Classification of Precedents by Modeling Tool for Action and Epistemic State: DEMO

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Abstract. To determine whether the crime is really caused by the defendant, the judge examines the causal relation of each action in the case to an external factor in the Penal Code. In this process, the judgement is greatly influenced by the predictability of results and the awareness about actions. In this paper, we model these predictability or awareness by Dynamic Epistemic Logic (DEL), and thereafter we describe the change of knowledge of the judge by Action Model. For this purpose, we pick up several typical precedents, and classify them from the viewpoints of predictability and awareness. We implement the process of these precedents in the trial on DEMO (Dynamic Epistemic MOdeling) which can specify epistemic models and action models, and we observe the change of the judge's epistemic states during the trial. Based on this observation, we categorize the outputs of DEMO into several patterns.

Keywords: Dynamic epistemic logic · Action model · Model checking · Penal Code

1 Introduction

To determine a criminality specified in the Penal Code, the followings are examined by a judge [15].

1. The defendant's action comes under the external factors defined by the Penal Code (*Actus reus*)[1].
2. There is no justifiable reason to dismiss the illegality[2].
3. There is no justifiable reason to dismiss the responsibility[3].

If these conditions are matched, the criminality is decided. Note that, in this paper, we deal mainly with the process of verifying the correspondence. (We take the position that the external factor includes the intent and the lapse. [17])

[1] The guilty acts or typified criminal acts, sometimes called as the objective element of a crime.

[2] A reason that there is no illegality about the act that illegality is usually estimated.

[3] A reason to deny the responsibility of the act that responsibility is accepted as a general rule.

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In general, as external factos of crime, "Action", "Result" and "Causality" are required. The evaluation of the defendant's action by intent (*Mens rea*)[4] or by lapse[5] is greatly influenced by the awareness about the action by the defendant and the predictability of results. For example, the intent is determined based on the awareness about a fact and the prediction of a result. For lapse, the predictability and the duty to prevent the result are the issue. Of actual crimes, there are so many cases [16] in which a fortuitous event happens between the action by the defendant and the result, or the action based on an uncertain awareness by the defendant causes the criminal result.

It is the commonly acknowledged that each case should be considered separately from other cases, and this attitude makes us difficult to classify the cases systematically. It should be more easy for us to handle the case, if the judge's epistemic states through the trial could be categorized. For example, argumentation frameworks have been studied and applied to judicial reasoning (recent examples are [1,13,20].) and these models can compute diagrams.

On the other hand, Dynamic Logic have been applied to describe belief revision ([3,9]). We have focused on predictability or awareness and need to represent the epistemic states of the judge or the defendant individually. So we try to classify some typical precedents, to represent them by using the DEL (Dynamic Epistemic Logic) [7], because Action Model in DEL can represent the local epistemic states and can update the states by various epistemic actions.

This paper is organized as follows. In Sect. 2, we briefly introduce the DEL and Action Model which are used to describe the precedents later sections. In the following Sect. 3, we define the usage of this language in the context of the judgement of crimes and actually pick up some typical precedents classifying them into 6 cases according to the judgement process. In Sect. 4, these precedents are modeled by using DEL and implemented on DEMO (Dynamic Epistemic MOdeling) software [8] and we observe these outputs and categorize them. Finally, we summarize our contribution.

2 DEL and Action Model

2.1 DEL and Action Model

Knowledge and belief are not static because of the communication between agents. Dynamic Epistemic Logic is an extension of epistemic logic [10] with dynamic operators '[ ]', and $[\pi]\varphi$ is read as "successfully executing program π yields a φ state" [7]. Namely, given a model M and a possible world s,

$$M, s \models [\pi]\varphi$$

iff M is properly changed by the execution of π and as a result φ holds. Public Announcement Logic [18] is an example of DEL where the epistemic action is

[4] A guilty mind or an intention to commit a crime.

[5] A failure to take reasonable care when they act by taking account of the potential harm to other people.

only restricted to public announcement. Action Models [2] are used to describe epistemic actions.

Definition 1 (Action model). Let $\mathcal{L}$ be any logical language for given parameters agents A and atoms P. An $S5$ action m kodel M is a structure $\langle \mathrm{S}, \sim, \mathrm{pre} \rangle$ where S is a domain of action points and for each agent a, $\sim_a$ is an equivalent relation in S, stating that two states are indistinguishable for a. pre: $\mathrm{S} \to \mathcal{L}$ is a preconditions function that assigns a formula in $\mathcal{L}$ to each $s \in S$. A pointed $S5$ action model is a structure (M, s) with s ∈ S

An epistemic state can be changed by an epistemic action, so the new state after updating is described as a pair of an old world with an action that has taken place in that state. The expression (s, s) indicates that action s is executable in the state s.

$$M, s \models \mathrm{pre(s)}$$

The two factual states are indistinguishable, if the following relation exists, where index a indicates for agent a.

$$(s, \mathrm{s}) \sim_a (t, \mathrm{t}) \text{ iff } s \sim_a t \text{ and } \mathrm{s} \sim_a \mathrm{t} \text{ (in S5 action model)}$$

Example 1: Read [7]**.** There are two epistemic states (0/1) where the proposition P is true (p) or false ($\neg p$) respectively and P is true actually. At first Agent a and b didn't know whether the value of P was true or false, so there is a link between 0 and 1 for a and b. This means that they cannot distinguish these states. A letter came to a that told p and a read it and knew that but b couldn't distinguish an action 'p' (a reads a letter which tells p) from an action 'np' (a reads a letter which tells $\neg p$), but b knew that a knew p or $\neg p$. In action model defined as below, this can be interpreted as a relation between these epistemic action points. The new epistemic state after updating by the epistemic action (Read, p) is expressed as the right figure of Fig. 1 where there is no link for agent a between state0 and state1 and the link for agent b remains.

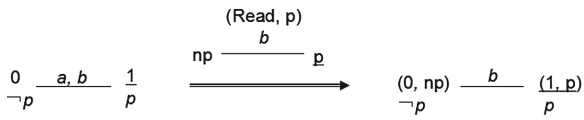

Fig. 1. State transition by an action read

Example 2: MayRead [7]**.** Agent b has left the table for a while, and when back, suspects a of having read the letter. There are two epistemic states (0/1) where the proposition P is true (p) or false ($\neg p$) respectively and P is true actually. In fact, agent a did not read the letter which tells P is true and doesn't know whether p is or is not. Agent b cannot know the agent a read or did not

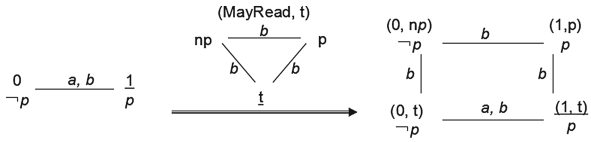

Fig. 2. State transition by an action MayRead

read it so he cannot distinguish three action points, i.e., a reads the letter and it contains p (p), a reads the letter and it contains $\neg p$ ($\neg$p) and a does not read (t), in addition to that he does not know whether p is.

The new epistemic state after updating by the epistemic action (MayRead, t) is expressed as the right figure of Fig. 2 where there is no link for agent a between upper two states which represents the a's action "read the letter", and there is a link for both agent a and b between lower two states which represents that agent a did nothing. The left vertical link represents that agent b cannot distinguish the state where $\neg p$ is and agent a did not read the letter from the state where $\neg p$ is and agent a read the letter containing $\neg p$, so there are two states where $\neg p$ is. Similarly the right vertical link represents that agent b cannot distinguish the state where p is and agent a did not read the letter from the state where p is and agent a read the letter containing p. There are also two p states. There are only four states according to the precondition of each action, i.e., the precondition of action $\neg$p is $\neg p$, p is for p and p or $\neg p$ for t.

Definition 2 (Syntax of Action Model Language). The language of action model logic is the union of the formulas of static epistemic logic and that of epistemic actions.

$$\varphi ::= p \mid \neg\varphi \mid (\varphi \wedge \varphi) \mid K_a\varphi \mid C_B\varphi \mid [\alpha]\varphi$$
$$\alpha ::= (\mathrm{M}, \mathrm{s}) \mid (\alpha \cup \alpha)$$

Definition 3 (Semantics of Action Model). The semantics of Action Model can be defined as follows. The first 5 definitions are the same as the logic of Public Announcement with Common Knowledge.
$M, s \models p$ iff $s \in V_p$
$M, s \models \neg\varphi$ iff $M, s \not\models \varphi$
$M, s \models \varphi \wedge \psi$ iff $M, s \models \varphi$ and $M, s \models \psi$
$M, s \models K_a\varphi$ iff for all $s' \in S : s \sim_a s'$ implies $M, s' \models \varphi$
$M, s \models C_B\varphi$ iff for all $s' \in S : s \sim_B s'$ implies $M, s' \models \varphi$
$M, s \models [\alpha]\varphi$ iff for all $M', s' : (M, s)[\![\alpha]\!](M', s')$ implies $M', s' \models \varphi$
where $[\![\alpha]\!]$ is the subset of domain where the precondition of α is true.
$(M, s)[\![\mathrm{M}, \mathrm{s}]\!](M', s')$ iff $M, s \models \mathrm{pre(s)}$ and $(M', s') = (M \otimes \mathrm{M}, (s, \mathrm{s}))$

The updated model $M'(= M \otimes \mathrm{M})$ is a restricted modal product ($\otimes$) of an epistemic model and an action model, which is defined as an structure $\langle S', \sim', V' \rangle$ where $S' = \{(s, \mathrm{s}) \mid s \in S, \mathrm{s} \in \mathrm{S}$ and $M, s \models pre(s)\}$

2.2 DEMO

DEMO [8] is a modeling tool for Dynamic Epistemic Logic and it allows modeling epistemic updates, display of action models, formula evaluation in epistemic models, so DEMO can be used to check semantic intuitions about what goes on in epistemic update situations.

DEMO is programmed in Haskell [14] and imports three modules, List, Char and DPLL. Here List and Char are standard Haskell modules and used to describe the data structure (model). DPLL is a module for propositional reasoning with the Davis, Putnam, Logemann, Loveland procedure [5,6]. And in it's main file, DEMO defines Action Model and Epistemic state as a pointed model and defines the relation between these points.

It receives an input of model definitions (Episteimc Action and Epistemic State) of individual case and it's updatings. It outputs the updated models or the evaluation of propositional formulas. It can also output the files which corresponds to the dot form [12] to represent the graphical images of the updated models.

3 Classification of Precedents

3.1 Handling of Awareness and Predictability in the Penal Code

External Factors Defined in the Penal Code. In general, external factors are roughly divided into subjective and objective ones [17]. (There are also several opposite theories [21] against this, such that both intent and lapse are regarded as the responsibility and should not be included in the external factors.) The objective factor contains action, result and causality between an action and a result. The subjective factors are comprised of intent and lapse.

Intent in the Penal Code. Intent is "an intention to commit a crime". (The Penal Code Article 38 paragraph 1 [19]). At least, awareness of an objective external factor such as an action, a result and prediction for causality are needed. Further, in general, the probability of occurrence or the admittance of the results by the defendant [4] are taken into account by the judge. As a kind of intent, there is an uncertain intent, for example the willful negligence (*dolus eventualis*)[6] is classified as this type.

Lapse in the Penal Code. The lapse is defined in the Penal Code Article 38 paragraph 1 as "The action without awareness to commit a crime, and it is not punishable. However, if there is a special provision in the code, this shall not be applied to." [19]. The lapse is applied in the case where the defendant did not foresee the result which might have been able to predict. Recently the duty of the defendant to avoid criminal results is more emphasized [11].

[6] The defendant is uncertain about the realization of crime but knowing that crimes may be implemented and he has accepted it.

Causality. A relationship between an action and a result is called causality. In order to affirm the causality, there should be not only a conditional relationship (without that there should not be this) between an action and a result, but also it is required to be regarded reasonable from the experience of the social life of ordinary people. (Legally sufficient cause [21]).

Evaluation Process of Correspondence to External Factors. To determine whether the defendant's action conforms to the external factors, the objective and the subjective factors are examined [17] (Fig. 3).

1. Awareness about the objective facts constituting the offense. At first, the defendant's recognition about the objective external factors such as an action, a result and a causality between them is verified. If the recognition is different from the actual fact, it is considered that a mistake in interpretation of facts [21] has occurred.

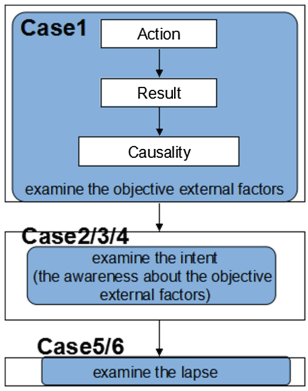

Fig. 3. Evaluation process

2. Awareness about subjective factors. Secondly, the intent (the awareness, the prediction and the possibility of occurrence of the result, etc.) and the lapse (the breach of the duty of predicting the result, the breach of the duty of avoiding the result) are examined.

3.2 Description of the Issues in the Precedents by DEL

From the above, in order to represent a process of deciding a judgement of precedents dealt in this paper, the followings descriptions are needed.

- Description of facts (action, result, causality) constituting an offense
- Description of awareness about the fact and intention
- Description of predictability

So we define issues in the process of a trial as follows.

Action α_a: Fan action point of Action Model by agent a.
Result φ: Fa proposition of a possible world (epistemic state).
Causality $[\alpha]\varphi$: Fa relation between an action and a state in DEL, if there is a causality between an action and a result.
Predictability: The predictability is described as a possibility of link cut between epistemic states. We describe that agent a cannot predicate the state at the state s as a's link between state s and state t.
Possibility of avoidance: This is represented as a link cut between the states of preconditions for the alternative action in Action Model of DEL.

Table 1. Classification of precedents

Precedents	Outline	Classified Cases
Accused of injury resulting in death case (No. A35, 2003)[a]	Four people assaulted the victim repeatedly. He ran away into the highway nearby and was run over by a car and died. The judge admitted a causal relationship between the assault and the death.	**Case1** The intervention of the unexpected action by the victim or the third person.
Accused of indecent document sale (No. A1713, 1953)	The defendant who translated and published the "Lady Chatterley's Lover" without knowing the legal meaning of "obscenity", were charged with selling obscene document	**Case2** (Normative) The recognition of meaning (legal concept)
Accused of murder case (No. RE 517, 1923)[b]	The defendant tried to murder the victim by strangulation and then made an attempt to conceal the crime by burying him in the sand of the coast, but he died because of sand absorption. The judge determined there was an intention because of the causal relationship.	**Case3** The mistake of a process or causality
Dealing with stolen goods case (No. RE238, 1947)[c]	The defendant bought stolen clothes without knowing that they were originally stolen. The judge applied the crime of illegal acquisition of the stolen goods.	**Case4** Willful negligence
Hokkaido University electric scalpel case (No. U219, 1974)	The nurse had mistakenly connected the cable of the scalpel, and the patient's right foot was damaged. The judge ruled professional negligence resulting in bodily injury.	**Case5** (lapse) Predictability (delinquency of duty of care)
The use of HIV contaminated blood in Teikyo University hospital (No. WA1879, 1996)	The doctor used unheated blood and the patient becomes HIV positive. The judge applied the innocence to the doctor.	**Case6** (lapse) a delinquency of duty of avoiding the result

[a]Similar Case: Accused of unlawful arrest and illegal confinement resulting in death case (No. A2901, 2005).The defendant imprisoned the victim in a rear trunk of a passenger car and a car driven by a third person bumped into the rear trunk and the victim died.

[b]Similar Case: Accused of murder and fraud (No. A1625, 2003) The defendant took the consciousness of the victim with chloroform and tried to murder him by drowning. The cause of his death is not clear either chloroform or drowning.

[c]Similar Case: The Stimulant Drug Control Law violations (No. A1038, 1998) The defendant carried stimulant drug without knowing the fact.

Intent: This is represented as an awareness about the prediction, so there is no link for the agent between an actual state and states where the precondition is false.

Lapse: Lapse is described as no intent by the defendant, the predictability and the possibility of avoidance from the view point of an usual person or a judge.

3.3 Classification of Precedents

According to the evaluation process written in the previous section, there are three main points where predictability or awareness is the issue in the judgement. The first point is the awareness of the objective facts which includes the problem of intervention of unexpected actions and a mistake in recognizing causality. The second is the intent of the defendant and the problem of willful negligence occurs at this point. The third is the lapse which includes the problem of predictability and possibility of avoiding results. From precedents often cited [16], some typical examples are listed below and they are classified into 6 cases from the point of view of awareness and predictability (Table 1) and these case are mapped to the three points above (Fig. 3).

4 Implementation and Result

The model checking for these cases is implemented by using DEMO [8]. In this implementation, the accessibility relations are restricted to S5 relation.

Updating the states is executed in two steps. The first step is by the defendant's actions during a crime (or the start of a trial where the judge has no prejudice.) and the second step is by the judge's actions from the start of a trial to the final judgement. In updating, the epistemic actions as follows are used.

message which notifies propositions to particular persons and the others may or may not know whether the message has reached. This corresponds to the situation that a prosecutor gives new evidence and the judge examines this evidence and the others don't know the determination of the judge's mind.

public which is the same as public announcement. This is used to describe the common sense which influence the criminal actions.

For example, (message b p) indicates that the judge knows p but the defendant may or may not know what is going on. (Fig. 4) The product of two states and two action points consists four states after updating, but there are only three states according to the preconditions of each action.

When we define the propositions, we take "p" as the primary (or the external factor) and "$q, r, ...$" as the subsidiary (the extraneous factor).

4.1 Case1: The Intervention of the Unexpected Action

The defendant committed the assault repeatedly. So the victim ran away into the highway nearby, was run over by a car and died. In this case, the defendant is on the crime of inflicting injury and the cause of the victim's death is an issue.

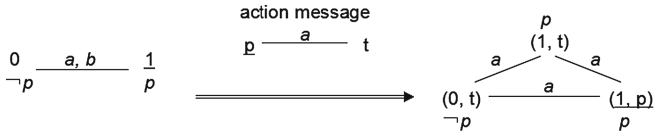

Fig. 4. Update by message

– Proposition p: The victim is injured.
– Proposition q: The victim is driven to the emotional corner.
– Agent a: The defendant (in the following all cases).
– Agent b: The judge (in the following all cases).

We set the proposition p (external factor) as the injury and q (substantial element) as the cause of a successive action. Four epistemic states are set where the valuation depends on these two propositions and it's true/false binary values respectively.

As the crime proceeds, the defendant takes actions. We interprets these non-epistemic actions as corresponding (whose preconditions are equivalent) epistemic actions which are points of Action Model. In this case there are two non-epistemic actions.

– "injure the victim" whose precondition is $\neg p$ (for injuring)
– "run into highway" whose precondition is q (for running into the highway)

It is necessary to update the epistemic states by two corresponding epistemic actions concerning these two non-epistemic actions described above. The defendant can recognize his own action of injuring the victim, so we update the states by the action of sending a message to himself whose precondition is the same as of the precondition of his non-epistemic action "injure". Figure 5 is an image of updating by this action "message a $\neg p$", where the $\neg p$ states (the states agent a believes $\neg p$) are copied for agent b because he cannot distinguish these states. These added states and links are represented as shaded states and doted lines in Fig. 5.

On the other hand, the victim's action "run into the highway" cannot be predicted by the defendant, so no additional information is sent to himself and the links between states where q is true or false($\neg q$) remain unchanged. That is the state at the time of the crime has happened. A part of the program code is as follows.

```
intervent  = initE[P 0, Q 0] --defines initial epistemic states
initInt = upds intervent [message a (Neg p)] --updating
```

Then we updates this epistemic state by the action of the judge. This process is regarded as the proceeding of the trial at the court. The actions for the final state (Fig. 7) are as follows.

message b (**Neg** p) The judge knows the defendant injured the victim. The result of updating by this action is shown in Fig. 6. The shaded states and doted lines describe the added ones by this updating.

message b (**Disj** $[p, q]$) The judge is informed that the victim was cornered by the defendant's action. (If there is a causal relation, the precondition of the action (assault) implies the result state under the occurrence of this defendant's action. And an implication can be represented by the disjunction. $\neg p \rightarrow q \Leftrightarrow p \vee q$ In the following cases, an implication is translated to a disjunction.)

message b (**K** a (**Neg** p)) The judge is informed that the defendant knows he injured the victim.

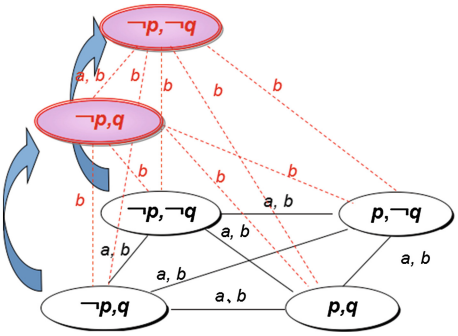

Fig. 5. Case1 updating by message a $\neg p$

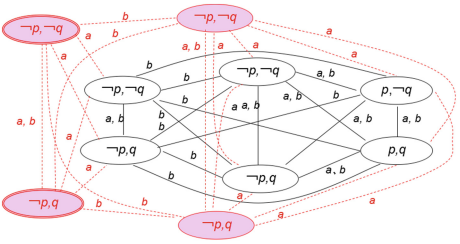

Fig. 6. Case1 updating by message b $\neg p$

4.2 Case2: Recognition of the Meaning (Normative Case)

The defendant who translated and published the novel "Lady Chatterley's Lover" were charged with obscene document sale.
The propositions and the states are as follows.

- Proposition p: The novel is obscene (legal meaning). q: The public order is violated.
- Four initial states (0..3), 0:$\neg p, \neg q$, 1:$p, \neg q$, 2:$\neg p, q$, 3:p, q:

The defendant's actions which update the epistemic states through the crime

public (**Disj** [**Neg** q, p]) "It is known that the violation of public order is a crime."

message a q "The defendant knows publishing this novel violates the public order."

The judge's actions which update the epistemic states during the trial

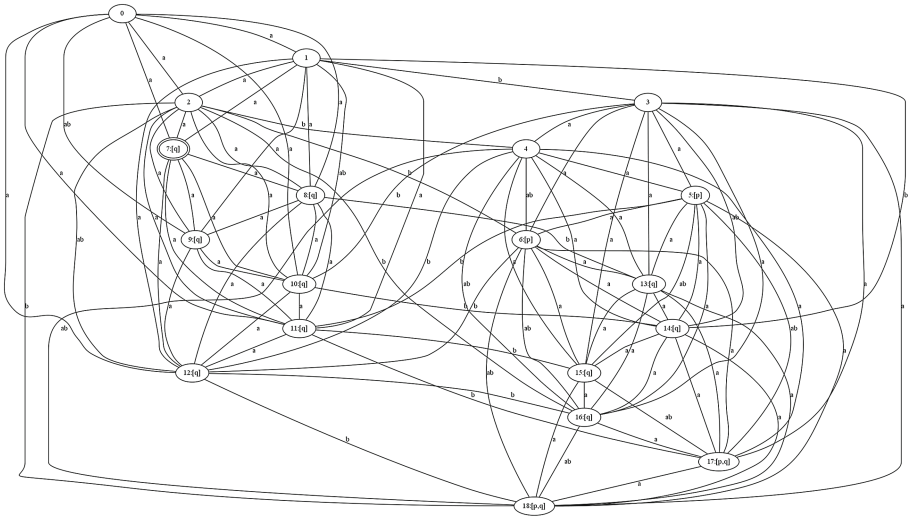

Fig. 7. Case1 the final state after the trial

message b p "The judge is informed that the novel is obscene in the legal meaning."
message b (**K** a q) "The judge is informed that the defendant knows the violation of the public order."

After these updates, the judge knows that the defendant knows the illegality and he can inflict the punishment based on the defendant's intention. This can be checked in DEMO as follows.

```
*DEMO> isTrue (upds initMeaning [message b p, message b (K a q)])
(K b (K a p))
True
```

The final state becomes like Fig. 8. The shaded circles (states) indicates the actual state and states which can be reached from the actual state by the agents' links. These are examined for classification later (in Subsect. 4.7).

4.3 Case3: Mistake of the Causality

The defendant tried to murder the victim by strangulation and then made an attempt to conceal the crime by burying him in the sand of the coast, but he did not die at that time and died because of sand absorption.

The propositions and the states are as follows.

– Proposition p: The victim is dead. q: The victim survives. the defendant's strangulation.

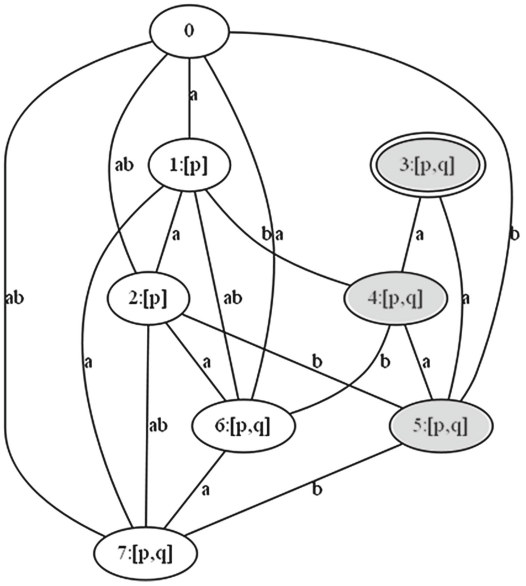

Fig. 8. Case2 the final state after the trial

The defendant's actions which update the epistemic states through the crime

message a (**Neg** p) "The defendant is conscious about his own action (strangulation)." (But the defendant does not know the victim survives.)

The judge's actions which update the epistemic states during the trial

message b (**Neg** p) "The judge knows the defendant strangulated the victim."
message b (**Disj** $[p, q]$) "The judge is informed that the concealment is a part of the process of strangulation."
message b (**K** a (**Neg** p)) "The judge is informed that the defendant knows he strangulated the victim."

The final state is the same as Case1.

4.4 Case4: The Willful Negligence

The defendant bought stolen clothes without knowing that they were originally stolen. He is accused of paid acquisition of stolen goods.

The propositions and the states are as follows.

- Proposition p: The goods are stolen. q: The probability of being stolen is high.
- State four states (0..3) 0:$\neg p, \neg q$, 1:$p, \neg q$, 2:$\neg p, q$, 3:p, q Agent a, b can not distinguish these states.

The defendant's actions which update the epistemic states through the crime

public (**Disj** [**Neg** q, p]) "It is known that the probability is high then the goods are perhaps stolen."
message a q "The defendant is informed that the probability of being stolen is high."

The judge's actions which update the epistemic states during the trial

message b p "The judge is informed that the goods are stolen."
message b (**K** a q) "The judge is informed that the defendant knows the probability is high."

The result is the same as case2. After these updates, the judge knows that the defendant knows the illegality, which deserves a punishment for the defendant's intention. This can be checked by DEMO, too.

```
*DEMO> isTrue (upds initWilneg [message b p, message b (K a q)])
(K b (K a p))
True
```

4.5 Case5: The Delinquency of Duty of Care

The doctor and the nurse made a mistake of connecting the cable of the scalpel incorrectly, and the patient's right foot below knee was damaged and resulted in an amputation. The propositions and the states are as follows.

- Proposition p: The patient is injured. q: The wrong connection highly tends to result in injury. r: The cables are connected wrongly.
- State eight states (0..7): Respectively binary values of P, Q, R.

The defendant's actions which update the epistemic states through the crime

public (**Disj** [**Neg** q, **Neg** r, p]) "It is common sense that if the cable is connected wrongly and the wrong connection tends to result in injury, then the patient is damaged."

The judge's actions which update the epistemic states during the trial.

message b p "The judge knows the patient is injured."
message b q "The judge is informed that the probability is high."
message b r "The judge knows the cable is connected wrongly."

4.6 Case6: The Delinquency of Duty of Avoidance

The doctor used an unheated blood and the patient becomes HIV positive. The doctor is innocent.

The propositions and the states are as follows.

- Proposition p: The medicine is infected with HIV. q: The probability of infection with HIV is high. r: Cryoprecipitate is better than unheated blood for the patient.
- State eight states (0..7), binary values for P, Q R respectively.

The defendant's actions which update the epistemic states through the crime

public (**Disj** [**Neg** q, r]) "It is common sense that if the probability is high, the doctor should give the patient cryoprecipitateis."
message a (**Neg** q) "The defendant is informed that the probability of infection isn't high."
message a (**Neg** (**Neg** r)) "The defendant doesn't know it isn't better and easy to give cryoprecipitate than unheated blood." (The opposite of the precedent, because the defendant become innocent in the precedent.)

The judge's actions which update the epistemic states during the trial

message b p "The judge knows the patient is infected by HIV."
message b (**Neg** q) "The judge knows the probability isn't high."
message b (**Neg** r) "The judge is informed that it isn't better and easy to give cryoprecipitate than unheated blood."

The final state after the trial. Model is consists of 32 states and the actual state is one where the defendant cannot distinguish p from $\neg p$ and r from $\neg r$. (he has the possibility of taking the other action.). The judge can distinguish p, q, r.

4.7 Patterns of the Final States

The final states of six cases after updating can be categorized into three graphical patterns according to the actual state and the links from this state.

- Intentional case (Case1,2,3,4)

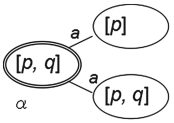

Fig. 9.

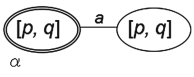

Fig. 10.

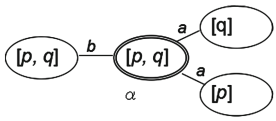

Fig. 11.

  - The agent b can distinguish an actual world and there is no link between the value of primary proposition p and $\neg p$ for the agent a. For the subsidiary proposition q, there is a link between states where q or $\neg q$ for agent a. (Case1,3) (Fig. 9)
  - The agent b can distinguish an actual world and for the agent a, there is no link between the states where both values of main proposition p and the subsidiary proposition q respectively. (Case2,4) (Fig. 10)
- Negligent (Lapse) case (Case5,6)
  - The agent b can access to worlds where the primary proposition is unique. But p is not decided for the agent a (the defendant) from $b's$ states. The subsidiary propositions q/r are not decided for a too. (Case5,6) (Fig. 11)

4.8 Legal Interpretation of Patterns

For the cases where the crime is committed by the defendant intentionally, the final state can be summarized to the first two patterns mentioned in the previous subsection where p can be decided (distinguishable from the $\neg p$ states).

- The judge knows the defendant's knowledge about his intention (p)
- The judge can distinguish an actual world.
- The defendant can distinguish (knows) the intention about p.

The first pattern is concerning the judge's awareness about facts (Case1,3) where the judge can know the defendant's intention about p directly from him and the subsidiary elements are examined by the judge.

The second is concerning the defendant's awareness about the meaning of his actions (Case2,4) where the judge can find the defendant's intention based on the common sense.

On the other hand, the cases where the crime is committed by the defendant's lapse, the final state can be summarized to the third pattern in which the judge knows that the defendant cannot distinguish p from $\neg p$. (Both worlds (p or $\neg p$) are reachable by the defendant's relation.) The subsidiary element (q or r) is not distinguishable for the defendant too. But the judge thinks p is distinguishable from $\neg p$ based on q or r(Case5,6).

5 Conclusion and Further Directions

5.1 Conclusion

We have examined the process of making judgement according to the Penal Code and found that awareness and predictability are the main factors to decide the correspondence of the defendant's action to the external factors. We picked up the typical six cases and verified these claims in Action Model.

In Action Model the predictability and the awareness in the precedents can be regarded as the link between epistemic states. If the states or the action is predictable from a state, there is no link between the two states.

These process of precedents can be reproduced by using DEMO. In this model, the epistemic states are updated by epistemic actions which simulates the change of the judge's epistemic state. Finally these result states after updating can be categorized into three patterns focusing on the actual state and it's links of the defendant and the judge from this actual state. For some typical and well cited precedents, the output of DEMO can be interpreted by adopting these patterns mentioned previously and these judgements can be checked.

5.2 Further Directions

To describe lapse or willful negligence, it is needed to employ the probability regarding to the predictability, and in this paper the propositions about probability are temporarily used. But the border of intent and lapse should be continuous. To describe that, the link between states should be directional and states are prioritized. And related to this, a model would require the defeasible reasoning.

In implementing these precedents, by the number of the states and the points of actions, the computational complexity increased rapidly, as we can find in Fig. 7. We can easily guess that if we deal with actual cases, as the number of factors is much larger, the link between epistemic states would be too complicated to be visible. Some of those actual cases, however, may be the combination of entangled predictability and awareness.Thus, if we could unravel this entanglement by human hand, we can reduce the complexity of actual cases to the tractable size and thus our classification may become feasible. Now, our contribution to real cases is summarized as follows; we may reduce the complication of an actual case to a tractable size in finding similarity to typical fundamental cases, or in other words, our results of six cases may serve as target analyses from the viewpoint of actual cases.

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