A multiple-landscape model on innovation

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Introduction

- Innovation is familiar to us, but not obvious
- Innovation Theory is a vast area
- Evolutionary Adaptation is a popular approach to modelling
- We treat innovation in purely abstract terms

Why another model?

- Current evolutionary models on innovation have problems
- Gradual innovation is fine, but what about radical innovation?
- Can we try to build something with similar features, but better?

Fitness Landscapes

- Concept "stolen" from evolutionary biology
- When dealing with evolutionary algorithms, some fitness measure appears
- Ties together a design landscape to specific fitness values
- Evolution/adaptation is a walk on this landscape, looking for local/global maxima

Fitness Landscapes

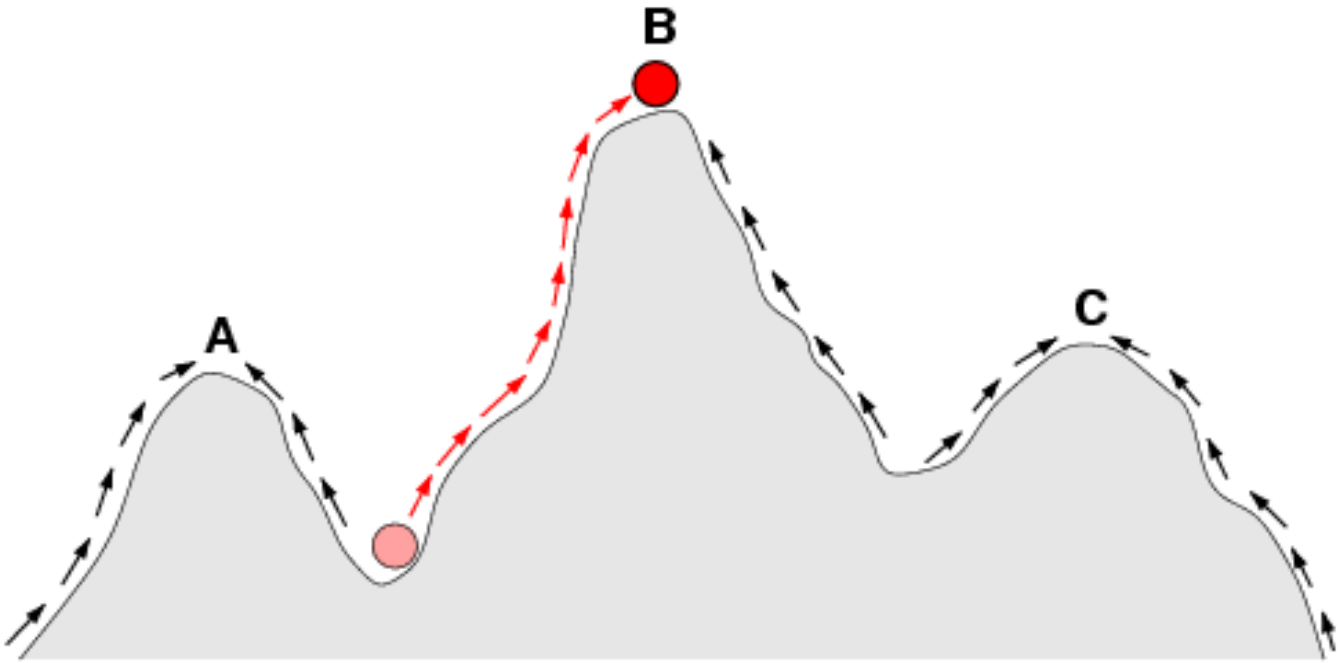
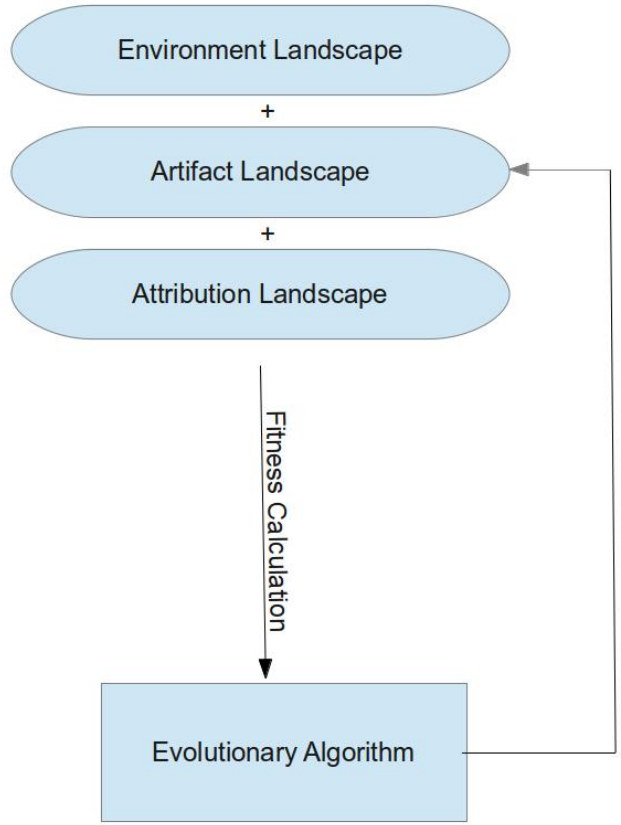


Figure: A fitness landscape and the way a population would evolve on it. Picture shamelessly taken from Wikipedia.

Our Model

- Instead of one fitness landscape, use of multiple landscapes to represent different factors
- Environment, attribution and artifact landscapes
- Evolution is not a walk in a landscape, but a change of landscapes

Our Model


Environment Landscape
+
Artifact Landscape
+
Attribution Landscape
Fitness Calculation
Evolutionary Algorithm

Our Model

- Environment: how much utility different tasks have
- Attribution: what is expected from a certain artifact, or to which tasks it is supposed to be suitable
- Artifact: how good a certain artifact is at performing each task

Our Model

- Not a design space anymore, but a functional space
- Optimization is not finding maxima anymore, but fitting functions
- Different artifacts might be good at different tasks, and have high fitness values based on completely different attributions

Our Implementation

- Three-dimensional landscapes, for simple visualization
- Environment landscape based on a NK-model
- Use of postfix strings for the artifact landscape
- Two-dimensional Gaussians for attribution
- Simple evolutionary algorithm
- Fitness calculated as a difference between artifact and environment, weighted by attribution

NK-landscapes

- Not generated from an analytic function, but from epistatic relations
- For 3-dimensions, each 2-dimensional coordinate was Gray-coded

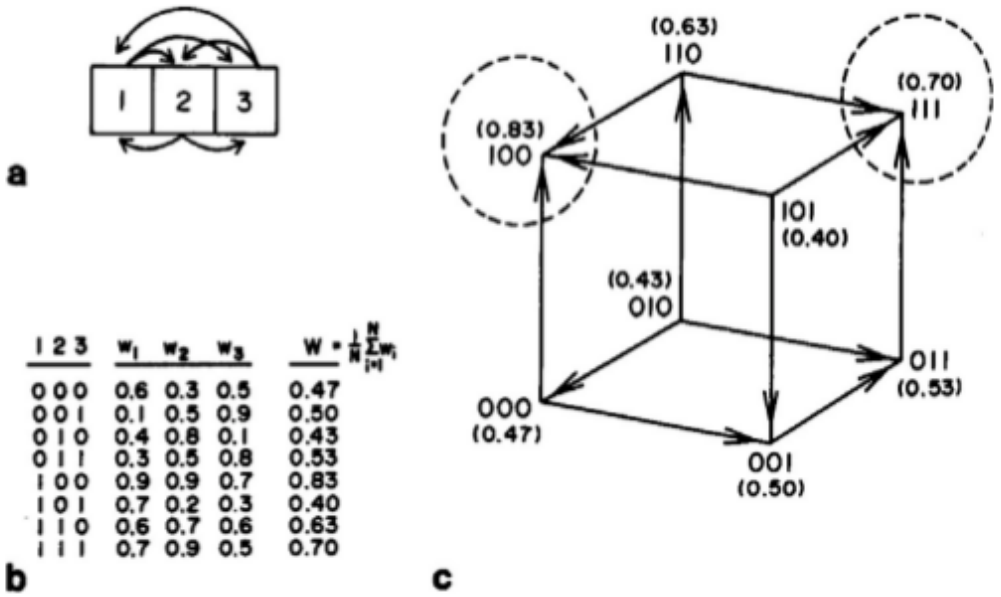


Figure: NK landscape with N=3 and K=2. (Picture from Frenken, 2006)

Postfix Strings

- Easy way to generate functions from genome-like structures
- A set of values and operators are concatenated and solved in reverse Polish notation
- Example:

$$5\ \mathbf{1}\ \mathbf{2}\ +\ 4\ *\ +\ 3\ -$$
$$5\ \mathbf{3}\ \mathbf{4}\ *\ +\ 3\ -$$
$$\mathbf{5}\ \mathbf{12}\ +\ 3\ -$$
$$\mathbf{17}\ \mathbf{3}\ -$$
$$14$$

Basic evolution/adaptation

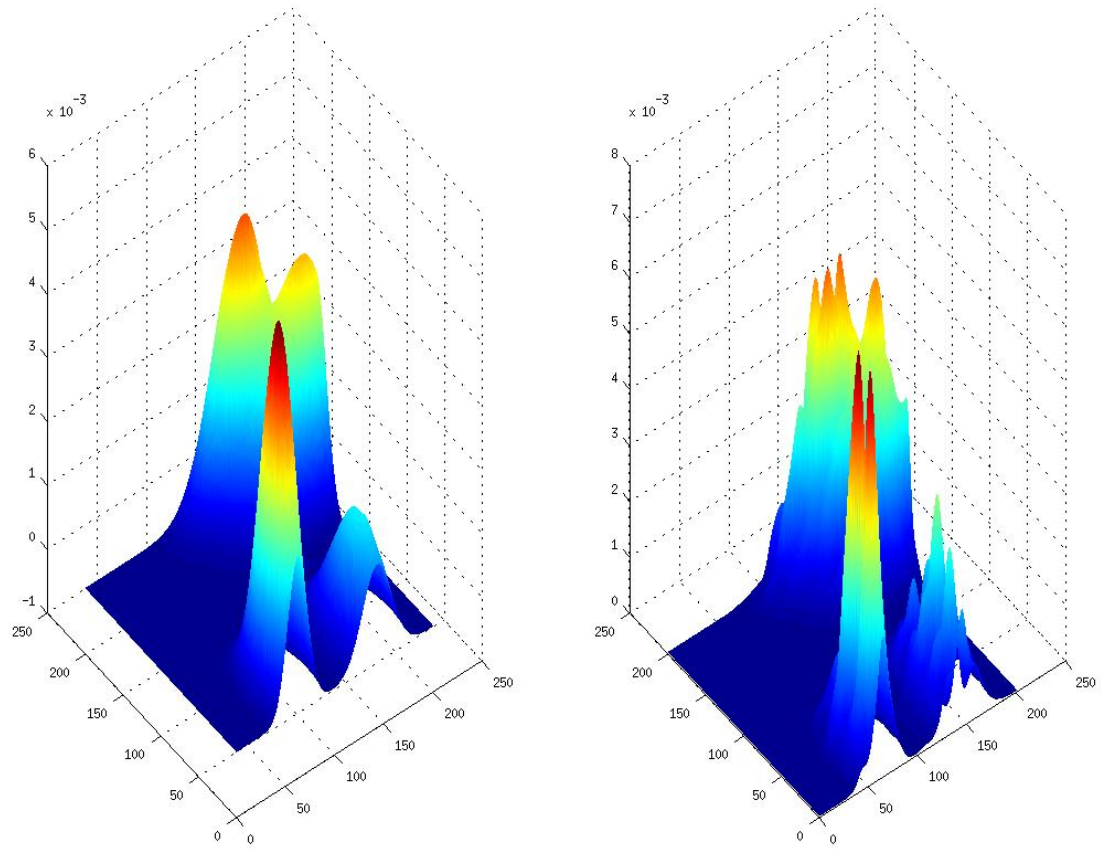


Figure: Weighted artifact landscape adapting to weighted environment landscape.

Specialization

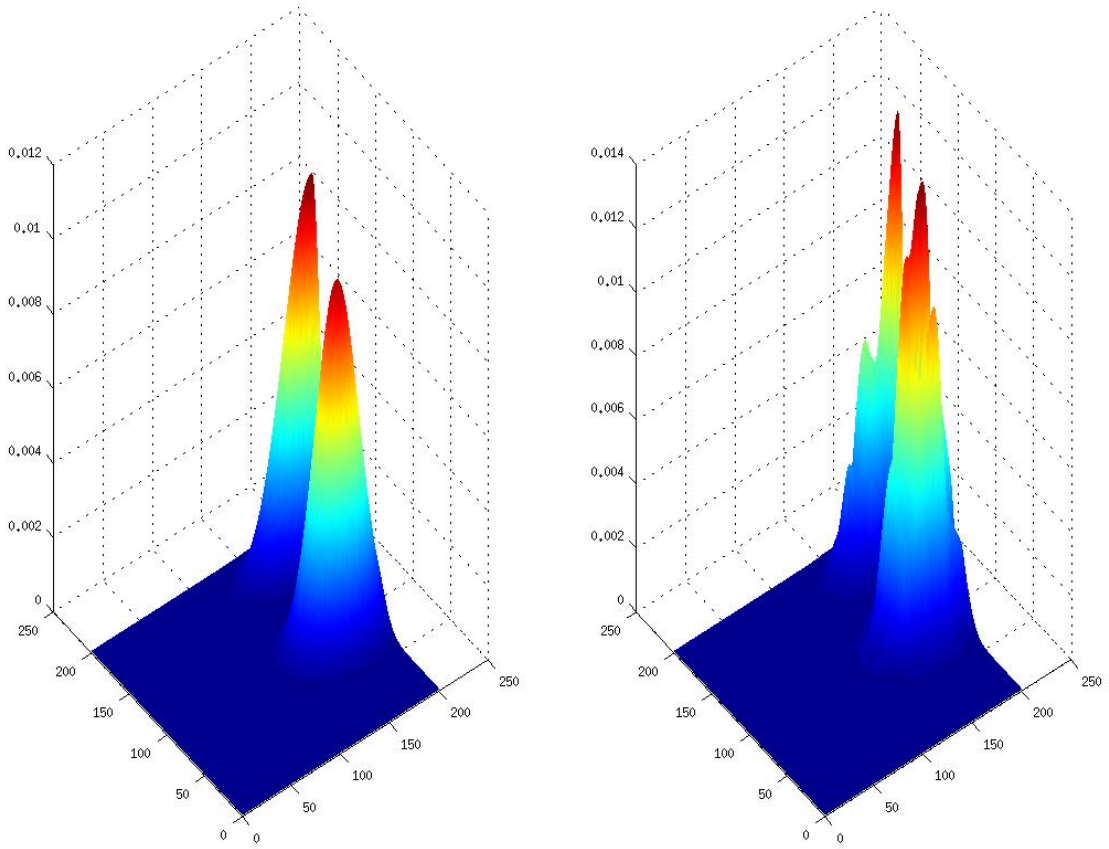


Figure: Artifact with two areas of attribution.

Specialization

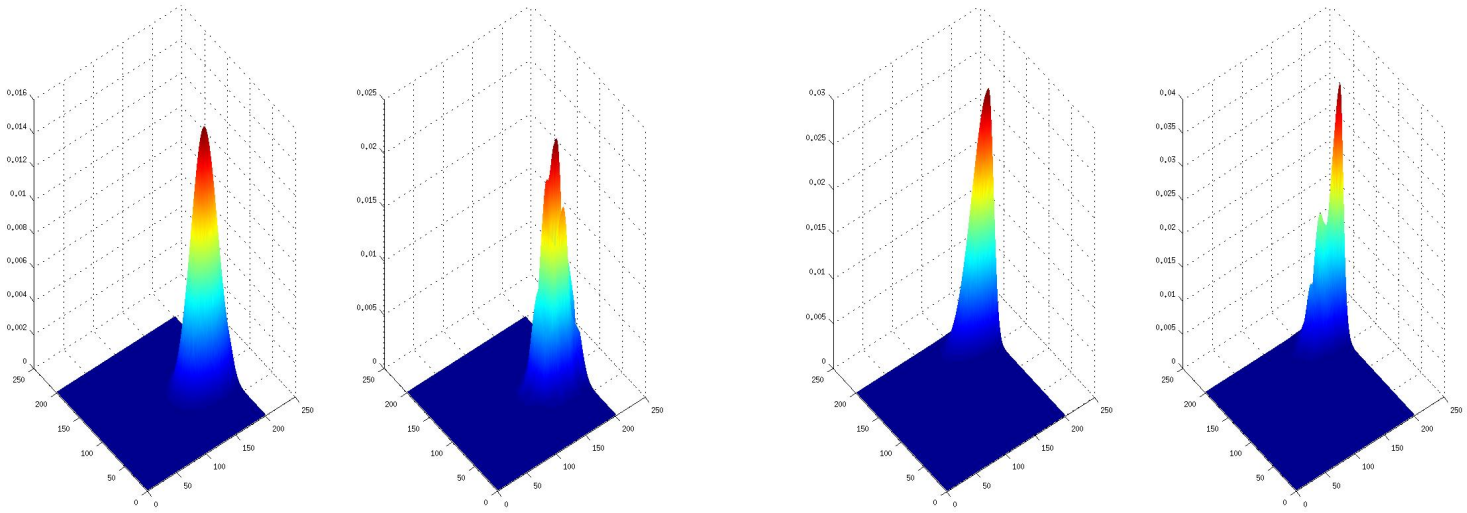


Figure: Two artifacts with separate attribution areas.

Generalization

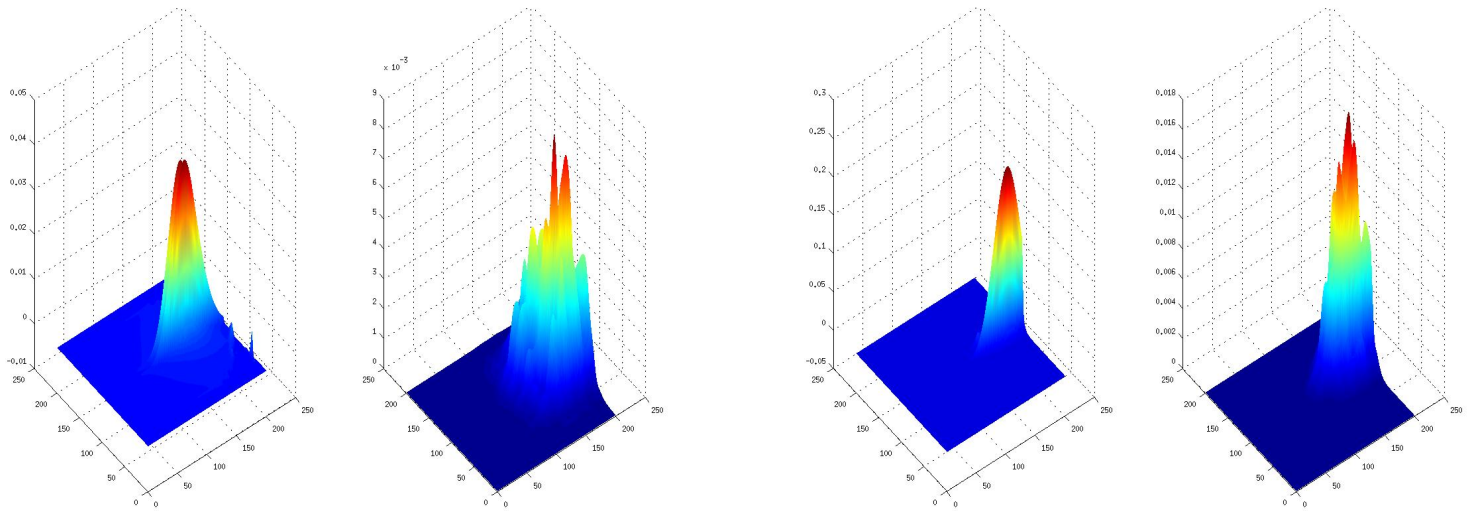


Figure: Two artifacts with separate attribution areas before generalization.

Generalization

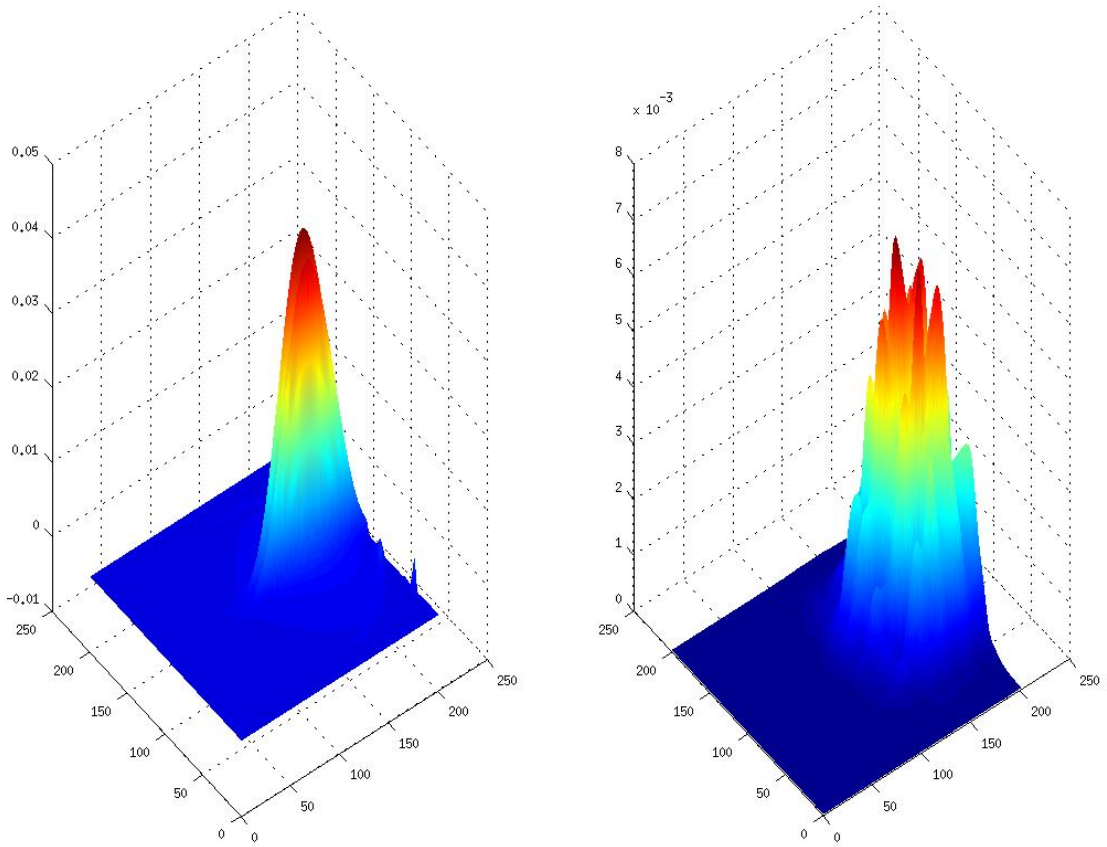


Figure: Artifact with both areas of attribution and taken the genome of one of the pre-generalized artifacts.

Non-implemented, but possible

- Changing environment
- Exaptation, variable attributions
- Competition between different artifacts

Conclusions

- Different paradigm on innovation modelling
- Might capture radical innovation better than other models, while retaining gradual innovation
- Capable of flexible modelling of different features on innovation theory

Future work

- More a framework than a finished, polished model
- Investigate different landscapes
- Make use of the framework established to create more specific models, be it on certain areas of innovation or on certain features

Thank you!