

Visualizing and Analyzing Activity Data: Initiating Collaborations with TDLC, LIFE, and Calit2

We propose a supplement to NSF-HSD project, DHB: A Multiscale Framework for Analyzing Activity Dynamics, to 1) build on an existing collaboration with Temporal Dynamics of Learning Center (TDLC) investigator Javier Movellan to exploit computer vision techniques to assist video analysis, (2) initiate interactions with TDLC researcher Emo Todorov to couple multiscale video analysis with the TDLC's facilities for motion capture to explore the fine-scale dynamics of movement and to investigate the dynamics of learning and social interactions, (3) extend a recent collaboration with Falko Kuester, who is leading display-wall visualization developments at Calit2, to add multitouch interaction facilities to the Calit2 HIPerSpace display as a basis for visualization and analysis of activity data and (4) reestablish an earlier informal collaboration on Diver video annotation facilities with Roy Pea of Stanford. Stanford is a partner along with U. Washington and SRI International in the Science of Learning Center called LIFE (Learning in Informal and Formal Environments).

A new generation of digital recording devices and storage facilities is revolutionizing data collection in behavioral science, extending it into situations that have not typically been accessible and enabling examination of the fine detail of action captured in meaningful settings. This is important because to understand the dynamics of learning and human activity, we must first understand the full context of those activities. Accomplishing this is central to achieving the TDLC goal of understanding the role of time and timing across multiple scales. Researchers from many disciplines are assembling extensive data collections of human activity. While such data are certainly needed, more data cannot be the whole answer, since many researchers already feel that they are drowning in data. Data without appropriate theoretical and analytical frameworks do not lead to scientific advances. The ability to record and share such data has created a critical moment in the practice and scope of behavioral research. The main obstacles to fully capitalizing on this opportunity are the huge time investment required for coding, visualization, analysis, and understanding how to coordinate analyses focused at different temporal scales so as to profit fully from the theoretical perspectives of multiple disciplines.

The intellectual merits of the proposed activity derive from three main components: (1) extending our vision-based analysis approach to incorporate motion capture data at TDLC and integrating annotation facilities from the Stanford Diver system, (2) exploiting a novel Calit2 HIPerSpace visualization facility to assist collaborative analysis of multiple timescale activity data, and (3) exploring the Integrated Rule Oriented Data System (iRODS), in use by other TDLC researchers for enforcing IRB privacy requirements, to protect video data and aid data sharing and collaborative analysis. The first two components will allow us to extend our analysis and visualization facilities to meet the varying timescales of data collected by TDLC and LIFE efforts. The later component will help manage privacy issues associated with collaborative analysis and sharing of video data.

In addition to better connecting the TDLC with social sciences research at UCSD, a *broader impact of the proposed activity* will be research linkages between TDLC and LIFE as well as between both Science of Learning Centers and Calit2. The proposed project will augment our existing effort to (1) accelerate analysis by employing vision-based pattern recognition capabilities to pre-segment and tag data records, (2) increase analysis power by visualizing multimodal activity and macro-micro relations, and coordinating analysis and annotation across multiple scales, and (3) facilitate shared use of developing frameworks and tools for collaborations not only within the TDLC via their Datagrid and iRODS technology but more broadly between our current project and researchers at LIFE, TDLC and Calit2.

Supplementary Budget Request for NSF-HSD-DHB: A Multiscale Framework for Analyzing Activity Dynamics



Existing NSF Project: A Multiscale Framework for Analyzing Activity Dynamics

The primary motivation for this project derived from our belief that we are at a critical moment in the practice and scope of behavioral research. We argue that the main obstacles to fully capitalizing on this opportunity are the huge time investment required for analysis using current methods and understanding how to coordinate analyses focused on different levels so as to fully profit from the theoretical perspectives of multiple disciplines. The research we are undertaking in this project is part of an explicit long-term strategy to reduce the cost of performing in-depth analysis, to increase the power of analyses, and to facilitate sharing analyses.

Reducing the Cost of Analysis

Today the high labor cost of analyzing rich activity data leads to haphazard and incomplete analyses or, all too commonly, to no analysis at all of much of the data. Even dataset navigation is cumbersome. Data records are chosen for analysis because of recording quality, interesting phenomena, and interaction density—producing a haphazard sampling of the recorded set. Good researchers have a nose for good data, but also have a tendency to focus on small segments of the record that contain “interesting” behavior, analyze them intensively, and then move on to the next project.

When analysis is so costly, few analyses can be done—so datasets are severely underutilized—and researchers come to have a large investment in the chosen data segments. Since each analysis may appear as an isolated case study, it can be difficult to know how common the observed phenomena may be. Larger patterns and contradictory cases can easily go unnoticed. Well-known human confirmation biases can affect the quality of the science when each analysis requires so much effort. Thus, one focus of our existing research is on the developing and assembling tools and practices to speed and improve analysis. We are extending use of computer vision techniques to automatically annotate video data from our focal domains and add facilities to help manage and coordinate both data collection and analysis. The goal is to facilitate the creation, maintenance and manipulation of temporal and sequential relations within and between analyses.

Increasing the Power of Analysis

A significant scientific challenge for all disciplines is how to represent data so as to make important patterns visible. In the behavioral sciences, researchers transcribe and code data in a wide variety of ways, creating new re-representations of the original events (Hutchins, 1995). Currently the coordination of multiple re-representations with the original data is typically done by hand, or not at all. Since this re-representation process—including all sorts of transcription, coding system development and implementation, and re-description—is what allows us to do science (Goodwin, 2000), even small improvements in automating coding, transcription, or coordination of representations can be crucially important. Recent developments in behavioral science theory create special challenges and opportunities

(Hollan, Hutchins, and Kirsh, 2000) in this regard. Increasingly theories are concerned with patterns that can emerge from the interactions of many dynamically linked elements. Such interactive patterns may be invisible to approaches that decompose behavior into the more or less independent components created by historical distinctions among science disciplines. This is why multidisciplinary science is necessary. But tools that match this multidisciplinary vision are also needed.

Visualizing Multimodal Activity

The richly multimodal nature of real-world human activity makes analysis difficult. A common strategy has been to focus on a single aspect of behavior or a single modality of behavior, and to look for patterns there. However, the causal factors that explain the patterns seen in any one modality may lie in the patterns of other modalities. In fact, recent work suggests that activity unfolds in a complex system of mutual causality. Analysis may still be based on decomposition of the activity, as long as there is a way to put the pieces back together again. That is, as long as there is a way to visualize the relations among the many components of multimodal activity.

Visualizing Macro-Micro Relations and Coordinating Multiple Scales

The structure of the existing academic disciplines attests to the fact that human behavior can be productively described at many levels of integration. Neuroscientists describe regularities at a finer scale than psychologists, who describe phenomena at a finer scale than linguists, who in turn tend to describe behavior at a finer scale than anthropologists. A deep understanding of the nature of behavior demands not only description on multiple levels, but integration among the descriptions.

As behavior unfolds in time, describable patterns that take place on the scale of milliseconds are located in the context of other describable patterns that display regularities on the scale of seconds. Those patterns in turn are typically embedded in culturally meaningful activities whose structure is described on the scale of minutes or hours. Patterns at larger time scales are created by and form the context for patterns at shorter time scales. Visualizing and reasoning about such nested temporal relations requires representations that allow coordination of analyses across multiple scales.

Facilitating Sharing of Analyses

The high cost of performing analyses on data that represent real-world activity means not only that too few analyses are conducted, but that analyses tend not to be shared. Most often when results of a video analysis are published, neither the activity of doing the analysis, nor the procedures that were used are shared. This creates a situation in which most analyses are idiosyncratic and possibly non-replicable. The multiscale timeline representation being developed in our project promises to provide a natural foundation for collaborative analysis. Specialists may do analyses in parallel and then tie them to a shared timeline backbone. Support for the coordination and comparison of multiple analyses may add to the power of the analysis, while simultaneously providing a medium for assessing inter-rater reliability. It will also make the analysis process itself more transparent. Making more of the analysis process visible to a critical audience of peer researchers makes science stronger. Making it more visible to students learning the techniques improves training. We also expect that facilitating the sharing of analyses will feed back to reduce the cost and increase the power of analyses as new techniques and analytic practices are discovered and shared.

Research Questions

We are integrating video and multiscale visualization facilities (Bederson, Hollan, Perlin, Meyer, and Furnas, 1996) with computer vision techniques (Lowe, 2004; Mutch and Lowe, 2006; Marks, Roddey, Hershey, and Movellan, 2004) to create a flexible open framework that we hope will radically advance analysis of time-based records of human activity. We are combining automatic annotation with multiscale visual representations to allow events from multiple data streams to be juxtaposed on the same timeline so

that co-occurrence, precedence, and other previously invisible patterns can be observed as analysts explore data relationships at multiple temporal and spatial scales. Dynamic lenses and annotation tools provide interactive visualizations and flexible organizations of data. The following are the motivating research questions being addressed in the current project:

- Can multiscale representations facilitate identification of relationships among patterns in human behavior described at different levels of integration?
- Can multiscale visualization techniques and lens-based information filtering and management facilities be extended to provide more effective analysis of multimodal data?
- Is it possible using a multiscale timeline to keep the macro context in view while examining a micro analysis? And can such timelines help us address the long-standing problem of visualizing and managing the relationships between analyses performed on differing timescales?
- Can existing computer vision algorithms be used effectively to automatically annotate video data to assist analysis?

Linkages to TDLC, LIFE, and Calit2 Research Enabled by Supplementary Funding



We see the opportunity for interesting research collaborations and linkages between our on-going project and researchers at TDLC, LIFE, and Calit2. From the perspective of our project this will create a forcing function to help ensure that our analysis and visualization facilities extend to match the wide range of data timescales being collected by TDLC and LIFE researchers. It will also more closely involve Professor Hollan and Hutchins, who are non-center investigators, and other members of their lab in center research activities. Here we discuss two specific linkages of the many we envision.

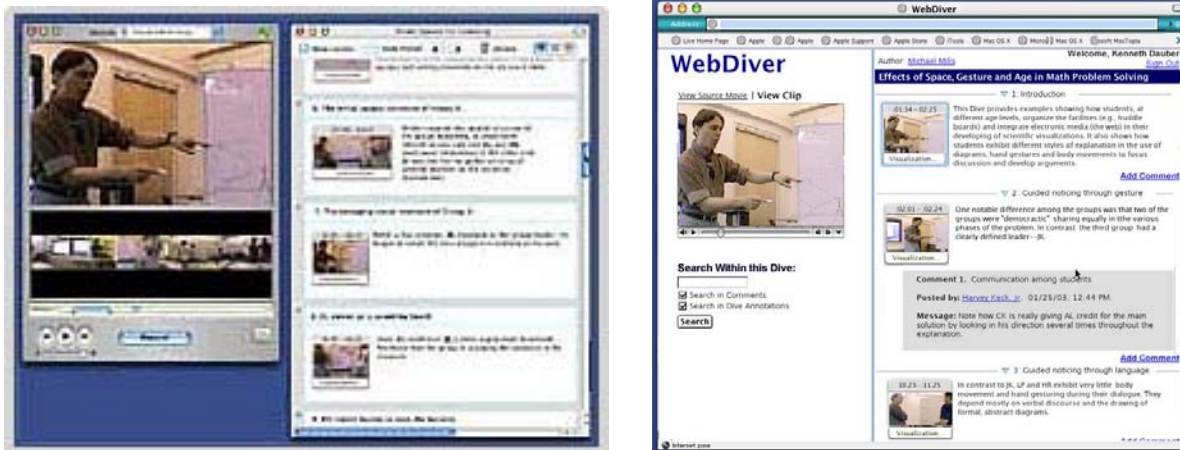
Calit2 HIPerSpace Visualization

The figure above shows two images of the HIPerSpace visualization facility. It is the next generation of ultra-high resolution distributed display systems being developed at Calit2 and has the potential to scale into the billions of pixels, providing unprecedented high-capacity visualization capabilities to experimental and theoretical researchers. Until now use of this facility has primarily focused on assisting earth and biomedical science researchers. We propose to enable and explore using HIPerSpace to support visualization and analysis of the widely ranging timescale data being collected in our project and in other efforts at TDLC and LIFE.

Our initial focus will be on integrating analyses of gesture data collected in ethnographic video with the more detailed motion capture facilities being used by Emo Todorov and colleagues at TDLC. As we discuss in recent work (Hollan, Hutchins, and Kirsh, 2000) linking analysis of data from real-world settings with data collected in controlled experiments is crucial to research advances. We have two related

scientific interests. The first is to understand how to exploit our analysis tools and HIPerSpace visualization facilities to help detect patterns in data that range from milliseconds to minutes and hours. The second is to evaluate the potential of HIPerSpace to aid collaboration of researchers. One of main potential benefits of such a display facility is to be able to visualize an enormous quantity of data at multiple timescales and at the same time. While we expect that our analysis tools will be exceptionally effective in such a rich display environment, we also anticipate that the ability for the first time to see large multi-timescale data collections *all at once* will catalyze scientific conversations that might likely never have otherwise occurred.

Desktop Diver and WebDiver



The above figure shows screen captures of the Diver system. Desktop Diver (for ‘Digital Interactive Video Exploration and Reflection’) is an application developed by Roy Pea and colleagues at Stanford for annotating and commenting upon audio-video source material, including the ability to incorporate analyses clips drawn from source video (Pea, et al, 2004). A Dive is an annotated perspective on a video record. WebDiver extends the facilities to the Web, allowing uploading and collaborative sharing of Dives.

We will explore integration of Diver facilities into the analysis tools we are constructing and explore its use within our timeline-based analysis facilities.. We agree with Pea and his collaborators that:

- Many insights in the learning sciences and distributed cognition have been built from careful multi-disciplinary analyses of video-recordings of human activities in their social and material contexts – including instructional interactions.
- There is a fundamental need for learning sciences—like genomics and other science disciplines— to build a cumulative knowledge base from primary data records for use by many research groups.
- We also have a central need for the socio-technical infrastructure to enable digital video collaboratories in the learning sciences.

In addition, we propose to extend the notion of a Dive to include not only a perspective on a segment of a video data record but also to enable the capture and sharing of perspectives on the process of analysis. Capturing annotated perspectives that document the process of analysis has extraordinary potential to aid scientific collaboration and instruction of graduate students.

An additional benefit of collaboration with TDLC will be the opportunity to explore the Integrated Rule Oriented Data System (iRODS), developed at SDSC and in use by other TDLC researchers for enforcing

IRB privacy requirements, to protect video data and aid data sharing and collaborative analysis. This is likely to benefit not only our research effort but has the potential to be widely shared with other researchers analyzing video data. This is exactly the kind of socio-technical infrastructure Pea and colleagues are referring to above.

Building on Earlier Collaborations via Students and Postdocs

The requested funding would enable us to continue a history of graduate student and postdoc based collaborations across laboratories and disciplines that began before the founding of the TDLC. Movellan and Hollan were co-advisors for Tim Marks, a recent UCSD cognitive science Ph.D. Marks then completed a postdoc with TDLC director Gary Cottrell. Early work that led to the NSF HSD-DBH proposal was assisted by Carrie Joyce. Joyce is a UCSD cognitive science Ph.D. who did two postdocs, the first with Cottrell and the second with Hollan.

The only additional funding we are requesting is for one postdoctoral fellow and one graduate student. This will allow us to continue a most productive history of collaboration and extend it to interactions with Todorov at TDLC and at Stanford. We just accepted a new graduate student who has worked with Movellan and that should allow for his rapid integration into the collaboration.

The additional postdoc and graduate student will enrich our ability to collaborate by spending significant portions of their time in each of the labs. This will help to seed and support collaborations. We have excellent facilities in our lab and at Calit2 for video conferencing. We will use these facilities in our collaboration with Pea and colleagues at Stanford. Through other sources we hope to augment these interactions with visits between our labs.

References

Bederson, B., Hollan, J., Perlin, K., Meyer, J., Bacon, D., and Furnas, G. Pad++: A Zoomable Graphical Sketchpad for Exploring Alternate Interface Physics, *Journal of Visual Languages and Computing*, 7, 3-31, 1996.

Goodwin, C. Professional Vision, *American Anthropologist*, 32, 1489-1522, 2000.

Lowe, D. Distinctive Image Features from Scale-Invariant Keypoints, *International Journal of Computer Vision*, 60, 2 (2004), pp. 91-110.

Mutch, J. and Lowe, D. "Multiclass Object Recognition with Sparse, Localized Features," *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 11-18, 2006.

Hollan, J., Hutchins, E., and Kirsh, D. Distributed Cognition: Toward a New Theoretical Foundation for Human-Computer Interaction. *ACM Transactions on Human-Computer Interaction*, 174-196, 2000.

Hutchins, E. *Cognition in the Wild*, MIT Press, Cambridge, 1995.

Marks, T., Roddey, J., Hershey, J. and Movellan, J. Determining 3D Face Structure for Video Images using G-Flow, *Neural Information Processing Systems*, 2004.

Pea, R., Mills, M., Rosen, J. Dauber, K., Effelsberg, W., & Hoffert, E. The DIVER Project: Interactive Digital Video Repurposing, *IEEE Multimedia*, 11(1), 2004, 54-61.



Dr. James Hollan
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March 3, 2008

Dear Jim:

I am writing in my capacity as the Interim Director of the University of California, San Diego Division of the California Institute for Telecommunications and Information Technology [Calit2] to strongly endorse your supplemental request for funding from NSF.

Calit2 has been a strong supporter of the Temporal Dynamics of Learning Center [TDLC] and believes that your proposed efforts would be an important contribution to a greater understanding of the science of learning. Your request would augment existing social science expertise in the TDLC, develop new tools for observational data with appropriate attention to privacy concerns, and assist in forming new research collaborations between researchers at Calit2 and the Learning in Informal Environments [LIFE] at Stanford University.

If I can be of any further assistance please do not hesitate to contact me.

Sincerely,

William Hodgkiss
Interim Director
University of California San Diego
California Institute for Telecommunications and Information Technology



DR. ROY PEA
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Email: roypea@stanford.edu

March 6, 2008

Dear Jim,

I am writing to enthusiastically support your supplementary funding proposal with Hutchins and Movellan - *Visualizing and Analyzing Activity Data: Initiating Collaborations with TDLC, LIFE, and Calit2* - because it provides an exceptional set of opportunities for leveraging multiple complex networks of research investigators and scientific studies. I currently serve as Co-PI of the LIFE Center (Learning in Informal and Formal Learning Environments), one of the six Science of Learning Centers funded by NSF. LIFE is a partnership of U. Washington, Stanford University and SRI International. In our research, a significant proportion of studies employ ethnographic methodologies and/or experimental settings in which we do audio/video recording as well as capturing other data sources (e.g., computer screen information for collaborating learners). Various research studies also utilize physiological data capture as well. We deeply share the assumption articulated in the proposal that “linking analysis of data from real-world settings with data collected in controlled experiments is crucial to research advances.” We concur that shared tools are one of the best ways to encourage shared research, and believe that the multimediated data analysis capabilities proposed will galvanize the communities of the Science of Learning Centers and correspondingly, the broader field of researchers in learning sciences and social sciences.

For reviewers, I want to note how you, Ed Hutchins and I developed a joint plan for research and development several years ago involving your multiscale activity dynamics analysis tools and our Stanford University group’s DIVER web-based digital video collaboratory system funded by NSF. Diver supports creating annotated perspectives on selections from archives of web-accessible video source material and distributed collaborative work on video data. While that particular joint Human and Social Dynamics infrastructure grant was not successful, I was very glad that your most recent proposal was funded, in partnership with TDLC researcher Javier Movellan: *A Multiscale Framework for Analyzing Activity Dynamics*. Since that time, the DIVER system has become integral to a range of research activities of the LIFE Center, and is in use by over 75 groups in 30 institutions around the world studying human interaction, learning, collaborative work, and educational practices, among other social science topics.

As Stanford Co-PI of the LIFE Center, I am keen to bring together the technical advances in the TDLC and LIFE centers with the new work proposed in your supplemental plan, and to ensure that our LIFE Center researchers and broader collaborators in the field of the learning sciences will contribute requirements to and users of the evolving platform of open tools and frameworks, and that our learning sciences research community will benefit from access to the proposed new capabilities of coupling multiscale video analysis with the TDLC's facilities for motion capture to explore the fine-scale dynamics of movement and investigate the dynamics of learning and social interactions. We are also hopeful that the supplement can make it possible to bring the Stanford DIVER software services into productive interconnection with the TDLC's work with Datagrid and iRODS technologies being developed by the SDSC. The postdoctoral fellow proposed in the supplement will work to develop the connections across our institutions and extend the Diver notion of perspective to include not only perspectives on video segments but also perspectives on the analysis process of using multiscale visualizations. Our LIFE Center researchers are also eager to explore these multiscale scientific data visualization capabilities being developed with TDLC, your team, and the Calit2, which may enable new forms of interdisciplinary learning science research activities and insights due to its unique affordances (e.g., multi-person, multi-level dynamic data display visualization from video to gesture to physiological data to speech streams).

Sincerely yours,



Roy D. Pea

Professor of Education and the Learning Sciences, Stanford University

Co-PI, The LIFE Center (<http://life-slc.org>)

Co-Director, H-STAR Institute (Human Sciences and Technologies Advanced Research:
<http://www.stanford.edu/dept/h-star/cgi-bin/hstar.php>)

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THE JACOBS SCHOOL OF ENGINEERING
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March 5th, 2008

RE: Letter of Support

Dear Prof. Hollan,

I am strongly supporting the research proposed in your supplementary funding proposal titled *Visualizing and Analyzing Activity Data: Initiating Collaborations with TDLC, LIFE, and Calit2*.

New modes, tools and environments for collaborative digital research are urgently needed, to enable co-located and spatially separated research teams to intuitively, interactively and most importantly collaboratively interrogate massive, multi-dimensional and multivariate data collections across multiple scales. In pursuit of better visual analytics workspaces, my team has developed the NSF supported HIPerWall and HIPerSpace environments, which are tightly integrated with the NSF-funded OptIPuter project. Both of these so-called OptIPortals, provide massive visual real-estate, operating at 200 megapixels and 220 megapixels resolution respectively. With these OptIPortals now being cloned on a global scale, a unique medium for collaboration between cross-disciplinary research teams is evolving. Of fundamental importance for this to succeed, is a thorough understanding about how users collaborate in this type of workspace, interact with the system itself, and perform analyses. The analysis of data rich video records will be vital for this and the proposed ideas to process, segment, tag, correlate data records across scales is very timely. The proposed research has an interesting self-recursion attribute to it, in that video data capturing users operating within this type of Cyberinfrastructure in turn can be analyzed on it, across different spatial and temporal scales.

I look forward to work with you and your team on the exciting visual analytics research challenges ahead and have allocated HIPerSpace time for this project.

Sincerely,

A handwritten signature in black ink, appearing to read 'F. Kuester'.

Falko Kuester
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Professor Jim Hollan
Cognitive Science Department
UCSD
La Jolla, CA

March 6th, 2008

Dear Jim,

I am pleased to express my strong support for the requested supplement to your NSF grant entitled, *Visualizing and Analyzing Activity Data: Initiating Collaborations with TDLC, LIFE, and Calit2*. The collaboration that will result between your group, including Javier Movellan of INC, and Roy Pea's group at Stanford, is just the kind of synergistic science that I hoped would come out of the Temporal Dynamics of Learning Center (TDLC). The Distributed Cognition and Human-Computer Interaction Lab you and Ed Hutchins direct is one of the premier labs in HCI. The annotation tools you are proposing in your supplement will have wide applicability, and has the potential to move the science of social interaction to a new level. The problem they describe, of the firehose of data that is being collected and left unanalyzed is one that must be surmounted in order to develop a true science of the temporal dynamics of learning. Imagine being able to take video of student teacher interactions and analyze it automatically at multiple time scales! The potential for standardization of tools is likewise crucial for turning the field of social interaction into a science. The work in this supplement is directly relevant to the goals of the Center, especially Initiative 3, The Temporal Dynamics Of Movement And Exploration: What are the temporal structures for body movements and sampling the environment and how are they learned? Without a good way to formally encode interactive movements in the natural environment, there is no way we will be able to extend our research into the world of the classroom. The work already begun on your NSF grant with Javier, *A Multiscale Framework for Analyzing Activity Dynamics*, will be synergistic with the work in this supplement.

Your group, in concert with Javier Movellan, is in an excellent position to bring this project to a successful conclusion. I would just like to point out (for the benefit of the NSF officials reading this letter, some important points about your expertise:

1. Your group has long term commitment to understanding cognition "in the wild" (Ed Hutchins is a MacArthur award-winning cognitive scientist best know for his book *Cognition in the Wild*);
2. Your expertise developing multiscale visualizations (You were recently elected to the ACM SIGCHI Academy for leadership in the field of human-computer interaction and led the development of Pad++, one of the first multiscale visualization facilities);
3. Your experience automatically annotating extensive video data collections in your collaborative project with computer-vision researchers at UCSD in which a car was equipped with ten video cameras to capture detailed data of real freeway driving;

4. Javier's lab's experience in analyzing video in real time and segmenting and tracking faces.

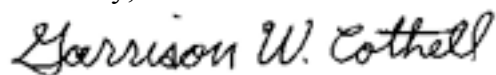
I think it is a great idea to fund a postdoc and a grad student with this supplement. I especially like the idea of having these trainees spend time in all of the labs. In particular, experience working in Javier's lab is crucial to the successful outcome of this project. I am envious of the wonderful datasets he will be able to work with as a result of this collaboration. In the Perceptual Expertise Network, our "bridge postdocs" who traveled between labs are a crucial element to binding our research together. Also, both of them will spend significant time at the Motion Capture/Brain Dynamics facility, and learn about the analysis tools available to them there. This should greatly aid not only their existing NSF effort, allowing them to integrate analyses of gesture data collected in ethnographic video with more detailed motion capture data, but also give TDLC researchers access to the tools they are developing as part of their framework for analyzing activity dynamics. Shared tools are one of the best ways to encourage shared research. These tools also have the potential to augment the TDLC Datagrid (being developed by DICE, our grid team at SDSC) as well as enable more efficient and effective analysis of video from the Motion Capture Lab. I envision a time when all of the networks in the TDLC make use of your tools, since all are dealing with extensive video files, ranging from facial data to rodent behavior.

Another extremely important aspect of your proposal is expanding interactions with Calit2 and LIFE. The collaboration you recently began with Falko Kuester, who is leading display-wall visualization developments at Calit2, will serve this project well. The HIPerSpace visualization facility, an ultra-high resolution distributed display system (currently a wall of 55 high-resolution displays and capable of scaling to billions of pixels) is an exciting tool to work with, and will motivate more students to join the project. It will be great to be able to use this facility for visualization and analysis of the widely ranging timescale data being collected at TDLC.

The supplement will also establish ties with the LIFE center, through the collaboration with Roy Pea at Stanford on the Diver video annotation system. I know you have worked informally with Roy before, and I hope this new funding will help cement the relationship. The Diver system is a great prototype that could be used to create the training sets necessary for the machine learning algorithms that will be necessary to automate your tools. Extending Diver to allow multiscale annotation and documentation of the analysis procedure will be crucial. As you say in your proposal, capturing annotated perspectives that document the process of analysis has extraordinary potential to aid scientific collaboration as well as instruction of graduate students.

In summary, the TDLC strongly supports this supplementary funding proposal. While the cost is modest (\$150K) the potential impact of increased collaboration between the TDLC and two non-center researchers and linkages with Calit2 and the Stanford portion of LIFE is large.

Sincerely,



Gary Cottrell

Director, The Temporal Dynamics of Learning Center



March 7, 2008

Dear Jim,

I am writing to express my enthusiastic support for your proposed project “Visualizing and Analyzing Activity Data: Initiating Collaborations with TDLC, LIFE and Calit2”. New methods for analysis and visualization of complex behavioral data can greatly facilitate our research at TDLC aimed at understanding movement control and learning. The state-of-the-art recording equipment we use – which includes marker-based motion capture, high-speed digital video, as well as force sensors and accelerometers – yields rich datasets but at the same time poses unique challenges when it comes to analyzing the data. Currently we can look at the individual measurements in isolation, however we lack the tools to combine all measurements in a way that is intuitive and illuminating with regard to the underlying neural control mechanisms. I suspect that the experimental data we have collected contains a lot more information than what we have been able to extract with existing tools. Therefore I am very excited about collaborating with you and developing better tools for analysis and visualization. Such tools will not only facilitate our research at TDLC but are also likely to have a large impact on the field of motor control in general. In return, the problems we are working on will provide a source of new ideas as well as a testbed for the methods you are developing. This will be a fruitful collaboration. I hope it gets funded!

Yours,

A handwritten signature in blue ink, reading "Emanuel Todorov".

Emanuel Todorov, PhD
Assistant Professor
Department of Cognitive Science
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tel: 858 822 1658



March 7, 2008

Dr. Jim Hollan
Distributed Cognition and HCI Laboratory
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Dear Jim,

I write to offer my strong support for the proposed supplement to NSF-HSD. The work you propose is aimed at removing one of the key roadblocks to progress in the cognitive and learning sciences. On the one hand, these fields require access to fine grained human activity data to gain insights. On the other hand, we only have the tools to barely scratch the surface of richness found in such data.

For the reasons you outline in your proposal, I think your work will take a meaningful step forward in our search for analytic depth. I am convinced that the efforts you propose to undertake will result in practical insights that will spur social science analysis forward.

This work couples to my HSD-funded work where we look in detail at the on-the-ground unfolding of education policy. I can see ways that your efforts will, at some point, bring nuance to social network and agent-based analyses of human activity. Your efforts also connect to the work of the NSF Spatial Intelligence Learning Center (SILC) - Science of Learning Center of which I am part. Here, I suspect, we will be very interested in visualization forms you create and human skills that you will develop to understand them.

I wish you all the best in this application. It is important work.

Sincerely,

A handwritten signature in black ink, appearing to read "Louis M. Gomez", written over a horizontal line.

Louis M. Gomez
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Professor of Computer Science
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