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Evolutionary Cobreeding of Cooperative and Competitive Subcultures

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***Abstract*—**Neoclassical and functionalist explanations of self organization in multiagent systems have been criticized on several accounts including unrealistic explication of overadapted agents and failure to resolve problems of externality. The paper outlines a more elaborate and dynamic model that is capable of resolving these dilemmas. An illustrative example where behavioral diversity is cobred in a repeated nonzero sum task via evolutionary computing is presented.

***Keywords*—**evolutionary stability, externalities, neofunctionalism, prisoners' dilemma.

I. Introduction

HOW can system level rationality and intelligence emerge in a community of simple agents with limited capabilities? Duality theories in optimization algorithms as well as mathematical economic models can demonstrate how the invisible hand of the market can bring about coordinated action through the blind forces of competition and pursuit of self interest. Equilibrium prices provide the necessary cues for individual agents so that they can collectively achieve coherence and find the best way of using scarce resources and applying their capabilities towards fulfillment of system level goals [1]. Proofs of achieving equilibrium and optimality, however, depend upon certain assumptions (e.g. convexity) the absence of which, designated as externality, precludes the possibility of achieving self organization. A public good, which in contrast to a private good, is nondepletable, poses an externality. When it is used by one person, what is available to others is not depleted in quality or quantity. In the presence of externalities and public goods competitive market equilibrium could not be expected to yield socially efficient resource allocations and policy correctives are said to be needed to fix inefficiencies of market economies [2]. Market failure is the standard economic rationale for government intervention. This provides the grounds for neoliberal ideologies that call for a mixed economy involving central planning and political intervention for reversing market failures caused by externalities. Our main motivation is the fact that externalities and public goods seem to become prevalent in our era. We have entered a new period that can be characterized by the convergence of economic and cultural spheres, increasing dependence on knowledge, omnipresence of computer and communication networks, and high levels of environmental risks [3]. In this new era, since the vast majority of productive and consumptive acts are social, it follows that they will involve externalities. Knowledge, for example, can be regarded as a public good having positive externalities [4, 5]. Open-access resources can also lead their use at high rates because individuals have no incentive to conserve those resources with no assurance that other users will do likewise. Will civil society become incapable of regulating individual actions in this new era when knowledge capital, social capital, and cultural capital seem to become the most important preconditions for development? Do we have to live under increasing levels of social control and compliance to plans enforced by political power? It is sought to demonstrate how rationality can be achieved via evolutionary arguments without the need of central interventions in multiagent situations. Furthermore, we wish to argue that evolutionary search for optimality need not result in homogeneity and diversity and coexistence of different subcultures, far from being sign of dysfunctionality, may be necessary for system level rationality.

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II. Mathematical Model

The basic mathematical framework for multiagent decision making is provided by game theory. A game involves choices of actions by different decision makers with different preferences. Nonzero sum games represent nontrivial cases where the gain of one decision maker in such games is not necessarily achieved at the cost of others' loss. It can be shown that the Nash equilibrium outcome and the Pareto optimal outcome, if both existent, need not be the same. For example in a nonzero sum cooperative game involving conflicts, if all agents cooperate, the outcome would be socially optimal in the sense of Pareto. But that possibility would not happen in the absence of external forces since some agents will be able to improve their take by defecting. Public goods and commons are examples of such externalities. A commons is a shared resource that every one can use. Internet, open source software and scientific knowledge are some examples of commons. If a good cannot be charged for then it is a public good. Public goods have nonexcludability and nonrivalrous consumption. Tragedy arises when agents want to use the benefits of commons but do not contribute to their production or maintenance [2]. This fact seems to be providing further theoretical justification for the failure of market forces and the need for political intervention [6]. The prisoner's dilemma is a typical example. Two or more agents have to choose whether they want to cooperate with other players or to defect. Based on their own choice and others' choices, each player receives a reward (or punishment). In this type of game, the reward of mutual cooperation is high, but the reward of defection while receiving cooperation from others is much higher. So there is always a motivation for defection. However, if the game is played iteratively, the fear of revenge and the shadow of future are conjectured to induce the players to cooperate [6]. Evolutionary stable strategies are rules of behavior that, once adopted by members of a community, are robust with respect to alternative strategies to be adopted by emerging subpopulations [2]. For example, in a society where cooperative culture dominates, if a new agent emerges with a noncooperative subculture, it will proliferate in subsequent generations since it receives the benefits of cooperation from the others while paying nothing as it always defects. Thus defection is an evolutionary stable strategy while the full cooperative society is not stable in evolutionary sense [2]. Repeating the game is by itself not enough for promoting cooperation. Before expanding the model, we should justify our use of evolutionary argument. Here, it is the way agents make decisions that are inherited by subsequent generations. Richard Dawkins [7] defines memes as a unit of cultural transmission, or a unit of imitation. Cognitive and behavioral patterns constitute some examples of memes. If the bearer of a meme receives higher rewards, then people learn and imitate it more frequently and it will proliferate. Propagation through cultural transmission is also prone to genetic operators like mutation and crossover via innovations and recombinations. But since our society is represented by a game, the influence of other memes has a vital role in the acquired fitness value. It means that a specific meme can do well in the presence of some other particular memes and the same meme can score low in their absence. For example, in a society of defectors, a cooperator meme cannot survive as it gains no score in the nonzero sum game designated as the prisoners' dilemma. But if it emerges in a colony of cooperators, it can gain much higher proliferation rate. In our expanded model, we assume that the agents have a mental structure the contents of which are updated after each observation of interacting agents' behavior. The decision fusion operators selecting agents' actions based on their mental states constitute the memes that are subject to cultural evolution. Finally, in order to provide survival chance for novel subcultures that have high fitness values only in the presence of favorable memetic pools, a social or proximity network is also assumed to exist [2]. Agents play games only with those other agents that are within their immediate proximity. A local subculture can thus proliferate and gain critical mass before extinction in a society where hostile memes predominate.

III. SIMULATION RESULTS AND CONCLUSIONS

We have conducted many simulations where a society of agents selecting actions, in a repeated game of prisoner's dilemma as elaborated in the previous section, is bred. These agents live in a grid world. The game consists of successive turns. In each turn, an agent must decide between cooperation and defection with its immediate neighbors. The same decision is made by the neighbors regarding the agent. At the end of each turn, a payoff is calculated for each agent. As a result, if an agent cooperates with a particular neighbor and the neighbor reciprocates with cooperation too, then both agents receive a high payoff. But if the neighbor defects in response to the received cooperation, the defector gains much more payoff while the cooperator receives nothing. In the case of both neighbors' defection, they both get very small payoff. At the end of each turn, agents evolve based on the rules of evolution. The more an agent gains payoffs in a turn, the more it has chance of survival [8]. Since the decision to cooperate with a neighbor will be very rewarding but only when that neighbor is also expected to cooperate, a four dimensional belief structure is assumed for each agent consisting of the propensity of the neighbor to cooperate or defect, based on its past decisions; and the extent it has accumulated more or less payoffs, so that it can have propensity to gamble once in a while. The final action is selected via Sugeno Integral as the decision fusion tool combining those mental states inducing cooperation or defection [2, 9, 10]. The result of our simulation showed that the evolutionary stable meme pool consisting of a majority representing a subculture of cooperative subculture, alongside a minority representing a subculture of defection. The fact that agents interact only within their social network prevents the otherwise evolutionary stable culture of defection to stop cooperative subcultures to proliferate. Even when defection is omnipresent, local subnetworks of cooperative memes can provide support for their early proliferation until they achieve a critical mass. On the other hand the threat of defection by others is necessary in order to eliminate the motivation for defection by any specific agent. The majority subculture provides the motivation for cooperation by promising higher rewards, while the minority subculture removes the motivation for defection by not providing even higher rewards. The population makeup changes when we change the relative payoffs in the game; striking the right balance for motivating cooperation while discouraging defection on the average. The significance of our model goes beyond economics providing new interpretations for classical viewpoints and showing how more sophisticated socioeconomic models can explain how civil society can deal with the seeming social dilemmas and externalities without any need for state intervention and centralized social control. In the more general social theories too, the model furnishes new interpretations for functionalist and system theoretic stances. Functionalism has been especially criticized for its assumption of overadapted agents. The uniformity of fully rational cultures and the assumption of evolutionary elimination of dysfunctional subcultures does not explain the empirical fact of omnipresent diversities in all social entities. Our model, however, shows that diversity can be bred in evolutionary sense. In other words, it gives rigorous support to neofunctionalist claims that seemingly dysfunctional minority subcultures, when viewed from the viewpoint of the total system, are in fact functional because they, so long as are there as minority, provide sustainability to the total system via increasing its effectiveness or removing threats of self destruction. In the case of prisoners' dilemma, the rational subculture of defection is sustainable but suboptimal, while cooperation, when practiced by all, yields better results but lacks sustainability. Cobreeding both subcultures can be thus argued to be the most functional outcome in evolutionary sense, when viewed in terms of the total system achieving better optimality while maintaining sustainability.

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