

Generating Conceptual Definitions from Indian Logic based on Argumentation

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Abstract. This paper presents the idea of generating definitions of world knowledge entities which actually evolve through a systematic argumentation process between two autonomous knowledge sharing agents. Prior to argumentative discussion, both the discussing agents will have various degrees of belief about the subject of discussion, in their own knowledge bases. Therefore, to attain valid knowledge about a particular subject, both the participants voluntarily undergo a *tarka* process where arguments and counter-arguments are interchanged, pertaining to several knowledge sharing criteria. At the end of discussion, the gathered valid beliefs about the subject of discussion are generated as definitions to demonstrate the value of knowledge shared through argumentation.

1. Introduction

Argumentation can be defined as a process which involves exchange of arguments and counter-arguments. There are different styles of argumentation like Argumentation for communication, Argumentation for persuasion, Argumentation for inquiry etc [2]. In this paper, we try to address persuasive kind of argumentation [20]; the objective is knowledge sharing that happens during the argumentation phenomenon. Persuasion aims at convincing others with one's own belief about the subject of discussion. In other words, it can also be referred as 'Deriving Inferences for the sake of convincing others'. This form of inferencing follows the five-membered syllogism of Tarka sastra [17]. Therefore, argumentation for persuasion shall be thought to follow the inference pattern recommended by Indian philosophy.

During argumentation, the mechanism of sharing valid knowledge is not readily available as an argument or counter-argument; rather, the valid beliefs about the subject of discussion is said to evolve as definitions throughout the argumentation process. For this to happen, the knowledge sharing volunteers taking part in argumentative discussion should adhere to certain rules for knowledge sharing [15]. These policies mainly regulate the argumentation community towards obtaining a definite conclusion.

The argumentation scenario goes like this: initially after adhering to the discussion criteria, the proponent submits an argument for discussion. The argument is analysed

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for defects by defect analysis procedures. The resulting 'defect set' is evaluated and the most prominent defect is identified. The argument elements which are responsible in creating those defects are located and refutation strategies to act upon those areas are identified. This results in a 'refutation set'. The defect set and refutation set are analysed to identify a best suitable refutation strategy applicable over the defect set. The counter-arguments are constructed and one counter-argument from the set of counter-arguments are chosen by game theoretic framework on argumentation [12]. The game theoretic framework takes optimal policy decisions before deciding upon the output counter-argument. The performance of the arguers is measured by defect gain and reward values.

2. Related Work

Argumentation has created a greater impact on the field of artificial intelligence. This influence does not only model the ways of rational behavior between human agents, but, it also concentrates on applying it to the virtual context i.e. artificial agents governed by rules regulating the procedure of argumentation [22]. Argumentation schemes are forms of inference from premises to a conclusion. They represent patterns of deductive and inductive reasoning in some instances, but sometimes capture stereotypical patterns of human reasoning, especially defeasible ones under conditions of uncertainty and lack of knowledge [21]. Argumentation schemes are used for identifying arguments, finding missing premises, analyzing arguments, and finally for evaluating them.

Unlike primitive reasoning, arguments need to be evaluated in the framework of a critical discussion with two sides. The idea is that the purpose of argumentation is to resolve a conflict of opinions, not exclusively by one side's producing arguments that are defeasible, but also by the other side's producing doubts, objections, and critical questions that probe into the weak points in the argument. Presences of fallacies weaken the argument and inhibit inferences. To make the argument more logical or stronger, these fallacies should be avoided while constructing the argument.

According to Walton, an argument necessarily involves a dialogue, because it requires two parties, one of whom has put forward a claim, and a second party who questions that claim [23]. Using the dialectical approach, each individual case of an argument needs to be analyzed and evaluated not just as a semantic form, but as an argument used for some purpose in a conversational setting.

The conversational setting is represented by a formal dialogue structure in which a proponent and a respondent take turns by making moves. The proponent puts forward an argument designed to incur the commitment of the respondent to the conclusion. But the argument can be, and often is defeasible, meaning that the respondent can make objections to it and ask critical questions. The argument and its reply need to be evaluated as a pair of moves, on a balance of considerations in a dialogue setting that allows new evidence to come in at a later point [21].

However, Indian philosophy takes a different perspective of approaching the definition of arguments. Indian philosophy classifies an argument to contain three defined structures: subject, reason and object to be inferred [17]. Attempting to interpret an

argument with a defective reason will result in fallacious reasoning of that argument. Indian philosophy has defined several types and sub-types of reason fallacies [19] which were actually utilized in the process of defect exploration [8] in argument gaming. The methodology for finding defects is inspired by Tarka sastra [3]. In addition, Indian philosophy also defines various techniques of refutations [17]. Several ideas for refutation are also adopted from the tamil literature, Nannool, [16,18,19] which discusses issues and criteria for disseminating knowledge while authoring a book. In this paper, we have adopted the fallacies and refutations quoted in Indian philosophy and have utilized them efficiently in resolving argument gaming for knowledge sharing.

3. Argument Gaming

Argument gaming is a scenario, where arguments and counter-arguments are exchanged between the participating rational entities. While arguing against an argument, many counter-arguments would be generated. Thus, the preference over counter-arguments cannot be determined and hence, the system is non-deterministic in deciding upon the output counter-arguments.

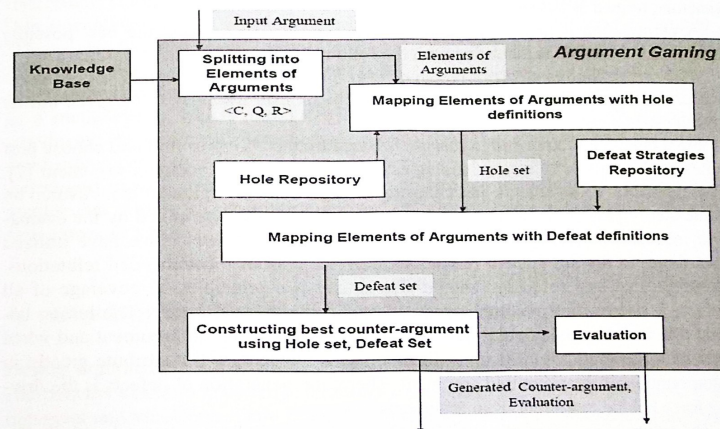


Figure 1. The process of Argumentative Reasoning

In procedural argumentative reasoning (Fig. 1) the input argument is initially *split into elements of arguments* [9]. The elements may be (i) concepts like subject, the object to be inferred or probandum, the reason or probans, which supports the subject or the object to be inferred (ii) relations which exist between the subject, probans and probandum [6]. Every argument is found to have at least few of the above-mentioned

components and such components are accumulated into an element set. This element set which is a representative of the input argument is fed as input to the rest of the reasoning system. Reasoning from argumentation [10] looks at arguments as a collection of world knowledge concepts which possess some meaning. During interpretation, the opponent stores the input argument in its memory (or knowledge base) and performs consistency analysis. If any conflicts arise, those are marked as inconsistencies and the counter-argument is generated highlighting those inconsistencies. In our work, we refer to the inconsistencies as 'hole' or 'defect'. The hole repository consists of the definition of holes and their category. The mapper maps the element set with that of the combinations in the generic hole repository and identifies the holes present in the element set, which are later termed as *Hole Set*.

More amount of knowledge is shared with more relevant defects identified. The method with which the opponent tries to attack the proponent highlighting the holes is called 'Refutation'. There are several strategies for refutation [17,18]. The refutation repository consists of combinations of fundamental argument elements and their interpretation and usage for every particular refutation strategy. If the elements in the element set match with those combinations, such elements of element set could be attacked or refuted by following the recommended refutation strategies as per the repository. Therefore, the mapper maps the element set with that of the refutation repository and picks up the necessary possible refutation strategies at that particular juncture, termed as *defeat set*.

A permutation is made across the hole set and defeat set, and the best possible pair(s) of hole-defeat is identified with the following criteria [11]:

With any refutation strategy recommended, the maximum relevant holes of the input argument need to be attacked at the next response, which is to be given out as counter-argument.

Final outcome of knowledge sharing is based on the ability to find and choose best holes and defeats or refutation strategies for every argument / counter-argument [7]. The evaluation of arguments and choosing the best counter-argument is motivated by game theory [12]. The choice of best refutation is actually determined by the evaluation mechanisms [5,14]. The belief-search algorithm [12] which we have utilized contributes to finding optimal refutations from the pool of recommended refutations. However, that best refutation should also satisfy two principles: 1. coverage of all defects 2. use of most recommended and applicable defeat strategy. The reason behind this is that, most popular defects, when identified from an argument and when utilized to generate the next immediate counter-argument, will contribute greatly in interpretation of the submitted argument. Therefore, generation of defects is the driving force behind reasoning from arguments.

The utility of argumentation for knowledge sharing shall be measured with the increase in overall knowledge of the participants. By adopting all the above philosophical definitions to suit knowledge sharing, rational discussion is modeled as procedural argumentation. The entire argumentation scenario follows the five-membered inference pattern of Indian philosophy [15,17]. The five-members of the inferential syllogism are: statement, reason, example, application and conclusion. Statement is an argument where things to be proved are stated; Reason is the supporting evidence which strengthens the proof; Example is a similar case that has occurred prior to the

statement; the idea of example can be derived and applied to the statement which shall be concluded towards the end of discussion.

Running Example:

Consider an argumentation scenario, where two persons are arguing about the existence of 'snake' in a dark room. The sample arguments exchanged are given below:

Arguer	Counter-arguer
I guess this would be a snake	
	How? It appears to be a rope
It is long and is glossy	
	Even a rope can be long and glossy
Snakes generally lie in a curling circular pattern	
	Need not be! Somebody might have put a rope like that! (jumps over it) See it is not moving...
Yes, not moving...I have seen a snake in my childhood; snakes normally stay like this when they have eaten 'rats'. This also looks like that...	
Therefore this should be a snake	

'This is a snake' (statement)

'Because it is long and glossy, lies in curling circular pattern' (reason)

'Since whatever is long, glossy and curly, i.e. the snake in my childhood' (example)

'This is also like that' (application)

'Therefore, this is a snake' (conclusion)

By following the above system of inference, argumentative reasoning can be seen as a methodology which introduces inferences through arguments for the sake of convincing the opponent. Arguments and counter-arguments along with the intermediate inferences thus generated are updated into the knowledge base. Since this is a continuous process, some conclusion has to be attained in finite steps. Therefore, we assume that if there is no counter-argument generated as response, the rational discussion comes to a halt.

4. Ontology and Knowledge Representation

During argumentative discussions, though knowledge representation is perfect, the components of entire knowledge base of the proponent are not entirely visible to the opponent and vice versa. Only through counter-arguments the opponent's knowledge is realised. The knowledgebase of every arguer is in the form of Indian logic based ontology [1]. Generation of defects could be appropriate if and only if the submitted argument is interpreted in the right sense. In this paper, we have utilized the Indian logic based mechanism of argument representation [6] to have a correct interpretation of the argument elements.

To analyse the input argument properly, the elements of arguments should have a correct mapping in the knowledgebase. In addition, the methodology with which the items of the knowledgebase are represented should also be convincing so that, there is

no mis-map of world knowledge into the knowledge base. Quick as well as complete knowledge representation formalisms are required which play a good role in finding the defects of the submitted arguments. Indian philosophical method of knowledge representation [4,13,17] comes to rescue at this juncture. It is a complete as well as descriptive kind of classification recommended from Nyaya Sastra, the famous Indian Philosophy. In this paper, we have utilized the classification recommendations [1,4] of Nyaya sastra, and interpret the elements of arguments into specially enhanced knowledge representation formalisms called Nyaya logics.

An ontological classification O_T is defined as the collection of all concepts under the given domain boundary

$$O_T = \sum_{i=1}^n c_i \quad (1)$$

An ontological commitment O_D is defined as the collection of all constraints defined by operator set Op over concepts C of ontological classification O_T under the given domain boundary

$$O_D = O_D(Op, O_T) - \text{collection of constraints} \quad (2)$$

Definition 1 (Abstract concept) A concept is an abstract entity which embeds several qualifying attributes of its own. The attributes are bound to the concept by relation existence. An attribute is a sub-property of a concept / relation which is used to define the concept set. Attributes are optionally supported by values.

An abstract concept c is a 7-tuple

$$c \equiv (O, Q, V, R^e, R^i, R', R^g) \quad (3)$$

where,

$$c = \{c_1, c_2, \dots, c_n\} \quad (4)$$

$$O \text{ is a set of object of the concept, } O = \{o_1, o_2, o_3, \dots, o_n\} \quad (5)$$

$$Q \text{ is a nonempty set of attributes, } Q = \{q_1, q_2, q_3, \dots, q_m\} \quad (6)$$

$$V \text{ is a set of values, } V = \{v_1, v_2, v_3, \dots, v_p\} \quad (7)$$

$$R^e \subseteq O \times O \text{ is a set of external relations; i.e. relations between a pair of concepts} \quad (8)$$

$$R^i \subseteq O \times Q \text{ is a set of internal relations; i.e. relations between a concept and its member attributes} \quad (9)$$

$$R' \subseteq Q \times Q \text{ is a set of tangential relations; i.e. relations between the member attributes of a given concept.} \quad (10)$$

$$R^g \subseteq Q \times V \text{ is a set of grouping relations between the member attribute and the values owned by it.} \quad (11)$$

Definition 2:(Abstract Quality) An abstract quality Q associated with an abstract concept C under an ontological classification O_T is a 4-tuple which is defined as:

$$Q \equiv (Q_{con}, V, R^e, R^i) \quad (12)$$

where,

$$Q_{con} \text{ is a set of constraints, } Q_{con} \subseteq \{Q_m, Q_o, Q_e, Q_x\} \quad (13)$$

i.e. mandatory, optional, exceptional and exclusive respectively.

$$Q \text{ is a nonempty set of attributes, } Q = \{q_1, q_2, q_3, \dots, q_m\}$$

$$V \text{ is a set of values, } V = \{v_1, v_2, v_3, \dots, v_p\}$$

$$R^e \equiv R^i \subseteq Q \times Q \text{ is a set of external relations; i.e. relations between qualities}$$

$$R^i \equiv R^e \subseteq Q \times V \text{ is a set of internal relations; i.e. relations between a quality and the values owned by it.}$$

Definition 3: (Concept in Argument) A concept in the argumentation framework is defined as a combination of abstract concept with other categorical properties of concept existence in argument gaming.

$$C_{AG} \equiv (c, C_{con}, C_{cat}, C_{cf}) \quad (14)$$

where c is the abstract concept in def. 1,

$$C_{con} \text{ is the constraint set under which concept } C \text{ is said to exist; } C_{con} \subseteq O_D \quad (15)$$

$$C_{cat} \text{ is the category of concept in the procedural argumentation scenario; the category can be of three types; } C_{cat} \subseteq \{C_S, C_{OI}, C_R\} \quad (16)$$

where C_S, C_{OI}, C_R denotes Subject, Object of Inference and Reason respectively.

C_{cf} is the confidence factor (a numeric value) associated with every abstract concept in the knowledgebase.

Definition 4: (Relation in Argument) A relation in the argumentation framework is defined as a combination of abstract relation with other categorical properties of relation existence in argument gaming.

$$R_{AG} \equiv (r, r_q, r_{con}, r_{cat}, r_{cf}) \quad (17)$$

where r is the abstract relation [refer def. 1],

$$r \subseteq \{R^e, R^i, R^t, R^s\} \quad (18)$$

$$r_q \text{ is the set of attributes of the abstract relation, } r_q \subseteq \{IC_i, D, X, Xp\} \quad (19)$$

IC_i is the set of invariable concomitance relations, where

$$IC_i \subseteq \{symmetric, +IC, -IC, neutral\} \quad (20)$$

where, $+IC$ denotes positive concomitance and $-IC$ denotes negative concomitance.

$$D \text{ is the set of direct relations, where } D \subseteq \{is-a, has-a, part-of\} \quad (21)$$

[Note: For convenience, direct relations are notated by r in rest of this paper]

X is the set of exclusive relations where

$$x_i \subseteq X \mid (X \subseteq r) \wedge (X \neq \phi) \quad (22)$$

Xp is the set of exceptional relations where

$$xp_i \subseteq Xp \mid ((Xp \subseteq r) \wedge (Xp \neq \phi)); (xp_i[V] = \text{true}) \text{ for some element } c_k \subseteq c; \text{ and false for other elements of } c \quad (23)$$

r_{con} is the constraint set under which relation r is said to exist;

$$r_{con} \subseteq \{\text{reflexive, symmetric, anti-symmetric, asymmetric, transitive}\} \quad (24)$$

$$r_{cat} \subseteq \{R_{S-OI}, R_{S-R}, R_{R-OI}\} \quad (25)$$

r_{cf} is the confidence factor (a numeric value) associated with every abstract relation in the knowledgebase

Definition 5: (Argument A) An argument is a set of propositions related to each other in such a way that all but at least one of them (the premise) are supported to provide support for the remaining (the conclusion). An argument A over argumentation framework AF is defined as a tuple

$$A = \langle A_{id}, f(c, r), A_{state}, A_{status}, A_{str} \rangle \quad (26)$$

where

$$f(c, r) = c_{cat} \times r_{cat} \text{ is a function of argument concepts \& relations} \quad (27)$$

A_{id} is the argument index;

A_{state} , the state of argument; $A_{state} \subseteq \{\text{premise, inference, conclusion}\}$;

A_{status} , the defeat status of arguments; $A_{status} \subseteq \{\text{defeated, undefeated, ambiguous, undetermined and}$

A_{str} , the strength or conclusive force of the argument.

By utilizing the above philosophical recommendations, arguments and counter-arguments are exchanged between the knowledge sharing entities about the subject of discussion. As the argumentation process continues, invalid beliefs about the subject of discussion are cleared through defect finding mechanisms. At the end of discussion, both the arguers would have learnt a considerable amount of knowledge related to the subject of discussion. This is generated as definitions by the knowledge sharing volunteers as they reach a definite conclusion.

5. Results

Agent 1	Agent 2
What is mountain ?	mountain has fire due_to smoke
	The Concept 'mountain' is a 'earth-substance' which has [tree, lake]. tree causes fire

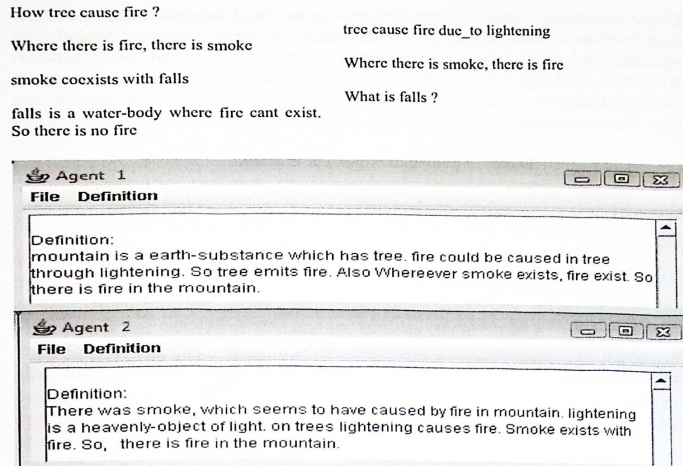


Figure 2. Sample argument "Mountain has fire due to smoke" and related argumentative discussion with definitions generated

The knowledge base consisted of 78 Indian logic concepts (enriched with qualities and other special attributes as recommended by Nyaya classification system [17]) and 149 relations on a whole, comprising domains like bird, animal, geography, dairy, metal and nature. A more realistic implementation of argumentative discussion was carried out with two knowledge volunteers Agent 1 and Agent 2, discussing about the occurrence of 'fire' over the 'mountain' region on perceiving the 'smoke' on that particular area. Agent 1 has concepts related to 'nature' domain, but it lacks information about 'trees'. Agent 2 has also some concepts related to 'nature' domain but it lacks information about 'falls'.

The entire discussion is shown in fig. 2. Argument proposed by Agent 1 is analysed for defects at Agent 2. Based on the defects analysed, the defect value is computed which contributes to identifying parts of knowledge in the argument which form the source of generation of counter-argument. The concepts and relations are assembled in a particular format (i.e. in natural language sentences) and the counter-argument is constructed and let out to continue further discussion. (Note: We have not concentrated on natural language generation aspect while generating counter-arguments; instead, we have various structures of training sets of counter-arguments, based on which the new counter-arguments are constructed; However, doing natural language generation would be very much appreciable, but since that is a different research by its own which is not related to our scope, we tend to ignore it here)

At every argument exchange, defects are analysed out of the submitted arguments at both the agents; i.e. Agent 2 does defect analysis on the arguments proposed by

Agent 1 and vice versa. When an argument is proposed and suppose, if the information is not found in the knowledgebase the maximum weight of a concept / relation in the knowledge base is given as a defect value. Generally, the defect value is maximum when the knowledge base is refreshed (and a defect is found) on a larger scale. The levels of knowledge refreshed in the knowledge base also contribute to the analysis of defects in arguments.

Table 1. Splitting of Argument Elements

Argument	Argument elements	Relation
mountain has fire due_to smoke	Subject: mountain; Object of Inference: fire; Reason: smoke	contact-contact (mountain, fire); invariable (smoke, fire)
tree cause fire due_to lightning	Subject: tree; Object of Inference: fire; Reason: lightning	causal (tree, fire) causal (lightening, fire)
smoke coexist with falls	Subject: smoke; Object of Inference: Falls; Reason: not stated	locative (falls, smoke)

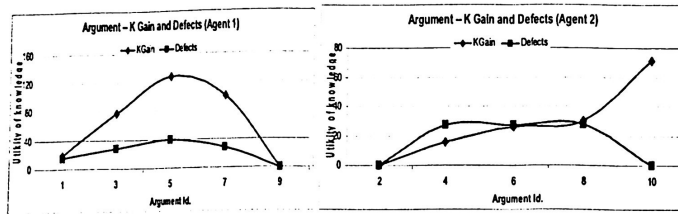


Figure 3. Knowledge Gain and Defect evaluation for Agent 1 and Agent 2 Interactions

The sample splitting of argument elements is summarised in Table 1 [8]. Ideally, if there is no defect gain, the reward tends to 'infinity'. But if there is incomplete information present in one's own knowledge base, obviously the counter-argument carries some form of 'assertive' statements for which the complete information is expected from the other end. In such cases of 'infinite' rewards, we analyse the counter-argument that has generated the reward, if it is assertive, we just allow the discussion to continue; or else, it shall be assumed that there is no defect found with the counter-argument and that the discussion has been concluded. The defect graph is shown in fig. 3. The graph displays the maximum defect gain observed from every argument during discussion.

Fig. 2 shows the generation of definitions from both the agents 1 and 2, after argumentative discussion. Agent 1 and agent 2 have different prior beliefs about the subject of discussion before arguing. Those beliefs may contain invalid means of knowledge which are cleared through argumentative discussion. The methodology of finding defects in the arguments and proposing respective counter-arguments to clear them, serve as an instrument to eradicate invalid beliefs from the knowledge base.

However, there may be more beliefs about the subject of discussion which might not be revealed through arguments during discussion. These beliefs remain as such without any change because the arguing agent has not exposed its belief to the opponent during argumentation. At the end of discussion, both the agents attempt to generate convincing definitions about the subject, which is composed of valid beliefs tested through argumentative discussion with the presumed beliefs in their own knowledge bases.

6. Conclusion

The aim of this paper is to propose an algorithm of reasoning by argument gaming. The objective is to utilize the presence of defects of the submitted argument for further generation of counter-arguments, to eventually arrive at more expanded knowledge about the subject of discussion. Besides 'tarka' style of argumentation and argument gaming, the reason fallacies and refutation mechanisms of Nyaya sastra are also taken into account along with the Nyaya sastra classification methodologies. In future, generating definitions from arguments using natural language analysis based approaches, to add to the efficient definitions generated currently through knowledge sharing by argument gaming, is of our interest.

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