

Numerical study of the efficiency of spatially homogeneous and inhomogeneous intermittent search strategies

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The successful usage of efficient search strategies is one of the most important needs in biology and human behaviour. It is observed on all length scales of life and in all kinds of complexity. Very often, so-called Intermittent Search strategies are observed, which are based on the alternation of a detection phase and a relocation phase. In the detection phase, the searcher is able to recognize the target, but there is less or even no spatial displacement. In the relocation phase, the searcher moves in a fast directed motion within the searching area, but there is no possibility of target detection. This strategy has been proven to be often more efficient than staying in the detection phase for the whole searching time. The model assumption of a searcher which does not remember its past leads to exponentially distributed switches in time between the two phases. Assuming no knowledge about its position within the searching domain would lead to homogeneously distributed relocation directions in space. In real life however, the searcher often “feels” at least some aspects of its position, e.g. chemotaxis sensitive searching killer cells or intracellular search with ballistic relocation along the anisotropic cytoskeleton.

Hence, we numerically compare the efficiency of purely diffusive search to spatially homogeneous and optimized inhomogeneous intermittent search strategies for the following problems: 1) narrow escape problem; 2) detection of an immobile target in the interior of the searching domain; 3) reaction-escape problem, i.e the searcher at first needs to find a diffusive target and has to solve a narrow escape problem afterwards.

Among others, the results indicate that for various intracellular transport problems the cytoskeleton network of cells realizes inhomogeneous search strategies which are more efficient than a homogeneous strategy.