Math*4060

Project 2:

Sunburn: Coevolving Strings

Andrew Crowell

Overview

The purpose of this experiment was to investigate the benefits and drawbacks of gladiatorial tournament selection on the evolution of a population of 200 ships with 20 systems (**G**uns, **L**asers, **M**issiles, **S**hields, or **D**rives) and a preferred range ranging from 1 to 20 generated at random. Each ship begins at a range of 20, and gradually moves to their desired position according to drives, all the while shooting their opponents and destroying parts of the ship. They fight each other until there is either a victor, or the battle ended in a tie. The effects of gladiatorial selection on evolution of the ship designs, given the starting constraints and a competitive survival-oriented environment, were observed.

Note that at a range *r* the probabilities of successful hits by weaponry systems were :

$P_{guns}(r)=0.6-(r-1)/38$

$P_{lasers}(r)=0.35$

$P_{missiles}(r)=0.1+(r-1)/38$.

Method

The code provided by the instructor follows the process described below using a random seed of 45169.

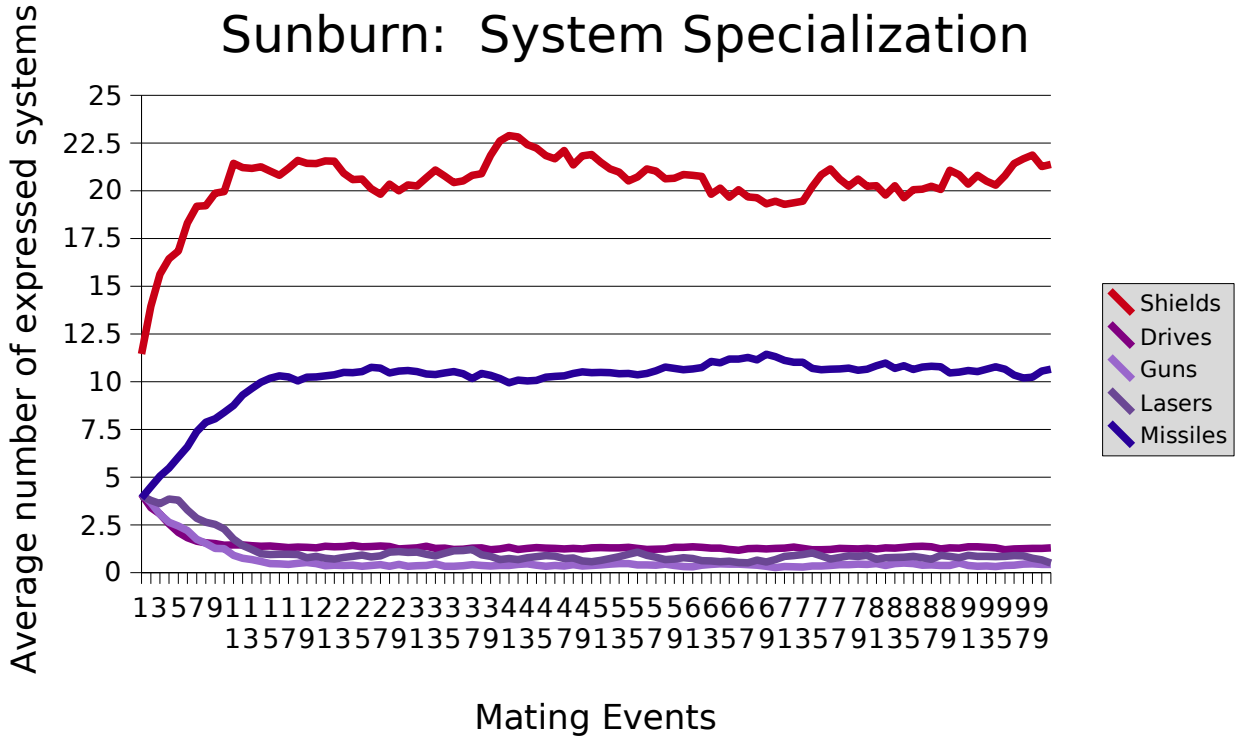
Use two-point crossover with the preferred range treated as the last character in the string making up the ship design. Use single-point mutation which replaces a ship's system locus with a new random system, or increments or decrements the preferred range by 1. Always use a starting range of 20.

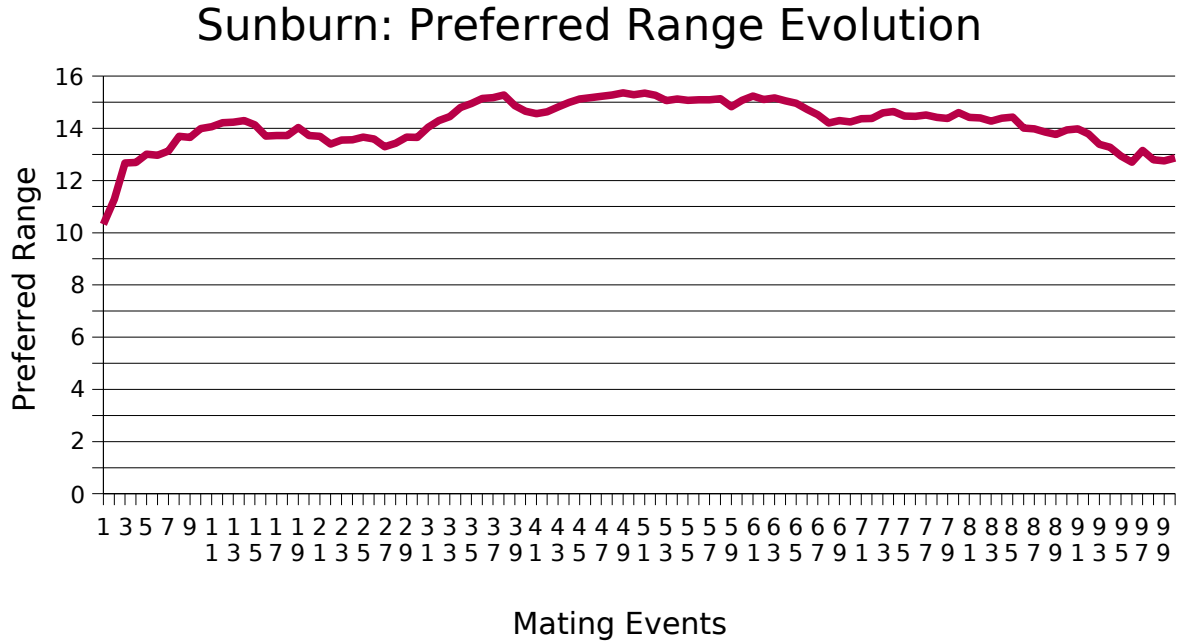
In place of generations, do 100 mating events. After each 100 mating events, report the fraction of the population's genes devoted to each type of system, the fraction of ships that have a drive in the last position (something the rules favor), and the ratio of shields (genetic loci that are ``S'') to weapons. In addition, report the mean and standard

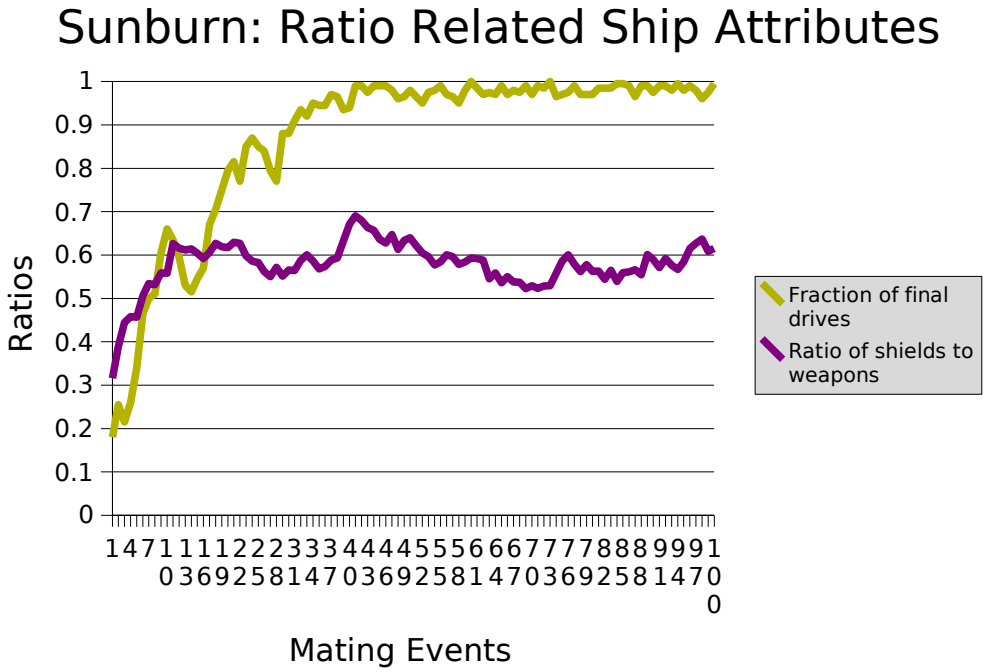
deviation of the preferred ranges and the fraction of combats that are draws. Run each population for 100 "generations," *i.e.*, 10000 mating events, and run 20 populations with distinct initial populations for comparison.

Results

The following are some charts summarizing various ship-related information, showing how the design evolved over “generations” of mating events for a typical evolved craft from the runs.







The following is a run-time summary extracted from the Runsummary.dat file the C++ program wrote. The counts list for the systems are averages for each run.

Time	Shields	Drives	Guns	Lasers	Missiles	Fraction of final Drives	Ratio of shields to weapon genes	95% confidence interval on final preferred range	% of draws
10000	20.58	1.27	0.4	0.65	10.83	0.99	0.58	12.835±2.92366	0.39%
10000	19.82	1.19	0.3	0.81	11.11	0.03	0.54	16.225±3.5587	0.45%
10000	20.25	3.66	1.28	1.23	7.09	0.98	0.7	8.055±8.38999	3.10%
10000	20.84	1.32	0.32	0.84	10.59	0.99	0.59	18.025±1.59824	0.37%
10000	20.19	1.33	0.39	1.08	10.48	0.99	0.56	10.03±1.86255	0.43%
10000	20.49	1.28	0.26	0.77	10.87	0.97	0.57	17.825±1.80952	0.33%
10000	20.06	1.23	0.55	1.14	10.4	0.95	0.55	13.33±3.24517	0.30%
10000	21.51	1.22	0.37	0.57	10.68	0.99	0.62	17.605±2.53357	0.32%
10000	19.4	1.29	0.33	0.57	11.36	0.99	0.53	16.41±2.22978	0.38%
10000	19.35	1.36	0.27	0.59	11.34	1	0.53	18.325±1.51307	0.28%
10000	20.75	1.3	0.32	0.57	10.9	0.98	0.59	18.495±2.39791	0.30%
10000	21.02	1.29	0.26	0.56	10.9	1	0.6	17.87±2.36709	0.40%
10000	20.81	1.32	0.34	0.85	10.56	0.96	0.59	10.755±7.43539	0.43%
10000	18.9	1.29	0.33	0.77	11.32	1	0.51	17.845±2.06421	0.35%

10000	21.99	1.22	0.52	0.96	9.97	0.02	0.64	9.355±2.90671	0.47%
10000	21.87	1.24	0.39	0.81	10.28	0.99	0.64	15.075±1.8972	0.36%
10000	19.92	1.44	0.3	0.62	11.01	0.98	0.56	18.115±1.4324	0.41%
10000	17.66	4.56	1.58	1.55	6.43	0.72	0.62	6.395±8.48404	1.71%
10000	20.04	1.22	0.38	0.77	10.96	0.98	0.55	17.31±2.06734	0.34%
10000	20.27	1.87	0.44	1.05	9.9	0.06	0.59	17.03±5.78698	0.46%

Discussion and Conclusions

After running this algorithm, it seems that given the starting range and weapon effectiveness, most of the best fit ships of each run tend to have lots of missiles, and very few guns or lasers. They typically have around 6-7 shield systems which effectively give them around 18-21 shields after they're moved to the front, which rose the chance of survial. None of the runs took less than 10000 mating events, which suggests the ship optimization was going in a good direction. Some of the runs had a higher percentage of draws (for example 3.10% on the third run), but it was not significant enough for it to substantially affect the evolution. Evolved ships either preferred a long range, or a range right around the middle. In most runs, there were about 1-4 drives. Almost all runs managed to, on average, put one drive sytem in the end slot, but about 3 failed. The good ships typically had around a shield:weapon ratio of 1:2.

From the chart of the first run, we can see that it takes about 15 mating events to get a fair idea of what systems it will stay with for the rest of the evolution. The preferred range remains mostly constant, but that is partially because there's only a 10% of mating affecting that. It becomes apparent that the arrangement of the systems is where the most development is spent, as it isn't until the ratio of drives at the end of the ship really starts to rise, and there really isn't much variation as far as what systems are kept and replaced later on.

As far as some of the more “failed” runs go (like where there are almost no drives on the end), it can be partially attributed to gladiatorial tournament selection – sometimes the bad ships just get lucky. This in turn starts to skew the evolution to favor this flawed ship design, and it will progress further. But although gladiatorial selection is at a slight disadvantage for its elitist tendancies, it at least makes the evolutionary process for combinatorial equipment-based combat survial a lot less complex and more computationally efficient.