Efficient aggregation of collective intelligence in infomation cascade voting system

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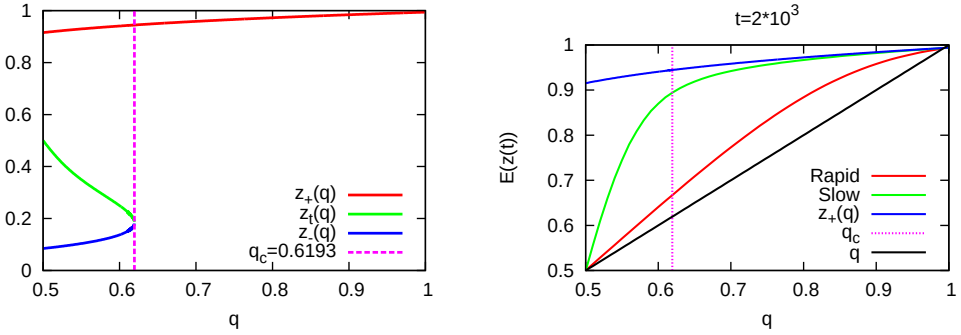
Non-linear Pólya urn in which $Z(0), Z(1), \cdots$, are the successive proportions of red balls in an urn to which at the tth state a red ball is added with probability $f(z(t-1))$ and a blue ball is added with probability $1-f(z(t-1))$. It is well known that $z(t)$ converges to a stable fixed point for f. If there are multiple stable fixed point, the probability of the convergence to a stable fixed point depends on $Z(0)$ and the dependence on $Z(0)$ plays the role of the order parameter for the non-equilibrium phase transition[1]. If one consider a potential function U for f, it means that $z(t)$ can be trapped in a local minimum z_- of U in non-linear Pólya urn and the probability for the convergence to the global minimum z_+ becomes less than one. The LEFT figure shows z_+(red) and z_-(blue) of the regression model for an information cascade experiment[2]. The horizontal axis shows the control parameter q, which represents the accuracy of the subjects' private information. If $q < q_c$, local minimum appears at z_- and z_+ and z_- are divided by the unstable fixed point of $f(z)$ at z_t(green). We consider a finite memory stochastic process where at the tth stage a red ball is added to an urn with probability $f(z(r,t-1))$ and a blue ball is added with probability $1-f(z(r,t-1))$. Here, $z(r,t-1)$ is the proportion of red balls in the recent r added balls. In Pólya process, we set $r=t-1$ and $z(r,t-1)=z(t-1)$. We denote the expectation value of $z(t)$ as $\mathrm{E}(z(t))$. The RIGHT figure shows $\mathrm{E}(z(t))$ vs. q with initial condition $\mathrm{E}(z(0))=q$. The red curve shows the result for the Pólya process case and we see that $\mathrm{E}(z(t))$ is low. If we keep r finite, $z(r,t)$ obeys $z(r,t) \sim e^{-\beta(r)U(z)}$ with a constant $\beta(r)$. If we adopt $r \propto \ln t$, $\mathrm{E}(z(t))$ converges to z_+[3]. The green curve shows $\mathrm{E}(z(t))$ for the logarithmic case. As t is small, the convergence to z_+ is not enough, $\mathrm{E}(z(t))$ is larger than that in the the Pólya process. However, the logarithmic schedule is too slow and we study more greedy schedule where $r \propto t^\alpha$ with $0<\alpha<1$ as an efficient aggregation algorithm of collective intelligence.



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