The u-shaped role of communication in diversity-enhanced collective intelligence

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In Computer Science, the notion of collective (or distributed) intelligence has long been defined as the problem solving where different cooperating agents work collectively on solvin a same task (Durfee, 1989). Hence, it is based on agent diversity and agent communication (Durfee, 2001). In the last two decades, it has been shown that, indeed, in models where multiple agents coordinate on a problem-solving task, the collective effort in general (Kennedy, 1998) and the diversity among agents in particular (Hong and Page, 2001, 2004) lead to either better or faster outcomes.

Roughly speaking, diversity of information carried by agents permits faster and wider exploration of problem spaces - which increases the likelihood of finding optimal solutions. This is particularly true for larger action spaces and for larger groups of diverse agents (Marcolino et.al. 2014). However, both in the models of collective intelligence and in the models of diversity-enhanced problem solving, individuals' diverse features are often assumed as exogenous and the communication through which individuals share such features is always assumed as a given. Here I try to relax both assumptions, investigating what happens at varying levels of quality of communication and also the case when agents' held information spreads and alters other agents'. When individuals supply part of their individuality (let's say, knowledge) to each other, such knowledge is itself altered. This way, people's diversity regarding the knowledge needed for solving a given task diminishes as collaboration proceeds. That being the case, assuming the communication between agents as a given becomes problematic, because the optimum collaboration relies precisely on the degree of communication.

To show that, I draw on Kennedy's idea of social thinking and on Hong and Page's models of diversity to build an Agent-Based model of multiple heterogeneous agents attempting to solve a set of tasks. Regardless of the challenge at hand, agents are modeled as holding diverse features (i.e. useful information about current task). They rely on such features for solving the problems at hand. They talk to each other to solve problems - otherwise diversity is of lesser value. Two models of deciding the pairs of agents that communicate are tested - random and by homophily. Agents have a non-zero probability of sharing features when they talk - that is, of influencing each other's held information about the taks. The model aims at representing the common process of assembling together different ideas to solve a task, but relaxing the assumption that such ideas are exogenous to the task-solving process.

In the end, I show that for many differen tasks, quality and speed of tasks' outcomes in a multi-diverse-agent cooperation scenario actually depend on the intensity and quality of communication between agents in a non-trivial way. Mainly, if communication is too weak or too noisy, it does not let room for diversity among agents to play a significant role in the problem solving. Nevertheless, if communication is too intense and clean of noise, agents' diversity gets lost: agents tend to change their original string of information by mimicking the initially most successful agents, loosing diversity too quickly and thus not yielding the problem-space exploration benefits of the original diversity.

References

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