UTS UNIVERSITY OF TECHNOLOGY SYDNEY

Understanding, Formalizing, and Reconstructing Mental Models with an Online Tool for Serious Discussions

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Doctor of Philosophy

under the supervision of Distinguished Prof. Alexey Voinov, Dr. Flavio Pileggi, Dr. Jaime Garcia, and Dr. Firouzeh Taghikhah

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Certificate of Original Authorship

I, *Madiha Anjum,* declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the *School of Computer Science*, *Faculty of Engineering & IT* at the University of Technology Sydney, Australia.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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DATE: 02-02-2023

Abstract

We live in a time when humanity faces many existential threats - climate change, resource depletion, biodiversity loss, and refugee crises. Wicked problems need to be properly approached and cannot be solved without human participation. These problems require stakeholder participation, which is hard to organize and support. Participatory modeling is one method that facilitates stakeholders' engagement in the decision-making process and enables collaboration to achieve a mutually acceptable solution. Mental models are essential tools in participatory modeling as mental models are informal representations of how the world works. The way we perceive, behave, and decide is also dependent on and influenced by our mental models. Direct observation, learning, and experience can help in maintaining and updating our mental models. At the same time, mental models are constantly relied upon to reason, explain, design, communicate, act, predict, and explore. Overall mental models play an essential role across all domains of human agency so, a tool that can help to formalize computer simulations from the mental models expressed by a group within a given problem situation will be of much benefit for experts and practitioners from various fields like behavioural science, psychology, economics, education, and sustainability as they can gain many insights.

We have developed a real-time, moderated tool, named Discussoo, for understanding and formalizing mental models of participants of online discussions. Users are presented with a topic, question, or problem to debate, on which they can express their opinions/thoughts in the form of comments. Users can also respond or expand on other users' opinions and/or initiate a new line of discussion. The discussion chain is then mined in real-time, using an ensemble of algorithms (including but not limited to concept mining, topic modeling, and sentiment analysis) to extract opinions, keywords, and concepts. This information is transcribed into formal models using Concept maps, Causal Loop Diagrams, and Networks Diagrams as the discussion evolves. To provide feedback, the system presents users with dynamic visualizations of the collective mental model, which they can use as contextual information to refine and update their individual mental models. Targeted moderator comments can also introduce feedback to steer or "nudge" the discussion towards a desirable collective mental model, outcome, consensus, or agreement.

Discussoo can be used in a variety of settings and problem situations, where the steering of collective mental models could improve the functioning, resilience, or sustainability of a given (social, environmental, or technical) system or used by policy makers or any other organization who would benefit from a more direct, transparent and meaningful engagement of their stakeholders.

To my parents

List of Publications Related to this thesis:

Journals:

Anjum, M., Voinov, A., Taghikhah, F. and Pileggi, S., 2021. Discussoo: Towards an intelligent tool for multi-scale participatory modeling. Environmental Modelling & Software.

Conferences:

Bakhanova, E., **Anjum, M**., Voinov, A., Raffe, W. & Garcia Marin, J. (2021). Gamification of Discussoo: an online AI-based forum for serious discussions, 24th International Congress on Modelling and Simulation, Sydney, Australia

Anjum, M, Voinov, A Pileggi, SF 2019(2020). Eliciting, Formalising, And Debiasing Mental Models Through an Online Tool For Serious Discussions, *iEMSs2020, Brussels, Belgium*

Anjum, M, Voinov, A, Castilla Rho, J & Pileggi, SF 2019, 'Understanding mental models through a moderated framework for serious discussion', 23rd International Congress on Modelling and Simulation, Canberra.

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