

NYU Today
April 16 Research Issue

ITP Professor Jean Marc Gauthier Designing 3-D Interactive Tool for Exploring the Genetic Diversity of World's 10,000 Bird Species

Jean Marc Gauthier, arts professor in the Interactive Telecommunications Program at the Tisch School of the Arts, has been assisting with the All Birds Barcoding Initiative (ABBI), which will collect DNA barcodes for the world's 10,000 bird species. Gauthier is a pioneer in designing 3-D interactive technology, chiefly for displaying data in a small space in order to show its relationship to surrounding data. His zoomable 3-D map of Manhattan's 6000 blocks (www.tinkering.net) is one example of this work.

Gauthier, in collaboration with Mark Stoeckle, adjunct faculty in the Program for the Human Environment at The Rockefeller University, whose interests include environmental genomics, DNA barcoding, and the Census of Marine life, is adapting that same 3-D technology to graph a usable map for birds. DNA barcoding is a standardized approach to identifying species by their DNA. Approximately 1.7 million species of plants animals have been named, and there are probably many more species not yet described, perhaps 10 million in all. Researchers around the world are collaborating on constructing a reference library of DNA barcodes derived from specimens identified by experts and stored in museums.

“Working with Jean-Marc has thus far been an exciting collaboration that I believe will help us better understand genetic diversity among the 10,000 species of birds,” said Dr. Stoeckle. “Birds are a window into biodiversity; what we learn by graphically exploring DNA barcodes of birds we can apply to fish, butterflies, beetles, and plants.”

Despite several hundred years of careful study, genetic surveys including those with DNA barcoding suggest there are hundreds of as yet undescribed avian species. ABBI aims to help speed discovery of new species, provide a practical tool for specimen identification, and open new avenues for scientific investigation. One way to do this is by depositing its records in other DNA barcode databases thereby establishing an open-access electronic library linking its DNA barcodes and other material for others.

The growing avian barcode library will be a valuable resource for conservation planners, ornithologists, ecologists, public health officials, and the interested public. For instance, DNA barcoding can be applied to confirm identification regardless of age, sex, or plumage, including from individual feathers. This will aid banding and customs operations, for example, and help improve airline safety by identifying feathers and tissue remnants from bird strikes. And ABBI is a testing ground for DNA barcoding, providing benchmarks for the larger initiative to barcode all animal and plant life.

Stoeckle explains that because there is genetic variation within species, “we aim to collect DNA barcodes for at least 10 individuals within each species. This has already resulted in discovery of

unsuspected genetic clusters that probably represent new species of birds—at least 15 new species of North American birds so far.”

“The difficult and interesting part is how to display DNA barcode data for thousands of individuals,” said Gauthier. He went on to say that traditional analytic software generates “trees” which display genetic distances among individuals, with one line per individual. With text labels there are about 50 lines per page, which means about 20 pages for 1000 individuals. Most bird specialists work with relatively small numbers of individuals from a small number of species, and even so published trees often are broken up over multiple pages.

“I have tried omitting text labels and find the maximum number of individuals that can be displayed in a genetic tree on one page is about 500,” remarked Gauthier. “We already have 12,000 sequences that we would like to look at in one space and we anticipate eventually having 100,000 sequences from birds, and many more from other groups. It would be interesting to compare genetic relationships among birds compared to those among fish and butterflies, for example.”

Like the 3-D map of Manhattan Gauthier created, his “bird map” plot with 10,000 squares, and each of the world’s 10,000 species is assigned a square, using x and y coordinates of the grid. The species are arranged on the grid according to their taxonomic order, which reflects evolutionary history and puts closely-related birds near to each other, starting with the most ancient lineages.

“What we are doing now is building small neighborhoods inside of the map where birds species can be viewed by height and color,” added Gauthier, “creating an array of ‘virtual buildings’ that display whatever features are of interest, such as differences among and within species, or number of individuals analyzed.” Using the Gauthier’s program on a laptop, someone can open a text file inside a web browser and experience browsing through a virtual city of data. The tool allows virtual cameras to zoom in and out and explore the map from high-up to look at birds as a whole, or close-in looking at single family or genus.

When it’s complete, Gauthier said he is “optimistic his approach will provide for new scientific insights into avian genetic diversity.”

For more about this subject go to:

Live demo using the 3D Life Player from Dassault Systems: <http://www.tinkering.net/bird>

Barcode of Life Database www.barcodinglife.org

Consortium for the Barcode of Life www.barcoding.si.edu

All Birds Barcoding Initiative www.barcodingbirds.org

Visualization projects: <http://www.tinkering.net/portfolio/Gauthier-visualization.pdf>