Journal of Engineering and Applied Sciences 13 (Special Issue 11): 8852-8856, 2018
ISSN: 1816-949X

Bystander Effect Model: Dynamic Simulation Environment in a Pedestrian Setting

Mohd Rashdan Abdul Kadir and Ali Selamat
Faculty of Computing, Universiti Teknologi Malaysia, 81310 Skudai,
Johor, Malaysia

Abstract: Agent Based Social Simulation (ABSS) is increasingly becoming an alternative method to predict social behavior without having to conduct social experiments which may be costly or too large a scope of study. The bystander effect is a social behavior where the likely hood of getting help from passersby's decreases with increasing number of observers. The objective of this study is to replicate the bystander effect model in a dynamic simulation environment using spatial and temporal supported simulation platform, modelled on a plausible scenario using a pedestrian movement setting as the simulation environment. The study aims to specify the limitations of the current referenced agent model regarding result inconsistency in relation to the BDI framework processes and proposes a redesigned model as well as cite future research potential for the modelled case study.

Key words: Bystander effect, agent based social simulation, agent simulation, agent modelling, BDI framework, Malaysia

INTRODUCTION

Concerning willingness to assist someone in a crisis, a trained individual would immediately come to aid but could not be said for the average person. In general terms, the feeling of unwillingness to help can be attributed to bystander effect, the more bystanders, the less likely the victim will receive help and diffusion of responsibility, people's belief or expect that others will or should help. The effect usually is strengthened by anonymity and considerably reduced by a reduction in psychological distance (Darley and Latane, 1968). Furthermore, the ambiguity of the emergency can also attribute to an increase in bystander effect. The social help process and various psychological barriers from noticing an emergency to actually provide help can be divided into 5 steps (Schulz *et al*., 2010). Several studies referencing literature dating back to 1970 with various social experiments and observations to simulate certain emergency scenarios have been documented. The phenomena can be further expanded into various factors to the bystander effect (Fischer *et al*., 2011). The higher the magnitude for bystander effect, the less likely a victim will get help from bystanders, thus, the negative impact on usual social norms. Some of the factors attributed versus the bystander effect magnitude can be summarized in Table 1.

Table 1: Factors attributed to bystander effect

	Magnitude	
Factors	Increase	Decrease
Community environment		
Urban	✓	
Rural		✓
Number of bystander		
Groups	✓	
Individual		✓
Responder's profile		
Presence of competent bystander		✓
Known acquaintances		✓
strangers	✓	
Situation ambiguity		
Ambiguous	✓	
Clearly known		✓
Incident severity		
High danger		✓
Low danger	✓	
Presence of perpetrator (threat level):		
Low physical intimidation		
Bystander presence-Individual		✓
Bystander presence-group	✓	
High physical intimidation		
Bystander presence-Individual		✓
Bystander presence-group		✓

Literature review: Models and simulation software has shown to be useful for urban planners and architectural designers in visualizing movements of crowds however, complex crowd phenomena is still an open research issue (Bandini *et al*., 2009). With agent modelling and simulation tools becoming more sophisticated, a wide selection of platforms are available as surveyed

Corresponding Author: Mohd Rashdan Abdul Kadir, Faculty of Computing, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia

(Nikolai and Madey, 2009). AnyLogic Version 7 (Anylogic 7) is chosen as the modelling platform to model and simulate the bystander effect in a pedestrian environment. The platform is able to model agent simulations mostly using graphical methods mainly state charts. For detailed custom modelling, AnyLogic 7 agents can be programmed using Java programming language.

Referenced framework: The “Belief-Desire-Intention” (BDI) framework is considered amongst the most common and simple architecture in designing human behavior models or in the context of this study in the domain of Agent Based Social Simulation (ABSS). Stemming from “Folk Psychology” in mapping the basic human thought process (Norling, 2009) and depending on the abstraction (how detailed) of the model, the BDI framework is able to model both rational and irrational (Adam and Gaudou, 2016) human behavior. Briefly, beliefs are the internalized information about the environment, desires are the possible states an agent wants to accomplish and intentions are the current commitment (from possible desires) being acted upon (Balke and Gilbert, 2014). The basic concept of BDI is the deliberation on decisions compared to the agent’s own desire (internal goals) and belief (perception) rather than being purely reactive to environmental perceptions.

Referenced model: Several social model of bystander effect has been illustrated in the literature, mainly in the works by Latane and Nida (1981) and later works (Fischer *et al.*, 2011) that would include surveys of several social experiments. The study by Gerritsen (2011, 2015) is used as the main referenced agent model. However, the simulation results of the referenced model show several discrepancies where the agent would have no belief and desire to intervene but intervenes anyway. This behavior seems inconsistent within the context of the BDI framework and is suggested due to the parallelism of the “belief” and “desire” of the bystander effect model designed in their research. To rephrase, there are some instances where the process flow of “belief” bypasses “desire” and “intention” to deliberation of action. The model proposed stays more closely to the model in the works of Latane’s 5 step mental model (Schulz *et al.*, 2010) which is categorized into the BDI framework as the agent’s process cycle and finally implementing the rule set from the works by Gerritsen (2011) to model the bystander effect.

MATERIALS AND METHODS

Simulation design

Model design: Although, AnyLogic 7 does not specifically support BDI framework implementation, agent behavior in AnyLogic can be modelled using state diagrams, thus in turn BDI aspects can be represented in said diagrams with rule sets defined and coded into the various states. This model also uses the default pedestrian movement tool to simulate agent movement in a unidirectional walkway. The rules used to model the bystander effect is taken from the referenced model (Gerritsen, 2011) with the differences shown in Table. 2 emphasising more towards singel decision flow from belief to desire much like by Lee and Son (2008), however, much simpler and general as shown in Fig. 1.

Table 3 and 4 show the applied rules (mainly using the rules in the referenced model) and the implementation of rules in the aspect of the BDI framework and Latane’s model. However, the rules set that deemed important is R5, R6, R7, R9, R10, R11 and other rules are considered redundant and is used as a representation of the human mental model when confronted with a bystander effect situation as coming from a human cognition point of view, thus can be simplified in the perspective of a modeler or a programmer.

It can be simplified that R1-R5: observed number bystander, audience inhibition, cost of intervention is considered the same value and is used to compare to a threshold value for belief state. In R6-R8: the updated seriousness formula constructed in relation to group

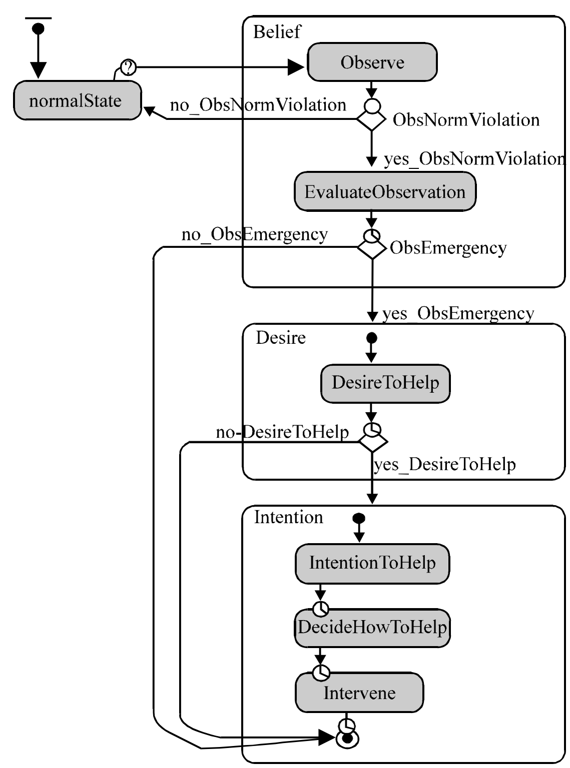

Fig. 1: Bystander effect model in the BDI framework

Table 2: Referenced model comparison

Aspect	Base reference model	Developed model
Simulation platform	Leadsto (Bosse *et al*., 2005)	Anylogic 7
Environment	Static (variable Input result output based)	Dynamic-pedestrian movement setting (2-dimensional space)
Model's variables: Bystander numbers	Static (specific number of bystander defined)	Rate/per h with random arrival rate (1000/h)
State chart flow	Parallel belief and desire criteria all converge into an intention action end point	Single flow belief and desire converge into an intention action end point
Event Of Interest (EOI)	Bystander intervention	Bystander intervention and total number of intervention in simulation runs

Table 3: Agent behavior rule set summary

Model rule set	Rules
R1:	
Social influence	If (observe No. intervention by others) then (belief intervention evaluated negatively)
R2:	
Noticeable actions	(Number bystander observing me) is (observed number bystander)
R3:	
Audience inhibition	If (intervention evaluated negatively) and (number bystander observing me) then (audience inhibition) is (number bystander observing me)
R4:	
Diffusion of responsibility	(Cost of intervention) is (observed number bystander)
R5:	
Cost of intervention threshold	If (audience inhibition) More than (seriousness threshold)* and (observed number bystander) More than (Seriousness threshold)* Then (personal responsibility)
R6:	
Updated seriousness	(Updated seriousness) is seriousness*/ObservedNumberBystander (α)* α-group influence factor (default 0.1)*
R7:	
Norm violation threshold	If (Updated seriousness) More than (norm belief)* Then (emergency)
R8:	
Believe in seriousness	If (emergency) then (DesireToHelp)
R9:	
Intention to help	If (personal responsibility) And (DesireToHelp) Then (IntentionToHelp)
R10:	
Opportunity to help	If (capable of helping) And (resources available) Then (opportunity to help)
R11:	
Performance of action	If (intention to help) And (opportunity to help) Then (help)

*Modeler defined by variable

Table 4: BDI framework, Latane's model (Fischer *et al*., 2011) and Gerritsen's rule set implementation (Gerritsen, 2011)

BDI aspect	Social help process	Rules applied
Belief	Observe	Environment sensing function: Number of nearby pedestrian detected Norm violator present Detection range
	Evaluate observation	R1, R2, R3, R4, R5
Desire	Desire to help	R6, R7, R8
Intention	Intention to help	R9, R10
Plan	Decide how to help	Action plan none implemented
Intention	Intervene	R11

influence and defined seriousness value from (Latane and Nida, 1981; Chekroun and Brauer, 2002) is used to finally, derive a comparative value for desire to help to compute for desire state. With that we assume the referenced model is at some part referencing the social impact theory, how individuals feel the presence of their peers and how they in turn influence other individuals (Castellano *et al*., 2009) although, different in formulation. However, the developed model still maintains all rules originally from the referenced model, since, we focus on the process flow (framework) rather than what algorithm or rules constitutes which process transition. Furthermore, by using the same rule as the referenced model, we are able to compare the results obtained and more. Finally, in R9-R11: the rules imply the pedestrian will intervene when capable of helping, resources available and intention to help, however, the former two values in the designed model are true by default. It can be noted that what is important in the current proposed model is the variable defined by the modeler (denoted by*). Figure 1 shows the decision making process where all the rules set are applied within the agent BDI state.

Environment design: A pedestrian walkway is implemented as the environment layout due to it being simple and common access points in an urban setting. Both the movement model and the mental model (BDI) for the bystander effect is represented separately. Separating the agent mental model and actions/movements makes it easier to develop and later on adapt other functions.

The agents enter the simulation environment (entrance) and later proceed to the designated exit point (exit). The agent arrival rate is set to 1000 agents per hour with 1h per simulation run. Normal agent movement is designated as moving from entrance to exit shown in Fig. 2. While moving to the exit point, the agent will come into the detection range of the norm violator and evaluate the situation depending on the mental model in Fig. 1. If an agent decides to help, the agent will change its current movement and move towards the norm violator,

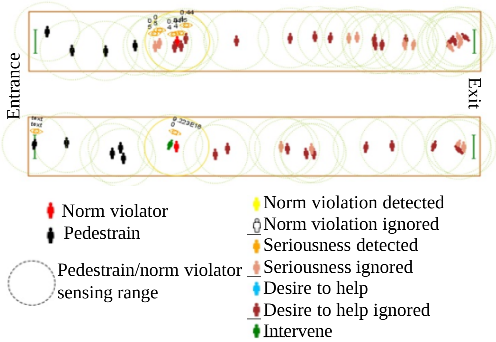

Fig. 2: Simulation environment for pedestrian bystander effect

otherwise, the agent will keep moving to the exit. Once the agent has arrived at the exit or norm violator, the agent will be removed from the simulated environment.

RESULTS AND DISCUSSION

The total number of pedestrian decided to help can be summarized in Table 5 and 6. Seriousness variable dictates the magnitude of the situation, higher the value the more serious the agents view the situation. Referencing R6, the number of bystanders reduces the updated seriousness value. While the higher the value for variable norm belief, the higher value of updated seriousness is required for the agent to register an emergency. The results obtained are consistent with the result obtained in the works of the referenced model where intervention depends on the number of bystanders and personal commitment of the agent. The model is also able to collect the total number of helping bystander in the simulation run as well as the maximum number possible helper at one given crowd cluster. It is also observed that none of the inconsistent results mentioned in the study was retained in the simulation and the agent behavior followed the unidirectional flow from belief to desire to intention.

Pedestrian density plays an important role in the simulation. The higher the pedestrian density, the higher the number of agents will ignore the seriousness of the situation (earlier stage of bystander effect) rather than ignoring to intervene (later stage of the bystander effect) as according to previous works.

However, there are various unrealistic observations for high norms belief (0.1) with high seriousness (0.6, 0.9) and moderate norms belief (0.5) with high seriousness (0.6, 0.9) as marked in grey. It is believed to be caused by the high numbers of helping pedestrians exiting the simulation too fast causing a sudden decrease in bystander density within the norm violation radius. This

Table 5: Total number of intervening versus ignoring pedestrians

Variable				
Norms belief	Seriousness	Total pedestrian	Ratio intervened (%)	Ratio ignored (%)
0.1	0.2	979	12.05	84.37
0.1	0.5	1031	62.27	36.95
0.1	0.6	1034	79.40	20.02
0.1	0.9	1020	93.63	1.27
0.5	0.2	1014	2.76	95.56
0.5	0.5	995	2.21	96.28
0.5	0.6	1002	81.44	17.47
0.5	0.9	1011	92.88	6.13
0.8	0.2	963	2.28	94.70
0.8	0.5	992	1.71	95.87
0.8	0.6	1000	2.40	95.20
0.8	0.9	989	47.42	50.35

Table 6: Total number of maximum bystander present for intervention

	Variables		
Maximum No. of bystander present	Norm belief	Seriousness	Seriousness threshold
1	0.1	0.2	2
4	0.1	0.5	5
5	0.1	0.6	6
8	0.1	0.9	9
0	0.5	0.2	2
0	0.5	0.5	5
5	0.5	0.6	6
8	0.5	0.9	9
0	0.8	0.2	2
0	0.8	0.5	5
0	0.8	0.6	6
3	0.8	0.9	9

can be remedied by improving and redesigning the model for future experiments especially by expanding the expected actions of the pedestrian agents or prevent the agent from exiting the simulation on contact with the norm violator. *Norm belief sensitivity (0.1 high, 0.5 moderate, 0.8 low) *seriousness sensitivity (0.9 high, 0.6 moderate high, 0.5 moderate low, 0.2 low).

Model: The model developed requires more comparative results with actual data (social experiments data). Additional possible agent action, for example, stop, observe and even communicatively influencing actions of other agents (persuading other bystander to help) can be implemented to expand the expected bystander behavior. In relation to expanding bystander behavior it would be interesting to observe an element of randomness in assigning the variables for seriousness and norm belief sensitivity for each agent in the simulation.

Framework: It is noted that the model does not capture the intricate social interaction of the scenario and other bystander effect factors mentioned (e.g., social influence, closeness factors) due to requirements for more complicated behavior to be implemented. With the limited abstractness of the BDI framework, there is potential implementation from BDI to more specialized normative agent frameworks, for example, EMIL-A, BOID, BRIDGE or NOA (Luck *et al*., 2013) which considers external and internal influences for agent decision as well as normative agent mechanisms.

CONCLUSION

By replicating the bystander effect model from the works by Gerritsen (2011) and implemented in a platform that support dynamic environment, the model is extended to be able to predict the total number of bystander help within a time frame while also being able to simulate in a plausible real life environment with pedestrian density being able to be adjusted. This model acts as a basis case study for further future implementation of norm theories and frameworks in agent based modelling. However, validation is also an issue as with other works in ABSS and hopefully results from this developed model can be compared to actual social experiment data or domain expert opinions. Future works can be grouped into two possible aspects for improvement.

ACKNOWLEDGEMENTS

The researchers wish to thank Universiti Teknologi Malaysia (UTM) under Research University Grant Vot-02G31 and Ministry of Higher Education Malaysia (MOHE) under the Fundamental Research Grant Scheme (FRGS Vot-4F551) for the completion of the research.

REFERENCES

Adam, C. and B. Gaudou, 2016. BDI agents in social simulations: A survey. Knowl. Eng. Rev., 31: 207-238.

Balke, T. and N. Gilbert, 2014. How do agents make decisions? A survey. J. Artif. Societies Soc. Simul., 17: 1-13.

Bandini, S., S. Manzoni and G. Vizzari, 2009. Crowd Behavior Modeling: From Cellular Automata to Multi-Agent Systems. In: Multi-Agent Systems: Simulation and Applications, Bandini, S., S. Manzoni and G. Vizzari (Eds.). CRC Press, Boca Raton, Florida, pp: 204-230.

Bosse, T., C.M. Jonker, V.D.L. Meij and J. Treur, 2005. LEADSTO: A Language and Environment for Analysis of Dynamics by SimulaTiOn. In: Multiagent System Technologies, Eymann, T., F. Klugl, W. Lamersdorf, M. Klusch and M.N. Huhns (Eds.). Springer, Berlin, Germany, ISBN:978-3-540-28740-7, pp: 165-178.

Castellano, C., S. Fortunato and V. Loreto, 2009. Statistical physics of social dynamics. Rev. Mod. Phys., 81: 591-591.

Chekroun, P. and M. Brauer, 2002. The bystander effect and social control behavior: The effect of the presence of others on people's reactions to norm violations. Eur. J. Soc. Psychol., 32: 853-867.

Darley, J.M. and B. Latane, 1968. Bystander intervention in emergencies: Diffusion of responsibility. J. Personality Soc. Psychol., 8: 377-383.

Fischer, P., J.I. Krueger, T. Greitemeyer, C. Vogrincic and A. Kastenmuller *et al*., 2011. The bystander-effect: A meta-analytic review on bystander intervention in dangerous and non-dangerous emergencies. Psychol. Bull., 137: 517-537.

Gerritsen, C., 2011. The Bystander Effect: Agent-Based Simulation of People's Reaction to Norm Violation. In: Neural Information Processing, Liang, L.B., L. Zhang and J. Kwok (Eds.). Springer, Berlin, Germany, ISBN:978-3-642-24964-8, pp: 26-35.

Gerritsen, C., 2015. Agent-based modelling as a research tool for criminological research. Crime Sci., 4: 1-12.

Latane, B. and S. Nida, 1981. Ten years of research on group size and helping. Psychol. Bull., 89: 308-308.

Lee, S. and Y.J. Son, 2008. Integrated human decision making model under belief-desire-intention framework for crowd simulation. Proceedings of the Conference on Winter Simulation WSC 2008, December 7-10, 2008, IEEE, Tucson, Arizona, ISBN:978-1-4244-2707-9, pp: 886-894.

Luck, M., S. Mahmoud, F. Meneguzzi, M. Kollingbaum and T.J. Norman *et al*., 2013. Normative Agents, Agreement Technologies. Springer Dordrecht, Netherlands, Pages: 220.

Nikolai, C. and G. Madey, 2009. Tools of the trade: A survey of various agent based modeling platforms. J. Artif. Societies Soc. Simul., Vol. 12,

Norling, E.J., 2009. Modelling human behaviour with BDI agents. Ph.D Thesis, University of Melbourne, Melbourne, Victoria.

Schulz, A.G., M. Ovelgonne and A.C. Sonnenbichler, 2010. Getting help in a crowd: A social emergency alert service. Proceedings of the 2010 International Conference on E-Business (ICE-B), July 26-28, 2010, IEEE, Karlsruhe, Germany, ISBN:978-989-8425-17-1, pp: 1-12.