Fault-Tolerant Computing with N-Version Genetic Programming

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Abstract
We applied N-version genetic programming (NVGP) to a path prediction problem, and compared the results with a single version GP. Statistics from the experiment suggest that NVGP is a viable method to increase reliability, which reduces output variance and thereby expected meantime to system failure.

1 INTRODUCTION
Programs inferred by sample training based methods such as genetic programming are likely to be incorrect, unless the sampling is exhaustive [1]. To cope with this dilemma, we developed an redundant module software system with an isolated island model GP, and applied it to predict the next location of a moving object. A fundamental assumption of N version programming is that independent modules will have uncorrelated faults, so that a composite system will be more reliable by avoiding simultaneous faults in different modules [2].

2 EXPERIMENT
Our NVGP consists of 5 GPs and one master. The master averages each GP’s prediction at time \( t_i \) to predict the next location of a moving object at time \( t_{i+1} \). After the prediction is output, the master receives the actual location from an external source as feedback. If a GP’s prediction error is beyond a pre-determined threshold, the GP is retrained using the 5 most recent actual locations received by the master. The moving object traverses the hand made path shown in Figure 1.

3 CONCLUSIONS
The NVGP predicts the target path with a statistically significantly narrower error band than a single GP system, even though the NVGP and the single GP produce the same mean of errors. This indicates a longer meantime to system failure, and suggests a degree of fault in the isolated island NVGP.

Table 1: Reliability Increase by NVGP

<table>
<thead>
<tr>
<th>Error Threshold</th>
<th>Reliability Increase</th>
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<tbody>
<tr>
<td>0.02</td>
<td>22.9%</td>
</tr>
<tr>
<td>0.03</td>
<td>163.2%</td>
</tr>
<tr>
<td>0.04</td>
<td>332.0%</td>
</tr>
</tbody>
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References