Generating arguments based on Data-oriented Belief Revision model

Mariela Morveli-Espinoza[1], **Cesar A. Tacla**[1]

[1]CPGEI – Universidade Tecnológica Federal do Parana (UTFPR)
Curitiba – PR – Brazil

morveli.espinoza@gmail.com, tacla@utfpr.edu.br

Abstract. *Data-Oriented Belief Revision (DBR) is a relatively recent approach that claims the difference between pieces of information gathered and stored by agent (data) and information revised and considered reliable (beliefs). Data structure proposed in DBR can also be used to implement the structure of an argument. It's worth noting that this approach can be considered as the first step to integrate both belief revision and argumentation areas and allowing them to be modeled in the same framework. Our objective is to continue making progress on this research from a computational view. This article is our first step, here we propose two ways to generate arguments and counter-arguments in a monological argumentation based on the DBR model's data structure.*

1. Introduction

Argumentation is a reasoning model based on the construction of arguments in favor of or against some statement and then to select the most acceptable of them [Amgoud 2005]. On the other hand, belief revision is focused on investigating knowledge bases in change. Proposed approaches give different interpretations to the term change. Gardenfors [Gardenfors 1988] identified three fundamental types of belief change: revision, expansion and update. Katsuno and Meldelzon [Katsuno and Mendelzon 1991] recommend updating to handle knowledge in a changing world. In general, belief revision means the process of adapting some set of beliefs to new data.

In an agent environment, an agent collates knowledge to construct arguments for and against a particular claim and after arguments construction the agent draws a conclusion. Most works on argument construction, also known as argument generation, propose techniques and algorithms that focus on how to deal with contradicting arguments or how to generate adequate arguments[Ontanon and Plaza 2007][Besnard et al. 2010]. However, the matter of the dynamics of the knowledge base (KB) is neglected, i.e. it is not taken into account that during argument generation process, an agent can also receive new data that may change its beliefs and can alter the final conclusion.

[Paglieri 2004] has proposed DBR, a belief revision model that not just best characterizes the epistemic dynamics but it also defines a data structure where the squema of argumentation is liable of immediate implementation [Paglieri and Castelfranchi 2006]; in other words, it allows to integrate argumentation and belief revision in a single framework. DBR model also proposes to separate the knowledge of the agent in data and beliefs. Data are pieces of information gathered and stored by the agent and beliefs are pieces of information revised and considered reliable by the agent. This proposal is supported by the fact that not all incoming data are to be believed, but it doesn't mean that not believed factual data are forgotten. Another reason to work with DBR model is that both data and belief states are finite and deductively open, and it is quite difficult that contradicting data become beliefs, since selection process is based on the measure of data credibility, and the credibility of contradicting data is conversely proportional.

In this paper, we propose, based on the DBR model, two ways for generating arguments from a set of data an agent has in advance or from new data. In our proposal, we take into account both the necessity of finding supports for a claim and the autonomous generation of arguments from new data.

This article is organized as follows: Section 2 shows DBR principal definitions used in our proposal. A motivational example and our proposal are presented in Section 3. Finally, some conclusions and future works are detailed in Section 4.

2. Data-oriented belief revision model and argumentation

Data-oriented Belief Revision (DBR) is a belief revision model alternative to the AGM approach [Gardenfors 1988]. As mentioned before, two basic informational categories are put forward (data and beliefs). Data are selected (or rejected) as beliefs on the basis of their properties, i.e. the cognitive reasons to believe them. These properties are:

1. **Relevance:** a measure of the pragmatic utility of the datum, i.e. the number and values of the (pursued) goals that depends on that datum;
2. **Credibility:** a measure of the number and values of all supporting data, contrasted with all conflicting data, both external and internal sources;
3. **Importance:** a measure of the epistemic connectivity of the datum, i.e. the number and values of the data that the agent will have to revise, should he revise that single one;
4. **Likeability:** a measure of the motivational appeal of the datum, i.e. the number and values of the (pursued) goals that are directly fulfilled by that datum.

In DBR, the data structure is conceived as network of nodes (data or beliefs), linked together by characteristic relations. This proposed form of arrange data lets to represent a net of arguments easily. The following are the three different types of data relations:

1. **Support:** ϕ supports ψ (in symbols: $\phi \Rightarrow \psi$) iff $c^{\psi} \propto c^{\phi}$, the credibility of ψ is directly proportional to the credibility of ϕ.
2. **Contrast:** ϕ contrasts ψ (in symbols: $\phi \bot \psi$) iff $c^{\psi} \propto 1/c^{\phi}$, the credibility of ψ is conversely proportional to the credibility of ϕ.
3. **Union:** ϕ and ψ are united (in symbols: ϕ & ψ) iff c^{ψ} and c^{ϕ} jointly (not separately) determine the credibility of another datum γ.

Where ϕ, ψ and γ are data or beliefs that are in the network.

3. Proposal

In this proposal, only relevance and credibility are used to assess data and only support and contrast relations are taken into account. Importance, likeability and union relation will be studied in future works.

Following definitions are necessary before continuing:

Definition 1. (*Argument*) An argument is a tuple $Ar = \langle C, S_C, K_C \rangle$ where:

- C is the claim
- S_C is the set of supports of claim C
- K_C is the set of contrasts (attacks) of claim C

Definition 2. (*Agent*) An agent is a tuple $Ag = \langle B_{Ag}, G_{Ag}, D_{Ag}, R_{Ag}, A_{Ag} \rangle$ where:

- B_{Ag} is the set of its beliefs
- G_{Ag} is the set of its goals
- D_{Ag} is the set of its data
- R_{Ag} is the set of relations among data or beliefs: support, union and contrast
- A_{Ag} is the set of accepted arguments.

3.1. Example

This example consists of two parts, in the first one the agent has existing data from which it constructs some arguments and reaches a preliminary conclusion. In the second part, the agent evaluates data that has arrived while it was in its construction process and it also looks for more data from other sources. Finally the agent reaches a final conclusion. See below how generation arguments process is carried out and which will be the conclusion of the agent.

C is an agent interested in investing in short-term trading stocks of company ACME ($f1$). Let's suppose that it already has related data that support its desire and others that don't. According to supporting data, it is recommended to invest in short-term trading stocks of company ACME because low capital is needed ($f3$), the reinvestment is quick ($f5$), leverage has no risks ($f6$) and C would earn more money than in long-term investing ($f7$). On the other hand, according to contrasting data, it is not recommended to invest in short-term trading stocks of company ACME because the stock market is too much volatile ($f8$), there is not enough time to take decisions ($f4$) and C would spend too much in bank rates ($f2$). Both support and contrast relations are denoted as follow:

- $f3 \Rightarrow f1$
- $f5 \Rightarrow f1$
- $f6 \Rightarrow f1$
- $f7 \Rightarrow f1$
- $f8 \perp f1$
- $f4 \perp f1$
- $f2 \perp f1$

Therefore $S_{f1} = \{f3, f5, f6, f7\}$ and $K_{f1} = \{f4, f8, f2\}$

3.2. Generation of arguments

3.2.1. Generating arguments out of necessity

It is triggered when a new goal is added to the list of goals of the agent. It can be generated from self claims or from contrasts the agent wants to defeat: $G_{Ag} = G_{Ag} \cup \{\alpha\}$, where α is the new goal. Agent looks for information that support its goals, it can obtain this by communication, perception or exists the possibility that agent already has some information in its data net that has not been evaluated.

Steps followed by agent to assess a datum or a set of data are:

1. The first step is to evaluate the relevancy of new entry data or data from the data network.
2. The agent must evaluate the credibility of those data considered relevant. The formula[1] used for this is:

   $$c^{\alpha} = [1 - \prod_{\mu \in S_{\alpha}} (1 - c^{\mu})] \times \prod_{\chi \in K_{\alpha}} (1 - c^{\chi})$$

   Besides supporting and contrasting data, the reliability of the source of some data is taken into account. This is considered as part of the set of supports when applying the formula. There are cases where a datum has neither supports nor contrasts, it only has information about its source. To calculate the credibility of a datum based upon its source, we use: $c^{\psi} = rel(src_{\psi})$ where, c^{ψ} is the credibility of datum ψ and $rel(src_{\psi})$ is the reliability of the source of datum ψ.
3. In order to know which data will become beliefs, the agent must evaluate data with the following condition:

   If $C : c^{\phi} > k$ then $B^{s} \in B$, where: $k = 0.5$ is the threshold.

   It is important to mention that this threshold value is just an example, since the value of threshold can vary from 0 to 1. This example setting expresses a thoroughly realistic attitude.

Following with the example, our agent C wonders whether it should or not invest in short-term trading, therefore $f1$ becomes its first goal: $G_C = \{f1\}$. Now, agent is going to try to find supports to its goal (this doesn't mean it can't find contrasts too). Since it already has data, it will begin to assess these ones.

It is important to clarify that, for the moment, reliability was arbitrarily set. The result of the evaluation of data (supports and contrasts) credibility is:

- $f2$: src_{f2}= university friend, $rel(src_{f2}) = 0.2$, therefore $c^{f2} = 0.2$.
- $f3$: src_{f3}= site specialized in investments, $rel(src_{f3}) = 0.9$, therefore $c^{f3} = 0.9$.
- $f4$: src_{f4}= investment blog, $rel(src_{f4}) = 0.3$, therefore $c^{f4} = 0.3$.
- $f5$: src_{f5} =investment magazine, $rel(src_{f5}) = 0.6$, therefore $c^{f5} = 0.6$.
- $f6$: src_{f6} =top investment magazine, $rel(src_{f6}) = 0.8$, therefore $c^{f6} = 0.8$.
- $f7$: src_{f7} =university friend, $rel(src_{f7}) = 0.2$, therefore $c^{f7} = 0.2$.
- $f8$: src_{f8} =investment magazine, $rel(src_{f8}) = 0.6$, therefore $c^{f8} = 0.6$.

The result of evaluating credibility of $f1$ is: $c^{f1} = (1 - 0.0064) \times 0.224 = 0.222$

Therefore, for now, $f1$ doesn't become a belief because its credibility is under the threshold, so C doesn't decide to invest yet. Updating beliefs: $B_C = \{f3, f5, f8, f6\}$ where $f3$, $f5$ and $f6$ are supports and $f8$ is a contrast. Figure 1(a) shows the configuration of the data and beliefs network of agent C.

Now, C will try to defeat $f8$ finding some contrasts for it, therefore $\neg f8$ becomes a new goal: $G_C = \{f1, \neg f8\}$. Agent C will take advice from a stock trading expert and he says that company ACME has demonstrated historically low volatility. This will be a new datum: $f9$.

- $f9$: src_{f9} = stock trading expert, $rel(src_{f9}) = 0.9$, therefore $c^{f9} = 0.9$.

[1] Both this formula and that used in point 3 were extracted from [Paglieri 2004].

Since $f8$ has a new contrast datum, its credibility must recalculated, the result is: $c^{f8} = [1 - (1 - 0.6)] \times (1 - 0.9) = 0.06$. Due to its credibility is now less than the threshold value, $f8$ is no longer a belief.

And $f1$ credibility must be also recalculated: $c^{f1} = (1 - 0.0064) \times 0.5264 = 0.5230$.

Taking into account this result, $f1$ becomes a belief and therefore agent C decides to invest in short-term trading in stocks of company ACME.

After these calculations, the state of agent C is: $B_C = \{f3, f5, f8, f6, f1\}$, $G_C = \{\}$, $A_C = \{f3 \Rightarrow f1, f5 \Rightarrow f1, f6 \Rightarrow f1, f8 \perp f1, f9 \perp f8\}$

3.2.2. Generating arguments from new entry information

It is triggered when new relevant data arrives. Since these data are relevant, the agent calculates their credibility. Some data can become beliefs and some arguments can be generated. These arguments are saved in A_C waiting for being used at any moment.

Resuming the example, agent C, during its decision process, receives the following data: dollar price will remain low during this year ($f10$) and this will have a positive effect on bank loan interests ($f11$). Hitherto, these data don't have any relation with its goals, hence they are not relevant. But, agent C also gets another data: if loan bank interests are low ($f11$) then leverage is really riskless ($f6$). Now, the former data becomes relevant because it has relation with one of its beliefs. Since all these new data are relevant, then, agent must calculate their credibility:

- $f10$: src_{f10}= economy channel, $rel(src_{f10}) = 0.6$, therefore $c^{f10} = 0.6$.
- $f11$: src_{f11}= economy channel, $rel(src_{f11}) = 0.6$, therefore $c^{f11} = 0.6$.

Since both are greater than the threshold, the agent updates its beliefs and recalculates credibility of $f6$ and $f1$ because $f11$ is a new support for $f6$.

The final state of our agent C is: $B_C = \{f3, f5, f6, f1, f10, f11\}$ e $A_C = \{f3 \Rightarrow f1, f5 \Rightarrow f1, f6 \Rightarrow f1, f10 \Rightarrow f11, f11 \Rightarrow f6\}$, with:

$c^{f6} = 1 - (1 - 0.6)(1 - 0.8) = 0.92$

$c^{f1} = (1 - 0.0032) \times 0.5264 = 0.5247$.

It can be noticed that $f1$ value increases slightly. Which means, C will really invest in short-term trading in stocks of company ACME. Figure 1(b) shows the final configuration of the data and beliefs network of agent C.

4. Conclusions and Future Work

It is worthwhile to note that the basic process of belief revision for integrating new data or update existing one is automatic. After revision, beliefs are automatically ready to form possible arguments, which facilitates the task of generation of arguments either by necessity or arrival of new data. It's also clear that DBR model gives support for the integration of belief revision and argumentation.

Since arguments are constructed from both directions top-down (a new claim needs supports) and bottom-up (new relevant data arrive), we can claim that using DBR

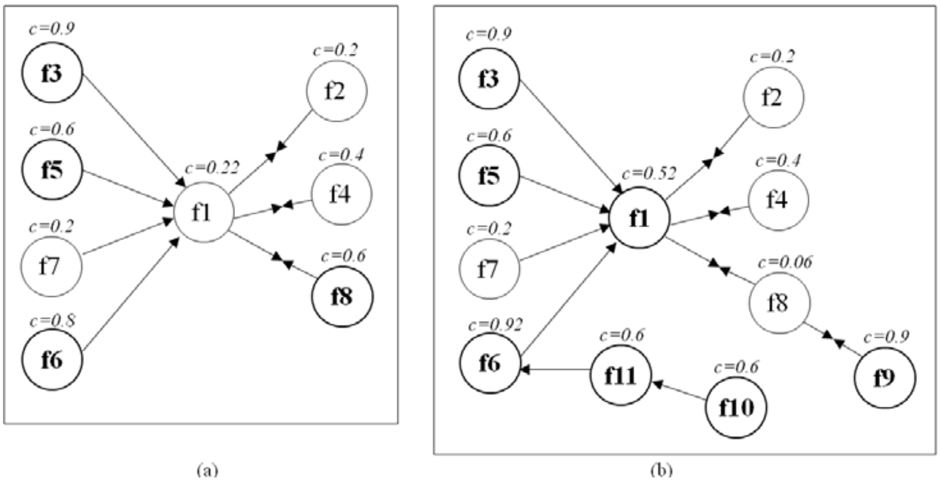

Figure 1. (a) Data an beliefs network configuration after the first credibility calculus. (b) Final data an beliefs network configuration. Beliefs are represented with bold line circles and data with normal line circles. Support relations are represented with normal arrows and contrast relations with contrasting arrows.

model in argumentation accelerates the process of argument generation and allows to generate arguments with more credibility.

Our next step is to make experiments and compare our proposal with other approaches to demonstrate that DBR model really helps to improve the process of argument generation. Others future works are argument selection and to use this proposal in persuasive dialogues between two or more agents.

References

Amgoud, L. (2005). A unified setting for inference and decision: an argumentation-based approach. In *Proceedings of the Twenty-First Conference on Uncertainty in Artificial Intelligence*, pages 26–33.

Besnard, P., Gregoire, E., Piette, C., and Raddaoui, B. (2010). Mus-based generation of arguments and counter-arguments. pages 239–244. Information Reuse and Integration (IRI).

Gardenfors, P. (1988). Knowledge in flux: Modeling the dynamics of epistemic states. The MIT press.

Katsuno, H. and Mendelzon, A. (1991). Propositional knowledge base revision and minimal change. pages 253–294. Artificial Intelligence.

Ontanon, S. and Plaza, E. (2007). Arguments and counterexamples in case-based joint deliberation. In *Argumentation in Multi Agent Systems. Springer Berlin Heidelberg*, pages 36–53.

Paglieri, F. (2004). Data-oriented belief revision: Towards a unified theory of epistemic processing. In *Proceedings of STAIRS'04*, pages 179–190.

Paglieri, F. and Castelfranchi, C. (2006). The toulmin test: Framing argumentation within belief revision theories. In *Arguing on the Toulmin model. Springer Netherlands*, pages 359–377.