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A bottom-up approach to the construction of socially optimal discrete choices under congestion

We consider the problem of N agents having a limited time to decide on a destination choice among a finite number of alternatives D. The agents attempt to minimize collective energy expenditure while favoring motion strategies which limit crowding along their paths in the state space. This can correspond to a situation of crowd evacuation or a group of micro robots distributing themselves on tasks associated to distinct geographic locations. We formulate the problem as a Min linear quadratic optimal control problem with non positive definite Q matrices accounting for negative costs accruing from decreased crowding. The solution proceeds in three stages, each one improving on the performance of the previous stage: (i) Mapping optimal paths for an arbitrary agent destination assignment; (ii) Mapping optimal paths for fixed fractions of agents assigned to each destination; (iii) Identifying the optimal fraction of agents' assignments to each destination. The cost function associated with stage (iii), as N goes to infinity, is proven to be convex, leads to simplified computations and to epsilon-optimal decentralized control policies when applied for N large.