Optimisation and Fitness Modelling of Bio-control in Mushroom Farming using a Markov Network EDA

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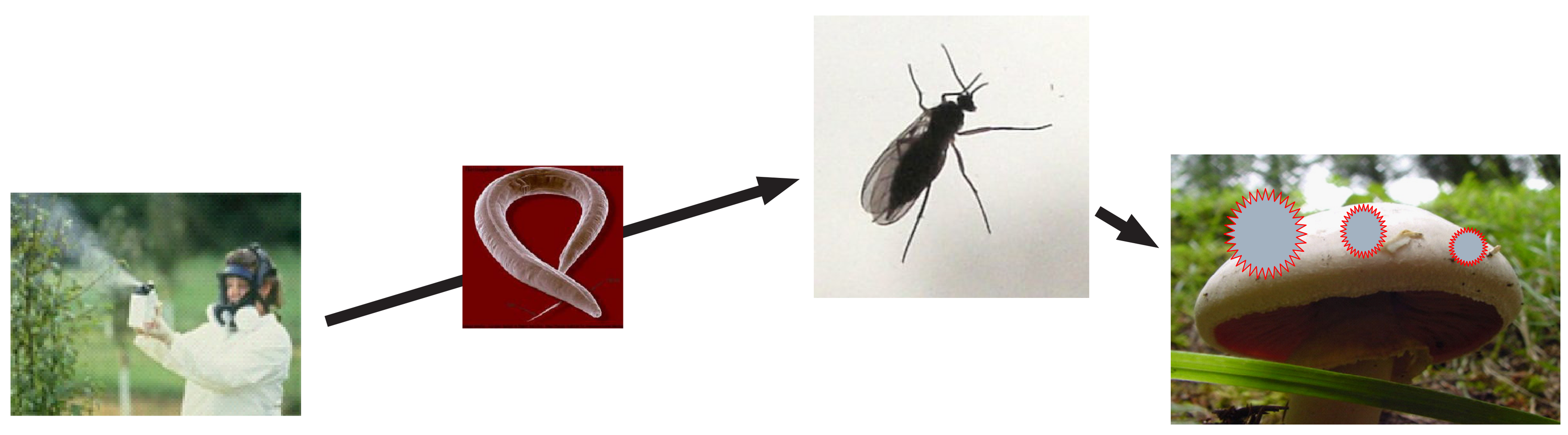
Abstract

We apply an Estimation of Distribution Algorithm using a Markov Network to the problem of bio-control in mushroom farming. GAs with modified crossover operators were previously applied to the problem; the EDA provides a small improvement to the solutions that are evolved. Moreover, the probabilistic models constructed closely match identifiable features in the underlying dynamics of the bio-control problem.

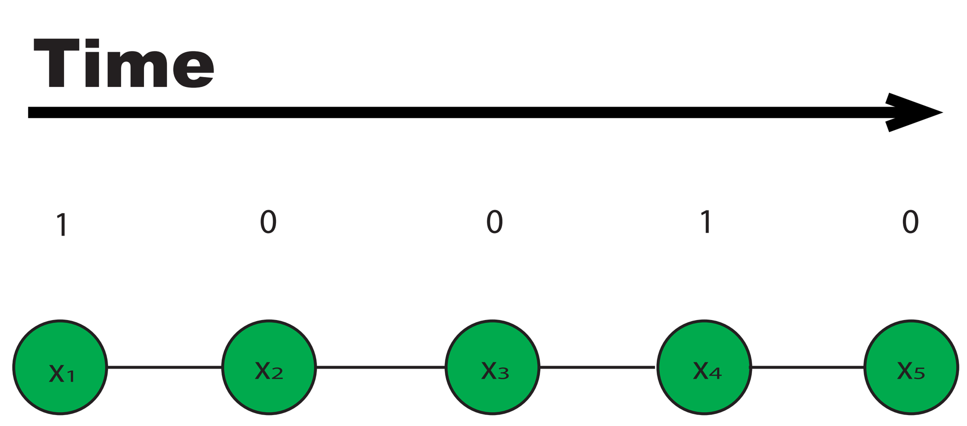
Bio-Control Problem

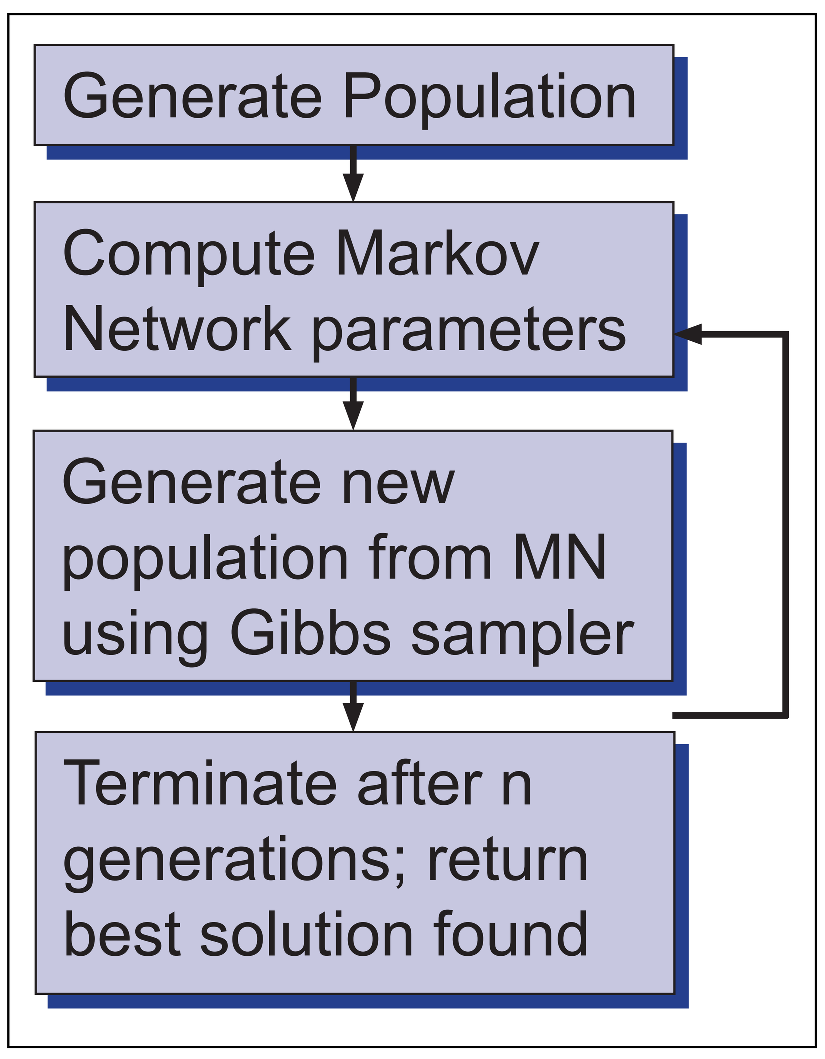


The problem is to find efficient timing interval for the application of nematode worms to sciarid fly infestation in mushroom crops. Optimisation objectives were developed in [1]. Previous EAs applied to the problem including TInSSel [2] used problem specific knowledge to alter genetic operators. The problem admits a bang-bang control strategy, that is a fixed dose of nematodes is applied or not applied at each time point.

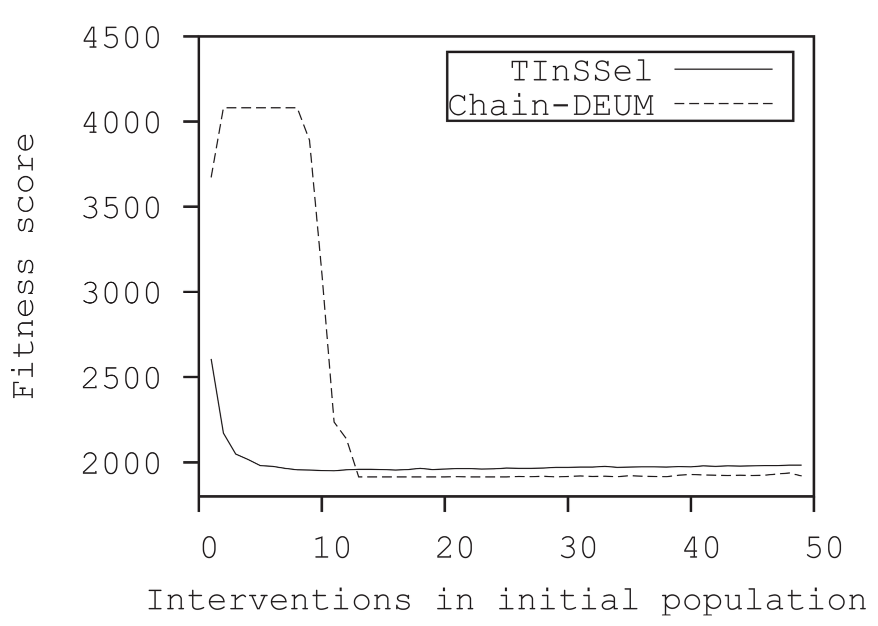
Distribution Estimation using Markov Networks (DEUM)

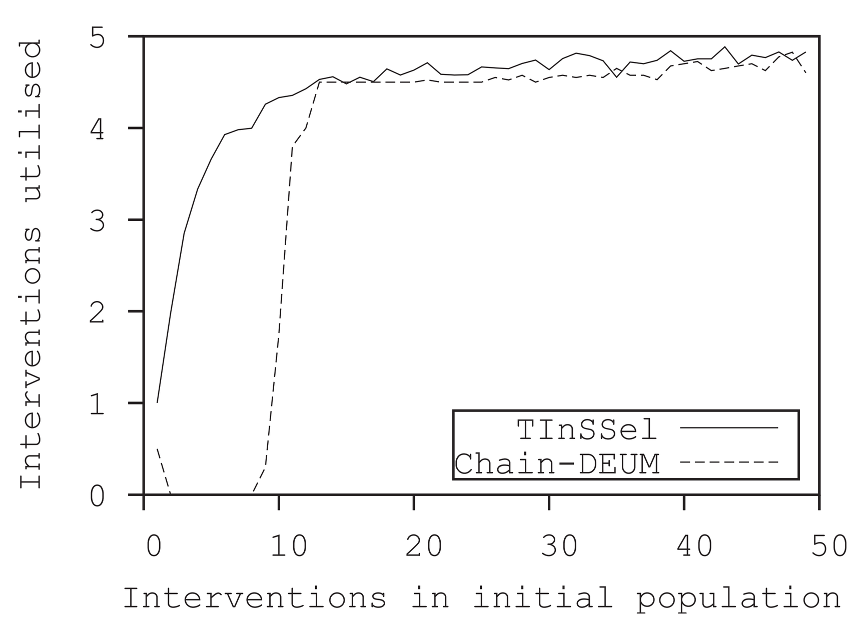
DEUM [4] is an Estimation of Distribution Algorithm [3] using Markov Networks to model the fitness function. In this application we use DEUM with a fixed chain structure.





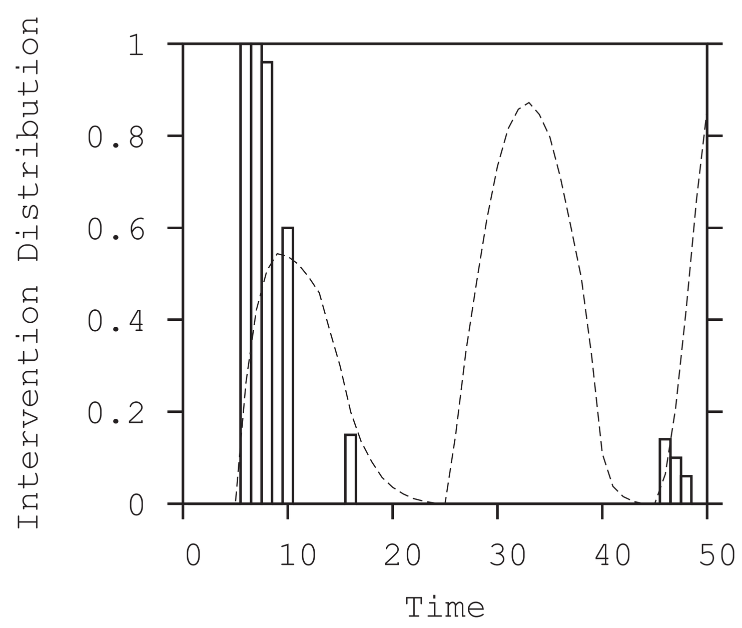
Effect of Seeding Population



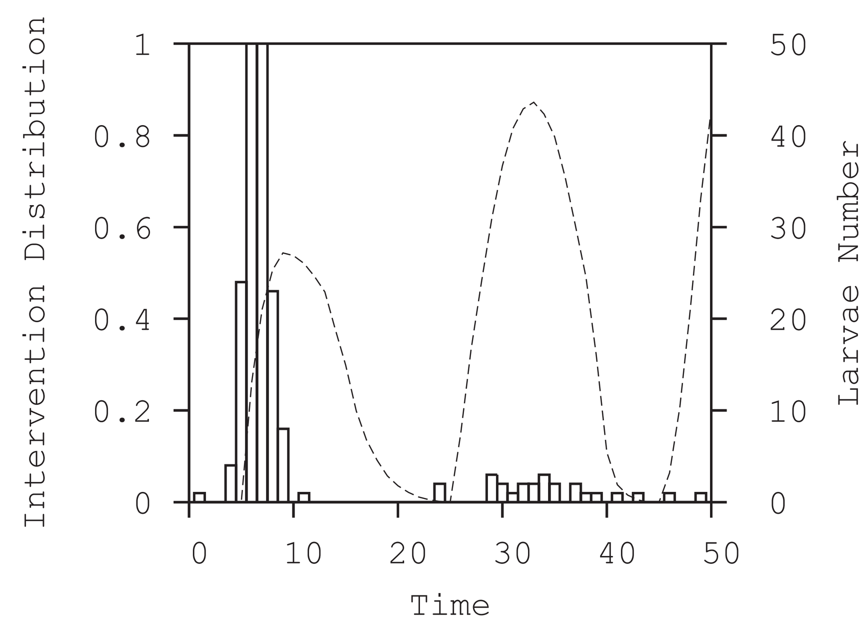


Here we see the fitness (left) and intervention usage (right) of the best solution found after 200 generations for different levels of seeding in the initial population. For constrained starting populations, TinSSel outperforms DEUM. This is reversed as control is removed from the starting population.

Intervention Points



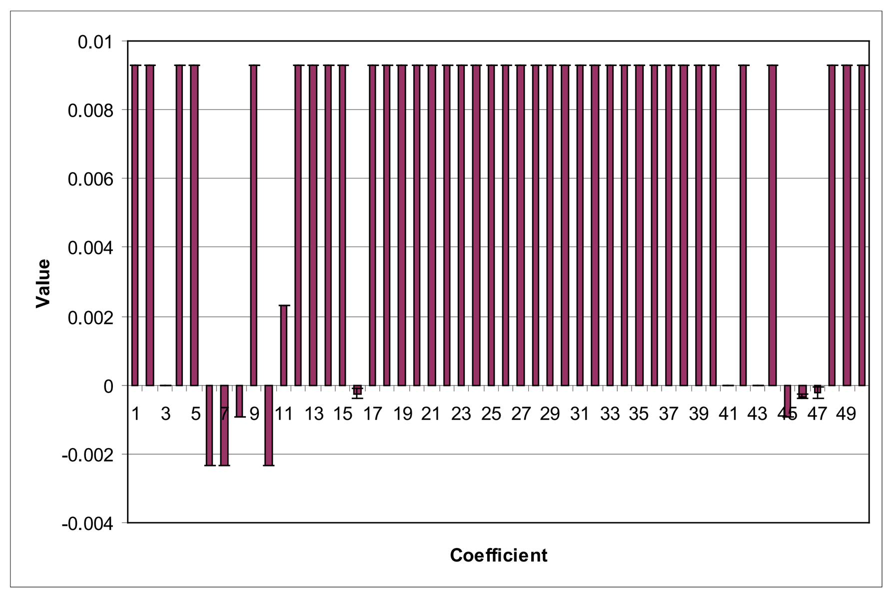
Probability of an intervention each day (DEUM)

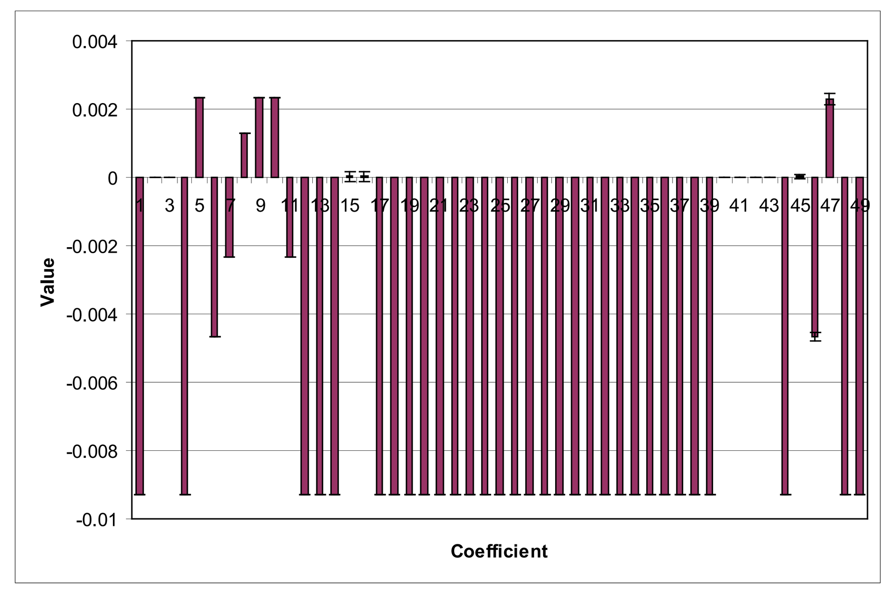


Probability of an intervention each day (TinSSel)

In this experiment, we recorded the days on which interventions occured in the best solution found by the algorithm. The histograms show the probability over 100 runs of an intervention occurring at each day. This is superimposed on the sciarid larvae population graph obtained by running the model with no interventions: that is, the natural growth cycle of the larvae. We can see that DEUM more consistently applies interventions at key points in the growth cycle.

Relation to the Model





The graph on the left shows coefficient values for α (univariate) terms and that on the right shows β (bivariate) terms in the Markov network learned in a single generation. Positive α terms indicate an intervention should not take place; positive β terms indicate points where control should switch from intervention to none (or *vice versa*). It can be seen in the illustrations that the model has detected dynamics of the underlying control system.

Conclusions

We have seen that the EDA finds slightly better solutions than the previous approach using a modified GA and how the probabilistic model constructed by the algorithm closely matches features present in the underlying problem. This provides motivation for further research into how successfully this approach could be applied to more general bang-bang control problems.This work has also revealed that while initialisation control can be helpful or at worst neutral for a GA, it hinders the EDA due to biasing of the model.

References

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