# Toward a Control Map for Niching

# Introduction

**Niching** for a set of high-quality alternative solutions

Successful niching promote both **cooperation** (coexistance of separate species) and **competition** (search for the best species)

What is the competitive-cooperative boundary in the space of possible niche relationship?

This boundary allows us to predict which pairs of interacting niches will survive under GA selection

# Introduction

Classifier system as an example of resource sharing:

- classifiers (classification rules)
- examples (test sets)
- each rule's fitness (number of examples correct classified/ covered)

Example sharing:

- An example can be shared (covered) by two or more rules

Sharing of resources leads to niching

- $f_A$, $f_B$, $f_{AB}$: fitness (number of elements covered by each rule)
- $f_{sh,A}$, $f_{sh,B}$ : shared fitness

GA's decision making between cooperation and competition can be guided by the shared fitness

# Introduction

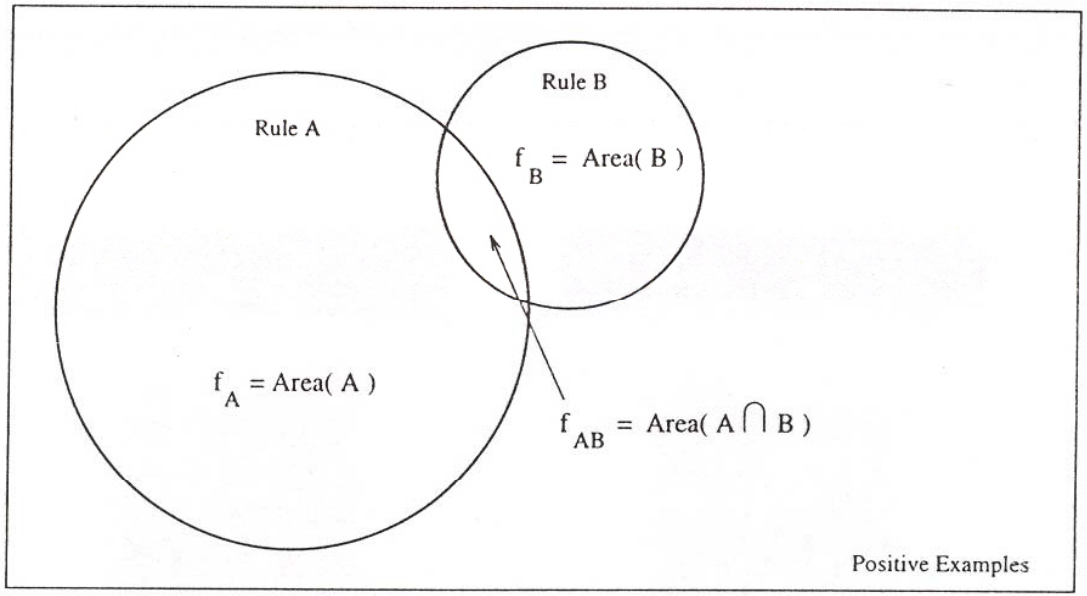
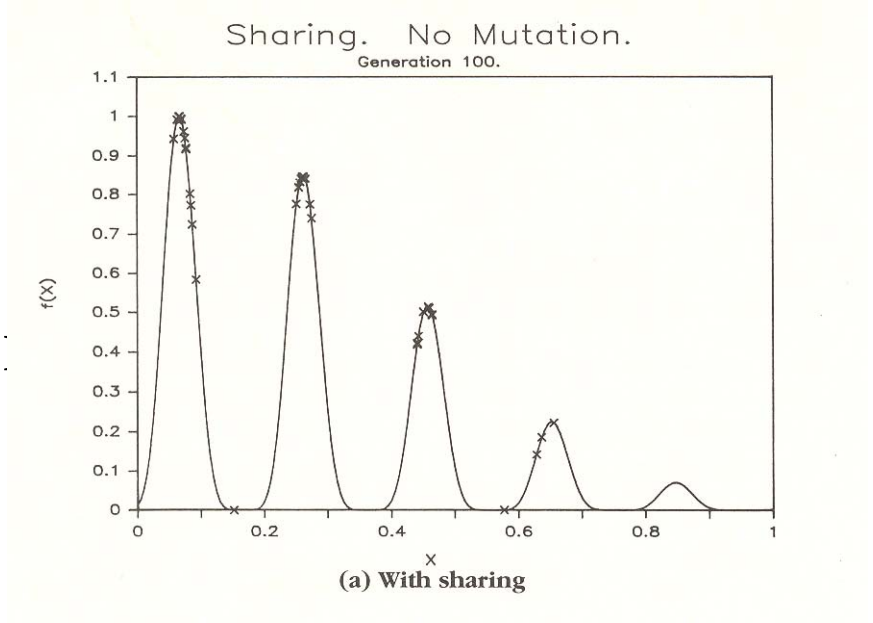



Figure 1: In the case of the learning classifier system (LCS), *implicit niching* is induced by rules competing to classify examples. We can use area in the space of examples to indicate a rule's coverage, which is also its *objective* (i.e., unshared) fitness.

# Key Niching Results




Niching Equilibrium conditio

$f_{sh,A} = f_{sh,B}$

Niche maintenance time

- How many generations can we expect selection to keep two niches in a population?
- When do we expect to lose the last individual from a niche?
- Very long niche maintenance time for one species/niche to completely take over the population
- Niche maintenance time grows exponentially in population size N

# Key Niching Results: Niche maintenance time

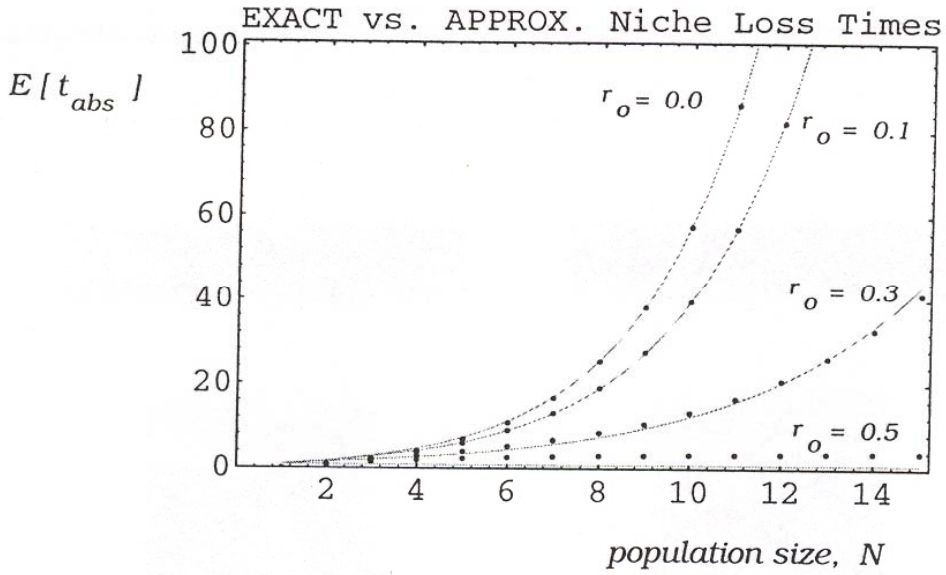



Figure 2: A comparison of *exact* expected niche loss times to the approximated times, as a function of population size. The exact results (from the Markov models) are shown as solid dots. The approximations, from the closed-form expression, are shown as dashed lines. The plots indicate general agreement for small niche overlap $r_o$. For all plots shown $r'_f = \frac{1}{2}$.

# Key Niching Results

## Convergence to Niching Equilibrium

- Fast convergence time to niche equilibrium
- Expected convergence times grows logarithmically in population size N

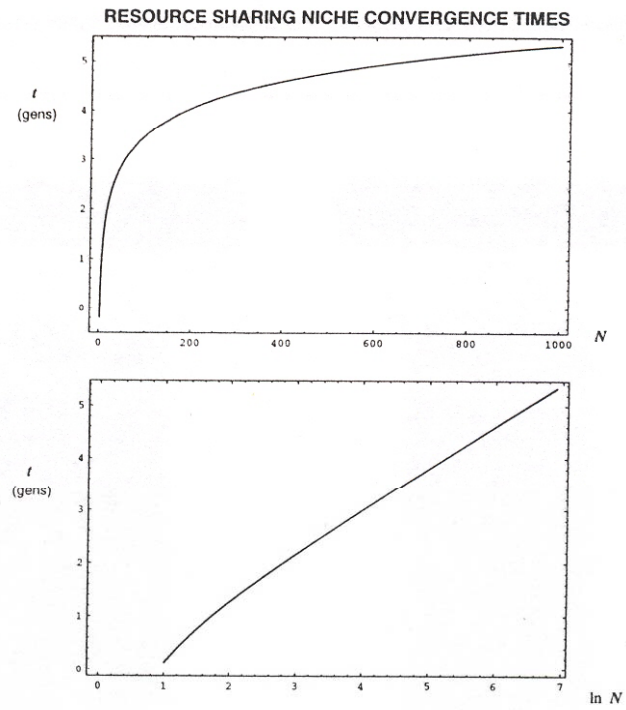



Figure 3: Expected niche convergence time grows logarithmically in population size $N$.

# A Map of Cooperation vs. Competition

- Small population size leads to competitive niches:
  - One niche is absorbed (niche failure) to another
  - More competitive when the ratio of overlap is high
- Large population size leads to cooperative niches:
  - High difference between convergence and extinction times
  - Successful niching with short convergence time and long maintenance time
- What is the boundary between cooperative pairs of niches and competitive pairs?
- How much longer the maintenance time than the convergence time for successful niching?

# A Map of Cooperation vs. Competition

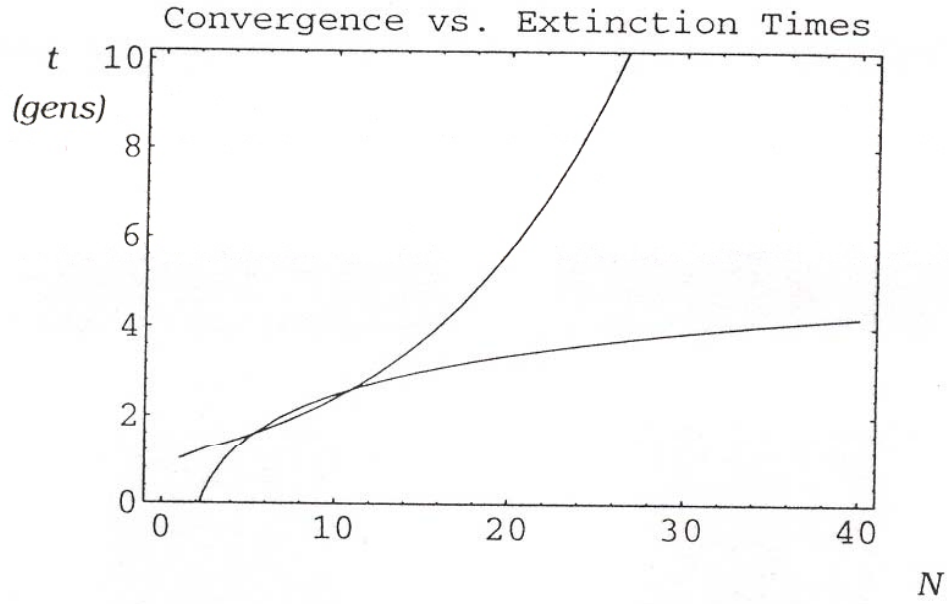



Figure 4: Expected niche extinction times (upper curve) versus expected niche convergence times (lower curve). Here fitness ratio $r_f = 2$ with very high overlap $r_o = 0.45$ (near maximum).

# A Map of Cooperation vs. Competition

The greater the difference between convergence and maintenance times, the less overlap and fitness difference

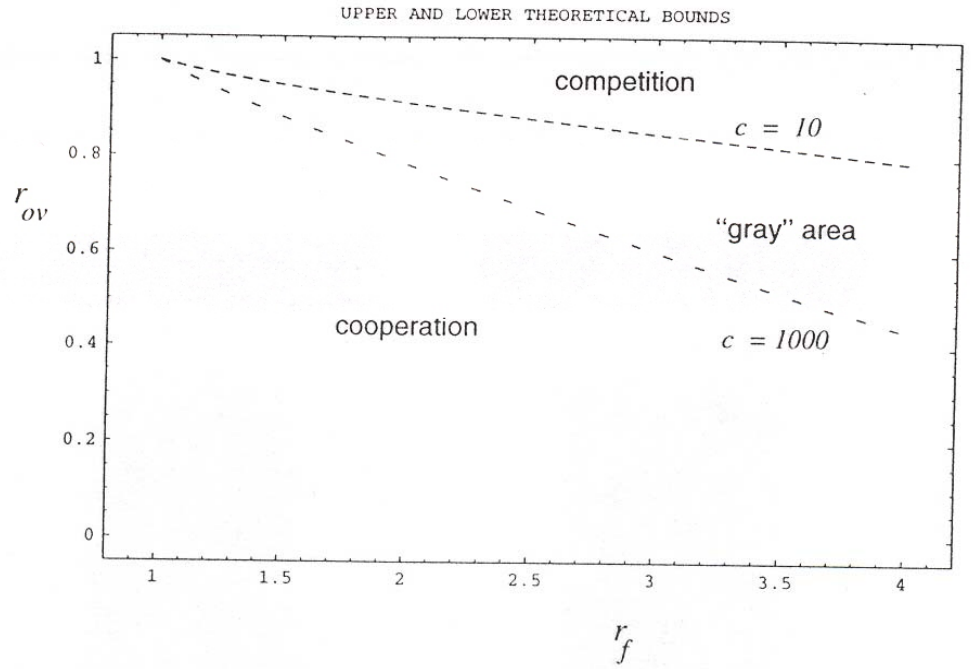



Figure 6: Theoretical *cooperative-competitive* boundary for resource sharing given population size $N = 50$, and by arbitrarily choosing $c = 10$ for the niching failure boundary (the lower bound on competition) and $c = 1000$ for the niching success boundary (upper bound on cooperation).