. We then define the relative strength and importance of all the features involved in these cases. We use the strength ordering of the features to decide the verdict for the new case based on the strength of its features. We need to connect our model with many applications. We believe that our method applied to presenting non-monotonic reasoning as case-based reasoning is the most interesting, see Example 7.

References

1. Amgoud, L., Cayrol, C.: Inferring from inconsistency in preference-based argumentation frameworks. J. Autom. Reason. **29**(2), 125–169 (2002). https://doi.org/10.1023/A:1021603608656
2. Bonissone, P.P., Cheetham, W.: Fuzzy case-based reasoning for residential property valuation. In: Handbook of Fuzzy Computation, pp. G14–1. CRC Press (2020)
3. Calegari, R., Sartor, G.: Burdens of persuasion and standards of proof in structured argumentation. In: Baroni, P., Benzmüller, C., Wáng, Y.N. (eds.) CLAR 2021. LNCS (LNAI), vol. 13040, pp. 40–59. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-89391-0_3
4. Cyras, K., Satoh, K., Toni, F.: Abstract argumentation for case-based reasoning. In: Fifteenth International Conference on the Principles of Knowledge Representation and Reasoning (2016)
5. Čyras, K., Satoh, K., Toni, F.: Explanation for case-based reasoning via abstract argumentation. In: Computational Models of Argument, pp. 243–254. IOS Press (2016)
6. Finnie, G., Sun, Z.: Similarity and metrics in case-based reasoning. Int. J. Intell. Syst. **17**(3), 273–287 (2002)
7. Finnie, G.R., Wittig, G.E., Desharnais, J.M.: A comparison of software effort estimation techniques: using function points with neural networks, case-based reasoning and regression models. J. Syst. Softw. **39**(3), 281–289 (1997)
8. Kampik, T., Gabbay, D., Sartor, G.: The burden of persuasion in abstract argumentation. In: Baroni, P., Benzmüller, C., Wáng, Y.N. (eds.) CLAR 2021. LNCS (LNAI), vol. 13040, pp. 224–243. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-89391-0_13
9. Kim, G.H., An, S.H., Kang, K.I.: Comparison of construction cost estimating models based on regression analysis, neural networks, and case-based reasoning. Build. Environ. **39**(10), 1235–1242 (2004)
10. Leake, D., Ye, X., Crandall, D.J.: Supporting case-based reasoning with neural networks: an illustration for case adaptation. In: AAAI Spring Symposium: Combining Machine Learning with Knowledge Engineering, vol. 2 (2021)
11. Perner, P.: Case-based reasoning – methods, techniques, and applications. In: Nyström, I., Hernández Heredia, Y., Milián Núñez, V. (eds.) CIARP 2019. LNCS, vol. 11896, pp. 16–30. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-33904-3_2
12. Prakken, H., Sartor, G.: Modelling reasoning with precedents in a formal dialogue game. In: Sartor, G., Branting, K. (eds.) Judicial Applications of Artificial Intelligence, pp. 127–183. Springer, Dordrecht (1998). https://doi.org/10.1007/978-94-015-9010-5_5
13. Prakken, H., Wyner, A., Bench-Capon, T., Atkinson, K.: A formalization of argumentation schemes for legal case-based reasoning in ASPIC+. J. Log. Comput. **25**(5), 1141–1166 (2015)
14. Wyner, A.Z., Bench-Capon, T.J.M., Atkinson, K.: Three senses of "argument". In: Casanovas, P., Sartor, G., Casellas, N., Rubino, R. (eds.) Computable Models of the Law. LNCS (LNAI), vol. 4884, pp. 146–161. Springer, Heidelberg (2008). https://doi.org/10.1007/978-3-540-85569-9_10
15. Zheng, H., Grossi, D., Verheij, B.: Case-based reasoning with precedent models: preliminary report. In: Computational Models of Argument, pp. 443–450. IOS Press (2020)