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CulSim: A simulator of emergence and resilience of cultural diversity

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Abstract

CulSim is an agent-based computer simulation software that allows further exploration of influential and recent models of emergence of cultural groups grounded in sociological theories. CulSim provides a collection of tools to analyze resilience of cultural diversity when events affect agents, institutions or global parameters of the simulations; upon combination, events can be used to approximate historical circumstances. The software provides a graphical and text-based user interface, and so makes this agent-based modeling methodology accessible to a variety of users from different research fields.

Keywords: Cultural simulations; Agent-based models; Cultural diversity; Cultural resilience

Code metadata

Current code version	2.2
Permanent link to code/repository used of this code version	https://github.com/ElsevierSoftwareX/SOFTX-D-16-00048
Legal Code License	*GNU General Public License (GPL) Version 3*
Code versioning system used	*Git*
Software code languages, tools, and services used	*Java*
Compilation requirements, operating environments & dependencies	*JDK 1.7 (or 1.8)*
If available Link to developer documentation/manual	https://github.com/ElsevierSoftwareX/SOFTX-D-16-00048/blob/master/README.md
Support email for questions	roberto.ur@protonmail.com

Software metadata

Current software version	2.2
Permanent link to executables of this version	https://github.com/ElsevierSoftwareX/SOFTX-D-16-00048
Legal Software License	*GNU General Public License (GPL) Version 3*
Computing platforms/Operating Systems	*Linux, OS X, Microsoft Windows, Unix-like*
Installation requirements & dependencies	*Java 7 (or 8)*
If available, link to user manual - if formally published include a reference to the publication in the reference list	https://github.com/ElsevierSoftwareX/SOFTX-D-16-00048/blob/master/README.md
Support email for questions	roberto.ur@protonmail.com

1. Motivation and significance

The existence of diverse cultural groups is considered paradoxical given that we live in an interconnected world where individuals constantly share information with each other. Moreover, this diversity persists, despite confrontations with drastic changes over the course of population lifetimes. As an example, the Maya have often been recognized for their cultural diversity, although they have been victims of catastrophic events: pre-Hispanic collapses around 800 AD [1]; Spanish invasion after 1521 [2]; and genocide, 1981–1983 [3].

CulSim, the computer simulation software presented here, is a tool to explore proposed models of the emergence of cultural groups [4–6]. It introduces events that, upon combination,

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can simulate catastrophic situations such as wars, pests, invasions, or natural disasters. The results allow researchers to study the resilience of cultural diversity in the provided models. CulSim includes my own recently proposed model, which introduced institutions to explore their effects on cultural diversity [6]. Here, it offers the possibility to analyze events on an institutional level (e.g. institutional collapses). Although the institutional model shows some methodological similarities with other studies focused on mass media [7–9], it distinguishes itself for letting the agents build their institutions and for dividing the feedback loop of information into two processes: bottom-up (democracy) and top-down (propaganda).

The ubiquity of different human groups raises questions regarding the emergence and resilience of cultural diversity. Researchers have proposed models to study the emergence of cultural diversity under social influence [10]. Formal models demonstrated that everyone should, in the long term, converge to the same opinion when all individuals are connected to the same social network [11–13]. More recently, agent-based models have facilitated the study of multiple factors that have been shown to affect the emergence and preservation of cultural diversity. Initially, Schelling [14,15] used the idea that a small "dislike" for a dissimilar neighbor could lead to complete segregation between multiple groups. Conversely, Axelrod [4] proposed a model that successfully allows the emergence of cultural diversity by using categorical opinions (as opposed to continuous [11–13]) and homophily, i.e. the principle of "like attracts like" [16–18], to regulate social influence. In this model, initial parameters heavily impacted the emergence (or non-emergence) of cultural diversity. For example, a smaller population size was conducive to diversity [4], while an increase in neighborhood size increased cultural homogeneity [19].

Later on, Axelrod's model was found to be sensitive to perturbations, noise that was introduced in two forms: mutations [20,21], i.e., random changes in a feature of an agent's cultural vector, and selection error [5], i.e., occasional perception mistakes of a neighbor's similarity (error estimating homophily). Klemm et al. [20,21] found that even tiny mutation rates produced a convergence towards a monoculture without any diversity, while large rates produced anomie, a term introduced by Durkheim [22,23] to describe a state in which each individual is culturally different from its neighbors. Since then, several researchers have addressed the robustness of the emergence of cultural diversity against perturbation, for example by proposing a dynamic social network [24]; by using frequency bias [25], where social influence is multilateral, meaning one is influenced by several individuals at once, instead of dyadic, where influence occurs between just two individuals (based on Boyd and Richerson [26]); by combining frequency bias and homophily [5], or, most recently, by introducing institutions [6], following up on Durkheim's idea that institutions play a large role in group formation [22,23].

To my knowledge, no research has investigated how events that can affect many individuals at the same time might impact cultural diversity in these kinds of models.

Table 1
Social mechanisms used by the models. The first column provides the identifier used in CulSim. The other columns indicate main social mechanisms that distinguish the models.

Identifier	*Homophily*	*Frequency bias*	*Institutions*
M1	Yes	No	No
M2	No	Yes	No
M3	Yes	Yes	No
M4	Yes	No	Yes

CulSim includes four models, all based on Axelrod's. The main social mechanisms that distinguish the models are indicated in Table 1. The description of the algorithms of models M1–M3 can be found in Flache and Macy [5, p. 975]; the algorithm of model M4 can be found in Ulloa, Kacperski and Sancho [6, p. 10].

CulSim supports eleven parameters. Seven (rows, columns, radius, features, traits, mutation, and selection error) can be applied to all models, and four (institutional influence, agent's loyalty, democracy and propaganda) are exclusive to the institutional model (M4). The Initial Parameters section of CulSim's user manual describes the parameters in depth, and summarizes some known effects according to previous studies. The user manual also presents a table with recommended values to start explorations [27]. Finally, the user manual describes in detail the ten configurable types of combinable events of CulSim (including population-related events, institutional-related events and parameter change events). The software provides a graphical user interface to visually explore singular scenarios or multiple repetitions, and a command-line interface to configure comprehensive experimental designs in computer servers. Video 1 gives a brief overview over the functionality of CulSim available at http://dx.doi.org/10.1016/j.softx.2016.07.005.

2. Software description

CulSim allows users to test different hypotheses about cultural diversity, in particular which conditions can sustain it, or which factors promote globalization instead. It is based on previous research on agent-based models [4–6,20,21,24,25]. In this line of research of agent-based models, also known as artificial societies [28], a world is represented by a number of agents interacting with each other on a grid layout (a $N \times M$ matrix). In CulSim, each cell of the grid represents an agent (which can be imagined to represent an individual). This agent has a list of F cultural features. Each feature can contain one of T cultural traits, for example a music feature could contain rock, salsa, or jazz ($T = 3$). Two agents are said to belong to the same cultural group if the agent's cells are adjacent to each other, and if they share the same trait for each of the possible features. An interaction occurs when an agent accepts (copies) another agent's trait (or group of agents' trait — when influence is multilateral) which could occur depending on the conditions imposed by the model, e.g. the homophily between the agents. The two agents that participate in an interaction have to be in a "Von Neumann" neighborhood of radius r; e.g. agent b is in the Von Neumann neighborhood ($r = 2$) of agent a in Fig. 1.