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Abstract

Guilty or not guilty: the decision in court often concerns if the accused could predict the outcome via an inevitable causality from his/her initiative action. Of course, if the accused had an intention to cause the crime he or she should be punished, however, in some cases, he or she claims that the resultant crime could not be predicted. The penal code requires the prosecutor to investigate if there was the motivation or intention with the accused; even though it is negative the judge needs to certify if the causality was not recognized, that is, the result was not predictable by the accused.

In this study, we try to formalize if there could be the predictability. We analyze the preceding cases, and model the knowledge state of the judge, the prosecutor, and the accused in terms of Kripke semantics of modal logic, where the knowledge of each agent is represented by the accessibility to the various possible worlds in which the truth values for the constituent propositions may be different.

At the beginning of this study, we have formalized the reasoning process of judgment by using an action model in dynamic epistemic logic (DEL) and have attempted to describe the precedents. DEL can describe the knowledge states of each agent respectively and an action model can represent the change of these states. By using these logical tools, we have represented the final knowledge states of the defendant and the prosecutor which are updated by an epistemic action based on their testimonies at the court. However, the prediction in legal cases depends not only on the states of knowledge but also on the finite attention by the agent. For example, there are some types of crime which is caused by an indeterministic intention like "*dolus eventualis*". We have found that the simple DEL with an action model is not suitable for reasoning the precedent of a crime.

As the second step in this study, we have employed DEL with awareness for multi-agent to represent the prediction about the result and have modeled the typical criminal precedents. For example, in an airport, we can interpret the announcement about the flight which we take or wait for. However if there is no relationship between the announcement and our flight, we are not conscious of it. We think the awareness can explain the limited reasoning which leads to a crime, and can explain the degree or the strength of an intention or a prediction about a result. We have proposed a revised semantics of an action model with awareness and defined the concrete action models like "consider", "implicitly observe", "explicitly see" or "infer" to reproduce the agent's considering or inference process. The revised language which includes these action models can describe the inference process of a new information within an awareness domain in an agent and this cannot be done by the existing semantics. We have also showed its soundness and completeness.

In addition to the formalization, we have implemented an extension program of modeling tool DEMO to include the awareness and the extended action model with an awareness (we call it $\texttt{DEMO}^{+\mathcal{A}}$). We have also presented GUI in this program to calculate the updated epistemic model easily and to classify precedents according to the degree of prediction. We have released this modeling tool in our site to all researchers who are interested in this topic.

Then we have analyzed the final epistemic models with an awareness of some precedents of the criminal law for the defendant and the prosecutor by using this newly developed tool and estimate them. We have modeled 7 cases which represent the typical interpretation like "*dolus eventualis*", "negligence" or "innocence" and so on. Finally we have examined these calculated final epistemic models of the precedents and have proposed the classification criteria of the precedents according to the degree of the the predictability about the result of a criminal action, which can be described by the awareness about the cause and the causal relation. We have compared these results with the actual interpretations of the precedents and have found that the awareness can explain well the one aspect of the precedents and this can classify the precedents according to this aspect.

Keyword: Dynamic Epistemic Logic; Awareness; Action model; Multi-agent; Legal reasoning; Modeling tool