Steve Dixon

4560 HW 5

**Q1:**

GA description:

For my GA, I use and array of individuals to represent the population. Each individual has and X value, a Y value, and a calculated fitness value. X and Y values are generated randomly using nextInt to get the integer value before the decimal and nextDouble is used to generate the value behind the decimal point. A child is created by Averaging the X and Y values of the parents. Each parent is selected in a 2-participant tournament. In the tournament each individual gets a random fitness multiplier of 0, 1, or 2. This ensures that even weak individuals have a potential to win tournaments. Mutation has a 1 in 40 chance of occurring based on a randomly generated value. The GA is a steady state GA. When replacing individuals, the newly created child enters a tournament with the weakest individual with the same rules as mentioned before. If the child wins, he replaces the weakest individual. If the child loses, the weakest individual gets to survive. As a side note, I noticed small population sizes lead to premature convergence so through experiment I have decided upon a final population size of 400 for the steady state GA.

Notes for operation:

There is a global/static Boolean variable at the top of the code called “verbose” if you want a more detailed printout of GA activity. Set “verbose” to false and recompile if you just want the calculation results without the extra printout data.

The fitness function can be changed by assigning 0,1, or 2 to the “fitnessFormulaOption” variable at the top of BOTH the Q1 and individualQ1 java files. Use 0 for default, 1 for the 3x function, 2 for Ackley's function.

Results: Original Fitness Function

Run 1:

The Best Individual Of 2000 Fitness Calculations:

X: 0.010678310693140514

Y: -0.1302044920960903

Fitness 0.20164245805169664

Run 2:

The Best Individual Of 2000 Fitness Calculations:

X: -0.4852659133315598

Y: -0.05826450880888023

Fitness 1.185413653577561

Run 3:

The Best Individual Of 2000 Fitness Calculations:

X: -1.9167290924663725

Y: -0.006840551842327791

Fitness 2.4623964712379496

Run 4:

The Best Individual Of 2000 Fitness Calculations:

X: -2.00217681463803

Y: -0.04669948175253957

Fitness 2.362402774557159

Run 5:

The Best Individual Of 2000 Fitness Calculations:

X: 0.17080857547386885

Y: -0.07946349589000357

Fitness 0.44004919111204815

Run 6:

The Best Individual Of 2000 Fitness Calculations:

X: 4.707535203172103E-4

Y: 0.7031039992514045

Fitness 1.2697594710771436

Run 7:

The Best Individual Of 2000 Fitness Calculations:

X: -1.0144485308295899

Y: 0.9997078521740159

Fitness 2.1073989772523163

Run 8:

The Best Individual Of 2000 Fitness Calculations:

X: -0.010517698658426777

Y: 0.17776128048800155

Fitness 0.2942634050016855

Run 9:

The Best Individual Of 2000 Fitness Calculations:

X: -2.9835912877062745

Y: 0.9797890882328764

Fitness 4.419083745022689

Run 10:

The Best Individual Of 2000 Fitness Calculations:

X: -0.2932531504314664

Y: -0.06166961807293769

Fitness 0.7059089672692247

Results: 3x Fitness Function

Run 1:

The Best Individual Of 2000 Fitness Calculations:

X: 0.6671194940443081

Y: 0.014788570869102458

Fitness 0.7795545346758593

Run 2:

The Best Individual Of 2000 Fitness Calculations:

X: -0.021777999747790655

Y: -0.0639387836070229

Fitness 0.15177085565785803

Run 3:

The Best Individual Of 2000 Fitness Calculations:

X: -0.2852143427169307

Y: -0.05879992118937016

Fitness 0.6757703065313138

Run 4:

The Best Individual Of 2000 Fitness Calculations:

X: 0.27708624408886706

Y: -6.092052873249987E-4

Fitness 0.41970204272649775

Run 5:

The Best Individual Of 2000 Fitness Calculations:

X: -0.4365368722677694

Y: -0.2847965169324227

Fitness 1.6360223212427103

Run 6:

The Best Individual Of 2000 Fitness Calculations:

X: -0.14321720527245252

Y: -0.07587498525588976

Fitness 0.5765135020228096

Run 7:

The Best Individual Of 2000 Fitness Calculations:

X: -0.0019727274566685438

Y: 0.34605866893803205

Fitness 0.3961424196731621

Run 8:

The Best Individual Of 2000 Fitness Calculations:

X: -0.023751012597121784

Y: -1.382992779747072E-4

Fitness 0.029223477744922784

Run 9:

The Best Individual Of 2000 Fitness Calculations:

X: -0.02991708382565115

Y: 0.004138338728579771

Fitness 0.044858947505247784

Run 10:

The Best Individual Of 2000 Fitness Calculations:

X: 0.31340179177877936

Y: 0.009026934807357279

Fitness 0.4100396275346946

Discussion:

The Fitness values calculated after the change in fitness function using 3x have resulted in a smaller range of fitness functions. These fitness functions tend to be closer to zero/minimization than the previous function that has a greater fluctuation of fitness values and typically larger fitness values. This indicated that the second function converges faster than the first function using this GA, but what is not known is whether the GA using the second fitness function is converging to a local optimum instead of a global optimum. We do know that second function increases the local optima by approximately 10 time. Therefore, is it safe to conclude that from this information combined with the less diverse final evaluations that it is more like than not that the GA is converging to a local optima.

**Q2:**

GA description:

The representation and operations are very similar to the above implementation except that there exists an array of length 30 as its genes rather than an x and y value. Also, the fitness function has been changed to the Ackley Function. In crossover, this array of length 30 is averaged between parents. Each parent is selected the same as previously. Mutation changes one element in the individual’s array to a randomly selected value within the given range of [-30,30]. Replacement behaves the same as before. Survival selection works with the same system as before but with the new fitness function. I changed the steady state population size to 40,000. I may make smaller and see if I get better results.

Run 1:

The Best Individual Of 200000 Fitness Calculations:

Genetics below:

-7.172095497842221

-12.055139554806724

1.1519257213265401

-4.201088563575433

1.4439971677761216

10.164094532631598

-14.07986491869083

-7.862779543327171

4.0231784663376695

4.823035592903232

1.8314452327283441

6.7885876383054375

19.755450043662947

7.065064985827772

-10.954777546071327

-19.08730011649345

-10.699973061530384

10.390033530946265

-8.035711150885826

0.07765733851953949

15.724148581762083

-14.414096625139917

7.194760459857927

-25.00454812500276

11.84094993708421

3.4808171913777706

2.3423772580775957

10.060016511990657

1.5949962100394606

25.820733285562373

Fitness 19.35045093958499

Run 2:

The Best Individual Of 200000 Fitness Calculations:

Genetics below:

-16.61034842689475

9.577364297725438

12.198003842684868

-0.5664884777570871

-5.619836965923453

9.357268621544781

-1.0416853137030637

5.0662348885056065

-12.252503719074694

-1.2956113674412253

5.272619707219734

6.2707922949005805

4.3364814047385325

-7.973252257900196

3.6377949206799953

-6.562610385305178

2.506324232078284

-2.7494369451641143

2.5367813832297865

3.5219139308263587

-19.022733405948184

9.276426801932008

22.988303875552972

-15.377182211233475

-7.574477116543536

-5.750748902655695

14.840129003878278

-21.959963582288736

-4.684388055844051

9.767853881689591

Fitness 19.315107460018893

Run 3:

The Best Individual Of 200000 Fitness Calculations:

Genetics below:

27.45283333725699

-1.1064112876507886

-0.7110173775096049

20.409609314104124

10.336986563613436

14.095805287226622

-8.557276822574403

-5.7699936892184045

12.105665118463989

-1.7219704347047888

-2.6241291241859894

-15.07304693596452

4.952069237247133

-5.167093331684109

-0.676924974396494

9.453122529818279

1.461684352771754

6.984841788354754

-16.428235839817006

-8.40544381355633

13.641190532195349

6.941332091413285

-17.248102705150764

8.193488610675486

14.785229816376454

0.8698758560080172

-0.8754904167975441

8.971191354244095

9.617510632098076

-1.4161675886702678

Fitness 19.439777037322813

Run 4:

The Best Individual Of 200000 Fitness Calculations:

Genetics below:

23.116428389821305

-1.3258565420734794

-6.821757033692664

11.178623961941058

14.73306555715638

3.131279028639446

0.8437895304926389

-15.304170368392523

-5.17834067437572

-8.644372687426998

-14.369926739320688

3.477974670536543

-7.166586037575657

1.0585070630968607

-6.644418130426246

0.9800485760178022

7.318395153801479

22.340566307409397

2.231917084261203

-4.058588736708298

10.325791569996554

10.78734331894928

-2.208097429506828

0.07631634651182118

-0.550079332279832

13.193677404833087

15.201812572613488

8.576992290224775

10.169596907835317

4.661156981322882

Fitness 18.94797008754074

Run 5:

The Best Individual Of 200000 Fitness Calculations:

Genetics below:

5.370908201980357

11.365397067013138

2.977515312526832

9.54295289313139

-3.6694067821107064

-5.9120371211602905

8.775856682310339

-7.033292946863691

1.4429002357561036

14.946810834243047

-12.653330719318392

-14.037091388674618

-18.336160660301815

-22.969338806567162

-24.8113343169393

-5.291350671920772

-0.9221859738863546

14.365401623040349

2.150918780697078

-9.08448427669899

-10.517670003807767

16.42849977433811

2.065445814167124

-11.707259187790296

-6.466570272060883

-0.46711453127511837

-10.851897153153855

-0.04111125496986079

-2.0282750348746363

0.88985819905938

Fitness 19.311372917231644

Run 6:

The Best Individual Of 200000 Fitness Calculations:

Genetics below:

14.022276935127886

-8.762062901978982

1.9246988142816626

0.41173756135241424

9.189106221198088

10.109902183441264

-8.93631274394699

-4.1712877740692305

-1.7412081108535529

5.16932297971067

-17.437860485967057

7.000282816580285

-1.6847415629984253

-6.031769842119124

-7.13389368531768

2.2576179326430967

-2.2387554617430774

-1.4300467049012386

-4.493741050780004

-9.538747704411682

-2.151574952308038

1.471726811762741

-19.10687082582853

-25.33265882335134

7.032918240935554

-1.7938335033709905

-22.880649580664667

-12.896505930024382

25.101393499570587

-2.0935424758124714

Fitness 19.189937602516626

Run 7:

The Best Individual Of 200000 Fitness Calculations:

Genetics below:

1.7115974198042683

-8.390445803712806

-12.005277753916376

-5.620380537881349

-12.660470788361769

-5.831743376759451

-9.40638252255479

-15.016740419452276

-10.434287161609106

-5.000797575118142

-9.837743429726448

-5.119956827512031

-19.452628355570074

-14.297569441898636

10.974513955528607

17.887718843986573

-11.293246197950674

-8.999526788957636

10.319780864098128

-27.970547599356863

13.550986588565257

-1.8244012788442303

-4.979493768912241

13.862452225596174

-11.906514626547816

7.0558695494533605

-5.7059382061165085

-4.5115202448292795

-2.708850923012172

-12.874624644545083

Fitness 19.54088891481118

Run 8:

The Best Individual Of 200000 Fitness Calculations:

Genetics below:

-5.469787409302457

-1.75705279582006

-28.08579864490122

4.930935870509813

11.8531022922998

-2.805716080600168

12.810228463484762

-6.022371244932856

-2.7602066411259245

12.072108332813391

5.062773818744121

-3.1760318760272184

-3.3760123793247

-9.177887314215036

7.905779164335497

-13.734637413923956

13.87924143514514

-10.122217711210212

12.189142844738358

10.619858142059687

-7.40335125155079

-9.018592785872729

-4.721230744683596

-22.920114390080858

13.280014907968138

11.354264687766866

17.90530951962132

11.824555432456446

14.114821992024607

1.6722716896769652

Fitness 19.362035516949113

Run 9:

The Best Individual Of 200000 Fitness Calculations:

Genetics below:

0.7586653461597495

0.870925041714844

-9.49501249190433

5.049442126670243

-19.96791431622005

12.92371554918801

-7.42953060951491

6.967376320842218

4.50823428233108

-21.20911911495573

10.242781004434116

-6.3511390787068915

-5.87754556407389

3.356997005320439

20.637155485135878

3.4802931098428216

1.6049377673322716

0.32792154085741876

8.001292434289336

-10.352527606072247

17.48460882296256

14.975322703056424

-6.79603596010543

-15.257576769691392

-5.101864384937087

-3.8290365958704378

-12.411741224170434

1.46708420647243

-12.84465357980318

0.42935003101680425

Fitness 19.264176613518057

Run 10:

The Best Individual Of 200000 Fitness Calculations:

Genetics below:

-5.020505666000315

-15.368131208609686

-19.849118854114405

9.628441040370452

10.705783902416487

0.5101368020573519

8.614299593416611

3.589578581625883

-5.4127667446177865

-5.701043128370787

-2.2098205264099535

-4.5011026270495185

-0.3648585881895696

-4.7272945889377205

9.473863792912141

-13.308136590814488

-4.510102915772447

-12.204780034227268

11.26995734784193

-4.177978112170655

-10.391248159717033

-0.43815222144975685

-15.610308888817174

1.6384110864543362

18.554178663330948

21.92948902026045

7.976641100339899

3.752147057265602

2.2690823937416833

12.649012068939447

Fitness 19.350362193047257

Discussion: because I could not get a sub 18 value, I will attempt to change some parameters. I have made mutation twice as likely (from 1 in 40 to 1 in 20) and cut the population size to 1000

Results of one run:

The Best Individual Of 200000 Fitness Calculations:

Genetics below:

-3.1529094350229387

15.421344553875626

-7.426734197681601

4.198685768347849

-1.1179437904253962

-0.993573921886005

-3.4433335559009848

-9.20357517587765

-2.9051111003480834

-5.040757785327359

-3.9711725040654033

3.911618822410645

-1.6003174692345699

-2.149125776082964

-9.905705177889892

-2.0810469178444793

4.090872805006557

-5.773446769833975

1.9804650652501126

-1.0878331578931841

3.001125923299403

8.254277549545897

4.846562681718267

3.052951350921704

-2.1220355510563924

0.867869634864737

0.9522102254922391

5.081061165057445

-12.044614424486985

-3.2866209398929707

Fitness 18.034851255730523

I decided to further decrease mutation rate to 1 in 5.

Result of one run:

The Best Individual Of 200000 Fitness Calculations:

Genetics below:

-9.009046915792785

-0.004626435625731895

-14.860111141431933

-3.2855877687162347

15.440803689491238

1.5138713949939562

-1.9689076578991904

2.309962540475092

-1.7411276624700633

-0.12367107707006264

4.012094352799043

6.597345645026895

1.9341381057471523

4.003930236534745

-2.0107527255764577

-1.0848727003685779

-3.108311701322065

-9.134214419383131

-1.2231383415435177

3.9476587541950106

11.2012566081083

4.986896004010757

9.072466294155975

-2.979608988880674

9.208462618815915

8.971496602382452

-1.919065364510429

1.9980105785645883

14.111841745678685

-0.7363473347836414

Fitness 18.0569425894241

The last result is comparable so I will further decrease population size to 500.

The Best Individual Of 200000 Fitness Calculations:

Genetics below:

-3.1247308649431718

-3.9434120294695436

3.0745839278515383

3.93926022078022

13.154219964346483

-7.099744474372624

9.954511113583795

3.085936645706893

4.0788371816878595

-8.182545221091743

-20.150960195341938

-16.948554574627988

-0.8398200191899085

-10.05692942306956

5.148996141933084

1.639053495355045

1.117808646816163

15.862231318097306

-0.1145702189605417

-3.721900684671809

2.8554845773456377

19.20334571307192

6.813956768905708

1.2805671272264916

-13.800791923606292

-5.928207332036591

8.885854499095139

-19.01697885802055

-3.8268832263343127

0.09851896542130556

Fitness 17.76091804553037

Population further decreased to 250

Result of one run:

The Best Individual Of 200000 Fitness Calculations:

Genetics below:

4.828647615786332

10.956247811073975

6.940175992733766

5.774706817859808

1.1646636445745382

-8.404972161411497

-2.1464848639765997

4.115284595942738

0.8844098022858493

-5.093333779854198

6.002263360992285

-7.193020345086347

3.1938220932312484

-3.731911965288182

-2.2040132605452927

-2.7433084712944504

7.109202170292577

-9.988656817075773

-9.947311681322173

-10.070043909356576

-0.2804021907071026

-6.28167746990195

-3.979612621219542

6.869054705988278

-0.7517138728092403

6.973520989317269

11.022415776752226

-3.203313529577638

-9.947804249616848

5.777222495247149

Fitness 17.679460742545444

Post discussion:

From my experimental results, there is strong evidence that my original mutation rate for the Ackley function runs was too high and my population size too large. I ran 10 more with a population size reduced from 40,000 to 4000 and a mutation rate of 1 in 40 to 1 in 5 chance of a single floating-point value in an individual’s genes being changed to a random value. Below are the results.

Run 1: Fitness 17.82454153458895

Run 2: Fitness 18.658500467238788

Run 3: Fitness 17.137306709408314

Run 4: Fitness 19.172744661886934

Run 5: Fitness 19.256941014642106

Run 6: Fitness 18.224940017079884

Run 7: Fitness 18.375826030505372

Run 8: Fitness 17.91557590216827

Run 9: Fitness 18.378205227396275

Run 10: Fitness 18.44314429556006

The final fitness values seem to be more varied, but we are also getting overall lower numbers which suggests on some runs that we could be escaping some local optima.