AN INTRODUCTION TO GENE EXPRESSION PROGRAMMING

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Agenda

- Evolutionary Computation Overview
- The Gene Expression Programming Algorithm
- What I’m doing with it
- Demonstration
- Conclusions
Evolutionary Computation

A *brief* introduction
Evolutionary Computation

- Biologically inspired algorithms
  - Survival of the fittest
  - Not attempting to duplicate nature

- Evolves populations of “programs”
- Effectively explores problem space
- Handles “noisy” environments
Evolutionary Computation

- Parallel by definition
- Easily distributed
- Very good at optimization
- Can perform multi-objective and coevolutionary searches
Some applications:
- Financial modeling
- Symbolic regression
- Circuit design
- Antenna design
- Evolving Neural Networks
Gene Expression Programming

A not so *brief* introduction
Gene Expression Programming

- Developed by Candida Ferreira
- Always produces valid programs
- Separates genotype and phenotype
Gene Expression Programming

- Linear Genotype Representation

012345678901234567890
+Q- /b**+*Qb aabaabbbbaaab
Tree-based phenotype representation
Gene Expression Programming

- Fixed length chromosome
- Genes make up chromosome
- Genes composed of Codons
Gene Expression Programming

- Genes divided into a Head and Tail
- Functions and terminals in Head
- Only terminals in Tail

\[ \text{Tail Length} = \text{Head Length} \times (\text{Max Arity} - 1) + 1 \]

- Open read frame is executed
Gene Expression Programming

- Replication
  - Fitness Proportional Selection with Elitism
Gene Expression Programming

- Chromosome selection by operators
  - GP = Individual based
  - GEP = Population based
Gene Expression Programming

- **Mutation**

\[
012345678012345678012345678 \\
-+-+-+abaaa/bb/ababb*Q*+aaaba
\]

\[
012345678012345678012345678 \\
Q+-+abaaa/bbQababb*b*+aaaba
\]
Gene Expression Programming

- Inversion

012345678012345678012345678
-+-+abaaa/bb/ababb*Q*+aaaba

012345678012345678012345678
-+-+abaaa/bb/ababb*++*Qaaaba
Gene Expression Programming

- Insertion Sequence Transposition

01234567890123456789012345678901234567890
*-*++a-+a*babbaaababababQ***+abQbb*aabbabaaabba

01234567890123456789012345678901234567890
*-*++a-bba+babbaaababababQ***+abQbb*aabbaaaabba
**Gene Expression Programming**

- **Root IS Transposition**

```
012345678901234567890012345678901234567890
-ba*+++-Q/abababbbaaaQ*b/+bbbabaaaaaaaaabbb
```

```
012345678901234567890012345678901234567890
-ba*+++-Q/abababbbaaa+bbQ*b/+bbaaaaaaaaabbb
```
Gene Transposition

012345678012345678012345678
*a-*abbab-QQ/aaabbQ+abababb

012345678012345678012345678
-QQ/aaabb*a-*abbabQ+abababb
One Point Recombination

\[ 012345678012345678 \]
\[ -b+Qbbabb/aQbbbaab \]
\[ /-a/ababb-ba-abaaa \]

\[ 012345678012345678 \]
\[ -b+/ababb-ba-abaaa \]
\[ /-aQbbabb/aQbbbaab \]
Two Point Recombination

0123456789001234567890
++a*bbccac*baQ*acabab-
*cbb+cccbcc++**bacbaab-

0123456789001234567890
++a*bbcccbcc++*Q*acabab-
*cbb+cccac*ba*bacbaab-
Gene Recombination

012345678012345678012345678
/aa-abaaaa/a*bbaaab/Q*+aaaaab
/-*//abbabQ+aQbabaa-Q/Qbaaba

012345678012345678012345678
/aa-abaaaaQ+aQbabaaa/Q*+aaaaab
/-*//abbab/a*bbaaab-Q/Qbaaba
More advanced GEP techniques

- ADFs (Automatically Defined Functions)
- GEP-RNC
What I’m doing with it...
What I’m doing with it...

- Studying migration
What I’m doing with it...

- Studying diversity
What I’m doing with it...

- Studying self-adaptation
What I’m doing with it...

- Self Adaptive Distributed GEP algorithm
- Syrah
A Brief Demonstration

Cross you fingers…
Conclusions

- GEP is fast
- GEP separates genotype and phenotype
- GEP is easily distributed
- GEP always created valid programs
Further Reading


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PROGRAMMING

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