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GETTING THE MOST OUT OF A INTERNATIONAL DIFFUSION MODEL THROUGH EVOLUTIONARY PROGRAMMING.

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ABSTRACT

The use of an evolutionary programming approach called differential evolution for configuring a simulation model is described. Designed to simulate the international diffusion of technology, the simulation model has eight bounded configuration parameters, six continuous and two discrete. The performance of the model is measured using the non-parametric rank order correlation of simulated versus actual year of national adoption of the technology in question. Results show that, with one exception, the best performing configurations identified for simulating the international diffusion of nine technologies compare favorably with a range of published works on diffusion and specifically the international diffusion process. The comparison provides some validation for the model and for the utility of differential evolution as a method for the heuristic search of simulation parameters. The paper can be viewed as a case study in differential evolution applied to finding good quality configurations of a simulation model.

1 INTRODUCTION

In this poster, we investigate the utility of an evolutionary programming approach called differential evolution (DE) for finding a good quality configuration of a simulation model. The model in question represents the international diffusion of technology, combining aspects of agent-based and system dynamics (AB-SD) modeling paradigms. The design and implementation of this particular model are described more fully by Swinerd (2012) while Swinerd and McNaught (2012) discuss the nature and design of hybrid AB-SD simulation models more generally.

The diffusion of nine technologies are simulated, including video cameras, mobile phones, satellite TV and broadband. For each, the year of national adoption is identified for samples of between 70 and 209 nations; i.e. the number of nations for which the year of adoption is known. That is defined here as the year for which user numbers are first reported in either Euromonitor Global Market Information Database (Euromonitor 2012) or the World Bank dataBank (World Bank 2012).

2 DIFFERENTIAL EVOLUTION

Evolutionary programming (EP) approaches employ the evolutionary metaphor to achieve improvement of some user-defined performance measure over search time. The best known approach is the genetic algorithm (GA) and there are numerous examples of its application to simulation optimization.

DE, (Storn and Price 1995), is another example of EP. It is similar to GAs in that it starts with an initial population of potential simulation configurations (or design points in the language of experimental design) and then updates this population through successive iterations known as generations by applying an evolutionary process. Each new configuration has an associated fitness function calculated, corresponding to the performance measure(s) of interest. This might be a single output measure or some multi-objective function of several output measures obtained from a simulation model or, as in this case, a non-

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parametric measure of how well the simulation fits a set of historical data based on rank order correlation. However, while GAs employ chromosomes which are a binary representation of a solution (design point or configuration), DE employs vectors of real-valued parameters. This then necessitates modification of the evolutionary operators although the underlying philosophies of the approaches are the same.

3 THE MULTI-NATIONAL DIFFUSION SIMULATION MODEL

Key traits associated with the diffusion of technological innovation were identified from the literature, e.g. (Rogers 2003) and represented within the model. Eight input parameters define the configuration and control simulation of the international diffusion process. The aggregate timing of the diffusion process lends itself to established equation based rate models, such as Bass (1969). Behavior arising from individual decision making within a social system on the other hand, suggests an AB framework. Another aspect of this model is the decision making of agents (nations). Established theories provide the theoretical foundation supporting 'intention to use' as a predictor of usage in technology acceptance models (Hamre 2008). These equation based theories define weighted combinations of internal and external influences that represent the fluidity of decision making, suggesting the inclusion of another SD module within the model. Hence, the simulation model developed is a hybrid agent-based system dynamics model.

4 IMPLEMENTATION OF DE WITH THE SIMULATION MODEL

Six continuous and two discrete simulation input parameters made up the solution vector which was explored relative to the defined performance measure. The control parameters F (amplification of differential variation) and Cr (probability of mutation) of the DE algorithm were determined through experimentation using the model set for adoption of Compact Disc Player/Recorder technology. The population size was set to 80, ten times the number of model input parameters, in accordance with Storn and Price's recommendation; this population size was used subsequently throughout all experimentation. In order to sample efficiently across the configuration space, Latin Hypercube Sampling was used to select the first DE population, although this is a novel aspect of our implementation rather than standard practice.

5 RESULTS AND CONCLUSION

Across nine technologies, the Wilcoxon signed rank test shows that the simulation model is able to produce results that consistently improve on the baseline rank correlation achieved; p-value < 0.01. Furthermore, model configuration through DE produces results broadly in agreement with diffusion research.

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