Language dynamics model with finite-range interactions influencing the diffusion of linguistic traits and human dispersal

Clément Zankoc, Els Heinsalu and Marco Patriarca
National Institute of Chemical Physics and Biophysics, Akadeemia tee 23, 12618 Tallinn

In recent years there has been a growing interest in modeling cultural dynamics. In some prototypical opinion dynamics models, such as the Axelrod model, each individual is characterized by a string of variables describing cultural features. During an interaction, the features can be passed from one agent to another one. Such models have proven to be valuable in understanding how different cultural traits spread and can become dominant. Instead, the Schelling model of segregation describes agents moving across a spatial domain; weather the agents move or not is determined by the agent's cultural similarity with neighboring individuals. While the Axelrod and Shelling models are on lattice and assume interactions between first neighbors, in reality, interactions between individuals can span a finite spatial range. In ecology, the finite-range character of interactions is known to be important in shaping population dynamics and the spatial distribution of organisms. Finite-range effects are expected to have an impact also on cultural dynamics. We propose a continuous-space model that aims to explore how individuals with different cultural traits self-organize, as a result of cultural diffusion and human dispersal, into groups that are relatively homogeneous. In this model, individuals are initially characterized by different strings of traits. Two individuals who are within a distance smaller than the interaction range, can interact pairwise. The direction of the interaction between them can be random, with one of the two agents randomly designated as the"speaker", passing a cultural trait to the other agent designated as "hearer," or biased, with the hearer chosen as the agent with larger "cultural proximity", computed as the average Levenshtein distance of the agent from the neighborhood defined by the interaction range. On the top of that, agents perform a culturally-biased random walk, that is also influenced by their cultural proximity. The results obtained show that incorporating the effects of finite-range interactions leads to a rich set of different scenarios, from cultural fragmentation to consensus; in all cases, a drastic reduction of the initial diversity takes place.

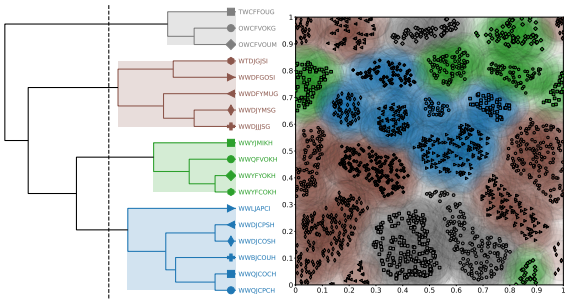

Fig. 1. Examples of equilibrium states for $N = 2000$ individuals, a raidus of interaction $R_i = 0.075$, and a diffusion length scale $R_m = 0.1$. Left: dendrogram computed using the hierarchical clustering algorithm (Ward's method). Right: spatial configuration of the individuals; different languages (represented by the strings shown in the dendrogram) are denoted by different symbols; languages belonging to the same group share the same color. Groups are defined by the LD threshold $\lambda^* = 6/8$. There is a single group in the bottom panel. Notice the geographical continuity of languages belonging to the same group (periodic boundary conditions apply).