The Effects of Accumulative Mutations on Selection and Heterogeneity in the Structured Moran Process

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While the classical Moran process models the evolution of types in well-mixed populations of fixed size, adding structure to a population restricts the interactions among individuals and affects its qualitative and quantitative behavior. A structured population is often represented by individuals living on the vertices of a graph. Birth-Death updates and mutations are two main mechanisms involved in the evolution of the spatial Moran process. In the Birth-Death update, an individual is first selected from the population at a rate proportional to its fitness to give birth to a new individual of the same type. Upon a birth event, a second individual is chosen uniformly at random from the neighbors of the first individual to die, and the newborn individual (the offspring of the first individual) takes its place. Additionally, the type of each individual mutates to a new or existing type at a constant rate.

In this project, we study the propagation of mutations and the heterogeneity of populations under the spatial Moran process with different geometric structures. We consider different types of accumulative mutation mechanisms and their effects on the fitness of types in our model. We compare the probability and time of fixation in the spatial Moran process on certain types of graphs with those of the classical Moran process, and examine the effect of the geometry of the structure on the fitness of types. Specifically, assuming an accumulative mutation mechanism, we investigate whether a specific graph amplifies or suppresses the effect of natural selection in the population. Our studies aim to enhance the understanding of how the geometry of a tissue influences the initiation mechanisms of cancer in certain spatial multi-stage carcinogenesis models.