Project Takes Fish Collection Into The Digital Age

Novel application of MRI leads to new tools for online digital dissection of preserved fishes from one of the world's most valuable natural history collections

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Debra Kain

The same medical technology used to image brain tumors and torn knee ligaments is now taking the field of marine biology to a new dimension by allowing anyone with Internet access to examine fish as never before.

Researchers at the University of California, San Diego's Keck Center for Functional Magnetic Resonance Imaging (fMRI) and Scripps Institution of Oceanography have been awarded a National Science Foundation grant to use magnetic resonance imaging (MRI) to create a high-resolution, three-dimensional, online catalog of fishes from Scripps's Marine Vertebrate Collection, one of the world's most comprehensive and valuable libraries of preserved fish specimens.

"This project will augment the Scripps Marine Vertebrate Collection by using a new tool and a new way to present information about fishes," said Philip Hastings, Ph.D., professor and curator of the Scripps Marine Vertebrate Collection. "It's part of our general effort to make the collection more available to a wider audience."

Project director Lawrence Frank, Ph.D., professor of radiology at the UCSD School of Medicine-who leads the biomedical applications program at the Keck fMRI Center -said that the project will further push development of MRI technology for unique applications in humans as well as other species.

"This project also shows the growing role of cutting-edge imaging and computer technologies in increasing our access to information about not only marine biology, but biodiversity and global ecology as well," said Frank.

The five-year, nearly $2.5 million Digital Fish Library project will support development and application of new MRI technology that, in conjunction with novel data analysis and visualization methods, penetrates through soft body tissue to provide 3-D images of physiological structures.

"The idea is to image the internal anatomies of the entire range of fishes," said Hastings. "Capturing the variation across all fishes will open the door to a range of interesting questions about how species differ. You can imagine comparing the brain of a coral reef fish that relies on vision with one from the deep sea that relies mainly on smell, or comparing the muscles of deep-sea fishes that regularly migrate to the surface with those that stay in the deep."

This variation is part of the challenge, as standard MRI is designed to image human patients, who slide inside large cylindrical "coils" that capture data that is then processed to create detailed computer images.

"Fish come in a variety of odd shapes, so we have to develop new hardware to image them," said Frank. "Engineer Larry May at our center is building special coils for fish. We are also working on new ways of collecting data, since fish tissue can be very different from the tissues we typically image. By tailoring the technology we will further optimize our use of MRI, whether we're imaging cardiac muscle, brain tissue, cartilage or fish."

The technology will enable researchers to acquire and process high-resolutiondata of various fish anatomies that can be placed on the Internet. Using this powerful and versatile imaging tool, scientists, students and anyone in the public will be able to digitally probe and dissect these fishes from a desktop computer anywhere in the world.

Scripps' Marine Vertebrate, or "Fish," Collection, is among the largest and most comprehensive collections of its kind in the world, containing 90 percent of all known families of fishes. With more than 2 million specimens, the collection is used by researchers around the world for investigations of the systematics, biodiversity, physiology, ecology and conservation of fishes. Through the Digital Fish Library project, coordinators will image at least one of every 482 fish families in the world.

MRI is unique in its sensitivity to a wide range of anatomical and physiological parameters, which makes the data complicated to analyze. This led the MRI team to work closely with scientists from computer science, math and engineering-including co-investigator and mathematician Anthony Gamst, Ph.D., Department of Family and Preventive Medicine at the UCSD School of Medicine-to develop novel methods for data analysis and visualization.

Project coordinators will create a resource that allows scientists to remotely study a range of the world's fish species, from the exotic to the mundane. In collaboration with the Birch Aquarium at Scripps, the scientists will also develop the "Digital Dissection Tool," an educational program for high school students that capitalizes on the interactive scientific research aspects of the project.

"By creating the Digital Fish Library, we hope to develop a tool that stimulates students to think independently and naturally leads them into questions that they might want to investigate," Frank said. "We hope to design an educational model that spurs students' interests and teaches them how to conduct research. It's not just teaching them about fish anatomy or physiology, it's teaching them about magnetic resonance imaging, computation and visualization."

Education modules within the Digital Dissection Tool will cover the basics of MRI, digital image processing of 3-D MRI data as well as aspects of marine biology. Under the guidance of co-investigator Cheryl Peach, Ph.D., of the Birch Aquarium-an expert in science education-elements of the project also will be incorporated into UCSD's Academic Connections Program, an intensive, three-week summer learning experience for college-bound high school students.

Hastings said that virtual dissections will help preserve fish specimens since traditional, physical dissections often destroy them. This is even more important with rare specimens. In a global environment in which marine species are being threatened by overfishing, pollution, climate warming and other risks, such libraries have become increasingly valued sources for new information and discoveries.

"The Digital Fish Library will not replace the collection of specimens, since there will always be specific information that can only be attained by examining the physical makeup of a fish," said Hastings. "The series of specimens in the Marine Vertebrate Collection are essential for understanding variation within species and their past and present distributions."

The new grant will be focused specifically on digital imaging and will not support the operational funding needs of the Marine Vertebrate Collection, which has been hampered in recent years due to state budget shortfalls.

"Many people don't realize how important scientific collections such as this are for ongoing and future discoveries," said Hastings. "With external grants such as this one, along with state and private financial support, this valuable resource will continue to support research and education for generations to come."

The web development for the Digital Fish Library project is being conducted by Cameron Perry in Frank's lab. Perry also performs the MR imaging, coordinating the specimen selection and transfer with H. J. Walker of

the Marine Vertebrate Collection. The data analysis and visualization software is being developed by German Eichberger in Frank's lab.

Media contacts: Debra Kain, 619/543-6163, or Mario Aguilera or Cindy Clark, 858/534/3624