Coevolution of Camouflage

Craig Reynolds
December 29, 2008

Introduction to a simulation-based model

Overview: this project seeks to construct a simple abstract model of evolution of camouflage in the natural world. Given a background texture, the system will discover camouflage textures for *prey* which make them hard to find (cryptic) against the background. Initially this judgement will be made by human observers. Later stages of the project will model **co**evolution of prey camouflage and predators based on machine learning and vision.

Hypothesis: selection pressure from the *visual predator* will gradually eliminate the least camouflaged (more conspicuous) prey, causing the evolutionary population of prey to converge on more cryptic camouflage.

Texture synthesis: camouflage patterns are generated with procedural texture synthesis. Texture is represented as programs written in a language consisting of simple primitive texture generators and operators on textures for combining and modifying the primitive textures. These programs are evolved in response to the predator's selection pressure by a *genetic programming* system[1].

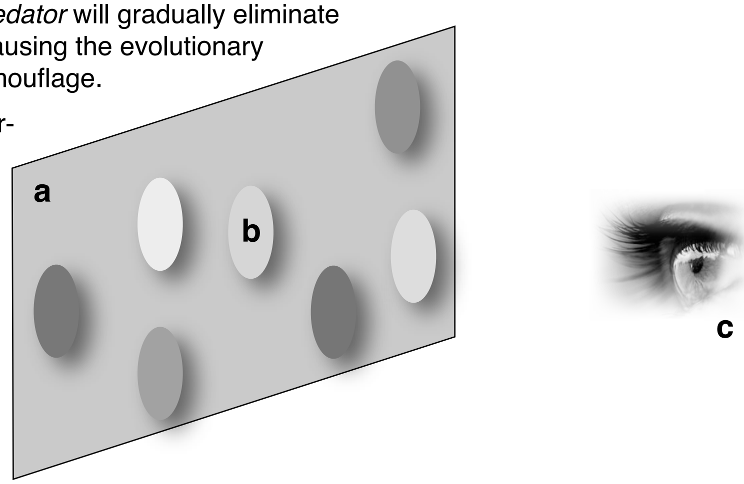

Figure 1. Three main components of the simulation: (a) a given background image, (b) "prey" objects covered with evolved camouflage texture, shown here as grays, (c) the observer, a visual predator.

Interactive evolution: initially the predator will be a human, looking at various prey composited over the background and selecting (with a mouse click) the locations of the *N* most conspicuous prey. At this stage the system is very much like Karl Sims' interactive evolution of textures[2] except instead of purely esthetic choices, the human has a more specific task. Setting a time limit for selections, and assigning scores for performance, will give this task the character of a game, "the camouflage game." The next step would be to accelerate the progress of camouflage evolution by taking advantage of *human computation*, recruiting more players over the Internet. This is very much in the spirit of Luis von Ahn's[3] concept of *Games with a Purpose* (GWAP) as well as earlier systems by Jordan Pollack *et al.*[4]

Coevolution: a larger question is the extent to which the role of the predator can be synthesized, extending the model to include the coevolution of camouflage and predator vision. This portion of the project is more speculative because there are many potential approaches to creating effective predators. Techniques from optimization, evolution, machine learning and machine vision may contribute to this task. For example, it may be possible to train a *support vector machine*[5] to classify sub-images as "just background" and "something over background". A classifier used this way must be able to adapt as the camouflaged prey begin to look more and more like background.

Hybrids: it may be useful to form combinations of human and artificial predators. Pollack's agents were first evolved against each other, and then the better ones were put into competition with human players.[4]

Status: a prototype of the texture synthesis library was implemented in late 2008. A more detailed research proposal is available at http://www.red3d.com/cwr/coc/Proposal.pdf

---

[1] Koza, J. R. (1992). Genetic Programming: On the Programming of Computers by Means of Natural Selection, MIT Press.

[2] Sims, K. 1991. Artificial evolution for computer graphics. In Proceedings of the 18th Annual Conference on Computer Graphics and interactive Techniques SIGGRAPH '91. ACM, New York, NY, 319-328.

[3] von Ahn, L. (2006). Games with a purpose, Computer, 39 (6), 92-94.

[4] Funes, P., E. Sklar, H. Juillé and J. Pollack (1999) Animal-Animat Coevolution: Using the Animal Population as Fitness Function, SAB 5: From Animals to Animats 5, MIT Press. pp 525-533.

[5] Cristianini, N. and J. Shawe-Taylor (2000) An Introduction to Support Vector Machines and other kernel-based learning methods. Cambridge University Press.