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Belief Change in Chivalry Case

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Abstract. *Chivalry case* is presented as an example legal case representing the judges' belief changes in the actual courtst. *Chivalry case* relates to a self-defense causing from a misconception. To formalize the judges' belief changes in this case, we propose a dynamic logical analysis composing of two dynamic operators, i.e., a commitment operator **com** and a permission operator **per**. For the commitment operator, we use a notion of local announcement from our previous work [8] in order to formalize a process of removing the accessibility in worlds. The permission operator is introduced to formalize a process of restoring the accessibility. In addition, our formalization is implemented in a computer to show that it can be use in a practical way.

Keywords: belief revision, belief change, legal case

1 Introduction

The logic has been applied to the the legal domain and has driven the development of related areas. Many studies [1–3] described the use of logical approaches in the legal systems. This stated the significance of logic in the law.

Recently, there are several theoretical and technical developments in the logic. Among of them, Dynamic Epistemic Logic (DEL) [4, 5] is a logical tool for studying information changes. In the real world, the information (e.g. knowledge or belief) can change all through the time, e.g., observations by agents, communication between agents, etc. Thus, we can find many researches in the area of belief change and DEL as [6, 7]. This paper focuses on belief changes of judges in a court. In each judgment, if judges obtain some new evidences, judges may change their belief and their decision. Thus, DEL is applied to formalize belief changes of judges.

Our previous work [8] introduced a dynamic operator for formalizing belief changes of judges. The dynamic operator represented an agent's commitment. For target legal cases, we considered two legal cases including Tanuki-Mujina case and Musasabi-Moma case. These cases related to the confusion in naming animals, i.e., each animal can have different regional names. In our previous work, the formalization provided only the process of removing links but did not include the process of adding new links. This property can be called a monotonicity. However, the monotonicity cannot handle some kinds of belief revision.

For this reason, this paper introduces a dynamic operator with non-monotonic features for formalizing dynamic belief changes of judges in legal cases. A non-monotonic feature is a characteristic that adding new knowledge can reduce the set of what is known. The formalization includes the process of removing and adding links. That is, this work can handle in the case of removing and adding the possibilities. We adopt an agent's commitment operator from our previous work for formalize the process of removing the possibilities. In order to formalize the process of adding the possibilities, we propose a new dynamic operator, that is, an agent's permission.

In this paper, *Chivalry case* is selected as the target legal case. *Chivalry case* is relevant to a self-defense, i.e., an act of defending oneself or any other person from attacking by others. If an act is considered to be the self-defense, Article 36 of Penal Code of Japan (see Section 2 for more details) will be applied. In *Chivalry case*, a defendant misunderstood another that he/she intended to attack himself so that he attacked him/her resulting in his/her death. As the defendant's attacking caused the death of another person, Article 205 of Penal Code of Japan (see Section 2 for more details) will be considered in the judgments.

The remainder of the paper is organized as follows. Section 2 describes the details of *Chivalry case*. Then, a logical formal tool for analyzing *Chivalry case* is presented in Section 3. In Section 4, we propose a dynamic logical analysis of *Chivalry case*. After that, Section 5 provides an implementation of logical formalization. Finally, our conclusion and future works are stated in Section 6.

2 Target Legal Case

2.1 Outline of Chivalry Case

This case composes of three persons; an observed drunken (o), a friend of the observed drunken (f) and a defendant (d) who is officially acknowledged to be a highly ranked *karate* (Japanese martial arts) master. The story of this case can be described as follows. On one day, while f was helping o who was drunken, d accidentally met them. Since they looked wrestling, d misunderstood that f was assaulting o, d jumped in them, and tried to help o. Then, d came to near to f with both hands open. When f looked at d, f crossed his hands with fists in front of him to protect himself from d. On the other hand, d misunderstood that f posed to fight, d quickly tried to kick f's face with an art of karate, also to protect himself. However, his left leg strongly kicked f's face, which made f fall down on the ground, and as a result, f's skull was crushed. Eight days later, f was dead by breeding cerebral dura mater and its crushed wound.

This story can be summarized as the following sequences.

1) f came to help o who was drunken.
2) d misunderstood that f was assaulting o.
3) d came to help o.
4) f posed to protect himself.
5) d misunderstood that f posed to fight.

6) d attacked f.
7) f was dead.

From the above summary of the story, the defendant has two misconceptions with f as follows.

- d misunderstood that f was assaulting o.
- d misunderstood that f posed to fight.

From this story, it shows that the defendant believed that f would attack him so that he kicked f to protect himself. Thus, the act of the defendant may be called as a self-defense in term of the following Article 36 of Penal Code[1].

> *Article 36* (self-defense)
> (1) An act unavoidably performed to protect the rights of oneself or any other person against imminent and unlawful infringement is not punishable.
> (2) An act exceeding the limits of self-defense may lead to the punishment being reduced or may exculpate the offender in light of the circumstances.

Nevertheless, the defendant's attacking is not an actual self-defense or called as a virtual self-defense because the defendant attacks f by the misconception that f poses to fight; in fact, f just poses to protect himself. That is, f does not really intend to attack the defendant. To judge this case, there were three trials as follows.

The first trial was conducted at Chiba regional court on February 7, 1984. The court judged the defendant to be innocent by the following reasons.

- Based on the supposed misconception of the defendant, his act belongs to a category of tolerable self-defense. Although the result is significant, this does not affect the adequacy of the defensive act.
- As the defendant is English, such a misconception cannot be his fault.
- His defensive attack by misconception is not intended, and as it is not his fault, the defendant is innocent by the above Article 36-1 of Penal Code.

In the second trial, Tokyo High Court judged the defendant to be guilty on November 11, 1984. He was sentenced to be imprisonment for 18 months with parole of three years. The reasons of the judgment were as follows.

- The defendant possessed other alternative methods to protect him. Notwithstanding this, the act of kicking by the defendant is such dangerous that the attack would be lethal.
- Thus, the act of the defendant is comparable to the excessive defense resulting in death. Therefore, the following Article 205 of Penal Code[1] is applied to this case. However, because of Penal Code Article 36-2, the penalty is reduced.

[1] An English translation of the article can be referenced from `http://www.japaneselawtranslation.go.jp/`.

Article 205 (Injury Causing Death)
A person who causes another to suffer injury resulting in death shall be punished by imprisonment with work for a definite term of not less than 3 years.

At last, in the final trial, Japan Supreme Court adopted the result of the second trail on March 26, 1987; it is obvious that the defendant's act of kicking f is an excessive self-defense, by the misconception of f's intended attack, and the case is accidental morality. However, the Penal Code Article 36-2 is also applied and the penalty is reduced, based on the preceding case of Jury 7, 1966.

In short, judges first believed that the act of the defendant was a reasonable self-defense so that the defendant was innocent by applying Article 36-1 of Penal Code. After that, judges changed their evaluation about the defendant's act. Since the kicking of the defendant was such dangerous enough for killing f, the defendant's act was not a reasonable self-defense or could be called as an excessive self-defense. Thus, Article 205 of Penal Code was applied to judge that the defendant was guilty because his act caused f's death. Nevertheless, the penalty was reduced as a result of Article 36-2 of Penal Code.

In order to formalize the judges' belief changes, we need a logical formalization for the following representations.

(1) To represent the misconception of the defendant.
(2) To represent the judges' belief on the defendant's belief, i.e., iterated beliefs between agents.
(3) To represent changing of the judges' belief that requires two dynamic operators, i.e., the judges' commitment and the judges' permission.

For the judges' commitment, we adopt an idea of our previous work [8] that is, an effect of an agent's commitment is valid only at the state where the agent commits him/herself to do something. The judges' permission, which is a new dynamic operator, is introduced for formalizing the case that judges need to permit some possibilities. This operator provides a non-monotonic change of belief, i.e., the judges' belief is changed from 'judges believed that the defendant's act belonged to the reasonable self-defense' to 'judges did not believe that the defendant's act belonged to the reasonable self-defense because it exceeded the limits of the self-defense or could be called as an excessive self-defense'.

3 Formal Tool for Analyzing Target Legal Case

3.1 Static Logic for Agents' Belief

In order to analyze the previous Chivalry case from logical point of view, we introduce a modal language which enables us to formalize the agent's belief.

Let G be a fixed *finite* set of agents. Our syntax $\mathcal{L}$ consists of the following vocabulary: (i) a set $\mathsf{Prop} = \{p, q, r, ...\}$ of propositional letters, (ii) boolean connectives: $\neg$, $\wedge$, (iii) belief operators B_i ($i \in G$), as well as (iv) the global modality E and (v) the modal constant n, denoting the actual state. A set of formulas of $\mathcal{L}$ is inductively defined as follows:

$$\varphi ::= p \mid \mathsf{n} \mid \neg\varphi \mid \varphi \wedge \psi \mid \mathsf{B}_i\, \varphi \mid \mathsf{E}\varphi,$$

where $p \in \mathsf{Prop}$, $i \in G$[2]. We define $\vee$, $\rightarrow$, $\leftrightarrow$ as ordinary abbreviations and use $\mathsf{A}\,\varphi$ to mean $\neg\mathsf{E}\neg\varphi$.

As before, let f, d, and j be agents of a friend of the observed drunken, a defendant who is a highly ranked karate (Japanese martial arts) master, and the judge of the first trial of Chivalry Case, respectively. Let us also denote 'f posed to fight against d' by p and 'the kick of d was beyond the range of self-defense' by q, respectively. We can provide some formalization relevant to our legal example as in Table 1. Note that we can regard '$\neg p \wedge \mathsf{B}_d\, p$' as a formalization of the sentence 'd misunderstood that f posed to fight against d.'

$\mathsf{B}_d\, p$	: d believes that f posed to fight against d
$\neg p \wedge \mathsf{B}_d\, p$	: f did not pose to fight against d, but d believes that f posed to fight against d.
$\mathsf{B}_j(\neg p \wedge \mathsf{B}_d\, p)$	: j believes that d misunderstood that f posed to fight against d.
$\mathsf{B}_j\, \neg q$	: j believes that d's kick was not beyond the range of self-defense.
$\mathsf{B}_j\, q$	: j believes that d's kick was beyond the range of self-defense.

Table 1. Examples of Static Logical Formalization for Chivalry Case

Let us provide Kripke semantics with our syntax. A *model* $\mathfrak{M}$ is a tuple

$$\mathfrak{M} = (W, (R_i)_{i \in G}, @, V),$$

where W is a non-empty set of states, called *domain*, $R_i \subseteq W \times W$, $@ \in W$ is a distinguished element called the *actual state*, and $V : \mathsf{Prop} \rightarrow \mathcal{P}(W)$ is a valuation. Given any model $\mathfrak{M}$, any world $w \in W$, and any formula φ, we define the *satisfaction relation* $\mathfrak{M}, w \models \varphi$ inductively as follows.

$$\begin{array}{lll}
\mathfrak{M}, w \models p & \text{iff} & w \in V(p) \\
\mathfrak{M}, w \models \mathsf{n} & \text{iff} & w = @ \\
\mathfrak{M}, w \models \neg\varphi & \text{iff} & \mathfrak{M}, w \not\models \varphi \\
\mathfrak{M}, w \models \varphi \wedge \psi & \text{iff} & \mathfrak{M}, w \models \varphi \text{ and } \mathfrak{M}, w \models \psi \\
\mathfrak{M}, w \models \mathsf{B}_i\, \varphi & \text{iff} & R_i(w) \subseteq [\![\varphi]\!]_{\mathfrak{M}} \\
\mathfrak{M}, w \models \mathsf{E}\varphi & \text{iff} & \mathfrak{M}, v \models \varphi \text{ for some } v \in W\ ,
\end{array}$$

where $R_i(w) := \{\, w' \in W \mid wR_iw' \,\}$ and $[\![\varphi]\!]_{\mathfrak{M}} = \{\, w \in W \mid \mathfrak{M}, w \models \varphi \,\}$ (we drop the subscript $\mathfrak{M}$ from $[\![\varphi]\!]_{\mathfrak{M}}$, if it is clear from the context). We say that φ is

[2] If the reader is familiar with hybrid logics, the following observation is useful: n behaves like a nominal in hybrid logic and we can define a satisfaction operator '$@_{\mathsf{n}}\varphi$' by $\mathsf{E}(\mathsf{n} \wedge \varphi)$.

valid on $\mathfrak{M}$ if $\mathfrak{M}, w \models \varphi$ for all $w \in W$. As for $\mathsf{A}\,\varphi$, we have the following derived semantic clause:

$$\mathfrak{M}, w \models \mathsf{A}\,\varphi \ \text{ iff } \ \mathfrak{M}, v \models \varphi \text{ for all } v \in W.$$

3.2 Dynamic Operators for Belief Changes of Judges

In the beginning of, e.g., the first trial of Chivalry case, a judge should be open to several possibilities of the defendant's belief. In the process of the trial, the judge receives new evidence and/or rejects some confirmed evidence, and then, he/she removes and/or sometimes adds some possibilities to reach his/her own decision. We want to simulate the effect of this process by introducing two dynamic operators for action to our static syntax.

We introduce two kinds of dynamic operators $[\mathsf{com}_j(\varphi)]$ and $[\mathsf{per}_j(\varphi)]$. Our intended reading of $[\mathsf{com}_j(\varphi)]\psi$ is 'after the agent j commits him/herself to φ, ψ' and we read $[\mathsf{per}_j(\varphi)]\psi$ as 'after the agent j permitted φ to be the case, ψ'. Semantically speaking, $[\mathsf{com}_j(\varphi)]$ restricts j's attention to the φ's states, and $[\mathsf{per}_j(\varphi)]$ enlarge j's attention to cover *all* the φ's states. We denote the expanded syntax with all $[\mathsf{com}_j(\varphi)]$ and $[\mathsf{per}_j(\varphi)]$ by $\mathcal{L}^+$. Table 2 demonstrates dynamic-logical formalization of the judges' belief, where we keep the same reading of agents and propositions as in Table 1.

$[\mathsf{com}_j(\neg p \wedge \mathsf{B}_d\, p)]\, \mathsf{B}_j\, \mathsf{B}_d\, p$	: After j's commitment of d's misunderstanding of p, j believes that d believes that p.
$\mathsf{B}_j\, q \wedge [\mathsf{per}_j(\neg q)] \neg\, \mathsf{B}_j\, q$	: j first believes that q, but after j's permission of $\neg q$, j does not believes that q.

Table 2. Examples of Dynamic Logical Formalization for Chivalry Case

Let us fix a Kripke model $\mathfrak{M} = (W, (R_i)_{i \in G}, @, V)$. A semantic clause for $[\mathsf{com}_j(\varphi)]\psi$ on $\mathfrak{M}$ and $w \in W$ is defined as follows.

$$\mathfrak{M}, w \models [\mathsf{com}_j(\varphi)]\psi \ \text{ iff } \ \mathfrak{M}^{\mathsf{com}_j(\varphi)}, w \models \psi,$$

where $\mathfrak{M}^{\mathsf{com}_j(\varphi)} = (W, (R_i)_{i \in G \setminus \{j\}}, S_j, @, V)$ and S_j is defined as: for all $x \in W$,

$$S_j(x) := \begin{cases} R_j(x) \cap [\![\varphi]\!]_{\mathfrak{M}} & \text{if } x = @, \\ R_j(x) & \text{otherwise.} \end{cases}$$

Let us move to a semantic clause for $[\mathsf{per}_j(\varphi)]$ on $\mathfrak{M}$ and $w \in W$.

$$\mathfrak{M}, w \models [\mathsf{per}_j(\varphi)]\psi \ \text{ iff } \ \mathfrak{M}^{\mathsf{per}_j(\varphi)}, w \models \psi,$$

where $\mathfrak{M}^{\mathsf{per}_j(\varphi)} = (W, (R_i)_{i \in G \setminus \{j\}}, S'_j, @, V)$ and S'_j is defined as: for all $x \in W$,

$$S'_j(x) := \begin{cases} R_j(x) \cup [\![\varphi]\!]_{\mathfrak{M}} & \text{if } x = @, \\ R_j(x) & \text{otherwise.} \end{cases}$$

Note that the effects of the agent j's commitment and permission of φ are restricted only at the distinguished element @. While $[\mathsf{com}_j(\varphi)]$ compatible with the *monotonicity* of j's belief (i.e., once a formula $\mathsf{B}_j\,\psi$ holds, it continues to be true), $[\mathsf{per}_j(\varphi)]$ may break this monotonicity. This is because an addition of new j's links allows the belief change from $\mathsf{B}_j\,\psi$ into $\neg\,\mathsf{B}_j\,\psi$. In this sense, $[\mathsf{per}_j(\varphi)]$ can capture the non-monotonic change of agents' belief.

The formulas of Table 3 are called *reduction axioms*, which can be regarded as a necessary criteria for introducing dynamic operators. With the help of the necessitation rules for $[\mathsf{com}_i(\varphi)]$ and $[\mathsf{per}_i(\varphi)]$: from ψ, we may infer $[\mathsf{com}_i(\varphi)]\psi$ and $[\mathsf{per}_i(\varphi)]\psi$, reduction axioms allow us to rewrite a formula of $\mathcal{L}^+$ to an equivalent formula in $\mathcal{L}$ with no occurence of $[\mathsf{com}_i(\varphi)]$ and $[\mathsf{per}_i(\varphi)]$.

$[\mathsf{com}_i(\varphi)]p$	$\leftrightarrow p$	$[\mathsf{per}_i(\varphi)]p$	$\leftrightarrow p$
$[\mathsf{com}_i(\varphi)]\mathsf{n}$	$\leftrightarrow \mathsf{n}$	$[\mathsf{per}_i(\varphi)]\mathsf{n}$	$\leftrightarrow \mathsf{n}$
$[\mathsf{com}_i(\varphi)]\neg\psi$	$\leftrightarrow \neg[\mathsf{com}_i(\varphi)]\psi$	$[\mathsf{per}_i(\varphi)]\neg\psi$	$\leftrightarrow \neg[\mathsf{per}_i(\varphi)]\psi$
$[\mathsf{com}_i(\varphi)](\psi\wedge\chi)$	$\leftrightarrow [\mathsf{com}_i(\varphi)]\psi\wedge[\mathsf{com}_i(\varphi)]\chi$	$[\mathsf{per}_i(\varphi)](\psi\wedge\chi)$	$\leftrightarrow [\mathsf{per}_i(\varphi)]\psi\wedge[\mathsf{per}_i(\varphi)]\chi$
$[\mathsf{com}_i(\varphi)]\,\mathsf{A}\,\psi$	$\leftrightarrow \mathsf{A}[\mathsf{com}_i(\varphi)]\psi$	$[\mathsf{per}_i(\varphi)]\,\mathsf{A}\,\psi$	$\leftrightarrow \mathsf{A}[\mathsf{per}_i(\varphi)]\psi$
$[\mathsf{com}_i(\varphi)]\,\mathsf{B}_k\,\psi$	$\leftrightarrow \mathsf{B}_k[\mathsf{com}_i(\varphi)]\psi$	$[\mathsf{per}_i(\varphi)]\,\mathsf{B}_k\,\psi$	$\leftrightarrow \mathsf{B}_k[\mathsf{per}_i(\varphi)]\psi \quad (i\neq k)$
$[\mathsf{com}_i(\varphi)]\,\mathsf{B}_i\,\psi$	$\leftrightarrow (\mathsf{n}\to\mathsf{B}_i(\varphi\to[\mathsf{com}_i(\varphi)]\psi))\wedge(\neg\mathsf{n}\to\mathsf{B}_i[\mathsf{com}_i(\varphi)]\psi)$		
$[\mathsf{per}_i(\varphi)]\,\mathsf{B}_i\,\psi$	$\leftrightarrow (\mathsf{n}\to(\mathsf{B}_i[\mathsf{per}_i(\varphi)]\psi\wedge\mathsf{A}(\varphi\to[\mathsf{per}_i(\varphi)]\psi)))\wedge(\neg\mathsf{n}\to\mathsf{B}_i[\mathsf{per}_i(\varphi)]\psi)$		

Table 3. Reduction Axioms for $[\mathsf{com}_i(\varphi)]$ and $[\mathsf{per}_i(\varphi)]$

Proposition 1. *All the formulas of Table 3 are valid on all models.*

Proof. We only establish the equivalence for $[\mathsf{per}_i(\varphi)]\,\mathsf{B}_i\,\psi$ here. Let us fix any model $\mathfrak{M}$ and any state w of $\mathfrak{M}$. We can proceed as follows: $\mathfrak{M},w\models[\mathsf{per}_i(\varphi)]\,\mathsf{B}_i\,\psi$ iff $\mathfrak{M}^{\mathsf{per}_i(\varphi)},w\models\mathsf{B}_i\,\psi$ iff $S'_i(w)\subseteq[\![\psi]\!]_{\mathfrak{M}^{\mathsf{per}_i(\varphi)}}$ iff

$$\begin{cases} R_i(w)\cup[\![\varphi]\!]_{\mathfrak{M}}\subseteq[\![\psi]\!]_{\mathfrak{M}^{\mathsf{per}_i(\varphi)}} & \text{if } w=@\\ R_i(w)\subseteq[\![\psi]\!]_{\mathfrak{M}^{\mathsf{per}_i(\varphi)}} & \text{if } w\neq @\end{cases}$$

$$\text{iff}\ \begin{cases} R_i(w)\cup[\![\varphi]\!]_{\mathfrak{M}}\subseteq[\![[\mathsf{per}_i(\varphi)]\psi]\!]_{\mathfrak{M}} & \text{if } w=@\\ R_i(w)\subseteq[\![[\mathsf{per}_i(\varphi)]\psi]\!]_{\mathfrak{M}} & \text{if } w\neq @\end{cases}$$

$$\text{iff}\ \begin{cases} R_i(w)\subseteq[\![[\mathsf{per}_i(\varphi)]\psi]\!]_{\mathfrak{M}} \text{ and } [\![\varphi]\!]_{\mathfrak{M}}\subseteq[\![[\mathsf{per}_i(\varphi)]\psi]\!]_{\mathfrak{M}} & \text{if } w=@\\ \mathfrak{M},w\models\mathsf{B}_i[\mathsf{per}_i(\varphi)]\psi & \text{if } w\neq @\end{cases}$$

$$\text{iff}\ \begin{cases} \mathfrak{M},w\models\mathsf{B}_i[\mathsf{per}_i(\varphi)]\psi \text{ and } \mathfrak{M},w\models\mathsf{A}(\varphi\to[\mathsf{per}_i(\varphi)]\psi) & \text{if } w=@\\ \mathfrak{M},w\models\mathsf{B}_i[\mathsf{per}_i(\varphi)]\psi & \text{if } w\neq @\end{cases}$$

The final line can be easily shown to be equivalent with the right-hand side of the equivalence axiom for $[\mathsf{per}_i(\varphi)]\,\mathsf{B}_i\,\psi$. □

4 Dynamic Logical Analysis of Target Legal Case

4.1 First Trial

In order to analyze the result of the first trial, we introduce the following specific model $\mathfrak{M}_1$ (for the graphical representation, see Fig. 1, where the solid circles around the states 1, 2 and 5 mean that they are reflexive states with respect to R_d-relation).

Definition 1. *Let $G = \{ d, j \}$, where recall that d and j mean the defendant and the judge, respectively. Define $\mathfrak{M}$ as follows:*

- $W = \{ \varepsilon \} \cup \{ 1, 2, 3, 4, 5 \}$.
- $R_j = \{ (\varepsilon, 1), (\varepsilon, 2), (\varepsilon, 3), (\varepsilon, 4) \}$.
- $R_d = \{ (1, 1), (2, 2), (1, 5), (2, 5), (3, 5), (4, 5), (5, 5) \}$.
- $@ := \varepsilon$.
- $V(p) = \{ 5 \}$ *and* $V(q) = \{ 1, 3 \}$.

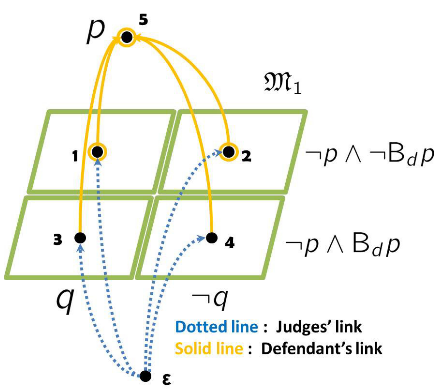

Fig. 1. A Model $\mathfrak{M}_1$ of Definition 1

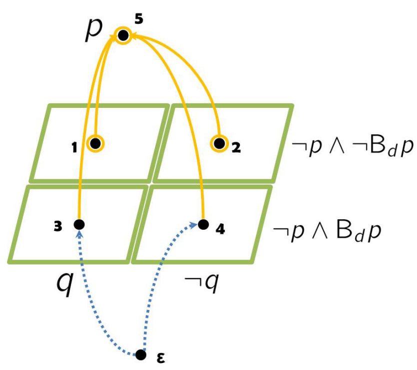

Fig. 2. Update $\mathfrak{M}_1$ by $[\mathsf{com}_j(\neg p \wedge \mathsf{B}_d\, p)]$

We regard the state ε as j's viewpoint at the initial stage of the first trial. In our model, we have

$$\mathfrak{M}_1, \varepsilon \models \neg\, \mathsf{B}_j(\neg p \wedge \mathsf{B}_d\, p) \wedge \neg\, \mathsf{B}_j\, \neg q,$$

i.e., the judge does not believes that d's kick was not beyond the range of self-defense, and the judge does not believe that d misunderstand p, either. In the first trial, the judge admitted that f did not pose to fight against d but d misunderstood that f posed to fight against d (i.e., p). Based on this, the judge also committed him/herself to $\neg q$, i.e., d's kick was not beyond the range of self-defense. Those process can be formalized by the successive updates of the model

$\mathfrak{M}$ by $[\mathsf{com}_j(\neg p \wedge \mathsf{B}_d\, p)]$ and $[\mathsf{com}_j(\neg q)]$. Let us see the effects of the updates step by step (Fig. 2 and Fig. 3). By the update of $[\mathsf{com}_j(\neg p \wedge \mathsf{B}_d\, p)]$, we delete all the links from ε into the states where $\neg p \wedge \mathsf{B}_d\, p$ is false. That is, we eliminate $(\varepsilon, 1)$ and $(\varepsilon, 2)$ from R_j (see Fig. 2). The result becomes $\{(\varepsilon, 3), (\varepsilon, 4)\}$. After this, the update of $[\mathsf{com}_j(\neg q)]$ requires us to delete all the links from ε into the states where q is true. Therefore, we furthermore need to delete $(\varepsilon, 3)$. Then, the final accessibility relation for j becomes $\{(\varepsilon, 4)\}$ and the judge j now believes both $\neg p \wedge \mathsf{B}_d\, p$ and $\neg q$ (see Fig. 3). Therefore,

$$\mathfrak{M}_1, \varepsilon \models [\mathsf{com}_j(\neg p \wedge \mathsf{B}_d\, p)][\mathsf{com}_j(\neg q)]\, \mathsf{B}_j((\neg p \wedge \mathsf{B}_d\, p) \wedge \neg q).$$

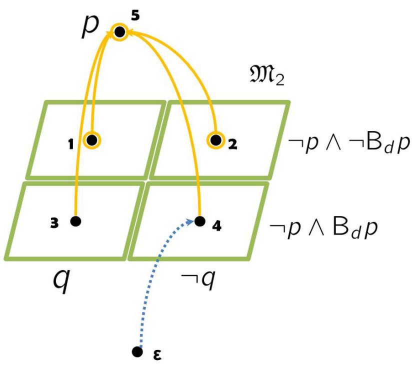

Fig. 3. Update Fig. 2 by $[\mathsf{com}_j(\neg q)]$

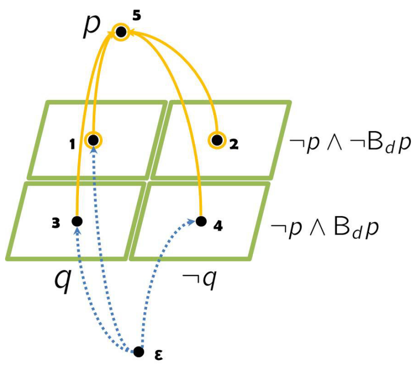

Fig. 4. Update $\mathfrak{M}_2$ by $[\mathsf{per}_j(q)]$

4.2 Second Trial

Let us denote by $\mathfrak{M}_2$ the updated model of $\mathfrak{M}_1$ by $[\mathsf{com}_j(\neg p \wedge \mathsf{B}_d\, p)]$ and $[\mathsf{com}_j(\neg q)]$, i.e., the model of Fig. 3. Precisely, $\mathfrak{M}_2$ is defined as follows.

Definition 2. *Define $\mathfrak{M}_2$ is the same model as $\mathfrak{M}_1$ except $R_j = \{(\varepsilon, 4)\}$.*

We can regard $\mathfrak{M}_2$ as the model of the beginning of the second trial. The judge of the second trial also committed him/herself that d misunderstood p but there is a difference between the first and the second trials, i.e., whether the judge accepts q or not. As we have seen in the previous section, the judge of the first trial accepts $\neg q$. On the other hand, the judge of the second trial reject $\neg q$ but accepts q instead. In order to overturn the decision, the judge of the second trial first needs to permit the possibility of q, i.e., the possibility that d's kick was beyond the range of self-defense. This was done by the operator $[\mathsf{per}_j(q)]$ in our logical framework. $[\mathsf{per}_j(q)]$ allows us to 'revive' the older links from ε to the states where q is true. By the update by $[\mathsf{per}_j(q)]$, R_j becomes $\{ (\varepsilon, 1), (\varepsilon, 3), (\varepsilon, 4) \}$ (see Fig. 4). Then, the judge becomes undetermined on q, i.e., $\neg \mathsf{B}_j\, q$ and $\neg \mathsf{B}_j \neg q$ hold at ε, i.e.,

$$\mathfrak{M}_2, \varepsilon \models \mathsf{B}_j \neg q \wedge [\mathsf{per}_j(q)](\neg \mathsf{B}_j\, q \wedge \neg \mathsf{B}_j \neg q).$$

After this reviving the links into the q-states, the judge successively commits him/herself to $\neg p \wedge \mathsf{B}_d\, p$ (the same as in the first trial) and then q (instead of $\neg q$ of the first trial) (Fig. 5 and see Fig. 6, respectively). By the update of $[\mathsf{com}_j(\neg p \wedge \mathsf{B}_d\, p)]$, j's accessibility relation is changed into $\{ (\varepsilon, 3), (\varepsilon, 4) \}$ (see Fig. 5). Furthermore, the update of $[\mathsf{com}_j(q)]$ deletes j's accessibility relation into $\{ (\varepsilon, 4) \}$, which implies that j now believes that p at ε (see Fig. 6). To sum up, we obtain the following *non-monotonic change* of j's belief from $\mathsf{B}_j(\neg q)$ into $\mathsf{B}_j\, q$:

$$\mathfrak{M}_2, \varepsilon \models \mathsf{B}_j \neg q \wedge [\mathsf{per}_j(q)][\mathsf{com}_j(p \wedge \neg \mathsf{B}_j\, p)][\mathsf{com}_j(q)]\, \mathsf{B}_j\, q.$$

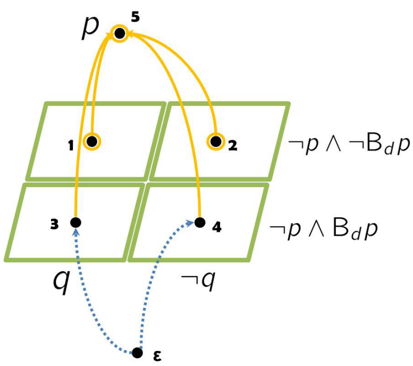

Fig. 5. Update Fig. 4 by $[\mathsf{com}_j(\neg p \wedge \mathsf{B}_d\, p)]$

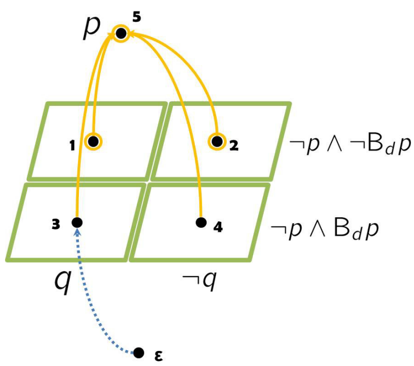

Fig. 6. Update Fig. 5 by $[\mathsf{com}_j(q)]$

5 Implementation

We show an alogrithm in Algorithm 1. `finall` finds all the accessible worlds from w_o, i.e. `findall` includes those w' such that $w_0 R_j w'$ into W'. Then Algorithm 1 investigates if ψ holds for all $w' \in W'$, to judge if $B_j \psi$ holds or not.

Algorithm 2 concerns the public announcement. `findall` collects all the accessible worlds w' from the current world (@), to build set W'. Next, `findall` finds all those in W', in which ψ holds, to build set W''. Then, R'_j is renewed to be a set of accessibility, in which all the accessible worlds from @ are restricted to those where ψ holds. Finally, with the renewed R'_j, we evaluate $(W, R'_j, R_d, V), w_0 \models \psi$.

Algorithm 1 $B_j\psi, w_0$

input $B_j\psi, w_0$, $\mathfrak{M} = (W, R_j, R_d, V)$
findall $w' \in W$, $w_0 R_j w'$
    w' **add** W'
end findall
forall $w' \in W'$, $\mathfrak{M}, w' \models \psi$
    $\mathfrak{M}, w_0 \models B_j\psi$
else
    $\mathfrak{M}, w_0 \not\models B_j\psi$
end forall

Algorithm 2 $[\mathsf{com}_j(p)]\psi, w_0$

input $[\mathsf{com}_j(p)]\psi, w_0$, $\mathfrak{M} = (W, R_j, R_d, V)$
findall $w' \in W$ $@R_j w'$
    add w' **to** W'
end findall
findall $w' \in W'$, $\mathfrak{M}, w' \models \psi$
    add w' **to** W''
end findall
$R'_j := (R_j \setminus \{(@, w') | w' \in W'\}) \cup (\{(@, w') | w' \in W''\})$
evaluate $(W, R'_j, R_d, V), w_0 \models \psi$

6 Conlusion

Thus far, we formalized the notion of *local announcement* [8], specifying the current world, and the result of announcement was only reflected in those worlds which were accessible from that current worlds. However, we realized this local announcement by restricting the accessibility in worlds, so that we hardly restore the former accessibility when further belief revision was required.

In this research, we have provided the commitment operator **com** which functions as local announcement, together with the permission operator **per**; the latter tolerates a proposition, restoring the accessibility to those worlds in which the proposition holds. With these equipments, we have shown an example of *Chivalry* case, where an action might look based on chivalry though the action was actually done by misconception. In the process of the trials, a court gave firstly a decision, but after then, with a different interpretation of penal code, the second judgment overturned the first decision. We could successfully depict this process by revising belief state in multiple times.

Our contribution in this paper is two-fold. One is that we have formalized the accessibility restoration; that is, we can re-revise one's belief, in terms of dynamic epistemic logic. The other is that we have actually implemented the process in a computer system to show its adequacy.

However, there are multiple ways to restore the accessibility and we need to choose the most plausible way among them. The difficulty is that this accessibility restoration depends on each situation, and we are to hardly able to give a general preference among them. We need to discuss this matter further in our future work.

References

1. Prakken, H., Sartor, G.: The role of logic in computational models of legal argument - a critical survey (2001)
2. Bench-Capon, T.J.M., Prakken, H.: Introducing the logic and law corner. J. Log. Comput. **18**(1) (2008) 1–12
3. Grossi, D., Rotolo, A.: Logic in the law: A concise overview. Logic and Philosophy Today, Studies in Logic **30** (2011) 251–274
4. Renne, B.: A survey of dynamic epistemic logic. Manuscript (July 2008)
5. van Ditmarsch, H., van der Hoek, W., Kooi, B.: Dynamic Epistemic Logic. Springer (2008)
6. Benthem, J.V.: Dynamic logic for belief revision. Journal of Applied Non-Classic Logics **14**(2) (2004) 129–155
7. van Ditmarsch, H.P., van der Hoek, W., Kooi, B.P.: Public announcements and belief expansion. In: Advances in Modal Logic. (2004) 335–346
8. Sano, K., Hatano, R., Tojo, S.: Misconception in legal cases from dynamic logical viewpoints. JURISIN 2012 (2012) 101–113