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THE VISIBLE EMBRYO PROJECT: EMBEDDED PROGRAM OBJECTS FOR KNOWLEDGE ACCESS, CREATION AND MANAGEMENT THROUGH THE WORLD WIDE WEB

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Abstract—We have designed a prototype knowledge management online environment for the biomedical sciences which integrates access to online representations of the scientific literature, bibliographic databases, high-performance visualization technologies, large-scale scientific databases, and tools for authoring new-generation scientific publications. This system will provide widespread access to its resources by using the World Wide Web for its underlying architecture. This system expands upon our Weblet™ Interactive Remote Visualization (IRV) server technology to produce a set of dedicated Internet "visualization servers" which provide interactive control of real-time visualizations from the Visible Embryo Project database from within Web pages viewed with our WebRouser™ software package. This system will be used to develop a set of prototype applications for both online education of medical students in developmental anatomy and for an interactive patient education system for expectant parents. We recognize that knowledge represented by these national resource databases is not static, therefore it is essential to include tools for both the creation of new "compound documents" which incorporate embedded objects, as well as for managing the peer-review of scholarly publications, in order to ensure the integrity of new knowledge as it is added to these databases in the future. We have therefore begun to design integrated tools for our system which facilitate both the creation of and the validation of new generations of scientific knowledge. Copyright © 1996 Elsevier Science Ltd.

Key Words: World Wide Web, Visualization, Applets, Plug-ins, Knowledge base, 3D, Reconstruction

OVERVIEW

The delivery of information via electronic networks has grown over the past several years to include many different types of data, including text, images, audio and video. Significant obstacles to overcome in distributing such information in a ubiquitous manner have included dealing with problems of content format and uniform accessibility. Although significant steps have been taken to alleviate these problems, it was not until the recent acceptance of the World Wide Web (WWW) as a global standard for information representation and transfer, and the availability of a portable and redistributable client for the WWW, in the form of MOSAIC from the National Center for Supercomputer Applications (NCSA), that a method has become available to users easy access to a wide variety of multi-media information in an inter-networked environment.

National initiatives like the Visible Embryo Project and the Visible Human Project will provide medical educators with a plethora of massive on-line information resources. The availability of these information banks to the biomedical scientist makes the effective access and use of such data a daunting task. There are so many different data types and viewing modalities represented by these resources that it is impractical to believe that scientists and students will either have the time or the endurance to learn the "native" interfaces to all of these databases. The World Wide Web and NCSA MOSAIC (1) provide a heretofore unapproachable degree of flexibility and efficiency for the task of designing and implementing a truly integrated information access, communication, and creation environment for the biomedical science community. The work described here represents a continuation of the Visible Embryo Project's ongoing research into these questions. Specifically, we will describe studies into the representation, navigation, and utilization of biomedical information as it relates to the study of the development of the human, as well as other vertebrate species.

The Visible Embryo Project is a multi-institutional, interdisciplinary research project to develop a large scale distributed "metacenter," or "collabora-

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About the Author—MICHAEL D. DOYLE, PhD, founded Eòlas Technologies Inc. after serving as Director of the UCSF Center for Knowledge Management (the UCSF Academic Computing Center, CKM), in San Francisco. He also is an adjunct member of the faculty of the UCSF Medical School. From 1992 to 1994, he was Vice President for R&D of Muritech Co., based in Boston, MA, and he currently serves as Chairman of MetaMAP, Inc., in Chicago, IL. Prior to his position at UCSF, he served as the Director of the UIC Biomedical Visualization Laboratory and as an Assistant Professor at the University of Illinois at Chicago from 1989 to 1993. He is named as the first of three inventors on the University of California patent application for embedded interactive applications in hypermedia documents, and is the sole inventor of the MetaMAP technology (U.S. PTO #4,847,604). He received his PhD in Cell and Structural Biology from the University of Illinois at Urbana-Champaign in 1991, and the BS degree in Biocommunications Arts from the University of Illinois at Chicago in 1983. He has served as a charter member, and officer, for several professional organizations, including acting as the first president for the Special Interest Group for Biological Computing, at the University of Illinois at Urbana-Champaign, in 1988, and founding, together with his UCSF CKM staff, SIGWEB, the Bay-Area Special Interest Group for the WWW, in 1993. Dr Doyle served on the Board of Scientific Advisors for the Visible Human Project at the National Library of Medicine and the Scientific Advisory Board for the National Museum of Health and Medicine. He has also served, and continues to serve, as a regular reviewer of computer-related research grants for the National Institutes of Health since 1992. He is a member of Sigma Xi, Mensa, and Phi Kappa Phi.

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About the Author—CHEONG S. ANG is a programmer at IBM Almaden Research Center. He received his MS degree in computer science from the University of Illinois at Chicago in 1993. He did his UIC thesis project while working in Dr Doyle's Biomedical Visualization Laboratory on interactive medical visualization using distributed parallel processing through (Inter)networked workstations. During this time, he developed a highly portable and modular system for distributed volume visualization (VIS) which later formed the basis for the first Weblet-style embedded program object. After moving to UCSF as a programmer/analyst in the Center for Knowledge Management, he did the primary coding for the demonstration system that embedded interactive applications within WWW HTML documents, viewable through NCSA's MOSAIC client software, modified with his enhancements. He is named as one of three inventors on the University of California patent application that has been submitted for this technology.