A bounded confidence model of emotionally aroused integrate and fire oscillators

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Introduction

The bounded confidence model introduced by Deffuant et al. [1] is a popular model of opinion dynamics in which actors have a $[0, 1]$-valued opinion and interact only if their opinions differ by at most a deviation threshold, then both move closer in barycentric fashion governed by a confidence factor. A number of extensions have been proposed in order to go beyond mean-field approximation [2] or to include emotional dynamics [3, 4].

Here, we propose a framework in which actors are prevented from interacting with those that differ in opinion (O) more than a deviation threshold determined by a decreasing function of their emotional arousal (EA). The higher the emotional arousal, the smaller the deviation threshold. Additionally, by interacting, they also influence each other's activity's timing.

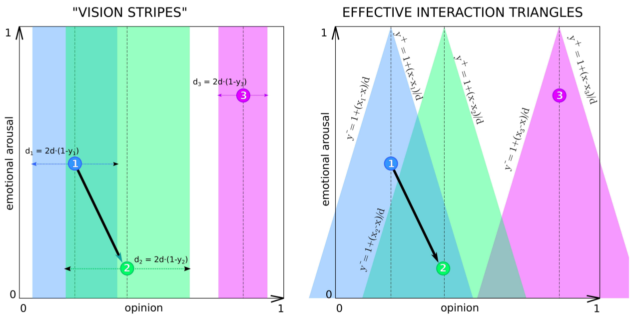

Fig. 1. Range of interaction for the oscillators. The stripes in the left panel correspond to the confidence area an emitter must be within in order to a receiver in a given opinion position O_j listens to his message. The cones in right panel correspond to the affectation area; receivers within the affectation area will be affected by emitters in a given opinion position O_i.

Results

We consider a two-dimensional continuous space, a square box with sides normalized to 1. Initially the agents are uniformly distributed in this area, their coordinates are given by their opinion position (O) in the abscissa axis and their level of emotional arousal (EA) in the ordinate axis. Additionally each agent has a phase ϕ, that increases uniformly with period T until it reaches a maximum value of 1, when a firing event - here understood as a communication action - occurs, after this the emitter's phase is reset to zero. In a firing event every emitter i broadcast a message that will be listened by any agent within the confidence cone of the emitter (see Fig. 1, right panel), and dismissed by agents situated outside this area. Each listener j (simultaneously) affected by a number of emitters n will update his phase by a factor $(1 + \epsilon)^n$ and will take a step in the O-EA plane, with a maximum longitude $d\bar{s} = \alpha$, moving towards the barycenter formed by the emitters that affected him in the current firing event as follows:

$$Q_j(t+1) = Q_j(t) + min(\alpha/d_{C_j}, 1)\frac{\sum_{i=1} n(Q_i - Q_j)}{n+1}; \quad Q \in \{O, EA\}, \tag{1}$$

where d_{C_j} is the distance between the j^{th} oscillator and the barycenter formed by the emitters.

The system evolves until all the oscillators remain immobile within a tolerance threshold we called μ ($\mu \ll \alpha$). At the end of the process all agents belonging to the same cluster - here defined as a weakly connected component in the interaction graph - have collapsed into a single point in the plane (except for deviations of order μ) and synchronized their phases $\forall\, \epsilon > 0$.

We find that, in general, the stationary state is characterized by an increase of the average EA and the final number of clusters is larger than the initial number of connected components of the interaction graph. Fig. 2 shows the evolution of the EA for a group of 100 agents which start forming one single (red) cluster and have $\langle EA\rangle \sim 0.5$. As the system evolves the initial cluster breaks into several components denoted by different colors, and the average level of EA increases. However, in panel A, corresponding to non-synchronized oscillators with $\epsilon = 0$ (i.e. they never synchronize), the number of final components is larger that in panel B, which corresponds to the opposite limit where all agents have the same phase from the beginning of the simulation.

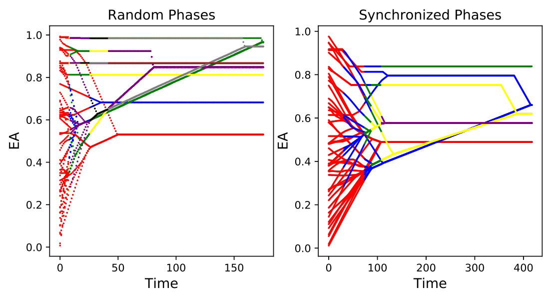

Fig. 2. Panel A. Evolution of the EA coordinates in a system of 50 oscillators with $d = 0.2$, $\alpha = 0.05$ using random initial conditions and $\epsilon = 0$. Panel B: The same as in Panel A, but in the opposite scenario of synchronized initial phases. Colors denote different weakly connected components.

[1] G. Deffuant, D. Neau, F. Amblard and G. Weisbuch, , Adv. Complex Syst. **3(4)**, 87-89 (2000).

[2] G. Weisbuch, , Eur. Phys. J. B **38(2)**, 339-343 (2004).

[3] P. Sobkowicz, , Front. Phys. **3**, 17 (2015).

[4] F. Schweitzer, T. Krivachy and D. Garcia, , Front. Phys. **3**, 17 (2015).