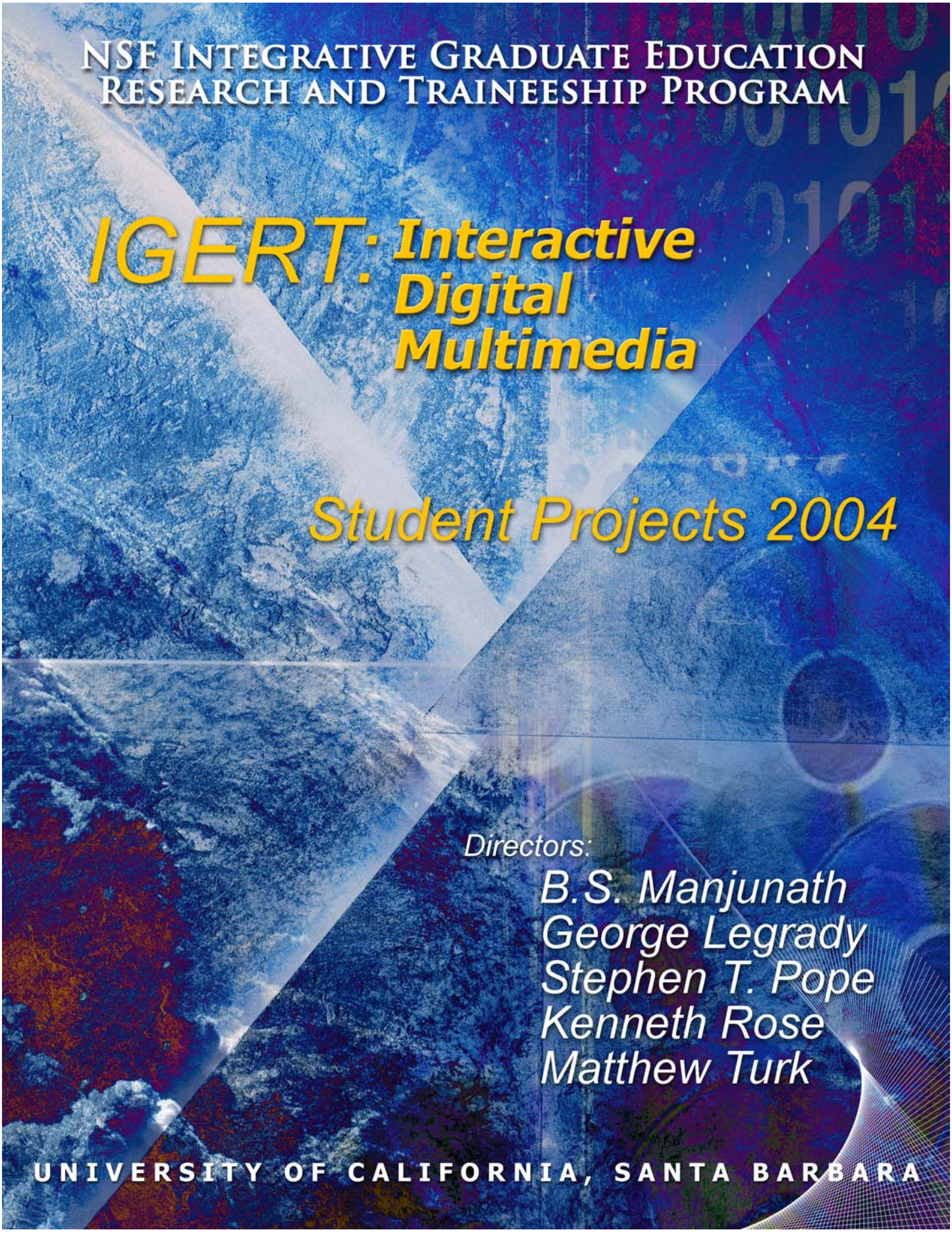
NSF Integrative Graduate Education
Research and Traineeship Program
IGERT: Interactive
Digital
Multimedia
Student Projects 2004
Directors:
B.S. Manjunath
George Legrady
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UNIVERSITY OF CALIFORNIA, SANTA BARBARA

Student Projects
2004

Interactive Digital Multimedia involves a range of technologies and applications centered on the creation, encoding, transmission, storage, presentation, and analysis of multimedia data, as well as the study of human interaction with multimedia systems. With the numerous applications of interactive multimedia in learning, communication, biology, medicine, arts and entertainment, and many other areas, a multidisciplinary approach to the subject is essential. Hence the basis for our IGERT program.

We end our first year with 20 participating students (11 Fellows, eight Research Associates, and one undergraduate scholar) from eight academic disciplines: Electrical & Computer Engineering, Computer Science, Media Arts & Technology, Statistics, Geography, Psychology, Education, and Music. Many of these students, upon recognizing their similar research interests, have formed groups and developed outlines for collaborative research projects that would promote digital media both synergistically and in their own disciplines. Other students with more specialized interests worked with faculty advisors to create projects with potential applications outside the normal scope of their own research.

2004 has been very exciting. In addition to collaborative projects, our students have also furthered their research by attending and presenting at national and international conferences and workshops.

Enclosed is a summary of the current research projects being conducted by the IGERT students. Initial ideas were discussed during a one-day project retreat on June 4, 2004. On October 8, 2004, the completed projects will be presented at our IGERT's first annual review, an event that will kick off our second program year. With seven new students entering in Fall 2004 and the possibility for more research associates coming aboard in Summer 2005, the next year promises to be even more exciting and productive.

Professor B.S. Manjunath, Director
IGERT in Interactive Digital Multimedia

Tim Robinson, Education Coordinator
IGERT in Interactive Digital Multimedia

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pStruct

Ethan Kaplan
Media Arts and Technology

Stephen DiVerdi
Computer Science

with ***George Legrady*** *and* ***Tobias Hollerer*** *advising*

pStruct explores and plays with the concepts of virtual reality, neural networks, and graph theory by allowing a world to be constructed around theoretical foundations and informed by the chaotic, social interactions of multitudes of users. On a broader level, *pStruct* is a tool for allowing relationships between disparate data to form relationships between each other autonomously in a goal-oriented environment. *pStruct* is implemented here in the form of a news aggregator and commentary system.

Ethan Kaplan is the primary back-end software developer for this project, working within the Java programming language. He architects the software as a massive multithreaded system and specifically designed to ensure scalability with large data-sets. He also helps with the aesthetics of the visualization for the system.

Stephen DiVerdi demonstrates how to present a useable and easily understandable view of the organized web forum data. This includes basic topic and post level navigation information, as well as analysis of user relationships and preferences for topics. His work consists of data mining the forum traffic graph and visualization of the extracted data.

Aesthetic Techniques for the Display and Mining of Information

August Black
Media Arts and Technology

with ***George Legrady*** *and* ***Sara Fabrikant*** *advising*

This project researches and develops visualizations of static and time-based data sets for the purpose of mining un-perceivable information and knowledge. There are two separate projects involved. One is the Seattle Public Library project, where call numbers of books are recorded and the amount of checked-out books per half-hour, per Dewey decimal category are tracked and visually displayed in quasi real-time. The second project is concerned with *Pockets Full of Memories* (www.pocketsfullofmemories.com), where quantifiable descriptions of objects have been collected from exhibitions in Paris, Rotterdam, Linz, Budapest, and Helsinki. The task here is to find criteria and mechanisms for searching the database and displaying the results in the form of multiple graphic visualizations.

This research tiles nicely inside the fields of data mining, statistics, and information visualization, and will use a number of proven algorithms for plotting, clustering, and pattern recognition. However, the guiding principles are inherently artistic and so being, the research should provoke aesthetic as well as informative results.

Features of Natural Scenes and their Implications for Saccadic Decisions

Barbara Drescher
Psychology

Laura Boucheron
ECE

with ***Miguel Eckstein*** *and* ***B. S. Manjunath*** *advising*

This research argues that visual information is weighted by prior expectations before saccadic decisions are made. Expectations regarding the location of objects in natural scenes heavily influence saccadic decisions and are based on experiences with features of those scenes. A database of natural scenes is collected and features extracted. This information is then compared with behavioral data of humans performing a search task to determine the relative influences of the features.

The present study investigates the role of scene context in visual search and observers' prior expectations of target locations employing stimuli comprised of natural scenes. The work involves several components. Two of these components, determining expected locations of objects and predicting saccadic eye movements, are primarily the responsibility of **Barbara Drescher**.

Laura Boucheron compares current state of the art in semantic image search and contextual priming algorithms with the behavioral data with hopes of providing a means to improve their performance. In addition to developing methods of extracting spatial configuration of high-level objects, it is possible that this research could also improve relevance feedback in data-mining and image search applications as well as provide insight into behavioral patterns.

Realism and Perceptions of Accuracy in Computer-Displayed Maps

Tony Boughman
Geography

with ***Sara Fabrikant*** *advising*

Issues in data quality are of interest as people continue to accumulate huge quantities of digital information. Creators of information are familiar with the inherent shortcomings in translating real-world observations into digital form, but do users understand the limitations of data? Cartographers are aware of the necessity of presenting an abstract view of the infinitely complex world. Improvements in computer technology allow increased realism in digital images and there seems to be a general movement toward more realistic display. More realistic visual rendering does not mean that the underlying data are more accurate and precise. Researchers are currently looking into the idea of communicating the degree of uncertainty in digital data to consumers by visualizing the uncertainty. Is the trend toward more realism doing the opposite and conveying the impression of more certainty in the data?

Do people infer greater accuracy and precision from maps that are more detailed and realistic? This experimental study compares a more generalized, abstract map to a more detailed, realistic-looking map. The maps are displayed on computer monitors and participants are asked to make judgments on the relative accuracy and precision of the maps by rating them and by performing estimation tasks.

Research on Blending Realism with Abstraction in Digital Maps

Julie Dillemuth
Geography

Nhat Vu
ECE

*with **Keith Clarke** and*
***B. S. Manjunath** advising*

A major challenge for individuals navigating with maps on mobile computers is the small screen size. Zooming and panning to view a large area can be disorienting and time-consuming. Level of detail is a primary concern; while a realistic map, such as an aerial photograph, resembles the actual environment in color and texture, the level of detail can overwhelm the user or make the map impossible to read. A generalized map can reduce visual processing load and computational load, but may not be as effective a tool for navigation. In this project **Julie Dillemuth** seeks to determine and measure factors that contribute to the effectiveness of blending realism with abstraction in maps for small screen displays on mobile devices, while **Nhat Vu** will focus on automatic extraction of vegetation from a set of aerial photographs of the UCSB campus. Preliminary experiments involve navigation tasks on foot with a handheld computer to evaluate particular blends of realism and abstraction.

Results of the research can inform design decisions for map display on mobile computers, with implications for field data collection and location based services.

Investigation into Subspace Clustering Techniques

Alex Villacorta
Statistics

*with **S. R. Jammalamadaka** advising*

Much of the current data being generated consists of complex data types which are associated with high dimensions. Traditional cluster analysis, which considers all dimensions for each data item, may not be appropriate for these types of situations. As a result, new methods are needed to effectively search through potential subspaces.

The main focus of this project is to study efficient clustering methods for multimedia data sets. Examples of such data sets are common in areas such as marketing data, digital music archives, gene expression data, image databases, and the web to name a few. Some unique aspects of these data sets are that they are associated with many levels of descriptive features and large amounts of noise. Traditional clustering Schemes, which find natural grouping structures, often break down in high dimensions due to the sparse feature space. However, interesting groupings are usually found on subsets of the original features and a natural extension is to search for clusters on these subsets. Since direct evaluation of all possible subsets is not realistic, this project aims to construct methods to find subspace clusters as efficiently as possible.

This research focuses on building subspace clustering methods specifically designed for multimedia databases and may define a clear measure of efficiency and accuracy so that other clustering methods may be ranked for a particular application.

Real-time Motion Tracking as a Musical Input Device

Michael Quinn
ECE

John Thompson
Music

Mary Li
ECE

*with **B.S. Manjunath**, **U. Madhow**, **George Legrady**, and **JoAnn Kuchera-Morin** advising*

This project utilizes a sensor network / real-time motion tracking system as a musical input device. The system records information about the subject(s) such as size, location, and velocity, and then uses the information for controlling the sound synthesis algorithms.

The idea of a sensor network is to have many small, low-power sensors scattered throughout an area. These sensors would be battery-powered and communicate wirelessly with each other and/or a base station. The goal is to develop ideas that will be applicable to low-power camera networks. Here, **Michael Quinn** experiments with different ideas geared toward reducing the energy requirements of the system.

Mary Li handles the image analysis and semantic labeling of the captured data, as well as designs the soft interface between the motion tracking system and the art application device.

John Thompson creates multiple time-scale, musical mappings of data captured from the motion tracking system. He also writes synthesis and transformation algorithms that map data from the motion tracking system to musically meaningful parameters. The challenge is to find successful strategies for the composition of interactive music that exists as an indeterminate set of spatially designed musical potentials.

Objective Perceptual Quality Measures in Video Compression

Jing Hu
ECE

*with **Jerry Gibson** advising*

Video compression algorithms address the problem of how to optimize the quality of the compressed video at a given bit rate for a given quality metric. The performance of the quality metric therefore plays an important role in determining the quality of the output video sequence. The general approach of calculating the Mean Squared Error (MSE) or Peak Signal-to-Noise Ratio (PSNR) between the reference and distorted frames in the pixel domain does not correlate well with perceived quality measurement and fails when one compares different kinds of artifacts, e.g., artifacts of block-based versus subband or wavelet coders. Perceptual distortion measures and masking play an important role in speech and audio compression, and human visual system (HVS) models have impacted the JPEG2000 still image compression standard. Models of HVS have played a lesser role in video compression. In this project, **Jing Hu** studies the models of HVS which involve contrast sensitivity, luminance/ contrast/texture masking etc., to set up an objective quality metric evaluating the end-to-end perceptual distortion of video sequences coded by the H.264/AVC standard, and further, to improve the coding schemes in terms of minimizing the visibility of the compression errors.

Placement of Annotations in Videos

Vineet Thanedar
Computer Science

with ***Tobias Hollerer*** *advising*

The augmentation of real video feeds with virtual elements is an important aspect of applications in areas such as real-time broadcasting and augmented reality. This project addresses the insertion and automated placement of graphical annotations (text/images) into video streams. Specifically, it focuses on the placement of annotations in "unimportant" or less interesting regions of the video imagery so that essential scene elements stay unoccluded. **Vineet Thanedar** is working towards building a framework and system prototype that enables the automated placement of arbitrary-sized annotations in either pre-processed or live videos in real-time. He approaches the problem from a human perceptual perspective by employing computer vision and image analysis techniques to search for suitable placement locations in the video over space and time. He presently identifies uniformity, motion, and clutter as Elementary Perceptual Descriptors and analyzes the video for these measures. He employs quantitative formulations for each of the perceptual properties and combines them to rate video regions for their placement suitability. Vineet intends to develop a generic system that can be easily applied in diverse application domains, such as augmented reality, Interactive TV, commercial advertising in telecasts, annotation of geographic map data, and interactive instructional/training videos.

Cartographic Design and Perceptual Salience

Kirk Goldsberry
Geography

with ***Sara Fabrikant*** *advising*

The eye-movement measurement methods developed in psychology have received renewed interest in human-interaction research to study how people interact with graphical user interfaces. This research studies map users' eye movements while they are inspecting a static map display. Cartographers control visual variables in order to make thematically relevant information in the display perceptually more salient.

The goal of this research is to enhance our understanding of how adjusting certain visual variables will influence people's viewing behavior dependent on perceptual salience in the display. Specifically, we create research stimuli (maps) that adhere to cartographic conventions as well as enable empirical research into the effects of visual variables on perceptual salience. Several map displays are produced using different cartographic techniques. In order to isolate the effects of the design variables, multiple maps representing the same geographic data set are generated. The eye-movement methods explore subjects' variable responses to these maps. The broader impacts of this research include progress toward an improved framework linking map-purpose and cartographic design decisions that would increase the communicative efficiency of geographic data displays.

Spatial Ability and the Use of a Dynamic, Interactive Animation

Cheryl Cohen
Psychology

*with **Mary Hegarty** advising*

Cheryl Cohen recently investigated the contributions of spatial ability and the use of interactive animation to performance on a spatial problem-solving task (drawing a 2D cross-section of an imaginary 3D object). Results showed that spatial ability and use of an animated model made significant contributions to task performance. Furthermore, spatial ability influenced the degree to which participants interacted with the animated model. High spatial participants interacted with the computer model more often and more systematically than did low spatial participants. In fact, many low spatial participants stated that they did not understand how the animated model could help them solve the problem.

Early in these experiments, Cohen videotaped and collected verbal protocols from five participants (four high and one low spatial) as they interacted with the animated model and drew the cross-sections. She will now complete a protocol study to compare the patterns of interaction and metacognitive strategies used by high and low spatial participants in this spatial problem solving task.

Student Engagement in Multimedia Classrooms

Monica Bulger
Education

*with **Richard Mayer** and **Kevin Almeroth** advising*

Usability testing can identify when students in digital classrooms engage and disengage from the classroom lecture. While observing writing classes held in on-campus computer labs, **Monica Bulger** noticed that student activities influence the effectiveness of available classroom technologies. In her preliminary observations of undergraduate classes held in the computer labs, she noticed that student disengagement from the lecture in favor of non-class related use of technology correlated to the organization and presentation of the lecture material. Furthermore, the return of student attention to the lecture and classroom activity was often in direct response to specific cues in the lecturer's presentation. In this project, Bulger works with an interdisciplinary team to collect data such as keystrokes, mouse moves, applications used, and websites visited and compare this with what was occurring during lecture. She synchronizes the computer data with transcripts from the lecture to test for correlations between lecture cues and student engagement.

Experiments in Sound Granulation and Spatialization for Immersive Environments

David Thall
Media Arts & Technology

*with **Curtis Roads** advising*

How can sound be diffused effectively in an immersive 3-D environment? What types of synthesis routines are needed to emulate real-world (and other-world) sounds? Can the production of complex sounds with width, depth, and trajectory be composed in real-time? If so, what types of control regimes in software and hardware must be developed to streamline this process?

With this project, **David Thall** conducts experiments in sound granulation and spatialization. Currently, there is no way to effectively synthesize and control the production of spatially complex ambient and environmental sounds in immersive environments. Creating this space is of utmost importance to the human auditory experience, and will contribute a great deal to the resulting multimedia fabrication. Using a plug-in he is writing for the Supercollider 3 sound synthesis server, Thall tests various ways to project sound particles in space. These spatial algorithms are scalable, from 1 to N channels, and could eventually be tested in the California NanoScience Institute *Sphere*. The granular model of sound also offers many other synthesis and control possibilities. Various algorithms are developed to generate this in real-time, along with a prototype software graphical interface to control the process.

Composition Space in Virtual Reality

Satoshi Morita
Media Arts & Technology

*with **Stephen Pope** advising*

Satoshi Morita researches the development of compositional space in virtual reality, where a composer is immersed in the three dimensional virtual world which visualizes the compositional parameters and sound outputs by three dimensional objects. Composers can manipulate their musical forms and sound synthesis/processing parameters by interacting with the objects representing each element and changing their attributes. Sound output is analyzed and represented in 3D objects for the feedback to the composer. Sound output is spatialized in the virtual environment either by using the measured response of a real space or synthesized space created by a composer. Composers are immersed in a virtual representation of a real space (i.e. a concert hall) or synthesized space for playback of their composition. Research goals are the following: a novel human-computer interface for complex time-based parameter composition using features particular to virtual reality; novel sound visualization in three dimensional spaces; and integration of multiple user interfaces for coherent user control.

Warehousing and Integration of Biological Databases

Kevin Hawkins
Computer Science

Vebjorn Ljosa
Undergraduate Mentor
Computer Science

*with **Ambuj Singh** advising*

The amount of data available to biologists is growing exponentially. These data reside in many databases with differing information and semantics. Scientists need a way to use all relevant information from these databases to help determine what proteins or genes might be interesting to use in an experiment. This emphasis on data-driven research creates the need to integrate the available databases to allow querying across multiple heterogeneous datasets. **Kevin Hawkins** has created a data warehouse composed of local copies of the protein-protein interaction databases MINT, DIP, and BIND. The warehouse has a global schema that allows users to formulate a query without having knowledge about the specific databases involved. A web interface provides an easy way to query the data warehouse. Results returned to the user may be a combination of information from different sources. The interface identifies to the user the source of each result, and when applicable a confidence value for the result is also displayed.

2004 IGERT in Interactive Digital Multimedia Participants

Students/Trainees:

August Black, Media Arts and Technology
Laura Boucheron, Electrical and Computer Engineering
Tony Boughman, Geography
Stephen DiVerdi, Computer Science
Julie Dillemuth, Geography
Barbara Drescher, Psychology
Ethan Kaplan, Media Arts and Technology
Michael Quinn, Electrical and Computer Engineering
John Thompson, Music
Alex Villacorta, Statistics
Nhat Vu, Electrical and Computer Engineering

Research Associates:

Monica Bulger, Education
Cheryl Cohen, Psychology
Kirk Goldsberry, Geography
Jing Hu, Electrical and Computer Engineering
Mary Li, Electrical and Computer Engineering
Satoshi Morita, Media Arts and Technology
David Thall, Media Arts and Technology
Vineet Thanedar, Computer Science

Faculty Advisors:

Kevin Almeroth, Computer Science
Keith Clarke, Geography
Miguel Eckstein, Psychology
Sara Fabrikant, Geography
Jerry Gibson, Electrical and Computer Engineering
Mary Hegarty, Psychology
Tobias Hollerer, Computer Science
S. R. Jammalamadaka, Statistics
JoAnn Kuchera-Morin, Media Arts and Technology/Music
George Legrady, Media Arts and Technology
B.S. Manjunath, Electrical and Computer Engineering
Rich Mayer, Psychology
Stephen Pope, Media Arts and Technology
Curtis Roads, Media Arts and Technology
Kenneth Rose, Electrical and Computer Engineering
Ambuj Singh, Computer Science
Matthew Turk, Computer Science

Postdoctoral Researcher

Xinding Sun, Electrical and Computer Engineering

Undergraduates and Mentors:

Kevin Hawkins, Computer Science
Vebjorn Ljosa, Computer Science (Undergraduate Mentor)

New IGERT Trainees in 2004-2005 *(and degree institutions)**:***

Maria del Mar Alvarez, Computer Science
B.S., University of Puerto Rico Mayaguez
Carlos Castellanos, Media Arts and Technology
B.A., San Francisco State University
Peter Khooshabeh. Psychology
B.A., University of California, Berkeley
Justin Muncaster, Computer Science
B.S., University of California, Santa Barbara
Dan Overholt, Music - Interdisciplinary PhD
B.S., Massachusetts Institute of Technology
Wesley Smith, Media Arts and Technology
B.A., Johns Hopkins University
Bob Sturm, Electrical and Computer Engineering
M.S., University of California, Santa Barbara
M.A., Stanford University
B.A., University of Colorado, Boulder

Faculty and students from the IGERT Program in Interactive Digital Multimedia
June 4, 2004


http://media.igert.ucsb.edu