# RESEARCH STATEMENT

## CURRENT RESEARCH

Currently I am working on my PhD in Electrical and Computer Engineering with Professor Kevin M. Passino. In my research we focus on the mathematical modeling and analysis of the stability, optimality, and allocation strategies for the Ideal Free Distribution (IFD). We are applying the methods to advancements in theoretical biology and the design of distributed feedback control systems (e.g., for multizone temperature control). Using a game-theoretic approach we explain how the IFD is a Nash Equilibrium. Hence, the IFD is optimal in the game-theoretic sense. In our work, we also show that the IFD possesses much stronger optimality properties by using nonlinear optimization theory (e.g., Lagrange multipliers). Also, we prove that the IFD is an equilibrium for the replicator dynamics, and we show the relationship between these dynamics and a gradient-based allocation process. We are considering extensions to the “effort distribution/allocation” problem and experimental implementations for temperature control.

## FUTURE DIRECTIONS

My most recent research has shown many interesting paths that have not been full exploited by the control community. Therefore, I feel that there exists a possibility to continue the investigation of more theoretical and experimental results in areas such as dynamic resource allocation and evolutionary game theory applied to control engineering. In resource allocation we have seen many theoretical results and applications in many areas, such as communications and control. However, the dynamics are difficult to take into account when we are doing the analysis, and hence this is still an important subject to be explored. On the other hand, game theory has played an important role in control engineering. One design application is where we view the controller as being the agent that needs to control a process, but it has to face many other hostile agents that can be seen as the disturbances. There are other applications such as “control in distributed, asynchronous, networked environment.”[1] Since the concepts are taken from biology, evolution plays a fundamental role in our analysis. These two areas combined have not been fully exploited, and also, their value in engineering applications has only received a limited attention. I feel that after a couple of years, this research will affect many different areas, such as engineering, biology, and economics, among others. Hence, if I start working on the development of experiments that will be able to explain the theoretical developments, maybe we will gain more insight on what can be done following this path.

As I mentioned before, we have to be aware that we have to reach out other scientific communities along with other engineering areas. One way to do that, besides courses and lectures, is the fact there does not exist good experiments in our area that are simple enough to be understood by most of the persons who do not have enough mathematical background. The development of these experiments will help both the university and the professors that are doing research, because the main objective is to have an excellent laboratory that will be useful for both education and theoretical/experimental research.

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[1] Murray, Richard M. (2003). Future directions in control, dynamics and systems: Overview, grand challenges and new courses. *European Journal of Control*.

**RESEARCH PROGRAM SUPPORT**

It is clear that I will not be able to investigate all topics in the above areas by myself in a short period of time. For that, I need to hire graduate students who are willing to learn different areas, and who are also excited about working on theoretical and experimental problems. For that, I will have to write proposals, and apply for grants in order to get the necessary money for my research. These proposals have to be submitted to different entities, i.e., government and industry.