Manabe, Int J Comput Softw Eng 2022, 7: 179
https://doi.org/10.15344/2456-4451/2022/179

International Journal of
Computer & Software Engineering

Methodology Open Access

Modeling and Simulation of Social Systems: Inherent Methodological Difficulties and Challenges

Tuncer Ören

Emeritus Professor of Computer Science, School of Electrical Engineering and Computer Science, University of Ottawa, Ottawa, ON, Canada

Abstract

Some sources of the complexity of human behavior, such as several types of cognitive biases, are outlined. The fact that simulation provides infrastructure for a multitude of disciplines by allowing to gain experience and perform experiments is mentioned. And the fact that simulation can be used as a litmus test to the understandability of any topic is posited. It is hoped that simulation can help testing understandability of many non-rational aspects of human nature as individuals and as groups of different sizes.

Publication History:

Received: April 30, 2022
Accepted: August 30, 2022
Published: September 01, 2022

Keywords:

Simulation, rationality, cognitive biases, other factors limiting rationality, dysrationalia, logical fallacies, simulation as litmus test to understand a topic

Introduction

Simulation, used for gaining experience or for performing experiments, is a very powerful infrastructure for many disciplines [1,2]. System theoretic foundation of simulation is well established and assures its robustness [3-5]. Accordingly, in simulation modeling in Mealy or Moore finite-state machines [6-8], and in GEST (System Theory implementor) for systems described by ordinary differential equations [9,10], in addition to constants and parameters used to describe a system model, there are three basic types of variables, namely, input, state, and output variables as well as two types of functions: state transition function and output function). In both formalisms, initial values of the state variables need also to be specified.

In the widely used DEVS (Discrete Event System Specification) formalism, the elements necessary to model a system consist of sets of input and output events, as well as sequential states and four functions: time advance function, external and internal transition functions, and output function [4,11].

Hence, in system modeling, input (variables, alphabet, events), states, and outputs are essential elements with mechanisms (or functions) to compute next states and outputs in trajectory simulations, as most of simulation studies are. In variable-structure system simulation, like L-system (or Lindenmayer system) simulation, the transitions of the structure of the system can also be simulated based on inputs, states, and outputs and state transition and output functions. L-systems, even though originally developed for biological systems [12], are also applicable to fractal systems.

In an early study, a type of time-varying system methodology was presented where in a coupled model, some component models may be replaced by others with the possibility of modifying the input/output relationship of the component models [13]. This methodology may be useful in modeling social systems. In a recent publication, it was clarified that "By incorporating time into every state transition, DEVS can be used to represent nearly any time-varying system" [14].

Rationality is highly desirable mental attitude. Scientific, engineering, and technological advancements depend on it. And in simulation studies, rationality is taken for granted.

Social system simulations may involve rational behavior. However, as outlined in the sequel, there are many sources of non-rational behavior which may open new vistas in social system simulations. Firstly, simulation of non-rational behavior would open interesting aspects of simulation of humans, individually or in groups. Secondly, remembering, attention, perception, and anticipation may alter reality and may introduce non-rationality.

Sources of Non-rational Behaviors

Sources of non-rational behaviors are part of the sources of methodological difficulties of social systems. They include (1) perceived and/or anticipated inputs, (2) cognitive biases, (3) dysrationalia, (4) difficulties of discrimination of information from disinformation and misinformation, and (5) phobias.

Inputs

A definition of input is: "Something that is put in: such as information fed into a data processing system or computer." (M-W-input). This implies that input to a system is generated outside of the system. Types of inputs as exogeneous and endogenous inputs were first discussed in 2001 [14]. In a recent article, 120 types of inputs were listed [15]. In social system modeling, the following types of inputs need to be taken into account:

1. Exogenous input (externally generated input)
2. Endogenous input (internally generated input)
3. Non-existing inputs

***Corresponding Author:** Prof. Tuncer Ören, Emeritus Professor of Computer Science, School of Electrical Engineering and Computer Science, University of Ottawa, Ottawa, ON, Canada, E-mail: oren.tuncer@sympatico.ca

Citation: Ören T (2022) Modeling and Simulation of Social Systems: Inherent Methodological Difficulties and Challenges. Int J Comput Softw Eng 7: 179. doi: https://doi.org/10.15344/2456-4451/2022/179

Both exogenous and endogenous inputs pay be altered by perceptions and anticipations. In physical systems, a non-existing input may not influence a system. However, in human systems, absence of an anticipated input may act to alter the state and output of the system.

Cognitive biases

"*A cognitive bias is a systematic error in thinking that occurs when people are processing and interpreting information in the world around them and affects the decisions and judgments that they make [16].*"

Desjardins' clarifications follow: "Humans have a tendency to think in particular ways that can lead to systematic deviations from making rational judgments. These tendencies usually arise from:

Information processing shortcuts
The limited processing ability of the brain
Emotional and moral motivations
Distortions in storing and retrieving memories
Social influence [17]."

There are a multitude of cognitive biases. For example, Wikipedia covers 180 types of cognitive biases [18] and Encyclopedia Britannica has a large number of entries for several types of cognitive biases (Britannica-cognitive biases). In visual capitalist "cognitive bias codex" several types of cognitive biases are presented in several groups presented under the following four clusters: (1) What should we remember? (2) Too much information, and (3) Not enough meaning, (4) We need to act fast [17].

In the sequel, the categorization used by Desjardins [17] is preserved. However, a tabular presentations is used to leave rooms for preparing an ontology-based dictionary of cognitive biases to combine the definitions with a classification. An example of such a dictionary was published in 2007 [19].

We store memories differently based on how they were experienced	
	Tip of the tongue effect
	Google effect (digital amnesia)
	Next-in-line effect
	Testing effect
	Absent-mindedness
	Levels of processing effect
We reduce events and lists to their key elements	
	Suffix effect (dilution effect)
	Serial position effect
	Partial list cuing effect (part-setcuing deficit) (retrieval-induced forgetting)
	Recency effect
	Primacy effect
	Memory inhibition
	Modality effect
	Duration neglect
	List-length effect
	Serial recall effect
	Misinformation effect
	Leveling and sharpening
	Peak-end rule
We discard specifics to form generalities	
	Fading affect bias
	Negativity bias
	Prejudice
	Stereotypical bias
	Implicit stereotypes
	Implicit associations
We edit & reinforce some memories after the fact	
	Spacing effect
	Suggestibility
	False memory
	Cryptommesia
	Source of confusion
	Missatribution of memory

Table 1: Types of Cognitive Biases (What should we remember) (Based on Desjardins, 2021)[17].

Other Factors Limiting Rationality

Dysrationalia

Stanovich "coined the term 'dysrationalia' (analogous to 'dyslexia'), meaning the inability to think and behave rationally despite having adequate intelligence, to draw attention to a large domain of cognitive life that intelligence tests fail to assess. Although most people recognize that IQ tests do not measure every important mental faculty, we behave as if they do. We have an implicit assumption that intelligence and rationality go together—or else why would we be so surprised when smart people do foolish things?" [20,21]. Several examples to clarify Dysrationalia are also offered by Stanovich [20].

Logical fallacies

"***Fallacies*** *are common errors in reasoning that will undermine the logic of your argument. Fallacies can be either illegitimate arguments or irrelevant points, and are often identified because they lack evidence that supports their claim.*" (Purdue Univ.).

Ability to Discriminate reality from its distortions

It is unfortunate that the following terms, used in the 21st century, make difficult distinctions of reality from its distortions: alternative facts [22], several types of deepfake [23], misinformation, disinformation, and mal-information [24].

Emotions, emotional intelligence, and empathy

Emotions, as also elaborated by Damasio, are very important and lead to emotional intelligence and empathy [25]. Some early, yet important philosophers, such Plato and David Hume "*conceived of emotion and rationality as conflicting opposites.*" (Britannica-emotions and rationality). However, some "*emotions can be rational in the sense that they can be used to achieve certain basic human goals and aspirations.*" (Britannica-emotions and rationality). Irrational aspects of emotions can be discussed separately.

We notice things already primed in memory or repeated often	
	Availability heuristics
	Attentional bias
	Illusory truth effect
	Mere exposure effect
	Context effect
	Cue-dependent forgetting
	Mood-congruent memory bias
	Frequency illusion
	Baader-Meinhof Phenomenon
	Emphaty gap
	Omission bias
	Base rate fallacy
Bizarre, funny, visually striking, or anthromorphic things stick out more than non-bizarre/unfunny things	
	Bizarreness effect
	Humor effect
	Von Resorff effect
	Picture superiority effect
	Self-relevance effect
	Negativity bias
We notice when something has changed	
	Anchoring
	Conservatism
	Contrast effect
	Distinction bias
	Focusing effect
	Framing effect
	Money illusion
	Weber-Fechner law

Table 2a: Types of Cognitive Biases (Too much information) (Based on Desjardins, 2021)[17].

We are drawn to details that confirm our own existing beliefs	
	Confirmation bias
	Congruence bias
	Post-purchase rationalization
	Choice-supportive bias
	Selective perception
	Observer-expectancy effect
	Experimenter's bias
	Observer effect
	Expectation bias
	Ostrich effect
	Subjective validation
	Continued influence effect
	Semmelweis reflex
We notice flaws in others more easily	
	Bias blind spot
	Naïve cynicism
	Naïve realism

Table 2b: Types of Cognitive Biases (Too much information) (Based on Desjardins, 2021)

We Project our current mindset and assumptions onto the past and future	
	Self-consistence bias
	Restraint bias
	Projection bias
	Pro-innovation bias
	Time-saving bias
	Planning fallacy
	Pessimism bias
	Impact bias
	Declinism
	Moral luck
	Outcome bias
	Hindsight bias
	Rosy retrospection
	Telescoping effect
We think we know what other people are thinking	
	Illusion of transparency
	Curse of knowledge
	Spotlight effect
	Extrincic incentive error
	Illusion of external agency
	Illusion of asymmetric insight
We simplify probabilities and numbers to make them easier to think about	
	Mental accounting
	Appeal to probability fallacy
	Normalcy bias
	Murphy's law
	Zero sum bias
	Survivorship bias
	Subadditivity bias
	Denomination effect
	Magic number 7 ± 2

Table 3a: Types of Cognitive Biases (Not enough meaning) (Based on Desjardins, 2021)

Phobias

Phobias are irrational fears triggered by either specific or general events or items. They act as inhibitors of rational thinking in their respective application areas. A large number of phobias are listed by Cherry [26]. They can be discussed separately.

Lack of ethics

Some attitudes/approaches may require rationality and intelligence but may be highly undesirable, due to lack of ethical considerations. Two examples follow.

First example is Machiavellianism for which any means to reach a goal is acceptable. This aspect necessitates rational thinking as well as intelligence. However, a definition of Machiavellianism reveals its dark sides:

We imagine things and people we're familiar with or fond of as better	
	Out-group homogeneity bias
	Cross-race effect
	In-group bias
	Halo effect
	Cheerleader effect
	Positivity effect
	Not invented here
	Reactive devaluation
	Well-travelled road effect
We fill in characteristics from stereotypes, generalities, and prior histories	
	Group ambition error
	Ultimate attribution error
	Stereotyping
	Essentialism
	Functional fixedness
	Moral credential effect
	Just-world hypothesis
	Argument from fallacy
	Authority bias
	Automation bias
	Bandwagon effect
	Placebo effect
We tend to find stories and patterns even when looking at sparse data	
	Confabulation
	Clustering illusion
	Insensitivity to sample size
	Neglect of probability
	Anecdotal fallacy
	Illusion of validity
	Masked man fallacy
	Recency illusion
	Gambler's fallacy
	Hot-hand fallacy
	Illusory correlation
	Pareidolia
	Anthropomorphism

Table 3b. Types of Cognitive Biases (Not enough meaning) (Based on Desjardins, 2021)

"*Machiavellianism: n. a personality trait marked by a calculating attitude toward human relationships and a belief that ends justify means, however ruthless. A* ***Machiavellian*** *is one who views other people more or less as objects to be manipulated in pursuit of his or her goals, if necessary, through deliberate deception. [Niccolò Machiavelli, who argued that an effective ruler must be prepared to act in this way]*" [27].

We favor simple-looking options and complete information over complex, ambiguous options	
	Less-is-better effect
	Occam's razor
	Conjunction fallacy
	Delmore effect
	Law of triviality
	Bike-shedding effect
	Rhyme as reason effect
	Belief bias
	Information bias
	Ambiguity bias
We avoid mistakes, we aim to preserve autonomy and group status, and avoid irreversible decisions	
	Status quo analysis
	Social comparison bias
	Decoy effect
	Reactance
	Reverse psychology
	System justification
To get things done, we tend to complete things we,ve invested time & energy in	
	Backfire effect
	Endowment effect
	Processing difficulty effect
	Pseudocertainty effect
	Disposition effect
	Zero-risk bias
	Unit bias
	IKEA effect
	Loss aversion
	Generation effect
	Escalation of commitment
	Irrational escalation
	Sunk cost fallacy

Table 4a. Types of Cognitive Biases (We need to act fast) (Based on Desjardins, 2021)

Another example, dark triad, can become danger to humanity.

"*The term "Dark Triad" refers to a trio of negative personality traits - narcissism, Machiavellianism, and psychopathy-which share some common malevolent features.*" [28].

Conclusion

Some of the human rationality limitations, such as cognitive biases, complicate understanding of human behavior. Having some knowledge about something may be sufficient to talk about it. However, simulation can be used as a litmus test for the understandability of a topic. If a topic can be simulated in every aspect of interest, then one can say that the topic is understood. It is hoped that simulation can

To stay focused, we favor the immeadiate, relatable thing in front of us	
	Identifiable victim effect
	Appeal to novelty
	Hyperbolic discounting
To act, we must be confident we can make an impact and feel what we do is important	
	Pelzman effect
	Risk compensation
	Effort justification
	Trait ascription bias
	Defensive attribution
	Fundamental attribution error
	Illusory superiority
	Illusion ofcontrol
	Actor-observer bias
	Self-serving bias
	Barnum effect (Forer effect)
	Optimism bias
	Egocentric bias
	Dunning-Kruger effect
	Lake Wobegone effect (Lake Wobegon Fallacy)
	Hard-easy effect
	False consensus effect (consensus bias)
	Third person effect
	Social desirability bias
	Overconfidence effect

Table 4b: Types of Cognitive Biases (We need to act fast) (Based on Desjardins, 2021)

help testing understandability of many non-rational aspects of human nature as individuals and as groups of different sizes.

Competing Interests

The author declare that he has no competing interests.

References

1. Ören T (2020) Shift of Paradigm from Model-based to Simulation-based. In Obaidat, M.S., T. Ören, H. Szczerbicka, (Eds.) (2020). Simulation and Modeling Methodologies, Technologies and Applications-9th International Conference, SIMULTECH 2019, Prague, Czech Republic, July 29-31, 2019, Revised Selected Papers. Springer (In the Series: Advances in Intelligent Systems and Computing), pp. 29-45.
2. Ören T (2022) The Big Picture (section 2.1). In: T. Ören, B.P. Zeigler, A. Tolk (eds.). Body of Knowledge of Modeling and Simulation: A Handbook compiled for the Society for Modeling and Simulation. Cham, Switzerland: Springer Nature.
3. Ören TI, Zeigler BP (2012) System Theoretic Foundations of Modeling and Simulation: A Historic Perspective and the Legacy of A. Wayne Wymore. Simulation 88: 1033-1046.
4. Zeigler BP, Muzy A, Kofman E (2019) Theory of Modeling and Simulation – Discrete Event & Iterative System Computational Foundations. Elsevier, The Netherlands.
5. Zeigler BP (2022) Rationale for Theoretical Basis of M&S (section 3.1). In: Ören T, Zeigler BP, Tolk A (eds.). Body of Knowledge of Modeling and Simulation: A Handbook compiled for the Society for Modeling and Simulation. Cham, Switzerland: Springer Nature.
6. Gill A (1962) Introduction to Mathematical Machine Theory. Addison-Wesley, Boston, Massachusetts.
7. Arbib MA (1969) Theories of Abstract Automata (1st edn.). Englewood Cliffs, N.J., Prentice-Hall, Inc.
8. Wikipedia-FSM, Finite-State Machine, (Accesses 2022-04-11)
9. Ören TI (1971) GEST: General System Theory Implementor, A Combined Digital Simulation Language. Ph.D. Dissertation, 265 p. University of Arizona, Tucson, AZ. to download (Accesses 2022-04-11)
10. Ören TI (1984) GEST - A Modelling and Simulation Language Based on System Theoretic Concepts. In: Simulation and Model-Based Methodologies: An Integrative View, Ören TI, Zeigler BP, Elzas MS (eds.). Springer-Verlag, Heidelberg, Germany, pp. 281-335.
11. Wikipedia-DEVS (2021). (Accesses 2022-04-11).
12. Lindenmayer A (1968) Mathematical models for cellular interaction in development I. Filaments with one-sided inputs. Journal of Theoretical Biology 18: 280-289.
13. Ören, TI. (1975) Simulation of Time-Varying Systems. In Advances in Cybernetics and Systems, J. Rose (ed.). Gordon & Breach Science Publishers, England, pp. 1229-1238. (Presented at the International Congress of Cybernetics and Systems at the University of Oxford, Oxford, England, 28th August - 1st September 1972).
14. Ören TI (2001) Software Agents for Experimental Design in Advanced Simulation Environments. In: Ermakov SM, Yu Kashtanov N, and Melas V(eds.) Proc. of the 4th St. Petersburg Workshop on Simulation, June 18-23, 2001, pp. 89- 95.
15. Ören T, Mittal S, Durak U (2019) Modeling and Simulation: The Essence and Increasing Importance. Chapter 1 in the book: Modeling and Simulation of Complex Communication Networks (M. A. Niazi, ed.), pp. 3-26. IET Book Series on Big Data. (Appendix A: A list of over 750 types of simulation, Appendix B: A list of 120 types of input), pp.3-26.
16. Cherry K (2020) What is a Cognitive Bias? Medically reviewed by A. Morin, verywellmind – Psychology (Accesses 2022-04-11).
17. Desjardins J (2021) Every Single Cognitive Bias in One Infographic. (Accesses 2022-04-11).
18. Wikipedia-Biases (Accesses 2022-04-11).
19. Ören TI, Ghasem-Aghaee N, Yilmaz L (2007) An Ontology-Based Dictionary of Understanding as a Basis for Software Agents with Understanding Abilities. Proceedings of the Spring Simulation Multiconference (SpringSim'07). Norfolk, VA, March 25-29, 2007, pp. 19-27. (ISBN: 1-56555-313-6) (Accesses 2022-04-11).
20. Stanovich KE (2009) Rational and Irrational Thought: The Thinking that IQ Tests Miss – Why smart people sometimes do dumb things. Scientific American Mind 20: 34-39.
21. Stanovich KE (1993) Dysrationalia: A new Specific Learning Disability. Journal of Learning Disabilities 26: 501-515.
22. Slang dictionary – Alternative facts (2018). (Accesses 2022-04-11).
23. Wikipedia-Deepfake (Accesses 2022-04-11).
24. Kujawski S, Sonawane M, Knust E (2019) penner/lgl2 is required for the integrity of the photoreceptor layer in the zebrafish retina. Biology Open.
25. Damasio A (1994) Descartes' Error: Emotion, Reason, and the Human Brain. Putnam.
26. Cherry K (2022) List of Phobias: Common Phobias From A to Z. Medically reviewed by S. Gans, verywellmind – Psychology (Accesses 2022-04-11).
27. APA (American Psychological Association) Dictionary – Machiavellianism: (Accesses 2022-04-11).
28. Psychology Today. Dark Triad. (Accesses 2022-04-11).