Advance Journal of Food Science and Technology 9(3): 215-219, 2015
DOI: 10.19026/ajfst.9.1997
ISSN: 2042-4868; e-ISSN: 2042-4876

Submitted: February 26, 2015 Accepted: March 20, 2015 Published: August 10, 2015

Research Article

Propagation Modeling of Food Safety Crisis Information Update Based on the Multi-agent System

[1]Meihong Wu, [1]Jingfei Yang and [2]Zhiling Hong
[1]Department of Computer Science,
[2]Software School, Xiamen University, Xiamen 361005, P.R. China

Abstract: This study propose a new multi-agent system frame based on epistemic default complex adaptive theory and use the agent based simulation and modeling the information updating process to study food safety crisis information dissemination. Then, we explore interaction effect between each agent in food safety crisis information dissemination at the current environment and mostly reveals how the government agent, food company agent and network media agent influence users confidence in food safety. The information updating process give a description on how to guide a normal spread of food safety crisis in public opinion in the current environment and how to enhance the confidence of food quality and safety of the average users.

Keywords: Belief set, extension modeling, food safety crisis, information dissemination, multi-agent system

INTRODUCTION

The issues of food safety have been at the forefront of societal concerns in recent years and indications exist that challenges to food safety will continue in future. For food businesses, to avoid food safety problems lies in the business of corporate legal regulatory compliance and usually focus on establishing a corporate relation. Fake food crisis in the enterprise network should be controlled to take appropriate means to control the unnecessary loss. Since customers call for food quality, integrity and safety, retailers will add further safety issues to their supplier requirements and governments are imposing new legislation that enforces traceability of food products during all stages of production, processing and distribution (Wilkinson and Young, 2003).

Food safety problem is the most direct kind of public crisis that affecting public life and health. As customers call for food quality, integrity and safety; retailers are adding further safety issues to their supplier requirements (Herrera-Viedma *et al*., 2005) and governments are imposing new legislation that enforces traceability of food products during all stages of production, processing and distribution (Steinle and Schiele, 2002). The food industry has implemented information systems to track food safety crisis information throughout the whole process while at the same time making information about the food safety crisis information transparent at all levels of information chains.

It was classified that multi-agent system allows tracking information through the production chain from harvest through transport, storage, processing, distribution and sales, then afterwards food security and safety information control (Coombs, 1999). Current environment traceability refers to the tracking of batches internally in one of the steps in the chain, for example, in the production process or in the food safety problem dissemination. Nowadays a lot of studies have dealt with traceability from the viewpoint of technology development and information system design (Maldonado *et al*., 2005; Hubbard, 2000; O'Sullivan and Haklay, 2000). However, how to deal with the food security crisis and food safety problem is still very difficult (McMeekin *et al*., 2006). Since the food safety problem is in the widest scope affecting public health, it is urgent to introduce a cognitive system that can depict food safety crisis information transmission (Moore, 2004).

The present study proposed a multi-agent system that the food regulatory agents can predict the issue of food safety and curb the occurrence of food safety issues to some extent and in the meantime the food security crisis through each agent in the information dissemination behavior of communication (Robertson, 2003).

In the process of food safety crisis information transmission, include the government regulators agents, food enterprises agents, news media agents and internet user agents. There is clear complex interaction between agents and the current environment. And the agent has belief set including exchange of knowledge and knowledge updating under the premise that can make their own judgment and take corresponding actions.

Since many complex systems, arise from the interaction of many autonomous agents, the way to

Corresponding Author: Zhiling Hong, Software School, Xiamen University, Xiamen 361005, P.R. China

approach emergent properties is to look for the simplest extension of the individual agents and how they interact. The system is enabled to refine agent behavior based on the large food information resources. Moreover, default rules simplify knowledge representation instead of describing all possibilities one can construct rules and exceptions. It allows representation of incomplete data and reasoning with it (Tompkin, 2001). This study describes a methodology for bringing agent based modeling to within reach of organizational strategists and executives with each kind of knowledge.

In this study, the extension is used to describe the agent's belief set and the knowledge propagation between a single agent and other agents in the multi-agent system environment, therefore add the new updating state to its own belief set.

A major effort is to devise models of food safety crisis information transmission wherein a knowledge base, representing an agent's view of its operational environment (Robertson, 2003). In this study focus on the problem that change in the world contradicts previous knowledge and then figure out how to modify the knowledge to cope with that change.

A major effort is to devise models of food safety crisis information transmission wherein a knowledge base, representing an agent's view of its operational environment. In this study focus on the problem that the change in the current environment contradicts with previous knowledge and then figure out how to modify the knowledge to cope with that information propagation.

MATERIALS AND METHODS

The multi-agent system framework: In this section a multi-agent system for the food safety crisis propagation model is proposed. The system is based on non-monotonic default reasoning, which allows agents to behave flexibly and efficiently. For food businesses, to avoid food safety problems lies in the business of corporate legal compliance and usually pay attention to establish a corporate image. In the following, the framework for agents reasoning and communication is proposed.

Definition 1: The multi-agent system frame $\langle \Sigma, \Delta_1, ..., \Delta_n \rangle$ consists of a collection of autonomous agents who can interact and collaborate among each other through communication, where $\sum$ represents n agents, that is $\Sigma = \{1, ..., n\}$ and let Δ_i be a set of food safety crisis information transmission theory, $\Delta_i = \langle D_i, W_i \rangle$ represents the i^{th} $(1 \le i \le n)$ agent theory including government regulators agents, food enterprises agents, news media agents and internet user agents and so on.

The agent operates within a chain of command subject to security restrictions and there is linear order in agents' knowledge. The extension E_i of $\Delta_i = \langle D_i, W_i \rangle$ may be regarded as the belief set about the world of i^{th} $(1 \le i \le n)$ agent. It also contains the information that had taken effect but had not been suspected when we identify the belief.

Definition 2: Let formula φ be the new food safety knowledge of extension E of food safety crisis information theory $\Delta = \langle D, W \rangle$ on F, where F is the supporting set of E, if $\varphi \notin E$, $\neg\varphi \notin E$ and $F \cup \{\varphi\}$ is consistent.

Definition 3: Let formula $K\varphi$ meet with the knowledge conflict in the extension E of default theory $\Delta = \langle D, W \rangle$, iff $K\neg\varphi \in E$, $K\varphi \in E$ and there exist a *Kripke* model M such that $M \models K\neg\varphi$.

Definition 4: Let formula φ be the new food safety crisis knowledge in the extension E of default theory Δ $\langle D, W \rangle$ on F, iff $\varphi \notin E$ and $\neg K\varphi \wedge \neg K\neg\varphi \in E$.

Definition 5: Let E be the extension of Δ on F, then the definition of default set $G(\Delta)$ of E in Δ is given as follows:

$$G(\Delta) = \{K\alpha : A\beta / B\gamma \in D | K\alpha \in E\} \tag{1}$$

Definition 6: Let $K_j\varphi$ be the knowledge that the agent i transfers to j. According to axiom L_{K_2}, we have $K_i K_j \varphi \to K_i \varphi$, that is the agent i obtains knowledge $K_i\varphi$.

As noted above, these definitions provide an appropriate characterization of the agents' current state in the multi-agent system.

In the following we solve the extension sets when the knowledge sets receiving from other Agents is the new food safety information or when the knowledge is the fake food crisis information respectively.

Dynamic acquisition for the food safety information propagation: In the framework proposed above, it can be seen that if there are current epistemic knowledge states, it is easy to build an information acquisition system. The difficulties mainly are reflected in the integration and complementary of multiple extensions. In other words, we must integrate epistemic system from different new knowledge such as new food safety information.

Corollary 1: If φ is the new food safety knowledge of extension E on F due to the current epistemic environment $\Delta = \langle D, W \rangle$, then φ is the new knowledge of W.

Proof: Assume to the contrary aspect, supposing φ is not the new knowledge of the current state W, then we have $W \to \varphi$ or $W \to \neg\varphi$. According to the definition of extension, either $\varphi \in E$ or $\neg\varphi \in E$, which contradicts the fact that φ is the new knowledge of extension E. Therefore φ is the new knowledge of *W*.

Theorem 1: Let E be the extension of $\Delta = \langle D_j, W_j \rangle$ on F and $K_j\varphi$ be the new food safety knowledge that Agent *j* receives, then the extension E' on F' must also be the extension of $\Delta' = \langle D_j, E_{k_j} \cup \{\varphi\} \rangle$ as well as that of $\Delta'' = \langle D_j, W_j \cup \{\varphi\} \rangle$.

Proof: Suppose $E''_0 = W \cup \{\varphi\}$, for $j \ge 0$, we have the following formula according to the definition:

$$E''_{j+1} = Th(E''_j) \cup \{ B_j\gamma \mid K_j\alpha : A_j\beta / B_j\gamma \in D_j \} \tag{2}$$

$$F''_{j+1} = F''_j \cup \{ A_j\beta, B_j\gamma \mid K_j\alpha : A_j\beta / B_j\gamma \in D_j \} \tag{3}$$

We prove $E' = \bigcup_{j=0}^{\infty} E''_j$, $F' = \bigcup_{j=0}^{\infty} F''_j$ in two different conditions:

First, we prove $E' \supseteq \bigcup_{j=0}^{\infty} E''_j$, $F' = \bigcup_{j=0}^{\infty} F''_j$ as follows:

- Obviously there is $E''_0 = W \cup \{\varphi\} \subseteq E_K \cup \{\varphi\} = E'_0$, $F''_0 = C = F'_0$
- Supposing that $E''_j \subseteq E'_j, F''_j = F'_j$ and $\theta \in E''_{j+1}$, in order to prove $E''_{j+1} \subseteq E'_{j+1}$, we only need to verify $\theta \in E'_{j+1}$

If $\theta \in Th(E''_j)$, as $E''_j \subseteq E'_j$, so $\theta \in Th(E'_j) \subseteq E'_{j+1}$, $F'_{j+1} = F'_{j+1} = F'_j$.

If $K_j\alpha : A_j\beta / B_j\gamma \in D_j$, where $K_j\alpha \in E''_j$ and $\neg(A_j\beta / B_j\gamma) \notin (E' \cup F')$, then we have $\theta = B_j\gamma$, as $E''_j \subseteq E'_j$ such that $K_j\alpha \in E'_j$ and $\neg(A_j\beta \wedge B_j\gamma) \notin (E' \cup F')$, so $\theta \in E'_{j+1}$, $F''_j \cup \{A_j\beta, B_j\gamma\} = F'_{j+1}$.

Therefore $E' \supseteq \bigcup_{j=0}^{\infty} E''_j, F' = \bigcup_{j=0}^{\infty} F''_j$ holds.

Second, we are to prove $E' \subseteq \bigcup_{j=0}^{\infty} E''_j$, $F' = \bigcup_{j=0}^{\infty} F''_j$ in the other condition.

At first we have to prove $E \subseteq \bigcup_{j=0}^{\infty} E''_j$, $F' \subseteq \bigcup_{j=0}^{\infty} F''_j$:

- Obviously we have $E_0 = W \subseteq W \cup \{\varphi\} = E''_0$, $F''_0 = C = F_0$.
- Supposing $E_j \subseteq E''_j, F_j \subseteq F''_j$ and $\theta \in E_{j+1}$, in order to prove $E_{j+1} \subseteq E''_{j+1}$, we only need to prove that $\theta \in E''_{j+1}$.

If $\theta \in Th(E_j)$, as $E_j \subseteq E''_j$, so $\theta \in Th(E_j) \subseteq E''_{j+1}$.

If $K_j\alpha : A_j\beta / B_j\gamma \in D_j$, where $K_j\alpha \in E_j$ and $\neg(A_j\beta \wedge B_j\gamma) \notin (E \cup F)$, then $\theta = B_j\gamma$, $\{A_j\beta, B_j\gamma\} \subseteq F$ and by $E_j \subseteq E''_j$, get $K_j\alpha \in E''_j$.

Because of $E_j \subseteq E''_j$ and $A_j\beta \wedge B_j\gamma \in E \subseteq E'$ that E' is inconsistent and contradictory if $\neg(A_j\beta \wedge B_j\gamma) \in E'$.

Therefore we have $\neg(A_j\beta \wedge B_j\gamma) \notin E'$ and $K_j\alpha \in E_j \subseteq E''_j$, it finally get $\theta \in E''_{j+1}$. And by Corollary, $E \subseteq E'$, $F \subseteq F'$ and $E' \cup F'$ is consistent, then $E'_j \cup F'_j \cup \{A_j\beta, B_j\gamma\}$, thus $\theta \in E''_{j+1}$ and $F_{j+1} = F_j \cup \{A_j\beta, B_j\gamma\} \subseteq F''_j \cup \{A_j\beta, B_j\gamma\} = F''_{j+1}$.

According to the above proof, $E \subseteq \bigcup_{j=0}^{\infty} E''_j$ holds.

Next we prove $E' \subseteq \bigcup_{j=0}^{\infty} E''_j$:

- As $E \subseteq \bigcup_{j=0}^{\infty} E''_j$, there exist some agent and one integer $p > 0$ such that $E \subseteq E''_p$, by $E''_0 = W \cup \{\varphi\}$, we have $E'_0 = E_K \cup \{\varphi\} \subseteq E''_p \cup \{\varphi\} = E''_p$
- Supposing $E'_j \subseteq E''_{j+p}$ and $\theta \in E'_{j+p+1}$, in order to prove $E'_{j+1} \subseteq E''_{j+p+1}$, we only need to verify $\theta \in E''_{j+p+1}$.

If $\theta \in Th(E'_j)$, As $E'_j \subseteq E''_{j+p}$, then $\theta \in Th(E''_{j+p})$, so $\theta \in E''_{j+p+1}$.

If $K_j\alpha : A_j\beta / B_j\gamma \in D_j$, where $K_j\alpha \in E'_j$ and $\neg(A_j\beta \wedge B_j\gamma) \notin (E' \cup F')$, since $E'_j \subseteq E''_{j+p}$, then $K_j\alpha \in E''_{j+p}$ and $\neg(A_i\beta \wedge B_i\gamma) \notin (E' \cup F')$, therefore $\theta \in E''_{j+p+1}$.

So for any $j \ge 0$, there exists some integer $p > 0$, such that $E'_j \subseteq E''_{j+p}$.

Therefore $E' = \bigcup_{j=0}^{\infty} E''_j$ holds and E' is the extension of $\Delta'' = \langle D_i, W_i \cup \{\varphi\} \rangle$.

RESULTS AND DISCUSSION

Fake food crisis in the enterprise network should be controlled to take appropriate means to curb the unnecessary loss.

The multi-agent system face the problem of non-monotonically updating agent's knowledge database to incorporate knowledge derived from different agents. When encountering the fake food crisis, the problem becomes that how to deal with the induced information could be contradictory.

In the *Kripke* model *M*, the formula $\Pi_{M(\neg\varphi)}$ which is consistent to ¬ φ in the extension corresponding to Agent is computed as follows:

$\Pi_{M(\neg\varphi)} = \{\varphi_i \mid \varphi_i \in W, M \models \varphi_i, M \models \neg\varphi\}$, $\bar{M}$ is ideal if and only if there does not exist another *Kripke* model M', such that $\Pi_{\bar{M}(\neg\varphi)} \subset \Pi_{M'(\neg\varphi)}$, that is $\Pi_{\bar{M}(\varphi)}$ is maximal.

Then we have the following concepts and theorems when acquiring the cognitive default set $P_i = \bigcup_{j=0}^{\infty} D_j$ concerning $W_i \cup \{\neg\varphi\}$.

Corollary 2: Let E_i be the extension of $\Delta_i = \langle D_i, W_i \rangle$ and $B_i\varphi \in E_i$ meet the conflict of knowledge $K\neg\varphi$, E_i' be the extension of $\Delta_i' = \langle G(\Delta_i), W \cup \{\neg\varphi\} \rangle$ and E_i'' be the extension of $\Delta_i'' = \langle G(\Delta_i), W \cup \{\neg\varphi\} \rangle$ on F_i'', then we will get $E_i' = E_i''$, $F_i' = F_i''$ and $G(\Delta_i') = G(\Delta_i'') = P_i$, where P_i is the applicable default set of Δ_i'.

Theorem 2: Let E_i be the extension of $\Delta_i = \langle D_i, W_i \rangle$ on F_i and $B_i\varphi \in E_i$ meet the fake food crisis information in W_i. If S_i is the extension of $\langle G(\Delta_i), W_i \cup \{K\neg\varphi\} \rangle$ on U_i, then there exist an extension E_i' of $\Delta_i' = \langle D_i, S_K \cup \{\neg\varphi\} \rangle$ on F_i', such that $P_i \subseteq G(\Delta_i')$ and $S_i \subseteq E_i', U_i \subseteq F_i'$.

Theorem 3: Let E_i be the extension of $\Delta_i = \langle D_i, W_i \rangle$ on F_i and $B_i\varphi \in E_i$ meet the fake food crisis information $\neg\varphi$, if S_i is the extension of $\langle G(\Delta_i), W_i \cup \{\neg\varphi\} \rangle$ on U_i and E_i' is the extension of $\Delta_i'' = \langle D_i, S_k \cup \{\neg\varphi\} \rangle$ on F', then E_i' must be the extension of $\Delta_i' = \langle D_i, W_i \cup \{\neg\varphi\} \rangle$ on F', where Υ_k is the original fact sets of S, that is $\Upsilon_k = \{K\alpha \mid K\alpha \in \Upsilon_i\}$.

The theorem shows that we can find one theorem that only considers the maximal cognitive default rule set P in $G(\Delta_i)$ on $W \cup \{K\neg\varphi\}$ and gain the extension S_i of default theory $\langle G(\Delta_i), W_i \cup \{\neg\varphi\} \rangle$ on U_i, After the acquisition of the extension F_i of $\langle G(\Delta_i), W \cup \{\neg\varphi\} \rangle$, we can get the extension E_i' of $\langle D_i, S_k \cup \{K\neg\varphi\} \rangle$ by the fix point extension theorem and then $\acute{E_\iota}$ must be the extension of $\langle D_i, W \cup \{K\neg\varphi\} \rangle$ on $\acute{F_\iota}$. However, the reverse is not necessarily the case because there is possibility of being a new cognitive system.

CONCLUSION

The food safety problem is the hotspots of study nowadays. Food safety problem is the most direct kind of public crisis that affecting public life and health.

This study brings a multi-agent model which can flexibly handle the food safety crisis problem, in which the information of an agent can be shared with others. Relative to the traditional numerical analysis method, multi-agent is an advanced computing. It not only provides modeling methods, but also gives solution of the problem. In this study, in order to cope with food safety crisis information transmission and the changing current environment, agents use default rules and default reasoning to communicate and transfer information.

This propagation model based on complex adaptive epistemic default theory and then using default and concise knowledge received from other agents to simulate the food safety crisis information dissemination in the current environment.

Furthermore, dynamic characteristics about the knowledge update for multi-agent system are being built to describe its non-monotonicity. The comprehensive and integrated approach based on agent is important future research directions in food safety problem propagation system.

ACKNOWLEDGMENT

The authors wish to thank the helpful comments and suggestions from my teachers and colleagues in speech and hearing research center. This study is supported by the 2014 Program for New Century Excellent Talents in Fujian Province University.

REFERENCES

Coombs, W.T., 1999. Ongoing Crisis Communication: Planning, Managing and Responding. Sage Publication Inc., Thousand Oaks, CA.

Herrera-Viedma, E, L. Martinez, F. Mata and F. Chiclana, 2005. A consensus support system model for group decision-making problems with multigranular linguistic preference relations [J]. IEEE T. Fuzzy Syst., 13(5): 644-658.

Hubbard, G., 2000. Strategic Management: Thinking, Analysis and Action. Pearson Education Pty Ltd., Frenchs Forest, Australia.

Maldonado, E.S., S.J. Henson, J.A. Caswell, L.A. Leos, P.A. Martinez, G. Aranda and J.A. Cadena, 2005. Cost-benefit analysis of HACCP implementation in the Mexican meat industry. Food Control, 16: 375-381.

McMeekin, T.A., J. Baranyi, J. Bowman, P. Dalgaard, M. Kirk, T. Ross, S. Schmid and M.H. Zwietering, 2006. Information systems in food safety management. Int. J. Food Microbiol., 112: 181-194.

Moore, S., 2004. Disaster's future: The prospects for corporate crisis management and communication. Bus. Horizons, 1: 29-36.

O'Sullivan, D. and M. Haklay, 2000. Agent-based models and individualism: Is the world agent-based? Environ. Plann. A, 32(8): 1409-1425.

Robertson, D.A., 2003. Agent-based models of a banking network as an example of a turbulent environment: The deliberate vs emergent strategy debate revisited. Emergence, 5(2): 56-71.

Steinle, C. and H. Schiele, 2002. When do industries cluster?: A proposal on how to assess an industry's propensity to concentrate at a single region or nation. Res. Policy, 31: 849-858.

Tompkin, R.B., 2001. Interaction between government and industry food safety activities. Food Control, 12: 203-207.

Wilkinson, I. and L. Young, 2003. A view form the edge. Market. Theor., 3(1): 179-195.