

jGE Experiments

Grammatical Evolution – Trigonometric Identity Experiments

Experiment 1 – Regular run (12/06/2006)

1a. Trigonometric Identity Tableau for GE (O'Neill-style)

Objective:	Find a new mathematical expression, in symbolic form that equals a given mathematical expression, for all values of its independent variables. Examined Function: $\text{Math.cos}(2 * x)$ Desired Trigonometric Identity: $1-2\text{Sin}^2x$.
Terminal Operands:	x, the constant 1.0
Terminal Operators:	The binary operators +, -, /, *, and - The unary operator Math.sin
Fitness cases:	The given sample of the pairs (x_i, y_i) of 20 data points in the interval $[0, 2\pi]$. The input data points (x_i) are randomly created and their corresponding output points (y_i) are automatically created by the expression $\text{Math.cos}(2 * x)$
Raw Fitness:	The sum, of the absolute values of errors taken over the fitness cases (x_i, y_i) . With the above Raw Fitness the best individuals have lower values. For this reason a kind of Adjusted Fitness will be used and assigned to each individual. Adjusted Fitness of an individual i is typically defined as following: $Fa(i) = 1 / (1 + Fs(i))$ where Fs the Standardised Fitness of i. In this case the Adjusted Fitness of an individual i is calculated as following: $Fa(i) = 1 / (1 + Fr(i))$ where Fr the Raw Fitness of i. The fitness value varies from 0 to 1 and Invalid individuals will have Raw Fitness Value 0.
Standardised Fitness:	Same as raw fitness.
Wrapper:	Standard productions to generate a Java Class with a main() method which prints the fitness values in the standard output
Parameters:	Population Size (M) = 500, Maximum Generations (G) = 50, Prob. Mutation (Pm) = 0.01, Prob. Crossover (Pc) = 0.9, Prob. Duplication (Pd) = 0.01, Prob. Pruning (Pp) = 0.01, Codon Size = 8, Selection Mechanism: Steady State GA with Generation Gap (G) = 0.9 Initial Population: Min Codons = 20, Max Codons = 30

1b. BNF Grammar

```

<expr> ::= <expr> <op> <expr> | ( <expr> <op> <expr> ) | <pre-op> ( <expr> ) | <var>
<op> ::= + | - | / | *
<pre-op> ::= Math.sin
<var> ::= x | 1.0
    
```

1c. Trigonometric Identity Results

Run	Generations	Phenotype	Raw Fitness
1	50	$\text{Math.sin} ((\text{Math.sin} (\text{Math.sin} (\text{Math.sin} (1.0))) - (x - 1.0 * (1.0 - x)))))$	0.4459783870705233
2	50	$\text{Math.sin} (\text{Math.sin} (1.0) + (x / 1.0) + x - (1.0 - (1.0 + \text{Math.sin} (\text{Math.sin} ((1.0 * 1.0))))) / ((\text{Math.sin} (1.0) * x / \text{Math.sin} (1.0)) / x))$	0.8333399712132575

Prob. Crossover (Pc) = 0.9, Prob. Duplication (Pd) = 0.01, Prob. Pruning (Pp) = 0.01, Codon Size = 8, Selection Mechanism: Steady State GA with Generation Gap (G) = 0.9 Initial Population: Min Codons = 20, Max Codons = 30
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2b. BNF Grammar

```

<expr> ::= <expr> <op> <expr> | ( <expr> <op> <expr> ) | <pre-op> ( <var> ) | <var>
<op> ::= + | - | / | *
<pre-op> ::= Math.sin
<var> ::= x | 1.0

```

2c. Trigonometric Identity Results

Run	Generations	Phenotype	Raw Fitness
1	50	$(1.0 - ((\sin(x) * \sin(x)) / x * (x + x) * 1.0))$	0.9999999999999984
2	50	$(1.0 * (1.0 - (\sin(x) * (\sin(x) + \sin(x)) / 1.0)))$	0.9999999999999984
3	50	$(\sin(1.0) - \sin(x) * (1.0 - (1.0 - \sin(x) * (\sin(1.0) - 1.0 + 1.0) / 1.0 + (\sin(1.0) * 1.0))))$	0.316074268522016
4	50	$((x / x) - \sin(x) * (\sin(x) + \sin(x)))$	0.9999999999999984
5	50	$(1.0 / ((1.0 * (\sin(1.0) + \sin(1.0))) * (\sin(1.0) + 1.0 + x / 1.0) * \sin(x) * \sin(x) + \sin(1.0) * 1.0 * 1.0))$	0.11020479647076155
6	50	$(1.0 - (\sin(x) / \sin(x)) - \sin(x) - \sin(x) + 1.0 / \sin(x) * \sin(x))$	0.9999999999999984
7	50	$1.0 - \sin(x) * \sin(x) * 1.0 * (\sin(1.0) + \sin(1.0)) / \sin(1.0)$	0.9999999999999991
8	50	$\sin(1.0) - (\sin(x) * (\sin(x) + \sin(x)) - 1.0 + \sin(1.0))$	0.9999999999999987
9	50	$\sin(x) * (1.0 / \sin(x) - (\sin(x) + \sin(x)) + (1.0 - 1.0))$	0.9999999999999989
10	50	$((x - x) - \sin(x) * \sin(x) * (\sin(x) * \sin(x)) + \sin(1.0) - \sin(x) * \sin(x))$	0.4371482233591061