**Center for Human Adaptive Systems and Environments (CHASE)**

Ramesh Balasubramaniam (Director).

CHASE Exploratory committee: David Ardell (Quantitative & Systems Biology: QSB), YangQuan Chen (Mechanical Engineering), Paul Maglio (Management), Suzanne Sindi (Applied Mathematics: AM), Chris Kello, Teenie Matlock & Michael Spivey (Cognitive & Information Sciences: CIS). Other participants: Stefano Carpin, Marcelo Kallman (Electrical Engineering & Computer Science: EECS), Arnold Kim, Harish Bhat (AM), Rick Dale, Anne Warlaumont, David Noelle, Jeff Yoshimi, Peter Vanderschraaf (CIS), Fred Wolf (QSB).

**Executive Summary of Intiative:**

CHASE is a planned Organized Research Unit (ORU) that will comprise several faculty members across all schools and diverse academic units at UC Merced. CHASE's vision is to create a **leading-edge comprehensive environment for research, educational and public outreach activities in the area of human adaptive systems and environments**. The mission of CHASE is to discover, comprehend, and communicate the unifying principles of human adaptive systems and environments as complex physical, computational, biological, and social systems across multiple spatial and temporal scales. CHASE will **provide a platform to target large government and industry funding and achieve research goals not possible within traditional by-law units and graduate groups alone**. We provide a plan for how CHASE will develop and grow over the next few years commensurate with the growth of UC Merced. We make the case for how these goals can be expanded through the initiative in **computation and data science**.

**Intellectual Components of the Initiative:**

CHASE will house research on adaptive systems comprised of human behaviors that are fundamentally intertwined with their environments.  These systems are inherently spatial and multi-scale, so CHASE research will tend to emphasize spatial and multi-scale methods and analyses.  Scales will span a wide range of activities, from neuronal to behavioral to organizational to cultural to ecological.  In all cases the focus is on activity as situated in its environment. This could range from the largest scale where the environment is the planet sustaining human interactions, all the way down to small scales such as the proximal "environment" provided by bodily structures and dynamics that shape behavioral and neural activities.  In the middle are social, organizational and cultural environments.  The emphasis on adaptive behavior-environment interactions is both empirical and theoretical (neural network modeling, agent-based modeling, dynamical and game theoretic analyses) as well as applied (systems/service science; environmental management; relevant areas of engineering, including virtual environments and neuromorphic technologies). Members of CHASE will be involved in research at all these levels and time scales, with a particular emphasis on identifying common ground across the entire range of problems. A unique contribution of CHASE will be to combine questions in the Social Sciences with approaches from the Natural Sciences and using methods/technology from Engineering.

Recent developments in complexity research show that human adaptive systems interact with their environments in lawful ways across multiple scales. The NSF has identified complex systems research as a priority area of funding and there are several programs within all the directorates of NSF that target complexity research. Identifying these lawful principles may transform our understanding of human adaptive systems, and our ability to guide and shape their interactions with environments towards sustainability and health. Investigating these principles requires the kind of interdisciplinary research that Centers like CHASE are designed to establish and foster. CHASE will initiate and foster interdisciplinary interactions across CIS, EECS, ME, Social Systems Science, Anthropology, Geography, ES, Applied philosophy, Management, Biology, QSB & Chemistry. While CHASE’s contributions are primarily in the area identified in the strategic focusing exercise (Round 1) as **Information, Computational, and Data Sciences, and Engineering**, it is important to underscore that some of CHASE activity is also of relevance to the **Human Health** and **Life Sciences** initiatives. This speaks to the broad interdisciplinary nature of CHASE and its relevance to multiple units on campus. This overlap is particularly important to situate in the context of multidisciplinary grant seeking initiatives that will benefit from President Obama’s brain initiative and several other federal funding initiatives on big data.

Background:

Dr. Balasubramaniam was hired July 2013 as the first Director of CHASE following the approval of a successful Strategic Investment Faculty proposal in 2011. In Fall 2013, he facilitated the assembly of an exploratory committee for the formation of CHASE, comprising Drs Ardell, Chen, Kello, Maglio, Matlock, Sindi & Spivey. This committee will oversee the formal application process for being recognized as an ORU, help chart the specific research directions of CHASE, work out a "constitution" for CHASE governance (in line with UC policy); identify potential members and external advisory members; organize Center activities and seek extramural and internal funding opportunities.

**Definition of Thematic Area:**

While there are several institutional efforts in creating clusters/centers for studying complexity, very few are engaged in research directly related to human adaptive systems. A leading pillar in complexity research is the Santa Fe Institute (SFI). Although it born out of studying fundamental problems in physics and computation, SFI contributions to how we think of unified theories in science is unparalleled. By studying how complex systems behave and by applying common mathematical principles across scales, SFI has been able to successfully model human social behavior as a nonlinear dynamical system, capitalism as a complex adaptive system and develop such approaches for studying human search behaviors, foraging and migration. SFI has taken a relentlessly theoretical approach to "big data" problems and have offered very creative solutions pushing the boundary of science. In doing so, they also captured the imagination of several generations of researchers through their summer schools, invited scholar and fellow-at-large programs. In a similar vein, we believe that CHASE has the potential to impact and transform the way we think of human adaptive systems in such a fundamental manner by capitalizing on existing strengths across the three Schools of UC Merced.

There are other Centers elsewhere in the United States that study complex adaptive systems, but their scope is typically much narrower and domain-specific. For example, the Center for Neural systems in Boston University is strictly to neural systems, as in the case with similar Centers at Arizona State and Florida Atlantic University although at different scales. UCSB's Center for Spatial studies deals primarily with spatial problem solving for learning and discovery. A few Centers work exclusively with complex adaptive systems in economics and decision-making. A comparable effort to CHASE can be found at the University of Michigan (http://www.lsa.umich.edu/cscs/) and the Beckman Institute at the University of Illinois (http://www.beckman.uiuc.edu). Still, their approach is very general and the study of human adaptation is merely one of several focus areas. Thus CHASE is in a unique position to contribute to and even lead in a high-growth area.

As mentioned earlier, one of the aims of CHASE is to **capitalize on the existing core interdisciplinary strengths at UC Merced and build a platform for studying transformative issues in human adaptive systems and environments**. Several ongoing efforts across campus are already looking into similar problems. CHASE will provide the right interdisciplinary learning and training environment to put us in a unique place to address these problems and catalyze efforts. A key area in which CHASE will lead the field will be in the **creative use of existing and growing strengths in computation and big data**. These strengths will be applied to tackle a range of problems using laboratory, field and modeling techniques.

**Faculty Participation:**

As outlined in the CIS strategic proposal, computation is a core focus of this group. But this theme is also found in many other groups at UC Merced including the Sierra Nevada Research Institute (SNRI), Health Sciences Research Institute (HSRI) Environmental Science (ES), Center for Quantitative Research (CeQR), research groups in AM, EECS, QSB, Management, Chemistry and Chemical Biology, and Applied Philosophy. What is unique about UC Merced is that many of these individuals are already collaborating. This strengthens the case for having a formalized environment to foster existing collaborations and make new ones. We believe that CHASE will provide the appropriate and context-specific glue to connect several exciting initiatives already underway at UC Merced. We also believe that CHASE will play a crucial role in the second phase of this strategic process by connecting individuals working on computational issues in ES, SNRI, Applied Math, QSB, Anthropology, History (Spatial Analysis Research Center: SPaRC), Management, HSRI and CRU efforts like the planned new Center for Theory and Computation (CTC). Below, we list a few already active collaborations across multiple spatial and temporal scales (many of them have resulted in external funding, leading journal articles and more important cross-disciplinary graduate student training + undergraduate research efforts).

(1) *Ramesh Balasubramaniam, Michael Spivey (CIS) Stefano Carpin (EECS):* Use of robotics for studying human motor control and cognition (currently seeking external funding ;

(2) *Rick Dale, Suzanne Sindi (Applied Math), David Ardell (QSB):* Commonalities between language and molecular evolution (funded by NSF INSPIRE);

(3) *Chris Kello (CIS), Stefano Carpin, Paul Maglio, David Noelle (CIS):* Next generation neural processing units (funded by DARPA);

4) *Stefano Carpin (EECS), YangQuan Chen (Mechanical Engineering), Chris Kello (CIS):* human-robot search teams and the use of fractional calculus for studying complex systems (currently seeking funding); 5) *Ramesh Balasubramaniam (CIS), Harish Bhat (AM):* Solutions for human motor control problems using time-delayed stochastic systems;

(6) *Teenie Matlock under SNRI:* Creation of the Center for Climate Communication (CCC: funded through several sources);

(7) *Teenie Matlock* (CIS) and Berkeley researchers: MetaNet: A large-scale multilingual metaphor extraction, representation, and validation system (funded by IARPA);

(8) *Teenie Matlock (CIS), Marcelo Kallman (EECS) Stefano Carpin (EECS), David Noelle (CIS):* Animation for studying human gestures with applications in health-care/physical therapy (funded by NSF instrumentation grants);

(9) *Anne Warlaumont (CIS) and Ajay Gopinathan (Physics):* Using random walk models to study the development of communication in infants. Additional collaborations are also underway to study infant development in naturalistic home environments in the Central Valley (with *Eric Walle*, *Psychology*).

(10) *Arnold Kim (Applied Math)* and several other researchers: Using computation as an underlying theme a new NRT proposal is being developed. CHASE will be an active participant in this venture that will enable a training program in computation and data science across multiple scales.

Taken together, these researchers have raised > $6M in funding (approx). Several of these researchers hold important leadership positions in the field including journal editorships, grant panel memberships and many of them are widely cited and held in the highest standing in their respective fields.

A major aim of CHASE is to provide a research environment that enables such high-quality collaborations to emerge and run seamlessly. Below, we outline what such an environment would ideally have and how to achieve it. The three main focus areas of CHASE are dynamic and complex systems (Balasubramaniam, Chen, Kello, Noelle, Spivey, Westerling, Yoshimi), spatial and environmental processes and analyses (Aldenderfer, Chen, Dale, Dicey-Jennings, Maglio, Matlock, Spivey, Westerling, Warlaumont), and computational modeling of emergent phenomena (Balasubramaniam, Dale, Kello, Noelle, Spivey, Vanderschraaf, Warlaumont Yoshimi).

Major themes to be explored in CHASE include computation and big data issues in human social interactions, human and automation interaction, brain and neural dynamics, modeling climate change, human sensorimotor control and evolution of language and communication. All involve core theoretical problems for which a common underlying mathematical/physical approach may present a solution. We attach with this proposal a network diagram (developed by Arnold Kim and Michael Spivey in the Computation and Data Science proposal) that shows the position of CHASE in the campus wide network of allied scientists, engineers and social scientists.

**UCM’s Role**

*Educational contributions:* CHASE is not directly involved in any single academic program or graduate group, yet it can contribute significantly to student experiences both at the undergraduate and graduate level. One of the first major tasks that CHASE will engage in will be to help set up a training program in Human Adaptive Systems across all schools and units. Planned support for sustaining these training programs include 1) federal support from NSF for research experience for undergraduates (REUs) with a particular emphasis on underrepresented groups, including women and minorities and 2) applying for funding to support integrated graduate and post-doctoral research training in human adaptive systems. The latter will be achieved through programs like NIH training grants and the erstwhile IGERT training grant from NSF. CHASE will actively try to grow graduate student numbers in the STEM disciplines, but equally so in the quantitative social sciences. CHASE will also make special efforts to recruit minority and underprivileged students to the sciences of data and computation.

Second, CHASE will provide an ideal learning environment for undergraduate and graduate students to participate in training that is not available through traditional academic units. CHASE is already involved in the organization of summer schools to initiate such training across a diverse range of topics. The first CHASE summer school will be held in May 2014 (at Yosemite and UC Merced campus) and will host 40 students from around the nation. We have already received $50K from NSF for this venture (PI: Chris Kello, Co-PIs: Matlock & Balasubramaniam). The theme of the first summer school is "Language, Music and Movement Dynamics". We plan to host summer schools in the next few years with planned topics including but not limited to 1) Human Interaction dynamics 2) Analysis of stability and metastability in complex systems 3) Learning in human networks 4) Social networks, small world networks and brain networks 5) Communicating the science of human-environment systems. We will actively seek funding to support the summer school efforts in future years. It is anticipated that CHASE will begin a high-impact seminar series modeled on the CIS (Mind, Technology & Society) series, but on a larger scale, possibly involving the city of Merced.

**Special Programmatic Needs:**

It is our belief that by 2020, CHASE as an ORU will be a self-sustaining unit that will be supported through overheads and research dollars. It is expected that we will need administrative support to organize grant-writing activities. As CHASE does not have affiliation with any specific By-law 55 units, we are not asking for any FTEs for the development of CHASE. However, CHASE will be actively participating in the activity of several units on campus (recruitment, collaboration, retention) as they participate in faculty growth, especially in the areas of computation across units and scales.

Space: It is expected that the space needs for CHASE growth will be commensurate the space requirements of the participating units and its members. However, it is anticipated that a **common core space** (similar the one presented in the CIS document) for CHASE activities will be required. This common core space will house human laboratories (behavioral, social and neural), high-performance computation clusters, a seminar room and administrative offices. Some space will also be needed to house post-doctoral fellows and graduate students from participating research groups. The Dean of SSHA has already allocated CHASE about 500 sq ft of space in the SSM building. This space is being utilized to house a meeting room and an additional space with the capacity to host three staff members. By 2020 we expect the space needs to have grown about tenfold, to house CHASE laboratories and interactions and ORU admin staff.

CHASE is currently involved in applying for extramural funding for state-of-the-art laboratories to study human adaptive systems (3D motion-tracking, robotics, etc.). Efforts are underway to explore virtual reality environments for studying human-environment interaction in various groups in the social sciences (anthropology, psychology). CHASE will be in a position to help foster collaborations of these social scientists with engineers and natural scientists in order to fund these laboratory ventures.

**Summary**

In sum, CHASE is an exciting new development that will increase the visibility of UC Merced, by bringing together individuals and enhancing leading-edge research while making substantial contributions to the educational environment by linking graduate and undergraduate students with world-class research and training opportunities.