Optimal Control in Individual Based Models: Implications from Aggregated Methods

Paula Federico, Louis Gross, Suzanne Lenhart, Daniel Ryan

The hypothesis we investigate is whether optimal control theory applied to an aggregated model (AM) of differential equations can be used to effectively control a harmful species modeled by an Individual-based Model (IBM), or whether interactions between individuals, their spatial distribution, and landscape heterogeneities limit the effectiveness of the control methods derived from the aggregated model. We develop a simple spatially explicit IBM with an invasive species (rabbits) and its resource (grass). Then we formulate a differential equation model for the rabbits and the grass to mimic the average time dynamics of the IBM, and choose appropriate parameters. We find an optimal control based upon harvesting the "harmful" species in the AM. This control is then applied to the IBM, and the results from both models with control are compared. We first investigate situations with no spatial heterogeneity in the resource (except stochastic fluctuations), and then investigate a situation with explicit spatial heterogeneity in the resource. The optimal control derived from the AM can be used effectively to control the invasive species in the IBM in the former situation for most of the parameter space. However in the case of an explicit strong spatial heterogeneity in the resource, the AM optimal control becomes inefficient even though the AM with no control closely captures the average dynamic of the IBM.

Paula Federico, Ph.D.

Assistant Professor

Department of Mathematics,

Computer Science and Physics

Capital University