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Stigmergy as a Universal Coordination Mechanism I: Definition and Components

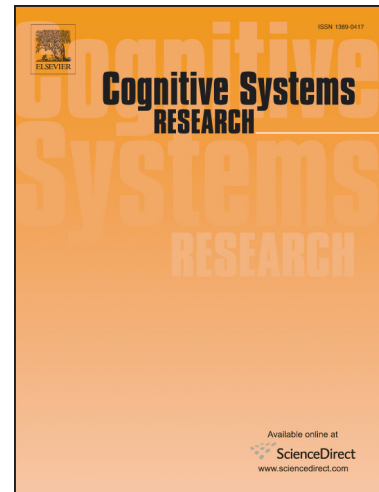
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# Stigmergy as a Universal Coordination Mechanism I: Definition and Components

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**Abstract:** The concept of stigmergy has been used to analyze self-organizing activities in an ever-widening range of domains, including social insects, robotics, web communities and human society. Yet, it is still poorly understood and as such its full power remains underappreciated. The present paper clarifies the issue by defining stigmergy as a mechanism of indirect coordination in which the trace left by an action in a medium stimulates subsequent actions. It then analyses the fundamental concepts used in the definition: action, agent, medium, trace and coordination. It clarifies how stigmergy enables complex, coordinated activity without any need for planning, control, communication, simultaneous presence, or even mutual awareness. The resulting self-organization is driven by a combination of positive and negative feedbacks, amplifying beneficial developments while suppressing errors. Thus, stigmergy is applicable to a very broad variety of cases, from chemical reactions to bodily coordination and Internet-supported collaboration in Wikipedia.

*Keywords:* stigmergy, coordination, actions, agents, self-organization, feedback

## **Past, present and future of the “stigmergy” concept**

The concept of *stigmergy* was proposed by the French entomologist Pierre-Paul Grassé (Grassé, 1959) to describe a mechanism of coordination used by insects. The principle is that work performed by an agent leaves a trace in the environment that stimulates the performance of subsequent work—by the same or other agents. This mediation via the environment ensures that tasks are executed in the right order, without any need for

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