ODD WP1: Energized crowding in communities

[1] The model description follows the ODD (Overview, Design concepts, Details) protocol for describing individual- and agent-based models (Grimm et al. 2006, 2010).

1. Purpose

This model will simulate social interactions and information exchange as constituent elements of energized crowding processes on an intra-community level. Energized crowding was originally developed in the field of settlement scaling theory, and is considered a generative dynamic that can result in community formation processes and economic growth, as well as scalar stress (Smith, 2019). While settlement scaling theory constitutes a quantifiable framework that posits predictable links between community sizes and their social, economic and infrastructural properties (Bettencourt, 2013), the exact dynamics of energized crowding are not as well understood. Several open questions remain: 1) is transmission of novel information essential, and if so, to what degree? 2) does interaction have to occur between stable interaction partners, resulting in feedback loops of information transmission, or is it essential to have a strong flux in interaction partners to ensure rapid transmission across a community? 3) does energized crowding require foci of interaction in the form of leaders transmitting specific information or does it emerge from the collective dynamics of the community? To address these questions, this model will explore various strategies of social interaction and information transmission as part of an energized crowding module which are expressed on a community level through scalar stress and socio-economic output.

2. Entities, state variables, and scales

The main entities in the model are individuals, and a single community that is the collective unit of these individuals. People move around and interact, exchanging information and generating novel information that is captured on a community level. People are initialized with one ‘unit’ of information, which could be conceptualized as a specific idea. The number of ideas is a function of the total number of people within the community, but is not necessarily unique within that community.

Basic state variables of people:

- Ideas (list)
- Interaction history

In a second phase, community leaders will be implemented, whose information states are broadcasted towards a larger part of the community and thus shape ideas and flows of information. They otherwise have the same state variables as other people.

People are aggregated in a collective community. The multitude of constituent interactions among individuals is captured on a community level, feeding into levels of scalar stress and socio-economic output.

Basic state variables of community:

- Population size (number of people)
- Scalar stress level

[1] References are given in the manuscript.

- Social organization level
- Socio-economic output

Spatial resolution: The model simulates dynamics within a single community. It is therefore a spatially abstract model.
Temporal resolution: Likewise, the temporal resolution of the model is abstract, but generally limited as one tick constitutes one round of interaction events within the community.

3. Process overview and scheduling

People move around and interact within their own communities, exchanging information and generating novel ideas. People are initialized with one 'unit' of information, which could be conceptualized as a specific idea. The number of ideas is a function of the total number of people within the community, but is not necessarily unique within that community.

Process:
- setup
- move
- interact
- energized-crowding

4. Design concepts

Basic principles.
The concept of energized crowding has been developed in settlement scaling theory, which constitutes a quantifiable framework that posits predictable links between community sizes and their social, economic and infrastructural properties. Energized crowding is a generative dynamic that can result in community formation processes and economic growth, as well as scalar stress, and thus plays a crucial role in the formation and disbandment of communities.

Emergence.
The model simulates the emerging outcomes of social interactions between individuals on a community level, expressed in scalar stress and socio-economic output. The goal is to show how conflicting dynamics of group formation and group fission result from these interactions and have an impact on group sizes.

Adaptation.
In the base model, people interact on a random basis. In subsequent developments, people will develop preferences for interaction partners based on interaction history and similarities in idea compositions (like-attracts-like). The development of community leaders will shape the dissemination of ideas in various ways.

Objectives.
No direct objective is implemented for the interaction processes. However, on a collective level, interactions will feed measures of scalar stress and socio-economic output that have a direct impact on the viability of the community, and its potential for continued growth. The objective in this sense is to overcome fission thresholds.

Learning.
Agents learn new ideas by exchanging information with other agents. The total diversity of the idea set is captured.

Prediction.
Agents do not predict future dynamics. Some degree of (bounded) knowledge of the environment is incorporated to facilitate interaction processes

Sensing.
The overall community senses 'scalar stress' if population size grows too large relative to the degree of social organization.

Interaction.
Agents interact directly to exchange ideas. Interactions consist of an 'encounter' where two individuals recognize each other as an interaction partner, and the initiation of an information transfer, where packaged of information are exchanged and stored in each agent's information list.

Stochasticity.
Stochasticity is involved in the balancing of scalar stress and social organization to allow group sizes to increase and community thresholds to be crossed.

Collectives.
Individuals form a collective community. Its features have been described elsewhere in the ODD.

Observation.
Data collected from the ABM are group sizes captured at certain intervals of the simulation and at the end. The end points are compared with known distributions of community sizes, whereas the interval measures are analysed as time series.
The first goal of this model, however is not necessarily to be fully validated by empirical data, but rather to explore the possibility space of energized crowding and its impact on a community level to feed the parameterization of the model in WP2.

5. Initialization

- A number of people are created with a slider between 50 and 150 (a population range informed by cross-cultural research)
- People are initialized with one unit of information, represented by a random value be-tween 0 and the total number of people of the community; and an empty interaction history
- The community starts with:
    - Scalar stress set to 0
    - Fission thresholds set at 500 (informed by cross-cultural research)
    - Social organization level at 1 (face-to-face community)

6. Input data

No input data is directly imported into the model.

7. Submodels

- Setup:
    - Create individuals based on slider
- Move:
    - Random movement within the community
- Interaction

    - If people encounter each other (i.e. are in proximity), then:
    - Initiate contact
    - Exchange information
        - A virtual coin is tossed to decide whether the package of information of each participant in the interaction is transferred to the other
        - If yes: added to information list with a probability of mutation (i.e. the development of new ideas)
- Energized-crowding: Total interactions, information exchange and generated novelty is aggregated on community level
    - Scalar stress update
        - More people → more interactions → higher scalar stress
    - Socio-economic output update
        - More people → more interactions → higher scalar socio-economic output
    - When reaching fission threshold: Probabilistic event:
        - Group sizes slashed to original level (~fission)
        - Threshold overcome: development of higher social organisation

References used in this document

Bettencourt, L. (2013). The Origins of Scaling in Cities. *Science*, *340*(6139), 1438–1441. https://doi.org/10.1126/science.1235823

Smith, M. (2019). Energized Crowding and the Generative Role of Settlement Aggregation and Urbanization. In A. Gyucha (Ed.), *Coming Together: Comparative Approaches to Population Aggregation and Early Urbanization* (pp. 37–58). New York: State University of New York Press.