S4Luhmann model

ODD+D P ROTOCOL

Outline		Guiding questions	Description
I) Overview	I.i Purpose	I.i.a What is the purpose of the study?	The model proposes a translation of some Luhmann's concepts (social sub-system, perturbation, dissipation, social communication and power) into a model using a stylized spatial-society as a metaphor of a Luhmann's social subsystem. The model has been used to improve the social theory understanding and to evaluate the effect of different parameterization in the global stabilization and individual/social power distribution.
		I.ii.b For whom is the model designed?	Scientists trying to understand the connection between Luhmann's theory and multi-agent systems
	I.ii Entities, state variables, and scales	I.ii.a What kinds of entities are in the model?	There are two types of individual agents (Agent-P) and a social entity (Agent-S) which interact with each other. Agent-P (turtles): - Each Agent-P dispose of a amount of capacity of action, - The goal is to approximate the cell board values into a particular target (real number). If a cell has a value close to the target, according to a threshold the cell is considered to be under the authority of the Agent-P, - They send to the Agent-S a message to add a positive or negative increment to a particular active cell, - Strategies: A) choose an active cell to change the value at random in all spatial board B) choose an active cell to change the value at random in all spatial board in a limited space of the spatial board. Agent-S (patches): - Spatial regular cell board (patches), - Each cell is associated to a real number, - The goal is to increase overall spatial autocorrelation (Moran's I index), - They change the status of each cell (inactive or active), - Strategy: if a small set of neighbors (rook type) cells are under authority of the same Agent-P then turn all of them inactive.
		I.ii.b By what attributes (i.e. state variables and parameters) are	Agent-P: - capacity -> real value used to change the patches' stakes,

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		these entities characterized?	- memory -> a list of the level of authority (individual power), - strategy -> 0 changes patches' stakes completely at random; 1 changes patches' stakes in one small area of the spatial board defined by the "ref-patch" - ref-patch -> referential patch chosen randomly Agent-S: - stakes -> real values in [0,100] , - active -> can be active 1 or not 0.
		I.ii.c What are the exogenous factors / drivers of the model?	Not applicable.
		I.ii.d If applicable, how is space included in the model?	Not applicable.
		I.ii.e What are the temporal and spatial resolutions and extents of the model?	The model uses discrete time steps, but there is no correlation between the setp (tick) and the real time. Each grid cell represents abstract social units without a defined metric.
	I.iii Process overview and scheduling	I.iii.a What entity does what, and in what order?	Initialization: In each trick: -
II) Design concepts	II.i Theoretical and Empirical Background	II.i.a Which general concepts, theories or hypotheses are underlying the model's design at the system level or at the level(s) of the submodel(s) (apart from the decision model)? What is the link to complexity and the purpose of the model?	Luhmann's society The proposed model according to the Rempel's terminology. Using the terminology of Rempel (1996) to describe this stylized spatial-social subsystem we have as binary code, holding or not holding cells; the basis of authority is the capacity to change spatial cells; the language of social communication is the struggle for cells authority; the generalized medium of communication is the artificial stake at disposal of each Agent-P; and the social function is the increasing of the positive spatial autocorrelation. Social communication (micro-macro connection) The Luhmannian social communication. The proposed social communication process consists of an information selection based on the reinforcement of positive autocorrelation, the utterance selection that will allow positive or negative incremental changes in cells at each time step, initiated by the Agents-P and approved by the Agent-S, and a meaning selection where Agent-S changes the status of neighbor cells according their values, affecting the Agent-P power share. The Rempel-Borch-Luhmann power definitions. The power of each Agent-P can be interpreted as the number of cells under his authority. And the power of the Agent-S

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			as a measure of positive spatial autocorrelation. Both powers may be originated from the Luhmannian communication process of perturbation/dissipation between Agents-P and Agent-S. It is important to note that there is no face-to-face communication among Agents-P.
		II.i.b On what assumptions is/are the agents' decision model(s) based?	Decisions are made based on the level of individual power (number of patches of his authority).
		II.i.c Why is a/are certain decision model(s) chosen?	Decision making by individuals is not central to this implementation.
		II.i.d If the model/ a submodel (e.g. the decision model) is based on empirical data, where does the data come from?	Not applicable.
		II.i.e At which level of aggregation were the data available?	Not applicable.
	II.ii Individual Decision Making	II.ii.a What are the subjects and objects of decision making? On which level of aggregation is decision-making modeled? Aremultiple levels of decision making included?	There is two levels of decision making: Agent-P (turtles) and Agent-S (patches).
		II.ii.b What is the basic rationality behind agents' decision-making in the model? Do agents pursue an explicit objective or have other success criteria?	The behavioral type of the Agent-P can be interpreted as rational because each Agent-P aims to increase the amount of patches over its authority and have all information they need to decide about what strategy to follow.
		II.ii.c How do agents make their decisions?	Agents decision rules are implemented mainly as if-then rules.
		II.ii.d Do the agents adapt their behavior to changing endogenous and exogenous state variables? And if yes, how?	No.
		II.ii.e Do social norms or cultural values play a role in the decision making process?	No
		II.ii.f Do spatial aspects play a role in the decision process?	Yes.
		II.ii.g Do temporal aspects play a role in the decision process?	Yes.
		II.ii.h To which extent and how is uncertainty Included in the agents' decision rules?	Not considered.
	II.iii Learning	II.iii.a Is individual learning included in the decision process? How do individuals change their decision rules over time as a consequence of their experience?	No.
		II.iii.b Is collective learning implemented in	No.

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		the model?	
	II.iv Individual Sensing	II.iv.a What endogenous and exogenous state variables are individuals assumed to sense and consider in their decisions? Is the sensing process erroneous?	In fact, there is no sensing mechanism, but two mechanisms of perturbation and dissipation.
		II.iv.b What state variables of which other individuals can an individual perceive? Is the sensing process erroneous?	None.
		II.iv.c What is the spatial scale of sensing?	Not applicable.
		II.iv.d Are the mechanisms by which agents obtain information modeled explicitly, or are individuals simply assumed to know these variables?	Not applicable.
		II.iv.e Are costs for cognition and costs for gathering information included in the model?	No.
	II.v Individual Prediction	II.v.a Which data uses the agent to predict future conditions?	There is no prediction.
		II.v.b What internal models are agents assumed to use to estimate future conditions or consequences of their decisions?	Not applicable.
		II.v.c Might agents be erroneous in the prediction process, and how is it implemented?	Not applicable.
	II.vi Interaction	II.vi.a Are interactions among agents and entities assumed as direct or indirect?	There is no direct interaction between Agents-P.
		II.vi.b On what do the interactions depend?	Not applicable.
		II.vi.c If the interactions involve communication, how are such communications represented?	Not applicable.
	II.vii Collectives	II.vii.a Do the individuals form or belong to aggregations that affect, and are affected by, the individuals? Are these aggregations imposed by the modeler or do they emerge during the simulation?	No.
		II.vii.b How are collectives represented?	Not applicable.
	II.viii Heterogeneity	II.viii.a Are the agents heterogeneous?If yes, which state variables and/or processes differ between the agents?	Agent-P can be Alter and Ego. The difference is the goal, the former wants to approximate the stakes of each patch toward zero and the last toward one-hundred.
		II.viii.b Are the agents heterogeneous in their	No.

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		decision-making? If yes, which decision models or decision objects differ between the agents?	
	II.ix Stochasticity	II.ix.a What processes (including initialization) are modeled by assuming they are random or partly random?	Randomly - Initial position of Agents-P - What new position of Agents-P
	II.x Observation	II.x.a What data are collected from the ABM for testing, understanding, and analyzing it, and how and when are they collected?	In graphical user interface, we plot the values of the following variables for each time step: - Spatial pattern of distributed authority - Moran's *I* statistics - Authorities distribution between Alters and Egos
		II.x.b What key results, outputs or characteristics of the model are emerging from the individuals?	There is a direct relationship between the proposed model and the Rempel'sdecomposition of the Luhmann's social subsystems. Then, the model's outputs can be interpreted as stylized outputs of real social subsystems such as the economic or politic social subsystems. For instance, the model can represents a political subsystem composed of two political parties struggling for power (authority over each cell) and the nal conguration of the spatial board of the Agent-S may represents the general distribution of power (very fragmented if low Moran's I or cohesive for high I). The spatial distribution of authorities in the Agent-S's spacial board may also be a representation of a persistent pattern originated from the Luhmannian social communication. As explained in section 2, the result of a social communication is originated from the meaning selection process output, and this can be a signed contract, a research project in execution, a funding by a special governmental program or something else. Using the model in this way, the model could be used to verify if there is any correlation between the pattern observed in the real world (spatial or not) and the spatial pattern of the model's output. Power is a important concept in many elds of research as in sociology, social psychology, political science, behavior science, etc. As stated by Rempel (1996) and Borch (2005), the Luhmann's theoretical framework can be extended to embraced the Foucault's evolutionary denition of power. Therefore, the model can be used to observe different mechanisms of power evolution according to different parametrization or agent's strategies.

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<tr><th colspan="2">Outline</th><th>Guiding questions</th><th>Description</th></tr>
<tr><td></td><td></td><td></td><td>Observe power relations dynamics in complex socioterritorial systems (CSTeS) can follow these approaches. Thereby, the CSTeS can be viewed as a political social subsystem and the Agents-P implemented as political groups. Another way is to implement how the CSTeS council's members communicate and observe the emergent power's pattern, such as persistent arguments, decisions, relations, etc. In fact, at this moment, the model may be used as a tool to test theoretical speculations about social communication, power evolution and individual-society interaction.</td></tr>
<tr><td rowspan="8">III) Details</td><td rowspan="2">III.i Implementation Details</td><td>III.i.a How has the model been implemented?</td><td>The model has been implemented in NetLogo 5.3.1.</td></tr>
<tr><td>III.i.b Is the model accessible and if so where?</td><td>The model will be made accessible at OpenABM at https://www.openabm.org/model/5543/version/1/view.</td></tr>
<tr><td rowspan="3">III.ii Initialization</td><td>III.ii.a What is the initial state of the model world, i.e. at time t=0 of a simulation run?</td><td>Values determined randomly at time 0
- Stakes of all patches
- Position of all Agents-P</td></tr>
<tr><td>III.ii.b Is initialization always the same, or is it allowed to vary among simulations?</td><td>No.</td></tr>
<tr><td>III.ii.c Are the initial values chosen arbitrarily or based on data?</td><td>Arbitrarily</td></tr>
<tr><td>III.iii Input Data</td><td>III.iii.a Does the model use input from external sources such as data files or other models to represent processes that change over time?</td><td>No external data is used.</td></tr>
<tr><td rowspan="2">III.iv Submodels</td><td>III.iv.a What, in detail, are the submodels that represent the processes listed in ‘Process overview and scheduling’?</td><td>Not applicable.</td></tr>
<tr><td>III.iv.b What are the model parameters, their dimensions and reference values?</td><td>
<table>
<tr><th>Parameter</th><th>Description</th><th>Standard value/range</th></tr>
<tr><td>rate</td><td>which is the amount of rate of energy used by agents to change the cells values by small positive and negative increments</td><td>< 0.05</td></tr>
<tr><td>boardSize</td><td>the side length of the squared regular spatial board</td><td>{2..18}</td></tr>
<tr><td>num-agents-Alter</td><td>number of agents which aim to</td><td>{1..50}</td></tr>
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<tr><td></td><td></td><td></td><td>approximate the cells values toward zero</td><td></td></tr>
<tr><td></td><td></td><td></td><td>num-agents-Ego</td><td>number of agents which aim to approximate the cells values toward one-hundred</td><td>{1..50}</td></tr>
<tr><td></td><td></td><td></td><td>init-capacity-Alter</td><td>the amount of stakes available for Alters to change the values of the cells</td><td>400</td></tr>
<tr><td></td><td></td><td></td><td>init-capacity-Ego</td><td>the amount of stakes available for Egos to change the values of the cells</td><td>400</td></tr>
<tr><td></td><td></td><td></td><td>change-strategy?</td><td>if true the Agents-P use two strategies, otherwise they will use only one strategy</td><td>{yes, no}</td></tr>
<tr><td></td><td></td><td></td><td>time-analyze-behavior</td><td>interval of times that the Agents-P will check if they need to change behavior</td><td>{0..1000}</td></tr>
<tr><td></td><td></td><td></td><td>delay-observation</td><td>the length of the memory of each Agent-P</td><td>{0..100}</td></tr>
<tr><td></td><td></td><td></td><td>radius-searching</td><td>the radius of searching for the second strategy</td><td>{0..5}</td></tr>
<tr><td></td><td></td><td>III.iv.c How were submodels designed or chosen, and how were they parameterized and then tested?</td><td colspan="3">Not applicable.</td></tr>
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References

Borch, C.: Systemic power: Luhmann, and analytics of power. **Acta Sociologica** 48(2), 155-167 (2005).

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