Taming a Flood with a T-CUP – Designing Flood-Control Structures with a Genetic Algorithm

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Abstract. This paper describes the use of a genetic algorithm to solve a hydrology design problem - determining an optimal or near-optimal prescription of Best Management Practices in a flood-prone watershed. The model has proved capable of discovering design prescriptions that are more cost-effective than existing designs, promising significant financial benefits in a shorter time period. The approach is flexible enough to be applied to any watershed with basic precipitation and soil data.

## 1 Introduction and Problem Description

We use the T-CUP (Total Capture of Urban Precipitation) hydrology model to drive a genetic algorithm that finds cost-effective prescriptions of Best Management Practices (BMPs) to address a severe flooding problem in the Sun Valley Watershed of northern Los Angeles County, California. Due in part to the T-CUP model, the Los Angeles County Department of Public Works recently diverted funds from a proposed $42 million storm drain system in order to retrofit the entire watershed with BMPs, a decentralized method of capturing runoff locally. BMP examples include cisterns, drywells, pavement removal, and planting trees, and are designed to retain most runoff on-site. The Sun Valley watershed is divided into 38 sub-basins that flow into each other.

Each chromosome represents a spatially-explicit prescription of BMP installations. We know a little about the search space and were able to dramatically improve our results through selective initialization - we initialize the first chromosome in the population to be all zeros - a prescription of zero installations of each BMP in each sub-basin. We use a modified version of Eshelman's Adaptive CHC genetic algorithm [1] and added a "tweak" option that allows a user to manually initiate a new epoch through cataclysmic mutation.

We found that the best solutions were not neccessarily a function of compute time or number of evaluations. As seen in Table 1, When large populations run for relatively few generations, the single null chromosome does not have time to propogate through the population before time runs out. Figure 1 plots objective function values (to be minimized) versus number of generations and shows the

Table 1. Summary table of performance for different population sizes and generations

# of generations	Population size				
	25	50	100	200	400
20	69,524	43,300	31,971	33,046	29,824
50	159,322	62,306	19,456	14,529	16,231
100	246,582	136,185	26,636	6796	5725
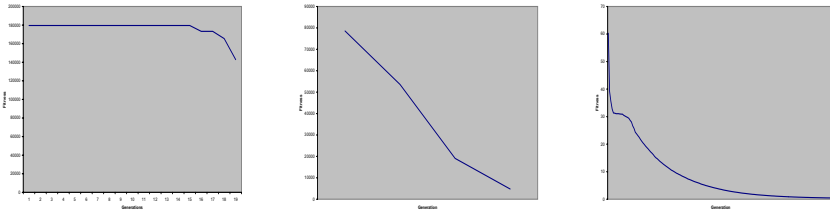
Fig. 1. System performance over three sequential phases.

three phases, geographic viability, meeting runoff targets, and cost minimization that our system goes through. The system quickly finds high quality solutions and we find that our users like to run with small population sizes to more quickly obtain feedback on the structure of promising prescriptions - even if larger population sizes lead to prescriptions with lower costs. The single all-zero individual also has much larger effect on a small population size.

T-CUP provides a useful tool for hyrdologists analysing and designing flood control structures. Our initialization procedure allows T-CUP to provide good flood control prescriptions in reasonable time. With large population sizes, the system can be used to provide a set of promising design solutions. We also find that users like to run the system with small populations to get real-time feedback on the structure of promising prescriptions and so getting a "feel" for the kinds of solutions that would suit a particular watershed. We have a number of improvements in mind and we encourage you to try the T-CUP demo available at www.parconline.com/ga/ – any feedback will be appreciated. The full paper is available at www.cs.unr.edu/∼sushil.

References

1. Larry Eshelman: The CHC Adaptive Search Algorithm, How to have safe search when engaging in nontraditional genetic recombination. in Rawlins G.J.E., editor. Foundations of Genetic Algorithms – 1, Morgan KauffMan (1991) 265–283.